NONRESIDENT
TRAINING
COURSE

October 1992

Gas Turbine Systems Technician (Electrical) 2

NAVEDTRA 14112

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

COMMANDING OFFICER
NETPDTC
6490 SAUFLEY FIELD RD
PENSACOLA, FL 32509-5237

10 Aug 1999

ERRATA #1

Specific Instructions and Errata for
Training Manual

GAS TURBINE SYSTEMS TECHNICIAN (ELECTRICAL)

1. No attempt has been made to issue corrections for errors in typing, punctuation, etc.

2. Whenever the following manuals are referenced, make the indicated changes in the training manual:

a. Change *Tools and Their Uses,* NAVEDTRA 10085, to *Use and Care of Hand Tools and Measuring Tools,* NAVEDTRA 12085.
b. Change NAVPERS 10868E (change 2), to NAVPERS 18068 (VOLUME 1). Change *Blueprint Reading and Sketching,* NAVEDTRA 10077, to *Blueprint Reading and Sketching,* NAVEDTRA 12014.
C. Change *Electrician's Mate 3&2,* NAVEDTRA 10546-F, to *Electrician's* Mate, NAVEDTRA 12164.

3. Change the following items in the training manual:

a. Page iii, delete "and PHM" from title of chapter 5.
b. Throughout the manual, delete all references to DDG-993.
C. Pages 1-5 through 1-7, Figures 1-1, 1-2, and 1-3, add "Note: See NSTM Chapter 220, Volume 2, Section 27, for updated sample entries utilizing these forms."
d. Page 2-2, under the heading "FFG-7 CLASS SHIPS" in the second paragraph, change "20 6-volt lead-acid storage batteries" to "10 12-volt maintenance free batteries..."
e. Page 5-39, under the heading "WATER WASH SYSTEM" in the second paragraph, delete "and PHM-" from the first sentence and delete the entire last sentence in same paragraph.
f. Page 7-1, change chapter title to read "LCAC PROPULSION SYSTEMS." Delete "and patrol combatant missile (hydrofoil) (PHM) class ships" from the first sentence in the first paragraph. Delete "or a PHM" from the second sentence in the first paragraph. Delete references to PHM in the second and third paragraphs.
g. Pages 7-19 through 7-40, delete the entire Patrol Combatant Missile (Hydrofoil) section, in the right column starting with "Now, let's look at the propulsion system of another type of landing craft, the patrol combatant missile (hydrofoil) or PHM." through page 7-40, including associated figures 7-18 through 7-36.
h. Pages 7-40 and 7-41, change the entire "SUMMARY" to the following:

'This chapter has provided you with a variety of information to help you become familiar with the propulsion systems and electrical systems on the LCAC class ships.

In this chapter, we discussed several of the control systems, design and basic maintenance. We also discussed the vessel's electrical system and the APU. We briefly described the LCAC's maintenance system and the troubleshooting techniques used in isolating and repairing equipment malfunctions.

As a GSE, you may find yourself assigned to this class of ship. This chapter should have provided you with a basic understanding of the engineering systems found on the LCAC class ships."

4. Change the following items in the appendices of the training manual:

a. Page AI-1, delete "AUTOMATIC CONTROL SYSTEM" and "BULKHEAD-MOUNTED ELECTRONICS ENCLOSURE (BMEE)" and associated definitions.
b. Page AI-3, delete ‘ENGINEER OPERATING STATION (EOS)" and associated definition.
C. Page AI-7, delete "SHIP'S SERVICE POWER UNIT (SSPU)" and associated definition.
d. Page AI-8, under the heading ‘WASTE HEAT BOILER (WHB)," delete "DDG-51."
e. Page AII-1, delete "ACS" and "BMEE."
f. Page AII-4, delete "PHM."
Page AII-5, delete "SSPU."
g. Page AV-1, add "Module 23 Magnetic Recording" and "Module 24 Introduction to Fiber Optics."
h. Pages AVI-5 and AVI-6, under the heading "Chapter 7," delete six references starting with *Mobile Electric Power Plant.*

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Specific Instructions and Errata for
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GAS TURBINE SYSTEMS TECHNICIAN (ELECTRICAL)

1. No attempt has been made to issue corrections for errors in typing, punctuation, etc., that do not affect your ability to answer the question or questions.

2. To receive credit for deleted questions, show this errata to your local course administrator (ESO/scorer). The local course administrator is directed to correct the course and the answer key by indicating the questions deleted.

3. Assignment Booklet

Delete the following questions, and leave the corresponding spaces blank on the answer sheets:

Questions

4-32 through 4-75

Make the following changes:

Questions	Change
1-55	In response #2, change "(a) 20" to "(a) 10"
2-24	In response #4, change "distribution" to "distributor"

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

COURSE OVERVIEW: In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following: engineering administration; uninterrupted power supply systems; engineering control system operations; engineering support systems maintenance; electrical and electronic systems maintenance; pressure, temperature, and level control devices; and the Landing Craft, Air Cushion (LCAC) and the Patrol Combatant Missile (PHM) propulsion systems.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

1992 Edition Prepared by
GSCS(SW) Anthony T. Askew

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AND TECHNOLOGY CENTER

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Sailor's Creed

"I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

CONTENTS

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

https://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

https://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N314
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
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NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you may earn retirement points for successfully completing this course, if authorized under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 6 points. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty,* BUPERSINST 1001.39, for more information about retirement points.)

Student Comments

Course Title: *Gas Turbine Systems Technician (Electrical) 2*

NAVEDTRA: 14112 **Date**: ____________________

We need some information about you:

Rate/Rank and Name: ____________________ SSN: ____________ Command/Unit __________________

Street Address: ________________________ City: ____________ State/FPO: ________ Zip ________

Your comments, suggestions, etc.:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00

CHAPTER 1

ENGINEERING ADMINISTRATION

The higher you advance, the more responsibility you will have for engineering administration. At this stage in your naval career, you must become more involved with the administration portion of your rating. This chapter deals briefly with certain aspects of your responsibilities in the areas of quality assurance and engineering administration.

This manual is a source of information as you continue training in the tasks you perform at the E-5 level of the Gas Turbine Systems Technician (Electrical) (GSE) rating. Your understanding of the information in this training manual (TRAMAN) combined with essential practical experience should help you perform your assigned tasks and accept greater responsibilities.

This TRAMAN should help increase your knowledge of the GSE rating. It should also provide you with a foundation from which you can begin your study and preparation for advancement to second class petty officer. Your contribution to the Navy, however, will depend on your ability to accept increasing responsibilities as you advance. When you assume the duties of a GSE2, you accept certain responsibilities for the work of others. As you advance in your career, you also accept additional responsibilities in military subjects and in the occupational and training requirements for the Gas Turbine Specialist (GS) rating.

QUALITY ASSURANCE PROGRAM

Some of your additional responsibilities will involve your support of the Navy's quality assurance (QA) program. The QA program is designed to provide Navy personnel with the information and guidance they need to manage a uniform policy of the maintenance and repair of ships. The QA program introduces discipline into the repair of equipment, safety of personnel, and configuration control. All these factors will serve to enhance your ship's readiness.

QA MANUAL

Basically, the instructions in the QA manual apply to every ship and activity in the force and state the minimum QA requirements for the surface fleet. At times, however, more stringent requirements will be imposed by higher authority. These requirements will take precedence over the minimum requirements set forth in the basic QA manual. As part of your ship's QA program, your QA manual should reflect any necessary additional requirements and changes to the basic QA instructions.

For the most part, requirements set forth in the basic QA manual pertain to the repair and maintenance done by the force intermediate maintenance activities (IMAs). These requirements, however, are also designed to apply to maintenance performed aboard ship by ship's force.

Because there is a wide range of ship types, equipment, and resources available for maintenance and repair, the instructions in the basic QA manual are general in nature. The overall goal is to have all repairs conform to basic QA specifications. Each activity, however, must carry out its own QA program to meet the intent of the basic QA manual. In cases where specifications cannot be met, your ship must complete a departure-from-specifications request reporting these conditions.

QA GOALS

The basic thrust of the QA program is to make sure you follow technical specifications during all work on ships of the surface fleet. The key elements of the program include the following categories:

- Administration. Administrative requirements include training and qualifying personnel, monitoring and auditing programs, and completing QA forms and records.
- Job execution. Job requirements include preparing work procedures, meeting controlled material requirements, and requisitioning material. This category also includes conducting in-process control of fabrication and repairs, testing and recertifying equipment, and documenting any departure from specifications.

A properly functioning QA program points out problem areas to maintenance managers so they can take corrective actions in a timely manner. The following goals are common to all Navy QA programs:

1. To improve the quality, uniformity, and reliability of the total maintenance effort

2. To improve work environment, tools, and equipment used in the performance of maintenance

3. To cut unnecessary man-hour and dollar expenses

4. To improve the training, work habits, and procedures of all maintenance personnel

5. To increase the excellence and value of reports and correspondence generated by the maintenance activity

6. To distribute required technical information more effectively

7. To set up realistic material and equipment requirements in support of the maintenance effort

QA ORGANIZATION

The QA program for naval forces is organized into different levels of responsibility. For example, the COMNAVSURFPAC QA program includes the following levels of responsibility: type commander, readiness support group/area maintenance coordinator, and the IMAs. The QA program for COMNAVSURF-LANT includes five levels of responsibility: force commander, audits, squadron commanders, IMAs, and force ships.

The QA program organization (Navy) begins with the commander in chief of the fleets, who provides the basic QA program organization responsibilities and guidelines.

The **type commanders (TYCOMS)** provide instruction, policy, and overall direction for implementation and operation of the force QA program. TYCOMs have a force QA officer assigned to control the force QA program.

The **commanding officers (COs)** are responsible to the force commander for QA in the maintenance and repair of the ships. The CO is responsible for organizing and implementing a program to carry out the provisions of the TYCOM's QA manual.

The CO ensures that all repair actions performed by ship's force conform to provisions of the QA manual as well as to other necessary technical requirements.

The **quality assurance officer (QAO)** is responsible to the CO for the organization, administration, and execution of the ship's QA program.

The QAO is responsible for coordinating the ship's QA training program and for maintaining the ship's QA records and test and inspection reports. The QAO conducts QA audits as required and follows up on corrective actions to assure compliance with the QA program.

The **ship quality control inspectors (SQCIs)** must have a thorough understanding of the QA program. The SQCIs are usually the work center supervisor and two others from the work center. The following list contains some of the other responsibilities the SQCI will have:

1. Inspect all work for compliance with specifications.

2. Maintain ship records to support the QA program.

3. Make sure only calibrated equipment is used in acceptance testing and inspection of work.

4. Witness and document all tests.

5. Make sure all materials or test results that fail to meet specifications are recorded and reported.

SPECIFICATIONS

In the field of quality assurance, the following terms are often misunderstood and confused: *level of essentiality* and *level of assurance.* To eliminate some of the confusion, this TRAMAN will define the levels of essentiality and levels of assurance required for equipment/systems on surface ships. There is no direct connection between the two terms.

Levels of Essentiality

Some early failures in surface ship systems were traced to the use of the wrong materials. This led to a system of prevention that involved levels of essentiality. A level of essentiality is a range of controls representing a certain high degree of confidence that procurement specifications have been met. The range of controls is defined into two broad categories.

- Verification of material
- Confirmation of satisfactory completion of test and inspections required by the ordering data

Levels of essentiality are codes that show the degree to which the ship's system, subsystem, or components are necessary in the performance of the ship's mission. The ship assigns these codes according to the QA manual. These codes show the impact that a catastrophic failure would have on the ship's mission capability and safety of personnel.

Levels of Assurance

Quality assurance has three levels: A, B, and C. Each level reflects certain quality verification requirements of individual fabrication in process or repair items. In the language of QA, the term *verification* refers to the total level of quality controls, tests, and inspections. **Level A** assurance provides for the most stringent of restrictive verification techniques. This level normally will require both quality controls and test or inspection methods. **Level B** assurance provides for adequate verification techniques. This level normally will require limited quality controls and may or may not require tests or inspections. **Level C** assurance provides for minimum or "as necessary" verification techniques. This level will require very little quality control in regard to tests or inspections.

The QA concept involves preventing the occurrence of defects. For this reason, QA covers all events from the start of a maintenance action to its completion and is the responsibility of all maintenance personnel.

By carefully following the procedures outlined in your QA program manuals and by paying careful attention to the quality of work, you will contribute to the operational effectiveness of your ship. For further in-depth knowledge about the QA procedures and practices, consult your area COMNAVSURFLANT/PACINST QA manual.

ENGINEERING LOGS, RECORDS, AND REPORTS

As mentioned before, responsibility increases as you advance in the GSE rating. Part of that responsibility includes the maintenance of various logs, records, and reports. You will be responsible for making sure that the proper logs and records are used. Using the proper logs and records will help your work center and department adhere to proper equipment operation and maintenance procedures.

ADMINISTRATION

Logs and records are a part of the Navy's record system. This system improves record keeping through standardization, automation, speed, and efficiency. Although the primary vehicle for record keeping aboard shift is the Maintenance Material Management (3-M) Systems, you will be required to become familiar with the administration procedures required for specific logs and records of the engineering department.

Accurate, legible, and up-to-date engineering logs and records plus the timely submission of accurate and legible reports reflect efficient administration of the engineering department. Logs and records maintained by the engineering department provide the data for engineering reports to higher authority. Reviewing the logs, records, and reports will allow the engineer officer an easy and effective method of keeping informed of the state of the equipment in the department.

Proper administration of the engineering logs, records, and reports system requires the regular and conscientious attention of all engineering personnel. The person filling out the log or record must have knowledge of the material recorded or reported. Your engineer officer has a record reference file containing complete information on the methods of maintaining required records. The engineer officer also uses a report tickler file. Both files are important tools in the administration of engineering logs and records.

There is no simple way for your department to ensure the accuracy of logs, records, and reports. First, the responsibility for keeping the logs and records and preparing the reports must be set up within the department. Next, the responsibility for checking and verifying the data contained in the logs, records, and reports must be assigned. The engineering department and division organization manuals provide excellent means for setting up departmental record keeping responsibilities. This is where your role of a second class petty officer becomes more apparent. As a work center supervisor, it will be your duty to review the logs and records taken on engineering equipment. As a collateral duty, it will be your responsibility to review the logs and records for the entire engineering department. An effective training program should acquaint engineering personnel with the proper procedures for getting data and maintaining records.

TYPES

Some engineering logs and records are mandatory. This means they are required by law. Other logs and records are essential for efficient operation of the engineering plant. The following sections of this chapter will briefly describe some of the logs, records, and reports necessary for a well-administered engineering department of a gas turbine-powered ship.

Legal Records

The engineering department must maintain certain legal records. These records are in the category of mandatory records required by law. The two legal records the engineering department must maintain are the Engineering Log and the Engineer's Bell Book.

Engineering department personnel must make certain that the Engineering Log and the Engineer's Bell Book are maintained in a conscientious and specific manner. The following list contains some of the basic guidelines you must follow while preparing or checking these logs for accuracy:

- Do not make erasures.
- Any errors should be overlined and initialed by the person who prepared the original entries. That person should draw a single line through the original entry so the entry remains legible. The same person should then insert the correct entry to assure clarity and legibility.
- The person who enters the change must initial that change in the margin of the page.
- After the commanding officer signs either of these records, no changes can be made without his or her permission.

Operating Records

Engineering operating records assure the regular inspection of operating machinery and provide data for performance analysis. Operating logs and records do not replace frequent inspections of operating machinery by supervisory personnel nor do they warn of impending casualties. They do, however, provide important information on the performance of operating equipment. Personnel who maintain operating logs and records must be properly trained to interpret and record data correctly and to report any abnormal conditions.

The following sections will briefly describe some of the engineering operating logs and how you may become involved with these logs as you advance in the GSE rating.

BOILER WATER AND FEEDWATER LOGS.— One important log on some gas turbine ships is the boiler water and feedwater log. The importance of the boiler water and feedwater chemistry logs and records must not be underestimated. The engineer officer and his or her assistants use the data reflected in these logs to measure the performance, stability, efficiency, and state of material readiness of the engineering plant. The decision-making process involved in an effective water chemistry program aboard your ship must be supported by the information in these logs.

As you advance in the GSE rating, you may become a member of the oil lab. If assigned to the oil lab, you will be required to test and treat boiler water and feedwater. To carry out these responsibilities, you must be familiar with the various logs and records used in the oil lab.

Three of the logs that are commonly used for recording and maintaining important data your' department will need to maintain the proper water conditions in a waste heat steam plant are as follows:

1. Cover Sheet and Monthly Boiler Data
2. Feedwater Chemistry Worksheet/Log
3. Waste Heat Boiler Water Chemistry Worksheet/Log

You should be familiar with the purpose, content, and general procedures for each of these logs.

Cover Sheet and Monthly Boiler Data.— A Cover Sheet and Monthly Boiler Data log sheet must be prepared for each waste heat boiler. Figure 1-1 illustrates a basic Cover Sheet and Monthly Boiler Data log sheet. Notice in view A that this log contains the signatures of the engineer officer and the commanding officer, verifying they have reviewed the package. On the reverse side of the cover sheet (view B) are the proper data entries for the boiler. These entries include information, such as total steaming hours, safety valve settings, and water chemistry standards.

Feedwater Chemistry Worksheet/Log.— A sample of the Feedwater Chemistry Worksheet/Log is shown in figure 1-2. Notice that the data entries are made on the front side (view A) and the section for remarks is on the reverse side (view B).

This log contains the daily chemical condition of the waste heat boiler feedwater system. The information recorded in this log includes the results of chemical tests, salinity indicator comparisons, shore steam and shore feedwater chemical test data, and remarks.

The Feedwater Chemistry Worksheet/Log must be started daily for each feedwater and condensate system in operation. A daily log is not needed, however, for a system that is not in operation. In this case, the dates that testing was not needed must be recorded on the front of one log. A remark should be included stating why testing was not necessary.

WATER TREATMENT LOG

MACHINERY PLANT NO. 1

USS G. TURBINE (DD-999)

MONTH DECEMBER, 1992

CONSISTING OF PAGES 1 THROUGH 96

REVIEWED W.T. DOOR, LT. USN 3 JAN 93
ENGINEER OFFICER DATE

EXAMINED P.T. BOAT, CAPT, USN 6 JAN 93
COMMANDING OFFICER DATE

NOTE: THIS RECORD WILL BE RETAINED ON BOARD FOR 2 YEARS AND DISPOSED OF IN ACCORDANCE WITH SECNAVINST 5212.5, SUP-1, PARA. 9610(1). TRANSCRIPT(S) WILL BE FURNISHED TO NAVSEASYSCOM WHEN REQUIRED.

NAVSEA 9255/6 (REV.1-87) (FRONT)

A. FRONT

NAVSEA 9255/6 (REV. 1-87) (BACK)

MONTHLY BOILER DATA

BOILER NUMBER	1	2	3
STEAMING HOUR DATA			
TOTAL STEAMING HOURS	28141.3	26431.4	21837.6
TOTAL LAST MONTH	261.4	142.3	101.4
HOURS THIS MONTH	110.3	91.7	37.6
INSPECTIONS			
SOPI			
DATE LAST INSPECTED	12 AUG 92	14 AUG 92	16 AUG 92
INSPECTED BY	IMA	IMA	IMA
STM. HRS. SINCE INSP.	1421.4	1574.3	1214.6
CHENG			
DATE LAST INSPECTED	15 MAR 92	17 MAR 92	17 MAR 92
INSPECTED BY	W.T. DOOR	W.T. DOOR	W.T. DOOR
STM. HRS. SINCE INSP.	1510.3	1634.1	1071.4
CLEANINGS			
WATER JET, WIRE BRUSH OR EDTA WATERSIDE CLEANING			
DATE LAST CLEANED	3 June 88	4 June 88	4 June 88
TYPE OF CLEANING	EDTA	EDTA	EDTA
STM. HRS. SINCE CLN.	2414.5	2571.3	1791.3
HYDROCHLORIC OR SULFAMIC ACID WATERSIDE CLEANING			
DATE LAST CLEANED	15 Feb 86	27 Feb 86	27 Feb 86
STM. HRS. SINCE CLN.	2110.4	2041.3	1344.8
FIRESIDE CLEANING			
DATE LAST CLEANED	3 June 88	4 Jun 88	4 Jun 88
STM. HRS. SINCE CLN.	2417.5	2571.3	2004.4
CONTAMINATION			
STM. HRS. MODERATE	10	7	3
% STM. HRS. MODERATE	9.5	5.2	8.4
STM. HRS. SERIOUS	2	2	1
% STM. HRS. SERIOUS	.5	10	8
CHEMICAL AND BLOWDOWN DATA			
TOTAL OUNCES TSP	57	31	30
TSP/1000 STM HR/1000 GAL	.22	.18	.17
TOTAL OUNCES DSP	50	20	10
DSP/1000 STM HR/1000 GAL	.17	.17	.17
TOTAL OUNCES C.S.	0	0	0
NO. OF SURFACE BLOWS	3	3	1
TOTAL % SURFACE BLOW	60	60	58
NO. OF BOTTOM BLOWS	2	1	1
TOTAL % BOTTOM BLOW	30	20	33

BOILER SAFETY VALVES SET	DATE	PRESSURE LIFT	PRESSURE RESEAT
BOILER NUMBER 1			
PILOT			
SUPERHEATER			
#1 DRUM	4 APRIL 92	125	108
#2 DRUM	4 APRIL 92	129	113
#3 DRUM			
#4 DRUM			
BOILER NUMBER 2			
PILOT			
SUPERHEATER			
#1 DRUM	4 APRIL 92	126	109
#2 DRUM	4 APRIL 92	130	113
#3 DRUM			
#4 DRUM			
BOILER NUMBER 3			
PILOT			
SUPERHEATER			
#1 DRUM	4 APRIL 92	125	108
#2 DRUM	4 APRIL 92	130	112
#3 DRUM			
#4 DRUM			

WATER CHEMISTRY STANDARDS RUN		
TEST	DATE	RESULT
CONDUCTIVITY	11 DEC 92	430
CHLORIDE	11 DEC 92	.40 epm
ALKALINITY	17 DEC 92	.20 epm
HARDNESS	11 DEC 92	.09 epm

HYDROSTATIC TEST DATES			
BOILER NUMBER	1	2	3
LAST 100% HYDRO	10 June 90	10 Jun 90	10 Jun 90
LAST 135% HYDRO	10 June 90	10 Jun 90	10 Jun 90
LAST 125% HYDRO	10 June 90	10 Jun 90	10 Jun 90

DATES OF IMPORTANT EVOLUTIONS			
BOILER NUMBER	PSI/DATE	PSI/DATE	PSI/DATE
SOOT BLOWER HOT	3 Feb 92	3 Feb 92	3 Feb 92
BOTTOM BLOWDOWN PIPING HOT	5 May 92	6 May 92	5 May 92
AIR CASING TEST	11 OCT 92	12 OCT 92	12 OCT 92
SATISFACTORY BOILER FLEXIBILITY TEST	10 DEC 92	10 DEC 92	10 DEC 92

GOVERNOR SETTINGS									
NUMBER									
FORCED DRAFT BLOWERS (DATE / SETTING)									
NUMBER									
FUEL OIL SERVICE PUMPS (DATE / SETTING)									
NUMBER									
MAIN FEED PUMPS (DATE / SETTING)									
NUMBER									
MAIN FEED BOOSTER PUMPS (DATE / SETTING)									

B. BACK

Figure 1-1.—Cover Sheet and Monthly Boiler Data log sheet.

FEEDWATER CHEMISTRY WORKSHEET/LOG

NAVSEA 9255/4 (8-88)(FRONT)

SYSTEM ONE SHIP USS G. Turbine (DD 999) DATE 10 May 92 PAGE 101

CHEMICAL TESTS AND SALINITY/CONDUCTIVITY INDICATOR COMPARISON (REQUIRED DAILY) NOTE: µMHO/145=EPM

TIME	INDICATOR LOCATION	CHLORIDE mL MERCURIC NITRATE x 0.1 = EPM CHLORIDE		INDICATOR READING		COMPARISON	HARDNESS mL EDTA x 0.2 = EPM HARDNESS		OIL KING INITIAL
		mL	EPM	µMHO/CM	EPM	SAT/UNSAT	mL	EPM	
0115	CNTL COND		.01		.01	SAT			
0130	COND CLR		.02		.02	SAT			
0321	COND CLR		.02		.05	UNSAT		.02	

DEAERATED FEED WATER

TIME	CODE	DISSOLVED OXYGEN LIMIT: 15 PPB	MORPHOLINE pH RANGE: 8.8–9.0	MORPHOLINE ROTAMETER SETTING	MORPHOLINE TANK LEVEL (GALLONS)

FEEDWATER TESTS

TIME	LOCATION	INDICATOR READING µMHO/CM / EPM	CHLORIDE mL MERCURIC NITRATE x 0.1 = EPM CHLORIDE		HARDNESS mL EDTA x 0.2 = EPM HARDNESS		OIL KING INITIAL
			mL	EPM	mL	EPM	

A. FRONT

FEEDWATER CHEMISTRY WORKSHEET/LOG

NAVSEA 9255/4 (8-88)(BACK) PAGE 102

TIME	REMARKS:
0321	COMPARISON TEST UNSAT. SALINITY READING IS GREATER THAN
	CHEMICAL CHLORIDE TEST BY MORE THAN 0.02 epm.
	WATER TESTED FOR HARDNESS. TEST IS .02 epm. WATER
	IS SAT FOR USE. SALINITY INDICATOR WILL BE CHECKED
	FOR MALFUNCTION.

LEGEND/TEST CODE

DISSOLVED OXYGEN TESTING

- PFB PRIOR TO FEEDING THE BOILER
- AOL WITHIN 3 HOURS AFTER BOILER ON LINE
- RTE WITHIN 24 HOURS

MORPHOLINE TREATED SYSTEM

- AOL 60 TO 90 MINUTES AFTER ON LINE
- RTE CARRIERS EVERY 4 HOURS OTHERS EVERY 12 HOURS

REQUIREMENTS/LIMITS (MAXIMUM)		CHLORIDE EPM SALINITY INDICATOR	CHLORIDE EPM CHEMICAL TEST	CONDUCTIVITY µMHO/CM	HARDNESS EPM
DISTILLATE		0.065	0.07	10.0	–
MAKEUP	DEMINERALIZED	–	–	1.0	–
	NONDEMINERALIZED	0.10	0.10	15.0	0.10
CONDENSATE, DRAINS & DFT	MORPHOLINE TREATED	0.04	0.02	6.0	0.02
	WITHOUT MORPHOLINE	0.02	0.02	3.0	0.02
DISTILLER AIR EJECTOR DRAINS		0.065	0.02	10.0	–

LCPO INIT.	LCPO DATE	MPA INIT.	MPA DATE	REVIEWED: (ENGINEER OFFICER)	DATE
AA	11MAY92	DR	11MAY92	W. T. DOOR	11 MAY 1992

B. BACK

Figure 1-2.—Feedwater Chemistry Worksheet/Log.

Waste Heat Boiler Water Chemistry Worksheet/Log.— A sample of a Waste Heat Boiler Water Chemistry Worksheet/Log is shown in figure 1-3. Notice that this log contains sections for entering data on chemical test results, chemical treatments, blowdowns, pH meter standardizations, steaming hours, and remarks. (See views A and B.)

The Waste Heat Boiler Water Chemistry Worksheet/Log is started daily and should contain any significant event or action that took place on the waste heat boilers.

LUBRICATING OIL LOGS.— Because of the importance of good quality lubricating oil, the Lube Oil Management Program was developed. The guidelines

WASTE HEAT BOILER WATER CHEMISTRY WORKSHEET/LOG

NAVSEA 9255/7 (8-88)(FRONT)

BOILER NO. 1 SHIP USS G. Turbine DD. 999 DATE 4 Dec 92 PAGE 40

TIME	CODE	ALKALINITY RANGE: 0.05–0.25 EPM		PHOSPHATE RANGE: 25 – 75 PPM		CONDUCTIVITY LIMIT: 500 µMHO/CM		CHLORIDE LIMIT: 1.0 EPM		OIL KING INITIAL	EOOW/EOO INITIAL
		mL PHENOL-PHTHALEIN	mL/4 = EPM ALKALINITY	mL METHYL PURPLE	mLx25 = PPM PHOSPHATE	TEMP. (°C)	CONDUC-TIVITY µMHO/CM	mL MERCURIC NITRATE	mLx0.4 = EPM CHLORIDE		
0815	FFT										
0920	LOF										
0940	AOL	0.9	0.225	2.3	57.5	25°	200	0.5	0.2	SK	AA
1645	RTE	0.8	0.2	2.4	55	25°	205	0.7	0.28	MK	LD
2000	PTS	0.8	0.2	2.4	55	25°	205	0.7	0.28	BC	FN
2011	SEC										

BATCH CHEMICAL TREATMENT

TIME	TRISODIUM PHOSPHATE (GRAMS)	TSP CORRECTION FOR PHOSPHATE	CURRENT PHOSPHATE LEVEL	CORRECTED PHOSPHATE	DISODIUM PHOSPHATE (GRAMS)
0815	30	—	—	—	22

TOTAL TSP INJECTED 30 | TOTAL DSP INJECTED 22

CONTINUOUS CHEMICAL TREATMENT

TIME	PUMP STROKE %	TANK LEVEL GAL	TSP (GRAMS)	DSP (GRAMS)
0935	60	50	30	20

BLOWDOWN

TIME	TYPE	CONDUCTIVITY BEFORE	CONDUCTIVITY AFTER	% BLOW-DOWN

TOTAL PERCENT BLOWDOWN

A. FRONT

WASTE HEAT BOILER WATER CHEMISTRY WORKSHEET/LOG

NAVSEA 9255/7 (8-88)(BACK)

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TIME	REMARKS

	STEAMING HOURS	STEAMING HOURS UNDER CONTAMINATION MODERATE	STEAMING HOURS UNDER CONTAMINATION SERIOUS
PRIOR HOURS STEAMED THIS MONTH	12206.7	305.7	225
HOURS STEAMED TODAY	10.9	—	—
HOURS STEAMED THIS MONTH	12217.6	305.7	225
HOURS SINCE LAST WATERSIDE INSPECTION	11,245.3		
HOURS SINCE LAST FIRESIDE INSPECTION	11,245.3		
HOURS SINCE LAST BOTTOM BLOWDOWN	38.1		
HOURS DRY OPERATION TODAY	0		
TOTAL HOURS DRY OPERATION	146.6		

LEGEND/TEST CODE

- AOL WITHIN 30 MIN. AFTER LIGHT OFF
- RTE WITHIN 8 HOURS
- ADO BATCH CHEMICAL INJECTION
- ACA 30 TO 60 MIN. AFTER CHEMICAL ADDITION
- PTB WITHIN 60 MIN. PRIOR TO BLOWDOWN
- ABO 30 TO 60 MIN. AFTER BLOWDOWN
- FFT FRESHLY FILLED AND TREATED
- LOF GENERATOR LIGHT OFF (STEAMING)
- GEN GENERATOR LIGHT OFF (DRY)
- SEC GENERATOR SECURED
- D BOILER DRAINED
- OTH OTHER
- PTS WITHIN 90 MIN. PRIOR TO SECURING
- PTL PRIOR TO LIGHT OFF

BOILER LAYUP

DRY LAYUP
- DES DESICCANT
- HTD HEATED AIR

WET LAYUP
- STM STEAM (SHIP)
- STS STEAM (SHORE)
- NIT NITROGEN
- DFT HOT DFW FILL
- HYD HYDRAZINE
- SN SODIUM NITRITE

BLOWDOWNS
- S SURFACE/SEPARATOR
- B BOTTOM

LCPO INIT.	LCPO DATE	MPA INIT.	MPA DATE	REVIEWED: (ENGINEER OFFICER)	DATE
A A	20 Dec 92	C K	20 Dec 92	W.T. DOOR	31 DEC 92

B. BACK

Figure 1-3.–Waste Heat Boiler Water Chemistry Worksheet/Log.

for this program are presented in the form of an instruction. Although this instruction may vary somewhat in the procedures it includes, the goals are the same. To accomplish these goals, gas turbine ships must maintain lubricating oil logs.

Samples of lubricating oil should be taken at definite intervals to determine whether the oil meets all requirements. The results of the samples must be entered in the proper log as specified in the Lube Oil Management Program.

PETROLEUM FUEL LOGS.— Stringent fuel quality requirements protect gas turbine engines from serious damage, such as corrosion of the gas turbine hot section, fouling of engine controls, and plugging of fuel nozzles. Maintaining a fuel system log helps the engineering department to achieve these requirements.

An example of a fuel management log is shown in figure 1-4. This log is a locally prepared document that includes spaces for recording the results of all shipboard fuel tests. Whenever test results exceed maximum parameters, the entries should include notations that corrective actions have been taken.

The fuel management log should include the following important categories:

1. A sequential listing of sample analyses
2. An operational procedures check-off list
3. Centrifugal purifier cleaning actions
4. Prefilter and filter/separator replacement actions
5. Tank inspections and findings

The information in the fuel management log serves as an integral part of shipboard maintenance. It aids in the prevention of delivery of contaminated fuel to the gas turbine engines.

JP-5 LOGS.— Since most gas turbine ships can support helicopters, an aviation fuel (JP-5) system is installed. Fuel quality requirements are more critical and extensive for JP-5 fuel than other fuels. Minute amounts of dirt and water in the fuel can cause engine failures. To monitor for these conditions, the oil lab should maintain a fuel sample log. This log will include a sequential listing of samples submitted for testing and the results of the tests as they are reported by the testing laboratory. The oil lab should include the following information in the JP-5 sample log:

- Identification of the ship submitting the sample (name and hull number)
- Type of fuel
- Date the sample is drawn

Fuel Sample Analyses

Date	Fuel Type	Sample Location	Visual	BS&W (%)	API Gravity	MK I (p/m)	MK III (mg/l)	Flashpoint (°F)	Shore Laboratory
10 OCT 92	F-76	Coalescer 1A	C/B	.07	40	<40	2.20	155 °F	
15 OCT 92	F-76	Coalescer 1B	C/B	.05	40	<40	2.13	162 °F	

Operational Procedure Check-off List Summary

Date	Centrifugal Purifier Cleani.	Replacement Action: Prefilter	Replacement Action: Coalescer Element	Replacement Action: Separator Element	Tank Inspections: Type	Tank Inspections: Finding

Date	Tank Stripping	Service Tank Recirculation	Fuel Rotation	Tank Ballasting	Fuel Receipt (Quantity)

Figure 1-4.—Suggested Fuel Management Log.

- Name of the person drawing the sample
- Fueling station number or filter/separator sampled
- Heading: Aviation Fuel Sample – Sediment and Flashpoint

The oil lab uses the fuel sample log in a continuing shipboard QA program to document the ship's QA efforts.

MARINE GAS TURBINE RECORDS.— Equipment records are an essential element of the gas turbine technical discipline. These records provide a history of operations, maintenance, and configuration changes of the equipment. Incomplete or inaccurate records can cause unnecessary maintenance of equipment. All activities having custody of marine gas turbine equipment must maintain service records in a proper and up-to-date status. *Naval Ships' Technical Manual (NSTM),* chapter 234, "Marine Gas Turbines," includes the procedures your department should follow to maintain these records.

The Marine Gas Turbine Equipment Service Record (MGTESR) is a comprehensive equipment service record. This record is in the form of a looseleaf log contained within a separate cover and bound in a binder. The cover page of an MGTESR is shown in figure 1-5.

The manufacturer of the equipment starts the MGTESR. The MGTESR is later maintained by the activity having custody of the equipment. The MGTESR always remains with its associated equipment. If a gas turbine engine is removed from the ship, for example, the associated record is transferred with the engine. The same procedure is followed even if only one of the removable accessories is removed from the engine and shipped for repair. In every case, the applicable service records must always accompany the removed items.

The MGTESR binder consists of 10 separate sections, each containing explicit information concerning one particular gas turbine engine. The following list contains the 10 sections of the MGTESR binder:

1. Cover sheet

MARINE GAS TURBINE EQUIPMENT SERVICE RECORD

NAVSEA 9400/1(10-74)

SECURE HERE

NOMENCLATURE OF EQUIPMENT			
GAS GENERATOR			
MODEL: LM2500PB101	SER. NO: GGA-999	AUTHORIZED OPERATING INTERVAL (IF APPLICABLE): On-Condition	
INSTALLATION HISTORY			
HULL TYPE AND NO	SERVICE/POSITION	DATE	BY (Activity)
CG 00	1A-AFT-STBD	6/11/83	LITTON/INGALLS
DD 975	1B-AFT-PORT	9/30/84	DD 975
DD 979	2A-FWD-PORT	4/22/88	DD 979
CG 52	1B-AFT-PORT	9/13/91	CG 52

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

NOTE: DO NOT ROLL OR BEND When removed from the log book for separate shipment, this record must be secured with a suitable fastener (e.g., a metal file fastener) at the points indicated. DO NOT USE STAPLES.

Figure 1-5.—MGTESR Cover Sheet.

2. Marine Gas Turbine Engine (MGTE) Custody and Transfer Record

3. MGTE Operating Log

4. MGTE Inspection Record

5. MGTE Record of Rework

6. MGTE Technical Directives

7. MGTE Miscellaneous/History

8. MGTE Selected Component Record

9. MGTE Selected Component Record (SCR) Card

10. Supplemental records

The following paragraphs will briefly describe the purpose of each of these sections.

Cover Sheet.— The MGTESR cover sheet is used only for equipment identification and installation data. The engine/equipment is identified by serial number. The installation history entries continue in the spaces provided to generate a chronological record of nonrepair activities at which the equipment was installed.

MGTE Custody and Transfer Record.— When an MGTESR is transferred as a part of an equipment transaction from one activity to another, the MGTE Custody and Transfer Record is completed before the transfer. (See fig. 1-6.) This record shows who has custody of the MGTESR and the engine or equipment's condition (complete/uncannibalized) at the time of transfer. The commanding officer or the person appointed signs this record.

MGTE Operating Log.— The MGTE Operating Log shows the total operating time of the engine, starting from the time the engine was new. It also shows the time interval since the last depot repair or rework was performed.

A sample of an MGTE Operating Log is shown in figure 1-7. Notice that the operating time and the number of starts must be entered on a daily, weekly, or monthly basis. You should also note that an engine start is defined as the engine's successfully going through the start cycle to idle. Motoring and hung starts should not be entered in the NO. STARTS column of the log.

MGTE Inspection Record.— Accurate inspection records are a primary requirement, and they prevent the unnecessary reinspection by a new custodian upon

MGTE CUSTODY AND TRANSFER RECORD

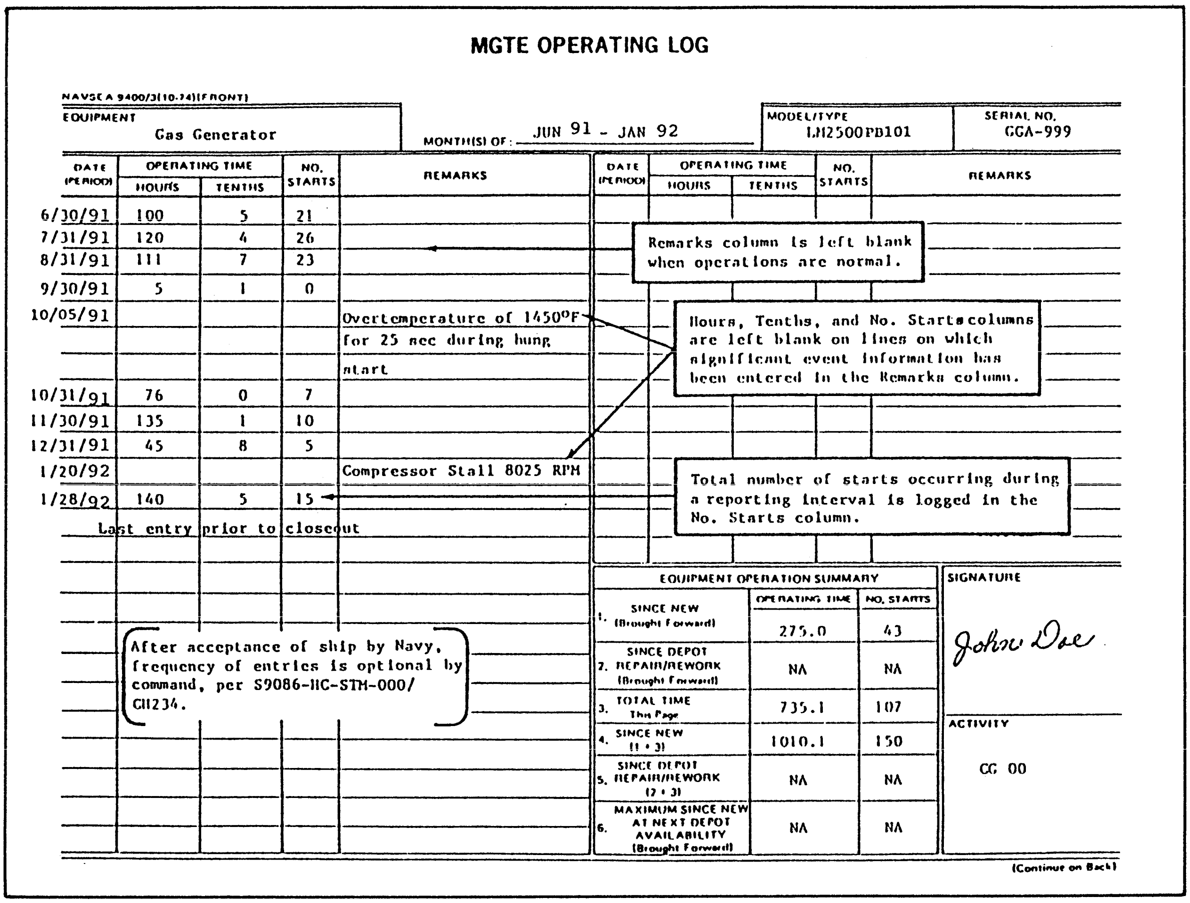
NAVSEA 9400/2(10-74) (FRONT) (Permanent Record)

EQUIPMENT NAME	EQUIPMENT MODEL/TYPE	SERIAL NO.
Gas Generator	LM2500PB101	GGA-999

DATE	FROM	TO	AUTHORITY	REMARKS	RECEIVED DATE-SIGNATURE
6/11/83	Litton/Ingalls	U.S. Navy, CG 00	Contract N00024-79-C-1055	Ship delivery to Navy	6/11/83 John Doe
1/28/84	CG 00	NSC San Diego	NAVSEASYSCOM 242300Z Jan 84	At time of transfer, GGA is certified to be complete (uncannibalized) John Doe.	2/10/84 John Doe
2/15/84	NSC San Diego	NAVAVNDEPOT NORIS		Non-RFI	2/15/84 John Doe
6/30/84	NAVAVNDEPOT NORIS	NSC San Diego		RFI	6/30/84 John Doe.
9/18/84	NSC San Diego	DD 975	NAVSEASYSCOM 171400Z Sept 84	RFI	9/30/84 John Doe.
6/10/88	CG 52	NSC San Diego	NAVSEASYSCOM 16005Z Jun 88	RFI	6/15/88 John Doe
11/11/91	NSC San Diego	NAVAVNDEPOT		Non-RFI	John Doe 11/11/91

(Continue on Back)

Figure 1-6.—MGTE Custody and Transfer Record.



MGTE OPERATING LOG

NAVSEA 9400/3(10-74)(FRONT)

EQUIPMENT	MONTH(S) OF:	MODEL/TYPE	SERIAL NO.
Gas Generator	JUN 91 - JAN 92	LM2500PB101	GGA-999

DATE (PERIOD)	OPERATING TIME HOURS	OPERATING TIME TENTHS	NO. STARTS	REMARKS
6/30/91	100	5	21	
7/31/91	120	4	26	
8/31/91	111	7	23	
9/30/91	5	1	0	
10/05/91				Overtemperature of 1450°F for 25 sec during hung start
10/31/91	76	0	7	
11/30/91	135	1	10	
12/31/91	45	8	5	
1/20/92				Compressor Stall 8025 RPM
1/28/92	140	5	15	

Last entry prior to closeout

EQUIPMENT OPERATION SUMMARY

		OPERATING TIME	NO. STARTS
1.	SINCE NEW (Brought Forward)	275.0	43
2.	SINCE DEPOT REPAIR/REWORK (Brought Forward)	NA	NA
3.	TOTAL TIME This Page	735.1	107
4.	SINCE NEW (1 + 3)	1010.1	150
5.	SINCE DEPOT REPAIR/REWORK (2 + 3)	NA	NA
6.	MAXIMUM SINCE NEW AT NEXT DEPOT AVAILABILITY (Brought Forward)	NA	NA

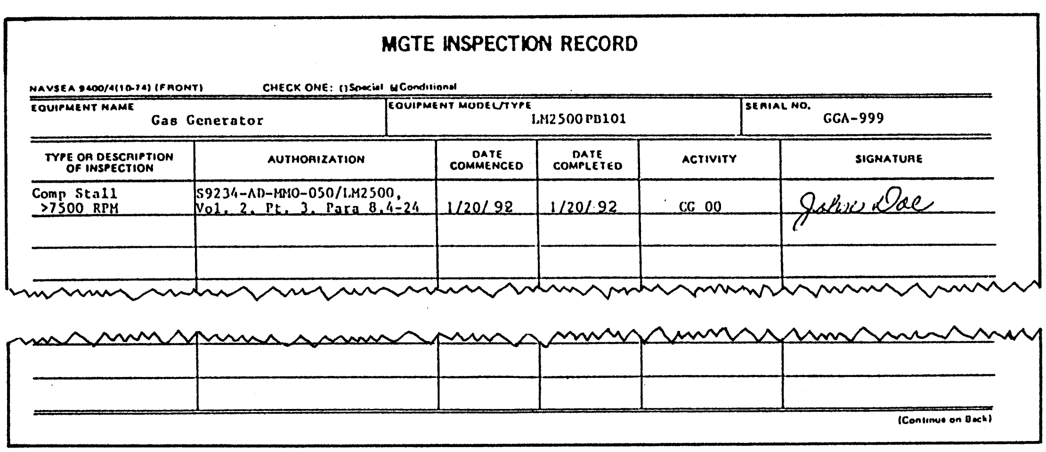
SIGNATURE: John Doe

ACTIVITY: CG 00

(Continue on Back)

Figure 1-7.—MGTE Operating Log.

transfer of an equipment item. The MGTE Inspection Record, shown in figure 1-8, provides for the logging and authenticating of the performance of all special and conditional inspections performed on the equipment. You should note that the performance of routine or periodic inspection requirements of the Planned Maintenance System (PMS) are not recorded on this record.



MGTE INSPECTION RECORD

NAVSEA 9400/4(10-74) (FRONT) CHECK ONE: ( )Special (X)Conditional

EQUIPMENT NAME	EQUIPMENT MODEL/TYPE	SERIAL NO.
Gas Generator	LM2500PB101	GGA-999

TYPE OR DESCRIPTION OF INSPECTION	AUTHORIZATION	DATE COMMENCED	DATE COMPLETED	ACTIVITY	SIGNATURE
Comp Stall >7500 RPM	S9234-AD-MMO-050/LM2500, Vol. 2, Pt. 3, Para 8.4-24	1/20/92	1/20/92	CG 00	John Doe

(Continue on Back)

Figure 1-8.—MGTE Inspection Record.

MGTE RECORD OF REWORK

NAVSEA 9400/5(10-74) (FRONT) (Permanent Record)

EQUIPMENT NAME	EQUIPMENT MODEL/TYPE	SERIAL NO.
Gas Generator	LM2500PB101	GGA-999

DATE INDUCTED	DATE COMPLETED	DESCRIPTION OF WORK	AUTHORIZATION	ACTIVITY	SIGNATURE
2/18/92	6/28/92	Repair	S9234-AB-MMO-020/LM2500	NAVAVNDEPOT NORIS	[signature]

Depot Repair Manual with appropriate section cited.

(Continue on Back)

Figure 1-9.—MGTE Record of Rework,

MGTE Record of Rework.— The MGTE Record of Rework, shown in figure 1-9, is a complete record of all repair, reconditioning, conversion, change, modernization, or rework performed on the equipment at a repair or rework facility.

MGTE Technical Directives.— The MGTE Technical Directives sheet is a record of technical directives (TDs) affecting the equipment and accessories. (See fig. 1-10.) A separate form is used for each type of TD, and all applicable directives are

MGTE TECHNICAL DIRECTIVES

NAVSEA 9400/6(10-74) (FRONT) TYPE DIRECTIVE Gas Turbine Changes

EQUIPMENT NAME	EQUIPMENT MODEL/TYPE	SERIAL NO.
Gas Generator	LM2500 PB101	GGA-999

NO.	STATUS	CAT.	DESCRIPTION	COMPLIANCE BY (Activity)	COMPLIANCE DATE	SIGNATURE	REVISIONS ISSUED
29		R	HPT Hook Bolt Diameter Increase	See Supplement Record			
30	NIS						
31	INC	R	Improved Aft Thermocouple Lead	NADEP	6/28/92		
32	NA		Other Equipment, PT	NADEP	6/28/92		
38		U	VSV Schedule Closure	See SCR Card			AA
39 PT 1	INC	R	Improved LPT Stg 1 Interstage Seal Bolting	NADEP	6/28/92		
39 PT 2	NA		Other Equipment, PT	NADEP	6/28/92		
40	C		NAVSEA 56X3 ltr Ser 302, 22 Jul 82	NADEP	6/28/92		
141			VSV Feedback Spring Damper, Main Fuel Control	See SCR Card			AA
52	NIS						
153	NINC	U	A&B Sump Nozzle				AA

The date recorded for TD Records consolidated during depot rework shall be the same as the date shown for the rework completion date in figure 234-28F.

The authorizing signature for TD records consolidated during rework is contained in the Record of Rework entry, figure 234-28F.

Above examples are for types of information recorded under the separate entry procedure for TDs.

(Continue on Back)

Figure 1-10.—MGTE Technical Directives,

MGTE MISCELLANEOUS/HISTORY

NAVSEA 9400/7(10 74) (BACK)

EQUIPMENT NAME	EQUIPMENT MODEL/TYPE	SERIAL NO.
Gas Generator	LM2500PB101	GGA-999

DATE	REMARKS
10/5/91.	T5.4 1450°F for 25 seconds during hung start. No overtemperature inspection required
	per S9234-AD-MMO-010/LM2500, Figure 3.1-6. Main Fuel Control specific gravity set incorrectly.
	Specific gravity adjustment made per S9234-AD-MMO-050/LM 2500, para. 8.2-10. John Doe
1/20/92	Inspection following compressor stall revealed tip curl on all compressor blades
	in stages 4 and 6. John Doe.

Figure 1-11.—MGTE Miscellaneous/History.

recorded. Gas turbine TDs are issued as gas turbine bulletins (GTBs) or gas turbine changes (GTCs). All gas turbine TDs, including the irrevisions and amendments, should be recorded by number in this section of the MGTESR.

MGTE Miscellaneous/History.— The Miscellaneous/History sheet, shown in figure 1-11, is used in the MGTESR to record pertinent information for which no other place has been provided. This information includes significant details that might beef service to personnel or activities involved in later diagnoses of problems with the equipment. The significant details include special test data, abnormal characteristics of the equipment, significant damage or repairs, and engine lay-up procedures.

MGTE Selected Component Record.— The MGTE Selected Component Record, shown in figure 1-12, maintains a current inventory and installation and

MGTE SELECTED COMPONENT RECORD

NAVSEA 9400/8(10-74) (FRONT)

EQUIPMENT NAME	EQUIPMENT MODEL/TYPE	SERIAL NO.
Gas Generator	LM 2500PB101	GGA-999

NOMENCLATURE	MFG CODE	SERIAL NUMBER	PART NUMBER	INSTALLATION DATA				REMOVAL DATA			
				DATE	TOTAL EQUIP COUNT	TOTAL COUNT ON ITEM SINCE NEW	TOTAL COUNT ON ITEM SINCE REWORK	DATE	TOTAL EQUIP COUNT	TOTAL COUNT ON ITEM SINCE NEW	TOTAL COUNT ON ITEM SINCE REWORK
Gearbox, Inlet	07482	EPE00485	L21082G06	6/28/92	1010H	1010H	NA				
Gearbox, Transfer	07482	EPE00430	L21441G14	6/28/92	1010H	1010H	NA				
Control, Fuel	66503	WYG37000	L16716P24	6/28/92	1010H	0H	NA	10/5/92	1035H	25H	NA
Pump, Fuel	11599	CGW51305	9039M45P09	6/28/92	1010H	1010H	NA				
Pump, Lube & Scav	51663	LJAM0637	L21289P01	6/28/92	1010H	1010H	NA				
Starter, Pneumatic	99193	OP780	L214063P04	6/18/92	150S	423S	37S				
Actuator, PLA	12511	SMM00585	L22264P04	6/28/92	1010H	1010H	NA				
Control, Fuel	66503	WYG15276	L16716P18	10/5/92	1035H	3773H	0.0H				
Sensor, CIT	66503	WPB23235	L21225P02	6/28/92	1010H	1010H	NA				

[Round off all operating hour data to nearest whole number.]

NOTE: "COUNT" AS INTERPRETED FOR USE OF THIS FORM SHOULD BE CODED AS FOLLOWS.
S = STARTS, H = OPERATING HOURS.
EXAMPLE 50 STARTS = 50S, 1,000 OPERATING HOURS = 1,000H.

(Continue on Back)

Figure 1-12.—MGTE Selected Component Record.

NOTE: Count as interpreted for use on this card should be coded as follows
S = STARTS H = OPERATING HOURS

INSTALLATION DATA						REMOVAL DATA			
JCN	INSTALLED ON	SERIAL NO	TOTAL EQUIP COUNT	TOTAL COUNT ON ITEM SINCE NEW	TOTAL COUNT ON ITEM SINCE REWORK	TOTAL EQUIP COUNT	TOTAL COUNT ON ITEM SINCE NEW	TOTAL COUNT ON ITEM SINCE REWORK	REASON FOR REMOVAL & JCN
New Production	LM2500	GGA-999	1010H	0.0H	NA	1035H	25H	NA	Fuel Contamination 20601-EH01-1274

Round off all operating hour data to nearest whole number.

The Removal Data section is completed when the fuel control is removed. The card is then removed from the visible card holder in GGA-999 logbook and shipped with the F/C to the repair activity.

TECHNICAL DIRECTIVES

TYPE DIRECTIVE AND NUMBER	STATUS	CAT	DESCRIPTION	COMPLIANCE BY ACTIVITY	COMPLIANCE DATE	SIGNATURE
GTC 7, 54	INC			Woodward Gov	3/15/92	John Doe
I41	NA		GTC 54 Incorporated	NAVAVNDEPOT NORIS	6/28/92	John Doe
GTB 9	NA		GTC 54 Incorporated	NAVAVNDEPOT NORIS	6/28/92	John Doe
GTB 10	INC		VSC Lever, Inspection of	NAVAVNDEPOT NORIS	9/30/92	John Doe

All TDs that pertain to an accessory or component for which an SCR card is maintained shall be documented in this section of the applicable card. The status indicated for the GTCs and the part number entry on the card shall be compatible

SELECTED COMPONENT RECORD SCR CARD

NAVSEA 9400 9 REV 8 80 PERMANENT RECORD

Stock Number	Manufacturer	MFG Code	Retirement Time If Applicable	Replacement Interval	Replacement Due
	Woodward Governor	66503			

Nomenclature	Serial Number	Part Number
Control, Fuel	WYG 37000	L16716P24

0 20 30 40 50 60 70

TYPIST PLEASE NOTE START ALL TYPING AT SAME POINT ON SCALE, THEN REMOVE THIS STUB BE SURE YOU HAVE A WELL INKED RIBBON. CARE USED IN TYPING WILL IMPROVE REFERENCE DURING THE ENTIRE LIFE OF THE INDEX. TRY A FEW IN THE POCKETS TO SEE HOW THEY LOOK BEFORE TYPING THE ENTIRE LIST

Figure 1-13.—MGTE Selected Component Record Card.

removal record for all equipment accessories and components that require selected component record (SCR) cards. When a selected component is replaced, the removal data for the removed component and installation data for the new component is entered in this record.

MGTE Selected Component Record Card.— For any equipment item, the continuity of historical data is essential. The MGTE Selected Component Record (SCR) Card, shown in figure 1-13, provides for the recording of installation and removal data, TD status, and repair/rework historyon selected accessories and components. When a component is removed from the equipment, the corresponding SCR card is removed from the MGTESR. This procedure ensures the continuity of important historical data.

Supplemental Records.— The two supplemental records required in the MGTESR are shown in figure 1-14. These records are the MGTE Turbine Rotor Disc Assembly Service Record and the MGTE Compressor Rotor Assembly Service Record. When a turbine rotor disc assembly is to be reworked, the rework activity must ensure that data associated with each disc is properly recorded. The same requirement is true if the compressor rotor assembly is reworked. Although one record is required for each turbine rotor disc or stage, only one record is required for the complete compressor rotor assembly.

DIESEL ENGINE RECORDS.— As a GSE2 on board an FFG-7 class ship, you can expect to review diesel engine records. The repair and history records are primarily for the operating personnel of the ship. They will prove valuable in making estimates of parts needed and work lists for the next availability. A system must be setup by which completely accurate and up-to-date records can be kept on all diesel engines.

MGTE TURBINE ROTOR DISC ASSEMBLY SERVICE RECORD

NAVSEA 9400/10110 (4) (FRONT) (Permanent Record)

NSN	SERIAL NO.	PART NO.	STAGE NO.
	MPOM 9420	9687M39P07	

INSTALLATION DATA

DATE	EQUIPMENT ASSEMBLY MODEL	EQUIPMENT ASSEMBLY SERIAL NO.	BY (Activity)	TOTAL EQUIP. HOURS	ROTOR/DISC HRS. SINCE NEW	ROTOR/DISC HRS. SINCE REWORK
1/25/88	LM 2500	GGA-999	GE Evendale	0.0	0.0	NA

REMOVAL DATA

DATE	TOTAL EQUIP. HOURS	ROTOR/DISC HRS. SINCE NEW	ROTOR/DISC HRS. SINCE REWORK	REASON FOR REMOVAL, ACTIVITY & JCN

Round off all operating hour data to nearest whole number.

ABNORMAL TEMPERATURE AND/OR OVERSPEED DATA

ROTOR BLANK DIAMETRICAL OR RADIAL MEASUREMENT	DATE	TOTAL EQUIP. HOURS	TOTAL ROTOR/DISC HOURS	TEMPERATURE OR SPEED	TIME OVER LIMIT	NATURE AND POSSIBLE CAUSE
	10/5/90	723	723	1450°F	25 Sec.	Defective starter

MODIFICATION

BULLETIN NUMBER	COMPLIANCE BY (Activity)	COMPLIANCE DATE	SIGNATURE

Entry of TD data in this section occurs only when compliance with a TD has been accomplished. No data is entered in this section when the status of a TD is NINC, C, or NIS.

(Continue on Back)

A.

MGTE COMPRESSOR ROTOR ASSEMBLY SERVICE RECORD

NAVSEA 9400/11110-14) (FRONT) (Permanent Record)

SECTION I - IDENTIFICATION

NSN	SERIAL NO.	ACCEPTING/INSTALLING ACTIVITY	DATE
	MPOK2258	SUPSHIP Pascagoula	6/11/91

SECTION II - SHAFT, DISC AND BLADE DATA

STAGE	SERIAL NO. (Assembly Date 1/25/88)	TIME DISC	TIME BLADE	SERIAL NO. (Assembly Date 6/28/92)	TIME DISC	TIME BLADE	SERIAL NO. (Assembly Date)	TIME DISC	TIME BLADE	SERIAL NO. (Assembly Date)	TIME DISC	TIME BLADE
1	MPOK2258	0.0	0.0	MPOK2258	1010	1010						
2	MPOW0017	0.0	0.0	MPOW0017	1010	1010						
3			0.0			1010						
4			0.0			0.0						
5			0.0			1010						
6	MPOM8306	0.0	0.0	MPOM8306	1010	0.0						
7			0.0			1010						
8			0.0			1010						
9			0.0			1010						
10	MPOK9612	0.0	0.0	MPOK9612	1010	1010						
11			0.0			1010						
12	MPOM3512	0.0	0.0	MPOM3512	1010	1010						
13			0.0			1010						
14			0.0			1010						
15	MPOM5820	0.0	0.0	MPOM5820	1010	1010						
16			0.0			1010						
17												

Round off all operating hour data to nearest whole number.

SHAFT NOMENCLATURE	SERIAL NO.	TOTAL TIME	SERIAL NO.	TIME SINCE LAST REWORK	TOTAL TIME	SERIAL NO.	TIME SINCE LAST REWORK	TOTAL TIME	SERIAL NO.	TIME SINCE LAST REWORK	TOTAL TIME
STUB (Front)											
STUB (Rear)	MPOJ3260	0.0	MPOJ3260	1010	1010						
CENTER											

SECTION III - INSTALLATION DATA

DATE	EQUIPMENT ASSEMBLY MODEL	EQUIPMENT ASSEMBLY SERIAL NO.	BY (Activity)	TOTAL ENGINE HOURS	COMPRESSOR ROTOR HOURS SINCE NEW	COMPRESSOR ROTOR HOURS SINCE REWORK
1/25/88	LM2500	GGA-999	GE Evendale	0.0	0.0	NA
6/28/92	LM2500	GGA-999	NAVAVNDEPOT NORIS	1010	1010	0.0

SECTION IV - REMOVAL DATA

DATE	TOTAL EQUIP. HOURS	COMPRESSOR ROTOR HOURS SINCE NEW	COMPRESSOR ROTOR HOURS SINCE REWORK	REASON FOR REMOVAL, ACTIVITY & JCN
2/18/84	1010	1010	NA	NAVAVNDEPOT NORIS, Comp. stall

B.

Figure 1-14.—Supplemental records.

DIESEL ENGINE OPERATING RECORD—ALL SHIPS
NAVSEA 9231/2 (9-78) (FORMELY NAVSEC 9410/2) S/N 0116-LF-082-3110

RETAIN 2 YEARS – THEN DISPOSE ACCORDING TO CURRENT DISPOSAL INSTRUCTIONS

U.S.S.	TIME ZONE DESCRIPTION	CLOCKS SET – BACK OR AHEAD	LOCATION	DATE
FRIGATE (FFG-1000)	+4Q	HRS. MINUTES AT	[X] AT SEA [ ] IN PORT	12/6/92

CHECK ONE [ ] PROPULSION [X] AUXILIARY ENGINE NO. 1

*Preferred to 30" Barometer

TIME	TACHOMETER	GENERATOR: ELECTRIC LOAD AMPS.	GENERATOR: ELECTRIC LOAD VOLTS	GENERATOR TEMPERATURE: AIR TO CLR.	GENERATOR TEMPERATURE: FWD. BRG.	GENERATOR TEMPERATURE: AFT. BRG.	TEMPERATURES: SALT WATER INJECTION	TEMPERATURES: SALT WATER OVER-BD.	TEMPERATURES: FRESH WATER TO ENG.	TEMPERATURES: FRESH WATER FROM ENG.	TEMPERATURES: FRESH WATER TO OIL CLR.	TEMPERATURES: LUBE OIL TO ENG.	TEMPERATURES: LUBE OIL FROM ENG.	TEMPERATURES: HOTTEST CYLINDER NO.	TEMPERATURES: HOTTEST CYLINDER TEMP.	TEMPERATURES: SCAV-ENGING AIR	PRESSURES: SEA WATER AT PUMP	PRESSURES: FRESH WATER TO ENG.	PRESSURES: LUBE OIL AT PUMP	PRESSURES: LUBE OIL AT ENG.	PRESSURES: FUEL OIL TO FILT.	PRESSURES: FUEL OIL FROM FILT.	PRESSURES: SCAV-ENGING AIR	PRESSURES: BACK PRES-SURE (IN.)	PRESSURES: VAC-UUM* (IN.)	PRESSURES: CRANK-CASE MA-NOMETER (IN.)	LUBE-OIL SUMP (GAL.)
0100	1800	1100	450	69	120	122	67	72	84	120	80	130	180	2	530	69	36	42	22	21	45	45	15	4	12	8	400
0200	1800	1100	450	70	120	118	65	72	84	121	82	130	182	2	540	69	37	41	22	22	45	45	15	5	13	8	400
0300																											
0400																											
0500																											
0600																											
0700																											
0800																											
0900																											
1000																											
1100																											
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1300																											
1400																											
1500																											
1600																											
1700																											
1800																											
1900																											
2000																											
2100																											
2200																											
2300																											
2400																											

DISREGARD WHEN NOT REQUIRED

TIME	CLUTCH AND REDUCTION GEAR: L.O. IN CLUTCH (°F)	L.O. OUT CLUTCH (°F)	L.O. IN R. GEAR (°F)	L.O. OUT R. GEAR (°F)	L.O. OR AIR IN CLUTCH (°F)	L.O. IN R. GEAR (P.S.I.)
0100	—	—	—	—	—	—
0200	—	—	—	—	—	—
0300						
0400						
0500						
0600						
0700						
0800						
0900						
1000						
1100						
1200						
1300						
1400						
1500						
1600						
1700						
1800						
1900						
2000						
2100						
2200						
2300						
2400						

ENGINE HOURS	TOTAL TODAY	BROUGHT FWD.	TOTAL
THIS COMMISSION	4318	22	4342
SINCE OVERHAUL	1847		
SNORKEL			

0000-0400	0400-0800	0800-1200
2345 – Assumed the WATCH ϕ345 – Properly Relieved By A.B. Seaman	ϕ345 – Assumed the WATCH ϕ745 – Properly Relieved By P.T. Boat	

A-6626

Figure 1-15.—Diesel Engine Operating Record—All Ships.

The Diesel Engine Operating Record, shown in figure 1-15, is a daily record maintained for each operating diesel engine. For ships with more than one diesel in the same machinery room, a separate record sheet is maintained for each operating diesel engine. The watch supervisor enters the remarks and signs the record for his or her watch. The engineer officer immediately receives a report of any unusual conditions noted in the record. The engineer officer then receives the record for his or her approval.

REDUCTION GEAR RECORDS.— Maintaining a log for the main reduction gear is extremely important. This log should be kept in the engine room and the readings must be taken and recorded at established intervals. A reduction gear log serves as a guide in detecting unusual and inefficient operating conditions. Temperatures, pressures, and the presence of oil in the sight flow indicators are important readings that should be included on this log.

AIR COMPRESSOR RECORDS.— A typical air compressor Operating Data Log Sheet is shown in figure 1-16. This log is kept by the operator who takes and records readings at established intervals. For extended operation, a data log sheet should be filled out during every watch. A log is helpful not only from the operational and maintenance standpoints but also as a troubleshooting guide for detecting unusual and inefficient operating conditions.

Depending on the ship's air system demand, the actual operating time on each compressor of a multicompressor installation might differ. For each compressor to provide the best service, the operating time should be equalized over each quarterly period. Reviewing the entries on these logs and noting the hours recorded will allow the operators to change the operating sequence of the units accordingly.

OPERATING DATA LOG SHEET

USS Destroyer (DD-1000) HPAC NO. 1 DATE 11/12/92

		SHUT-DN	MIN	NORMAL	MAX	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
FRAME OIL PRESSURE (PSIG)		14^{a}	14	25*-50*	50	45	45	37	39	39	40																		
PRESSURE	1st STAGE	60^{b}	32	40-45*	59	42	42	42	42	40	40																		
(PSIG)	2nd STAGE	330^{b}	209	250-270*	324	270	270	270	270	270	270																		
	3rd STAGE	1225^{b}	940	1055-1075*	1200	1060	1060	1060	1060	1060	1060																		
	4th STAGE - h	[illegible]	4200	4200-4675	5100	4500	4500	4500	4500	4500	4500																		
TEMP	1st STAGE-suct		49	84	122	93	93	83	83	93	92																		
(°F)	1st STAGE-disch	430^{a}		336	415	330	370	370	376	340	340																		
	2nd STAGE-suct			122		120	120	120	120	120	120																		
	2nd STAGE-disch	430^{a}		374	415	375	375	360	390	310	370																		
	3rd STAGE-suct			119		120	120	130	130	120	125																		
	3rd STAGE-disch	430^{a}		356	415	370	370	370	374	370	370																		
	4th STAGE-suct			119		125	125	125	125	125	125																		
	4th STAGE-disch	430^{a}		376	415	400	400	400	404	404	400																		
FINAL DISCH TEMP			115		125	120	120	118	118	118	117																		
CLG WTR OUTLET TEMP		125^{a}	95	95-115*	120	100	100	111	111	110	110																		
CRANKCASE OIL TEMP			135		170*	160	160	160	160	160	150																		
CRANKCASE OIL LVL			LOW	MIDDLE	HIGH	M	M	M	M	M	M																		
CYL LUBE OIL LVL			1/2		FULL	F	F	F	F	F	F																		
CLG WTR PMP DISCH PRESS			25		175	120	150	130	130	140	150																		
CLG WTR INLET TEMP					95	90	90	90	90	90	90																		
LUB FLOW RATE	1st STAGE		10^{d}	11	15^{e}	11	11	11	11	11	11																		
(DROPS/MIN)	2nd STAGE		10^{d}	11	15^{e}	11	11	11	11	11	11																		
	3rd STAGE		10^{d}	13	15^{e}	12	12	12	13	13	13																		
	4th STAGE		10^{d}	13	15^{e}	12	12	12	13	13	13																		
CUNO AIR FILTER		DRAIN BOTH EVERY HR. g				✓	✓	✓	✓	✓	✓																		
MOISTURE SEP FLASK		DRAIN BOTH EVERY HR.				✓	✓	✓	✓	✓	✓																		
DHYR PREFILTER		DRAIN EVERY TOWER CHGE-OVER				✓	–	–	–	✓	–																		
DHYR BY-PASS CARTRIDGE		REPLACE CARTRIDGE f				–	–	–	–	–	–																		
CONDENSATE DRAINAGE		MUST BE OBSERV.-6 MIN CYCLE				✓	✓	✓	✓	✓	✓																		

* CIRCLE LOG VALUES WHICH ARE OUTSIDE THE NORMAL RANGE LIMITS INDICATED IN RED.
a - WILL SHUT DOWN AUTOMATICALLY.
b - RELIEF VALVE LIFTS.
c - WILL CAUSE WET AIR TO BE SUPPLIED TO BANKS, RESET BACK PRESSURE CONTROL VALVE ON DEHYDRATOR.

* FOR WORTHINGTON CLASS AA, 13.0 CFM 4500 PSI AIR COMPRESSOR TECH MANUAL 349-0730 (NAVSEA 0349-073-0006)

d - INADEQUATE LUBRICATION BELOW THIS RATE.
e - CAUSES EXCESS CARBON & OIL CARRYOVER ABOVE THIS RATE.
f - WHEN USED, REPLACE CARTRIDGE AFTER 4 HRS-TWO COMPRESSOR USE OR 8 HRS SINGLE COMPRESSOR USE. FOR #3 HPAS COMP REPLACE EVERY 8 HRS OF THE COMPRESSOR USE.
g - REPLACE ELEMENT EVERY 200 HRS COMPRESSOR USE OR MONTHLY, WHICHEVER FIRST.
h - DISCHARGE PRESSURES BETWEEN 4675 lb/in^{2}g AND RELIEF VALVE SETTING MAY BE DUE TO DESICCANT PLUGGING OF FILTERS.

Figure 1-16.—Typical Compressor Operating Data Log.

DISTILLING PLANT OPERATING RECORD.— The Distilling Plant Operating Record is a daily record of the operating ship's evaporators and their auxiliaries. Entries are made for each hour while the distilling plant is operating. Different gas turbine ships have many different types of distilling plants, but all daily distilling plant operating records will require practically the same type of data entries. The following list includes the required information:

1. Temperature, pressure, vacuum, flow, chemical analysis, and density data from various points in the distilling plant

2. Scaling record for each evaporator unit, including the date of the last scaling, the hours operated, and the quantity of distilled water produced since the last scaling to the day of the record and since the last scaling to the end of the day record

3. Starting, stopping, and total operating time of each evaporator and various auxiliary machinery parts, such as air ejector and pumps

4. Remarks about the operation and maintenance of the distilling plant for each watch of the day

You must make accurate entries in the Distilling Plant Operating Record. Accurate entries will help predict trouble. If abnormal operating conditions should suddenly develop, the entries in the record should aid in locating the sources of trouble.

REFRIGERATION/AIR-CONDITIONING RECORDS.— Your department will use the daily operating log for refrigeration equipment or air-conditioning plants to maintain a record of operating conditions. The log, shown in figure 1-17, is a guide for the continued analysis of operating conditions and operating results found in the equipment. Notice that data entries are made on both sides of the form. (See views A and B.)

The information in this log provides a method for engineering personnel to determine when and what corrective measures are necessary when a plant is not operating properly. Data taken at various points in the system are compared with corresponding data taken during normal plant operation. The corresponding data

REFRIGERATION/AIR-CONDITIONING EQUIPMENT OPERATING RECORD

INSTRUCTIONS

1. Take readings every two hours. Take compressor and condenser readings:ONLY WHEN COMPRESSOR IS OPERATING.
2. Code for Bull's-Eye level: H = High, L = Low, N = Neutral.
3. Code for condition of liquid line sight flow indicator: C = Clear, B = Bubbles.
4. Code for condition of liquid line moisture: W = Wet, D = Dry.
5. For compartment normal range, enter the normal temperature range (NIR) of the refrigerated space (do not include comfort air-conditioned compartments).

DATE 10/2/92

MAKE	SIZE/MODEL	REFRIGERANT	APPLICATION	PLANT NO.	LOCATION
YORK	150 T	R-114	AIR Condition	1	AMR 1

TIME	MACH. SPACE AMB. TEMP. °F	COMPRESSOR						CONDENSER (Water cooled)			LIQUID LINE			OPERATING TIME METER READING	INITIALS
		SUCTION		DISCHARGE		LUBRICATING OIL		WATER SUPPLY		DISCH.					
		PRESS. PSIG	TEMP. °F	PRESS. PSIG	TEMP. °F	PRESS. PSIG	BULL'S-EYE LEVEL	PRESS. PSIG	TEMP. °F	TEMP. °F	TEMP. °F	CONDITION AT SIGHT FLOW INDICATOR	CONDITION AT MOISTURE INDICATOR		
0200	70	3	50	30	110	70	N	35	88	87	60	C	D	1433	AA
0400	70	3	51	30	117	70	N	38	88	87	60	C	D	1633	BO
0600															
0800															
1000															
1200															
1400															
1600															
1800															
2000															
2200															
2400															

A. FRONT

REFRIGERATION/AIR-CONDITIONING EQUIPMENT OPERATING RECORD

TIME	WATER CHILLER					REFRIGERATED COMPARTMENT							REMARKS
	SUPPLY		RETURN			NO.	NO.	NO.	NO.	NO.	NO.	NO.	
	PRESS. PSIG	TEMP. °F	PRESS. PSIG	TEMP. °F		NIR	NIR	NIR	NIR	NIR	NIR	NIR	
0200	35	44	37	43		—	—	—	—	—	—	—	
0400	35	50	37	43		—	—	—	—	—	—	—	
0600													
0800													
1000													
1200													
1400													
1600													
1800													
2000													
2200													
2400													

GENERAL REMARKS

2345- Assumed the Watch

0345- Properly Relieved By John A. Doe

B. BACK

Figure 1-17.—Refrigeration/Air-Conditioning Equipment Operating Log.

must be taken under the same heat load and circulating water temperature conditions.

Daily Reports and Records

Maintenance of daily fuel, lubricating oil, and water accounts is essential to the efficient operation of the engineering department. The TYCOMs prescribe the forms and procedures necessary to account for fresh water and fuel. These reports and records inform the engineer officer of the status of the ship's liquid load and form the basis of several important reports, which are sent to higher authority. The most important of these reports is the report of the amount of burnable fuel on hand.

FUEL AND WATER REPORT.— The Fuel and Water Report, shown in figure 1-18, is a daily report of the fuel and water status prepared to reflect these conditions at 0000 hours. The commanding officer receives this report daily. The report contains data, such as total fuel and total lube oil on board and the amount of potable water and reserve feedwater on board. The Fuel and Water Report also includes the previous day's feedwater and potable water consumption figures and the results of the water tests. The officer of the deck (OOD) receives the original copy in time for submission to the commanding officer or command duty officer with the 1200 reports. The OOD retains the copy.

DAILY WATER ACCOUNT.— Some gas turbine ships maintain a Daily Water Account. The Daily Water Account is a daily record of the feedwater for the boilers and the potable fresh water in the potable water tanks. The data are recorded on the form by the oil king and checked for accuracy by his or her leading petty officer. The division officer also checks the form. When completed and checked, the record is submitted to the engineer officer for his or her approval and signature.

DUTIES, RESPONSIBILITIES, AND REQUIREMENTS

From reading this chapter, you should recognize that there are many logs and records engineering department personnel are required to maintain. The responsibilities only begin with the accurate recording of data for the machinery and equipment. The entries must be made not only in the proper logs or records but also in the appropriate sections of these logs or records. One of the most important responsibilities will be verifying the accuracy of these entries. The importance

FUEL AND WATER REPORT

NAVSEA 9255/9 (1-87) (FRONT)
(FORMERLY NAVSEA 9610/1)

DATE 15 MAR 92

TO: COMMANDING OFFICER, USS C. TURBINE (DD-999)

	FUEL (GALLONS)	LUBE OIL STORAGE TANKS (GALLONS)		WATER (GALLONS)	
	BURNABLE FUEL	2190	9250	POTABLE	RESERVE FEED
ON HAND LAST REPORT	244,000	1,500		9,500	750
RECEIVED (+)	0	0		0	0
DISTILLED (+)					
EXPENDED (-)	20,200	200	0	6,400	600
GAIN (+) LOSS (-) BY INVENTORY	+ 150	0	0	0	0
ON HAND THIS REPORT	203,950	1,300	0	9,200	720
ON HAND %	92	70		82	92

POTABLE WATER RECORD			FEEDWATER CONSUMPTION	
PERSONNEL ON BOARD	GALLONS USED PER PERSON	STANDARD	NOT UNDERWAY (GALLONS PER HOUR)	UNDERWAY (GALLONS PER HOUR)
243	26	27		357

REMARKS:

* STRIPPED 200 GALS FROM JP-5 SERVICE TK
* GAINED 150 GALS SOUNDING TANKS DURING HEAVY SEAS

Figure 1-18.—Fuel and Water Report.

of this responsibility should not be underestimated. Engineering personnel will base their determinations in regard to the condition of the equipment on the information contained in these logs and records.

Verification Procedures

As you advance in the GSE rating, you will be required to verify many of the engineering logs and records. In fact, you may be required to review many logs and records on a daily basis. In reviewing logs and records, there are certain details you should look for and take note of. Although each situation or type of log or record may have its own set of required procedures, the following list contains a few of the most important basic details for which you should check:

- All readings and entries must be legible.
- All entries must be placed in the proper location in each log.
- Out-of-limits entries must be circled in RED and explained in the REMARKS section of the logs.
- All required initials and signatures must be present.
- All logs and records must be free of erasures.
- All required logs and records must be present.

As stated earlier, the verification process is one of the most important responsibilities you will face as you advance in the GSE rating. Another important part of your increasing administrative duties will involve learning the correct disposal procedures for the records your department will no longer need to keep.

Disposal Procedures

Before destroying any engineering department records, study the *Disposal of Navy and Marine Corps Records, USN and USNS Vessels,* SECNAVINST P5212.5 (revised). This publication provides the official procedures for disposing of records. For each department aboard your ship, these instructions list the permanent records that must be kept. The instructions also list the temporary records that maybe disposed of according to schedule.

At regular intervals, such as each quarter, records that are more than 3 years old are usually destroyed. When a ship that is less than 3 years old is decommissioned, the current books are retained on board. If a ship is scrapped, the current books are sent to the nearest naval records management center. All reports sent to, and received from, NAVSEA or another superior command may be destroyed when they are 2 years old, if they are no longer required.

To control the volume of paper work, reports should be kept on board only if they are

1. required,
2. serve a specific purpose, or
3. provide repair personnel with information not found in other available publications or manuals.

As you assume more extensive administrative responsibilities, you will be required to become increasingly aware of the retention, disposal, and maintenance procedures required for your department.

FILES AND TICKLER SYSTEMS

As a second class GSE, you will be required to learn how to maintain correspondence files, messages, and tickler systems. You will need to determine the requirements of your division. You should know how to set up the files, what to file, and how to use the files to gather necessary information. You will also need to make sure that information your division develops is sent to higher authority in the proper form of reports or packages.

The accuracy of a filing system and the ease in retrieving information is extremely important if the system is to be effective. Administration of the engineering department requires easy access to previous information either received or sent out. Efficiently managed files contribute directly to the overall effectiveness of the engineering department.

Each month the engineering department should close out the files, logs, and records of the previous month. This means a new set is needed for each new month. When starting up a new month's logs, records, and files, always take a look at last month's logs, records, and files. Determine which logs, records, or files were bulky and which contained only a few pieces of paper. Use this information to set up your new folders. Some files may have to broken down to make them quicker to find. Some files may be combined to save space.

One final decision to make when setting up files is how to keep your logs, records, and files centralized. This step will help you prevent a backlog of requests for information or delays when you must produce a particular log or record.

Efficiency can be maintained by a thorough training program for all engineering personnel involved in log keeping. If all personnel are familiar with the filing system, they will place the logs and records in the proper location.

As a GSE2, you will likely be assigned to maintain a variety of files. Most routine files will involve those for correspondence, messages, or tickler systems. Each of these categories is briefly described in the following sections.

Correspondence

Correspondence includes all written material–publications, messages, memoranda, and so on–sent to and from a command. You must read and understand these types of correspondence. The system used to file your division's correspondence should be one that all personnel can use.

Messages

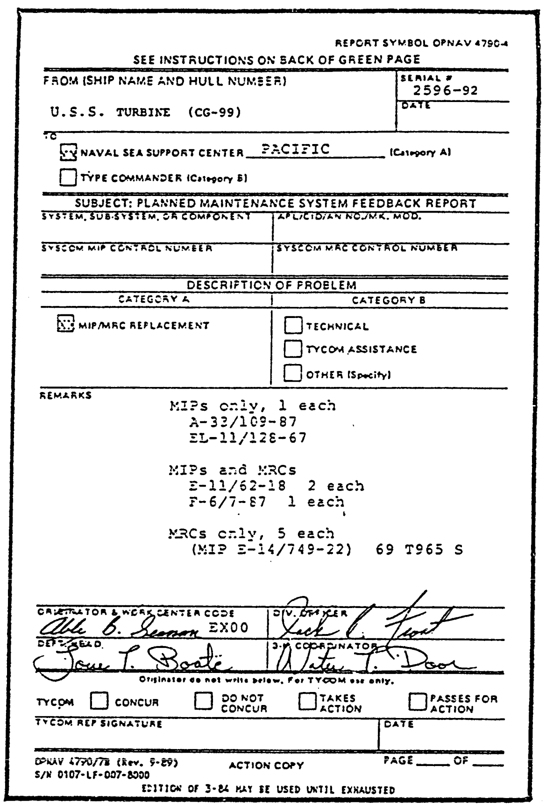
Messages are the quickest form of written communication in the Navy. This is because our telecommunications system is capable of getting time-sensitive or critical information to addressees rapidly for effective use of information. There are several methods used to file messages. Your division may file messages according to date-time group (DTG), precedence category, or subject matter. You should learn your division's message filing system to help you locate critical information.

Tickler Systems

A tickler system consists of record cards, usually organized in a standard desk-top box, in chronological or alphabetical order. This system makes handling recurring reports simpler. The reports tickler file requires daily attention if it is to be an effective tool. You must keep it and the information it contains up to date, and you must inform responsible personnel of current requirements for reports.

PMS FEEDBACK FORMS

The PMS Feedback Report (FBR) is a form ships use to notify the Naval Sea Support Center (NAVSEACEN) or the TYCOM of matters related to PMS. The FBR is a five-part form composed of an original and four copies. A completed FBR is shown in figure 1-19. The front side, shown in view A, is used for



REPORT SYMBOL OPNAV 4790-4

SEE INSTRUCTIONS ON BACK OF GREEN PAGE

FROM (SHIP NAME AND HULL NUMBER): U.S.S. TURBINE (CG-99) | SERIAL #: 2596-92 | DATE

TO: [X] NAVAL SEA SUPPORT CENTER PACIFIC (Category A) [ ] TYPE COMMANDER (Category B)

SUBJECT: PLANNED MAINTENANCE SYSTEM FEEDBACK REPORT

SYSTEM, SUB-SYSTEM, OR COMPONENT | APL/CID/AN NO./MK. MOD.

SYSCOM MIP CONTROL NUMBER | SYSCOM MRC CONTROL NUMBER

DESCRIPTION OF PROBLEM

CATEGORY A: [X] MIP/MRC REPLACEMENT

CATEGORY B: [ ] TECHNICAL [ ] TYCOM ASSISTANCE [ ] OTHER (Specify)

REMARKS

MIPs only, 1 each
A-33/109-87
EL-11/128-67

MIPs and MRCs
E-11/62-18 2 each
F-6/7-87 1 each

MRCs only, 5 each
(MIP E-14/749-22) 69 T965 S

ORIGINATOR & WORK CENTER CODE: EX00 | DIV. OFFICER

DEPT. HEAD | 3-M COORDINATOR

Originator do not write below. For TYCOM use only.

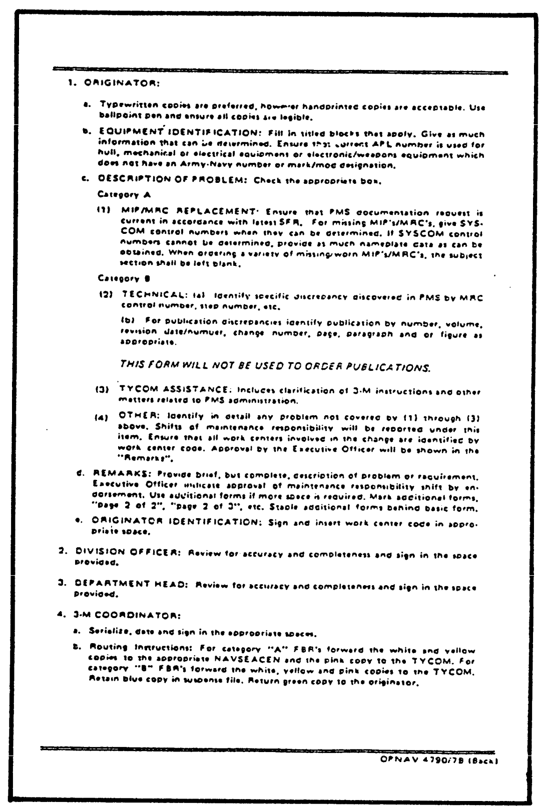
TYCOM [ ] CONCUR [ ] DO NOT CONCUR [ ] TAKES ACTION [ ] PASSES FOR ACTION

TYCOM REP SIGNATURE | DATE

OPNAV 4790/7B (Rev. 9-89) S/N 0107-LF-007-8000 ACTION COPY PAGE ___ OF ___

EDITION OF 3-84 MAY BE USED UNTIL EXHAUSTED

A. FRONT



1. ORIGINATOR:

a. Typewritten copies are preferred, however handprinted copies are acceptable. Use ballpoint pen and ensure all copies are legible.

b. EQUIPMENT IDENTIFICATION: Fill in titled blocks that apply. Give as much information that can be determined. Ensure that current APL number is used for hull, mechanical or electrical equipment or electronic/weapons equipment which does not have an Army-Navy number or mark/mod designation.

c. DESCRIPTION OF PROBLEM: Check the appropriate box.

Category A

(1) MIP/MRC REPLACEMENT: Ensure that PMS documentation request is current in accordance with latest SFR. For missing MIP's/MRC's, give SYSCOM control numbers when they can be determined. If SYSCOM control numbers cannot be determined, provide as much nameplate data as can be obtained. When ordering a variety of missing/worn MIP's/MRC's, the subject section shall be left blank.

Category B

(2) TECHNICAL: (a) Identify specific discrepancy discovered in PMS by MRC control number, step number, etc.

(b) For publication discrepancies identify publication by number, volume, revision date/number, change number, page, paragraph and or figure as appropriate.

THIS FORM WILL NOT BE USED TO ORDER PUBLICATIONS.

(3) TYCOM ASSISTANCE: Includes clarification of 3-M instructions and other matters related to PMS administration.

(4) OTHER: Identify in detail any problem not covered by (1) through (3) above. Shifts of maintenance responsibility will be reported under this item. Ensure that all work centers involved in the change are identified by work center code. Approval by the Executive Officer will be shown in the "Remarks".

d. REMARKS: Provide brief, but complete, description of problem or requirement. Executive Officer indicate approval of maintenance responsibility shift by endorsement. Use additional forms if more space is required. Mark additional forms, "page 2 of 2", "page 2 of 3", etc. Staple additional forms behind basic form.

e. ORIGINATOR IDENTIFICATION: Sign and insert work center code in appropriate space.

2. DIVISION OFFICER: Review for accuracy and completeness and sign in the space provided.

3. DEPARTMENT HEAD: Review for accuracy and completeness and sign in the space provided.

4. 3-M COORDINATOR:

a. Serialize, date and sign in the appropriate spaces.

b. Routing Instructions: For category "A" FBR's forward the white and yellow copies to the appropriate NAVSEACEN and the pink copy to the TYCOM. For category "B" FBR's forward the white, yellow and pink copies to the TYCOM. Retain blue copy in suspense file. Return green copy to the originator.

OPNAV 4790/7B (Back)

B. BACK

Figure 1-19.—PMS Feedback Report.

data describing a specific PMS problem. The reverse side of the last copy, shown in view B, provides instructions for preparing and submitting the form. As you advance in the GSE rating, you will prepare, submit, and review several FBRs. The following information will help you understand your responsibilities concerning the FBR.

Preparation Procedures

When a PMS-related problem occurs, you should try to correct the problem, especially if it presents a safety hazard. The PMS FBR is your vehicle for the solution to the problem. To prevent delays in correcting the problem, however, you should make certain to complete and submit the form correctly according to the instructions on the back.

Once you identify a PMS problem, you should immediately start entering the documentation on the FBR. You can either use a typewriter or neatly handprint your entries. Remember to insert your ship's name and hull number. Leave the date and serial number blank. The 3-M coordinator will insert the information in these two blocks.

Next, you must determine what category your particular problem is assigned to. There are two categories of FBRs—Category A and Category B. These categories are defined as follows:

- Category A–This category is nontechnical in nature and meets PMS needs that do not require technical review. The FBRs assigned this category pertain to the need for replacement of missing or mutilated maintenance index pages (MIPs) or maintenance requirement cards (MRCs).

- Category B–This category is technical in nature. It is submitted by the ship's 3-M coordinator to the applicable TYCOM. FBRs assigned this category pertain to the notification of a shift in maintenance responsibilities from one work center to another. These FBRs also pertain to TYCOM assistance in the clarification of 3-M instructions. This category also applies to technical discrepancies inhibiting PMS performance. These discrepancies can exist in documentation, equipment design, maintenance, reliability, or safety procedures. The discrepancies can be operational deficiencies in PMS support (parts, tools, and test equipment), as well.

NOTE

When the reason for submission of a PMS FBR involves safety of personnel, or potential for damage to equipments, and relates to the technical requirements of PMS, the FBR is considered URGENT. Urgent FBRs must be sent by naval message to both NAVESEACENS with information copies to the cognizant SYSCOM/BUMED/NAVSAFECEN/TYCOM.

Your next step is to fill in the equipment identification section. This information consists of system, subsystem, or component, allowance parts list (APL), MIP number, and MRC control number. Under the DESCRIPTION OF PROBLEM section, check the proper block under either Category A or Category B. In the REMARKS section, provide a brief description of the problem or requirement. Remember to include sufficient information to describe the problem. Next, insert the work center code and sign the FBR. The FBR will then be routed through your chain of command for review and approval.

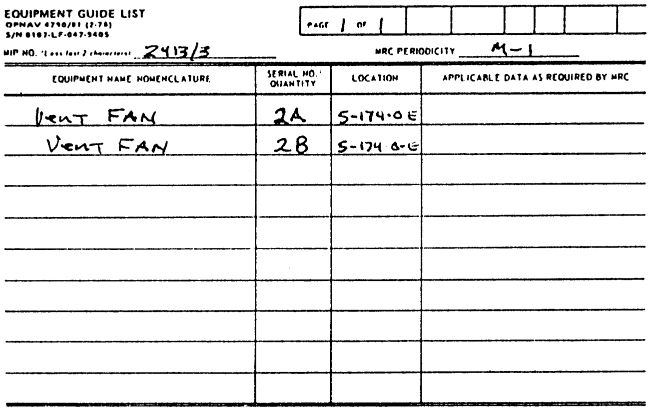
Review Procedures

Before sending your FBR through the chain of command, you should review the form for completeness and accuracy. One section you should closely scrutinize is the equipment identification section. Errors in this section will cause delays in processing your FBR. Provide as much information as you can. Make certain you use the correct APL number for hull, mechanical, or electrical equipment. Read the comments in the REMARKS section. Make certain the comments are legible and complete. On handwritten FBRs, be sure each copy is clear and legible. Observation of these simple guidelines will help you maintain your equipment in a high state of readiness.

EQUIPMENT GUIDE LIST

The Equipment Guide List (EGL) is a 5" x 8" card that is used with a controlling MRC. (See fig. 1-20.) When the MRC applies to the same type of items (motors, controllers, valves, test equipment, and so forth), use an EGL card. Each ship prepares its own EGLs. Standard EGL forms are available from the Navy supply system.

When determining the number of items to include on an EGL, you should consider the skill level of the assigned maintenance person and the time that will be required to complete the maintenance on each item.


EQUIPMENT GUIDE LIST
OPNAV 4790/81 (2-78)
S/N 0107-LF-047-9405

PAGE 1 OF 1

MIP NO. (Less last 2 characters) 2413/3   MRC PERIODICITY M-1

EQUIPMENT NAME NOMENCLATURE	SERIAL NO. QUANTITY	LOCATION	APPLICABLE DATA AS REQUIRED BY MRC
Vent FAN	2A	5-174-0 E	
Vent FAN	2B	5-174 0-E	

Figure 1-20.—Standard Equipment Guide List.

Remember, each page of an EGL should contain no more than a single day's work. If more than one day is required, prepare a separate EGL page for each day, and number the pages consecutively.

DIAGRAMS AND EQUIPMENT LAYOUTS

Drawings and equipment layouts are the universal language used by engineers and technicians. They convey all the necessary information to the individual who will maintain, operate, and repair the equipment and machinery.

To complete assigned tasks, a GSE must be able to read and understand electrical and electronic prints and diagrams. To read any electrical or electronic print, you must be familiar with the standard symbols used for these prints and the various methods of marking electrical conductors, cables, and equipment items.

ELECTRICAL PRINTS

GSEs use Navy electrical prints in the installation, maintenance, and repair of shipboard electrical equipment and systems. These prints include various types of electrical diagrams. The following sections will provide a brief description of these prints. For more detailed information, refer to *Blueprint Reading and Sketching,* NAVEDTRA 10077-F1.

Pictorial Wiring Diagram

A pictorial wiring diagram shows actual pictorial sketches of the various parts of an equipment item and the electrical connections between the parts.

Isometric Wiring Diagram

An isometric wiring diagram shows the outlines of a ship and the location of equipment, such as panels, connection boxes, and cable runs.

Wiring Diagram

A wiring diagram shows the individual connections within a unit and the physical arrangement of the components.

Schematic Diagram

A schematic diagram uses graphic symbols to show how a circuit functions electrically.

Elementary Wiring Diagram

An elementary wiring diagram shows how each conductor is connected within the various connection boxes of an electrical circuit or system.

Block Diagram

A block diagram includes the major components of an equipment item or system by means of squares, rectangles, or other geometric figures.

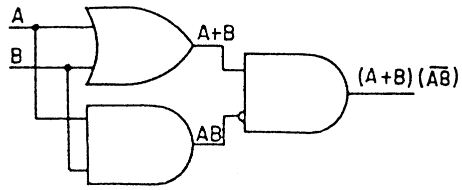
Single-Line Diagram

A single-line diagram uses lines and graphic symbols to simplify a complex circuit or system.

ELECTRONIC PRINTS

Most of the work performed by GSEs involves the maintenance and upkeep of the Engineering Control and Surveillance System (ECSS) consoles. A different type of diagram is used to troubleshoot the complex components of these consoles. For this reason, a GSE will use electronic prints more often than electrical prints. Electronic prints are similar to the electrical prints discussed earlier. Electronic prints, however, are usually more difficult to read than electrical prints because they represent more complex circuitry and systems. Shipboard electronic prints include isometric wiring diagrams, block diagrams, schematic diagrams, and interconnection diagrams.

Associated with some electronic prints are logic diagrams. Operation and maintenance of digital computers and digital computer systems requires the use



A	B	A+B	AB	(A+B)($\overline{AB}$)
0	0	0	0	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	0

Figure 1-21.—Basic logic diagram.

of logic diagrams. There are two types of logic diagrams-basic and detailed.

Basic logic diagrams show a particular operating unit or component. Figure 1-21 is an example of a basic logic diagram. In a basic logic diagram, basic logic symbols are shown in their proper relationship to show operation only in the most simplified form.

Detailed logic diagrams show all logic functions of the equipment concerned. In addition, they also include such information as socket locations, pin numbers, and test points to ease troubleshooting. A detailed logic diagram for a complete unit may consist of many separate sheets. An example of a detailed logic diagram is shown in figure 1-22.

EQUIPMENT LAYOUTS

Engineering personnel use equipment layouts as aids to locate various pieces of equipment throughout a machinery space. Equipment layouts are extremely helpful to newly reporting personnel who are not familiar with the engineering spaces. The main purpose of an equipment layout is to show the physical relationship of the equipment to its location in a space. Some layouts are more detailed than others, but the primary purpose is the same. While some equipment layouts may show only the physical location of machinery, others will show the piping that connects various pieces of equipment together.

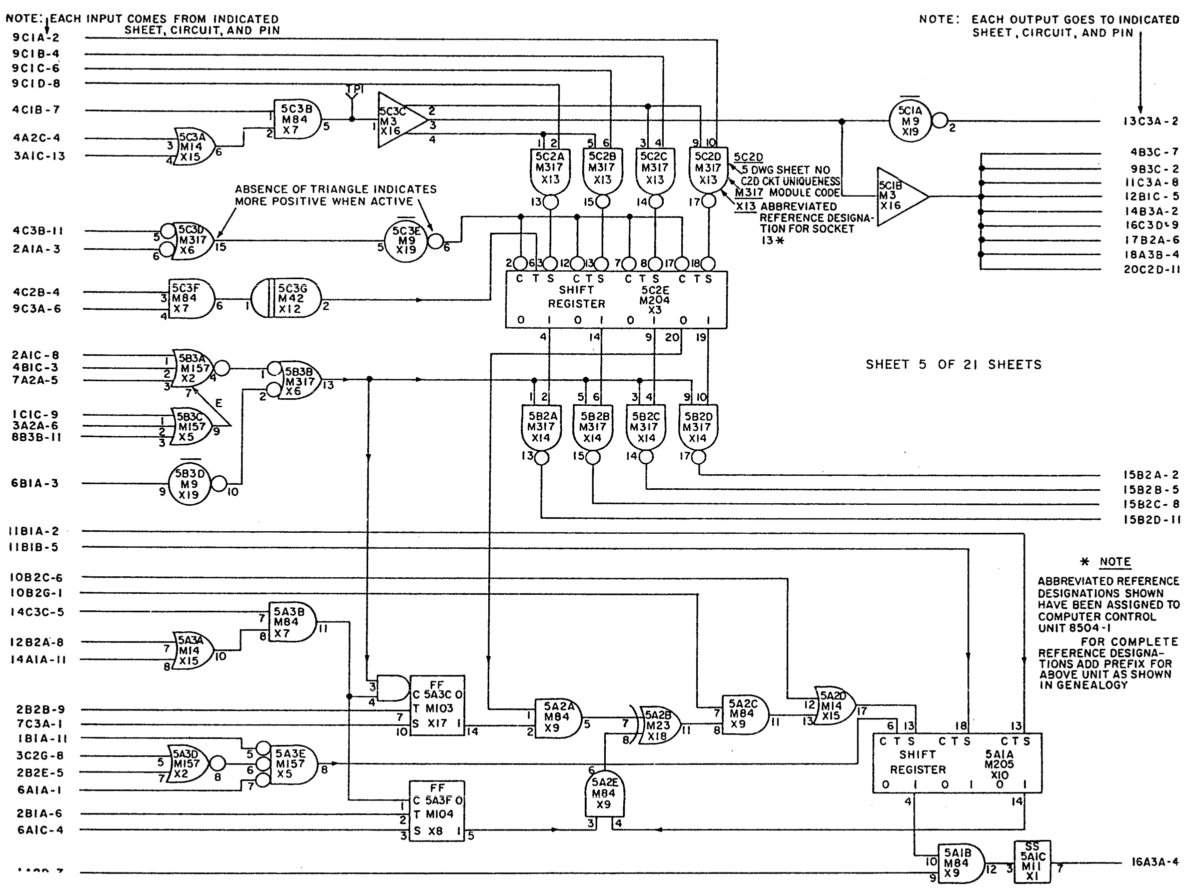


Figure 1-22.—Detailed logic diagram.

On a gas turbine-powered ship, you will primarily find equipment layouts in the Engineering Operating Procedures (EOP). The equipment layouts in the EOP are used mainly for training new personnel. To be able to use an equipment layout for system tracing depends upon the amount of detail included in the equipment layout.

SUMMARY

This chapter has provided you with a variety of information to help you become a more efficient and effective gas turbine specialist.

This chapter described the Navy's QA program and how you, a work center supervisor, will become involved in this program. This chapter also described the engineering administration system. The preparation procedures for various operating logs and records were discussed along with general guidelines for maintaining files, correspondence, and messages. This chapter also described preparation and submission procedures for PMS FBRs and the various uses of diagrams and layouts you will encounter as a GSE.

CHAPTER 2

UNINTERRUPTED POWER SUPPLY SYSTEMS

The propulsion control consoles on gas turbine-powered ships require a constant power source. Most of these consoles cannot withstand an interruption of this power source. If power is removed, the main fuel valve on the GTE will close, causing the GTE to shut down. This is why an uninterrupted power supply to the control consoles is so important. It keeps the engineering plant operating at maximum efficiency.

Gas turbine-powered ships are equipped with battery backup systems. These systems provide an alternate, short-term power source to vital pieces of equipment when a failure of normal ship's service power occurs. The control consoles, especially, will require an immediate source of backup power. Because the battery backup system must have a rapid method of transferring the load to the backup, electronic switching is used. Electronic switching allows backup power in the form of an uninterrupted power supply to be sent to the control consoles. Consequently, the battery backup system used on gas turbine-powered ships is appropriately called the uninterrupted power supply (UPS).

The UPS systems used on gas turbine-powered ships will be different for each class of ship. The main purpose for all UPS systems, however, is the same: to supply backup power to vital equipment when the normal power supply fails. In the following paragraphs, we will briefly discuss the operation and components of these systems and the different configurations you will find among the different classes of ships.

DD-963, DDG-993, AND CG-47 CLASS SHIPS

The UPS system for DD-963, DDG-993, and CG-47 class ships supplies emergency dc power to maintain operation of critical ship control systems during loss of normal ac power. The UPS can supply a nominal value of 150 volts dc to the control consoles for about 30 minutes.

Figure 2-1 shows a typical UPS system used on DD-963, DDG-993, and CG-47 class ships. The UPS originates from a bank of lead-acid storage batteries located in the ship's control UPS battery room. This

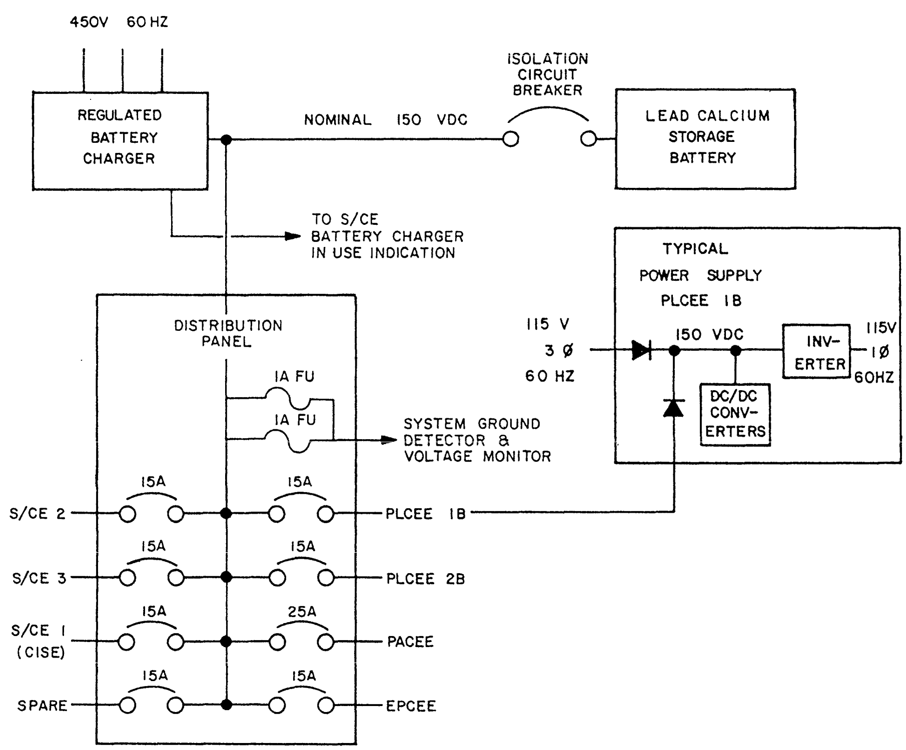


Figure 2-1.—Diagram of UPS system for DD-963, DDG-993, and CG-47 class ships.

equipment consists of a regulated battery charger, a battery rack, and a distribution panel.

You can monitor UPS voltage by using the meters located on the electric plant control console (EPCC) and the battery charger. You can also dial up the UPS battery voltage on the demand display indicators (DDIs). The nominal voltage is 150 volts dc. If this voltage drops below 122 volts dc, an alarm will sound at the EPCC. The EPCC also has an indicator light that illuminates when the battery charger is active. The 150 volts dc is transformed by dc-to-dc converters to different dc voltage levels required by the consoles. An inverter produces 115 volts ac to run each power supply cooling fan and for GTE igniter power.

The battery charger maintains a floating charge on the battery bank. With current limited to 30-amperes, a discharged battery bank can be recharged within 8 hours. Realize, however, that the engineering control and surveillance system (ECSS) does not fully discharge the batteries. If the dc bus voltage drops below 120 volts, the power supplies will shut down. The battery charger input power is 450 volts ac, 60 hertz (Hz). It originates from the main switchboard through a vital propulsion power panel.

Nine lead-acid batteries are mounted in a rack in the battery room. Eight of the batteries are connected in series and the ninth battery is a spare. The shelf life of the spare battery is about 1 year, after which time the battery charger cannot reactivate the battery to full charge. Special attention should be given to battery maintenance as the UPS batteries are of special design.

The distribution panel circuit breakers are normally left closed, and UPS power is available at the console power supplies. The console power supplies are located in the respective electronics enclosures. When normal ac power is lost at the power supplies, the dc power requirements will automatically be transferred onto the UPS. Indicator lights at each console will illuminate when the console is operating on UPS. After about 3 minutes of operation on UPS, internal supplies will shed noncritical loads within the console.

The UPS battery charger is interlocked through the battery room exhaust ventilation controller. The battery charger will shut down if the ventilation is lost. This is a necessary safety feature because charging batteries produce dangerous amounts of hydrogen.

FFG-7 CLASS SHIPS

The UPS on the FFG-7 class ship furnishes maximum continuity of service for the propulsion and electric plant control system. The UPS is a self-contained unit that consists of five major components. As shown in figure 2-2, these components are as follows:

- A 120-volt dc to 120-volt ac, 60-Hz inverter
- A 120-volt dc battery charger/rectifier
- A solid-state automatic load transfer switch
- Control equipment
- A 120-volt dc battery bank (not in the unit)

The UPS is located in the engine room. It is energized from the engine-room lighting panel. Normal and alternate power from the ship's service switchboards is provided by an automatic bus transfer (ABT). There are 20 6-volt lead-acid storage batteries located in the engine room. The UPS is connected in series with the load and is designed to be continuously

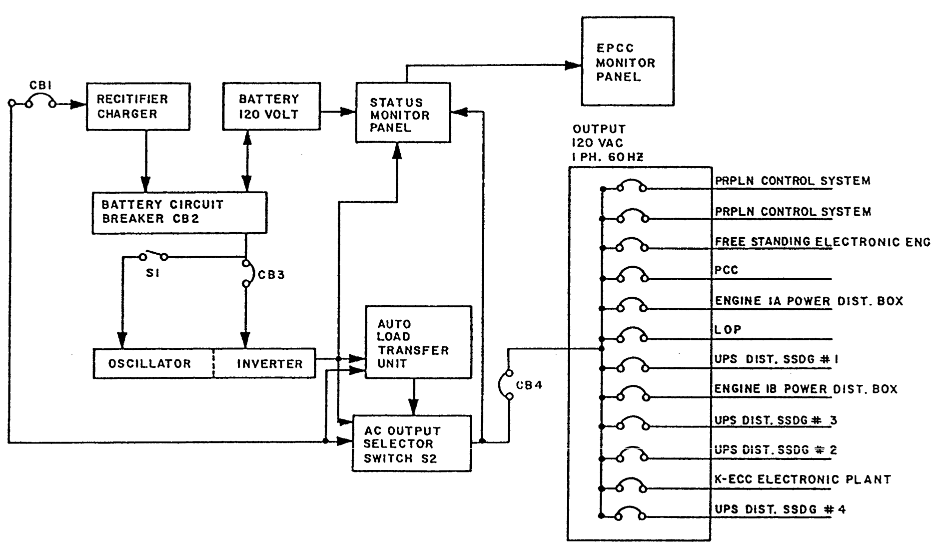


Figure 2-2.—Diagram of UPS system for FFG-7 class ships.

energized from the ship's 120-volt ac, 3-phase, 60-Hz power source.

The battery charger/rectifier is connected to maintain the charge of the ship's battery bank while simultaneously supplying power to the inverter. Upon failure of the ship's ac input to the UPS, power from the ship's battery bank will automatically provide dc power to drive the inverter. This causes the inverter to maintain the ac output to the load without power interruption for up to 15 minutes. When the ship's ac input returns, the battery charger/rectifier of the UPS will supply the inverter and charge the battery bank. The transfer of power to and from the battery bank takes place without any interruption of power.

The ship's service 120 volts ac is supplied through a circuit breaker to a transformer and then rectified to produce the 120 volts dc. The 120 volts de is applied to an oscillator and a single-phase bridge inverter. The 120-volt ac, 60-Hz, 1-phase output of the inverter is the normal input to the automatic load transfer switch. To supply power if the inverter fails, one phase of the ship's 120-volt ac, 3-phase power supply is routed to the alternate input to the automatic load transfer switch.

The control devices of the UPS consist of a four-position mode switch and a two-position ON-OFF switch. The mode switch selects NORMAL, ALTERNATE, AUTOMATIC, or OFF. NORMAL selects inverter output only and ALTERNATE selects ship supply output only. AUTOMATIC selects the transfer switch selected output and OFF removes UPS from the output circuit breaker.

When it is in the ON position, the ON-OFF switch connects 120 volts dc to the oscillator. The 120 volts dc must be applied to the oscillator before the 120 volts dc is energized to the inverter. The 120 volts dc must remain on until after the inverter is de-energized to avoid possible damage to the parts of the inverter.

The ship's UPS battery bank is connected to the battery charger/rectifier by a circuit breaker. The output from the battery charger/rectifier maintains the charge on the batteries during regular conditions. The batteries may be discharged while they are supplying 120 volts dc to the inverter if the ships's service power to the UPS is de-energized. When ship's service power returns to the UPS, it allows the battery charger/rectifier to recharge the battery bank to full charge.

The UPS system is equipped with instrument and indicator light monitoring devices. These devices provide a continuous visual display of the UPS operation. They consist of power available indicators, a battery bank voltmeter, a battery ammeter, and two oscillator-inverter status indicator lights. The system also contains four devices that show the UPS output power condition and three indicator lights that show which power source is supplying the load.

DDG-51 CLASS SHIPS

Figure 2-3 shows a block diagram of the UPS system used on DDG-51 class ships.

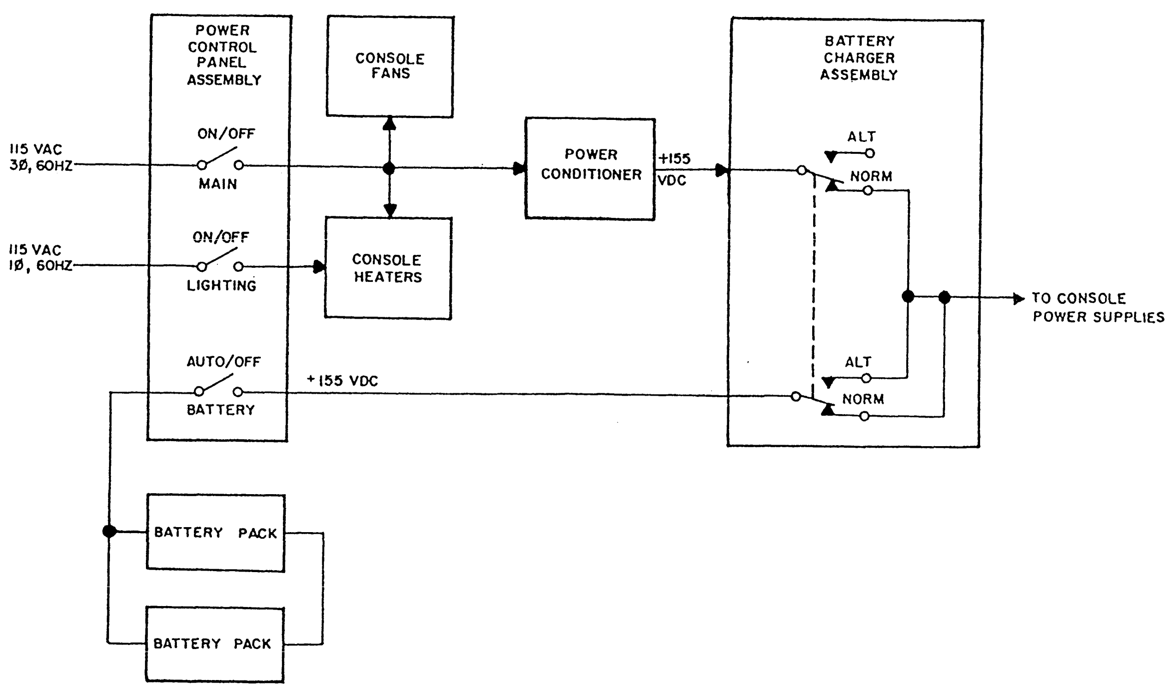


Figure 2-3.—Block diagram of the UPS system for DDG-51 class ships.

All machinery control system (MCS) consoles, except the bridge control unit (BCU), are protected from a loss of 155-volt dc electrical power. The UPS battery cells located in each console provide this protection. The capacity of the multicell battery pack powers its connected units for at least 30 minutes following a power failure. The batteries are contained in fumetight, slide-mounted assemblies that are vented outside the MCS consoles. Each console has from one to three racks of cells, depending on its power requirements. The battery-charging circuits of each console can automatically recharge a battery from 40 percent capacity to 80 percent capacity within 8 hours. Battery charging does not affect normal MCS operation.

The interim integrated electronic control (IIEC) also includes an UPS battery pack system. The IIEC contains the electronic support module (ESM) and the engine control module (ECM). (See fig. 2-4) The IIEC performs functions similar to those of the free standing electronics enclosure (FSEE) on other gas turbine ships. The battery pack for the IIEC is contained in the ESM. The ECM also uses the UPS battery pack that is contained in the ESM.

The MCS consoles require single-phase and 3-phase, 115-volt ac, 60-Hz power. The single-phase power energizes the console heating elements whenever the 3-phase power is not in use. The normal power source for each MCS console is the 3-phase, 115-volt ac. Its use raises console temperatures above expected dew point levels, avoiding hardware problems. The heating elements maintain the protected environment when the consoles are off-line.

The MCS console battery charger will automatically shift the load to battery power when the normal power supply fails. The batteries, located in the lower section of the console, are a 155-volt dc source. When the shift to UPS power occurs, an alarm will sound and the UPS IN USE indicator on the console will illuminate. A message showing that a particular console is on UPS will be displayed on the plasma display units. The UPS is designed to supply needed power for a minimum of 30 minutes.

Normal or UPS battery power enters the console power distribution system through the power control panel assembly. Three-phase voltage is rectified to +155 volts dc in the power conditioner and sent to the battery charger. This normal 155-volt dc power automatically charges the UPS batteries and provides input to the power supplies. The UPS battery power is connected to the power supplies when the load shifts. The battery charger assembly logic is designed to use the normal power source when it is available.

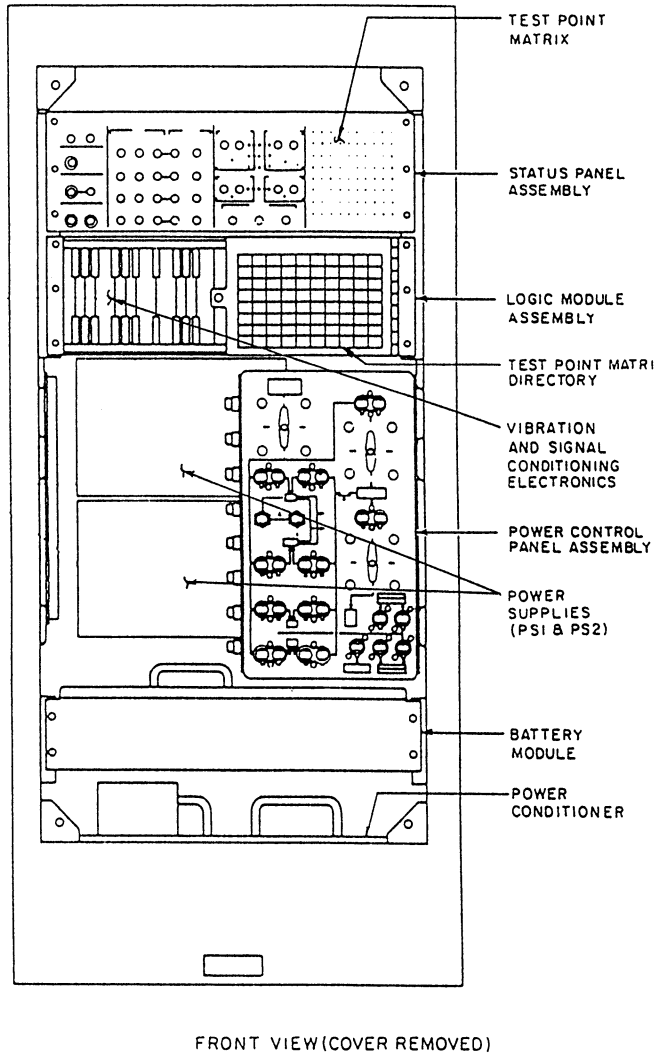


Figure 2-4.—Electronic support module (ESM).

BATTERY MAINTENANCE

You must give the same careful attention to the maintenance of UPS batteries that you would to the maintenance of any other power unit. Lack of intelligent supervision in the care of a UPS battery can result in temporary impairment or permanent damage. Carefully follow all instructions contained in the maintenance requirement cards (MRCs), manufacturer's technical manual, and data on the battery nameplates. These instructions will help you make sure the batteries perform as designed. In the following paragraphs, we will briefly discuss some of the maintenance tasks and procedures you will use with the UPS battery systems.

STATE OF CHARGE

The specific gravity of the electrolyte gradually decreases on discharge and gradually increases on charge. This decrease or increase is directly proportional to the number of ampere-hours taken out of or put into a battery. You can determine the state of charge of a vented battery, where the electrolyte is accessible, by testing the specific gravity of the electrolyte. The only way you can determine the state of charge of a sealed battery is by measuring its open-circuit voltage.

CHARGING

Except in an emergency, do not charge batteries in an enclosed space, unless the space has adequate ventilation. Stop charging if ventilation is interrupted. Do not resume charging until ventilation is restored. The UPS system on gas turbine-powered ships is interlocked with the ventilation system. If ventilation is interrupted, the UPS charging system will shut down.

Before starting a charge, make sure the electrolyte is at the proper level. The proper electrolyte level is about 3/8 inch above the plates or separators. If the electrolyte is too high, it will flood out of the filling tubes during the charge. This is caused by the expansion that takes place inside the cell as the temperature rises and by gassing. If the electrolyte gets too far below the top of the plates or separators and remains there, the exposed parts will dry and harden and will no longer function. This will cause a reduction in capacity and shorten the life of the battery.

SAFETY CONSIDERATIONS

Since a certain amount of gas is always given off from a vented battery, flames or sparks of any kind must never be allowed near any storage battery. Extra care is necessary after opening a battery compartment that has been sealed. No light switches should be turned on, no electrical connections of any kind should be made or broken, and no work should be performed in the compartment until it has been ventilated.

To prevent electrolyte from spraying out or foreign matter from entering the battery, always keep the vent plugs in place. You can remove the vent plugs when taking temperature and specific gravity readings or adding water. Always keep the vent hole free of obstructions.

All batteries and battery lockers must be kept clean and free of foreign matter. Clothing, cloth, or wiping rags should not be allowed to remain in battery lockers. When vent plugs are removed from cells, you must prevent anything from falling into the battery cell. You should avoid spilling acid or water in battery rooms. Collections of acid or dirt around a battery will lead to trouble and will cause corrosion. After adding water to the batteries, wipe the tops of the cells and the sides of the batteries clean. If acid has collected on the case, remove it by wiping the case with a cloth moistened in a diluted ammonia solution or bicarbonate of soda solution. While using ammonia or bicarbonate of soda, make sure the solution does not enter the battery cells.

SUMMARY

In this chapter, we have discussed the UPS systems used on the different classes of gas turbine-powered ships. We have also discussed some of the basic maintenance and safety procedures you should use when operating and maintaining the UPS system on your ship.

The conditions under which the UPS batteries are used vary from ship to ship. The frequency of inspection and maintenance necessary to ensure that the UPS batteries are in good operating condition will also vary. For detailed maintenance procedures associated with the UPS batteries, refer to the appropriate technical manuals.

As a GSE, you will find that your involvement with the UPS system will vary from ship class to ship class. On some ships, the maintenance of the complete UPS system will be your responsibility. However, on other ships you may be responsible for only the dc power at the power supplies. In any case, this chapter should have provided you with a basic understanding of the UPS systems found on gas turbine-powered ships.

CHAPTER 3

ENGINEERING CONTROL SYSTEM OPERATION

One of the most remarkable design features of a gas turbine-powered ship is the fact that the engineering plant can be operated, monitored, and controlled from a central area located away from the actual equipment and systems. The engineering control system makes this possible. Currently, three major designs of engineering control systems exist for gas turbine ships. The DD-963, DDG-993, and CG-47 class ships use the engineering control and surveillance system (ECSS) to operate the gas turbine equipment. The FFG-7 class ships use the engineering plant control system to both operate and monitor the gas turbine equipment. The relatively new DDG-51 class ships use the machinery control system (MCS) to both control and monitor the gas turbine equipment.

After reading this chapter and completing the associated nonresident training course (NRTC), you should have a good understanding of the function and operation of the major engineering control systems used on gas turbine-powered ships. Remember, this material is meant for training purposes only. It is not meant to replace the engineering operational sequencing system (EOSS) or the technical manuals.

The control consoles associated with the engineering control systems will not be discussed, in depth, in this chapter. Gas *Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* Volume 2, contains a detailed description of the control consoles used on gas turbine-powered ships.

After reading this chapter, you should be familiar with the operation of the engineering control systems and be able to discuss how they relate to the engineering plant. While you may never work on all types of control systems, this chapter should provide you enough information to help you advance in rate. As you become senior in the GS rating, this introduction to engineering control systems will be helpful in your watch-station qualifications.

ENGINEERING CONTROL AND SURVEILLANCE SYSTEM (DD-963, DDG-993, AND CG-47 CLASS SHIPS)

The ECSS is the automated electronic control and monitoring system used on the DD-963, DDG-993, and CG-47 class ships. This system uses both analog and digital circuitry. The ECSS can control the propulsion plant, electric plant, and supporting auxiliary machinery.

CONTROL AND MONITORING FEATURES

The ECSS communicates control commands to the engineering plant equipment. The system also provides the operator with various monitoring features. The system provides the following major control features:

- Automatic sequencing of the starting or stopping of the propulsion gas turbines, including automatic control of the main reduction gear (MRG) brakes and clutches during propulsion plant mode changes.
- Throttle and pitch control, providing integrated (combined) one-lever control for each shaft. This feature automatically schedules the rpm and pitch to their proper values for the engine order telegraph (EOT) order given.
- Centralized control of the electric plant, including initiation of gas turbine generator set (GTGS) starting and automatic sequencing of paralleling operations.
- Automatic sequencing and operation of some of the propulsion support and auxiliary equipment.

The system also provides monitoring features that include display of equipment status, annunciation of abnormal conditions, and printed records of major engineering plant parameters. A one-line diagram of the ECSS is shown in figure 3-1.

CONTROL AND MONITORING STATIONS

The automated ECSS system allows control and monitoring of the engineering plant from various locations. This feature makes the engineering plant on gas turbine-powered ships extremely versatile and reliable. The following paragraphs list the major control and monitoring stations on the DD-963, DDG-993, and CG-47 class ships.

Central Control Station (CCS)

The CCS is the main operating station from which most of the engineering plant machinery can be controlled and monitored. The ECSS equipment located in the CCS includes propulsion and auxiliary machinery control equipment (PAMCE), electric plant control equipment (EPCE), and propulsion and auxiliary machinery information system equipment (PAMISE). The following paragraphs briefly discuss these control equipments.

PAMCE

The PAMCE provides all controls and displays necessary to operate both main propulsion plants and their associated auxiliary and support systems. Automatic and manual propulsion plant controls and the integrated throttle and pitch control are available.

EPCE

The EPCE contains the logic circuitry to initiate the start and stop of a GTGS or automatically sequence generator breakers and bus tie breakers. It provides for automatic paralleling of any selected combination of generators. An automatic start-up feature is included if a GTGS failure occurs. Monitoring capabilities are provided for the GTGSs and the ship's service distribution system. On the CG-47 class ships, a turbine overload protection system (TOPS) is provided to monitor the GTGSs and the ship's electrical load.

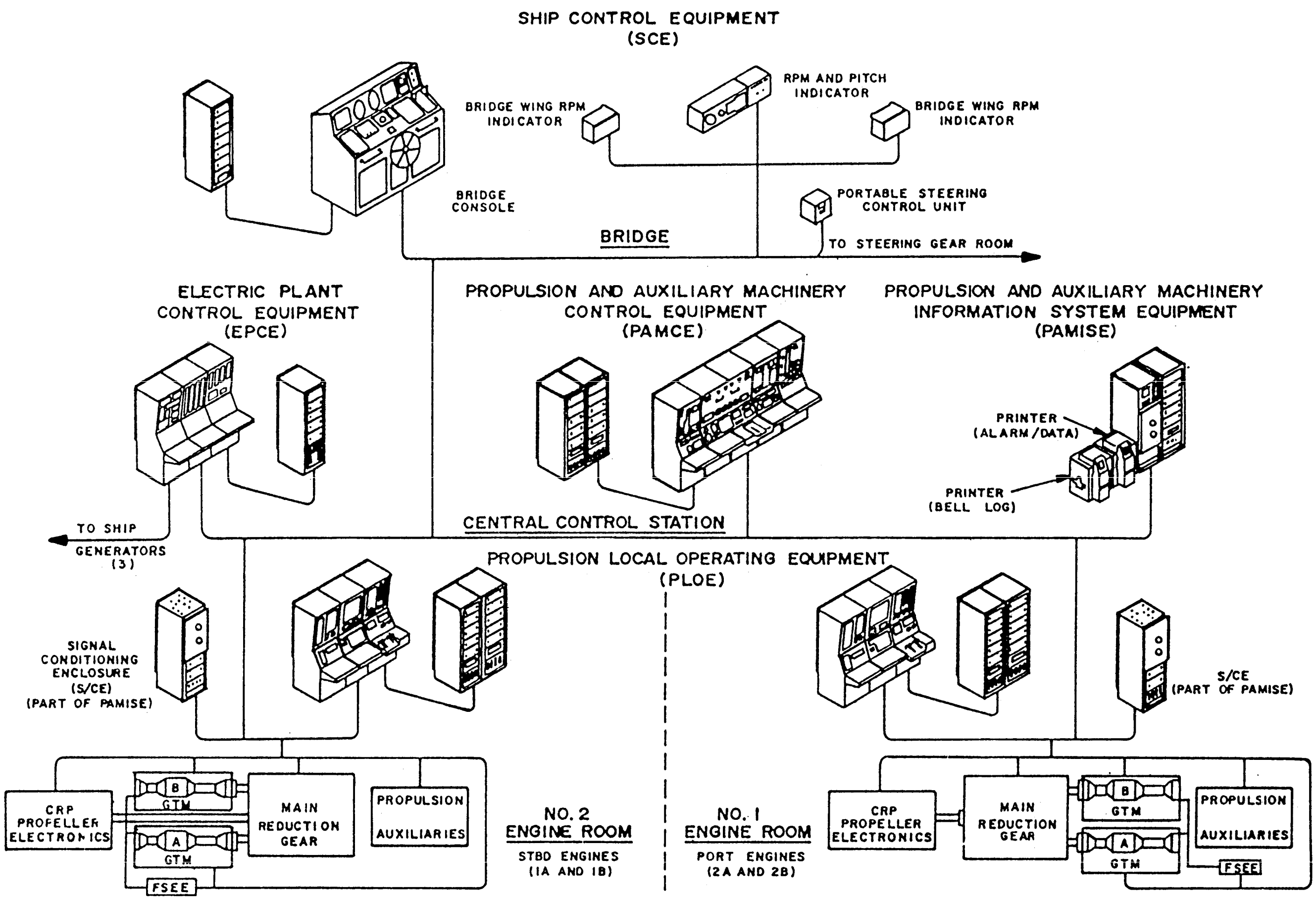


Figure 3-1.—Engineering control and surveillance system.

PAMISE

The PAMISE consists of a digital computer, signal conditioning equipment, and two printers. This equipment receives, evaluates, and logs the engineering plant performance, status, and alarm state. A signal conditioner performs the function of a central gathering point of sensory inputs. The signal conditioner processes these inputs so they will be compatible for computer use and to perform the alarm generation function.

Pilothouse

Throttle and pitch commands to each shaft can be directly controlled from the bridge by the integrated throttle and pitch controls located on the ship control equipment (SCE). This equipment also provides for EOT, rudder angle, and autopilot control. Digital readouts are provided at the main console of the SCE, the bridge wing display units (BWDUs), and the pilothouse rpm and pitch indicator unit (RPIU). The readouts display actual shaft rpm, actual propeller pitch, and EOT settings. A portable bridge wing steering unit is available for steering control from one of the selected bridge wings

Main Engine Room (MER)

The ECSS equipment located in each MER consists of the propulsion local operating equipment (PLOE) and one signal conditioner (part of PAMISE). The PLOE provides for local control and monitoring of the main propulsion gas turbine engines and the associated auxiliary equipment in each engine room. Each PLOE contains controls and status indicators as found at PAMCE, but only those of that particular engine room.

INFORMATION EXCHANGE AND PROCESSING METHODS

Now that we have told you about the main control areas of the ECSS used in DD-963, DDG-993, and CG-47 class ships, let's look at how the ECSS communicates, processes, and exchanges information. We will discuss the various types of sensory devices used, signal conditioning, serial data bus interconsole communication, and hardware. We also will discuss the types of control interfacing between the ECSS consoles and the engineering plant equipment.

Sensors and Remote Signal Conditioning

Most of the information that the ECSS receives is developed from various sensors located throughout the engineering plant. The sensors used with the engineering plant systems are either discrete or analog. Discrete is an either/or situation (ON/OFF, OPEN/CLOSE). Analog is a constantly changing value (speed in rpms, temperature in degrees). The types of sensors used on gas turbine-powered ships include the following:

1. Contact sensors (ON/OFF, OPEN/CLOSE)
2. Temperature sensors
3. Pressure sensors
4. Tachometer sensors
5. Ship's service electrical distribution sensors
   a. Voltage
   b. Amperage
   c. Wattage
   d. Frequency
6. Pressure switches
7. Level sensors

Signal conditioning is accomplished by the PAMISE at the signal conditioning enclosures (S/CEs), No. 1, No. 2, and No. 3. The purpose of these S/CEs is to convert all the sensory inputs into a common electrical range of 0 to 10 volts dc so they are compatible with the rest of the ECSS. Each signal conditioner receives a sensor (or external signal conditioner), voltage, current, ohmic, or frequency input. These inputs are converted to a 0- to 10-volt dc analog signal. These signal-conditioned parameters are processed by other electronic circuitry of the ECSS for alarm generation, analog meter displays, and digital demand displays.

Serial and Parallel Data Communication

Most of the control and status information communicated between the ECSS control consoles is exchanged in the form of binary signals. These signals are in groups or arrays of information known as data words. Each binary signal within the data word is called a data bit and has a binary zero or a binary one logic value. The number of data bits contained in a data word is called the word bit length. The data words can be exchanged in either a parallel or a serial format.

PARALLEL FORMAT.— In this format, the data transmitting and receiving electronics hardware must have one data line (wire) for each data bit. For example, a 10-bit data word requires 10 data lines. In parallel data word transmission and reception, each bit of the data word is presented simultaneously on the data lines. Therefore, the entire data word is sent or received simultaneously. Parallel format is used only for data communication within a console to allow a more rapid communication and transfer of information. This format also reduces the amount of electronic hardware required.

SERIAL FORMAT.— In the serial format, data bits are sent and received one at a time in a timed sequential manner using a single data line. Serial format is used for data communication within a console and between consoles. The data line between consoles is time shared, and clock synchronization between the consoles permits information exchange control. There are three types of data lines for serial data transmission. They are called subsystems and are as follows:

- Command and control serial data subsystem
- Demand display serial data subsystem
- Digitized analog serial data subsystem

The advantage of the serial data format is the significant reduction of the amount of wiring required for communications.

TESTING AND CALIBRATION METHODS

In this section, we will briefly discuss the methods used by the ECSS and the GSEs to test and calibrate the engineering control system used on DD-963, DDG-993, and CG-47 class ships. We will discuss the tests automatically performed by the executive control unit (ECU). We will also briefly discuss the calibration procedures that you, the repair GSE, should use. For a more detailed description of the tests required to maintain ECSS equipment, refer to the appropriate technical manuals.

ECU Self-Tests

The ECU program tests the functions of the ECU as a rest mode background test. That is, the self-test routines are done when the program is restarted or when commanded by actuation of the required program sense switches on the ECU control panel. The self-tests are broken down into four groups.

- Verification of memory contents
- Testing of memory functions
- Testing of the central processing unit (CPU)
- Testing of the input/output (I/O) channels

VERIFICATION OF MEMORY CONTENTS.— When the ECU program is loaded into the ECU, a specific memory location contains the arithmetic sum of all "fixed" memory locations; that is, the arithmetic sum of the contents of all memory locations that cannot be changed during operation. When the program is restarted, the computer will automatically add the location contents and compare the two sums. If the two sums do not agree, the computer will halt or "lock up."

TESTING OF MEMORY FUNCTIONS.— Again, when the ECU program is loaded, a series of test patterns are assigned to specific memory locations. These test patterns are used to store and retrieve information from any memory location that can be changed during operation. The test pattern is stored, retrieved, and finally compared to the original test pattern. If the two patterns do not agree, the ECU will halt.

TESTING THE CPU.— Upon progam start-up or as a rest mode background test, all commands for the CPU are tested. All possible combinations of data needed to execute the program are also tested.

TESTING THE I/O CHANNELS.— This test verifies the operation of the interface functions. This is accomplished by sending a test pattern out into the system and then receiving it back from the system. A comparison determines proper operation. Again, the computer will halt should the comparison fail.

If the computer halts because of a test failure, it will identify the nature of the failure by the data display light emitting diodes (LEDs) on the ECU. To determine the failure, the repair GSE selects the CPU position on the DISPLAY SELECT switch. The LEDs 0 through 4 will indicate the location of the failure.

Calibration Process

A calibration subprogram contains a listing of all the tables you will need to set the calibrated values into the S/CEs. The information contained in these tables includes voltage equivalents for power turbine overspeed trip set points, gas generator speed range, and header pressure transducer inputs.

To start the calibration process, you will energize the calibration panel in one of the S/CEs and select the type of card to be calibrated. Once you place the card in the calibration slot, the computer will identify the specific card and retrieve its own calibration constant. The computer will then compare the card against the constant and inform you if the set point is too high, too low, or right on. Using a screwdriver, adjust the potentiometer until the RIGHT ON light illuminates. If the card fails to calibrate, replace it.

Now that you have read about the ECSS used on the DD-963, DDG-993, and CG-47 class ships, let's look at the engineering control system used on the FFG-7 class ships.

ENGINEERING PLANT CONTROL SYSTEM (FFG-7 CLASS SHIPS)

The engineering control system is found on the FFG-7 class ships. It consists of several consoles within the engineering plant that are part of the automated electronic control and monitoring system.

MONITORING AND CONTROL FEATURES

The engineering control system can control and monitor the propulsion plant, auxiliary machinery, fire-extinguishing systems, and bilge levels throughout the ship. The system provides the following major control features:

Automatic sequencing of the starting or stopping of the propulsion gas turbines.

Throttle and pitch control, providing programmed (combined) one-lever control for the shaft. This feature automatically schedules the rpm and pitch to their proper values for the commanded EOT order.

Centralized control of the electric plant, including initiation of ship's service diesel generator (SSDG) starting and automatic sequencing of paralleling operations.

Automatic sequencing and operation of some of the propulsion support and auxiliary equipment.

The system also provides monitoring features that include display of equipment status, annunciation of abnormal conditions, printed records of major engineering plant parameters, and a printed record of the bell log. A diagram showing the relationship between consoles of the engineering control system is shown in figure 3-2.

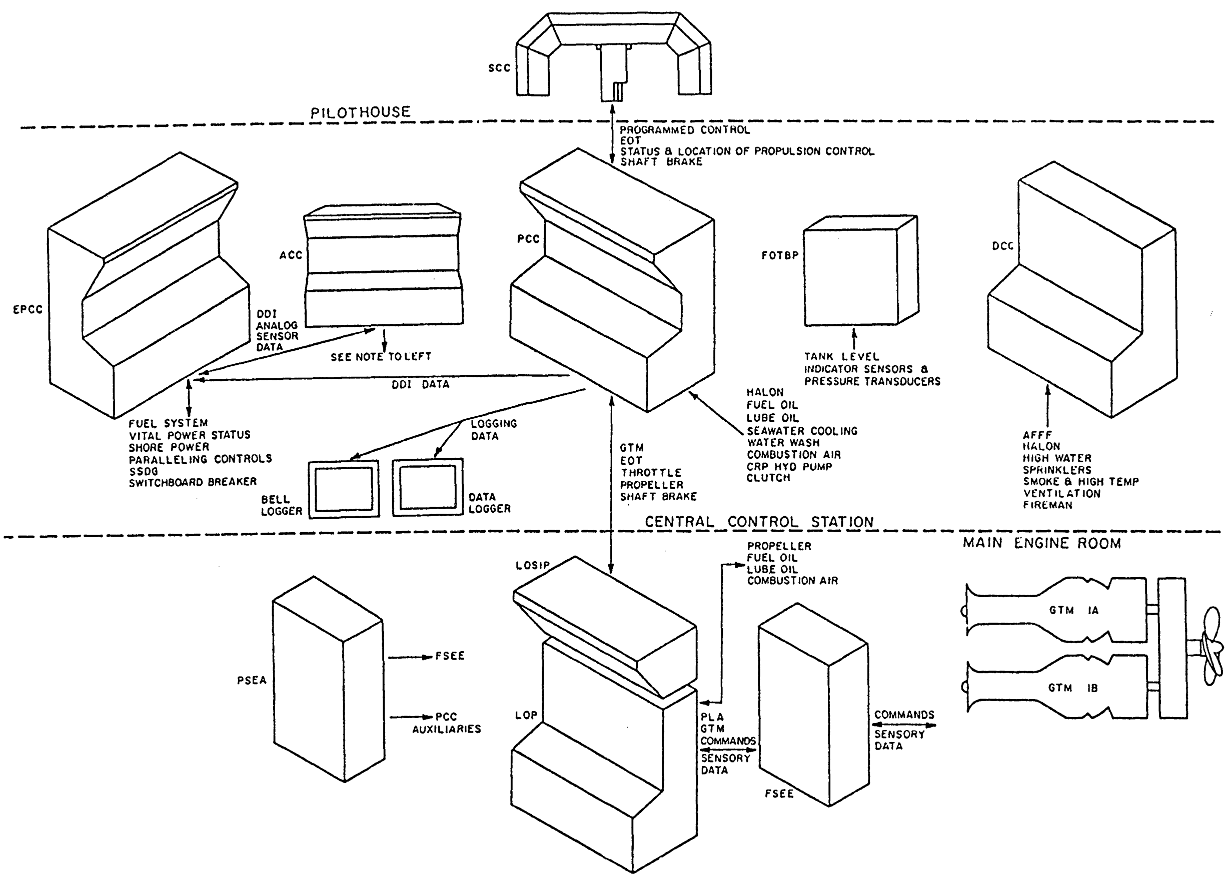


Figure 3-2.—Engineering plant control system.

INFORMATION EXCHANGE AND PROCESSING METHODS

In this section, we will describe the methods used by the control consoles to communicate between each other and between the engineering plant equipments and the consoles. We will discuss the various types of sensory devices used, signal conditioning, and data processing and distribution. Our discussion also will include a brief description of the processor program.

Sensors and Remote Signal Conditioning

Most of the information the engineering plant control system receives is developed from various sensors located throughout the engineering plant. A sensor is a device that responds to a physical stimulus and sends a resulting signal. The physical stimulus can be a fluid level, air pressure, motor speed, switch or relay contact closure, or exhaust temperature. The resulting output from the sensor is an electrical signal.

Sensors are referred to by many names, depending upon the manufacturer, construction, or use. For example, they might be called a detector, transducer, or shaft encoder.

The engineering plant control system uses many types of sensors to detect different parameter inputs, and it changes this input to an electrical signal. The types of sensors used on the FFG-7 class ships include the following:

1. Tank fluid level
2. Temperature sensors
3. Pressure sensors
4. Tachometer sensors
5. Contact closure
6. Vibration sensors

The propulsion control system (PCS) uses two types of sensed output signals: (1) conditioned and (2) unconditioned. These signals drive the light indicators, meters, motors, and alarms. The interface circuitry performs various functions. These functions are performed by analog-to-digital (A/D) converters, multiplexer, alarm and tone generators, relay and lamp drivers, and processors.

Both discrete and analog sensed signals may be signal conditioned or unconditioned. The unconditioned sensed signal goes directly to the equipment item it is driving: a lamp or a meter. The signal conditioner converts the sensed discrete or analog output signal into various forms used throughout the PCS.

DISCRETE SIGNAL CONDITIONER.— The discrete signal conditioner converts its sensed signal to an output signal level of 0 to +5 volts dc (logic 0 or 1). This signal is used to light the front panel indicator and trigger an alarm generation circuit. Often the sensed signal is conditioned to an output level of 0 or 3.5 volts dc (logic 0 or 1) to be compatible with the PCS.

ANALOG SIGNAL CONDITIONER.— The analog signal conditioner converts its input sensed signal to a 0- to 10-volt continuous output analog signal. These input signals are from fuel tank level, temperature, turbine speed, and pressure sensors.

Processor Hardware

All digital computers (processors) are divided into the following four basic units:

1. Control
2. Arithmetic
3. Memory
4. I/O

Using these four units with data lines, address lines, and control lines, the computer can effectively respond to the demands and protection of the engineering plant systems under a preprogrammed set of instructions. Let's briefly look at each of these units.

CONTROL UNIT.— A set of cards in the processor makes up the control unit. This set of cards provides the control logic that enables the computer to execute the desired instructions and control the address generation. These cards also control the timing required to execute power-up initialization and processor control.

ARITHMETIC UNIT.— The set of cards that makes up the arithmetic unit performs all the arithmetic functions for the processor, such as address offset and jump computation. In reality, the only true arithmetic function performed by this unit is adding two numbers. The unit uses the most significant bit (bit 0) to indicate the sign of arithmetic values and the negative number to be represented in the two's complement to perform subtraction by addition.

MEMORY UNIT.— The memory section of the processor includes read only memory (ROM) and random access memory (RAM). Addressing the ROM and RAM boards is accomplished by memory address multiplexer in the processor. The ROM contains both the necessary information and the program to perform the processor's assigned tasks. The RAM provides temporary storage of processed data for final output to the bell and data logger.

I/O UNIT.— The I/O unit consists of a set of cards that provides the interface between the processor and all peripherals or devices. These devices include multiplexer, scanners, timers, and loggers. In this unit, analog data is converted to digital data and routed directly to the digital multiplexer through the I/O buffer and into the processor. The processor outputs the data that are routed to the panels and external devices. Digital data outputs from the processor are also routed to the bell and data logger.

Processor Maintenance

The processor in the engineering plant control system has a maintenance panel. This panel is located behind the EPCC and propulsion control console (PCC) below the alarm backup override panel. The processor maintenance panel enables the operator to check the condition of the processor circuitry by observing the sequence of the instruction execution. By manipulating the various controls, you, the GSE, can also create diagnostic programs to isolate problem areas of the computer system. You have the option to stop, run, or single step the processor. You also can enter data and address bits from the maintenance panel.

For a more detailed description of the processors and the tests required to maintain engineering plant control system equipment, refer to the appropriate technical manuals. Let's now take a look at the control system used on DDG-51 class ships.

MACHINERY CONTROL SYSTEM (DDG-51 CLASS SHIPS)

The machinery control system (MCS) is found on the relatively new DDG-51 class ships. The MCS is an automated electronic control and monitoring system that uses six AN/UYK-44(V) console computers. These computers communicate with each other over the data multiplex system (DMS). The DMS is a modular communication system.

MONITORING AND CONTROL FEATURES

The MCS controls and monitors the propulsion plant, electric plant, propulsion and independent auxiliaries, and damage control system through seven consoles or units. The MCS consoles communicate with each other through the AN/USQ-82 DMS only.

Some command and status communications between MCS equipment and selected peripheral devices do not use the DMS. For example, the EPCC uses electrical wiring to control and monitor the ship's service gas turbine generators (SSGTGs).

CONSOLES AND EQUIPMENT

The MCS equipment group consists of six major control consoles, one multipanel unit, and one remote display. The electrical and electronic equipment is installed on the panels or within the console or chassis. Each console is self-contained with power supplies and cooling fans.

The system also provides monitoring features that include display of equipment status, annunciation of abnormal conditions, and printed records of major engineering plant parameters. A diagram of the MCS is shown in figure 3-3.

The MCS operator equipment is located within six spaces of the ship. These spaces are the MER, CCS, combat information center (CIC), pilothouse, and repair station No. 2.

CCS

The CCS is the main operating station on the DDG-51 class ship. Much of the engineering plant machinery can be controlled and monitored from this station. The MCS equipment located in the CCS includes the propulsion and auxiliary machinery control console (PACC), the electric plant control console (EPCC), the damage control console (DCC), and the engineering officer of the watch/logging unit (EOOW/LU).

CIC

The CIC's controllable plasma display unit (PDU) displays the data provided by the EOOW/LU console computer. A keyboard is provided to allow the operator to select required display information. The CIC PDU will not generate audible alarms.

Pilothouse

The pilothouse MCS equipment consists of a multicomponent bridge control unit (BCU). Throttle and pitch commands to each shaft are controlled from the bridge by a programmed control lever on the throttle

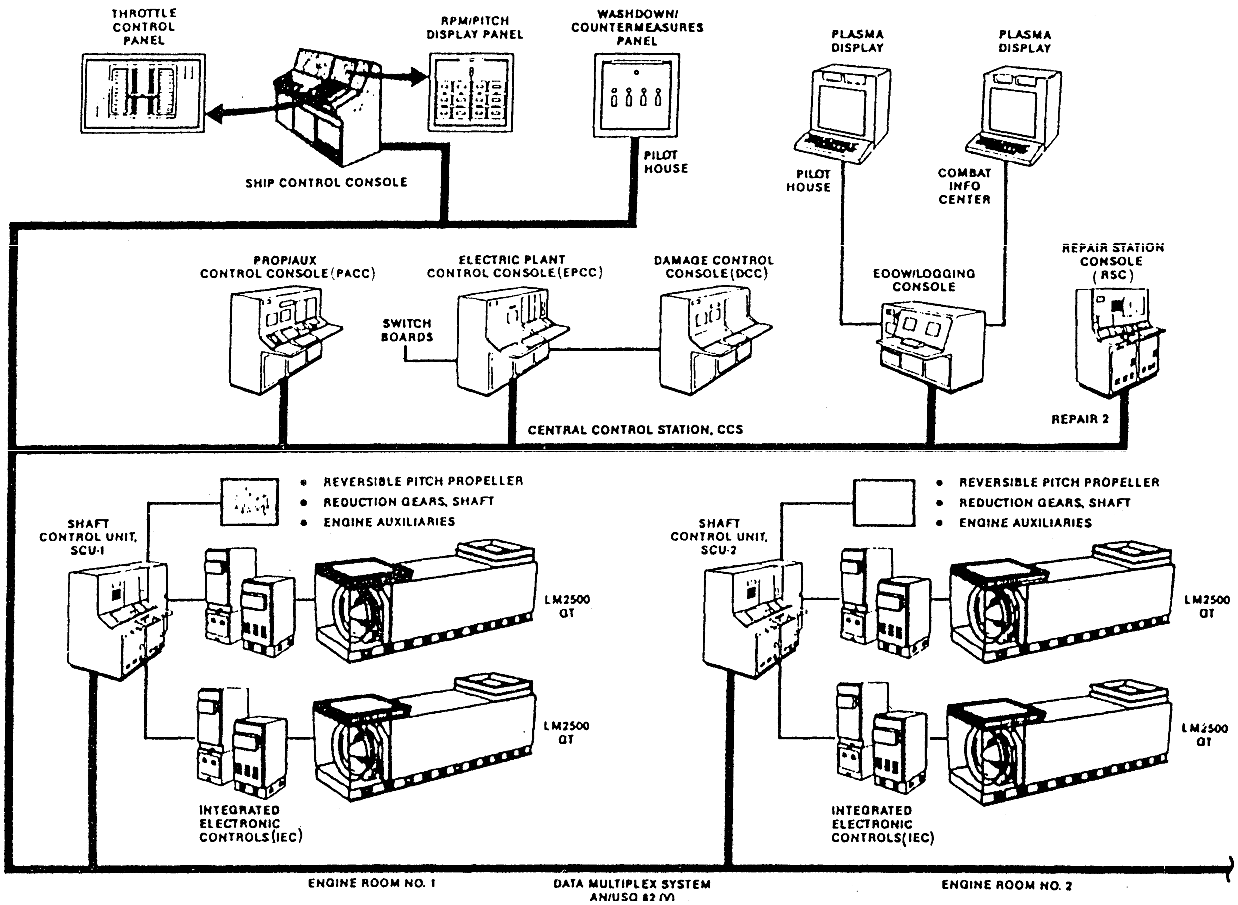


Figure 3-3.—Machinery control system.

control panel of the ship control console (SCC). The MCS console having propulsion control is shown on the SCC. Digital readouts display actual shaft rpm and propeller pitch, and EOT orders and acknowledgments.

MER

The MCS equipment located in each MER is a shaft control unit (SCU). Related propulsion equipment in each MER are two integrated electronic control cabinets and two GTEs. An SCU computer communicates with each cabinet, various plant sensors, and other MCS consoles. The computer also receives commands from the BCU and PACC.

Now that you have read about the major control areas of the MCS found on the DDG-51 class ships, let's look at how this system processes and exchanges information.

MCS INFORMATION EXCHANGE AND PROCESSING METHODS

The MCS receives, processes, displays, and transmits engineering plant information. These tasks are carried out by various MCS consoles and units, each of which is designed to control and monitor specific functions. In this section, we will describe the methods used by the MCS to communicate between the consoles of the MCS system and between the engineering plant equipments and the consoles. We will discuss the various types of sensory devices used, the MCS computer programming, the AN/USQ-82(V) DMS, and the types of control interfaces.

Sensors and Remote Signal Conditioning

Sensors that monitor engineering plant conditions provide either discrete (digital) or analog inputs to the MCS. Remember, a discrete input is an either/or situation described by a contact sensor (ON/OFF, OPEN/CLOSE). An analog input is a continuous measure of a parameter that may vary over a period of time (speed in rpms, temperature in degrees). The following types of sensors are used on the DDG-51 class ships:

1. Contact sensors
2. Tank level sensors
3. Temperature sensors
4. Pressure sensors
5. Tachometer/frequency sensors
6. Ship's service electrical distribution sensors

Signal conditioners external to the MCS provide the control and monitoring interface between a GTE and the SCU, and between a SSGTG and the EPCC. Signal conditioners on the bottom of the GTE provide analog inputs to an interim integrated electronic control (IIEC). The IIEC processes and conditions the GTE parameter inputs to the SCU in its MER. The IIEC analog outputs range from 0 to 10 volts dc. The IIEC discrete outputs are either 0 volts dc or +10 volts dc.

Signal conditioners in the SSGTG local control panel (LOCOP) provide analog inputs to a microprocessor inside the LOCOP. The LOCOP processes and conditions SSGTG inputs and provides a set of outputs to the EPCC. The LOCOP analog outputs range from 4 to +20 milliamps. The LOCOP discrete outputs are microprocessor-controlled relay contact state changes (open/close).

Serial and Parallel Data Communication

Interconsole and intraconsole information exchanges are in the form of binary signals. These signals are discrete signals, characterized by high and low voltage levels. These voltage levels represent conditions such as on/off, opened/closed, or digitized analog data. The signals are arranged in groups or arrays known as data words. Each binary signal within the data word is called a data bit and has a binary zero or a binary one logic value. The number of data bits contained in a data word is called the word bit length. The data words can be exchanged in a parallel or a serial format. Data is sent and received by the same methods we described for the DD-963 and CG-47 class ships.

DMS

The AN/USQ-82F(V) DMS is a dedicated signal processing and high-speed serial data transmission system. It is composed of interconnected data flow control and monitoring units. A dual-stage DMS configuration is used on the DDG-51 class ship. The term *dual-stage* indicates that multiplexing occurs in two stages. The first stage is done in the remote multiplexer, while the second stage is done in the area multiplexer. The DMS converts signals suited to machinery monitoring and control to signal types best suited to high-speed communications.

MCS COMPUTER PROGRAM FUNCTIONS

Each MCS console computer on a DDG-51 class ship is programmed with common and specific functions. The common functions are the general MCS console and the EOOW/LU operating functions. The specific functions relate to the control and monitoring of the engineering plant equipment assigned to a specific console. In this section, we will discuss briefly the methods used by the MCS and the GSEs to test the engineering control system. For a more detailed description of the test and calibration procedures required to maintain the MCS equipment, refer to the appropriate technical manuals.

Self-Test Program

The self-test function provides testing of major components in a console during unit initialization, after a system reset, and about twice each second during normal operation. The self-test function carries out the computer and peripheral automatic tests. The test results are placed in the console computer database for display on the PDU when requested by the GSE.

Test Functions

The self-test functions at each console are summarized in table 3-1.

Table 3-1.—MCS Console Self-Tests

	SCU	PACC	EPCC/ DCC	RSC	EOOW/ LU
AN/UYK-44(V)	X	X	X	X	X
Panel Distributor	X	X	X		
Input/Output Multiplexer	X		X	X	
Availability	X	X	X	X	X
Console Status	X	X	X	X	X
Manual	X	X	X	X	X

Let's take a brief look at each of these self-tests and how they work.

AN/UYK-44(V) TESTS.— The AN/UYK-44(V) built-in test (BIT) determines the operational status of the central processor, I/O controller, I/O channel adapters, and main memory. If an error is detected, an AN/UYK-44 BIT ERROR alarm will be displayed on the PDU. When the computer BIT cannot be completed in the time allotted, an AN/UYK BIT NOT CMPLT message is displayed on the PDU.

PANEL DISTRIBUTOR TESTS.— The panel distributor self-tests check the contents of its two RAMs and the console front panel push-button switch position messages for proper format. The SCU and DCC each have one panel distributor, while the PACC has two. A PACC panel distributor supports the controls and indicators associated the SCU. If the RAM does not conform to a predetermined format, an error message is displayed on the PDU.

I/O MULTIPLEXER TESTS.— The I/O multiplexer self-tests check that all inputs and outputs are valid. In addition, the computer tests all analog inputs to determine if they are within their permissible range. The computer generates test signals that are sent directly from an output multiplexer to its respective input multiplexer. If a computer-generated signal is received out of limits, an error message is displayed on the PDU.

The computer also tests actual analog signal inputs from the engineering plant to determine if they are within 7 percent of their full-scale range. For example, an analog input of 10.7 volts dc or greater, with a frill-scale range of 0 to 10 volts dc, is out of range. When this condition is detected, an error message is displayed on the PDU.

AVAILABILITY TESTS.— The availability self-test ensures that MCS computer communication with a peripheral, through a I/O channel assembly, is uninterrupted. If communications with a specific peripheral are interrupted, an alarm is displayed on the PDU.

CONSOLE STATUS TESTS.— The console status tests are not initiated by the computer self-test function. The computer receives the console status inputs, in the form of contact closure, through a panel distributor, I/O multiplexer, or RS-232C channel. If a contact closes to indicate a console hardware fault, an alarm will appear on the PDU. A power supply alarm will also be shown on the plasma display unit if a console power supply fault occurs.

MANUAL TESTS.— A manual testis started by the console operator. The operator depresses either the LAMP TEST pushbutton or AUDIBLE ALARM TEST push button. The LAMP TEST operates the MCS console LED driver circuits only and does not test the computer program function that controls the indicators. The AUDIBLE ALARM TEST push button operates the alarm annunciator printed on the push button (SIREN, HORN, BELL, or BUZZER).

You have just read about engineering plant monitoring and control systems for the DD-963, DD-993, CG-47, FFG-7, and DDG-51 class ships. In the following section, we will focus on the CCS operations on these ships.

CENTRAL CONTROL STATION OPERATIONS

The CCS is the main operating station from which the engineering plant can be controlled and monitored. On the DD-963, DDG-993, and CG-47 class ships, the PACC, EPCC, FSCC, and DCC are located in the CCS. On the DDG-51 class ships, the PACC, EPCC, EOOW/LU, and DCC are located in the CCS. On the FFG-7 class ships, the PCC, EPCC, ACC, and DCC are located in the CCS. In the remainder of this chapter, we will briefly discuss some basic operations performed from the major consoles located in the CCS of gas turbine-powered ships. First, we will discuss the operations of the consoles located in the CCS of the DD-963, DDG-993, and CG-47 class ships, followed by a discussion of the consoles on the DDG-51 class ships. Finally, we will discuss console operations from the CCS on the FFG-7 class ships. Refer to the EOSS, the EOP, and the appropriate technical manuals for a detailed description of console operating procedures.

DD-963, DDG-993, AND CG-47 CLASS CCS OPERATIONS

On the DD-963, DDG-993, and CG-47 class ships, the CCS is located remotely from the machinery spaces. This configuration allows for monitoring and control of the engineering plant with a minimum of personnel. The two major consoles of the engineering plant on these classes of ships are the PACC and the EPCC. The PACC is the console in the ECSS where control of the propulsion plant and auxiliary systems is normally located. The EPCC is the console where control of the electric plant is normally located. On the CG-47 class ships, the EPCC also controls and monitors the distribution of the ship's 400-Hz power. We will briefly discuss the operation of the PACC and EPCC in the following paragraphs.

PACC

The propulsion plant control systems monitor and control the performance and operation of the equipment of the main propulsion systems. The operation of this equipment is controlled from the PACC. The remotely produced commands from the PACC operate controls either to sequence the operation of the main propulsion equipment or to control subsystem operation.

The PACC contains the electronic equipment capable of controlling and monitoring both propulsion plants and most of the ship's auxiliary systems. Figure 3-4 shows that each panel of the PACC is dedicated to particular types of control and monitoring. In this section, we will briefly discuss the following control systems that are operated from the PACC:

1. Fuel oil service system
2. Lube oil system
3. Air system
4. GTE control
5. EOT control
6. Throttle and pitch
7. Plant mode
8. Auxiliaries

Refer to the EOSS, the EOP, and technical manuals for a detailed description of the operation of these systems.

Fuel Oil Service System

The fuel oil service system control and monitoring functions available at the PACC can be divided into two major categories: (1) fuel oil service control and monitoring, and (2) gas turbine module fuel oil control and monitoring. Together they function to deliver fuel

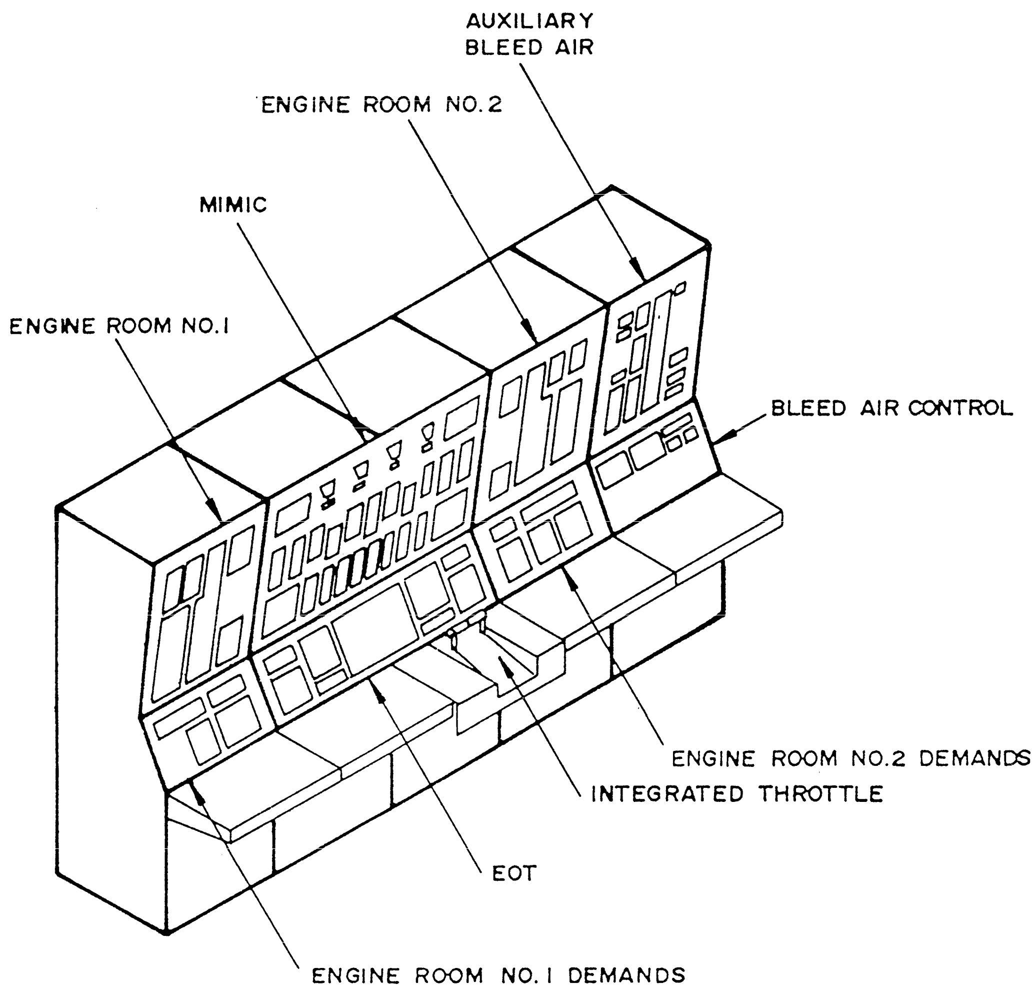


Figure 3-4.—PACC layout.

oil at the proper pressure and temperature to the individual propulsion gas turbines.

The following fuel oil service system control and monitoring functions are available at the PACC:

1. Fuel oil service tanks A/B temperature monitoring
2. Fuel oil service tank suction and recirculating valves control and monitoring
3. Fuel oil service booster pump A and B control and monitoring
4. Prefilter differential pressure monitoring (CG-47 class only)
5. Header pressure and temperature monitoring
6. Heater temperature monitoring
7. Coalescer filter monitoring
8. Leak detection tank monitoring
9. Suction strainer differential pressure monitoring

Monitoring functions are available at the PACC and the PLCC continuously, but control is available only at one console at a time.

PACC control of the fuel oil service system consists of remote manual control of the suction and recirculating valves associated with the two service tanks. The PACC also has automatic or remote manual control of the two fuel oil service pumps.

Valve control consists of open and close commands to the valve motor controllers. Commands are applied simultaneously to the suction and recirculating valves. Both valves associated with a service tank must be in the same state (open or closed) for proper operation. Separate control switches are provided to allow each service tank to be operated independently. Service tank monitoring consists of tank temperature high and low alarms.

The two service pumps can operate in manual or automatic control mode. When the pump mode switch is set to MANUAL, the operator can use the push buttons on the PACC to control the two pumps individually. Setting the pump mode switch to either A LEAD or B LEAD position sets up the automatic control circuits to select a lead pump and a standby pump. Pump control is then a function of header pressure and time.

The following GTE fuel oil control and monitoring functions are available at the PACC:

1. Supply temperature monitoring
2. Fuel purge control
3. Fuel falter monitoring
4. Main fuel valves control and monitoring
5. Emergency trip fuel valve control

GTE fuel oil controls available at the PACC pertain primarily to controlling the GTE fuel shutdown valves and emergency trip valves. Controls are also provided for fuel purging operations. Closure of either of the two main fuel valves prevents fuel flow to the engine fuel manifold. Control of these valves depends on the GTE control mode: manual, manual initiate, and auto initiate.

In the manual control mode, the main fuel valve control signals to the free standing electronic enclosure (FSEE) are generated by the push-button indicator on the PACC. In the manual initiate and auto initiate control modes, the fuel valve control signals are automatically generated by the start/stop sequence control logic.

The remaining GTE fuel oil controls available at the PACC are related to fuel purging operations. If an engine has been shut down for 15 days or longer, it may have to be purged before starting. Purging is accomplished by motoring the GTE with the fuel purge valve open. Depressing the FUEL PURGE ON push button at the PACC opens the purge valve and allows fuel oil to flow through the engine fuel lines and into the leak detection tank. The purge valve can be opened only when the operator depresses the push button on either the PACC or PLCC.

Lube Oil System

Each MER has its own separate and independent lube oil system that can be controlled and monitored from the PACC. Monitoring is available continuously at both consoles, but control is available at only one of the consoles at a time. Lube oil control available at the PACC consists of manual and automatic control of the two lube oil service pumps. These pumps function to augment the MRG attached lube oil pump.

If the pump controls at the PACC are to be enabled, the control location switch on the local controllers of the pumps must be in the REMOTE position. Manual control of the two pumps is individually accomplished with three push-button indicators. Setting the pump mode auto/manual logic switch to MANUAL allows operator control of pump speed. The push-button indicator causes the associated command to be relayed to the PLCC circuitry and then to the pump motor controller. Setting the pump mode switch to either the A LEAD or B LEAD position sets up the automatic control circuits to select a lead pump and a standby pump. Pump control is then a function of lube oil header pressure and time.

Lube oil pump control is transferred to the PACC by depressing the control transfer switch at the PLCC. The PACC commands are sent over the serial data bus to the PLCC. The PLCC pump control circuitry then initiates the proper signals to the pump motor controllers.

Air System

There are two main air systems associated with the GTEs and the GTGSs: (1) the bleed air system and (2) the high-pressure air system. The bleed air system and high-pressure air system are interconnected by piping and valves. These systems are monitored and controlled at the PACC. Control is available continuous y and simultaneously at both the PACC and the PLCC.

BLEED AIR SYSTEM.— We will look at the bleed air system in terms of its four distinct subsystems:

1. Starter air
2. Masker air
3. Prairie air
4. Anti-icing air

Located in each bleed air line for each GTE is a motor-operated bleed air valve. The position of the GTE bleed air valve can be controlled manually at the PACC as long as GTE control is transferred to the PACC. This valve can be controlled automatically by the start/stop sequence logic circuits. There are status indicator lights on the PACC that show the position of the bleed air valves.

The GTGS No. 3 has a bleed air isolate valve that can isolate the GTGS No. 3 bleed air from the rest of the ship's system. The ISOLATE push button, located on the PACC, is illuminated when the valve is closed and No. 3 GTG is isolated. On the CG-47 class ship, the GTGS solenoid-operated bleed air valves can be controlled from a bleed air valve control panel in CCS.

Starter Air System.— The starter air system has three operating modes available at the PACC: (1) normal, (2) emergency, and (3) motor.

Normal start air is used during a normal start sequence. The start air for the GTE is controlled by the motor air regulator valve. This valve is controllable at the PACC and provides one of two functions: valve opened nonregulated (start position) and valve opened regulated at 22 psig (motoring position). The last valve in the GTE start air flow is the starter air valve. This valve is controlled either manually or automatically at the PACC, if GTE control is transferred to the PACC. The last valve in the GTGS start air flow is the starter air valve that is controlled by the GTGS's system.

Emergency start air is started by depressing the EMERGENCY push button on the PACC. This action causes air from the high-pressure storage flasks to be available for GTE starts. The high-pressure air is reduced and enters the GTE start air system upstream of the motor air regulator valve.

Masker Air System.— The masker air system causes the start air system valves to line up to one of two possible states depending on whether masker air is on or off and if the air system is in automatic control mode. For the first condition (masker air on) after a start sequence, the start air system valves will automatically align to allow masker air to the masker air belts. For the second condition (masker air off) after a start sequence, the masker transfer valve will remain in the start position. Both valve alignments can be performed manually from the PACC.

Prairie Air System.— The prairie air system controls consist of a prairie air supply valve. The PACC control operates prairie air in both engine rooms from one ON/OFF push-button indicator. If one of the prairie air supply valves fails to respond to a command, the failure is shown by a lack of illumination of both sections of the indicator push button.

Anti-icing Air System.— The anti-icing system includes a bleed air injection system and an electrical intake heater system. The bleed air injection system is used to increase the intake combustion air temperature for the GTEs and GTGSs. The electrical heater system is used to prevent ice formation on the stack intake louvers and blow-in doors. The intake heater controllers must be in the ON position for the PACC push buttons to operate the heaters.

The bleed air injection system anti-icing system monitoring is available at the PACC for each GTE and GTGS. The injection of bleed air is manually controlled by operating personnel.

HIGH-PRESSURE AIR SYSTEM.— The high-pressure (HP) compressed air system provides HP air to the weapons systems, aviation equipment, gas turbine starting, and backup for the ship's service air system. This system consists of two vertical reciprocating air compressors, various storage flasks, two dehydrators, and a piping distribution system.

GTE Control System

Most of the GTE control and monitoring circuitry functions primarily for normal start-up and shutdown of the propulsion gas turbines. All four GTE control and monitoring functions can be accomplished at the PACC. There are three possible start/stop modes for each GTE at the PACC: (1) manual, (2) manual initiate, and (3) auto initiate. The auto initiate mode will be discussed in the plant mode control section of this chapter.

The manual control mode consists of operator generation of the start or stop commands at every step of the sequence. The operator must make sure each step is accomplished at the proper time. Sequencing of these manual controls is the same as the time sequential flow charts found in the technical manual.

The manual initiate mode consists of starting and stopping the GTM in a semiautomatic mode. In this mode, the engine will start up or shut down automatically. The control electronics at the PLCC will automatically sequence the start-up and shutdown steps required. This mode is semiautomatic because the brake and clutch (brake only on the CG-47 class ships) operation must be done manually.

EOT Control System

The ECSS uses the following three types of EOTs for propulsion command information:

1. Standard order EOT - Consists of standard engine commands, such as 2/3 back, 1/3 back, stop, 1/3 ahead, and 2/3 ahead

2. Digitized EOT - Provides rpm commands of 0 to 200 rpm in 1-rpm increments and pitch commands of –50 percent to +100 percent in 1 percent increments

3. Plant mode EOT - Provides commands of secured, split plant, and full power

All three EOTs are at the SCC and PACC. All three EOTs communicate via the command and control serial data bus.

STANDARD.— The standard orders are initiated at the SCC by moving the integrated throttle control (ITC) lever to the commanded standard order position and depressing the standard order ALERT pushbutton. This action sends the order to the PACC and PLCC for that particular shaft. If the PACC has control, the operator can acknowledge the order by using either one of two procedures. The first is by pushing the STD ORDER switch indicator, which silences the EOT bell, and then moving the ITC to match the command from the bridge displayed by the ITC flashing indicator. This action will cause the indicator to illuminate steadily. The PACC operator can also acknowledge the order by moving the ITC lever to the new indicated command. This will silence the bell and illuminate the indicator steadily.

DIGITIZED.— The digitized EOT provides for communication of nonstandard orders for pitch and rpm. A nonstandard order is a command for a specified pitch or rpm that is outside the predetermined settings. If the PACC has throttle control, the operator can set the thumbwheel switches to make the SET and ORDERED digital indicators agree. The operator then moves the ITC to the ordered position.

PLANT MODE.— The plant mode EOT consists of three possible orders: (1) secure, (2) split plant, and (3) full power. When plant mode is activated, the signal is sent to the PACC and flashes the indicator for the given order and sounds the bell. The operator acknowledges the order by depressing the flashing indicator. When the new plant condition is achieved, the indicator will illuminate steadily.

Throttle and Pitch Control System

The throttle and pitch control system provides control of shaft speed and propeller pitch. This control system is an analog control system that uses continuously variable signals to control shaft speed and propeller pitch.

ECSS throttle and pitch control is available at the PLCC, PACC, and SCC. Manual throttle and pitch control is available at the PLCC and PACC. Automatic or integrated throttle and pitch control (ITC) is available at the PACC and SCC. The PACC ITC levers, one for each shaft, allow single lever automatic scheduled control of throttle and pitch. Figure 3-5 shows an overall control block diagram of the throttle and pitch control system.

Plant Mode Control System

The plant mode control electronics is located in the PACC. The control works with the start/stop logic at the PLCC. Auto initiate mode is a part of the plant mode control logics. In plant mode control, the operator can start up or shut down main engines in both engine rooms without using the individual GTE start/stop controls. The plant mode control is normally used only when all of the following systems are in AUTO:

1. GTE start/stop control

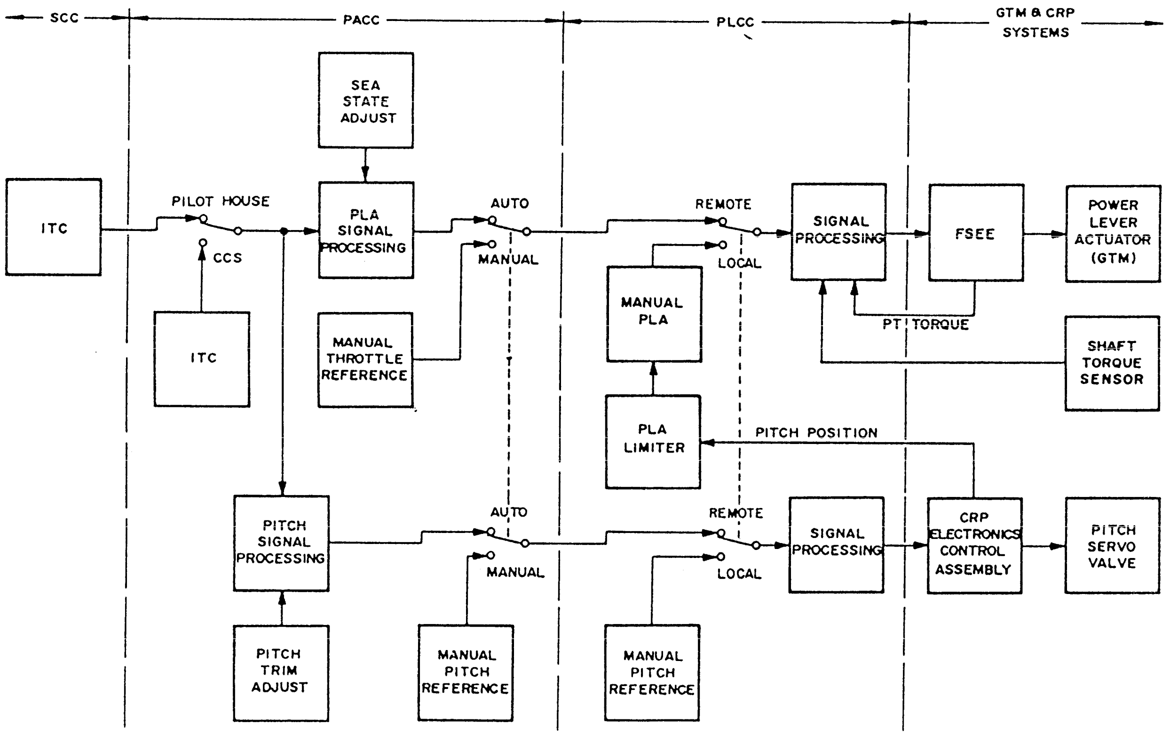


Figure 3-5.—Throttle and pitch control block diagram.

2. Throttle

3. Brake

4. Air

With these systems in auto and the propulsion plant in one of three propulsion configurations (secure, split plant, or full power), plant mode control is enabled. With plant mode control enabled, the following mode changes can be performed at the PACC:

1. Secure to split plant (CG-47 class only)

2. Split plant to full power

3. Full power to split plant

4. Full power or split plant to secure

5. Change engine

Auxiliaries Systems

There are certain engineering plant auxiliaries that can be monitored and controlled by the ECSS, and there are others that can only be monitored. The following list contains the auxiliaries that can be either controlled or monitored at the PACC:

1. Waste heat boiler (WHB) (monitored)

2. Seawater service (controlled and monitored)

3. Freshwater service (controlled and monitored)

4. Refrigeration plant (monitored)

5. Sewage and waste system (monitored)

6. Distilling plant (monitored)

7. Air-conditioning plant (monitored)

8. High-pressure air system (monitored)

9. Ship's service air system (monitored)

10. Chilled water expansion tank system (CG-47 class only) (monitored)

11. Combat dry air system (CG-47 class only) (monitored)

12. AEGIS pump system (CG-47 class only) (monitored)

For additional information on these systems, we recommend you consult the propulsion plant manual for each particular class of ship.

Now that you have read about the control systems at the PACC, let's look at those at the EPCC.

EPCC

The electric plant control systems monitor and control the performance and operation of equipment associated with the ship's electrical systems. The remotely produced commands operate controls to sequence the operation of equipment or to control subsystem operation. The operation of the electrical distribution systems equipment is normally controlled from the EPCC.

The EPCC contains the controls and indicators that are used to remotely operate and monitor the ship's service power generation and distribution systems. Figure 3-6 shows that each panel of the EPCC is dedicated to particular types of control and monitoring, based on the class of ship. (See views A and B.) Notice in view B that the EPCC on the CG-47 class ships has an additional section for the 400-Hz system. In this section, we will take a look at the following control systems:

1. GTGS monitoring
2. Electrical distribution system monitoring
3. Circuit breaker control
4. Gas turbine control
5. Generator control
6. System configurations
7. Load shedding
8. TOPS
9. 400-Hz power system

We will briefly discuss these control systems. For a detailed description of the operation of these systems, we recommend you refer to the EOSS, the EOP, and the appropriate technical manuals.

GTGS Monitoring

Each GTGS has sensors to provide remote monitoring of the gas turbine engine and the generator. The sensor information is sent to the EPCC in one of the three following ways:

1. Directly from alarm contact switches
2. Through alarm detector circuits in the generator control panel
3. Through the PAMISE via the S/CE No. 1

The PAMISE provides the high vibration alarm and parameter information for the demand display indicator (DDI).

There are several GTGS alarms at the EPCC that indicate abnormal conditions to the operator. With two exceptions, these alarms are initiated by contact sensors at the GTGS. The alarms that are not initiated by contact

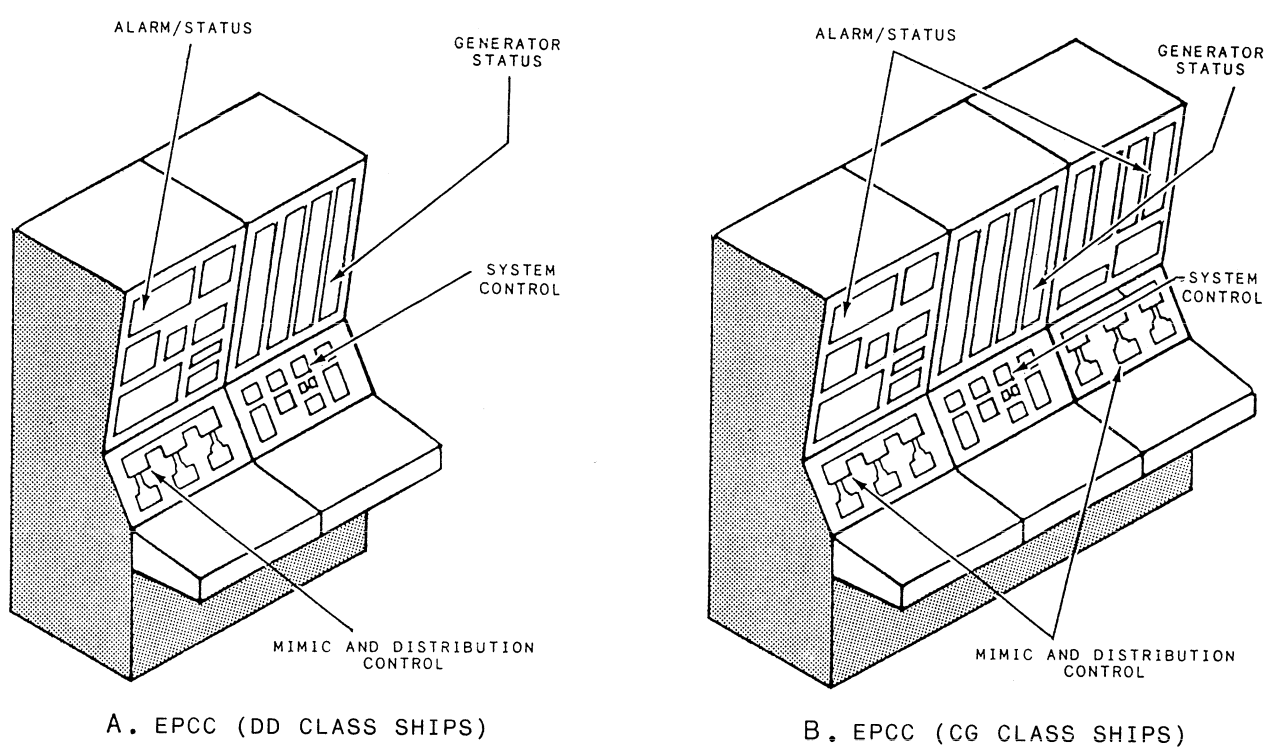


Figure 3-6.—EPCC layout.

sensors at the GTGS are the high vibration alarm and the high turbine inlet temperature (TIT) alarm. The high vibration alarm is generated by an alarm detector in S/CE No. 1. The high TIT alarm is initiated by a TIT high relay in the gas turbine generator control panel. In addition to the alarm lights, there are status lights at the EPCC for each GTGS.

Electrical Distribution System Monitoring

The generator status panel at the EPCC provides meter displays and alarms for monitoring the output of the GTGSs. An additional section of this panel is for shore power monitoring. The electrical distribution system provides monitoring by using meter displays and alarm lights. The operator can test the conditions of shore power by using the phase sequence meter and its associated switch.

Circuit Breaker Control

The EPCC provides centralized control and monitoring of the generator circuit breakers, bus tie breakers, and load center breakers. The push-button indicators used to operate these breakers are located on the EPCC mimic panel. Control of circuit breakers from the EPCC is enabled only when the generator control switches at the switchboards are in the REMOTE position.

Circuit breaker control at the EPCC can be divided into two categories: operator initiated and logic initiated. Operator initiated circuit breaker control is provided at the mimic panel with the push-button switch indicators. Logic initiated circuit breaker "Close" commands originate when the EPCC is in the automatic operating mode. Bus tie breakers 3S-1S and 3S-2S are the only breakers with "Auto Trip" commands. The commands isolate switchboard No. 3 if all three generators are in parallel for more than 2 minutes.

Gas Turbine Control

Gas turbine control available at the EPCC consists of gas turbine start and stop control and gas turbine frequency control.

Manual GTGS control available at the EPCC consists of a START push button, a STOP push button, and a HP AIR/LP AIR GTRB start mode selector switch. The start controls are enabled only when the control transfer switch at the generator control panel and switchboard are in the REMOTE position. The operator initiates a start by selecting the type of air (HP or LP) to be used and depressing the START push button.

The EPCC STOP pushbutton is not affected by the control transfer switches. When depressed, a signal is sent to the turbine stop relay at the switchboard. The stop relay sends a stop signal to the generator control panel to initiate a normal stop.

Frequency of each GTGS is controlled by an electronic governor. The electronic governor senses the frequency of the permanent magnet alternator (PMA) and sends signals to a hydraulic actuator on the gas turbine. The actuator adjusts the fuel flow in the engine to maintain engine speed. Frequency adjustment is made at the EPCC by raising or lowering a motor-driven potentiometer. There are two modes of governor operation: NORMAL and DROOP. The NORMAL mode is isochronous or constant frequency. The DROOP mode is an alternate mode where frequency decreases with increasing load.

Generator Control

Control of generator field excitation for a GTGS is accomplished by its voltage regulator. There are two modes of voltage regulator operation available at EPCC: AUTO and MANUAL. In the AUTO mode, the voltage regulator regulates the generator output voltage to a level set by a motor-driven reference potentiometer. In the MANUAL mode, excitation current from the voltage regulator is set by a motor-driven rheostat located at the switchboard. Voltage adjustment is made at the EPCC by commanding either the reference potentiometer motor (AUTO mode) or the manual rheostat motor (MANUAL mode) in the RAISE or LOWER direction. There are two modes for the voltage regulator: NORMAL and DROOP.

System Configurations

The electrical system is designed so two generators can supply all electrical loads. The third GTGS can be put on standby and then automatically started and synchronized to the bus on failure of one or both of the on-line generators. Automatic failure detection and recovery is available only when the EPCC is in control and in automatic mode, and the electric plant is in a standard parallel or standard split-plant configuration.

STANDARD SPLIT-PLANT CONFIGURATIONS.— Standard split-plant operation requires two on-line generators, but not paralleled. The switchboard bus of the off-line generator is energized through the bus tie connection to one of the on-line switchboards. The remaining bus ties are not energized. (See fig. 3-7, view A.) The EPCC configuration status logic can identify any split-plant configuration by monitoring the open and close status of the generator and bus tie breakers.

STANDARD PARALLEL-PLANT CONFIGURATIONS.— In parallel-plant operations, two generators are on line and paralleled. Additionally, all bus tie breakers are closed to connect the three main switchboards in a loop system. Configuration status logic at the EPCC identifies the on-line generators for auto recovery logic. (See fig. 3-7, view B.)

NONSTANDARD PLANT CONFIGURATIONS.— The open loop paralleled generator configurations, as shown in view C of figure 3-7, energize all three switchboards with two generators. These configurations are operator selected or are the result of a failure. All electrical distribution functions have these configurations, but automatic recovery capability is not available.

EMERGENCY CONFIGURATIONS.— Normal plant operation requires two generators in parallel or split-plant configurations. In an emergency with two generators inoperative, one generator must energize the three switchboards. (See view D in fig. 3-7.) Overpower protection will cause load shedding of preselected nonvital and semivital loads. If automatic load shedding does not reduce the load sufficiently, additional loads will have to be removed manually.

Load shedding

Load shedding is a process by which loads are removed from the electrical bus to prevent overloading of the on-line generators. Load shedding can be accomplished manually or automatically. On the CG-47 class ships, load shedding is completely independent of the TOPS.

Manual load shedding can be accomplished by depressing the LOAD SHED push-button indicator on the EPCC. This switch transfers +28 volt dc power to a load shed relay.

Automatic load shedding is initiated by any overpower sensor circuit in one of the switchboards. The sensor circuit energizes a self-contained relay whose contacts are in parallel with the LOAD SHED ACTIVATED pushbutton at the EPCC. Closure of these contacts energizes the same load shedding control relay as in manual load shedding.

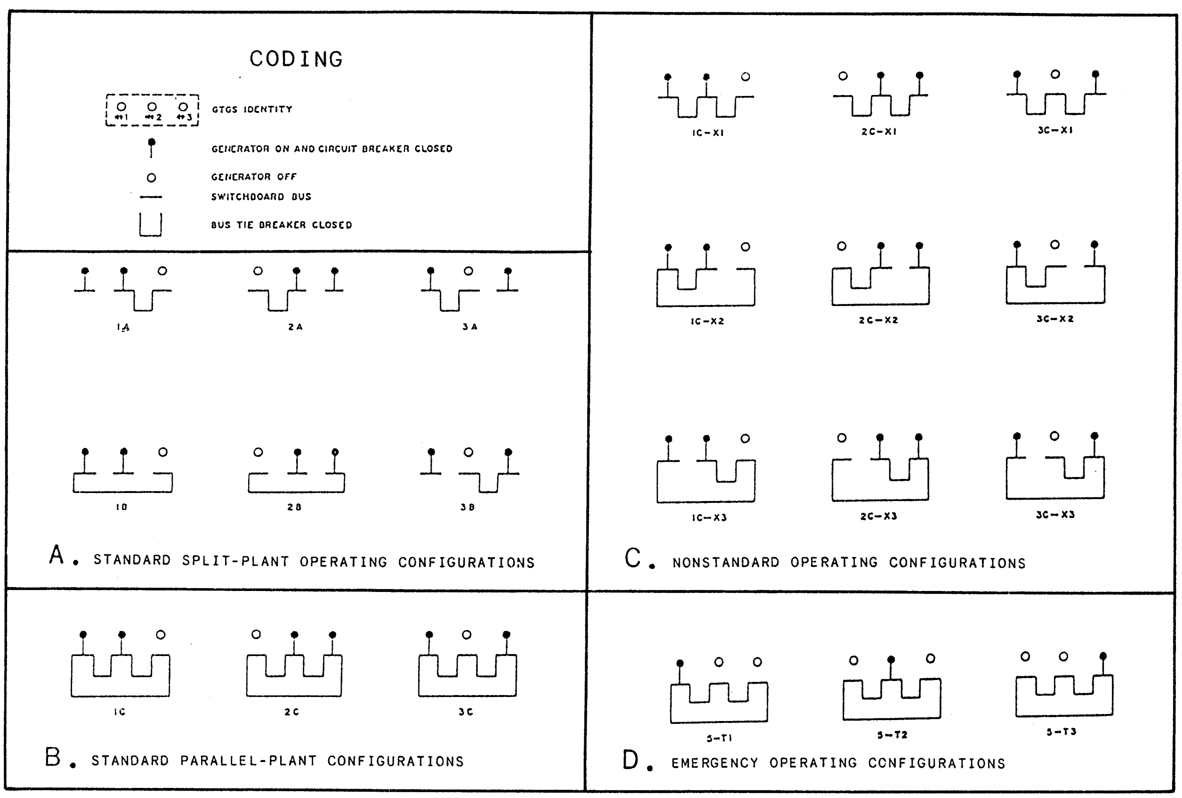


Figure 3-7.—Electric plant configurations.

When the load shedding control relay is energized, its contacts pick up tripping relays in each main switchboard. The tripping relays complete power circuits to the trip coils unselected main switchboard circuit breakers. The coils open the circuit breakers to remove load from the line. Additionally, other loads are similarly inhibited in load center switchboards by activation of tripping relays.

TOPS

The TOPS is an automatic protection system designed to prevent the loss of a GTGS due to overtemperature. The TOPS control panel (shown in fig. 3-8) receives analog inputs, such as GTGS inlet temperature, rpm, and kilowatt. These signals originate from the PAMISE. The control panel also receives digital inputs from the EPCC. These signals are generator breaker status, bus tie breaker status, and shore power status. The control panel processes the signals and provides a listing to the display unit. Based upon the results of the analysis of the data, the control panel issues the commands to close the bleed air valves and/or initiate load shed. The TOPS control panel will take whatever action is needed to maintain the vital electrical load.

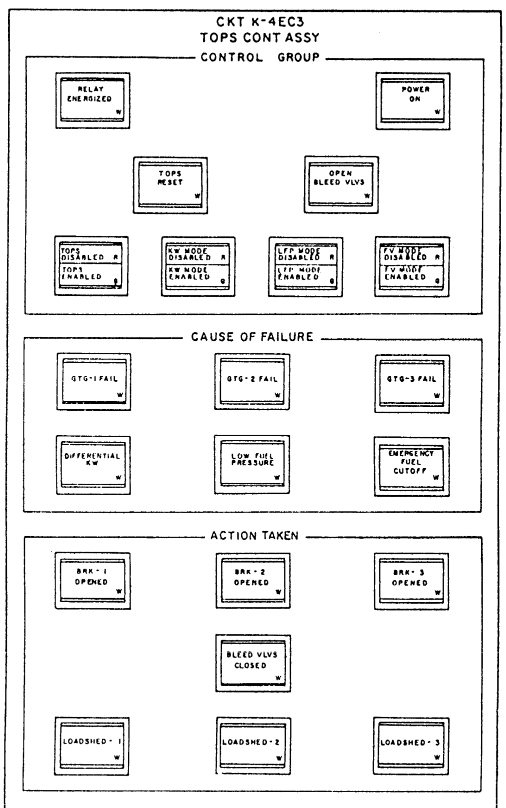


Figure 3-8.—TOPS control panel.

400-Hz Power System

The EPCC on the CG-47 class ships can remotely operate a total of six 60/400-Hz static converters. Only four converters are used on this class of ship. The 60/400-Hz converters on the DD-963 and DDG-993 class ships cannot be controlled from the EPCC. The three converter units on these classes of ships each provide a shutdown signal, a summary temperature high signal, and a power available signal to the EPCC.

On the CG-47 class ships, the converters may be controlled from the EPCC only when the CCS IN CONTROL indicator is illuminated. Starting, paralleling, and stopping the 60/400-Hz converters is possible from the EPCC. Control and monitoring of each static converter is provided by the following controls and indicator lights:

1. 60-HERTZ POWER AVAILABLE - Ship's power is available at the converter input breaker.

2. 400-HERTZ POWER AVAILABLE - The converter is running. Closing of the converter output breaker is enabled.

3. BUS TIE ENABLE - Converters are synchronized and parallel operation is enabled. Closure of the bus tie breaker is enabled.

4. SHUTDOWN - The converter is off. An alarm or the operator has stopped the converter.

5. COOLANT FLOW LOW - Summary alarm for all three liquid cooling mediums. The flow is low or has stopped.

6. TEMPERATURE HIGH - Summary of high temperature shutdown alarms.

7. LOCAL CONTROL - Control of the converter input and output breakers is at the converter master control unit.

8. CCS IN CONTROL - Control of the converter input and output breakers is at the EPCC.

9. CURRENT - A meter that shows the converter amperage to a maximum of 481 amperes.

Refer to the 60/400-Hz converter technical manual for a detailed description of the operation of the static converters.

You have just read about CCS operations on DD-963, DDG-993, and CG-47 class ships. Now let's look of the CCS operations on the DDG-51 class ships.

DDG-51 CLASS CCS OPERATIONS

The CCS on the DDG-51 class ships is also located remotely from the machinery spaces. The CCS is the main operating station from which the engineering plant, with the exception of the steering system, is controlled and monitored. The three major consoles of the engineering plant on this class of ship are the PACC, the EPCC, and the EOOW/LU. The PACC can control and monitor all systems and components that interface with the SCUs. This equipment includes the propulsion machinery, propulsion auxiliaries, and independent auxiliaries. The EPCC controls and monitors the SSGTGs and electrical distribution system. This includes restart control and monitoring of the four air-conditioning plants and some fuel service monitoring. The EOOW/LU controls and monitors the MCS data logger and bell logger. We will briefly discuss the operation of these consoles in the following paragraphs.

PACC

The MCS propulsion plant control equipment consists of two SCUs and the PACC. The PACC is located in the CCS and communicates with the SCUs through the DMS. The PACC provides all controls and displays necessary to operate MCS equipment in both engine rooms. It also provides for much of the MCS's associated auxiliary and support systems operations. Figure 3-9 shows that each section of the PACC is dedicated to particular types of control and monitoring. Some of the major controls and monitoring systems are discussed briefly in the following paragraphs.

Fuel Oil Service System

The fuel oil service system is remotely controlled and monitored by the PACC in two parts: (1) fuel oil service and (2) propulsion fuel. The fuel oil service and

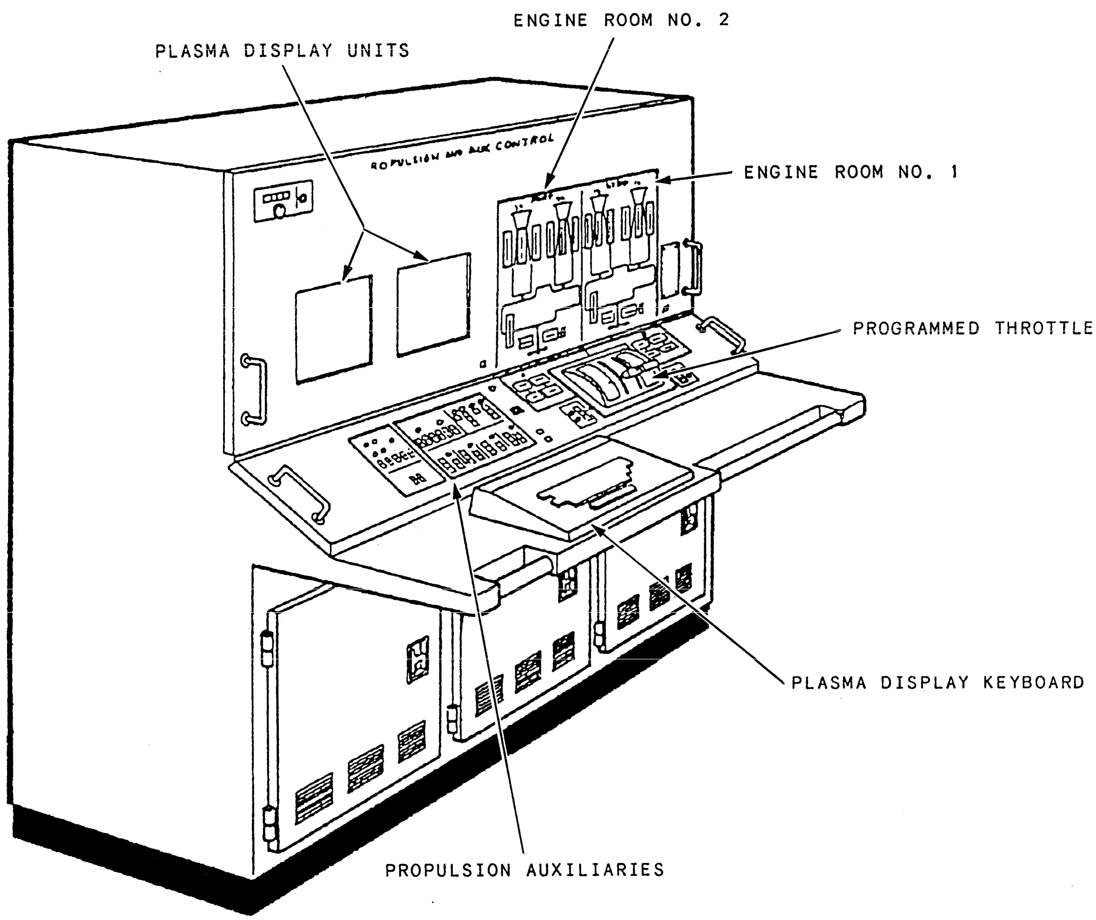


Figure 3-9.—Overall view of PACC.

propulsion fuel controls deliver fuel oil at the proper pressure and temperature to each GTE. The fuel oil service system may also be operated locally.

The following fuel oil service system control and monitoring functions are available at the PACC:

1. Fuel oil service tank level monitoring
2. Fuel oil service tank suction and return valves control and monitoring
3. Fuel oil service pumps A and B control and monitoring
4. Fuel oil service heater temperature monitoring
5. Prefilter differential pressure monitoring
6. Filter/separator differential pressure monitoring

Monitoring functions are available at the PACC and the SCU continuously, but control is available only at one console at a time.

PACC control of the fuel oil service system consists of remote manual control of the suction and return valves associated with the two service tanks. The PACC also has automatic or remote manual control of the two fuel oil service pumps.

The fuel oil suction and return valves computer program function allows the operator to open or close both service tank valves simultaneously. Separate control push buttons are provided to operate each service tank valve pair independent of the other service tank valve pair. The computer simultaneously sends the selected (open or close) command to both of the valve motor controllers associated with a single service tank. The PACC controls all four valves through their respective SCU computers.

The PACC operates both A and B fuel oil service pumps automatically when their respective motor controllers are aligned for remote operation. The push-button indicators at the PACC allow manual control computer program function for the fuel oil service pumps. The operator may depress the OFF, LOW SPEED, or HIGH SPEED pushbutton whenever a service pump motor controller is in remote. However, the computer program function will override operator LOW SPEED and HIGH SPEED push-button inputs if they are contrary to the automatic mode logic of the computer program function. The operator may command the operating fuel oil service pumps OFF at any time. When a fuel oil service pump is in the OFF state, the automatic mode of the computer program function is inhibited for that pump. In the automatic mode, after a fuel oil service pump is started, it is controlled by the computer program function. This program controls the fuel pumps with respect to fuel oil header pressure and time.

The following propulsion fuel control and monitoring functions are available at the PACC:

1. GTE fuel oil manifold pressure monitoring
2. GTE fuel oil valve control and monitoring
3. GTE fuel oil purge control and monitoring
4. GTM fuel oil filter differential pressure monitoring

The propulsion fuel oil controls available at the PACC are limited to opening and closing the module fuel inlet valve and fuel purging. Alarm and status indicators are also located at the PACC.

One solenoid-operated module fuel valve is located external to the module, in the fuel oil supply piping near each GTE. The valve is electrically energized closed and de-energized open. The valve isolates the module fuel oil system from the fuel oil service system. The module fuel oil inlet valve is controlled by push-button indicators on the PACC. Separate controls are provided for each GTE. Depressing the MODULE VALVE CLOSE push button energizes the valve and prevents fuel flow to the GTE regardless of operating status. If the MODULE VALVE CLOSE pushbutton is depressed when a GTE is ON LINE, ON, or in a cooldown, an automatic shutdown occurs.

Fuel purging is an operator-initiated function that allows the GTE fuel manifold to be drained of cold or contaminated fuel oil before starting. Purge control is available for each GTE through PURGE ON and PURGE OFF push-button indicators at the PACC. A fuel oil purge is started by the operator from the PACC when PURGE ON is depressed. This action energizes (opens) the solenoid-operated purge valve in the GTE. The operator depresses PURGE OFF to close the valve when fuel temperature and purity are satisfactory. The purge valve's position is indicated by limit switches that control the PURGE ON and PURGE OFF indicators at the PACC. A status message is also shown on the PDU.

Lube Oil System

Each MER contains an independent lube oil system that is controlled and monitored from the PACC. Monitoring is available continuously at both consoles, but control is available at only one of the consoles at a time. The PACC controls the lubricating oil service system pressure through the computer program function for the lube oil service pumps. Operator commands are started by push-button indicators in the reduction gear lube oil section of the propulsion mimic panel.

Motor-driven lube oil service pump control signals from the PACC are sent via the DMS to the appropriate SCU computer. Two modes of motor-driven lube oil service pump control are available: MANUAL and AUTO LEAD. MANUAL mode allows the operator to select pump speed with OFF, LOW SPEED, and HIGH SPEED push-button indicators. AUTO LEAD also allows the operator to select pump speeds manually and tells the SCU computer which pump to start first in response to the MRG hydraulically most remote bearing pressure. The control location switch on a lube oil service pump motor controller must be in REMOTE for the computer to control pump operation. Manual control of the lube oil pumps is individually accomplished with three push-button indicators. Automatic and manual pump operation are enabled when the operator depresses an AUTO LEAD pushbutton. AUTO LEAD prevents the operator from commanding pump speeds that contradict the lube oil service pump's automatic mode logic. When pump control is in AUTO LEAD, the pumps cycle as a function of the MRG hydraulically most remote bearing pressure.

Air System

There are two compressed air systems associated with the GTEs and the GTGSs: (1) the bleed air system and (2) the high-pressure air system. We will look at the bleed air system first.

BLEED AIR SYSTEM.– The bleed air system contains four distinct subsystems that include the following:

1. Starter air
2. Masker air
3. Prairie air
4. Anti-icing air

The bleed air system is supplied with combustion air extracted from each operating GTE and SSGTG compressor. Each GTE and SSGTG has a bleed air valve that controls the flow of air from the engine to the bleed air header. The bleed air valve for each GTE is motor-operated and may be controlled from the SCU or the PACC. The bleed air valve for the SSGTG is solenoid-operated and may be controlled from the SSGTG LOCOP or the EPCC.

Starting Air System.— The starting air system is supplied by the high-pressure air system through banks of high-pressure air flasks and the bleed air header. The bleed air system is the normal source of starting air when gas turbines are operating. The high-pressure air system flasks are the starting air source when no turbines are operating or a bleed air PRESS LOW alarm is set.

The operator selects the starting air source at the PACC by depressing the starting air BLEED or HIGH PRESS push-button indicator. These push buttons interface with the starting air select computer program function in the SCU computer. When the BLEED or HIGH PRESS push button is depressed, a status message appears on the PDU. The BLEED or HIGH PRESS signal is sent with an ON or ON LINE command, to align the appropriate starting air valve. Valve alignment for a BLEED or HIGH PRESS start is initiated by the SCU engine state logic-on computer program function.

A GTE maybe motored with bleed or high-pressure air using the same air paths as a bleed or high-pressure start. The only difference is the motor air regulator valve is set to the motor position by the engine state logic-motor computer program function. The motor air regulator valve regulates air pressure to 22 psig when in the motor position. A motor sequence is started when the MOTOR push button at the PACC is depressed for a GTM in the OFF state.

Masker Air System.– The masker air system is aligned by the HULL MASKER ON and OFF push-button indicators at the PACC. These pushbuttons operate the masker air select computer program function in the SCU computer. The HULL MASKER ON push button places the bleed air transfer valve in the masker position if a GTE start or motor command is not active in the same MER. The HULL MASKER OFF push button places the bleed air transfer valve in the start/motor position. The bleed air transfer valve position is displayed on the PDU.

Prairie Air System.– The prairie air system is supplied with bleed air through a prairie air cooler and supply valve in each MER. The PRAIRIE ON and OFF push-button indicators provide manual inputs to the SCU computer to issue commands to its connected prairie air supply valve. When the prairie air supply valves are operated from the PACC, the appropriate indicator illuminates and a status message is displayed on the PDU.

Anti-icing Air System.– The anti-icing air system is supplied by bleed air injected into the gas turbine intakes upstream of the moisture separator/blow-in panels. A manually operated anti-icing valve is located downstream of each GTM bleed air regulating valve. The anti-icing valve position is monitored by the computer in the SCU, which generates a status message on the PDU. An ICING alarm indicator for each GTE is provided on the PACC propulsion mimic panel.

HIGH-PRESSURE AIR SYSTEM.– The HP air system provides compressed air at 3000 psig to air storage flasks of various sizes and special-purpose functions. The HP air system is supplied by two HP air compressors. This system is used as an alternate source of starting air for the SSGTGs and GTEs. It also supplies the 5-inch gun, torpedo tubes, helicopter services, and, if necessary, the ship's service air system.

GTE Control System

Control and monitoring of all four GTEs is available from the PACC. However, normal control functions are only available from either the PACC or appropriate SCU at anyone time. The following items of the GTE control system are discussed in this section:

1. Engine fan control
2. Engine state logic
3. Emergency controls

The engine fan control computer program function is always enabled. It automatically operates the module cooling fan and damper in response to any one of the following three inputs: (1) GTE cooling air outlet temperature transducer, (2) GTE start command, and (3) the Halon release command. The SCU computer controls the GTE cooling fan and vent damper.

There are five possible engine states for a GTE. Each engine state is associated with a computer program function in the SCU computer. An engine state computer program function senses the actual state of the GTE and allows an operator to start an engine state change. The push buttons that enable an engine state change are on the gas turbine propulsion mimic of the PACC and SCU. The five engine state logic computer program functions are defined as follows:

1. Off - fuel off, power turbine (PT) brake on and disconnected from programmed control

2. Motor - engine off before alignment of an air system for motoring

3. On - engine running at idle, disconnected from programmed control, PT brake on, and stop not commanded

4. On Line - engine running, connected to programmed control, PT brake off, and clutch engaged

5. Cooldown - engine running at idle, disconnected from programmed control, and PT brake on

The SCU computer controls the GTE brakes, valve alignment, cooling fan, and vent damper automatically to fulfill any legal engine state change requested by the operator.

The GTE emergency controls consist of three separate, but interrelated, categories: (1) emergency stops, (2) automatic shutdowns, and (3) GTE fire detection and control.

An operator can initiate an emergency stop, while a GTE is in the ON or ON LINE state, by depressing the EMER STOP, PRI(RSV) HALON RLSE, or MODULE VALVE CLOSE push button. Depressing a HALON RLSE or MODULE VALVE CLOSE push button indirectly causes the SCU to send an emergency stop command to the IIEC. The SCU sends an emergency stop command to the IIEC in response to a module Halon actuation alarm or loss of GTE fuel manifold pressure.

An IIEC automatic shutdown is indicated when the AUTO SHUT DOWN lamp on the PACC illuminates. Each automatic shutdown causes the SCU computer to carry out an emergency stop in addition to the IIEC shutdown sequence. There are nine automatic shutdowns associated with the MCS system. GTE lube oil supply pressure low, power turbine vibration high, and power turbine overspeed shutdown are examples of automatic shutdowns. Five of the nine automatic shutdowns are inhibited when BATTLE OVRD ON is depressed. The five automatic shutdowns inhibited by battle override are as follows:

1. GTM fail to light off or flameout shutdown
2. GTM lube oil supply-low pressure shutdown
3. GTM power TIT high shutdown
4. GTM gas generator vibration high
5. GTM power turbine vibration high

The GTE fire detection system consists of three ultraviolet flame detectors in the module and a signal conditioner located under the module. When a fire is detected, an alarm message appears on the PDU and a MODULE FIRE lamp illuminates on the PACC and

SCU. Halon maybe actuated by depressing the PRI or RSV HALON RLSE push button at the PACC or SCU. After actuation of Halon, a HALON SYSTEM ACTUATED alarm is displayed on the PDU.

Thrust Control System

The thrust control system consists of throttle/pitch and brake mode control from an MCS control station. This station can be the PACC, SCU, or the BCU. Throttle/pitch control is unified under the programmed control and order difference computer program functions when NORMAL PROGRAMMED MODE is selected. Throttle and pitch controls are separated, and only available at the SCU, when LOCKOUT MANUAL MODE is selected. Brake mode control is available in both modes. However, brake engagement requires additional operator action when LOCKOUT MANUAL is selected. LOCKOUT MANUAL MODE places unit control at the SCU and inhibits control station transfers.

Programmed control is the normal method of controlling ship's speed. It simultaneously positions the controllable pitch propeller (CPP) blades and GTE power lever angle (PLA) for a propulsion shaft with a single lever. Two programmed control levers are available at the PACC. The port and starboard programmed control levers at the PACC may be latched to ensure the shaft horsepower is equal. The programmed control levers have a TRIM potentiometer for fine throttle/pitch adjustments.

The programmed control computer program function is designed for fuel economy. To provide this fuel economy, the programmed control has been divided into two operating regions. The first operating region, modulate transmission mode, is used for slower ahead and astern thrust settings. The second operating region, modulate engine mode, is used for faster ahead and astern settings.

Independent Auxiliaries Systems

The independent auxiliaries are systems controlled and/or monitored through an SCU, which do not have a direct impact on the propulsion and propulsion auxiliary equipment. The seawater cooling system pumps are the only independent auxiliaries controlled from the PACC. The independent auxiliaries associated with the MCS are as follows:

1. Seawater cooling system
2. Sewage and drainage system
3. Freshwater service
4. Air-conditioning/chill water system
5. High-pressure air system
6. Ship's service air system
7. Internal communication system

Now that you have read about the control systems available at the PACC on the DDG-51 class ships, let's look at those available at the EPCC.

EPCC

The EPCC provides centralized control of the ship's electric plant. In the DDG-51 class ships, the EPCC provides centralized control of the SSGTGs and bus distribution equipment. These features include a panel arrangement of SSGTG controls and display devices in three groups, one for each generator. Each group also has controls and indicators for generator circuit breaker operation and status. Load shedding, shore power switching, and a visual synchronization presentation for all power sources are added features. Limited status of each air-conditioning plant status is displayed and restart controls for each plant are provided. The major electrical generation and distribution equipment is located in auxiliary machinery room (AMR) No. 1, MER No. 2, and the generator room. Each of these spaces contains one SSGTG and its associated switchboard.

An integral AN/UYK-44(V) computer provides for control and monitoring of the electric plant. The MCS requires that the electric plant remain operable if the EPCC computer fails. So, many switch functions are hardwired rather than using the DMS. The wiring is from the EPCC to the controlled device in the generator spaces. The required electric plant sensors are also hardwired to the EPCC panel indicators to provide status. An EPCC computer failure causes a loss of electrical plant alarm detection, EPCC DMS communications, and any displays at the PDU.

The EPCC contains the controls and indicators that are used to remotely operate and monitor the ship's service power generation and distribution systems. Figure 3-10 shows the locations of the control and indicator panels of the EPCC. In this section, we will briefly discuss the following control systems operated from the EPCC:

1. SSGTG control and monitoring
2. Electrical distribution monitoring and control
3. Circuit breaker operation

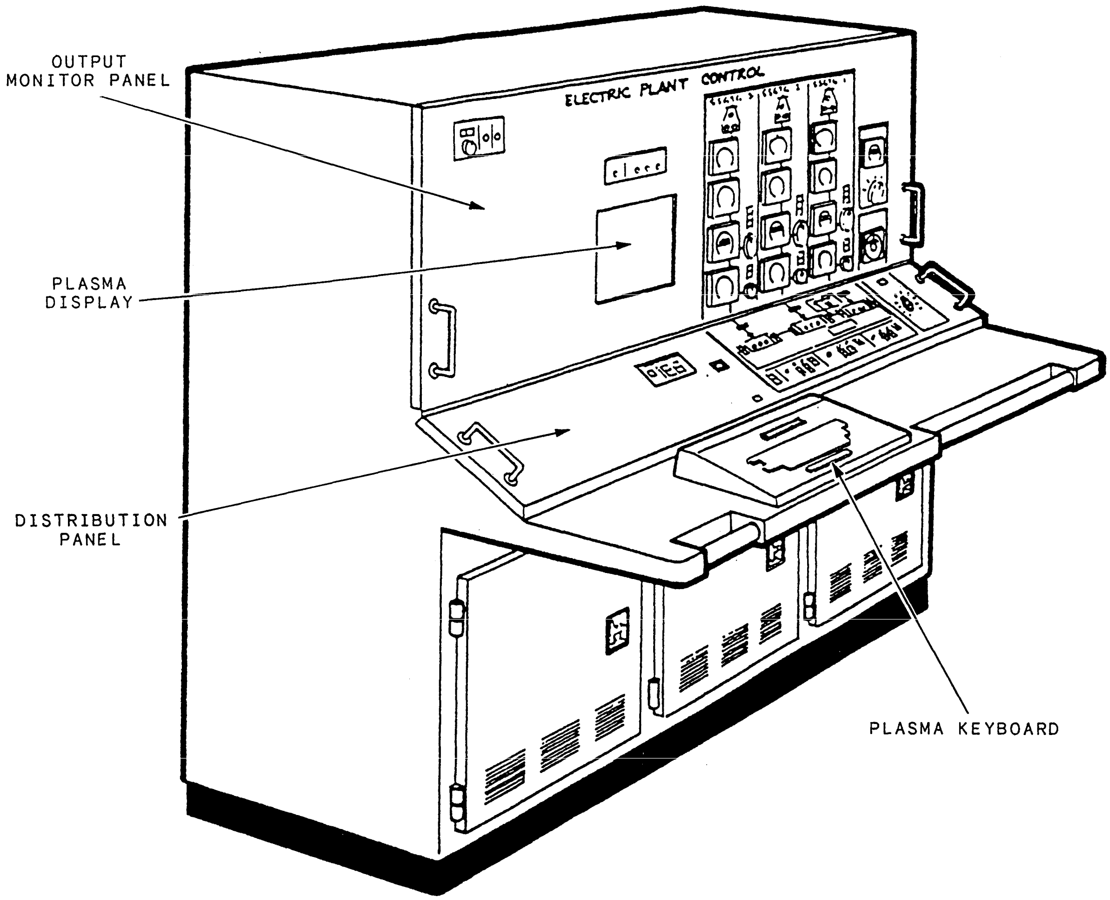


Figure 3-10.—EPCC panel locations.

4. Gas turbine control
5. Generator control
6. Load shedding system operation
7. Air-conditioning (A/C) plant operation
8. 400-Hz power system operation

Again, refer to the EOSS, the EOP, and technical manuals for a detailed description of the operation of these systems.

SSGTG Control and Monitoring

Most SSGTG control functions reside in its LOCOP and exciter control panel (EXCOP). The EPCC and switchboard control stations provide only discrete inputs to the LOCOP and EXCOP. The LOCOP provides monitoring for the gas turbine and generator, and control for the gas turbine. This includes speed control, which the LOCOP governor uses to regulate generator output frequency. The EXCOP controls generator output voltage by regulating generator field excitation. The EXCOP is enabled by the LOCOP when gas turbine speed exceeds 12,225 rpm.

A SSGTG has sensors to allow remote monitoring of its gas turbine, generator, and supporting systems. The EPCC receives sensory information in one of the following four ways:

1. Directly from controllers or contact switches
2. Directly from temperature or level monitoring devices
3. Discrete inputs from the SSGTG LOCOP
4. Analog inputs from the SSGTG LOCOP

Inputs to the EPCC are processed by its computer to determine if an alarm condition exists. Alarms are indicated on the PDU and by an EPCC control panel alarm indicator. Eight alarm conditions for each SSGTG are displayed by specific alarm indicators at the EPCC. All other alarms are indicated by the appropriate SSGTG summary alarm light above the PDU.

There is one SSGTG summary alarm LED for each SSGTG at the EPCC. The summary alarm lights for SSGTGs No. 1 and No. 2 operate when at least 1 of 22 alarm conditions occurs. The SSGTG No. 3 summary alarm light operates when at least 1 of 25 alarm conditions occur.

Any inputs to the EPCC not originating from the SSGTG LOCOP are classified as direct. These direct inputs can be either discrete or analog. Direct discrete inputs are typically received from auxiliary contacts in equipment controllers or contact switches associated with the SSGTG support system. Direct analog inputs are received from the resistance temperature elements (RTE) or tank level receivers associated with an SSGTG.

Electrical Distribution Monitoring and Control

An electrical switchboard has analog and discrete sensing devices for monitoring generator or bus output and circuit breaker status. Alarm, status, and control information flows between the switchboard and the EPCC. The EPCC receives this information in one of three ways:

1. Directly from potential transformers and current transformers

2. Directly from circuit breakers

3. As discrete inputs from switchboard relay logic circuits

The voltage and current signals from the current and potential transformers are sent to transducers in the EPCC to generate voltage, current, frequency, and power signals. These signals directly drive the power generation and distribution and system output LED meters. These signals are also sent to the computer for alarm generation and the PDU's demand display. The voltage displayed on the system output panel meter is selected by the position of the associated SOURCE selector switch.

The electrical distribution system can be operated manually from either the switchboard or the EPCC. Automatic sequencing takes place in the switchboards only when a fault condition exists. The EPCC does not automatically control any circuit breakers as a part of the standby generator start or any other function. Switchboard relay logic and LOCOP sequencer "Generator Breaker Trip Command" are the only automatic breaker controls.

Shore power breaker control from the EPCC is limited to sending a trip command to each breaker simultaneously when the ALL CB OPEN pushbutton is depressed. All shore power close control and phase monitoring devices are locally operated from switchboard No. 2 in MER No. 2. When the shore power breakers are closed, circuits in each switchboard will automatically command each SSGTG governor to DROOP to prepare for a shift from ship's power to shore power.

Circuit Breaker Operation

The EPCC provides centralized control and monitoring of 3 generator circuit breakers, 6 bus tie breakers, and 12 shore power breakers. The push-button indicators for these circuit breakers are located on the EPCC mimic panel. Control of circuit breakers from the EPCC is enabled only when the LOCAL CONTROL alarm light for a switchboard is extinguished.

EPCC operation of circuit breakers is accomplished through the same circuits used by the switchboard controls. Depressing an EPCC push-button indicator energizes a 28-volt dc close or trip relay at the associated switchboard. The 10-position synchronization CIRCUIT BREAKERS select switch and SYNC MONITOR BYPASS push button enable operation of the close circuit. When a relay is energized, a control circuit in the breaker assembly energizes a close or open trip coil to execute the desired status change.

Gas Turbine Control

The gas turbine controls available at the EPCC consist of gas turbine start air selection, governor mode selection, and manual bleed air valve control. Also available at the EPCC are gas turbine start and stop control and gas turbine frequency control. These operator interfaces provide discrete inputs to the LOCOP, which operates all SSGTG support systems and gas turbine control elements.

The availability of an SSGTG start from the EPCC is a function of the LOCOP 301 sequencer "ready to start" discrete output, LOCOP LOCAL/REMOTE switch, and switchboard voltage regulator mode switch. When the LOCOP is in REMOTE, the switchboard and EPCC can start the SSGTG. When the switchboard GTG START TRANSFER switch is in LOCAL, both the EPCC and the switchboard can start the SSGTG. When the switchboard GTG START TRANSFER switch is in REMOTE, only the EPCC can start the SSGTG.

The manual SSGTG start controls at the EPCC are the ON, HIGH PRESS, and BLEED pushbuttons. When ON is depressed, it is combined with the HIGH PRESS or BLEED indication signal in the EPCC input/output multiplexer hardware. The start air push buttons provide only a hardware logic signal within the EPCC and do not cause the start air piping valves to realign. Depending upon which start air indicator is illuminated, the EPCC will send a high-pressure start or bleed air start signal to the LOCOP.

An SSGTG stop is always available from its LOCOP, its associated switchboard, and the EPCC. The EPCC OFF push-button switch sends a signal to the LOCOP, which initiates a normal SSGTG stop and opens the associated generator circuit breaker. An SSGTG will also automatically stop if certain abnormal conditions occur (slow start, module fire, and so forth).

The output frequency of each SSGTG is controlled by an electronic governor in the LOCOP. The electronic governor regulates frequency by adjusting fuel flow to the gas turbine. When the governor control is at the EPCC, frequency adjustments can only be made from the governor mode RAISE/LOWER switch at the EPCC. RAISE increases fuel flow to the gas turbine, while LOWER reduces the fuel flow to the engine. There are two modes of governor operation: isochronous (ISO) and DROOP. The ISO mode is a constant frequency mode where fuel flow is regulated to maintain a constant generator output frequency. The DROOP mode is a constant fuel flow mode where increasing or decreasing the electrical load will cause frequency to decrease or increase, respectively. The mode is selected by depressing either the ISO or DROOP push button at the EPCC. When on shore power, DROOP is automatically selected by the switchboard.

Generator Control

Generator field excitation is controlled by one of two automatic voltage regulators in the EXCOP. Generator output voltage can be controlled manually or automatically. One manual mode and two automatic modes are available at the switchboard and at the EPCC. In the MANUAL mode, excitation current from the voltage regulator is set by a motor-driven manual voltage adjust circuit in the EXCOP. The two automatic modes are differential (DIFF) and DROOP. In these modes, the voltage regulator sets the generator output voltage to a level determined by the setting of a motor-operated potentiometer in the EXCOP. The DIFF mode is used during parallel operations to allow the on-line SSGTGs to share the reactive load equally at a selected output voltage. The DROOP mode is used for operating generators on an isolated bus. It is basically the DIFF mode without cross-current compensation.

Load Shedding System Operation

A load shedding operation can be started manually or automatically. Manual load shedding is started by operating the appropriate INIT push-button indicator at the EPCC or the spring-loaded LOAD SHED switch at the switchboard. Automatic load shedding is started when an overpower relay in a switchboard or an overcurrent relay on a shore power breaker is energized.

When one overpower relay is energized, its contacts operate tripping relays in each switchboard. The tripping relays complete power circuits to the trip coils on selected circuit breakers. When a shore power overcurrent relay is energized, load shed stage 1 and stage 2 relays in switchboard No. 2 are also energized. These relays complete power circuits in the switchboards to trip circuit breakers in the load shed system. All circuit breakers opened during a load shed operation must be closed locally. An exception is the air-conditioning plant circuit breakers that can be closed remotely from the EPCC. The tripped circuit breakers cannot be closed until any overpower or overcurrent condition clears.

Air-Conditioning Plant Operation

The A/C plant normal and alternate supply circuit breakers can be closed from the EPCC. All four A/C plants have a remote restart capability to bring a plant that was operating before a power interruption back on line. Each A/C plant can be reconnected to the main bus and restarted from the EPCC after a stage 2 load shed or an unexpected power loss.

After a stage 2 load shed, all the primary and alternate sources of power to each A/C plant will have been tripped. Depressing the POWER RESTORE push button at the EPCC closes the primary and alternate A/C plant circuit breakers. All eight breakers will close, regardless of switchboard LOCAL CONTROL alarm status, to energize each A/C plant controller.

400-Hz Power System Operation

The 400-Hz power system consists of two 60/400-Hz static converters that feed separate 400-Hz switchboards. The EPCC on the DDG-51 class ships neither controls nor monitors any part of the 400-Hz power system. Remote operation of the 400-Hz power system is accomplished in combat systems maintenance central. The only 400-Hz monitoring done by the MCS is in the interior communication switchboards.

EOOW/LU

The EOOW/LU provides a central location for the engineering officer of the watch (EOOW) to monitor the status of the DDG-51 class machinery plants. The EOOW/LU, shown in figure 3-11, provides a centralized station for accumulating, processing, and displaying the MCS status. Additional functions of the console are to provide the data for display on the console displays and on the PDUs on the bridge and in the CIC. The console also provides the means of loading the bubble memories for use by the other MCS consoles. This console is also used to change selected alarm parameters in the software tables of the AN/UYK-44 computer memories in the other consoles, to set the date and time, and to update the shaft revolutions count for use by other programs. The principal operating units finished with the console are the following:

1. Two PDUs and one keyboard
2. A bubble memory tape drive unit
3. A bell log printer
4. An AN/USH-26(V) signal data recorder-reproducer set
5. An AN/UYK-44(V) computer

Let's take a brief look at each of these units,

Plasma Display Units

The EOOW/LU panel has two PDUs with a single keyboard. The panel CONTROLLED DISPLAY switch connects the keyboard to the left or right unit. The keyboard CONTROLLABLE PLASMA/WORK-STATION SELECT key swaps the PDU assignments of "controllable" and "work station." This arrangement separates the housekeeping and operational functions. It also eases the PDU casualty operations for the EOOW. The controlled PDU is the automatic alarm and status, and summary group and demand display unit. Manual entry, log tape read, alarm acknowledgement, bubble memory loading, and edit operations are all workstation PDU capabilities.

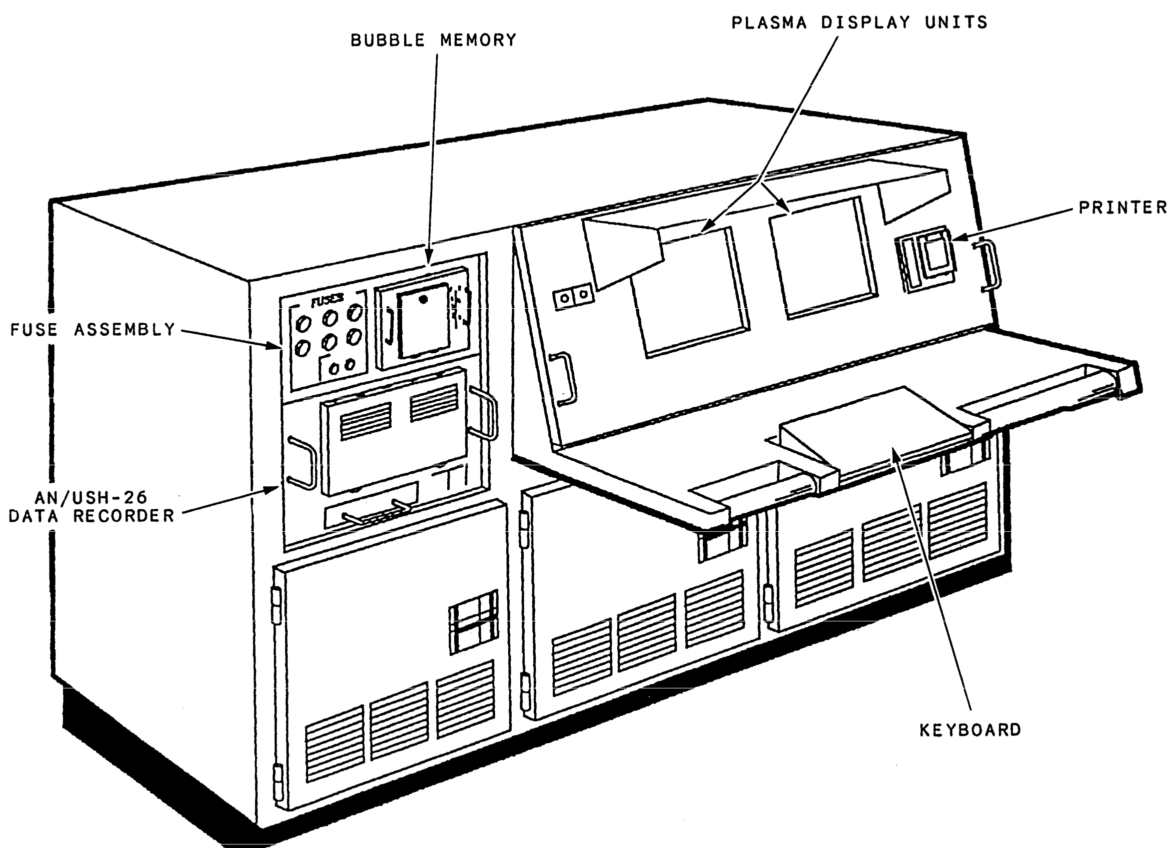


Figure 3-11.—Overall view of the EOOW/LU.

Manual entry is a keyboard message input system allowing up to 32 characters. The message is released to all PDUs in nearly simultaneous fashion. Log tape reading causes data from a tape cartridge to appear on the PDU. This is useful for reviewing events that occurred previously. Both single-entry and tabular modes are available. The single-entry mode displays the latest entry and allows scrolling to view older data. Tabular mode displays, up to 25 demand display selections, are produced for six dates at a particular time. The operator views an individual 25-entry set as a log page and progresses from page-to-page by using the keyboard. Editing allows the operator to adjust the current date and time information, alarm parameters, and shaft revolution counter reset data.

Bubble Memory Unit

When the EOOW/LU is first energized, the console's bubble memory cassettes must be installed in the drive unit. The computer's start-up program will cause the console's operating program software on the cassettes to be loaded into the computer's memory. The loading operation will be repeated anytime the computer is rebooted if the cassettes are installed.

Each bubble memory for the MCS has unique console software programming. A new AN/USH-26 master tape cartridge is provide whenever software changes are required. The new cartridge is inserted in tape drive 0. Bubble memory cassettes are loaded into the EOOW/LU bubble memory drive unit. The EOOW/LU console transcribes the new master tape program to the cassettes. After the cassettes are installed in their MCS console and the console's initialization and bootstrap procedure is run, the new programs are set in motion.

Bell Log Printer

The bell log printer is installed in the EOOW/LU console front panel. It is a thermal style printer. The printing head elements are heated and pressed against the heat-sensitive paper. The EOOW/LU computer program issues printer control and data print commands.

Signal Data Recorder-Reproducer Set

The AN/USH-26(V) signal data recorder-reproducer set is panel mounted. It is a cartridge tape drive unit configured for four tape drives. The tape drives are numbered tape drive 0 through 3; however, only two drives are used because no hardware is installed in drives 2 and 3. Drive 0 is a read only drive and drive 1 is a write only drive. There is a magnetic tape driver in the computer program. The driver interfaces with the set to provide data writing and data program readings. The driver also rewinds the tape and reads the set's status register.

A tape read or write operation starts when the EOOW/LU computer sends a 16-bit command word to the AN/USH-26(V). The tape unit performs the action and follows up with feedback status. The feedback is a status word reporting on the command word's operational success within the tape unit. Feedback status after each command operation is issued. When the status word is error free, the system is assured that satisfactory command completion has resulted. Added operations are entered if a status error exists and may result in a local tape error alarm.

EOOW/LU Computer

The AN/UYK-44(V), embedded in the EOOW/LU, controls and monitors the MCS by using the DMS. The AN/UYK-44(V) is a general-purpose, self-contained computer. The acronym AN/UYK-44(V) is defined as follows:

AN - Army/Navy

U - General utility

Y - Data processing

K - Computing

44 - 44th machine designated as AN/UYK

V - Various component groupings available

The computer has a set of hardware modules contained in an air-cooled card cage. It also has a cooling fan, control and maintenance panel, and power supplies. The basic modules are standard electronic modules (SEMs), which are built to military standards (MILSTDs). The control and maintenance panel is located on each console for convenient start-up and maintenance purposes.

The computer is the principal unit in the interchange of information for the EOOW/LU. It accomplishes these tasks with the DMS. Each MCS console has an AN/UYK-44(V) computer that may monitor the propulsion plant, electric plant, auxiliary machinery, and firemain and hazard detection systems. However, control and alarm input capability varies within the program functions assigned to each console computer. The computer enters a bootup process at power turn-on. When required, the computer can also be rebooted from the control panel. The operating program is loaded, during the boot process, from bubble memory cassettes installed in a tape drive unit within the console. The program is unique to each console housing a computer.

You have just read about CCS operations on the DDG-51 class ships. Now let's take a look at the FFG-7 class ships.

FFG-7 CLASS CCS OPERATIONS

On the FFG-7 class ships, the CCS is the main operating station. Most of the engineering plant machinery can be controlled and monitored from this station. The CCS is designed for remote monitoring and control of the engineering plant with a minimum of personnel. The major consoles of the engineering plant on this class of ship are the PCC, the EPCC, and the auxiliary control console (ACC). The PCC provides all controls and displays needed to operate the GTEs and their associated auxiliary and support systems. The EPCC provides control of the diesel generators and the electrical distribution equipment. The ACC controls and monitors 15 auxiliary subsystems. In the following paragraphs, we will briefly discuss the operation of these major consoles.

PCC

The PCC, located in the CCS, is the primary propulsion plant operating station on the FFG-7 class ships. The PCC provides all the controls and indications required to startup and shutdown the propulsion system and its related auxiliaries. It also provides the controls and indications to operate the PCS in either the programmed control mode or remote manual control mode. The PCC contains signal conditioning, logic, multiplexing circuits, and the processor for the PCS. Figure 3-12 shows that each section of the PCC is dedicated to particular types of control and monitoring.

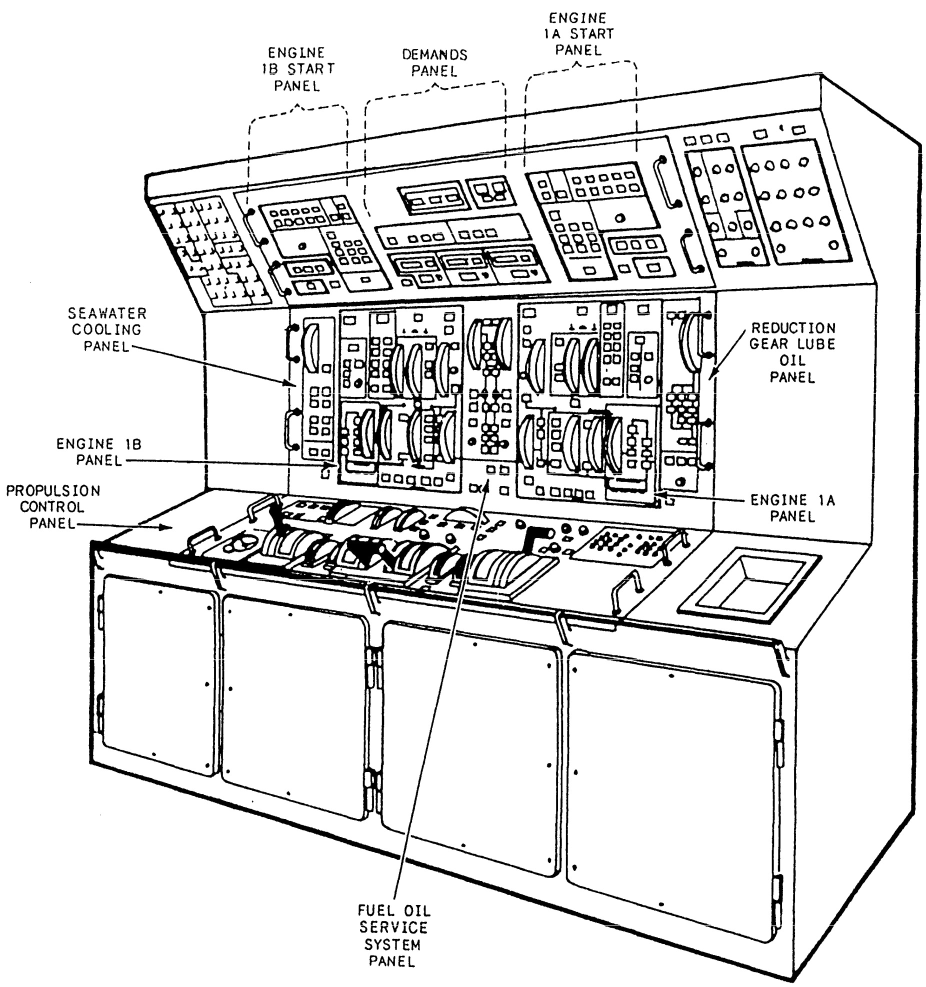


Figure 3-12.—Overall view of the PCC.

Some of the major controls and monitoring systems are discussed briefly in the following paragraphs.

Fuel Oil Service System

The fuel oil service system supplies fuel to the GTEs. The control and monitoring function available at the PCC can be divided into two major categories: fuel oil service and gas turbine module fuel oil. Together they function to deliver fuel oil at the proper pressure and temperature to the individual propulsion GTEs.

FUEL OIL SERVICES.– The following fuel oil service control and monitoring functions are available at the PCC:

1. Fuel oil service tank level monitoring
2. Fuel oil service tank suction and return valves control and monitoring
3. Service pump suction valve monitoring
4. Service pump control and monitoring
5. Service pump discharge valve monitoring
6. Fuel oil heater discharge temperature monitoring
7. Fuel oil prefilter strainer differential pressure monitoring
8. Fuel oil filter/separator differential pressure monitoring

PCC control of the fuel oil service system consists of remote control of the suction and return valves and automatic or remote manual control of the fuel oil service pumps.

The suction and return motor-operated valves are electrically connected so when the tank suction valve is opened, the return valve also opens. An OPEN/CLOSE alternate-action push button controls the valves from the PCC. The split-legend indicator provides the OPEN or CLOSE status of the valves.

The fuel oil service pump operation can be controlled at the PCC in either the auto speed advance or manual mode. The operator selects low speed, high speed, or stop by depressing the corresponding switch in the manual mode. The pump will advance from low speed to high speed if the pressure is below 40 psig and in the auto advance mode. The pump must be manually reset to low speed.

The following gas turbine fuel oil control and monitoring functions are available at the PCC:

1. Emergency fuel supply valve monitoring
2. Supply cutoff valve control and monitoring
3. Fuel supply pressure monitoring

The fuel pressure entering the GTE is monitored on an edgewise meter located on the PCC. The supply cutoff valve control at the PCC is provided by an alternate-action switch that is inoperative when local lockout is in effect. The fuel oil supply cutoff valve is a normally-closed, energized open valve that fails to the closed position upon loss of power. A split-legend indicator provides the status of the fuel supply cutoff valve.

The gas turbine emergency supply valve is a normally-open, energized closed valve that fails to the open position upon loss of electrical power. A split-legend indicator provides the status of the emergency fuel supply valve.

Lube Oil System

The reduction gear lubricating oil service system consists of two main parallel branches, each containing a pump and a relief valve. An air motor drives a coastdown pump that provides lube oil automatically upon loss of electrical power to both lube oil pumps.

The right most panel on the PCC center section is the auxiliary panel that provides the control and monitoring for the MRG lube oil system. The normal pump assignment signal to the indicator on the PCC comes from the position of the local transfer switch at the lube oil service pump control station. The manual operation requires the operator to start, stop or change speeds of the normal and standby pumps. The auto speed advance mode increases the speed of the normal pump, starts the standby pump, and increases speed of the standby pump to maintain lube oil pressure. Lube oil pressure is monitored at the most remote bearing for the auto speed advance mode. The auto speed advance mode has no control features to reduce the speed or stop either pump. Reducing speed or stopping either pump is a manual operation, regardless of the position of the mode switch.

The PCC propulsion control panel provides a mimic layout of the MRG with 29 indicators representing the 28 gearbox bearings and the one line shaft bearing. All the bearing temperature alarms are set at 20 degrees above maximum frill power builder trial data for the individual ship.

Air System

There are three main air systems associated with the start air for the GTEs: (1) the bleed air system, (2) the high-pressure air system, and (3) the emergency start air system from the start air compressors (SAC). The SACS are driven by the diesel generators.

The bleed air system provides air for the starter, masker, prairie, and anti-icing air systems. The bleed air system can be supplied by either of the running GTEs. An electric motor-operated bleed air valve is located in each bleed air line inside the module enclosure. This valve is opened and closed with the BLEED AIR VALVE OPEN/CLOSE push-button indicating switch on the PCC. The bleed air lines direct the bleed air to both the anti-icing system associated with the respective gas turbine engine and the check valve leading to the bleed air system header.

Each gas generator provides the bleed air for anti-icing for its associated intake system and intake plenum. The solenoid-operated bleed air shut-off valve and the motor-operated anti-icing valve have control alternate-action push-button switches and split-legend indicators on the PCC. The anti-icing system splits into two branch lines. One line is for downstream of the moisture separators with a manual valve that is normally open. The other line is for anti-icing upstream of the moisture separators with an isolation valve that is normally closed.

GTE Control System

There are three modes that can be selected at the PCC by a three-position switch: OFF LINE, MANUAL, and AUTOMATIC. The engine 1A and 1B start panels are mirror images of each other. They provide the same controls and indicators presented in the following four subsystems:

1. Pre-start status
2. Starting systems
3. Engine water-wash group
4. Sequencer mode switch

The off-line auxiliary mode is used for motoring and maintenance. The fuel and ignition cannot be enabled simultaneously in the off-line mode. Tests of either the ignition or fuel control system without starting the GTE is accomplished in the off-line mode. An engine water wash is also accomplished in this mode.

A manual mode of starting the GTE from the PCC is available provided the 18 permissive conditions required are satisfied. The READY TO START indicator illuminates when all 18 pre-start permissive conditions are met. The STARTER ON momentary-action push button will begin the manual starting sequence. The command to the start/stop sequencer located in the FSEE enables the starter to turn the gas turbine. The start/stop sequencer provides the time sequence and engine parameters for information only. The IGNITION ON and FUEL ON push-button switches on the PCC must be manually operated to provide the commands.

The automatic (program) mode starts the associated GTE with automatic timed commands from the start/stop sequencer in the FSEE. The same permissive as in a manual start must be satisfied before the engine can be started. The auto sequence START push button initiates the auto start command to the start/stop sequencer. The start/stop sequencer that initiates the IGNITION ON and FUEL ON commands as acceptable parameters are detected by the FSEE.

Three different methods for securing a GTE are available at the PCC. These methods are normal stop, manual stop, and emergency stop. The engine also can be shut down automatically either during a start sequence or while running by detection of certain faults.

A normal stop can be initiated by the operator in either the programmed control mode or the manual control mode. The manual stop must be used if control was transferred from the local operating panel (LOP) to the PCC after starting the engine. A normal stop is initiated by depressing the NORMAL STOP alternate-action push-button switch. A normal stop can be aborted at any time before the automatic fuel shutdown valve closes by advancing the gas generator speed above idle.

A manual stop is initiated by the operator either in programmed control mode or in the remote manual control mode. Before a manual stop is initiated, the gas generator should be run at idle speed for 5 minutes to allow the engine parts to cool evenly. A manual stop uses the circuitry in the start/stop sequencer to stop the GTE. The manual stop command, provided by depressing the MANUAL STOP push-button switch, causes both automatic fuel shutdown valves to close.

An emergency stop can be initiated by the operator at any time, in any control mode, and without regard to which console has GTE control. The EMERGENCY STOP OVERRIDE switch at the LOP must not be enabled to accomplish an emergency stop at the PCC. The emergency stop command causes the circuitry in the LOP and FSEE to immediately de-energize the POWER TURBINE OVERSPEED TRIP switch. This action causes both automatic fuel shutdown valves to close and latch. This will shut down the GTE.

EOT Control System

The EOT control system on the FFG-7 class ship is a standard Navy installation. The EOT provides an electromechanical communication system between the bridge and the PCC. The EOT on the PCC is located on the lower or propulsion control panel and provides continuous position indication. The EOT also provides signals to the discrete multiplexer, which are inputs to the PCS bell logger program.

The EOT is used to relay standard orders from the bridge to the PCC. When the bridge orders a change of speed, one of the pointers in the EOT will point to the requested speed. The PCC operator acknowledges the order by moving the other pointer to match the bridge pointer. This is done by using the knob below the EOT.

Throttle and Pitch Control System

The throttle and pitch control system provides control of shaft speed and propeller pitch. The control system can be operated in three modes: local manual control, remote manual control, and programmed control.

The propulsion control system can be operated in the manual control mode from the PCC or the LOP. The programmed control mode is the primary mode of operation and is initiated from the PCC or SCC. The relationship between the pitch and throttle is automatically scheduled by the PCS in the programmed mode.

Now that you have read about the control functions available at the PCC, let's look at those available at the EPCC.

EPCC

The EPCC contains the controls and indicators that are used to remotely operate and monitor the ship's service power generation, distribution, and related support systems. As shown in figure 3-13, each panel

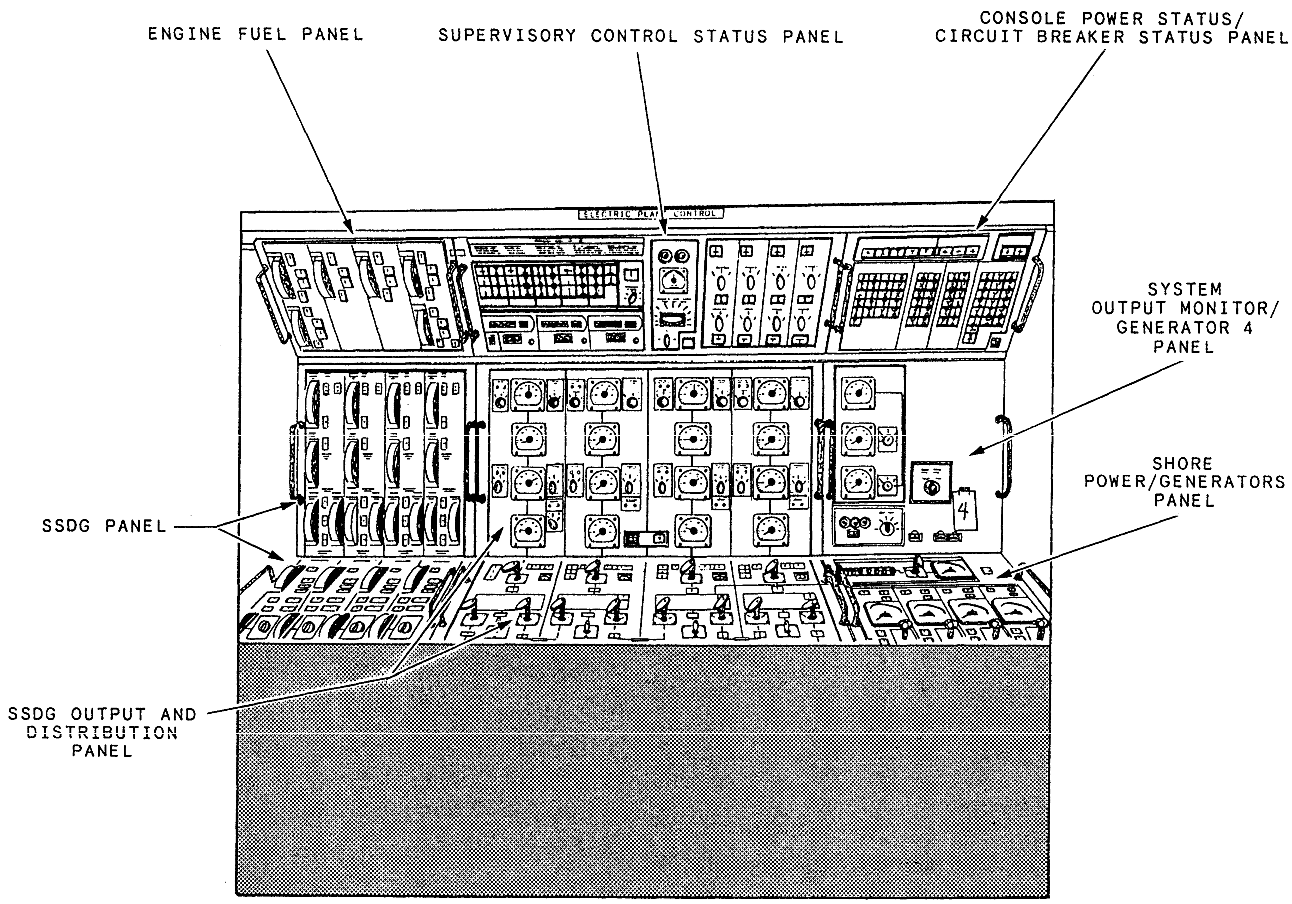


Figure 3-13.—EPCC panel locations.

incorporates a variety of control and monitoring devices. These devices include: alarm and status indicators, generator status, mimic and distribution control, and plant system control.

In this section, we will briefly discuss the following control systems that are operated from the EPCC:

1. Diesel control and monitoring
2. Generator monitoring and control
3. Switchboard and distribution monitoring and control
4. Shore power monitoring and control
5. Engine fuel oil service system
6. Auxiliary fuel oil service system
7. Jacket water system
8. Supervisory control system (SCS)

We will provide only a brief discussion of these systems. Again, refer to the EOSS, the EOP, and appropriate technical manuals for a more detailed description of the operation of these systems.

Diesel Control and Monitoring

Each SSDG has sensors to provide remote monitoring of the diesel engine and generator. The sensor information can be viewed either on meters or the DDI. Sensor signals are of two types: analog and discrete. Analog signals represent parameters, such as fuel levels, temperature, pressure, or rpm. Discrete signals indicate the occurrence of an event, such as a breaker open, breaker closed, motor running, or motor not running. Commands are control outputs from the EPCC, and some action is expected in response to this signal.

The EPCC monitors several conditions of the SSDG and displays them in several ways. The EPCC monitors the diesel for the following conditions:

- Engine fuel tank level, fuel pressure, and return temperature
- SSDG manifold pressure
- Diesel fuel temperature
- Turbocharger air pressure
- SSDG lube oil discharge pressure, temperature, and sump level
- Engine speed and exhaust temperature

Alarms on the EPCC are of two types: hardwired and processor generated. Hardwired alarms come directly to the alarm display unit, causing an alarm to sound and an indicator lamp to illuminate. The operator can cancel the sound by depressing the ALARM ACKNOWLEDGE push button. There are two levels of audible alarms at EPCC. The first level is a horn that signifies a problem that requires immediate operator action to prevent damage or loss of power. The second level is a bell for a problem that needs correction as soon as practical.

The EPCC controls the diesel for both start-up and shutdown. The SSDG can be shut down under normal conditions or in an emergency. Under emergency conditions, some diesel functions must be reset. Once the generator set is running, the EPCC controls what type of voltage regulation will be used and how the governor will control SSDG speed and load. The processor in the EPCC can control the operation of the SSDG when the AUTO mode is selected.

The EPCC operator can start the generator set if the LOCAL/REMOTE switch is ON and all safety conditions are met. Starting from the EPCC can be either automatic or manual. As engine speed builds up, a fuel oil pressure switch opens and de-energizes a pilot cracking relay. Once the engine is started and engine speed starts to pickup, the governor will maintain SSDG speed. Initially the speed is controlled by the mechanical governor until the limit setting is reached. Then as generator voltage builds up, the electrical governor takes over control. A 115-volt ac power supply is required for the automatic start sequence, although the start can be accomplished manually.

Under normal conditions, the engine is stopped, by the operator by pushing the engine STOP push button on the local panel or depressing the remote PRIME MOVER STOP push button on the EPCC. During this stop sequence, the governor actuator is disconnected from the governor control circuit. Dropping resistors apply a fixed voltage into the governor actuator, causing it to go to the shutdown mode. As the engine loses speed, the fuel pressure drops and opens a switch that deactivates the shutdown condition.

An emergency stop can be initiated by the operator at the EPCC by depressing the EMERGENCY STOP push button. This is the same sequence as the normal shutdown except the air intake system is closed off by activating the engine air box relay. After an emergency stop, the air intake solenoid must be manually reset. Until it is reset, an engine-mounted shutdown lockout switch will inhibit the engine from being started.

Generator Monitoring and Control

The generator section of each SSDG is monitored for control and synchronizing. Transducers pick up parameters that need to be monitored and send them up to the EPCC. The parameters are processed by the DDI and the SCS and by alarm circuits and gauges.

Current, voltage, frequency, and power readings are available from the EPCC by dialing in the appropriate address on the DDI or reading the parameters directly off meters on the EPCC. Stator temperature is monitored for each phase of the generator. This is the only meter on the EPCC that reads out in degrees centigrade rather than degrees Fahrenheit. The status of the voltage regulator and fields exciter is indicated on the EPCC by two green lights: one for manual mode and the other for automatic mode. Two more green lights on the EPCC monitor the state of the differential or droop selector.

The generator can be controlled through the governor system, the voltage regulator, and the synchronizer. The voltage regulator is used to vary the field excitation that, in turn, controls the speed of the generator.

The governor controls the generator set in two different modes: isochronous and droop. The isochronous mode is used to share the loading on the generators and yet keep a constant speed or frequency. The amount of fuel to the diesel determines the load each generator can carry. In the droop mode, the frequency will vary as the load is changed, but only within predefine limits. This predefine area of droop is O to 6 percent of the bus frequency. The frequency of a generator also can be controlled manually from the front panel of the EPCC. The increase/decrease knob will change the frequency higher or lower, when the operator needs to match a generator to a bus to parallel it.

The voltage regulator controls the generator output through the field excitation. The voltage can be manually controlled from the respective switchboards, except from switchboard No. 4. Switchboard No. 4 is in the same space as the EPCC and has the manual voltage control on the EPCC panel. The manual preset potentiometers give the field excitation circuit a reference from which to work. The second mode is the AUTOMATIC mode. The voltage regulator AUTO ADJUST potentiometer on the EPCC can raise or lower the voltage by controlling a motorized potentiometer on the generator set. The motorized potentiometer sets a limit for field excitation and voltage output. If the voltage goes up, feedback causes the field excitation to drop, bringing the voltage back into tolerance.

Switchboard and Distribution Monitoring and Control

Power from the generator is monitored, controlled, and distributed through a system of meters, electronics, and circuit breakers. Under automatic operation, the EPCC can perform all three functions through the processor software programs.

The circuit breaker status of each SSDG is monitored for the generator, bus tie, and load shed circuit breaker position. The EPCC will illuminate a status indicator if the circuit breaker at the switchboard is different from the switch position at the EPCC. Vital power circuit breakers, such as fire pump controls, are monitored at the EPCC on the vital power feeder circuit breaker status panel.

The main breakers for the generator set, load sheddings, and bus ties are monitored on the EPCC. Others, such as the radar room or seawater pump circuit breakers, are also monitored but not controlled from the EPCC. Other functions that are monitored from the EPCC are power supplies, uninterruptible power supplies (UPS), and the console heaters. At the EPCC, the total output for the ac generation system is monitored for frequency, voltage, and current. Individual bus ties can be monitored for current loads by selecting each bus tie with the rotary switch on the EPCC.

The generator can be taken off the line if REMOTE control is given to the EPCC and the generator switch is turned to the TRIP position. The switch will work in the CLOSE position only if the paralleling mode switch is in the BYPASS or PERMISSIVE position and the generator switch is at the BUS position. The PERMISSIVE mode permits manual closure of the breaker only when the automatic paralleling device (APD) senses the generator is in synchronization with the power bus. The BYPASS disables the APD so synchronization has to be accomplished manually. The generator breaker is closed manually by the operator.

The load shed circuit breaker is opened and tripped by the EPCC operator when the EPCC is in the REMOTE mode. This circuit breaker can be manually or automatically tripped. The sensors from the generator bus will trip all load shed circuit breakers when an overload condition is sensed. This action will remove the nonvital bus from the bus ring.

As mentioned earlier, the manual voltage control for the No. 4 switchboard is on the EPCC since the switchboard and the EPCC are both in the CCS. The No. 4 switchboard does not have a remote control mode;

therefore, there is no LOCAL/REMOTE indicator on the EPCC for this switchboard.

Shore Power Monitoring and Control

The EPCC operator can monitor the seven breakers connected to shore power and can use the TRIP lever to trip all seven breakers. current up to 3000 amperes from the shore power source can be monitored on a meter at the EPCC. Each of the seven breakers can handle 400 amperes. The status of each breaker is indicated by illumination of its own blue light. The EPCC controls the transfer of shore power to ship's power only. The transfer of ship's power to shore power can only be accomplished by the 3SA switchboard.

Engine Fuel Service System

The EPCC provides for remote monitoring of the SSDG's fuel service system. The EPCC indicates with alarms when the fuel tank level is beyond the high level of 90 percent of tank capacity or drops below the low level of 20 percent of capacity. Engine fuel discharge pressure and manifold pressure are monitored by the EPCC through the SCS. Engine fuel discharge pressure is displayed on edgewise meters on the EPCC front panel. To avoid transient alarms, the supervisory provides a 16-second delay on the level indicating alarms.

Auxiliary Fuel Service System

The EPCC controls the suction valves for each of the six auxiliary fuel tanks. The EPCC operator can control which tank is used to supply SSDG No. 4 or SSDG No. 1, since they have two tanks. The SSDG No. 2 and No. 3 share two day tanks; therefore, the EPCC operator can only open or close these tanks. The EPCC operator cannot transfer fuel to the day tanks. This transfer is done locally in auxiliary room No. 2.

Jacket Water System

The jacket water system provides cooling water to the jacket of the diesel engine and acts to cool the lubricating oil. Each engine is served by its own jacket water system. The water is circulated through each system by a centrifugal pump that is apart of the diesel engine.

Two resistance temperature detectors (RTDs) are provided in the jacket water outlet line from the diesel engine. One detector provides a signal to the EPCC to provide continuous display and to actuate a HIGH TEMPERATURE audible and visual alarm. The second detector supplies a signal to an indicator mounted on the diesel engine gauge board. A temperature switch is also located in the diesel engine jacket water outlet piping. The switch energizes a high-temperature alarm on the local switchboard.

A pressure transducer, located at the discharge of the jacket water pump, provides a signal to the EPCC for demand display readout. The expansion tanks have both a liquid level gauge and a low level alarm. The low level alarm energizes an audible and visual alarm at the EPCC when the level drops to 7 1/2 gallons.

The EPCC controls the flow of seawater to the jacket water system by opening or shutting the motor-operated valve leading from the seawater chest. A dual illuminated indicator on the EPCC monitors the OPEN or SHUT condition of the seawater valve. The discharge of seawater, after it has picked up heat from the jacket cooler, is routed to the overboard valve. The EPCC has controls and monitoring associated with this discharge.

SCS

This program module SCS monitors the electric plant for failures or degradation of performance. If either condition occurs, the SCS either initiates corrective action or alerts the operator to take corrective action. The supervisory control is executed during the allotted 50-millisecond interval of every 200-millisecond program cycle when the supervisory control mode switch is in the AUTO position. When executed, this function reads the SHORE POWER indicator, the supervisory control mode, and each SSDG control mode. If the electric plant is on shore power or the supervisory control mode is off or all SSDGs are in the local control mode, control is returned to the executive control program. Otherwise, the status of each SSDG is established and a bit pattern is generated to identify the SSDG status and those SSDGs operating in parallel. Each SSDG status is recorded in a 16-bit computer word and updated each program cycle. Refer to the appropriate technical manual for a detailed discussion on the SCS.

ACC

The ACC, shown in figure 3-14, controls and monitors 15 auxiliary subsystems and interfaces with the software program of the EPCC. This interface provides for demand display readout, alarm monitoring, and logging data on the data logger. Controls and

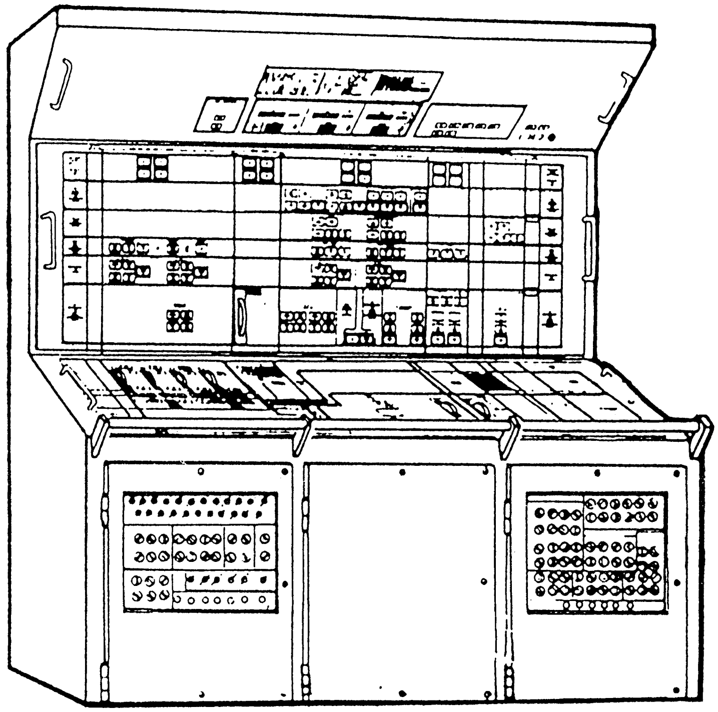


Figure 3-14.—Auxiliary control console.

indicators are arranged on the ACC in a logical manner. This arrangement aids the operator in relating the panel control and monitoring to the location of the auxiliary systems in the ship.

The following 15 specific auxiliary subsystems interface with the ACC:

1. Machinery space ventilation
2. Fuel fall, transfer, and purification
3. Chilled water circulation
4. Waste-heat water circulation
5. Compressed air plants
6. Main engine starting air
7. Potable water
8. Fill valves
9. Distilling plants
10. Saltwater service system
11. Drainage system
12. Masker, prairie, and bleed air
13. Sewage disposal system
14. Refrigeration system
15. IC/SM - Summary alarm

For a detailed description of these systems and the associated controls and indicators, refer to *GSE3/GSM3,* Volume 2, NAVEDTRA 10564.

Parameters considered critical are continuously displayed on the console for operator monitoring. Those parameters not considered critical are available to the operator on demand by entering a specific code for the parameter on a thumbwheel switch assembly. This assembly is located next to the alphanumeric demand display. In addition to the auxiliary system parameters, all electrical system and propulsion system demand display parameters can be selected at the ACC.

The ACC interfaces with the data processor in the EPCC to exchange information. The following are three of the primary functions performed by this interface.

1. Processing of the discrete and analog data to provide a backup for alarm detection

2. Processing of data for output to the demand display at the ACC

3. Data logging through communications with the data processor in the PCC

Each of these functions is under the control of the electric plant and auxiliary control system software program. This program is stored in the EPCC data processor memory. Data is transferred from the EPCC to the ACC over digital data lines that connect the digital transmitter circuits with the digital receiver circuits in the ACC. The EPCC output data consist of address information for both input and output data transfers and digital data that drive the DDIs on the ACC.

ENGINEERING CASUALTY CONTROL

The mission of engineering casualty control is the maintenance of engineering services in a state of maximum reliability under all conditions of operation. In regard to the CCS, casualty control includes both machinery and electrical casualty control. Efficient CCS casualty control is the result of effective personnel organization and training. The ability to detect and identify signs of initial trouble in equipment is developed through familiarization with plant operation.

The details on specific casualties that can occur in the CCS of a gas turbine-powered ship are beyond the scope of this TRAMAN. Detailed information on casualty control can be obtained from the engineering operational casualty control (EOCC) portion of the EOSS. The EOCC contains important information ship's personnel can use to recognize casualty symptoms and determine their probable causes and effects. The EOCC also contains information on actions CCS personnel can take to prevent casualties. It specifies procedures for controlling single- and multiple-source casualties. The EOCC manuals are available at each watch station in CCS for self-indoctrination. The manuals contain documentation to assist engineering personnel in developing and maintaining maximum proficiency in controlling casualties to the ship's propulsion plant.

In the CCS, the speed with which corrective actions can be applied to an engineering casualty is frequently of paramount importance. This is particularly true when casualties can affect the propulsion power, steering, or electrical power generation and distribution. If casualties associated with these functions are allowed to become cumulative, they may lead to serious damage to the engineering plant. When possible risk of permanent damage exists, the commanding officer has the responsibility of deciding whether to continue operation of the affected equipment under casualy conditions.

Although speed in controlling a casualty is essential, actions should never be undertaken unless engineering department personnel have accurate information concerning the affected equipment and associated system. Without accurate information, the casualty could be mishandled, in turn causing irreparable damage to the equipment and possible loss of the ship. Speed in the handling of casualties can be achieved only when engineering personnel have acquired knowledge of the equipment and associated systems and have been thoroughly and repeatedly trained in the routines required to handle specific predictable casualties.

SUMMARY

This chapter has provided you with a variety of information you will need to become an efficient gas turbine specialist. In this chapter, we discussed the various engineering control system operations found on the gas turbine-powered ships. We described the methods used by these control systems to exchange and process the information necessary to control a gas turbine engineering plant. We also described some testing and calibration procedures for these systems and some basic operational procedures performed at the consoles located in the CCS of DD-963, DDG-993, CG-47, DDG-51, and FFG-7 class ships.

As you advance in the GS rating, your responsibilities for the engineering control system and its operation will increase. The information provided in this chapter should help you further understand the electrical and electronic interfaces provided by the engineering control systems. We also referred you to other publications that will give you a more in-depth explanation of the material covered in this chapter. You should study these additional publications to become a more proficient and reliable technician.

CHAPTER 4

ENGINEERING SUPPORT SYSTEMS MAINTENANCE

As a GSE, you will be tasked primarily with the operation and maintenance of gas turbine engines. You also will be tasked with the maintenance and repair of some of the engineering support systems. In this chapter we will describe some of the maintenance you may perform on various engineering support systems. These systems include the ship's service fuel system, the bleed air and start air system, the gas turbine fuel system, the main lube oil system, and the waste heat recovery system.

The engineering support systems are an essential part of the main propulsion plant. In fact, the plant could not operate efficiently without these systems. As a GSE, you will be assigned to perform PMS, repair, and maintenance on the electrical and electronic parts of the support systems. On DD-, CG-, and DDG-class ships, your responsibilities will also include the waste heat boiler (WHB) control panel.

Since the engineering support systems will vary among ship classes, we will describe these systems in general terms. The examples you will see in this chapter are from various ship classes. Always refer to your ship's engineering operating procedures (EOP) and engineering operational sequencing system (EOSS) for detailed information on these systems.

SHIP'S SERVICE FUEL SYSTEM

The ship's service fuel system is designed to condition and supply clean fuel to the main engines and the generators. The fuel is delivered at the proper temperature and pressure for efficient operation of the engineering plant. A ship's fuel service system usually consists of service tanks, strainers, booster pumps, filter/coalescers, prefilters, and associated piping. As a GSE, you will mainly be concerned with the maintenance of the booster pump motors, the booster pump controllers, and the filter/coalescers.

OPERATION

The ship's fuel service system on board gas turbine ships is normally operated and monitored by the engineering control and surveillance system (ECSS), propulsion control system (PCS), or the machinery control system (MCS). On the DD-963, DDG-993, and CG-47 class ships, the fuel service system controls and indicators are located on the propulsion and auxiliary control console (PACC) and the propulsion local control console (PLCC). On the FFG-7 class ships, the fuel service system controls and indicators are located on the propulsion control console (PCC). On the DDG-51 class ships, these controls and indicators are located on the PACC and the shaft control unit (SCU).

The pumps and valves for the fuel service system are controlled from the control consoles. The control consoles provide for stopping and starting of the fuel pumps and opening and closing of the tank valves. From the control consoles, you can place the pumps in slow (low), fast (high), or stop. The operation of the fuel pumps also can be placed in manual or automatic control from the consoles.

COMPONENTS

As mentioned earlier, the ship's service fuel system consists of several parts. In the following sections, we will discuss only the parts that are of primary concern to the GSE. This discussion will include the maintenance and repair of the fuel booster pump motors, fuel booster pump controllers, motor-operated valves, and fuel filter/coalescers. Refer to chapter 5 of this TRAMAN for a detailed discussion of the maintenance and troubleshooting procedures associated with motors and controllers.

Fuel Booster Pump Motors

The motors for the fuel service system are 3-phase, 60-hertz (Hz), 440-volt ac, fan-cooled motors. These two-speed motors are designed for constant-speed and continuous-duty operation. On the DDG-51 and FFG-7 class ships, the fuel pump motors drive the fuel pump through a reduction gear unit. If you are assigned to a DDG-51 or FFG-7 class ship, you will need to check the oil level in the reduction gear unit periodically.

MAINTENANCE.– You will maintain the ship's service fuel booster pump motors the same as you would any other motor. This includes keeping the insulation clean and dry, the electrical connections tight, and the motor in good mechanical condition. Usually, you will accomplish maintenance through PMS. Be sure to keep the interior and exterior of the motor clean and free of dirt. Remember, dirt and debris are the major causes of motor failure.

TROUBLESHOOTING.— As a GSE, you must troubleshoot the fuel booster pump motors whenever malfunctions occur. A fault in the motor is usually caused by short circuits, open circuits, or grounds. You must locate and repair these faults to restore the fuel system to its maximum operating condition. Refer to chapter 5 for additional information on troubleshooting the fuel booster pump motors.

Fuel Booster Pump Controllers

On gas turbine-powered ships, the controllers for the fuel service system are located in the engine rooms. The controllers operate from a 3-phase, 60-Hz, 440-volt ac source and provide local control of the fuel booster pumps. The pumps can be stopped and started from these controllers. The controllers are usually equipped with reset push buttons to restore motor overloads.

MAINTENANCE.– The maintenance for the ship's service fuel booster pump controllers is the same as for any other type of electrical controller. On most gas turbine-powered ships, you, the GSE, will be responsible for the maintenance of these controllers. On some ships, however, this task may be the responsibility of the electrician's mates (EMs).

In any case, proper preventive maintenance will reduce the chance of failure in this equipment. Routine PMS includes keeping the insulation resistance of the control and power circuits high and making sure the electrical connections are tight. Any problems you find in the controllers must be corrected immediately. Make sure you follow the proper electrical safety precautions during the maintenance of these controllers.

TROUBLESHOOTING.— During PMS on the fuel booster pump controllers, you will sometimes find it necessary to troubleshoot these devices. A fault in the controller is usually caused by short circuits, open circuits, or grounds. Since the controller is an electromechanical device, it will sometimes give in to mechanical failure. You, the GSE, also must locate and repair these types of faults to the controller. Refer to chapter 5 for additional information on troubleshooting fuel booster pump controllers.

Motor-Operated Valves

Motor-operated valves allow the console operator remote control of certain valves in the ship's service fuel system. Motor operators are found on the fuel service tank suction and recirculating valves and fuel booster pump suction valves.

Study the motor-operated valve shown in figure 4-1. The motor-operated valve assembly consists of an electric motor driving a gear drive system that is coupled to a valve. The motor housing contains a torque limiter that protects the valve and the motor from overload damage. Most types of motor-operated valves will also include a handwheel that permits manual operation if electrical malfunction occurs. Motor-operated valves on gas turbine-powered ships are remotely controlled from the PCC, PACC, PLCC, and SCU, or locally at the valve controller.

MAINTENANCE.— The maintenance on motor-operated valves includes cleaning, inspecting, and testing. The controller of a motor-operated valve is nothing more than a simple reversing controller. The maintenance procedures used on motor-operated valves are the same as those you would use to maintain basic motors and controllers. On most gas turbine-powered

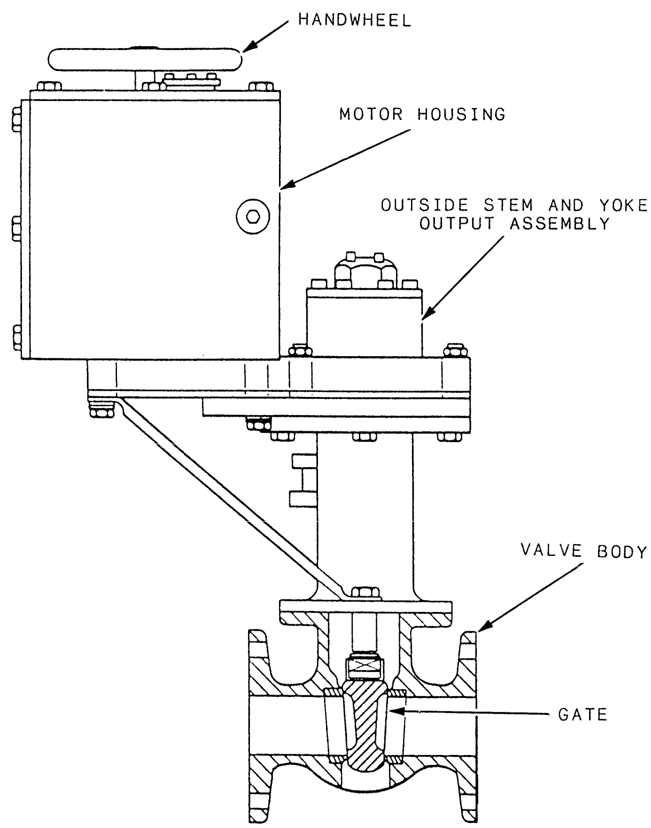


Figure 4-1.—Fuel service system motor-operated valve.

ships, the GSEs perform the maintenance on motor-operated valves. Depending on the class of ship, however, this task may be the responsibility of the GSEs or EMs.

TROUBLESHOOTING.— You can locate the faults in a motor-operated valve by using the same troubleshooting procedures we discussed for motors and controllers. These faults are usually caused by short circuits, open circuits, or grounds. Since a motor-operated valve is an electromechanical device, many problems can be traced to the interface between the controller and the gear drive system. Mechanical failures in motor-operated valves are not uncommon. The GSE is usually called to locate and repair faults in these components. Refer to chapter 5 for additional information on troubleshooting a motor-operated valve.

Fuel Filter/Coalescers

Fuel filter/coalescers are installed in the ship's service fuel system to filter out solid particle contamination and to coalesce and remove all suspended water. These units combine the processes of filtration of solids and separation of immiscible liquids in two successive stages. On the DD-963, DDG-993, and CG-47 class ships, fuel filter/coalescers have an electrical control box that controls the automatic shifting of the unit. On the DD-963 and DDG-993 class ships, the electrical control box is located behind the instrument panel and contains the electrical control circuit. (See fig. 4-2,

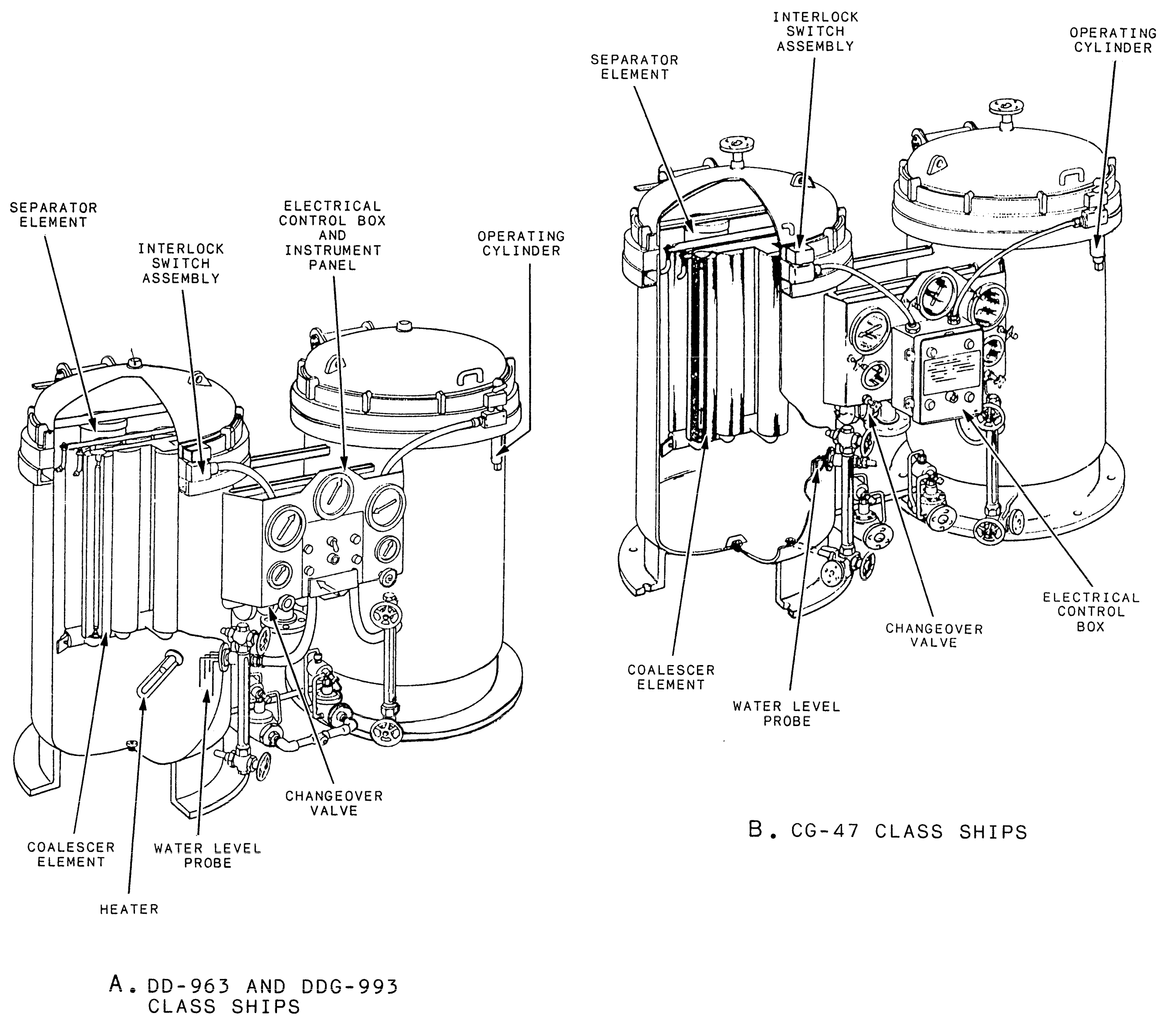


Figure 4-2.—Fuel oil filter/coalescers.

view A.) The four indicator lights, the heater switch, and the changeover switch are mounted through the back of the box and protrude through the instrument panel. On the CG-47 class ship, the electrical control box is located in front of the instrument panel. Notice that the electrical control box in figure 4-2, view B, does not have a heater switch.

MAINTENANCE.— The electrical control box for the filter/coalescers is nothing more than an electrical controller. You will maintain the electrical control box in the same manner as you would any electrical controller. Routine maintenance on the control box includes cleaning, inspecting, and testing. Proper preventive maintenance reduces the chance of failure of the filter/coalescer electrical control box. Routine PMS includes keeping the insulation resistance of the control circuits high and making sure the electrical connections are tight. Because of its location, there is the chance that fuel oil can enter the control box, causing short circuits and fires. When performing PMS, make sure you remove all fuel residue from inside the control box. Any problems found in the control box must be corrected immediately. Make sure you follow the proper electrical safety precautions whenever you perform maintenance on this unit.

TROUBLESHOOTING.— During PMS on the filter/coalescer electrical control box, you must troubleshoot the control box whenever malfunctions occur. A fault in the control box is usually caused by short circuits, open circuits, or grounds. The control box has a mechanical interface with the shifting mechanism. Sometimes the shifting mechanism and the microswitches become misaligned, causing false indications on the control consoles. You, the GSE, must also locate and repair all faults that occur to the control box. Refer to chapter 5 for additional information on troubleshooting the filter/coalescer electrical control box.

Fuel Service Heaters

The fuel service heaters on the DDG-51 class ships are of the electrical type. One fuel heater is installed in each fuel service system. All fuel service heaters are located downstream from the fuel pumps. Each heater operates on 440 volts ac, 60 Hz, 3 phase and is rated at 180 kilowatts (kW) and 236 amps. The fuel outlet temperature from the heater is regulated by a solid-state heater controller.

The fuel heaters are electrically interlocked with the fuel service pumps. The heaters will not operate until a fuel service pump is operating. The heater control circuitry may be energized, however, before a fuel service pump is started. This condition will be shown by a green CONTROL ON indicating light. (See fig. 4-3.) When the fuel service pump is started, the heater will automatically start operating. This will be shown by a green HEATER ON indicating light on the heater controller.

MAINTENANCE.— The fuel service system heater controller is maintained in the same way as any other controller. The difference in this controller is that it contains solid-state devices. The routine maintenance on the heater controller, however, is the same as it would be on any electrical controller. This routine maintenance includes cleaning, inspecting, and testing. Proper

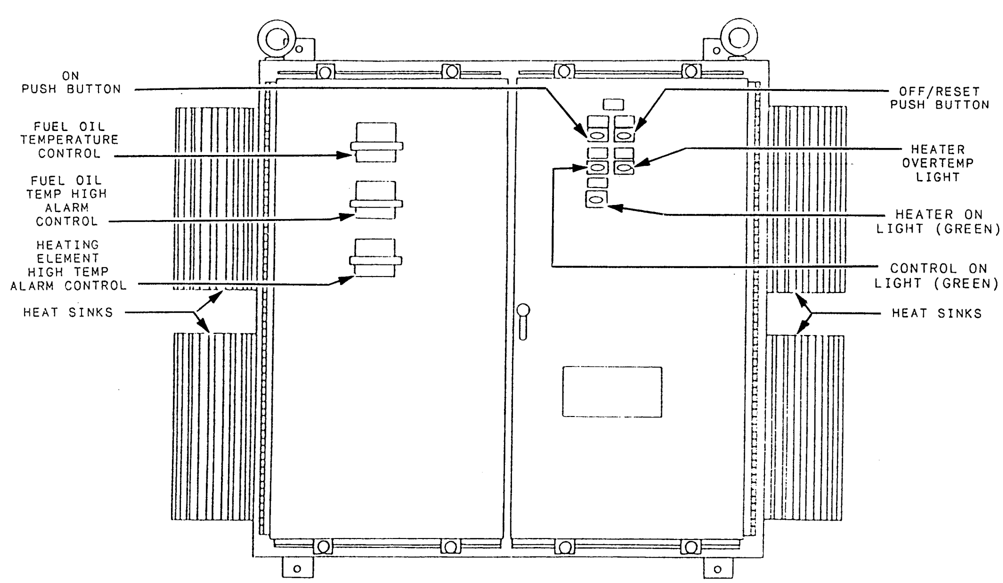


Figure 4-3.—Fuel service system heater controller.

preventive maintenance reduces the chance of failure of both the fuel heater and the controller. You must connect any malfunctions to the heater controller immediately to maintain the desired fuel quality to the GTEs. Make sure you follow the proper electrical safety precautions when performing maintenance on the fuel heater controller.

TROUBLESHOOTING.— If you are called upon to troubleshoot the heater controller, make sure you follow the procedures listed in the technical manual. You must have a thorough knowledge of solid-state devices to troubleshoot this unit effectively. Faults in the heater controller can be caused by short circuits, open components, or grounds. Since the controller is completely solid-state, there is a chance that the components can fail from excessive heat. The heater controller is equipped with heat sinks to help reduce the heat buildup inside the controller. Your job as a GSE will be to locate and repair all faults that occur to the fuel heater controller.

BLEED AIR SYSTEM

There are five systems (four on the FFG-7 class ships) that make up the ship's bleed air system. These systems include the following:

- Bleed air collection and distribution system
- Masker air system
- Gas turbine start/motor air system (not on the FFG-7 class ships)
- Prairie air system
- Gas turbine anti-icing system

In the following paragraphs, we will give you a brief description of each of these systems.

BLEED AIR COLLECTION AND DISTRIBUTION SYSTEM

The bleed air collection and distribution system collects compressed air extracted from the compressors of all operating GTEs and delivers it to the other systems. This system consists of regulating valves, isolation valves, piping, a main header, and relief valves.

MASKER AIR SYSTEM

The masker air system receives hot compressed bleed air from the bleed air collection and distribution system. This system cools the bleed air and distributes it to the masker emitter rings outside the ship's hull or to the gas turbine start/motor air system. The masker air system consists of cutout valves, coolers, falters, transfer valves, regulating valves, piping, and emitter rings.

GAS TURBINE START/MOTOR AIR SYSTEM

The gas turbine start/motor air system receives both hot bleed air from the collection and distribution system and cool bleed air from the masker air system. This system distributes bleed air to both the propulsion and the electrical GTEs for starting and motoring. The components of this system consist of cutout valves, mixing valves, filters, regulating valves, and distribution piping.

PRAIRIE AIR SYSTEM

The prairie air system receives hot bleed air from the collection and distribution system. It then cools the bleed air and distributes it through the propeller shaft to the leading edges of the propeller blades. The components of the prairie air system include coolers, cutout valves, and distribution piping.

GAS TURBINE ANTI-ICING SYSTEM

The gas turbine anti-icing system receives hot bleed air from the collection and distribution system. The system then distributes bleed air to the propulsion and electrical GTE intakes to prevent the formation of ice. The components of this system consist of manual butterfly regulating valves and distribution piping. The gas turbine anti-icing system is not used to remove ice because engine damage may result from ice ingestion.

OPERATION

The bleed air system on board gas turbine-powered ships is normally operated and monitored by the ECSS, PCS, or the MCS. On the DD-963, DDG-993, and CG-47 class ships, the bleed air system controls and indicators are located on the PACC and the PLCC. On the FFG-7 class ships, the bleed air system controls and indicators are located on the PCC and the auxiliary control console (ACC). On the DDG-51 class ships, the bleed air system controls and indicators are located on the PACC and the SCU.

The valves for the bleed air system are controlled and monitored from the control consoles. The consoles provide for the opening and closing of the bleed air valves. Some valves, such as the anti-icing valves, are manually operated. Their status, however, is monitored from the control consoles.

COMPONENTS

As mention earlier, the bleed air system consists of several parts. The parts that are of primary concern to the GSEs are the control valves. Consequently, our discussion will be limited to the maintenance and repair of these valves. You should refer to chapter 5 of this TRAMAN for a detailed discussion of the maintenance and troubleshooting procedures for control valves.

The bleed air control valves are located throughout the bleed air system. They control the flow of bleed air through the system.

Most of the control valves are pneumatic piston-actuated, butterfly-vane, solenoid-controlled shutoff valves. An example of a typical bleed air control valve is shown in figure 4-4. Atypical bleed air control valve consists of a shutoff assembly and an actuator assembly. The shutoff assembly consists of the valve body and the butterfly vane. The actuator assembly consists of the solenoid-operated pilot valve and the actuating piston and control linkage. A spring-loaded microswitch is also provided to show the valve status on the ECSS, PCS, or MCS equipment.

Maintenance

Routine maintenance of the bleed air control valves usually consists of cycling the valves to check for proper operation. If a valve fails to cycle or fails to display the proper status indication, you, the GSE, will be called. Refer to chapter 5 of this TRAMAN for specific maintenance procedures used with solenoids and microswitches. Always use the appropriate technical manual when working on control valves.

Troubleshooting

When you are called to troubleshoot a malfunctioning bleed air control valve, make sure you get all the symptoms from the operating personnel. First, you must know what the operator was trying to accomplish. In some instances, certain permissive must be met before a control valve will cycle. Sometimes the problem is not with the valve but with the system alignment.

Troubleshooting procedures for bleed air control valves include inspecting, testing, and repairing the solenoids and microswitches. Specific procedures used to maintain and troubleshoot solenoids and microswitches are discussed chapter 5 of this TRAMAN.

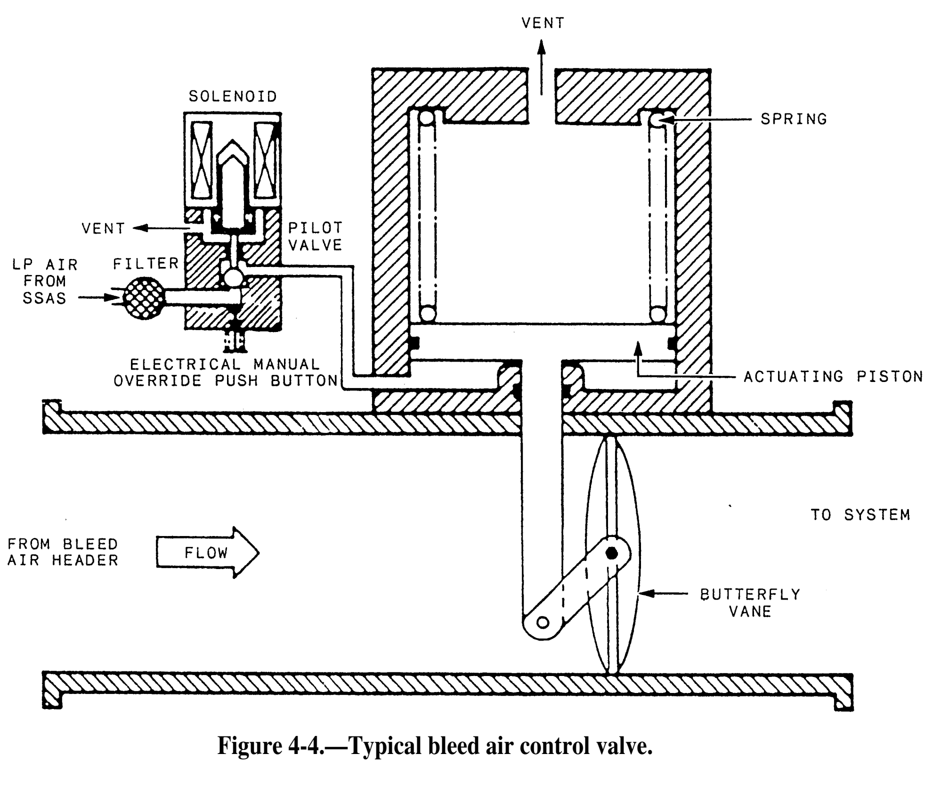


Figure 4-4.—Typical bleed air control valve.

When troubleshooting, repairing, and maintaining bleed air control valves, you must be aware of potential hazards to personnel. Always follow specified electrical safety precautions whenever you troubleshoot or repair control valves. Since bleed air temperatures can range from 100°F to more than 900°F, you must make sure the valve has cooled sufficiently before you begin working on it. If possible, secure and tag out the bleed air system before you start work on any bleed air valve.

GAS TURBINE FUEL SYSTEM

The gas turbine fuel system regulates and distributes fuel to the combustion section of the GTE to control gas generator speed. This system consists of a fuel pump, main fuel control, fuel shutdown valves, pressurizing valve, fuel manifold, fuel nozzles, and power lever angle actuator. The system also contains a purge valve, variable stator vane actuators and a compressor inlet temperature sensor.

The GSE will be concerned mainly with the fuel shutdown valves. There are two fuel shutdown valves in the gas turbine fuel system. The fuel shutdown valves are pilot-valve actuated and electrically controlled.

OPERATION

The fuel shutdown valves are piped hydraulically in series. They are operated in parallel by control logic at the control consoles during an automatic sequence. They also can be operated manually at the control consoles. Both valves must be energized to port metered fuel to the fuel manifold. De-energizing either valve will bypass the fuel back to the fuel pump inlet. Normally, both valves are de-energized to shut down the engine. The second valve acts as a backup should the first valve fail to function. The two valves may be operated independently from the PLCC, SCU, PCS or the free standing electronics enclosure (FSEE) as a maintenance check.

MAINTENANCE

You should check the fuel shutdown valves according to PMS. Preventive maintenance of the fuel shutdown valves consists of running the GTE and activating one of the fuel check switches on the control console. If the engine shuts down, the valve is satisfactory. Check the other fuel shutdown valve the same way. If one of the valves fails to secure the GTE, you, the GSE, will be called to investigate the system. You also will be called if the valves fail to give the proper status indication on the control console.

TROUBLESHOOTING

Troubleshooting the fuel shutdown valves requires the same skills you need to maintain solenoids. Refer to chapter 5 of this TRAMAN for specific procedures for troubleshooting solenoids and solenoid valves. Always use the appropriate technical manual when working on any part of the gas turbine fuel system. Remember, when you are called to troubleshoot the gas turbine fuel system, make sure you get all the symptoms from the operating personnel. Certain permissive must be met before you can open the fuel shutdown valves. Sometimes an apparent problem will be nothing more than a misaligned system.

When troubleshooting and repairing the fuel shutdown valves, make sure you follow all electrical safety precautions. Refer to the technical manual for the general gas turbine safety precautions to be used whenever you are working on the engine. Remember, the GTE must be secured and tagged out before you start work on the fuel shutdown valves.

MAIN LUBRICATING OIL SYSTEM

The main lubricating oil system provides clean oil at the proper temperature and pressure to the main reduction gear (MRG). Lube oil supplied to the MRG is used for lubrication and cooling of the reduction gear bearings, pinions, and clutch and brake assemblies. Lube oil is used as a cooling medium in the gas turbine synthetic lube oil coolers. The major parts of the main lubricating oil system are the MRG sump, service pumps, a cooler, a duplex filter or strainer, an unloader valve, and associated piping. As a GSE, you will mainly be concerned with the maintenance of the lube oil service pump motors and the service pump controllers.

OPERATION

The ship's main lube oil system on board gas turbine ships is normally operated and monitored by the ECSS, PCS, or MCS. On the DD-963, DDG-993, and CG-47 class ships, the lube oil system controls and indicators are located on the PACC and the PLCC. On the FFG-7 class ships, the lube oil system controls and indicators are located on the PCC. On the DDG-51 class ships, the lube oil system controls and indicators are located on the PACC and the SCU.

The lube oil service pumps are controlled from the control consoles. The consoles provide for stopping and starting of the lube oil pumps. From the control consoles, you can place the pumps in slow (low), fast (high), or stop. The operation of the lube oil pumps also can be placed in manual or automatic control from the consoles.

COMPONENTS

In the following sections, we will discuss only the parts that are of primary concern to the GSE. This discussion will include the maintenance and repair of the lube oil service pump motors and the lube oil pump controllers. Refer to chapter 5 of this TRAMAN for a detailed discussion of the maintenance and troubleshooting procedures associated with motors and controllers.

Lube Oil Service Pump Motors

The motors for the main lubricating oil system are 3-phase, 60-Hz, 440-volt ac, fan-cooled motors. These two-speed motors are designed for constant-speed, continuous-duty operation. Each lube oil pump motor circuitry is contained in its associated electric controller.

MAINTENANCE.— The main lube oil service pump motors are maintained the same as any other motor. This includes keeping the insulation clean and dry, the electrical connections tight, and the motor in good mechanical condition. Usually, this is accomplished through PMS. Be sure to keep the interior and exterior of the motor clean and free of dirt. Dirt and debris are the major cause of motor failure.

TROUBLESHOOTING.— When a malfunction occurs to the lube oil pumps, you, the GSE, must troubleshoot the lube oil pump motors. A fault in the motor is usually caused by short circuits, open circuits, or grounds. You must locate and repair these faults to restore the lube oil system to its maximum operating condition. Refer to chapter 5 for additional information on troubleshooting the lube oil pump motors.

Lube Oil Service Pump Controllers

The controllers for the lube oil system are located in the engine rooms on gas turbine-powered ships. The controllers are normally the dripproof, ac magnetic type. They operate from a 3-phase, 60-Hz, 440-volt ac source. The lube oil pump controllers provide local control of the lube oil pumps. The pumps can be stopped and started from these controllers. The controllers are usually equipped with reset push buttons to restore motor overloads.

MAINTENANCE.– The main lube oil service pump controllers are maintained in the same manner as any other electrical controller. On most gas turbine-powered ships, it is the responsibility of the GSE to maintain these controllers. On some ships, however, the EMs will maintain the controllers. Proper preventive maintenance reduces the chance of failure of the lube oil pump controllers. Routine PMS includes keeping the insulation resistance of the control and power circuits high and making sure the electrical connections are tight. Any problems found in the controllers must be corrected immediately. Make sure you follow the proper electrical safety precautions during the maintenance of these controllers.

TROUBLESHOOTING.— While performing PMS on the lube oil pump controllers, you will sometimes find it necessary to troubleshoot the controllers. A fault in the controller is usually caused by short circuits, open circuits, or grounds. Since the controller is an electro-mechanical device, it will sometimes give in to mechanical failures. You, the GSE, must be able to locate and repair these types of faults to the controller. Refer to chapter 5 of this TRAMAN for additional information on troubleshooting the lube oil pump controllers.

WASTE HEAT RECOVERY SYSTEM

Steam for ship's services on DD-963, DDG-993, and CG-47 class ships is generated by three waste heat boilers (WHBs). The WHBs use the hot exhaust gas from the gas turbine generator sets (GTGS) as the heat source. The boilers are the forced-recirculation, water-tube type. The major parts of the ship's waste heat recovery system consist of the WHB, boiler control panel, recirculating pump, feed pump, control condenser, separator, and feedwater tank. As a GSE, you will mainly be concerned with the maintenance of the boiler control panel and the feedwater and recirculating pump motors. The maintenance and troubleshooting procedures used for the feedwater and recirculating pump motors are the same as those discussed earlier in this chapter. In the following paragraphs, we will describe only the maintenance and troubleshooting procedures used for the boiler control panel.

OPERATION

The selector switches on the boiler control panel, when in the AUTO mode, will start the WHB when the gas turbine starts. With the feedwater pump selector switch in AUTO, the feedwater pump must reach a discharge pressure of 100 psig 10 seconds after the WHB has received an auto start command. If not, the feedwater pump will be shut down. During normal operation, if the feedwater pump discharge falls below 100 psig, the feedwater pump will immediately be stopped. The selector switch also can be placed in the

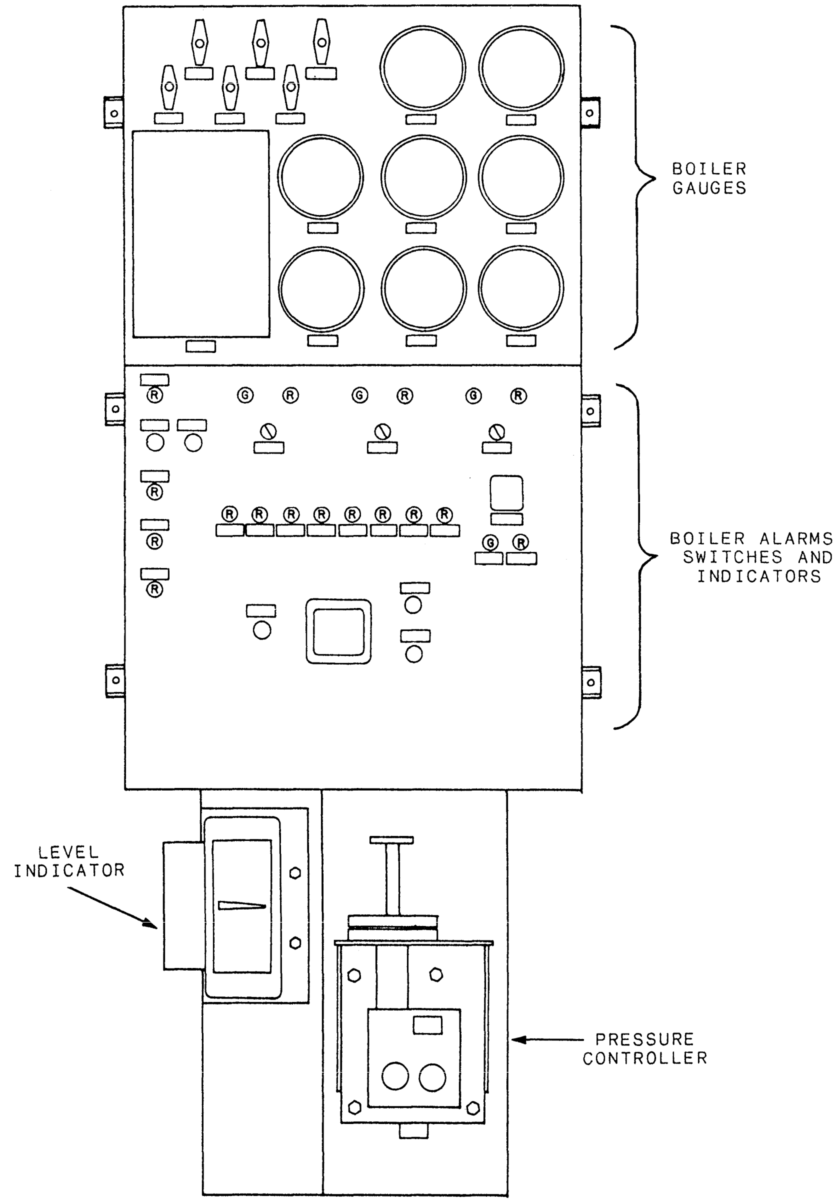


Figure 4-5.—WHB control panel controls and indicators (CG-47 class).

OFF or ON position for the circulating pump and feedwater pump. Regardless of the selector switch position, the circulating pump will automatically stop during LOW-LOW DRUM WATER LEVEL conditions. The circulating pump will restart automatically when the condition has cleared. The main steam stop valve has been provided with a CLOSED or OPEN position indicator.

The WHB is normally operated and monitored from the boiler control panel. The ECSS allows the PACC operator to monitor steam header pressure and to emergency stop the WHB. Depressing the emergency stop switch at the PACC de-energizes the solenoid valve associated with the steam stop valve, thereby closing the steam stop valve. A WHB summary alarm is also provide at the PACC.

WHB CONTROL PANEL

The boiler control panel is an integral part of the WHB. It contains the boiler controls, warning lights, alarm bell, indicator lights, and gauges for local monitoring of all boiler operating parameters. The WHB control panels for the CG- and DD-class ships are shown in figures 4-5 and 4-6, respectively.

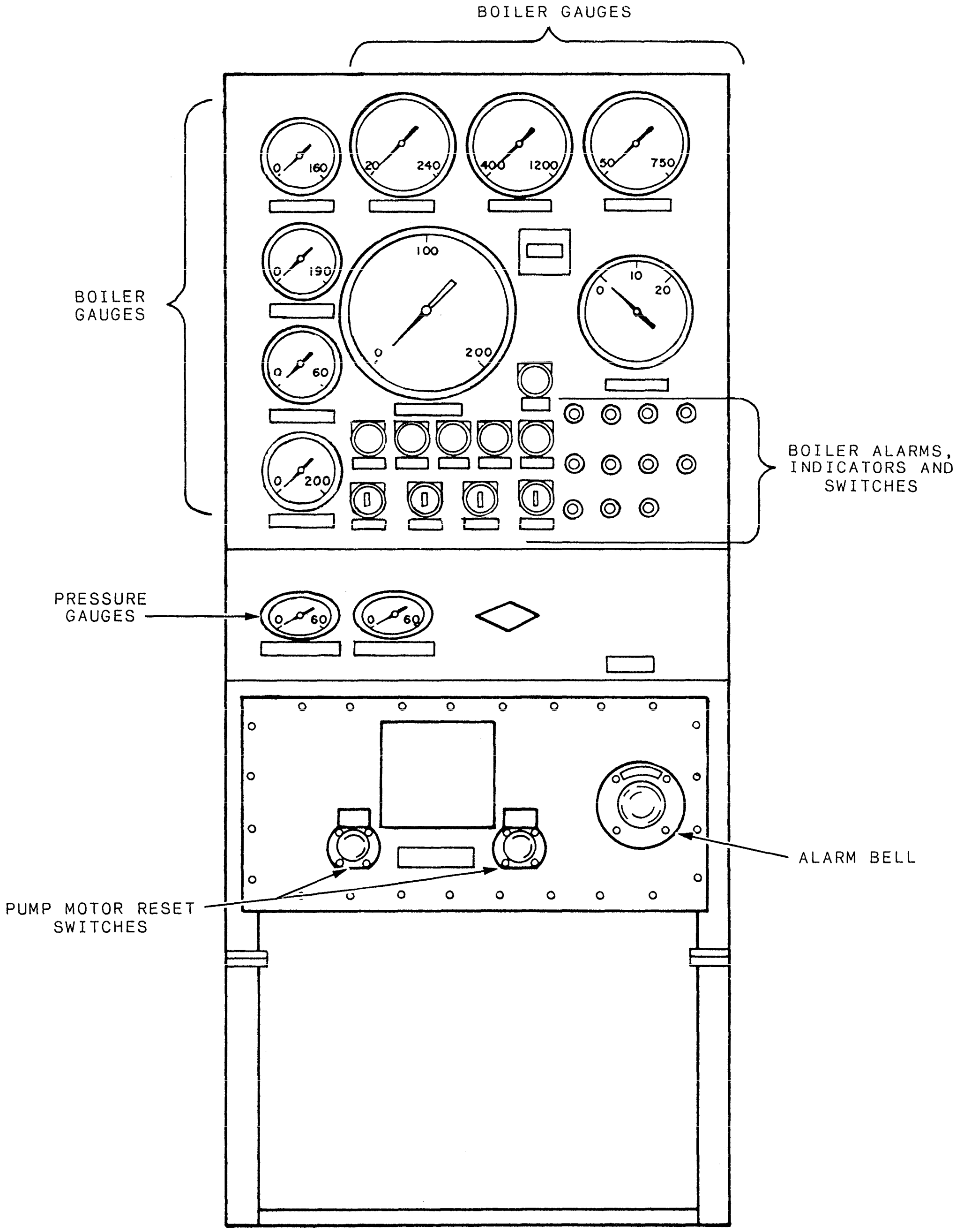


Figure 4-6.—WHB control panel controls and indicators (DD-963 class).

The boiler control panel is located next to its associated WHB. There are multiple voltage inputs to the boiler control panel. These voltages are 440-volt ac, 115-volt ac, and 28-volt dc. The boiler control panel provides local control of the WHB.

Maintenance

Although the boiler control panel may look complicated, it is maintained the same as any other electrical controller. As a GSE, you will be responsible for the maintenance of the WHB control panel. Proper preventive maintenance reduces the chance of future of the WHB and its associated electrical components. Routine PMS includes conducting insulation checks of the control and power circuits and making sure each electrical connection is tight. Any problems found in the WHB control panel must be corrected immediately to ensure the waste heat recovery system is at its maximum readiness condition. Make sure you follow the proper electrical safety precautions during the maintenance of the WHB control panels.

Troubleshooting

The WHB control panel contains all the circuits required to control the operation of the WHB. When you troubleshoot the WHB, it is essential for you to use the manufacturer's technical manual. A fault in the boiler control panel is usually caused by short circuits, open circuits, or grounds. The WHB control panel contains several timers (AGASTATs) that control the automatic on and off times for the pumps. Sometimes, these components become misadjusted, causing incorrect cycling of the pumps. You, the GSE, also must locate and repair all types of faults to the WHB control panel. Remember to refer to the manufacturer's technical manual when troubleshooting the boiler control panel. Also, refer to chapter 5 of this TRAMAN for additional information on the basic troubleshooting techniques used on electric controllers.

SUMMARY

In this chapter, we have discussed your role as a GSE in the maintenance of the engineering support systems found on gas turbine-powered ships. We have discussed the troubleshooting, maintenance, and repair of the components of the ship's fuel service system, bleed air system, and the gas turbine fuel system. We have also discussed the maintenance procedures associated with the main lubricating oil system and the waste heat recovery system.

As a GSE, you will be the primary person contacted when an electrical or electronic failure occurs to the engineering support systems. The information presented in this chapter covers some of the important areas of your maintenance and repair responsibilities. If you have any questions or you need additional information about the sections in this chapter, we recommend you study chapter 5 of this TRAMAN.

CHAPTER 5

ELECTRICAL AND ELECTRONIC SYSTEMS MAINTENANCE

Your primary responsibility as a Gas Turbine Systems Technician (Electrical) (GSE) is the maintenance of the electrical and electronic systems of the main propulsion plant. These systems include electronic control circuits, control consoles, signal conditioners, and electrical generating systems. You, the GSE2, are the backbone of electrical and electronic maintenance in the engineering department. For that reason, your knowledge of the electrical and electronic systems must be exceptional. Advancement to second class requires that you strengthen the maintenance skills you acquired as a third class GSE.

This chapter discusses the troubleshooting, repair, and maintenance of electrical and electronic circuits. It covers control circuits and systems, motors, generators, and controllers. It also describes the maintenance techniques associated with jacks, plugs, multiconductor cables, and auxiliary systems. This chapter also discusses casualty inspecting and reporting procedures, wire wrapping operations, and pump logic calibrating procedures. You will also read about various safety techniques associated with the maintenance of electrical and electronic circuits.

ELECTRICAL AND ELECTRONIC SAFETY

Most GSEs working on electrical and electronic circuits take risks. Usually, we get our jobs done without any injuries. Many of the injuries that occur simply result from our not understanding the risk or danger. Electrical and electronic equipment in the fleet has become increasingly complex and sophisticated. It includes such areas as power amplifiers, digital devices, computers, and associated control equipments.

RECOGNIZING SAFETY HAZARDS

Safety from the viewpoint of the technician requires a full appreciation of various factors and hazards involved in maintenance. Electronic equipment requires adequate safety features, such as suitable enclosures, provisions for grounding, and protective interlocks. Regardless of the efforts made during design and installation, safety depends on the technician being continuously aware of hazards. A reliable technician stays alert to guard against these hazards. The information in this chapter should help you safely perform your tasks by alerting you to remove or at least reduce potential mishaps.

OBSERVING SAFETY PRECAUTIONS

The most important action you can perform as a GSE2 is to work safely. For this reason, several precautions are included as the first subject in this chapter. Of course there are more precautions, but the following guidelines are those YOU should always think about. The key word here is *think.* Think safety.

- Never work alone.
- Never receive an intentional shock.
- Don't work on energized equipment unless it is absolutely necessary.
- Keep loose tools, metal parts, and liquids from above electrical equipment. Never use steel wool or emery cloth on electric or electronic circuits.
- Use only one hand when operating circuit breakers or switches.
- Use proper tag-out procedures for regular and preventive maintenance.
- Keep protective closures, fuse panels, and circuit breaker boxes closed unless you are actually working on them.
- Never bypass an interlock unless authorized to do so by the commanding officer, and then properly tag the bypass.

Before attempting any repair or maintenance work on electrical or electronic equipment, **disconnect the equipment from the power supply.** Properly tag the main switch so it cannot be accidentally energized. If there is any doubt whether the supply circuits have been deenergized, check them with a voltmeter. Use an approved grounding probe to make certain that the power supply filter capacitors are shorted and grounded.

Check the wiring diagram to determine if there are any other capacitors that should be discharged.

NOTE: An exception to the rule for deenergizing the equipment is when you must observe operation. In this case, obey the safety precautions necessary to prevent electrical shock.

You can find additional and more detailed information on safety in the *Electronics Installation and Maintenance Book (EIMB), General,* NAVSEA SE000-00-EIM-100.

PREVENTIVE MAINTENANCE

Preventive maintenance is the planned accomplishment of actions considered necessary to remove or reduce failures in equipment. These actions prolong the useful life of the equipment. Preventive maintenance actions are grouped into the following three basic groups:

1. Routine maintenance
2. Testing
3. Adjusting

We will discuss each of these groups briefly in the following paragraphs. A more useful knowledge of preventive maintenance can be gained by understanding the program that plans and schedules the routine maintenance, testing, and adjusting of equipment. This program, the Planned Maintenance System, is discussed *GSE3/GSM3, Volume 1,* NAVEDTRA 10563.

ROUTINE MAINTENANCE

Routine maintenance is the application of special procedures of inspection, cleaning, and lubrication of equipment. These procedures are special in that they use approved and standard methods during such maintenance actions. For example, certain approved methods are developed for the cleaning and lubricating of ball bearings. When a ball bearing needs lubrication, it should first be cleaned and then lubricated with the proper lubricant. Included with the lubricating instructions are lubrication charts that specify the approved lubricants and their use. Such approved methods are routine in that they apply whenever ball bearings are lubricated and must be accomplished at specified intervals.

Routine inspections include such actions as checking equipment ground straps, screws, nuts, and bolts. They also include checking oil reservoirs for proper quantity of oil and checking front panel indicators and bulbs. These inspections require direct analysis by the person performing the check

TESTING

Testing of electrical and electronic equipment involves the use of calibrated instruments to monitor and record data. By observing the responses and indications of the test instruments, and by comparing the data with established standards, you can determine if the circuit or device is operating properly.

Inspections require direct examination by human senses, normally sight and touch, whereas a test requires the use of an instrument. The difference between a test and an inspection is that when you perform a test, you must use an instrument to acquire the necessary information. This information represents a form or function of energy that is not perceivable by human senses. Using the information provided by the instrument, you can make an examination or analysis of the equipment or system you are checking.

ADJUSTING

The adjusting of electrical or electronic equipment is a broad area that encompasses all phases of the following actions:

- To rearrange or change a function or characteristic
- To align circuits by adjusting two or more sections of a circuit or system so their functions are properly synchronized
- To calibrate circuits in which you check circuits or instruments of a given standard of accuracy against standards of higher accuracy, and then align or adjust them accordingly.

CORRECTIVE MAINTENANCE

Corrective maintenance of electronic equipment consists of the actions and operations you must perform to restore improperly operating equipment to a fully operative condition. Corrective maintenance actions may be those you will need to repair equipment after a fire or to locate and replace a faulty part. Corrective maintenance actions are also those you may need to locate a faulty function and then adjust its circuit for an output that is within specifications. Common to each of these corrective maintenance actions is a sequence of three basic operations that are always performed. These operations are

1. symptom recognition,
2. malfunction location, and
3. repair.

Each of these operations is discussed in the following sections.

SYMPTOM RECOGNITION

Symptom recognition is the weakest link of the three basic operations. Many incidents occur where malfunctioning equipment is operated for hours, days, and even months without notice of a failure. The symptoms of many malfunctions are subtle and may not be easily recognized. So, the need for trained operators and technicians in the methods of symptom recognition is very important. To be a good technician, you must first know proper equipment operation and the function of each operating control.

Very often, a qualified console operator can see a malfunction in the equipment that he or she can correct without the aid of a technician. A console operator can make some adjustments to the equipment, provided they do not require a lot of technical skill. Console operators are not always technically qualified technicians to work on the consoles they operate. They are, however, still responsible for reporting any symptoms of malfunction to a GSE.

Not all equipment produces symptoms that are easily recognized. Some symptoms can only be found while preventive maintenance is being performed. For these reasons, you must recognize the not so apparent as well as the apparent troubles.

MALFUNCTION LOCATION

The process of malfunction location is better known to the GSE as troubleshooting. This process begins after a symptom of a malfunction has been recognized and ends when the cause of the malfunction is located. GSEs, operators, and others who have worked with electronic equipment know what troubleshooting is. But, then, why does so much downtime occur?

Modern electrical and electronic equipment is extremely complex because of so much interfacing and interacting circuitry. To troubleshoot this type of equipment can be annoying. Your troubleshooting efficiency depends on the knowledge that you have of the operation of the equipment. This is very important. You must first know what the equipment does before you can determine what it is not doing or is doing incorrectly. To troubleshoot efficiently, you must perform the following five logical operations:

1. Identify the symptom.
2. Identify the malfunction.
3. Localize the malfunction.
4. Locate the cause of the malfunction.
5. Perform failure analysis.

Identifying the Symptom

After an equipment trouble is noted, a good technician then uses all available aids designed into the equipment to further elaborate on the symptom. By using the front panel controls, indicators, and other testing aids, you can obtain a better description of the symptom.

Identifying the Malfunction

Your next step in troubleshooting is to prepare some logical choices for the basic cause of the symptom. The logical choices should be mental decisions based on your knowledge of equipment operation and a full description of the symptom. The overall function description in the technical manual can help you outline the logical choices.

Localizing the Malfunction

Now that you have identified the malfunction, you must localize its basic source. Localizing the malfunction is normally accomplished by using the block diagrams in the technical manuals. You can test the logical choices by following the signal flow of the faulty function. If one test does not prove that the function is faulty, test the next logical choice. Continue this procedure until you can localize the faulty function.

Locating the Cause of Malfunction

After localizing the malfunction, you must make additional choices to find which circuit is at fault. Again, use the block diagrams (with schematics) to find the faulty circuit. If the trouble is not immediately apparent, use proper test methods to further isolate the fault. Some common test methods you may use include voltage and resistance checks, semiconductor testing, and module testing. Continue this process until you locate the specific cause. Defective components, improper wiring, and improperly soldered components are all examples of specific causes.

Failure Analysis

After locating the faulty part, review your troubleshooting procedures before making the repair. This step will help you determine exactly why the fault had a certain effect on the equipment. It will also help you make certain that the fault you found is actually the cause of the malfunction, not the result of the malfunction. For example, a faulty transistor may have caused the loss of a certain function. Upon analysis, you may determine that inadequate cooling of the transistor caused it to fail. The real culprit could simply be a dirty air filter or an improperly installed heat sink. In addition to replacing the faulty transistor, the cause of the overheating also must be corrected.

INSPECTING EQUIPMENT CASUALTIES AND REPORTING DAMAGE

When casualties or damage occur to electrical or electronic equipment, you must thoroughly inspect the equipment and make the proper reports. Damaged or deranged equipment or circuits present possible safety hazards to personnel inspecting the casualties. When inspecting or working on damaged electrical equipment, obey all electrical precautions. During the inspection, follow all precautions for maintenance on energized circuits until it is verified that the circuits are deenergized.

INSPECTING EQUIPMENT

Your inspection of damaged equipment should not be limited to a visual examination. A thorough inspection includes your touching and shaking the electrical connections and mechanical parts. Pay particular attention to the following points:

1. Make certain all electrical connections and mechanical fastenings are tight. Overtightening can be as detrimental as undertightening.

2. See that mechanical parts are free to function.

3. Check the condition of control wiring. Check the wiring for frayed or broken leads.

4. Check the ventilation paths of rheostats and resistors for obstructions.

REPORTING DAMAGE

After performing a thorough inspection, you must report the results of your examination to higher authority. This authority can be your work center supervisor, division chief, division officer, or the engineer officer. They will use the information that you provide to help eliminate future problems. The information you provide can form the basis for changes in design, application, or method of operation. It should now be apparent to you why a complete and thorough inspection is extremely important.

TESTING AND TROUBLESHOOTING ELECTRICAL AND ELECTRONIC COMPONENTS

On gas turbine-powered ships, a large part of the ship's ability to complete its mission depends on the efficiency of the electronics of the engineering plant. As the technician responsible for these systems, you are the focal point in ensuring their reliability. If a system fails, it is your responsibility to repair the system in an accurate and timely manner. Whether troubleshooting or doing PMS, you must test and repair various types of electrical and electronic components. The information in this section is presented so you can become more aware of the various electrical and electronic components commonly found in gas turbine engineering systems.

A basic principle you should observe is to troubleshoot an equipment failure to the component level. Usually, GSEs are expected to troubleshoot and identify a faulty module or printed wiring board (PWB). In some cases, the GSE must troubleshoot and identify faulty components. A quick glance at the Navy's concept of operation explains why you must troubleshoot to the faulty component level.

A deployed ship is a self-sustaining unit. Storage space for bulky items or electronic modules to be used as ready spares is limited. Therefore, it is logical that the ship must store only individual components that are common to several pieces of equipment. Some of these components are discussed in the following sections.

RELAYS

Relays are electrically operated control switches. They are classified according to their use as control relays or power relays. Control relays are usually simply known as relays. Power relays are called contractors. Contractors are mostly found in controllers.

As a GSE, you will deal mostly with control relays. Control relays are used in the control of low power circuits. The LM2500 gas turbine engine (GTE) fire detection system, for example, uses control relays. On some ships, however, GSEs are responsible for the power relays in controllers that control equipment, such as fuel pumps and turbine ventilation systems.

Construction and Operation

To test a relay, you must understand its construction and operation. A relay acts according to the same basic principle as a solenoid. In fact, the basic difference between a relay and a solenoid is that the relay does not have a movable core (plunger).

A relay consists of a magnetic core, and its associated coil, contacts, springs, armature, and mounting. Figure 5-1 shows the construction of a relay. When the coil is energized, the flow of current through the coil creates a strong magnetic field. This field pulls the armature downward to contact Cl, completing the circuit from the common terminal to Cl. At the same time, the circuit to contact C2 is opened.

Most of the relays in the propulsion control system are the multiple-contact type. Figure 5-2 shows a multiple-contact relay that has four different contact combinations. Any number of sets of contacts may be built onto the relay. This configuration makes it possible to control many different circuits at the same time. This type of relay can be a source of trouble because the motion of the armature does not assure movement of all the movable contacts.

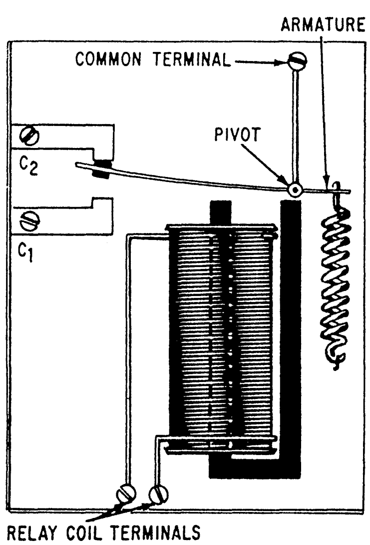


Figure 5-1.—Basic relay construction.

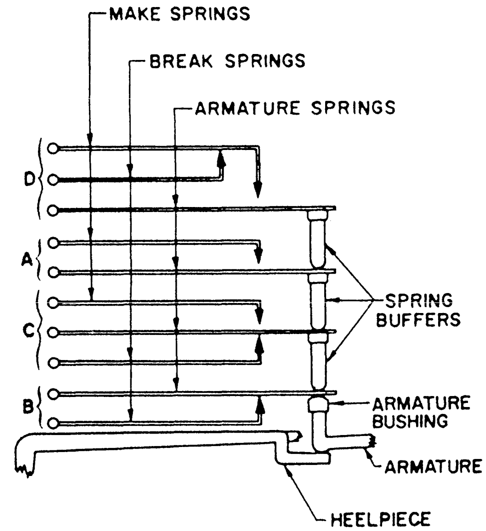


Figure 5-2.—Relay contact arrangement.

Maintenance

The relay is one of the most dependable electrical devices in use. Like any other mechanical or electrical device, relays occasionally wear out or become inoperative. If you detect that a relay is faulty, remove the relay and replace it with another of the same type. Make certain you get the same type of relay as a replacement. Relays are rated in voltage, amperage, type of service, and number of contacts. Relay coils usually consist of a single coil. If a relay fails to operate, test the coil for an open circuit, a short circuit, or a short to ground. An open coil is a common cause of relay failure.

During preventive maintenance, you should check for conditions that will cause a relay to fail. When checking a relay, make certain you follow all general safety precautions. The conditions that usually cause a relay to fail consist of the following:

- Charred or burned insulation on the relay
- Darkened or charred terminal leads
- Loose power terminal connections
- Film buildup on the contact surfaces
- Bent or broken contact arms

If a relay fails to function, examine the movement of the contacts. Contact clearances or gap settings must be maintained according to the operational specifications of the relay. When the relay has bent contact arms, you should use a point bender (shown in fig. 5-3) to straighten the contacts. Using any other tool could cause further damage to the relay. This could result in your having to replace the entire relay.

If a film buildup is visible on the contact surfaces of a relay, the contacts require cleaning. You should use a burnishing tool, such as the one shown in figure 5-4, to clean the contacts. When you clean relay contacts, be careful to avoid altering the shape of the contacts.

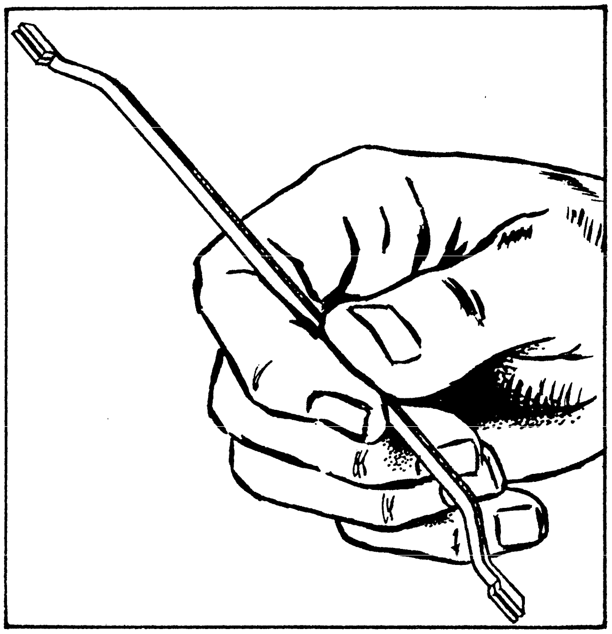


Figure 5-3.—Point bender.

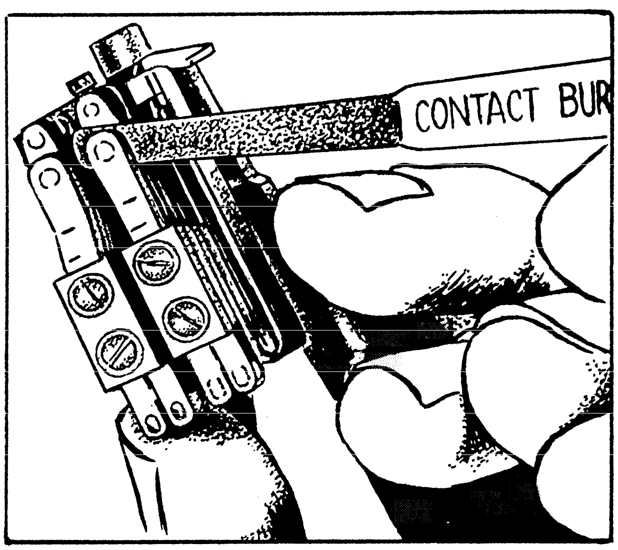


Figure 5-4.—Burnishing tool.

CAUTION

Do not use files, sandpaper, or emery cloth to clean the contacts as these materials will damage the contacts and leave metal particles or debris in the equipment.

CONVERTER/INVERTER ASSEMBLIES

Dc/dc converters produce the dc voltages required to operate the circuits of the ship's control equipment system. Each different voltage level requires a separate dc/dc converter. Many of the electronic enclosures and consoles on gas turbine ships contain converters/inverters. The basic configuration of all the dc/dc converters is the same. The differences exist in the final output transformer and the associated faltering components.

Maintenance Requirements

Once installed in the equipment, converters/inverters require minimum maintenance. As with all transistorized units, heat is the major problem. Preventive maintenance is limited to cleaning and periodic adjustments. Corrective maintenance requires the use of specific test equipment and procedures outlined in technical manuals.

Symptoms of Overheating

During preventive maintenance, you should check for conditions that indicate overheating of the converter/inverter. Make certain to observe all standard electrical safety precautions when replacing or repairing converter/inverters. The following conditions usually indicate overheating of a converter/inverter:

- Charred or burned insulation on the converter/inverter
- Darkened or charred resistors and transistors
- Excessively hot components

CONTROL CIRCUITS

The operation of many of the engineering systems depends on effective operation of the control circuits. In fact, all electrical systems and equipment are controlled in some manner by one or more controls.

Checking and Adjusting Set Points

Control circuits should be checked regularly for circuit continuity and proper relay, switch, or indication lamp operation. There are so many types of control circuits installed in naval ships that it is impractical to list any definite operating test procedures. In general, control circuits are best tested by using the circuits as they are intended to be operated. When testing control circuits, always use standard safety precautions to guard against damage to associated equipment.

Control circuits send commands (signals) that operate valves, pumps, fans, and other electrical and electronic circuits. One important device used in control circuits is the precision snap-acting switch.

Maintaining Precision Snap-Acting Switches

A precision snap-acting switch is a switch in which the operating point is preset and very accurately known. The operating point is the point at which the plunger causes the switch to "switch." This switch is commonly known to the GSEs as a microswitch. An example of a microswitch is shown in figure 5-5.

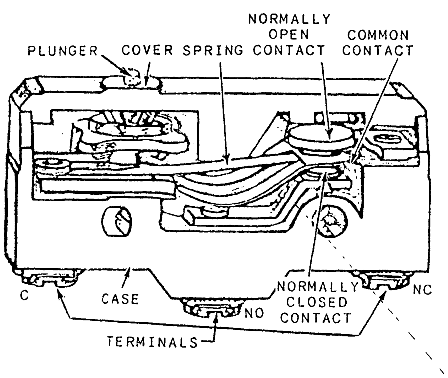


Figure 5-5.—Microswitch.

MICROSWITCH DESIGN AND OPERATION.– The frill description of the microswitch shown in figure 5-5 is a two-position, single-pole, double-throw, single-break, momentary-contact, precision, snap-acting switch. Notice the terminals marked C, NO, and NC. These letters stand for common, normally open, and normally closed. The common terminal is connected to the normally closed terminal until the plunger is depressed. When the plunger is depressed, the spring will "snap" into the momentary position. The common terminal is now connected to the normally open terminal. As soon as the plunger is released, the spring will "snap" back to the original position.

This basic microswitch is used in many applications as an automatic switch. Several different methods are used to operate this type of switch. Some of the more common actuators and their uses are shown in figure 5-6.

MICROSWITCH MAINTENANCE.– Microswitches are usually very reliable electrical components. This means they do not fail very often. Most micros witches are designed to operate more than 100,000 times without failing if the voltage and current ratings are not exceeded. Even so, microswitches do fail.

There are two basic methods used to check a microswitch. You can use an ohmmeter or a voltmeter. Earlier in your career, you learned to remove power from the circuit and isolate the component being checked. The best way to isolate a microswitch is to remove it completely from the circuit. This is not always practical, however, and sometimes you must check a microswitch while power is applied to it. In those cases,

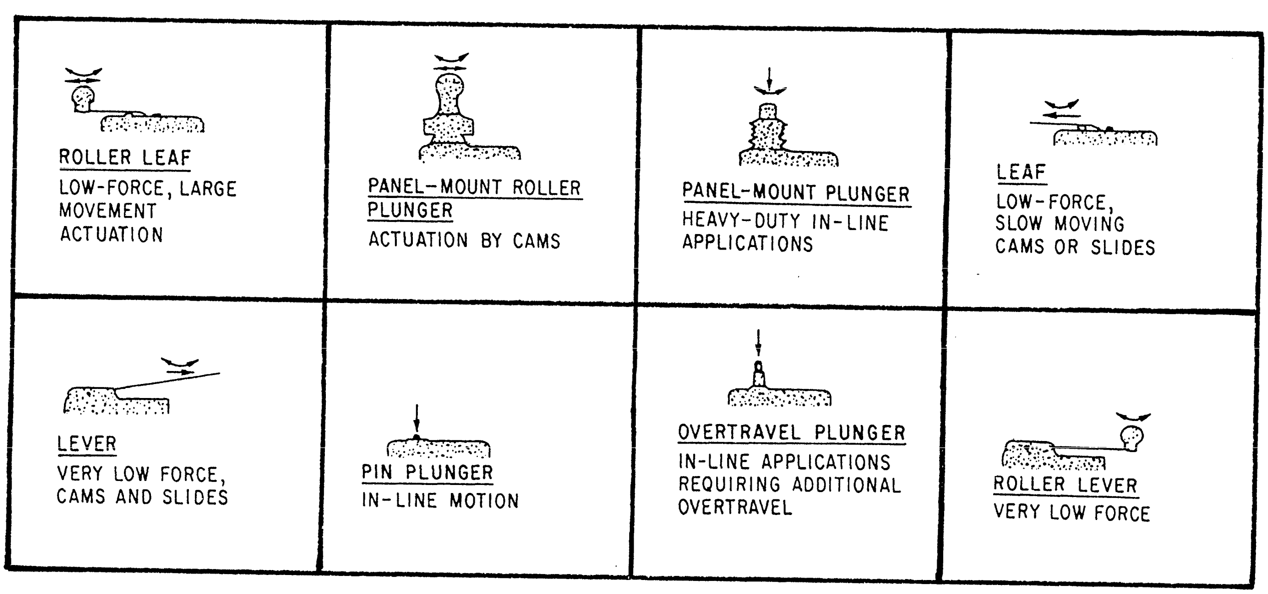


Figure 5-6.—Common microswitch actuators.

you should use a voltmeter instead of an ohmmeter to check the microswitch.

When a microswitch is faulty, it must be replaced. The technical manual for the equipment specifies the exact replacement switch. If you must use a substitute microswitch, observe the following guidelines. The substitute microswitch must have all the following characteristics:

- At least the same number of poles
- At least the same number of throws
- The same number of breaks
- At least the same number of positions
- A voltage rating equal to or higher than that of the original microswitch
- A current rating equal to or higher than that of the original microswitch
- A physical size compatible with the mounting

As already mentioned, microswitches do not fail very often. There is, however, a need for preventive maintenance. Periodically check the switches for smooth and comet operation, physical damage, and corrosion at the terminals. You can inspect most microswitches visually for corrosion and damage. Check the operation of the switch by moving the actuator. When the actuator moves, you can feel whether the microswitch operation is smooth or seems to have some friction To check the actual switching, observe the operation of the equipment or check the microswitch with a meter.

MAINTAINING ELECTRICAL CONNECTORS AND MULTICONDUCTOR CABLES

The proper installation and maintenance of the various electrical and electronic propulsion systems are very important to the GSE. Multiconductor cables and electrical connectors are a major part of the ship's electrical and electronic propulsion system. The repair of battle damage, alterations, and some electrical repairs require that you make changes or additions to the equipment's cables and connectors.

ELECTRICAL CONNECTORS

On gas turbine-powered ships, electrical connectors are commonly called cannon plugs. In the following discussion, the word *connector* is used in a general sense. It applies equally well to connectors designated by AN numbers and those designated by MS numbers. AN numbers were formally used for all supply items cataloged jointly by the Army and Navy. Many items, especially those of older design, continue to carry the AN designator even though the supply system has shifted over to MS (military specification) numbers. Although AN specification numbers for connectors have been replaced by MS numbers, you may still hear connectors referred to as AN connectors.

Electrical connectors (cannon plugs) provide a detachable means of coupling between major components of electrical equipment. The construction of these connectors permits them to withstand the extreme operating conditions imposed by continuous service. They must make and hold electrical contact without excess voltage drop despite extreme vibration, rapid shifts of temperature, and so forth.

Types

Electrical connectors vary widely in design and application. Each connector consists of a plug assembly and a receptacle assembly. The two assemblies are coupled by some type of coupling device (coupling nut, pressure fitting, and so forth). Each assembly consists of an aluminum shell containing an insulating insert, which holds the current-carrying contacts. The plug is usually attached to a cable end and is the part of the connector on which the coupling device is mounted. The receptacle is the half of the connector to which the plug is coupled. The receptacle is usually mounted on a part of the equipment.

There are wide variations in shell type, design, size, layout of contacts, and style of insert. Six types of connector shells are shown in figure 5-7.

Connector MS 3100 is a wall-mounting receptacle. It is intended for use with a conduit to eliminate the need for installed conduit boxes.

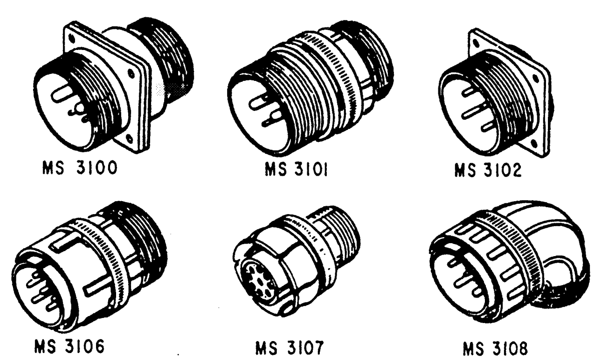


Figure 5-7.—Types of connector shells.

Connector MS 3101 is a cable-connecting receptacle. It is used with cables or in other installations where mounting provisions are not required.

Connector MS 3102 is a box-mounting receptacle. It is intended for use where a detachable connection is required on a shielded box or unit of equipment.

MS 3106 is a straight plug that is used when circuits are to be connected where space limitations are not critical. It consists of a front shell (often called an insert barrel), a coupling ring, the insert, an insert retaining device, and a rear shell.

MS 3107, a quick-disconnect plug, is used where very rapid disconnections must be made. A special coupling device is used instead of a coupling ring. This type of plug is similar to the MS 3106.

Connector MS 3108 is a 90-degree-angle plug that is similar in construction to the M-S 3106 connector. The difference is that the rear shell of the MS 3108 provides a right-angle bend, required where space is limited.

Classes

There are six classes of MS connectors, each designed for a particular kind of application. Letter designations are assigned for the types of shell indicators used. As an example, in the MS 3106E, the letter *E* indicates an environment-resistant shell. Letter designators and the kinds of shells used areas follows:

- A- Solid
- B - Split
- C - Pressurized
- E - Environment-resistant
- K - Fireproof
- R - Environment-resistant (lightweight)

Solid-shell connectors are used where no special requirements are necessary. The rear shells are made from a single piece of aluminum.

Split-shell connectors allow maximum access to soldered connections. The rear shell is made in two halves, either of which maybe removed. An exploded view of one type of split-shell connector is illustrated in figure 5-8.

Pressurized connectors provide a pressuretight feedthrough for wires that pass through walls or bulkheads of pressurized compartments. The contacts are usually molded into the insulator, and the shell is spun over the assembly to seal the bond.

Fireproof connectors are made under specifications that require that the connectors maintain effective electrical service for a limited time even when exposed to fire. The inserts are made of a ceramic material, and special crimp-type contacts are used.

Environment-resistant connectors are used in areas where changes in temperature may cause condensation or where vibrations are likely to occur.

Identification Symbols

Each connector is given an identification symbol called the MS part number. This symbol indicates the shell type, the shell design, the size, the insert type, the insert style, and the insert position. An example is the designator MS 3106A18-4SX, shown in figure 5-9. A description of the designator is as follows:

1. The standard letters indicate that the connector was manufactured to government standards.

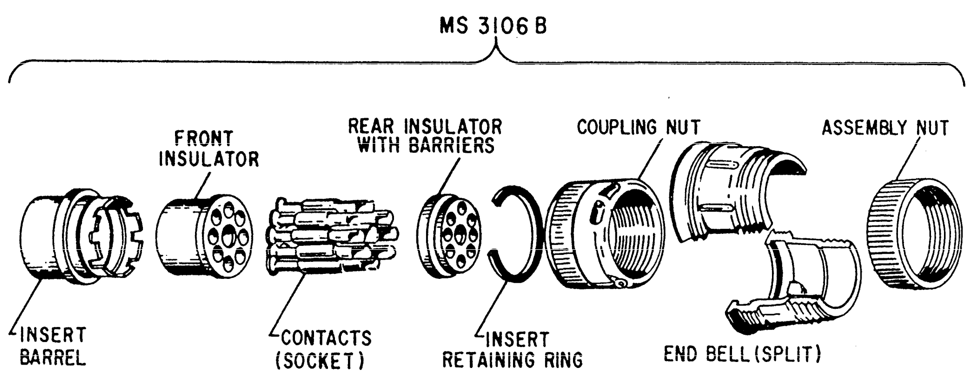


Figure 5-8.—Exploded view of a split-shell connector.

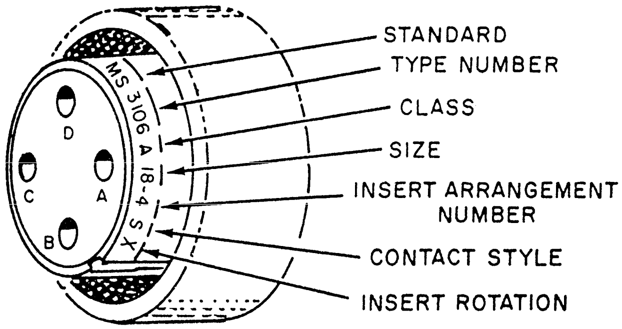


Figure 5-9.—MS connector marking.

2. The type number indicates the type of shell.

3. The class letter indicates the design of the shell and the purpose for which the connector is normally used.

4. The size number indicates the shell size. This size is either the outside diameter of the mating part of the insert or the diameter of the coupling threads (in sixteenths of an inch).

5. The insert arrangement number indicates the arrangement of the contacts in the insert but not the number of contacts.

6. The contact style letter indicates that the contacts are of two styles: socket (female), shown by the letter *S;* or pin (male), shown by the letter *P.*

7. The insert rotation letter indicates an alternate insert position. Insert rotation letters *W, X, Y,* or *Z* indicate that the insert has been rotated (with respect to the shell) a specified number of degrees from the normal position. If the insert is in the normal position, no letter is used.

For more detailed information on types and designations of connectors, refer to *Handbook of Installation Practices for Aircraft Electric and Electronic Wiring,* NAVAIR 01-1A-505.

MULTICONDUCTOR CABLES

Engineering electrical and electronic systems require a large variety of electrical cables. Some circuits require only a few conductors having a high current capacity. Other circuits require many conductors having a low current-carrying capacity. A GSE must learn the proper techniques used in cable maintenance.

The engineering control systems on gas turbine ships consist primarily of multiconductor cables. These cables connect the operating consoles to the respective equipment. Figure 5-10 is an example of a multiconductor cable. Multiconductor cables consist of any number of individual conductors. This number ranges from as few as *2* conductors to as many as *36* conductors.

Splicing Requirements

Some electrical components on gas turbine ships are located in areas where they are subjected to salt spray, oil, and water. These conditions can cause connections to corrode and conductors to break To connect these cable faults, the GSE must know how to splice multiconductor cables properly.

Conductor splices are an essential part of any electric or electronic circuit. Any electric or electronic circuit is only as good as its weakest link. The basic requirement of any splice is that it be both as mechanically and electrically sound as the conductor or device with which it is used. Quality workmanship and proper materials will ensure lasting electrical contact and physical strength.

Joining small, multiconductor cables together presents somewhat of a problem. Each conductor must be spliced and taped. If the splices are directly opposite each other, the overall size of the joint becomes large and bulky. You can create a smoother and less bulky joint by staggering the splices.

Figure 5-11 shows how a two-conductor cable is joined to a similar cable by staggering the splices. In

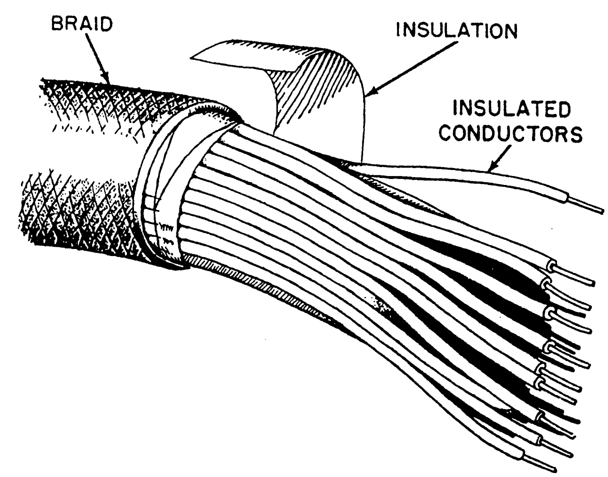


Figure 5-10.—Multiconductor cable.

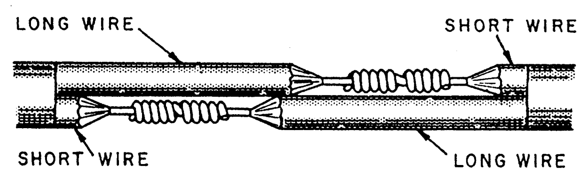


Figure 5-11.—Staggering splices.

performing this procedure, be careful to ensure that a short wire from one side of the cable being spliced is connected to a long wire from the other cable. Make certain the sharp ends are then clamped firmly down on the conductor. The figure shows a Western Union splice being staggered.

Fabrication Procedures

As a GSE, you must learn to fabricate a cable using connectors. The type of connector you must use is specified in the service and overhaul instructions for the particular equipment.

To fabricate a cable, use the following steps:

1. Disassemble the connector to allow access to the contacts. Devise a means of holding the connector so you will have both hands free. (A small bench vise is useful for this purpose.)

2. Cut the cables to the correct length,

3. Strip the wire ends with a wire stripper or knife. If you use a knife, avoid cutting or nicking the wire strands.

4. Tin the bare wire ends.

5. Run the wires through the connector assembly and coupling nuts.

6. See that all surfaces are clean.

7. Flow rosin-core solder into the connector terminals.

8. Insert each wire into its terminal by holding the tip of the soldering iron against the terminal. As the solder melts, push the wire into the cavity, and then hold the wire steady while the solder cools.

CAUTION

Be careful to avoid damaging the connector insulation with the soldering iron. When you solder the connector, the recommended sequence is to start from the bottom connection and work from left to right, moving up a row at a time. After soldering the connections, solder the shields (if used) to a common terminal on a ferrule. Then lace the cable and reassemble and moistureproof the connector, if necessary.

INSPECTION, MAINTENANCE, AND REPAIR PROCEDURES

Routine maintenance of electrical connectors and multiconductor cables involves the inspection, troubleshooting, maintenance, and repair of these components. In this section, we will briefly describe these areas.

Inspection and Troubleshooting

In the maintenance of cables and connectors, the first consideration is a thorough visual inspection. This check should reveal such defects as corrosion, chafing, loose connections, broken wires, evidence of overheating, and mismated connectors. You can make additional checks to be sure there are no open or shorted conductors in the cable. Usually, you will use an ohmmeter to perform these checks.

CAUTION

Many ohmmeters are supplied with test leads that are slightly larger than the female sockets used in connectors. Forcibly inserting these probes can irreparably damage the sockets. Exercise care to prevent such damage.

In reference to the caution, most GSEs make pin testers. Some examples of pin testers are shown in figure 5-12. A pin tester is a device constructed of the pins and receptacles of cannon plugs (view A). The pin tester can also be a complete replacement cannon plug that has the electrical cable attached and the ends of the individual wires exposed (views B and C). A pin tester can help you prevent short circuits or incorrect readings caused by trying to use ohmmeter or voltmeter test leads to get the readings from the cannon plugs. The test leads can slip off the pin of the cannon plug and short circuit to the other pins. This could result in serious damage to the cannon plug or the equipment. Make certain you follow all applicable electrical safety precautions when using fabricated pin testers.

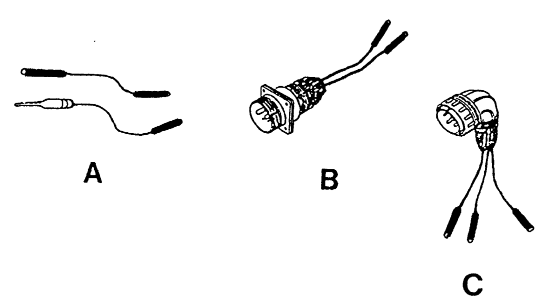


Figure 5-12.—Fabricated pin testers.

In checking a suspected conductor for either an open or a short, you may have to apply a slight pressure to the conductor or simulate vibration. Shorts are often caused by moisture, foreign particles, or a defective solder connection at the plug terminals. Therefore, be sure to check the connectors carefully before replacing the cable.

Repair and Replacement Procedures

In support equipment, conduit is eliminated wherever possible. Its elimination eases cable installation and maintenance. In replacing a cable, take particular care to replace it in the exact position in which it was installed originally. Do not try to reduce the length of the cable by taking what might seem to be a logical shortcut.

When installing or replacing wire or wire bundles, make sure there is no excessive slack along the run. Normally, slack should not exceed a 1/2-inch deflection with normal hand pressure. Provide enough slack at each end to allow for the following:

1. Easy removal and connection of plugs
2. Replacement of terminals two times
3. Prevention of mechanical strain on the wires
4. Free movement of shock and vibration-mounted equipment
5. Shifting of equipment during maintenance

Bends in individual wires should normally be limited to a minimum bend radius of 10 times the diameter of the bundles. However, where the wire is suitably supported at each end of the bend, a radius of three times the diameter of the bundles is acceptable.

Wires passing through a bulkhead or structural member must be supported at the hole by a cable clamp. If the clearance between the wire and the edge of the hole is less than 1/4 inch, use an approved supporting grommet in the hole.

Maintain a clearance between wiring and any movable control. If this cannot be done, install guards to prevent contact of the wiring with the control. When routing the wiring parallel to plumbing that is carrying flammable fluids, maintain as much separation as possible. Never support any wire or wire bundle from a plumbing line that is carrying combustible liquids.

Install cable clamps so the mounting screws are above the wire bundle. (Otherwise the weight of the cable may bend and break the clamp.) If practical, try to rest the back of the clamp against a structural member. Be careful not to pinch wires in the cable clamp.

LACING AND KNOTTING TECHNIQUES FOR WIRE BUNDLES OR GROUPS.– Wire groups and bundles should be laced or tied with cord to provide ease of installation, maintenance, and inspection. This precaution keeps the cables neatly secured in groups and bundles and helps avoid possible damage from chafing or equipment operation. A wire group is two or more wires tied or laced together to give identity to an individual system. A wire bundle is two or more wires or groups tied or laced together to ease maintenance. A typical example of wire bundles is shown in figure 5-13.

Materials.— Use cotton, nylon, or fiberglass cord for lacing or tying wire bundles. Make sure the cotton cord is waxed to make it moisture and fungus resistant. Nylon and fiberglass cords are moisture and fungus resistant and usually will not need waxing. Use pressure-sensitive vinyl electrical tape only where the use of tape is specifically permitted.

The following sections describe some proper lacing and tying techniques. Refer to figures 5-14 through 5-16 as you read these sections.

Precautions.— When lacing or tying wire bundles, observe the following precautions:

1. Lace or tie the bundles tightly enough to prevent slipping, but not so tight that the cord cuts into or deforms the insulation.

2. Do not place ties on that part of a wire group or bundle that is located inside a conduit.

3. Lace wire groups or bundles only inside enclosures, such as junction boxes. Use double cordon groups or bundles larger than 1 inch in diameter. Use single or double cord for groups or bundles 1 inch or less in diameter.

Single Cord Procedure.— To lace a wire group or bundle with a single cord (fig. 5-14), use the following steps:

1. Start the lacing at the thick end of the wire group or bundle with a knot consisting of a clove hitch with an extra loop.

2. At regular intervals along the wire group or bundle (and at each point where a wire or wire group branches off), continue the lacing with half hitches. Space half hitches so the group or bundle is neat and securely held.

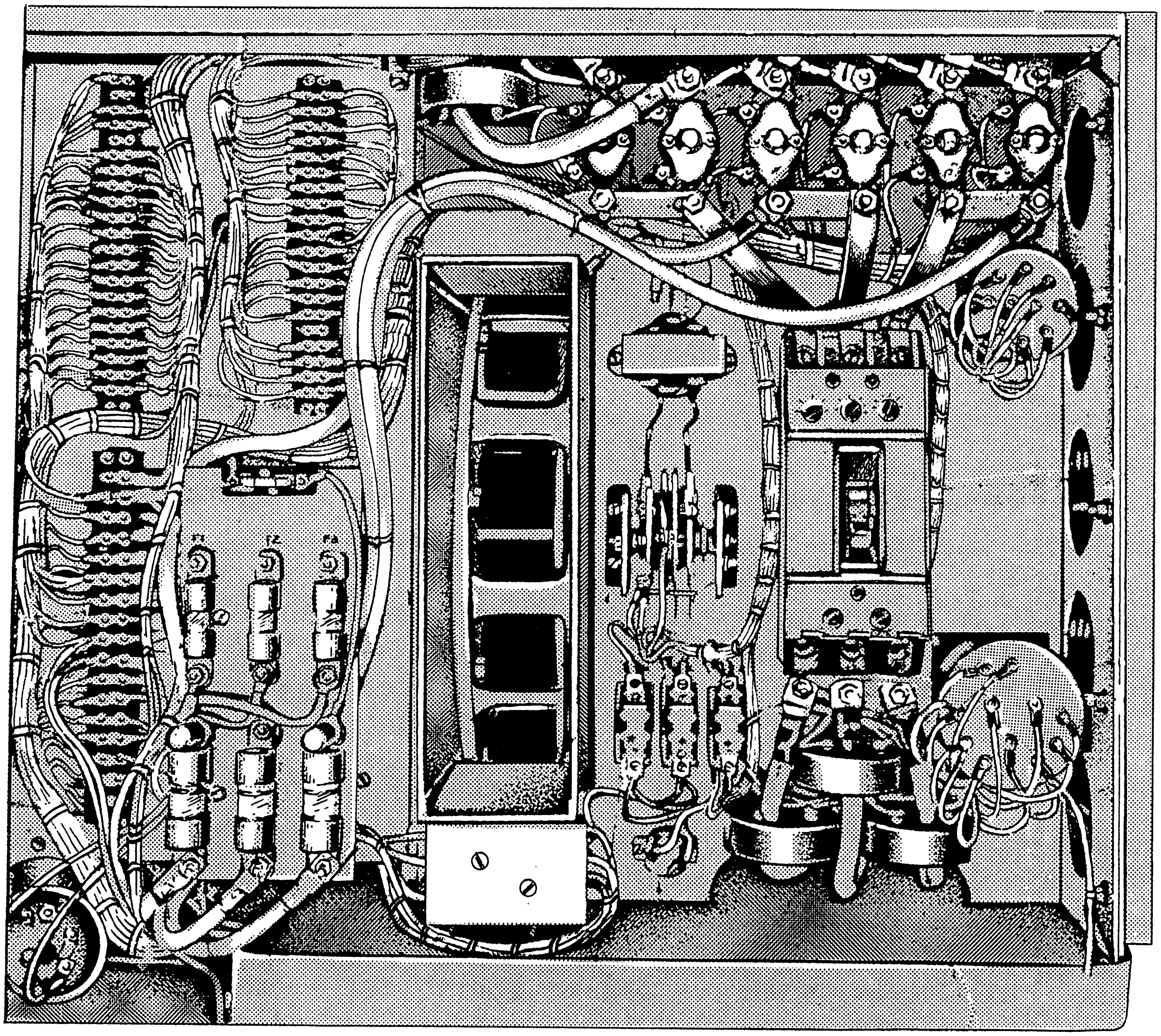


Figure 5-13.—Wire bundles laced and tied in an electrical control panel.

3. End the lacing with a knot consisting of a clove hitch with an extra loop.

4. Trim the free ends of the lacing cord to a 3/8-inch minimum.

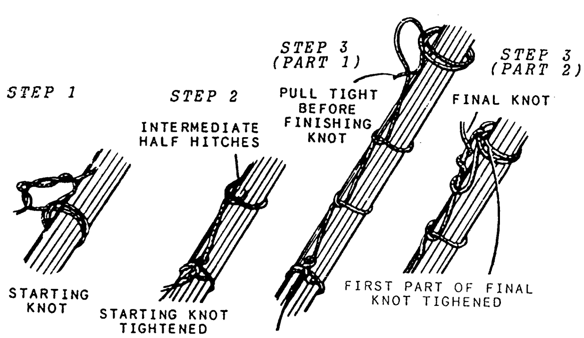


Figure 5-14.—Single-cord lacing.

Double Cord Procedure.— To lace a wire group or bundle with a double cord, use the following steps:

1. Start the lacing at the thick end of the wire group or bundle with a bowline on a bight.

2. At regular intervals along the wire group or bundle (and at each point where a wire group branches off), continue the lacing with half hitches holding both cords together. Space half hitches so the group or bundle is neat and securely held.

3. End the lacing with a knot consisting of a half hitch. Use one cord clockwise and the other counterclockwise. Tie the cord ends with a square knot.

4. Trim the free ends of the lacing cord to a 3/8-inch minimum.

Branch-off Procedure.— To lace a wire group that branches off the main wire bundle (fig. 5-15), use the following steps:

1. Start the branch-off lacing with a starting knot located on the main bundle just past the branch-off point. When using single-cord lacing, make the starting knot the same as for regular single-cord lacing. When using double-cord lacing, use the double-cord lacing starting knot.

2. End the lacing with the regular knot used in single- and double-cord lacing as described earlier.

3. Trim the free ends of the lacing cord to a 3/8-inch minimum.

TYING TECHNIQUES.– You will use specific tying techniques for different conditions. Some of these techniques are described in the following sections.

Spacing Ties.— On the all-wire groups or bundles where supports are more than 12 inches apart, space ties 12 inches or less apart (fig. 5-16).

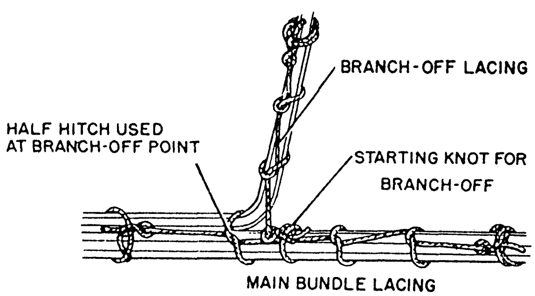


Figure 5-15.—Lacing a branch-off.

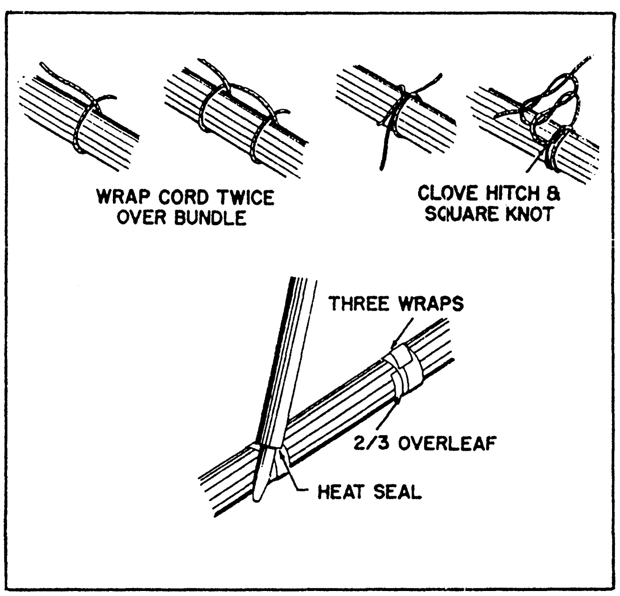


Figure 5-16.—Tying groups of bundles.

Make a tie as follows:

1. Wrap cord around the wire group or bundle.

2. Make a clove hitch, followed by a square knot with an extra loop.

3. Trim the free ends of cord to a 3/8-inch minimum.

Tying Sleeves.– When tying sleeves to wire groups or bundles, make the ties the same way as you would for wire groups or bundles.

When it is permitted to use tape, use the following method:

1. Wrap the tape around the wire group or bundle three times with a two-thirds overlap for each turn.

2. Heat-seal the loose tape end with the side of a soldering iron heating element.

Do not use tape for securing wire groups or bundles that may require frequent maintenance.

Using Cable Straps.– Cable straps are adjustable, self-clinching, lightweight, flat, nylon straps with molded ribs or serrations on the inside surface to grip the wire. Use cable straps instead of individual cord ties for fast securing wire groups or bundles. Cable straps are available in various sizes and colors to clamp and identify different sizes of wire groups or bundles.

WIRE WRAPPING

During maintenance and troubleshooting of engineering control and surveillance system (ECSS) consoles, take notice of the method used to attach the wires to the backplanes of the consoles. The procedure used is called wire wrapping. In this section, we will discuss the principles and techniques involved in this important procedure.

In simple terms, wire wrapping is the process of using a series of turns to wrap a single solid wire around a pin. The equipment on which you would use wire wrapping have long, square pins or posts at the rear of the female connectors. The back plane of a console is a good example of this configuration. The pins are long enough to allow one to three wires to be wrapped around them in separate wraps. (A wrap is a single solid wire wrapped around a pin in a series of turns.) The female connectors are then connected from pin to pin by a small, solid-insulated wire, which may or may not be color coded.

NOTE: Machine-wrapped assemblies usually do not have color-coded wiring. Hand-wrapped assemblies do have color-coded wiring. The color-coded wire in hand-wrapped assemblies offers an advantage because each wire is distinctive and fewer errors are likely to result.

PRINCIPLES

The principles behind wire wraps are simple. For proper conduction to occur between two metals, the oxide coating that has formed on both surfaces must first be penetrated. Remember, the pins used in wire wraps are squared off. They have cornered edges that will penetrate the oxide coating of the wire when it is properly wound on the pin. The edges will also lose their oxide coating when they penetrate the surface of the wire. The junction formed is strong, gastight (tight enough to seal out gases, in addition to liquids), and resistive to corrosion.

MATERIALS

For wire wrapping, a special solid-conductor insulated wire is required. This type of wire allows the coil to form tightly about the pin and remain that way without noticeable slippage. The wire is a composition of a silver alloy with a copper coating. Silver offers an advantage in that its oxide is almost as conductive as the metal itself. The insulation material used on the wire is usually Teflon or Meline. Teflon offers the advantage of very high temperature stability and ease of cutting (for stripping by automatic machinery). Teflon, however, also has the undesirable trait of "cold flow." Cold flow results when the insulation gradually reduces or wears away at a point of pressure. When Teflon-insulated wire is in contact with a pin and cold flow occurs, an intermittent short may occur at that point. Meline withstands continued exposure to pressure much better than Teflon. Although Meline is more resistive to cold flow, it does not have the high-temperature stability of Teflon. Because of the cold flow problem, however, Meline has become more widely used.

TOOLS

Some ships will have wire-wrap kits for you to use. Other ships may require you to use certain hand tools authorized for wire-wrapping procedures. Several useful tools, as well as the techniques for using them, have been developed for doing wire wraps. The tools shown in figures 5-17 through 5-19 provide limited examples. For a basic source of wire-wrap tools, refer to *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechcmical) 3, Volume 1,* NAVEDTRA 10563. For more detailed information on wire-wrap tools and techniques, refer to MILSTD 1130B, Notice 2, of 20 July 1983, *Connections, Electrical, Solderless, Wrapped.*

TECHNIQUES

The techniques of wire wrapping are simple. Simply stated, the process involves coiling a special solid-conductor insulated wire tightly around a pin. Although the process is simple, you must use skill and judgment to perform the steps correctly. Refer to figure 5-17 as you read the following paragraphs.

Using Correct Procedures

Your first step in wire wrapping is to determine the correct gauge of wire you need to perform the job. Strip

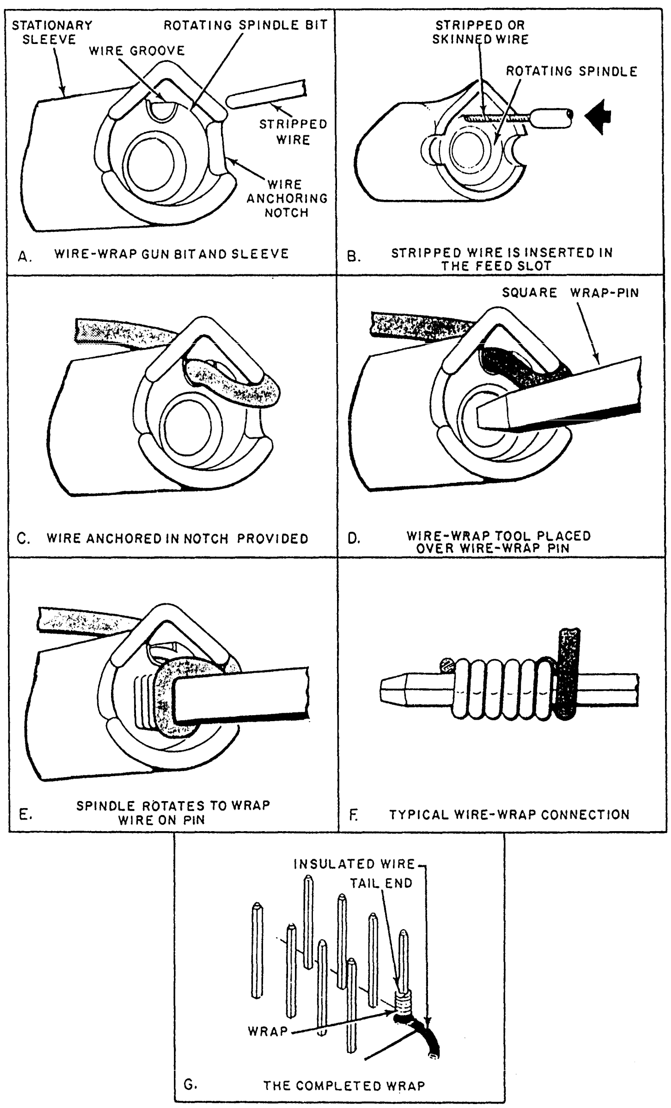


Figure 5-17.—Basic wire-wrap procedure.

off enough insulation to allow the correct number of turns to be wound around the pin. Then, either place the end of the wire in a long shallow groove along the barrel of the wire-wrap tool or insert it into the smaller hole at the end of the barrel, as shown in view A of figure 5-17. The groove (or hole) for the wire is carefully sized to provide the exact amount of tension you will need to form a secure wrap. Make certain the insulation bottoms into the wire funnel, as shown in view B. This will allow you to wrap the correct amount (one to one and a half turns) of insulated wire around the wrap pin. Anchor the wire by bending it into the notch in the sleeve, as shown in view C. Next, slip the center hole at the end of the barrel down over the pin, as shown in view D. Then rotate the barrel around the pin. (Depending on the design of the wire-wrap tool, the barrel will rotate as a result of finger, hand, or motor action.) The wire should twist around the pin, as shown in view E. As the wire twists around the pin, the stripped portion of the wire that is being held in the groove (or in the other base hole) will be drawn down to twist and coil around the pin. The coiling action of the wire on the pin lifts the tool enough for you to continue the wire coil up the pin, as shown in views F and G. Your skill is especially important at this point because too much pressure on the tool will cause the coils to bunch or overlap. If you are replacing a wire, carefully run the wire to the next connection and perform the same procedure on the opposite end. Be sure you allow enough spare wire for the required number of wraps on the pin.

Before actually doing a wire wrap on the item you are repairing, take time to practice this procedure. Find a spare connector or spare pin similar to those you will repair. Using the same materials required for the actual job, practice a few times. Figure 5-18, view A, shows a good wire wrap. It has five to seven and a half snug turns of wire. Place the insulation about the bottom one or two turns with no spacing between adjacent turns, no bunching as one turn tries to cover another, and no observable nicks in the wire. The number of turns you will use is based on the wire gauge. Wires and pins with larger diameters require fewer turns; those with smaller diameters require more turns.

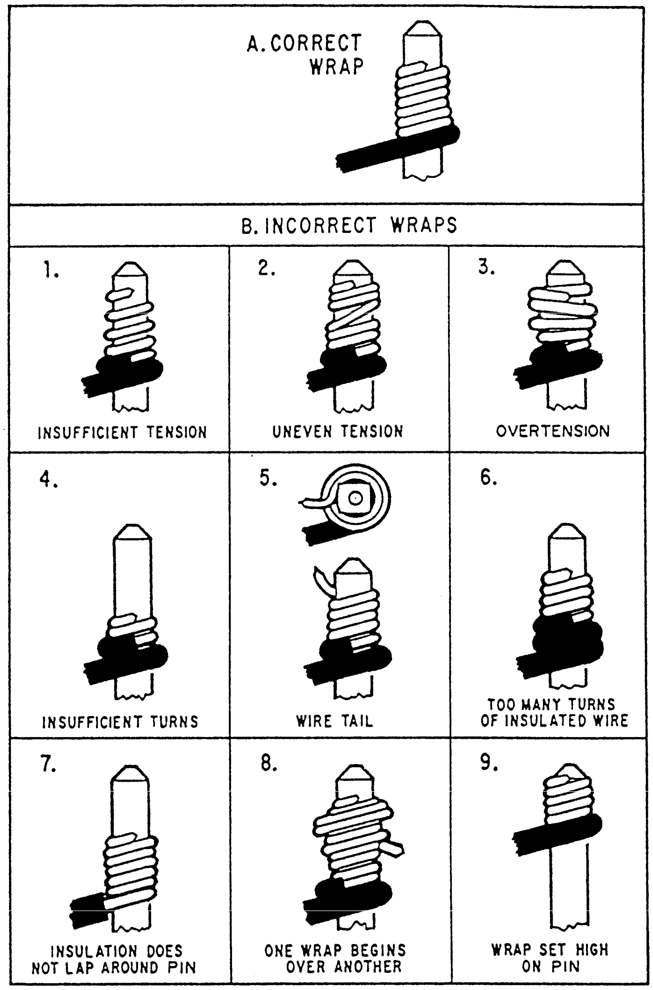


Figure 5-18.—Correct and incorrect wire wraps.

Avoiding Errors

The following list describes a variety of INCORRECT wire-wrapping techniques. Some of these faults are evident in the numbered sections in view B of figure 5-18.

1. Not enough tension on the wire, resulting in a loose connection. You can detect this fault by the open spaces between adjacent turns. (See fig. 5-18, view B, sec. 1.)

2. Overtension on the wire, resulting in a loose connection. You can detect this fault by the turn overlaps and the fact there is not enough surface contact with the pin. (See sec. 3.)

3. Insufficient number of turns (fewer than five), resulting in poor contact. (Not enough wire was stripped first.) (See sec. 4.)

4. Insulation does not extend to the pin, resulting in increased chances of shorts or wire breaks. (Too much wire was stripped.) (See sec. 7.)

5. Reuse of uncoiled wrap. (Each reuse increases the likelihood of wire breaks.)

6. Attempts to wrap by hand, resulting in insufficient and uneven tension and poor contact.

Removing a Wire Wrap

Normally, you should use a wire-wrap removal tool, as shown in view A of figure 5-19, to remove a wire wrap. This precaution will prevent stress and possible damage to the wire-wrap pin. If you must remove the wire by hand, however, unwrap the wire without applying stress to the pin. You can accomplish this by gently uncoiling the wire with a slight rotating movement over the point of the pin. Make sure that the manner in which you remove the wire does not cause movement of the pin itself, as shown in view B. If a pin is bent, it will probably break when an effort is made to straighten it. If a pin breaks, first ensure that the broken length is not left in the wiring to cause possible shorts. Then take the necessary steps to install a new pin.

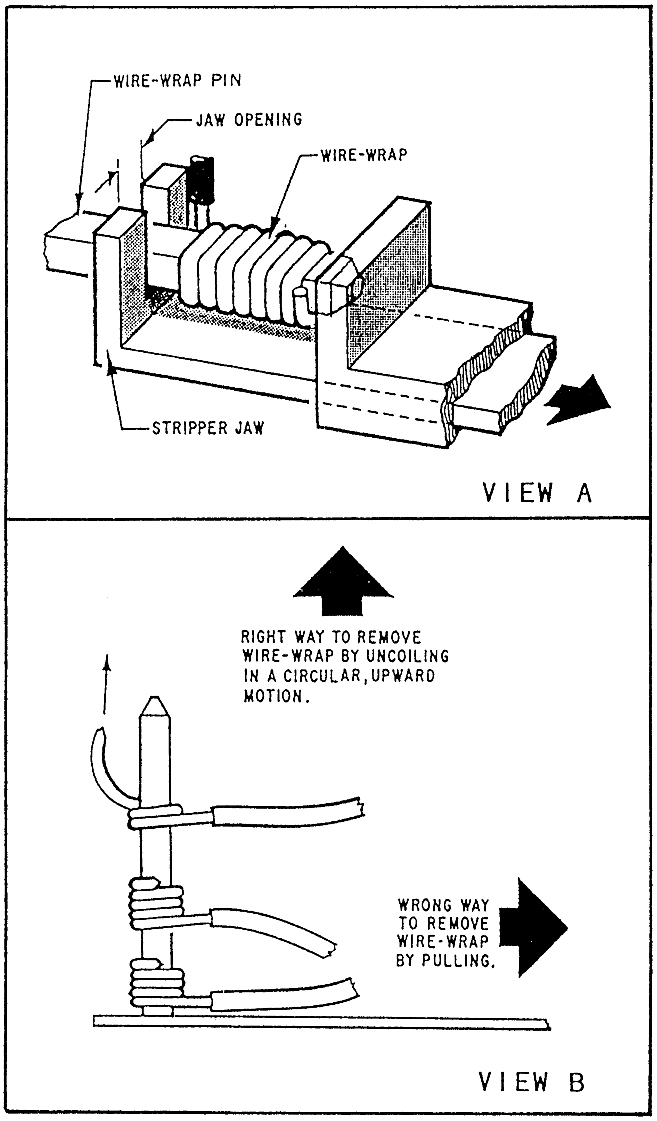


Figure 5-19.—Wire-wrap removal procedures.

Normally, inner wire wraps are placed near the bottom of the pin to assure that additional wraps can be added easily. If you have to remove a lower wire wrap, first remove each wrap above it. Do not remove a wire wrap by trying to pull it along its axis, as shown in view B. Remember, each wrap is easily identified because it is formed from the multiple turns of a single solid wire.

When removing a wire wrap from a pin, you must be careful not to disturb other wraps on the same or adjacent pins or to dislodge the pin. This would cause poor continuity or an open circuit.

ADVANTAGES AND DISADVANTAGES

As with any process, certain advantages and disadvantages are associated with wire wrapping. A good technician can recognize the pros and cons and can use this knowledge for maintenance and troubleshooting purposes. A few of the advantages and disadvantages are discussed in the following sections.

Pros

Some of the advantages associated with wire wrapping are described in the following list:

1. It is a simplified technique for repairs. (YOU can just uncoil the wires to remove them and use the proper simple tool to replace them.)

2. There is no possibility for solder spills. (This means you can make repairs without removing components.)

3. There is no danger of the components overheating. (This is not the case in soldering processes.)

4. You can perform more in-equipment repairs, and repair times are faster.

5. There is no danger of burns to ship's personnel. (This is not the case when hot soldering irons are used.)

6. It provides for durable electrical contact. (The results are just as good as those achieved with good soldering techniques, and better than those resulting from bad soldering.)

Cons

Recognizing the cons of wire wrapping will help you in some of your troubleshooting efforts. The following list describes some of the cons:

1. Solid wire must be used; therefore, the likelihood of wire breakage is increased.

2. Problems, such as cold flow, can occur with the insulation.

3. Wire wrapping is not suitable for subminiature assemblies.

4. There is no wire color coding in machine-wrapped assemblies.

5. The process requires clipping off the wrapped portion of the wire and stripping back the insulation to expose the new wire before you make the next wrap. If the wire is too short, you must replace it. You cannot reuse the same portion of wire in a new wrap because this area will have been structurally weakened by nicks from the previous use, and you will weaken it even further if you reuse it.

SAFETY PRECAUTIONS

Use caution when working with wire-wrap assemblies. Wire-wrap assemblies resemble a bed of nails, and several people have become injured by disregarding the proper safety precautions. Several facial injuries have occurred when technicians have tried to get a good look at these assemblies from the side. You should remember that this position can expose your eyes to a needless hazard. If you must use this position to get a firsthand view, use sufficient lighting to make out the details, use small mirrors whenever you can, and wear safety goggles. When inspecting or repairing the back planes or other areas of possible damage, remember that ac or dc voltages may still be present. Always make certain you are using the proper safety precautions for working with energized equipment.

ELECTROMECHANICAL CONTROL SYSTEMS MAINTENANCE

Gas turbine-powered ships are becoming more automated and complex with each class of ship delivered to the Navy. This complexity is visible inmost of the equipment the GSEs maintain. Electromechanical devices have also become more complex. The GSE rating is responsible for maintaining these electromechanical devices in peak operating condition.

There are several devices on gas turbine ships that are classified as electromechanical devices. These devices include the following components:

- Motor-operated valves
- Solenoid-operated valves
- Remote-indicating valves
- Electrical controllers
- Bus transfer switches

The GSE's counterpart, the GSM, performs maintenance on the mechanical parts of the valves. The GSE performs maintenance on all electrical parts of the valves. These two ratings must work closely with each other when performing maintenance on these electromechanical devices.

MOTOR-OPERATED VALVES

Motor-operated valves provide a means for a console operator to operate essential valves remotely. Motor-operated valves are found on fuel oil service tanks, fuel oil storage tanks, and the main seawater cooling system of some gas turbine-powered ships.

A motor-operated valve is nothing more than a valve, a motor, and a reversing controller. Most motor-operated valves also contain microswitches to show the valve's position. The console operator pushes either an open or a close push button. The resulting signal is sent to the reversing controller of the valve, thereby opening or closing the valve. An actuating rod in the valve rotates or slides, depressing either the open or close microswitch. The signal from the microswitch is then sent backup to the console, indicating the valve's position.

The maintenance on motor-operated valves includes inspecting, cleaning, testing, and troubleshooting the motor and controller. These maintenance procedures are the same procedures you would use to maintain basic motors and controllers. These maintenance procedures will be described later in this chapter.

SOLENOID-OPERATED VALVES

Solenoid-operated valves are used extensively on gas turbine-powered ships. These valves are located in the bleed air system, the start air system, and the prairie and masker air system. Solenoid-operated valves are also found on the gas turbine generator and the main propulsion turbine systems.

Construction and Operation

A solenoid-operated valve consists of a valve (needle, poppet, or spool) and a solenoid. Most solenoid-operated valves also contain microswitches to show the valve's position. The console operator depresses a pushbutton to cycle the valve to a new position. This signal is sent to the solenoid of the valve. Depending on the signal received, the solenoid cycles the valve to the requested position. An actuating rod in the valve rotates or slides, depressing a microswitch. The signal from the microswitch is sent backup to the console, indicating the valve's position.

The maintenance on solenoid-operated valves includes inspecting, cleaning, testing, and troubleshooting the solenoid and the microswitches. The procedures used to maintain and troubleshoot microswitches were discussed earlier in this chapter. We will now briefly describe the maintenance procedures associated with solenoids.

To properly troubleshoot a solenoid, you must first know how it is constructed and how it works. Figure 5-20 is a cutaway view of a solenoid showing the solenoid action. A solenoid is an electromagnet formed by a conductor wound in a series of loops in the shape of a spiral. Inserted within this coil is a soft-iron core and a movable plunger. The soft-iron core is pinned or held in an immovable position. The movable plunger (also soft iron) is held away from the core by a spring when the solenoid is de-energized. Notice the position of the plunger in view A when the coil is de-energized. Compare view A with view B, which shows the plunger position when the coil is energized. When current flows through the conductor, it produces a magnetic field. The magnetic flux produced by the coil results in establishing north and south poles in both the core and the plunger. (See view B.) The plunger is attracted along the lines of force to a position at the center of the coil. As shown in view A of figure 5-20, the de-energized position of the plunger is partially out of the coil due to the action of the spring. When voltage is applied, the current through the coil draws the plunger within the coil, resulting in mechanical motion. When the coil is de-energized, the plunger returns to its normal position because of spring action. The effective strength of the magnetic field on the plunger varies according to the distance between the plunger and the core.

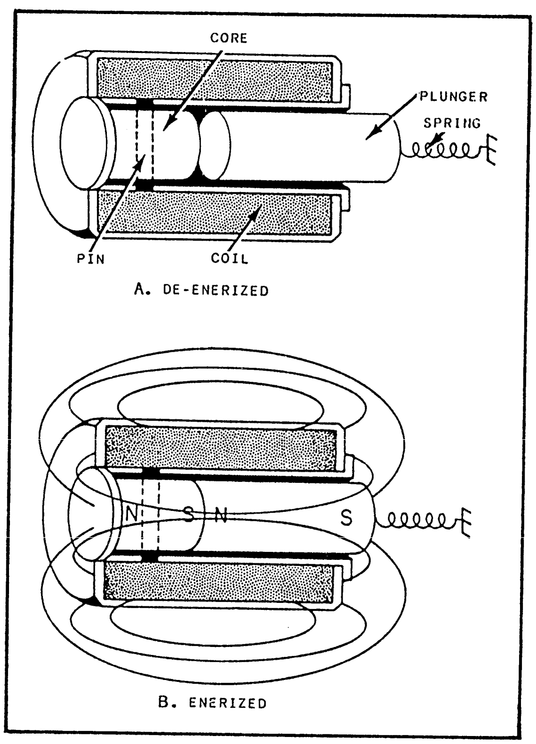


Figure 5-20.—Solenoid action.

Maintenance of Solenoids

If you suspect that a solenoid is not working properly, your first step in troubleshooting is a good visual inspection. Check the connections for poor soldering, loose connections, or broken wires. Check the plunger for cleanliness, binding, mechanical failure, and improper alignment. Check the mechanism to which the solenoid is connected (actuates) for proper operation.

Your second step is to check the energizing voltage with a voltmeter. If the voltage is too low, the result is less current flowing through the coil and a weak magnetic field. A weak magnetic field can result in slow or poor operation. Low voltage could also result in chatter or no operation at all. If the energizing voltage is too high, it could damage the solenoid by causing overheating or arcing. In either case, you should reset the voltage to the proper value so that further damage or failure of the solenoid will not result.

Next, check the solenoid coil with an ohmmeter for opens or shorts, and the proper resistance. If the solenoid coil is open, current cannot flow through it and the magnetic field is lost. A short results in fewer turns and higher current in the coil. The net result of a short is a weak magnetic field. A high-resistance coil will reduce coil current and also result in a weak magnetic field. A weak magnetic field will cause less attraction between the plunger and the core of the coil. This will result in improper operation similar to that caused by low voltage. If the coil is open, shorted, or has changed in resistance, the solenoid should be replaced.

Finally, you should check the solenoid to determine if the coil is shorted to ground. If you find a short to ground, remove the short to restore the solenoid to proper operation.

REMOTE-INDICATING VALVES

A remote-indicating valve is a manually-operated valve that gives a remote indication of the valve's status. One example of this type of valve is the primary manual valves used in the fuel oil transfer and recirculating system on DD-, DDG-, and CG-class ships. These valves are equipped with open and close limit switches. These switches provide open and close signals to the fuel system control console (FSCC) and the associated fuel oil local control panel indicator lights.

A remote-indicating valve is a manual valve with two microswitches (limit switches). The valve is manually opened or closed. When the valve reaches its desired position, a tang or lobe attached to the valve stem actuates the appropriate limit switch. The switch sends the signal to the console to illuminate the associated indicator light.

The maintenance of remote-indicating valves includes inspecting, cleaning, testing, and troubleshooting the limit switches. The procedures used to maintain and troubleshoot microswitches (limit switches) were discussed earlier in this chapter.

ELECTRICAL CONTROLLERS

The most common electromechanical device used in the Navy is the electrical controller (motor controller). A motor controller functions to protect a motor from damage, to start or stop it, to increase or decrease its speed, or to reverse its direction of rotation. The GSE rating is responsible for the maintenance of several different types of electrical controllers in the engineering department.

Electrical controllers can be found throughout the engine rooms of gas turbine-powered ships. They are used on space ventilation fans, motor-operated valves, turbine enclosure cooling fans, and various pumps and motors. The maintenance of these components and systems is the responsibility of the GSEs. As a GSE, you must be able to recognize proper operation of a controller and to take actions to correct any problem that arises.

Controller Maintenance

Proper preventive maintenance lessens the chances of failure of electrical controllers. Since electrical controllers are electromechanical devices, they often give into mechanical failure. Center your attention in these areas. Electrical controllers do have electrical problems, but most of the problems stem from the mechanical interface within the controllers. In general, when a controller fails to operate or signs of trouble (heat, smoke, unusual noise, or smell of burning) occur, you can find the cause of the trouble by a simple examination. This consists of using your sense of feel, sight, sound, or smell. At other times, however, finding the trouble will involve a more detailed process. See the appropriate manufacturer's technical manual for a list of common troubles, their causes, and the corrective actions.

Imagine you are a GSE on a gas turbine-powered ship. You are sent to investigate an apparent electrical controller system failure. You first press the START button (or, in the case of motor-operated valves, the OPEN or CLOSE button). When this does not start the system, you press the RESET push buttons (if applicable). Now you try to start the motor. If the motor operation is restored, you will not need to perform further checks. If the motor still fails to start, however, you must check the motor circuit for continuity. If the main contacts fail to close, you must check the control circuit for continuity.

In the following paragraphs, we will guide you through a procedure for troubleshooting a motor-controller electrical system. We will describe the sequence of steps you should follow in locating a fault. Refer to figure 5-21 as we take you through this process. First, let's analyze the power circuit, and then the control circuit.

Power Circuit Analysis

When no visual signs of circuit failure are clear and an electrical failure is indicated in the power circuit, first check the line voltage and fuses (or circuit breaker), as shown in figure 5-21. Place the voltmeter probes on the line side of the fuses, as shown at position A. (The symbol VM refers to your voltmeter.) A line voltage reading tells you that your voltmeter is operational. It tells you that you have voltage to the source side of the line fuses. You can also check between the other lines. To check the fuse in line 1 (L1), place the voltmeter across the line fuse, as shown at position B between L1-L2. A voltage reading shows a good fuse in L1. Likewise, check the other two fuses between L1-L3 and L2-L3. A no-voltage reading would show a faulty fuse.

If the line fuses check good and the main contacts are closed, then check the voltage between terminals

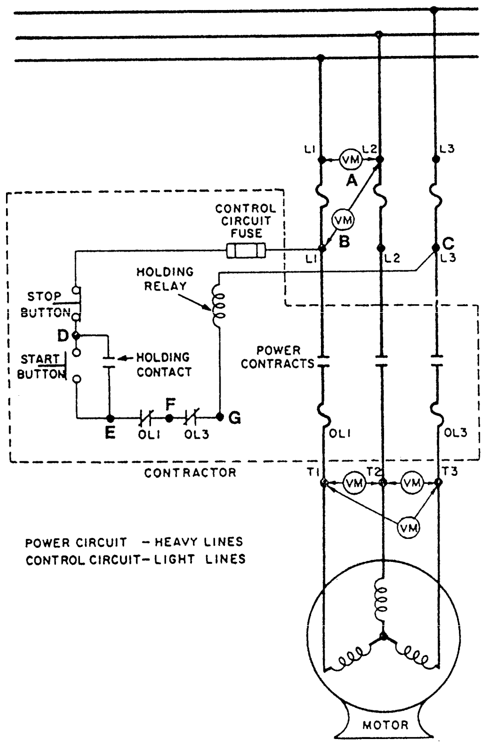


Figure 5-21.—Troubleshooting a 3-phase magnetic controller.

T1-T2, T2-T3, and T1-T3. The controller is faulty if there are no voltmeter readings on all three of the terminal pairs. You should then proceed to check the main contacts, overloads, and lead connections within the controller. However, if there is voltage at all three terminals, the trouble is either in the motor or the wires leading to the motor.

Control Circuit Analysis

Suppose the overload reset buttons have been reset and the START button is closed. If the main contacts do not close, check the control circuit. Your testing procedure should include the following steps:

1. Check for voltage in the controller at L1, L2, and L3.
2. Place the voltmeter probes at points C and D (fig. 5-21). You should have a voltage reading when the STOP button is closed. You should have a no-voltage reading when the STOP button is open. These conditions would indicate a good STOP button and control circuit fuse.
3. Next, check the voltage between points C and E. The START button is good if you get a no-voltage reading when the START button is open. The START button is also good if you get a voltage reading when the START button is closed.
4. Place the voltmeter probes at points C and F. A voltage reading with the START button closed would indicate a good OL1. It also would indicate one of the following components is open: OL3, the main coil, the control fuse, or the connection to L3.
5. Place the voltmeter probes at points C and G. Close the START button. A no-voltage reading would indicate that the trouble is located in the control circuit to OL3.

The following conditions would indicate a faulty auxiliary contact: (1) The system operates only as long as the START button is depressed; and (2) when the button is released, the system shuts down.

When starting a 3-phase motor, if the motor fails to start and gives a loud hum, you should stop the motor by pushing the STOP button. These symptoms usually mean one of the phases to the motor is not energized. You can assume the control circuit is good. This is because the main coil has operated and the auxiliary contacts are holding the main contactor closed. Look for trouble in the power circuit (the main contacts, overload relays, cable, and motor).

In the GSE rating you will come across various types of control circuits. Some control circuits are more complex than the one shown in figure 5-21, while others are simpler. The troubleshooting principles we have just described will work on any type of control circuit. You, however, as the technician, must make certain you have the correct schematics when you are troubleshooting any type of electrical controller.

BUS TRANSFER EQUIPMENT

Bus transfer equipment is installed at load centers, distribution panels, or loads that are fed by both normal and alternate, or emergency feeders. Bus transfer equipment allows you to select either the normal or alternate source of ship's service power. If an emergency feeder is provided, the bus transfer unit will also allow you to get power from the emergency distribution system.

Automatic bus transfer (ABT) equipment allows you to select between two power supplies to obtain power for the following systems:

1. Emergency lighting

2. Interior communication switchboards and panels

3. ECSS consoles

4. Steering power panels

Manual bus transfer (MBT) units are used for all loads having low voltage protection (LVP) control features, except in the case of pumps associated with the main and auxiliary machinery plant which have their own low voltage release (LVR) control features. MBT units are also used for loads having manual restart after a voltage failure and for electronics power distribution panels. Loads that have LVR or LVP control features and require two sources of supply are sometimes combined and supplied from an ABT unit. MBT units are located as close as possible to the panel or equipment being fed from the bus transfer unit.

On power systems, there is a short time delay after the normal feeder is de-energized and before the ABT switch takes over. During this shift, the load is without power. Remember, however, that ABT switches on lighting systems have no time delay and transfer power instantaneously.

Testing

Bus transfer equipment should be tested according to your ship's preventive maintenance system (PMS) schedule. For MBT equipment, manually transfer a load from one power source to another. Check the mechanical operation and mechanical interlocks of the MBT. For ABT equipment, check the operation by using the test switches. Your test should include a check to see if operation starts after you cut off power (by opening the feeder circuit breaker). This check will confirm that the automatic transfer unit is working.

CAUTION

When you are testing the ABT units, be careful they do not supply vital and sensitive electronic circuitry. Some sensitive electronic circuits are adversely affected by a loss and almost instant return of power. Before conducting the test, make certain all personnel concerned are informed of the power interruptions.

Be careful when testing an MBT unit. Make certain you follow the correct procedure when shifting an MBT from normal to alternate power. You should get permission from the EOOW before starting the test of an MBT. Failure to do so could cause loss of vital equipment that is on line.

Maintenance

If any problems are discovered during the testing of bus transfer equipment, you, as the GSE, must correct them immediately. Remember to follow all standard electrical safety precautions when you are troubleshooting and repairing bus transfer equipment.

Your first step in the maintenance of bus transfer equipment is to perform a functional check of the ABT or MBT. You will normally follow the applicable PMS card to perform this check. Your check should include cycling or shifting the bus transfer equipment from the normal to the alternate power source and vice versa. Observe the operation and note any problems that occur.

Use the correct procedures for performing a functional check of an MBT by taking the following steps:

1. Make certain the alternate power indicator lamp is on, showing that alternate power is available.

2. Open the normal power circuit breaker (CB).

3. Shift the interlock to prevent closure of the normal power CB, and enable the closure of the alternate power CB.

4. Close the alternate power CB.

Using these steps, you will shift the MBT back to the normal power source. The MBT shifting process is purely a mechanical one. If power is not transferred during the functional check, look for a faulty CB in the MBT unit.

You can perform the functional check of an ABT in two ways. First, manually test the ABT by placing the control disconnect switch in the MANUAL position and shifting the manual switch to the opposite position. (See fig. 5-22.) Second, automatically test the ABT by placing the control disconnect switch in the AUTO position and turning the spring-loaded test switch to the TEST position. The ABT should shift to the alternate power source. Releasing the spring-loaded test switch allows the ABT to shift back to the normal source of power. If the ABT fails to perform in this reamer, you must begin troubleshooting.

Various types of ABTs are used throughout the Navy. You must make certain you get the correct manufacturer's technical manual before you begin to troubleshoot and repair the ABT. Once again, follow all standard electrical safety precautions when working on this equipment.

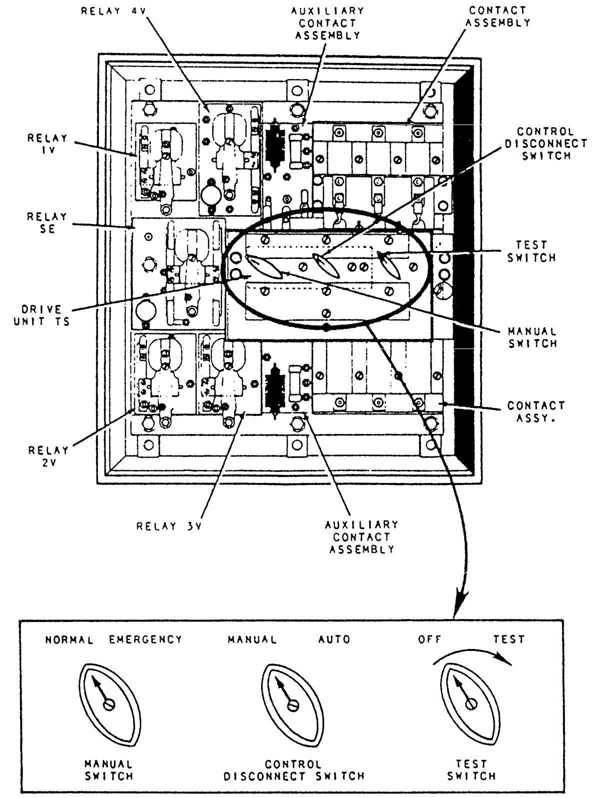


Figure 5-22.—Pictorial view of an ABT.

As a good maintenance technician, you should try to localize the problem by following the basic troubleshooting steps. In troubleshooting the ABT, you should first make certain that both power sources are available to the ABT. If both sources are available, you will then have to de-energize both sources of power and tag the ABT out of service. First check the mechanical operation of the ABT, then make an electrical examination. After you locate the faulty part, remove it and replace it. Your final step in troubleshooting the ABT is testing the effectiveness of your repair.

These troubleshooting steps are general in nature. Always use the manufacturer's technical manual and the appropriate troubleshooting charts whenever you are repairing or replacing components of MBTs and ABTs.

ELECTROHYDRAULIC CONTROL SYSTEMS MAINTENANCE

An electrohydraulic control system is one that uses electrical or electronic signals and components to control the flow of oil or hydraulic fluids. On gas turbine-powered ships, the most important electrohydraulic control system is the controllable reversible pitch (CRP) propeller or controllable pitch propeller (CPP) system. This system is called the propeller pitch control system on the landing craft, air cushion (LCAC) vessels. The purpose of CRP/CPP system is to provide the ahead and astern propulsion thrust for a ship by changing the pitch of the propeller blades.

The operation, maintenance, and repair of the CRP, CPP, and propeller pitch systems are within the capabilities of ship's personnel. Since these systems interface electronics with mechanical operations, the GSEs must work closely with the GSMs when troubleshooting and repairing these systems.

DD-963/DDG-993 CLASS SYSTEM

The pitch of the CRP propellers is established electrically through two identical electrohydraulic pitch control systems. One is located in each main engine room. Each system has two basic parts or groups of components. These are the CRP electronics enclosure and the oil distribution (OD) box-mounted components. The OD box-mounted components consist of the electrohydraulic servo control valve and two slide-type potentiometers. Figure 5-23 shows the relationship between the two basic parts of the system. Refer to figure 5-23 as you read the following paragraphs.

The procedures you will use to troubleshoot the electrohydraulic servo control valve are the same as those we discussed for troubleshooting solenoids. The servo valve consists of a two-coil solenoid. Each coil has a dc resistance of about 1000 ohms. Check this with an ohmmeter. The total resistance of the solenoid should read 500 ohms when you measure it from the two conductors that run between the electronic enclosure and the terminal box.

The linear feedback and shaped potentiometers (LINEAR POT and SHAPED POT in fig. 5-23) are mounted side by side on the top of the OD box. Each potentiometer is housed in a rectangular box about 18 inches long, 1 1/2 inches wide, and 1 1/2 inches tall. A shaft that moves the sliding contact extends out of the forward end of each potentiometer box. A Y-shaped yoke connects the ends of the potentiometer that extend out the forward end of the OD box. The follow-up rod provides a mechanical positioning of the potentiometer shafts that corresponds to actual propeller pitch positions. The follow-up rod also positions a mechanical pointer along a calibrated scale mounted between the potentiometers. Slots in the potentiometer mounting feet provide for longitudinal position adjustments when you are calibrating the zero pitch feedback and readout signals.

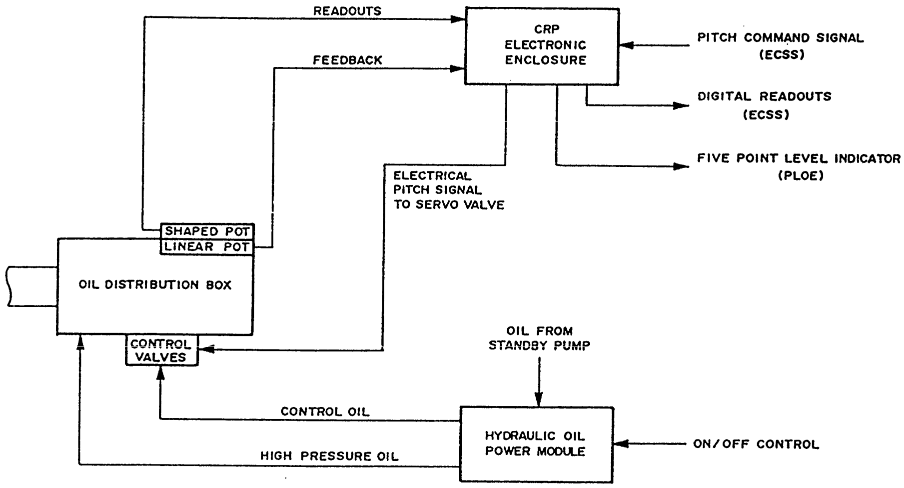


Figure 5-23.—Electrohydraulic signal flow between CRP components.

Linear Potentiometer

The linear potentiometer provides the pitch feedback signal to the servo valve controller card in the CRP electronics enclosure. The resistance element is about 10 kilohms from end to end. The term *linear* means that the resistance is evenly distributed along the potentiometer body. The voltage picked up by the sliding contact is proportional to its position along the potentiometer body.

Shaped Potentiometer

The shaped potentiometer generates the pitch readout signal that is used to display pitch on the digital demand display at the ECSS operating stations. The resistance across the shaped potentiometer from end to end is about 15 kilohms. The term *shaped* is used to describe this potentiometer because the resistance is not evenly distributed along the potentiometer body. There is slightly more resistance at the ends than in the middle. This non-linear resistance distribution is necessary to counteract the increased sensitivity of the propeller pitch when the valve rod is at the extreme ahead or astern pitch settings.

CRP Electronics Enclosure

The CRP electronics enclosure is a rectangular case that contains six circuit cards. These cards are plugged into receptacles for easy removal and replacement from the front. The CRP electronics enclosure front panel is shown in figure 5-24. A printed circuit board, containing a diode rectifier bridge, is bolted to the top of the enclosure. Study figure 5-24 as you read the descriptions of the enclosure power supply and module circuit cards in the following paragraphs.

±28V DC POWER SUPPLY.— The power supply receives 115 volts ac, single phase power from the propulsion local operating equipment (PLOE) console through two 3-amp fuses. The incoming 115 volts ac is reduced to 45 volts ac by a step-down transformer. This voltage is then rectified by the rectifier circuit board to provide a +25 and a -25 volt dc source. Three +25 volt dc bus lines and three -25 volt dc bus lines carry power throughout the enclosure.

± 15V DC VOLTAGE REGULATOR.— Two ±15 volt dc voltage regulator circuit cards supply regulated power (±.015 volt dc variance for either +15 volts dc or -15 volts dc) to other circuit card modules. Several test point jacks and a failure alarm light are mounted on the regulator card front panels. There are two output voltage trimmer potentiometers mounted on the front panels of the regulator card.

SERVO VALVE CONTROLLER CARD.— This card provides the signal that operates the electrohydraulic servo control valve on the OD box. The pitch command signal from the ECSS comes into this card and is summed with the feedback voltage from the linear potentiometer. These two signals are compared and a correcting signal is sent to the servo valve if necessary. The front panel of the servo valve controller card has three recessed potentiometers. Two of the potentiometers provide separate gain adjustments for ahead and astern pitch command signals. The third potentiometer feeds a small voltage to the command input and feedback summing junction to compensate for misalignment of the linear potentiometer. The servo

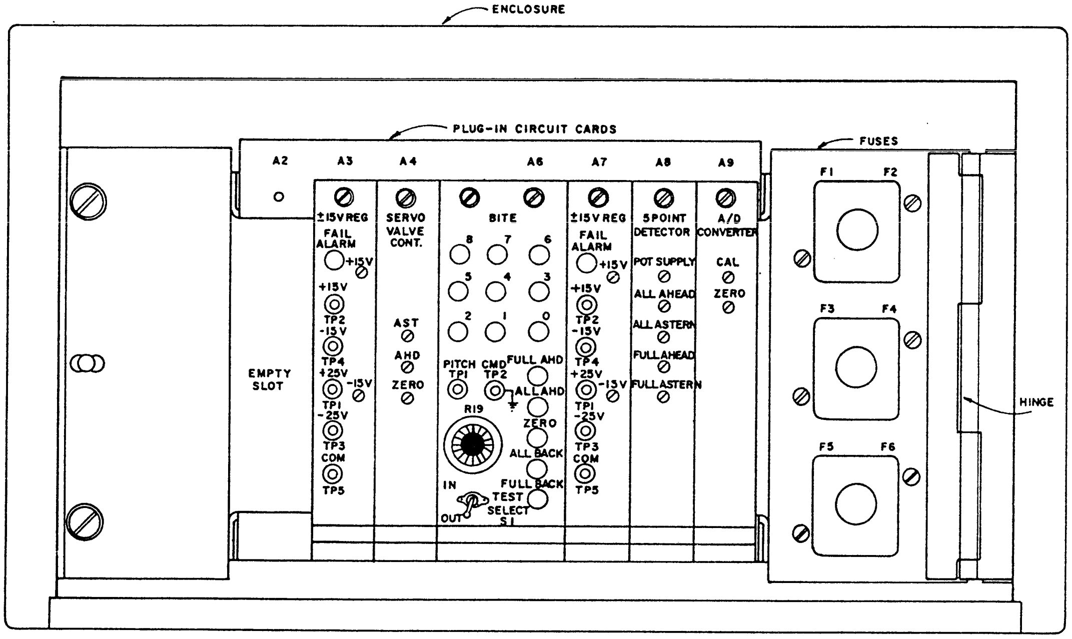


Figure 5-24.—DD-963 CRP eletronics enclosure front panel.

valve controller card also supplies the linear potentiometer with +15 volts dc and -15 volts dc.

FIVE-POINT LEVEL DETECTOR CIRCUIT CARD.– The five-point level detector causes the five-point indicator light assembly on the PLOE to display the actual propeller pitch. This is accomplished by using the signal from the shaped potentiometer. The labels on the five indicator lights identify the conditions FULL AHEAD PITCH, AHEAD PITCH, ZERO PITCH, BACK PITCH, or FULL BACK PITCH. This display of five indicator lights is also provided on the front panel of the built-in test equipment (BITE) circuit card for ease of testing and calibration. The five-point level detector card also supplies the shaped potentiometer with +10 volts dc on one end and zero volts on the other end.

ANALOG TO DIGITAL (A/D) CONVERTER CIRCUIT CARD.– The A/D converter output provides the digital signals to ECSS for display of the actual propeller pitch. Actual propeller pitch is displayed on the digital demand readouts in the engine rooms and in the central control station (CCS). The A/D converter receives the shaped potentiometer signal from the five-point level detector card. This signal is within the range of 0 to + 10 volts dc The signal is changed by the A/D converter circuitry to a nine-bit binary signal. This binarn, signal is sent to the ECSS signal conditioning enclosure (S/CE).

BUILT-IN TEST EQUIPMENT CIRCUIT CARD.– The BITE card contains the local indicating lights that constantly check the five-point level detector and A/D converter outputs. The indicating lights are red light emitting diodes (LEDs) mounted in the circuit card front panel. These lights provide maintenance personnel with a local indication of the five-point level detector output being sent to the PLOE. There are nine A/D bit lights that check the output of the A/D converter. They are located on the upper half of the BITE card front panel. Each light monitors one of the nine digital output lines. An illuminated light indicates a digital logic "one," which is about 5 volts dc. A darkened light indicates a digital logic "zero," which is about 0 volt dc These lights are designed primarily to aid in calibration and testing of the A/D converter.

CG-47 CLASS SYSTEM

The CRP propeller system on the CG-47 class ships is almost identical to the DD-963 system just discussed. The primary difference is the potentiometer setup on the OD box and one card in the CRP electronic enclosure. The OD box has only one potentiometer that sends signals for both indication and control.

Figure 5-25 shows the CRP electronics enclosure front panel found on CG-47 class ships. Notice that the A/D converter circuit card in the electronics enclosure has been replaced with a slew rate controller circuit card. The purpose of the slew rate controller card is threefold. First, it provides an integrated "burst" signal to the servo valve. This signal is of correct polarity to prevent sticking of the valve and possibly overdriving the actual

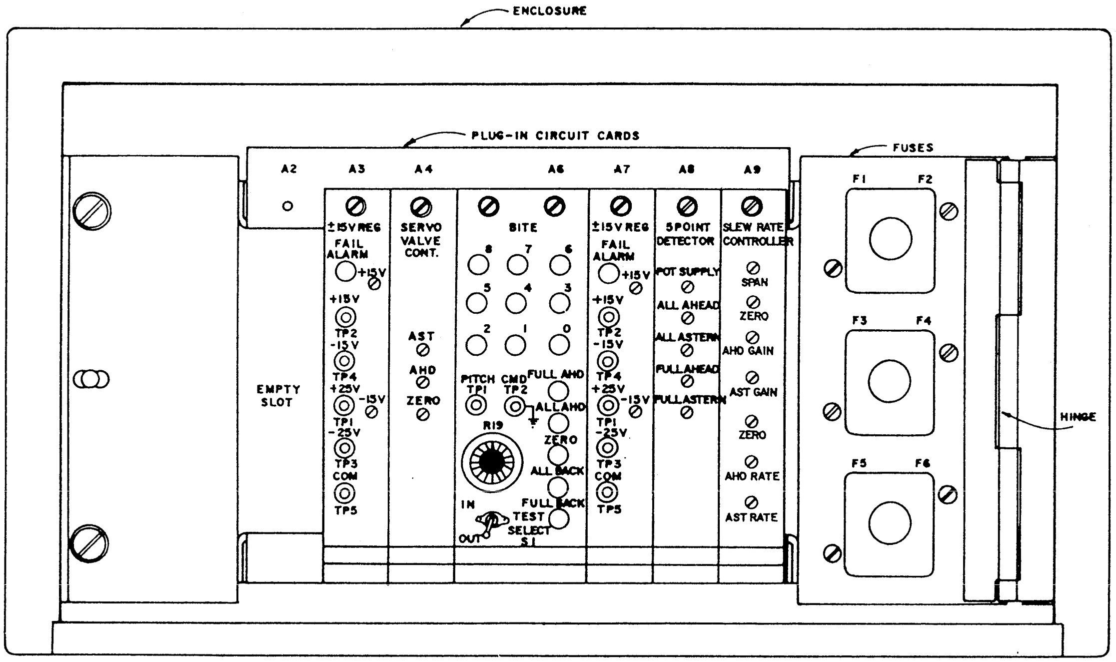


Figure 5-25.—CG-47 CRP electronic enclosure front panel.

pitch commanded. Second, it provides a "shaped" input to the five-point level detector circuit card. Third, it provides a scaled output signal that represents actual pitch position.

FFG-7 CLASS SYSTEM

The operation of the electrohydraulic control system of the FFG-7 class ships is similar to that of the CG-47 class ships. The FFG-7 class electrohydraulic control system does not have a separate CPP electronics enclosure. The electronics unit for the CPP system is located in the buckets of the local operating panel (LOP). The OD box on the FFG-7 class ship has the same potentiometer setup as that of the CG-47 class ship. The pitch of the CPP propeller is established electrically through a single electrohydraulic pitch control system. The system provides ahead and astern propulsion thrust by changing propeller blade pitch without changing propeller shaft rotation direction.

DDG-51 CLASS SYSTEM

In the DDG-51 class ships, the pitch of the CPPs is established electrically through two identical electrohydraulic pitch control systems. One is located in each main engine room. The system provides ahead and astern propulsion thrust by changing propeller blade pitch without changing propeller shaft rotation direction.

This system includes three major interfaces: pitch control; remote pitch indication; and alarms, indicators, and sensors. GSEs aboard DDG-51 class ships will be directly involved with the maintenance of this system. For this reason, we will briefly describe the three major interfaces between the ship's control system and the CPP system.

Pitch Control

The electrohydraulic servo control valve receives pitch change commands from the ship's main propulsion plant control system.

Remote Pitch Indication

Remote pitch indication is transferred to the ship's main propulsion plant control system by the temperature compensated pitch indicator (TCPI) and the electronic pitch indicator (EPI).

Alarms, Indicators, and Sensors

System pressures, oil levels, filter differential pressures, and hydraulic oil flow are provided to the ship's main propulsion plant control system.

The electrohydraulic servo control valve on a DDG-51 class ship is an electrically actuated, 4-way valve with a normally closed center position. The maximum inputs to the valve's torque motor are

±10 volts dc. The polarity of the ±10-volt dc process signal determines the direction of pitch change. The size of the signal determines the rate of pitch change.

The ahead or astern pitch signal from remote operating stations is fed directly to the electrohydraulic servo control valve. The pitch signal routed to the electrohydraulic servo control valve is directly proportionate to the amount of pitch desired. A linear potentiometer is mounted on the pitch scale of the TCPI assembly. The mechanical arm indicator is also attached to an actuating rod of a linear potentiometer. The function of the linear potentiometer is to transfer, or feed back, an indication signal representing actual valve rod position back to the remote control stations.

LCAC SYSTEM

In an LCAC, the purpose of the propeller pitch control system is to allow the operator to control the speed and direction of the craft by changing the propeller pitch. The propeller is capable of forward or reverse pitch. The greater the angle of pitch, the faster the craft will move. The propellers are controlled by two control levers located on the left-hand console of the operator control station and yoke in and out movement. (See fig. 5-26.)

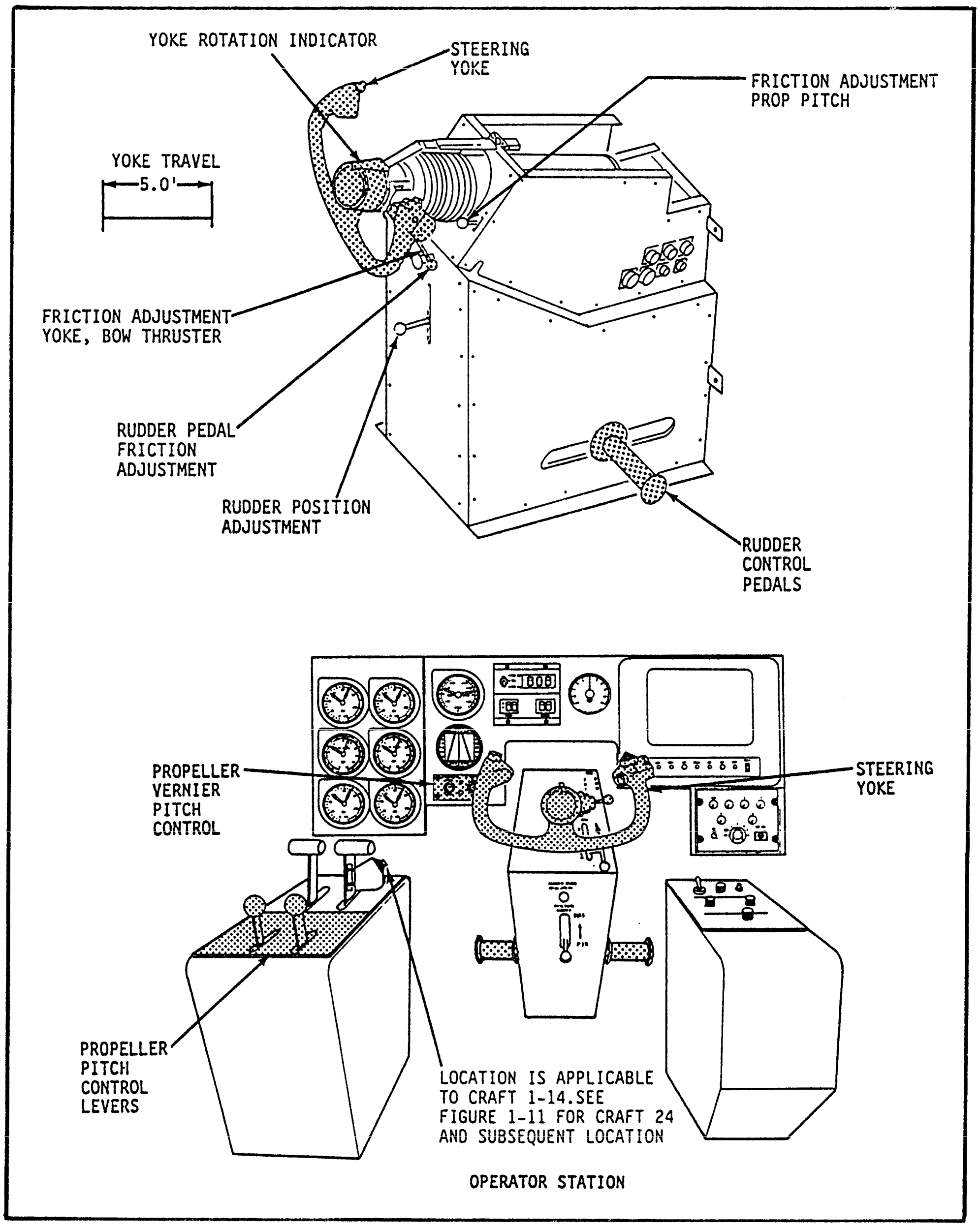


Figure 5-26.—LCAC steering control station.

The propeller pitch control system is composed of the yoke assembly, propeller pitch indicator, a control unit, pitch levers, potentiometers, and amplifiers. Pushing the yoke in or pulling it out will cause electrical signals to be sent to the electrohydraulic servo valve and actuator, which permits the operator to control the pitch of the propellers. (Refer to fig. 5-27). An indicator at the operator station provides an indication of propeller pitch.

Electrical control signals for the propeller pitch control are generated by the propeller pitch levers and by moving the yoke in and out. The propeller pitch levers set the center point for the plus and minus, in and out, movement of the yoke. Inward movement causes a pitch increase; outward movement causes a pitch decrease. Placing the propeller V PITCH switch in the OFF position takes the yoke out of the propeller pitch control system. Propeller pitch is then controlled by the propeller pitch levers. The propeller pitch signals are sent through the control systems electronic package (CSEP) to the propeller. If a CSEP malfunction occurs, a secondary CSEP channel maybe selected by using the command and control keyboard. The control voltage supplied to the propeller pitch control has a positive to negative voltage range.

TROUBLESHOOTING CRP/CPP SYSTEMS

For a GSE, familiarity with normal gauge readings and maneuvering times under varying conditions is essential to troubleshooting electrohydraulic control systems. Normal operating pressures will vary along with the following conditions:

- Changes in shaft speed
- At every position change throughout the pitch-changing stroke
- Between shaft sets because of manufacturing tolerances

As an operator or maintenance technician, you should avoid making any variations from these norms.

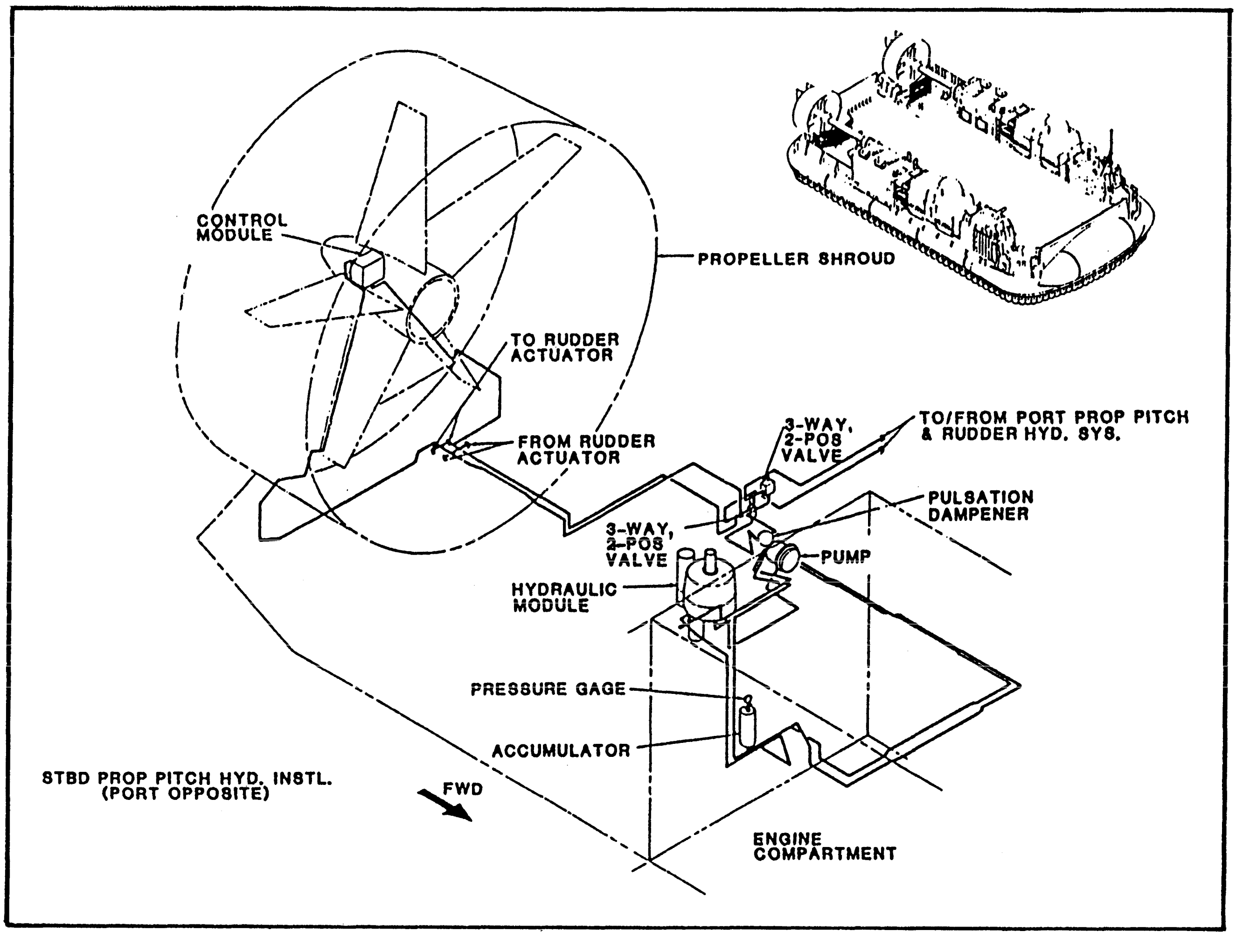


Figure 5-27.—LCAC propeller pitch control system.

When trouble occurs, examine the system, determine the cause, and record your findings.

Whenever you are troubleshooting pitch control systems, using the appropriate manufacturer's troubleshooting guide is essential. This guide is provided as an aid to troubleshooting and correcting faults that may occur in the propeller pitch system. The troubleshooting guide contains a description of symptoms noticeable to the operator along with a list of possible causes. Using this guide allows you to direct your attention to a specific component. Being able to identify both the type of malfunction and the faulty component will allow you to make a logical decision to repair, replace, or investigate further. Remember, a complete loss of control is most often caused by two malfunctioning components acting together. Either component alone might not cause any noticeable impairment of operation. Repairing one component may restore operation, however, it may also set the stage for a recurrence should a second malfunction be present.

When troubleshooting CRP/CPP systems, you should use the most effective method. This method includes the following steps:

1. Communicate with the personnel on watch when the system was performing correctly.

2. Communicate with the personnel on watch when trouble with the system first occurred.

3. Determine if corrective or scheduled maintenance was accomplished before the trouble was reported.

Troubleshooting the electrohydraulic control systems of different classes of ships is practically the same. All systems contain an electrohydraulic servo control valve. As a GSE, your troubleshooting efforts will be concentrated in this area. If your ship experiences erratic, slow, or no pitch response to normal commands, then you should suspect the electrohydraulic servo control valve. The following list contains some of the steps you can take to locate the exact cause of the failure:

1. Check for the voltage to the electrohydraulic servo control valve.

2. Check the electrohydraulic servo control valve falter for cleanliness.

3. Check the electrohydraulic servo control valve solenoid for proper operation.

4. Check the control circuitry of the electrohydraulic control system.

Another area of the electrohydraulic control system that deserves your concern is the pitch indicating system. If pitch readings on the remote consoles do not match the actual mechanical pitch settings, then trouble exists in the pitch indicating system. The circuits used to produce and display these indications are different on the various types of gas turbine ships. The methods you will use for troubleshooting the pitch indicating systems, however, are the same. The safety precautions you should observe and the equipment you should use for troubleshooting are the same.

Once again, the most important tools in troubleshooting the CRP/CPP systems are the manufacturer's technical manual and the troubleshooting guide. Remember, if you are troubleshooting the pitch indicating system, you will also have to use the technical manual for each specific console involved.

MOTOR AND GENERATOR MAINTENANCE

Another important job of the GSE is the maintenance of the motors and generators located in the main engine room. This maintenance includes keeping the motors and generators clean and troubleshooting any faults that occur. Faults with the brushes, brush rigging, and bearings are normally the extent of the repairs performed by the GSE. Larger and more extensive repairs, such as rewinding, insulating, varnishing, and balancing, are accomplished by tenders, shipyards, and sometimes by the electrician's mate (EM) on board your ship.

MAINTENANCE PROCEDURES

The essential points in the maintenance of electric generators and motors include the following steps:

1. Keep the insulation clean and dry and make sure it has high resistance.

2. Keep all electrical connections tight.

3. Keep the machines in good mechanical condition.

We will discuss each of these steps in the following paragraphs.

Cleanliness

Keeping the interior and exterior of motors and generators clean and free from dirt and debris is important. Dirt, salt, lint, oil, water, and especially carbon or copper dust, all present hazards to motors and generators. They can cause overheating, electrical grounds, and short circuits.

Electric motors and generators usually have some type of permanent air filter. This can be wire-mesh screen, perforated metal, or closely spaced metal strips. These air filters should be kept clean or at least replaced quarterly. When the ship is in an overhaul yard, adequate protection should be provided to electrical motors and generators. Motors and generators not required to be operated during the yard period should have their openings sealed to prevent entry of dirt and debris. Machinery required for operation should have protective screens of suitable filter material installed.

Several methods are used to clean motors and generators. You should choose the cleaning method that is the safest and most productive for your situation. The following list contains some of the preferred methods for cleaning motors and generators:

1. Wipe the motor or generator with a clean, lint-free, dry rag to remove loose dust or foreign particles. Make sure you clean the end windings, slip ring insulation, connecting leads, and all the terminals.

2. Use a vacuum cleaner to remove abrasive dust, dirt, and particles from inaccessible parts. This method is preferred over the use of compressed air because it lessens the chance of damage to the insulation.

3. Use air pressure to blow out inaccessible areas, such as armature air vents. Use air pressure up to 30 pounds per square inch (psi) to blow out motors and generators of 50 horsepower (hp) or 50 kilowatts (kW). Use air pressure up to 75 psi to blow out higher-rated machines.

4. Use inhibited methyl chloroform to remove grease and pasty substances consisting of oil and carbon or dirt. NEVER use gasoline, benzene, petroleum ether, or carbon tetrachloride for cleaning motors and generators.

5. Motors and generators that have been wet with salt water should be flushed out with fresh water and then dried. If possible, the machinery should be disassembled to permit a thorough cleaning.

Bolts and Mechanical Fastenings

Bolts and mechanical fastenings on both the stationary and rotating members should be tightened securely when the motor or generator is assembled. The bolts and fastenings are then checked after the equipment has run for a short time and thereafter checked at regular intervals to make sure they are still tight. You must pay particular attention to the bolts used to clamp any insulation.

Electrical Connections

All electrical connections should be inspected at regular intervals to make sure they are tight. Particular attention should be paid to terminals and terminal board connections. Loose connections result in increased contact resistance and increased heating that may result in breakdown. Use lock nuts, lock washers, or other means to lock connections that could come loose due to vibration. Make sure exposed electrical connections are adequately insulated to protect against water and moisture and injury to personnel. This applies especially to exposed connections at terminal straps extending outside the frames of motors and generators.

Bearings

One of the most frequent tasks for a GSE consists of maintenance, troubleshooting and replacing bearings in motors and generators. Bearings are designed to allow a rotating armature or rotor to turn freely within a motor or generator housing. Bearings must be properly maintained to reduce the heat caused by friction. Preventive maintenance of bearings consists of cleaning, lubricating, and periodic checks of bearing wear and conditions of bearing surfaces. For a more detailed description of bearing maintenance, refer to *GSE3/GSM/3, Volume 1,* NAVEDTRA 10563, and *NSTM,* chapter 244.

Brushes

Brushes are used in electric motors and generators to provide a passage for electrical current to an internal or external circuit. Proper maintenance practices will go far towards eliminating brushes as a frequent cause of failure. PMS procedures are established for the maintenance of brushes and brush riggings. The correct grade of brush and the correct brush adjustment are necessary to avoid trouble in motors and generators. You must identify the type of brush and its manufacturer when replacing brushes in motors and generators. Never mix different manufacturer's brushes or grades of brushes from the same manufacturer. Rapid brush wear could result from a mismatched set of brushes.

Whenever new brushes are installed or the old brushes do not fit, they should be fitted and seated. Accurate seating of the brushes where their surfaces contact the collector rings (slip rings) is essential. Sand paper and a brush seater are the best tools you can use to accomplish a true seat. The following paragraph describes the method you can use to seat the brushes of a generator by using sandpaper.

First, disconnect all power from the generator. You must take every precaution to make sure the generator will not be accidentally started while you are performing brush maintenance. Next, lift the brushes to be fitted and insert (sand side up) a strip of fine sandpaper between the brushes and the collector rings. Hold the sandpaper tightly against the collector rings. Allow the brushes to be held down by normal spring pressure. Pull the sandpaper in the direction of normal rotation of the generator, as shown in figure 5-28. When returning the sandpaper for another pull, lift the brushes. Repeat this procedure until the brushes are accurately seated. Always finish with a finer grade of sandpaper. Use a vacuum cleaner during the seating operation to prevent dust from reaching the generator windings and bearings. After sanding, use a vacuum cleaner to clean the collector rings and windings to remove all carbon dust.

Collector Rings

The collector rings on an ac generator should be given careful attention. The following procedures will help you to maintain good, polished surfaces:

1. Inspect the brushes regularly to see that they move freely in their holders.

2. Keep the rigging free from dust, oil, salt, lint, metal particles, and dirt.

3. Brushes need no lubrication, so you should keep the rings free from coating and scaling of any kind by cleaning them periodically.

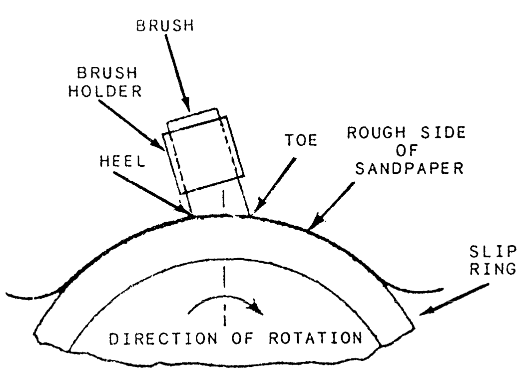


Figure 5-28.—Method of sanding brushes.

4. Inspect the working surfaces of the brushes occasionally and keep the full surface bearing on the rings. To prevent the formation of brush slivers, make sure the brushes do not extend beyond the edges of the rings.

Scoring of the collector rings is usually due to hard particles that become imbedded in the brush contact surfaces. This condition is also caused when the incorrect grade of brush is used. Correct scoring by resanding and refitting the brushes or by changing to the correct grade of brush.

Flat spots or pitting on the collector rings develop from many causes. Black spots can also sometimes appear on the collector rings. These are normally not serious, but they should be removed immediately (at the first securing of the generator). Rub the collector rings lightly with fine sandpaper to remove these spots.

Pitting sometimes develops because of the electrolytic action on the surface of the rings caused by current flow. This pitting is general over the entire ring area and does not cause localized flat spots. When this condition occurs, reverse the polarity of the rings. Leads to the collector brushes or at the switchboard should be made long enough to permit this reversal of polarity. Reversal of the polarity of the rings will in no way affect the phase rotation of the generator.

TROUBLESHOOTING PROCEDURES

Though proper preventive measures are taken on motors and generators, sometimes the GSE must troubleshoot these machines. Three of the most recurrent electrical troubles in motors and generators are grounds, open circuits, and short circuits. Because you, as a GSE, will have to locate and repair these faults, we will discuss each of these faults in the following sections.

Grounds

A ground on a motor or generator is a zero or low-resistance path that is caused by a breakdown in insulation. This condition extends from ground to a winding or some other conductor in the machine. If no other part of the system is grounded, a single ground in any of the windings of a machine will cause no particular harm to the machine. If, however, the machine and its connected circuit have *two* zero or low resistance grounds at points of different potential, the result will be similar to a short circuit. This condition could cause considerable damage. This danger can be avoided by keeping the machine and its connected circuits free from grounds. This is the reason that motors and generators are periodically tested for grounds.

When testing for grounds (except when a permanently installed ground detector system is used), make sure the machine is disconnected from its power supply. Make sure the machine cannot be accidentally started while you are performing the tests. Remember to use the proper electrical insulation test equipment for these tests.

Open Circuits

Open circuits in ac stator windings are usually due to damaged connections at the ends of the windings where the coils and circuits are connected. You can usually find this type of open circuit by visual inspection. When this does not suffice, taking resistance measurements between the phase terminals will reveal the presence of open-circuited coils. An open circuit seldom, if ever, occurs within the stator windings of an ac generator.

Open circuits that develop in the field windings of an ac generator that is carrying a load are indicated by the immediate loss of load and voltage. A generator with an open-circuited field winding should be secured immediately and examined to locate the open circuit. Open circuits infield windings usually occur at the connections between poles and can be located by visual inspection.

Open circuits can occur in brushless exciters as a result of centrifugal forces on the rotating diode assembly. Diode failure can result in either a reduction of exciter output (main generator field) voltage or a complete loss of output voltage. Diode failure by open circuiting can occur, but is uncommon.

Short Circuits

A short circuit in the stator of an ac machine will be indicated by smoke, flame, or odor associated with charred insulation. Secure the machine and feel the ends of the coils before they have time to cool. The shorted coil will be hotter than those next to it.

Short circuits in field coils of a machine may be indicated by these symptoms:

1. Vibration of the rotor due to unbalanced magnetic pull

2. Smoke or the odor of burning insulation if the short circuit is severe

3. The need to increase field current in generators to maintain normal voltage with the machine running at normal speed

Immediately secure a machine with a short-circuited field coil. You can find the shorted coil by passing normal current through the field circuit and measuring the voltage drop across each coil. The shorted coil will have the lowest voltage.

Short circuits occurring in brushless exciters are commonly the result of one or more defective diodes on the rotating rectifier assembly. Loss or reduction of field voltage combined with smoke or odor are symptomatic of this failure.

Vibration Analysis

Another method used in troubleshooting motors and generators is monitoring their vibration signatures. On a scheduled basis, performance monitoring teams come aboard ships to perform regular vibration checks on assigned equipment. The data obtained from their checks are recorded and analyzed to determine if the equipment is operating properly.

Vibration analysis is a program established as a preventive maintenance tool. It is a method of determining a piece of machinery's mechanical condition by measuring its vibration characteristics under normal operating conditions. It can also accurately show whether a machine has mechanical defects and whether a specific part is defective.

The principle of vibration analysis is based on the fact that all machines vibrate. These vibrations are caused by the allowable tolerance errors that are inherent in the machine's design; they form the baseline vibration signature of the individual machine. Similar machines have similar vibration signatures that differ from each other by only their manufacturing and installation tolerances.

A comprehensive vibration analysis program on board your ship is a proven preventive maintenance tool. This is made possible through periodic inspections to follow machinery condition trends and pinpoint possible failures. It also can be used to troubleshoot equipment for suspected problems, to verify proper repairs have been made to overhauled equipment, and to check newly installed equipment for proper installation. Most machinery problems can be detected in their early stages. In this way, you can prevent complete equipment failure and possible severe damage.

When a machine's vibration signature changes under its standard operating conditions, an impending defect is starting to change the machine's mechanical condition. Different defects will cause the vibration signature to change in different ways. Analyzing these data will provide a means of determining the source of the problem as well as a warning of the problem itself.

SAFETY AND HANDLING PROCEDURES

When it becomes necessary to disassemble and reassemble a motor or generator, follow the procedure outlined in the manufacturer's technical manual. Use the greatest care when handling the machines to prevent damage to any part. Remember, careless handling of parts will often cause more damage to a machine during disassembly or reassembly than the machine will receive in years of general use.

All rotating elements of motors and generators are carefully balanced in the manufacturer's plant before assembly. This reduces noise, vibration, and wear of collector rings and brushes. It also improves the overall electrical and mechanical performance of the machine. The balance tends to become worse during normal service because of vibration and shock. To maintain optimum performance, remember to handle the rotating parts carefully during disassembly and assembly.

ELECTRIC PLANT CONTROL SYSTEM MAINTENANCE

As you advance in the GS rating, your responsibilities for the maintenance, repair, and operation of the electric plant control system will increase. Your assigned tasks will include troubleshooting and repairing motor controllers, motors, power panels, lighting circuits, and distribution switchboards. It may appear that most of these tasks would belong to the EM. However, on most gas turbine ships, most of the electrical and electronic equipment and systems in the main engine rooms and the generator room is the responsibility of the GSEs.

The information in this section will provide you with a basic knowledge of 60-hertz (Hz) switchboards, transformers, voltage regulators, and water wash systems. After reading this section, you should be able to identify basic maintenance procedures involved with these components.

SWITCHBOARDS

Distribution of the electrical power generated by a ship's service gas turbine generator (SSGTG) or a ship's service diesel generator (SSDG) is accomplished by the switchboards. The operation and maintenance of the 60-Hz switchboards on all gas turbine-powered ships are similar, though they will, of course, consist of some items unique to a particular class of ship.

Construction

Switchboards are constructed to withstand high-impact shocks. Switchboard units consist of a sturdy box frame built of angles and other structural shapes. This design provides enough strength for the unit to resist breakage and distortion resulting from shock. It also provides enough stiffness to prevent excessive vibration.

All switchboards on gas turbine-powered ships are of the dead-front construction. This means the switchboard units are protected by a sheet metal enclosure. Figure 5-29 is an example of a dead-front

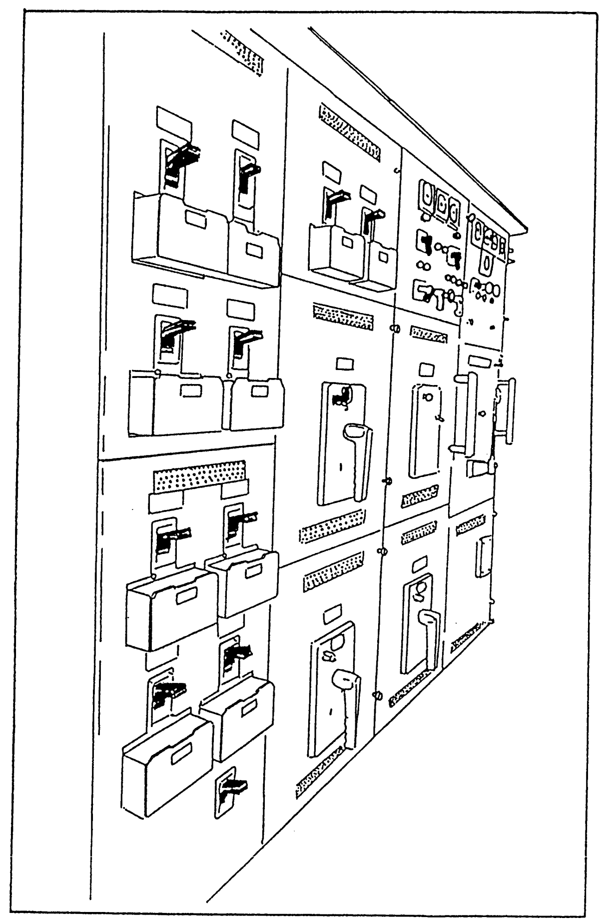


Figure 5-29.–Dead front of a ship's service switchboard.

switchboard. Notice that only the meters, operating handles, and switches protrude at the front of the switchboard. Figure 5-30 is an example of the rear of a switchboard that may be installed on a gas turbine-powered ship. The rear of the switchboard is enclosed in expanded metal or solid louvered panels for protection of personnel. The switchboard may consist of a single section, or several sections, physically separated and connected by cables. This sectional arrangement provides greater protection against damage. For you, as the technician, it also provides a means for localizing damage and for removing a damaged section for repairs or replacement.

Maintenance

Several failures of electrical equipment are caused by loose electrical connections and mechanical fastenings. Loose connections can be readily tightened. You must first, however, perform a thorough inspection to detect them.

INSPECTION.– Once a year and during each overhaul, each switchboard, load center, and distribution panel should be de-energized for a complete inspection and cleaning. The inspection should not be limited to a visual examination. It should also include grasping and shaking electrical connections and mechanical parts. This lets you make sure that all electrical connections are tight and that all mechanical parts are free to functiono

Check the supports of bus work and make sure the supports will prevent any contact between bus bars of opposite polarities. Also make sure the supports will prevent any contact between bus bars and grounded

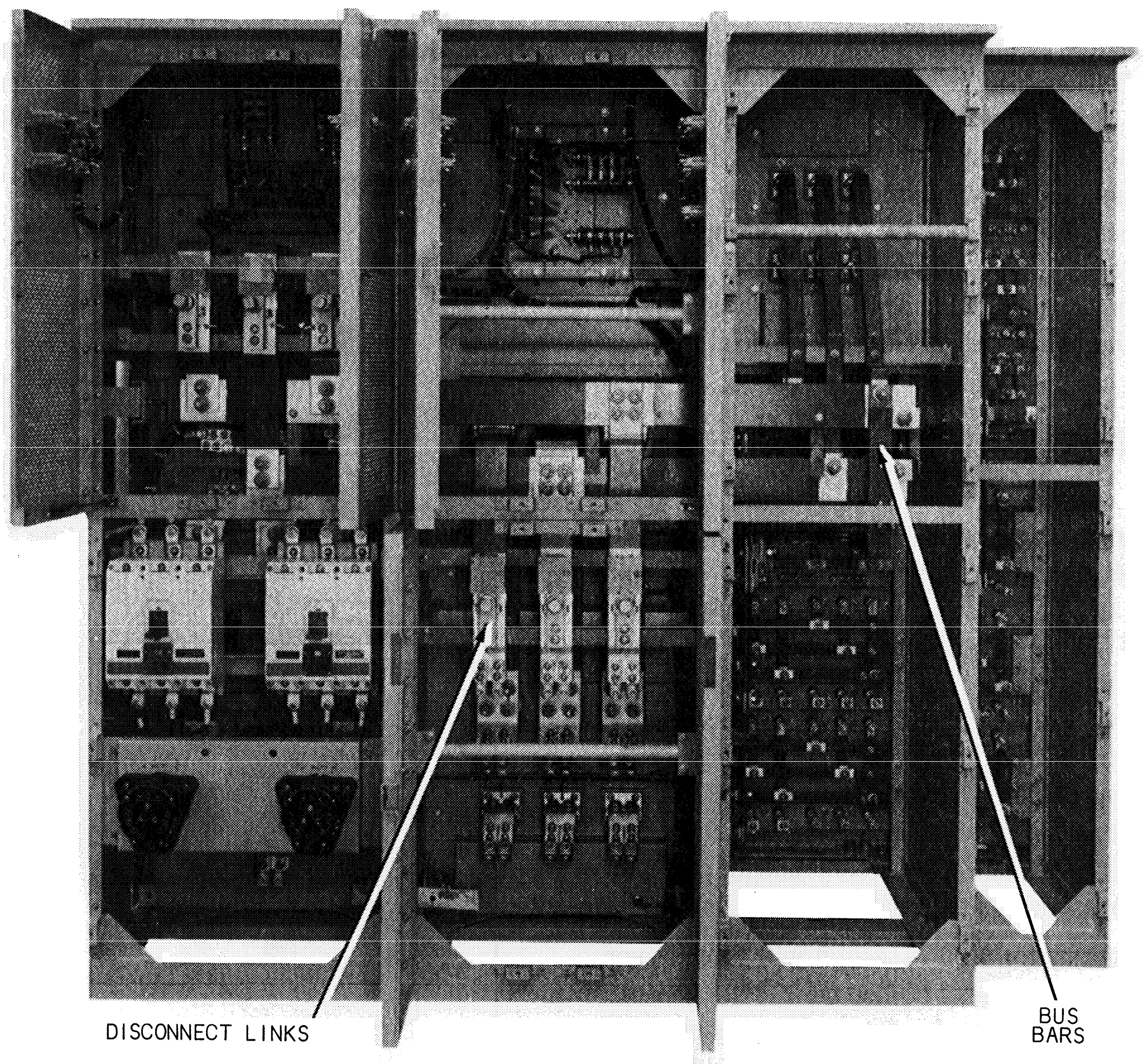


Figure 5-30.–Rear view of a ship's service switchboard,

parts during periods of shock. Be sure to clean both the bus work and the surfaces of the insulating materials.

Check the condition of control wiring and replace it if necessary. Make sure the ventilation of rheostats and resistors is not obstructed. Replace all broken or burned-out resistors. You can make temporary repairs by bridging the burned-out resistors when replacements are not available. Check all electrical connections for tightness and all wiring for frayed or broken leads. Check all meters for up-to-date calibration tags. Meters are calibrated at a calibration laboratory or on board a tender during regular availability. Make sure that all fuses are the right size and that the clips make firm contact with the fuses.

In addition to the inspections we have just discussed, make sure (impractical) that switchboards and distribution panels are de-energized after firing of the guns and inspected for tightness of both the electrical connections and the mechanical fastenings.

Protective circuits, such as reverse power, undervoltage, or underfrequency circuits, usually cannot be tested by actual operation because of the danger involved to the equipment. You should visually check these circuits. When possible, operate these relays manually to be certain that the rest of the protective circuit performs its intended function. Exercise extreme care not to disrupt vital electrical power service or to damage electrical equipment.

Your inspections should not be confined to switchboards and distribution panels. Your inspections must also include all adjacent installations that may cause serious casualties. Check the rubber matting in the way of switchboards for signs of deterioration, such as cracks in the material and separations at the seams.

The following examples are installation faults that could cause casualties:

1. Ventilation openings located to permit water to discharge onto electrical equipment

2. Insufficient insulation overhead to prevent heavy sweating near electrical equipment

3. Missing or inoperative drip-proof covers and spray shields on electrical equipment

4. Location of water piping and flanges where leakage could spray onto switchboards

Take action immediately to have these unsatisfactory conditions corrected.

CLEANING.– You can usually clean bus bars and insulating materials sufficiently by wiping them with a dry cloth. You can also use a vacuum cleaner to clean the bus bars. Be sure the switchboard or distribution panel is completely de-energized and remains so until the work is completed. Avoid cleaning energized parts and circuits because of the danger to personnel and equipment. Always follow the specified electrical safety precautions whenever you are cleaning or working around switchboards.

No live contacts are externally exposed on any switchboard on a gas turbine ship. You can clean the insulated front panels of switchboards without de-energizing the switchboard. Just wipe them clean with a dry cloth. However, you may have to use a damp, soapy cloth to remove grease and fingerprints. Afterward, wipe the surface with a cloth dampened in clear water to remove all soap, and dry it with a clean, dry cloth. Wring out the cleaning cloths thoroughly so no water will run down the front panels. Clean a small section at a time and then wipe it dry.

CAUTION

NEVER WIPE A METER FACE WITH A DRY CLOTH. Wiping can cause static electricity to buildup on glass faces and affect meter readings. Breathing on a meter face can help dissipate a charge of static electricity.

Troubleshooting

During troubleshooting of ship's service switchboards, you may have to remove, test, and replace many parts. Handle these parts with care. Improper handling of these electrical components can throw off the alignment of relays and potentiometers. When replacing these components, make sure the parts are placed back in proper alignment to assure correct operation. Again, make certain that all applicable safety precautions are followed.

Normally, working on energized switchboards is NOT permitted. However, on the occasion when you have to perform electrical repair on energized switchboards, take the following precautions:

1. Get the approval of the commanding officer.

2. Station safety observers at the switches or circuit breakers.

3. Demetalize yourself.

4. Wear rubber gloves and boots.

5. Make sure communications are established with all other sources of power that can be secured, if required.

6. Make sure a person qualified in cardiopulmonary resuscitation (CPR) is standing by.

On board ship, the most frequent troubles in electrical distribution systems will be electrical grounds. Frequent and proper use of ground detectors provided on the ship's service switchboards and certain power panels will help you to locate grounds. When troubleshooting, remember the electrical hazards inherent in ungrounded systems resulting from leakage currents.

To test a switchboard for grounds, use a megohmmeter (Megger). When preparing to test a switchboard for grounds, you must first determine if there is any low-voltage equipment in the circuit you are testing. The 500-volt output of the Megger could damage the components in these circuits. Since transistors, diodes, capacitors, and some rectifiers can be damaged by the high output of the Megger, they must be removed or short-circuited before you start testing for grounds.

TRANSFORMERS

A transformer transfers energy from one circuit to another by electromagnetic induction. This energy is always transferred without a change in frequency. It is, however, usually transferred with a change in voltage and current. Transformers are found in many circuits and components maintained by GSEs. You must understand their construction and operation to effectively troubleshoot and repair them.

Construction

The typical transformer has two windings insulated electrically from each other. These windings are wound on a cylindrical or rectangular cardboard form. In effect, the core material is air and the transformer is called an AIR-CORE TRANSFORMER. Transformers used at low frequencies, such as 60 Hz, require a core of low-reluctance magnetic material, usually iron. This type of transformer is called an IRON-CORE TRANSFORMER. In its most basic form, a transformer consists of four parts. As shown in figure 5-31, these four primary parts and their functions areas follows:

1. A core, which provides a low-reluctance path for the magnetic lines of flux

2. A primary winding, which receives energy from the ac source

3. A secondary winding, which receives energy from the primary winding and delivers this energy to the load

4. An enclosure, which protects all of the components from dirt, moisture, and mechanical damage

When a transformer is used to step up the voltage, the low-voltage winding is the primary winding. Conversely, when a transformer is used to step down the voltage, the high-voltage winding is the primary winding. The primary winding is always connected to the source of power. The secondary winding is always connected to the load.

Maintenance

The power-handling capacity of a transformer is dependent upon its ability to dissipate heat. If the heat can safely be removed, the power-handling capacity of the transformer can be increased. The heat built up in a transformer can be high enough to cause the insulation around the wire to break down. If this happens, the transformer may be permanently damaged. To help prevent this condition, a thorough inspection and cleaning of a transformer is necessary.

INSPECTION.— Periodically, each transformer should be de-energized for a complete inspection and cleaning. Since there are no moving parts in transformers, inspection is a simple task. This inspection should not, however, be limited to a visual examination. You should check the electrical connections for looseness by grasping and shaking them.

There is one inspection you can perform while the transformer is energized. As a competent technician, you should be constantly on the look out for transformers that are operating excessively hot. Take the proper corrective action quickly to prevent any permanent damage to the transformer.

CLEANING.— Dirty windings or clogged ventilation ports will usually cause a transformer to operate hotter than normal. When you notice a transformer that is operating excessively hot, make plans to have it secured and cleaned. YOU can usually sufficiently clean transformers by wiping them with a dry cloth. Be sure all transformers are completely de-energized and isolated and remain so until the work is completed. Always follow all electrical safety precautions when you clean transformers.

Troubleshooting

Transformers are usually trouble-free. Because transformers normally do not malfunction, troubleshooting should be a simple task. Since

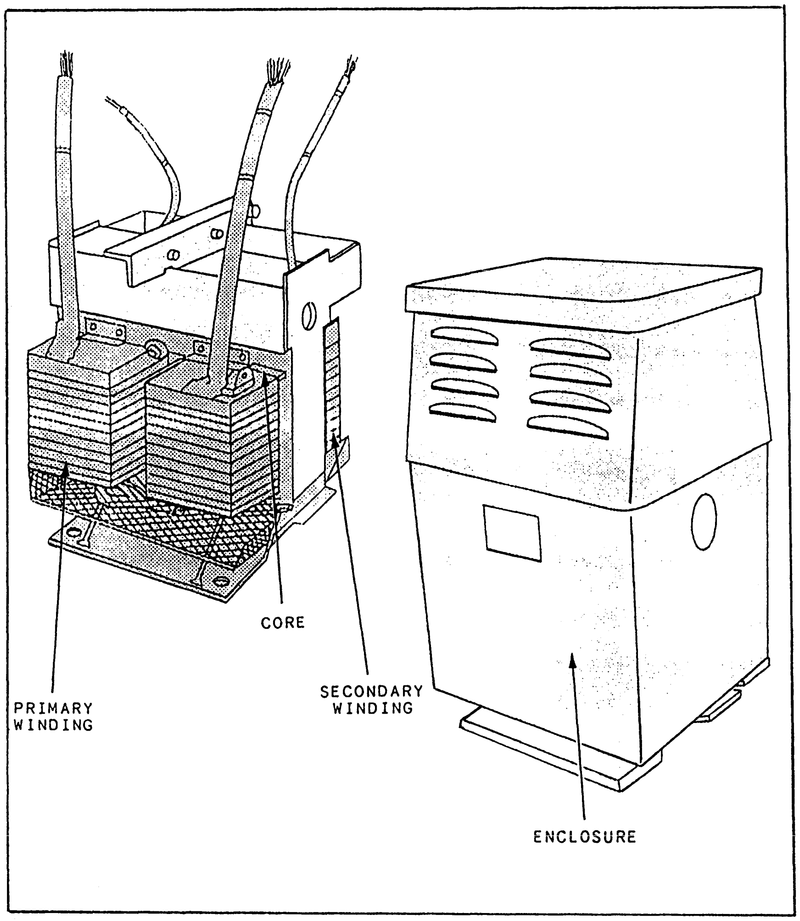


Figure 5-31.—Basic parts of a single-phase transformer.

transformers have no moving parts, only electrical malfunctions will occur. The windings can become short-circuited, grounded, or open-circuited. The troubleshooting techniques you should use to isolate these problems are the same as those you would use for any other electrical component. When taking readings on the primary and secondary windings of a transformer, make sure the windings are isolated from other circuits. This precaution will help you to eliminate errors in your readings.

Once again, observe the standard safety precautions when working on transformers.

WARNING

Always wear safety goggles. The cooling liquids used in transformers could damage your eyes if the transformer should overheat and explode.

Keep a cool head and think about the possible consequences before you perform any action. Carelessness is the cause of most accidents. Remember the best GSE is not necessarily the fastest one, but the one who will be on the job tomorrow.

VOLTAGE REGULATORS

The voltage regulators used on gas turbine-powered ships differ in type and design. The auxiliary equipment used with each voltage regulator may also differ in type, function, and design. Because of these differences, no attempt will be made in this TRAMAN to describe in detail the construction, operation, care, and maintenance of each type of voltage regulator. The following discussion will be limited to general information that will provide you with some basic guidelines in the care and maintenance of voltage regulators.

Always refer to the applicable technical manuals for a detailed description of the construction, operation, care, and maintenance of any particular voltage regulator. You should be thoroughly acquainted with the contents of the technical manual and with the information contained in this section.

A voltage regulator consists of a control element and the associated mechanical or electrical means to produce the changes in the generator field current. These changes are necessary to maintain a predetermined constant generator terminal voltage. The function performed by voltage regulators and their auxiliary equipment is to keep the generator terminal voltage within specified limits. The voltage regulator also provides for proper division of the reactive current between generators operating in parallel.

If you consider all the possible combinations of types of voltage-sensitive elements and their associated control means, you can visualize why there are so many different types of voltage regulators. The two types used specifically on gas turbine-powered ships are the

- static exciter and electronic voltage regulator, and the
- rotating brushless ac exciter with electronic voltage regulator.

We will briefly discuss each of these types.

Static Exciter Voltage Regulator

The static exciter voltage regulator system supplies dc current to the ac generator field by rectifying a part of the ac generator output. The voltage detector consists of a network of capacitors, reactors, and resistors. It controls the power input to the generator field by magnetic amplifiers or silicon controlled rectifiers (SCRs).

This type of voltage regulator system is found on the DD-963, DDG-993, and FFG-7 class ships. The voltage regulator on the DD-963 and DDG-993 class ships is located in the generator control unit (GCU) for the associated generator. The GCU is mounted near each associated switchboard. The voltage regulators on the FFG-7 class ships are located in cabinets in the auxiliary machinery rooms (AMRs) and in the switch gear room.

Brushless AC Exciter Voltage Regulator

The brushless ac exciter voltage regulator system controls the dc power delivered to the stationary field of a brushless exciter. Its rotating armature ac output is rectified by SCRs mounted on or in its shaft. The regulated dc power is connected directly to the main generator field. This statically controlled rotating system is brushless, having no commutators or slip rings. Because of this design, measurement of main generator field voltage and current is not practical.

This type of voltage regulator is found on the CG-47 class ship and is located in the GCU mounted near each associated switchboard. The voltage regulator on the DDG-51 class ship is located in the exciter control panel (EXCOP).

Maintenance

Voltage regulator systems on board gas turbine-powered ships are maintained by PMS. Remember to refer to the appropriate manufacturer's technical manuals for detailed instructions concerning the maintenance of voltage regulators. You can, however, use the following general instructions whenever you are performing maintenance on any voltage regulator:

1. Make sure all connections to the voltage-sensitive element and those between the element and all the auxiliary equipment are tight. These connections should be exactly as specified in the manufacturer's wiring diagram.

2. Make all necessary adjustments according to the manufacturer's technical manual.

3. Make sure all contacts are clean and free from grease, dirt, or other foreign material.

4. Make sure all brushes, relays, contractors, damping devices, and motor-operated potentiometers move freely and smoothly. Make sure these components are unobstructed by any foreign material.

5. See that the connections to the contacts of the voltage-sensitive element and relays give the correct direction of rotation to the pilot motor of the field rheostat.

6. Make sure the contact arm of the motor-operated field rheostat moves smoothly over its entire range. This movement should be at the same speed up and down, when driven by the pilot motor or when operated by hand.

7. Check the limit switches to see that they function properly to disconnect the pilot motor from the line when they are tripped by the contact arm.

8. Make sure the pilot motor is clean and free from cracks, chips, and obstructions. Check the motor for signs of overheating.

Troubleshooting

When troubles develop in voltage regulators, you must locate the faulty component, remove it, and replace it with a new one. Once again, you should use the manufacturer's technical manual to isolate the troubles. Remember, you should consider the common malfunctions we will discuss in the next paragraph as supplemental information to the specified malfunctions and corrective actions in the appropriate technical manual.

When a voltage regulator is not operating properly, you must observe the symptoms provided to you. You must know what the unit is supposed to do before you can determine what it is not doing or what it is doing incorrectly. The following list contains several common malfunctions that occur in voltage regulators:

- Open circuits in leads to and from the rectifier assembly
- Open circuits between the exciter field and the regulating resistance
- Short circuits of the regulator terminals
- Obstructions in any of the moving parts
- Loose or faulty connections in various circuits
- Binding or function in the pilot motor assembly
- Friction in the moving parts of relays or rheostats
- Dirt, grease, or other foreign materials on the contacts of relays or rheostats
- Faulty diodes, transistors, capacitors, and other small electronic components
- Misalignment of the gears, screw, or rod of the motor-operated potentiometer assembly

During troubleshooting, you can loosen many of the connections to perform various tests. You can also remove and replace several parts during these tests.

A voltage regulator is a very sensitive piece of equipment. You must make sure to handle its parts with care. The alignment of limit switches, control relays, and motor-operated potentiometers can be thrown off by improper handling. When replacing these components, make sure to place the parts back in proper alignment to ensure correct operation. Make sure you use the correct soldering and resoldering techniques. (Sometimes, more harm than good is done by use of improper soldering techniques.)

You must also use extreme care when tagging out the voltage regulator for maintenance. Most voltage regulators have multiple sources of power. When securing power to the voltage regulator, make sure you investigate your ship's particular system. Finally, be certain you follow all applicable electrical safety precautions whenever you are performing maintenance and repair on voltage regulators.

WATER WASH SYSTEM

A water wash system is a maintenance feature provided to remove dirt, salt, or other foreign deposits from the internal parts of a gas turbine. Water washing is accomplished by spraying a mixture of distilled water and cleaning agent into the compressor while the gas turbine is motoring. Rinsing is done in the same manner, using distilled water only.

A water wash system is found on the LM2500 GTE for the DD-, DDG-, CG-, FFG-, and PHM-class ships. It is also found on the Allison gas turbine generators on the DD-, DDG-, and CG-class ships. The LCACs have a water wash system on Lycoming TF40B main engines and the Sunstrand T-62T auxiliary power unit. The PHMs also have a water wash system on the Garrett ship's service power unit.

The water wash system on each gas turbine-powered ship is unique in its own design. Although many different types of components are found in each design, the following electrical components are common to most water wash systems on gas turbine-powered ships:

- Level switches
- Solenoid-operated valves
- ON/OFF water wash toggle switches
- TANK EMPTY indicators
- Heaters
- Magnetic controllers

We will briefly discuss the maintenance and troubleshooting techniques for these common components.

Maintenance

You can accomplish the maintenance procedures for the components of your ship's water wash system by using the basic procedures we have already covered in this chapter. Like other systems, the water wash system must be periodically inspected and tested. Failure is often caused by loose electrical connections and inoperative solenoid valves. The keys to maintaining a trouble-free water wash system are thorough inspections and tests.

INSPECTION.— The gas turbine engine should be water washed according to PMS. During PMS, the system should be inspected according to the MRC. The inspection should not be limited to a visual examination, but also should include checking for loose electrical connections and mechanical parts.

Check the condition of control wiring to the solenoid valves and replace it if necessary. Check all electrical connections for tightness and all wiring for frayed or broken leads. Check the printed circuit card for signs of overheating around the resistors.

TESTING.– Testing the water wash system should also be accomplished through PMS. In fact, the components of the system should be tested during a water wash cycle. As a GSE, you will be looking for any signs of electrical trouble. If you are called upon to investigate a problem with the water wash system, you must understand how the system operates. This knowledge will help you to cut down maintenance time.

Troubleshooting

Troubleshooting the water wash system presents no new techniques. Earlier in this chapter we discussed the procedures you should use to troubleshoot and repair many of the components of the water wash system, such as the solenoids, microswitches, and controllers. In the following paragraphs, we will limit our discussion to the procedures you will use to maintain and repair level switches (float switches) and heaters.

LEVEL SWITCHES.– Level switches are used in water wash systems of gas turbines for different reasons, depending on the system installed. On FFG-7 class ships, there are three level switches in the water wash tank One switch provides a high-level signal for logic circuits in the propulsion control system (PCS). Another switch provides a low-level signal for the logic circuits in the PCS. The other switch controls the energizing of the tank heater. On the DD-, CG-, and DDG-class ships, one level switch is installed in the water wash system. This switch provides a signal to illuminate the water wash TANK EMPTY indicator lights at the local console. The LCAC system also has one level switch. It is located in the supply tank and provides a FULL indication at the fill connection.

Most floats used inside the wash tanks are maintenance-free. The switch contacts are sealed inside a bell-shaped float. A wire extends out of the top of the float to allow for connection to the circuits. As the float rises and tips over, the contacts close, completing the circuit to the water wash system's electronics. If the float fails to operate, you must gain access to the float to replace it.

To test the float, first drain the wash tank. Then open the access cover to remove the float from the tank. Of course, you must follow all applicable safety precautions, including those for tagging the system out of service and securing the electrical power. Next, using an ohmmeter, tip or raise the float while reading the resistance value at the connections. If there is no change in the resistance, the switch in the float is faulty. Since the contacts are sealed inside the float, you cannot repair the switch. You must, therefore, remove and replace the float.

HEATERS.– A heater is located in the wash tank of the FFG-7 class water wash system. It is used to heat the water wash solution (if required). You can energize the heater by depressing the ON push button on the heater's magnetic controller.

Troubleshooting the heater is a simple task for a GSE. Just take a resistance reading on the input leads to the heater. Refer to the manufacturer's technical manual to find the correct ohmic value for the heater. If the reading is within tolerance, check the magnetic controller for a fault. Use the maintenance and troubleshooting procedures for magnetic controllers we discussed earlier in this chapter.

POWER SUPPLIES

In today's Navy, all electronic equipment requires some form of power supply. On gas turbine-powered ships, the electronic control consoles contain many power supplies. Although the appearance and construction of these power supplies may differ, the basic operation is the same. In this section, we will discuss the components and the operation of a basic power supply. We will also discuss the maintenance and troubleshooting techniques involved with power supplies.

It is beyond the scope of this TRAMAN to try to discuss all types of power supplies used on gas turbine-powered ships. The differences are too abundant; therefore, we will discuss only the common points of interest. For a more detailed description, refer to the technical manual that applies to your ship's equipment.

BASIC POWER SUPPLY

Most power supplies are made up of four basic sections: a (1) transformer, (2) rectifier, (3) filter, and (4) regulator. Study figure 5-32, which shows the block diagram of the basic power supply.

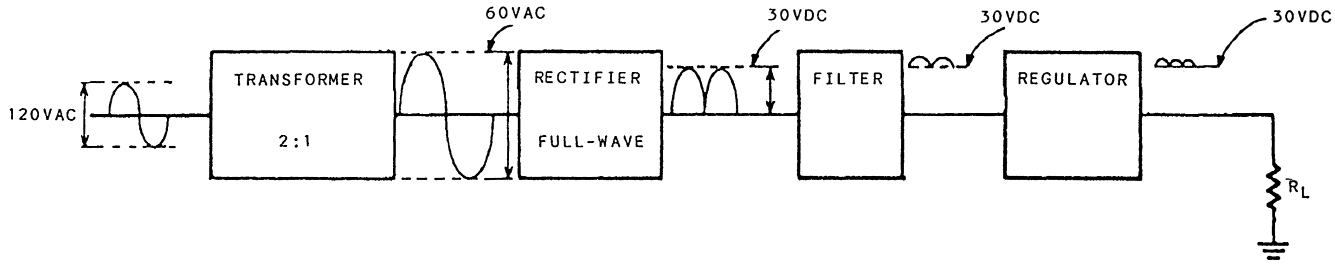


Figure 5-32.—Block diagram of a basic power supply.

The first section is the transformer. The transformer serves two purposes: (1) to step up or step down the input voltage to the desired level and (2) to couple this voltage to the rectifier section. The rectifier section is used to convert the ac signal into a pulsating dc voltage. However, this pulsating dc voltage is not desirable and must be smoothed. For this reason, the filter section is used to convert the pulsating dc voltage into a filtered dc voltage. The final section, the regulator, does just what its name implies. It maintains the output of the power supply at a constant level in spite of large changes in load current or in input line voltage. The output of the regulator will maintain a constant dc voltage within certain limits.

Now that you know what each section does, let's trace a signal through the basic power supply. You will see what changes are made to the input signal as it passes through each component of the power supply. Refer to figure 5-32 during this discussion.

The input signal of 120 volts ac is applied to the primary windings of the transformer. The transformer has a turns ratio of 2:1. The output of the step-down transformer is calculated by dividing the input voltage by the ratio of turns in the primary windings to the turns in the secondary windings. Therefore, 120 volts ac ÷2 = 60 volts ac at the output. Because the diodes in the rectifier section conduct only on the positive half of the input signal, the output will be only half of the input signal. The output will be 30 volts of pulsating dc, sent to the filter section of the power supply. The filter section contains a network of resistors, capacitors, or inductors. These components control the rise and fall time of the varying signal so the signal remains at a more constant dc level. You can see that the output of the filter is at a 30-volt dc level with an ac RIPPLE voltage riding on it. (Ripple voltage is a small ac voltage riding at some dc voltage level. Normally, ripple voltage is an unwanted ac voltage created by the filter section of a power supply.) The output signal from the filter goes to the regulator. The regulator maintains a signal of about 30 volts dc to the load. You will read about voltage regulators in the following sections.

REGULATORS

The output of a power supply varies somewhat with changes in input voltage and circuit load current requirements. The electronic consoles on gas turbine ships require operating voltages and currents that remain constant. For this reason, some form of regulation is needed. The circuits that maintain power supply voltage or current outputs within specified limits, or tolerances, are called regulators. They are designated either as dc voltage regulators or dc current regulators.

Voltage Regulators

Voltage regulator circuits are additions to the basic power supply circuits. The purpose of the voltage regulator is to provide an output voltage with little or no variation. Regulator circuits sense changes in output voltages and compensate for the changes. Regulators that maintain voltage within plus or minus 0.1 percent are common.

Current Regulators

In most power supplies, current is not directly regulated. Fuses and other circuit protection devices are used to set an upper limit to the amount of current that can flow in a power supply. Current is left unregulated because the load will draw from the power supply only the amount of current that it needs. Fluctuations in the power supply voltage caused by variations in load current are usually controlled by the voltage regulator.

TROUBLESHOOTING

Whenever you are working on the power supplies of the ship's consoles, using the proper safety precautions is the most important thing you should remember. Always refer to the manufacturer's technical manual when you are preparing to adjust power supplies. Before starting work on any electronic equipment, always make sure the equipment is properly grounded. Also make sure the rubber matting you are standing on is in good condition.

Although the power supplies for the consoles are more sophisticated than the one described in this section, the troubleshooting principles are the same. Many of the power supplies on gas turbine ships have LEDs to show when the output of the power supply is out of limits. Usually, one LED indicates high output voltage and another LED indicates low output voltage. There may be still another LED that indicates a fault has occurred in the power supply. Remember, you must refer to the appropriate technical manual to understand what causes each LED to light.

TESTING

In testing electronic power supplies, there are two widely used methods you will use: (1) visual check and (2) signal tracing. Because you will use both of these methods to test and maintain your ship's power supplies, we will describe the procedures for each of these methods, starting with the visual check.

Visual Check

The importance of the visual check should not be underestimated because many GSEs can find defects right away simply by looking for them. A visual check does not take long. In fact, you should begin to see the problem in about 2 or 3 minutes, if it is the kind of problem that can be seen.

When visually checking power supplies, you should use the procedures described in the next paragraph. You will find yourself using this method often, as it is good not only for power supplies but also for any other type of electronic equipment.

Before you install any power supply in a console or electronic enclosure, look for the following problems:

1. SHORTS–Examine any terminal or connection that is close to the chassis or to any other terminal for the chance of a short. A short in any part of the power supply can cause major damage. Look for and remove any stray drops of solder, bits of wire, nuts, or screws. It sometimes helps to shake the power supply module and listen for any tell-tale rattles.

2. A DISCOLORED OR LEAKING TRANSFORMER—This is a sure sign there is a short somewhere in the power supply circuits. If the equipment has a fuse, find out why the fuse did not blow. See if the correct size fuse is installed. Also make sure there is not a short across the fuse holder.

3. LOOSE, BROKEN, OR CORRODED CON - NECTIONS– Any connection that is not in good condition is a trouble spot. If it is not causing you trouble at the present, it will probably cause problems in the future.

4. DAMAGED RESISTORS OR CAPACI- TORS— A resistor that is discolored or charred has been subjected to an overload. An electrolytic capacitor will show white deposits at the seal around the terminals. Whenever you notice a damaged resistor or capacitor, check for a short. Make a note to replace the damaged or faulty part after you have performed your signal tracing procedures. There is no sense in risking a new part until the trouble is located.

After you install a power supply, apply power to the console or the electronic enclosure and look for the following defects:

1. SMOKING PARTS— If any part smokes, or if you hear any boiling or sputtering sounds, power the unit down immediately. Somewhere there is a short circuit you have missed in your first inspection. Use an ohmmeter to check the power supply once again. It is a good idea to begin in the area of the smoking part.

2. SPARKING— Tap or shake the power supply. If you hear or see any sparking, you have located a loose connection or short. Once again, check the power supply and repair it.

If you locate and repair any of these defects, make a note of what you find and what you plan to do to correct it. It is likely you have found the trouble. However, a good GSE takes nothing for granted. You must prove to yourself that the equipment is operating properly and that no other troubles exist.

If you do not find any of the defects we have just discussed, go ahead with the second check used in testing: signal tracing. The problem is something you cannot see directly with your eyes. You must view it through the eye of your test equipment.

Signal Tracing

Tracing the ac signal through the power supply is the most rapid method you can use to locate trouble you cannot find by a visual check. It is helpful to use an oscilloscope when you are testing power supplies. The idea is to trace the ac voltage from the transformer, to see it change to pulsating dc at the rectifier section, and then to see the pulsations smoothed out by the filter. The point where the signal stops or becomes distorted is the place you should look for trouble.

Before you begin signal tracing, it is a good idea to measure the dc voltage. If you have no dc output voltage, you should look for an open or a short in your signal tracing. If you have low dc voltage, you should look for a defective part. Keep your eyes open for the place where the signal becomes distorted.

No matter what power supplies you may come across on the various classes of gas turbine-powered ships, they all do the same thing. They change ac voltage into usable dc voltage(s). For that reason, basic troubleshooting and testing will be the same. Although you may experience problems that have not been covered specifically in this section, you should have gained enough knowledge to localize and repair any power supply problem that may occur.

ADJUSTMENTS

Many console power supplies contain dc/dc converters that require adjustment of their output levels. The adjustment variable resistor and the test points for monitoring converter output are accessible when the power supply cover is removed. An example of a dc/dc converter with test points, fault LEDs, and an output adjustment resistor is shown in figure 5-33.

Power supplies contain different types of de/de converters. These converters vary only in their development of different outputs. The procedures for adjusting each converter will differ only in the specification of the output level. When adjusting the converters of console power supplies, make sure they are under normal load conditions. Some power supply converters are wired in parallel pairs. Adjust these by alternately securing the power to one power supply, while adjusting the other.

PUMP LOGIC CALIBRATION

One important and frequently performed task of the GSE is to make sure the fuel oil and lube oil pumps cycle as designed. This action is called pump logic calibration. Pump logic calibration is accomplished according to PMS. As a GSE, you must be able to recognize and correct any malfunctions that occur with pump logic. Your actions will help keep the engineering plant operating at its maximum efficiency.

Each gas turbine-powered ship has different pump logic settings. These differences are too numerous for us to cover in this TRAMAN. In this section, however, we will discuss the basic elements of pump logic calibration. Remember, refer to the appropriate technical manual for detailed descriptions of the proper settings for fuel oil and lube oil pumps.

PUMP LOGIC FUNCTION

During normal operation, the fuel oil booster pumps and lube oil pumps are automatically cycled by pump control logic. They are cycled between off, slow, and fast to maintain header pressure. Pump control logic will control the pumps to increase header pressure when pump output is inadequate to meet demand.

The cycling characteristics and pressures differ on each class of ship. Fuel oil pump control logic prevents loss of fuel to the gas engines by cycling the pump (or pumps) up to fast when the pressure drops. Sometimes, fuel pump control logic cycles both pumps to stop if pressure does not recover after a determined number of seconds. This action prevents flooding of the engine room if a fuel leak develops.

On some ships, the fuel pumps must be slowed or stopped manually. Lube oil pump control logic prevents reduction gear damage by constantly providing positive lube oil pressure to the gear. Pump logic usually cycles the lube oil pumps up and down with respect to lube oil pressure.

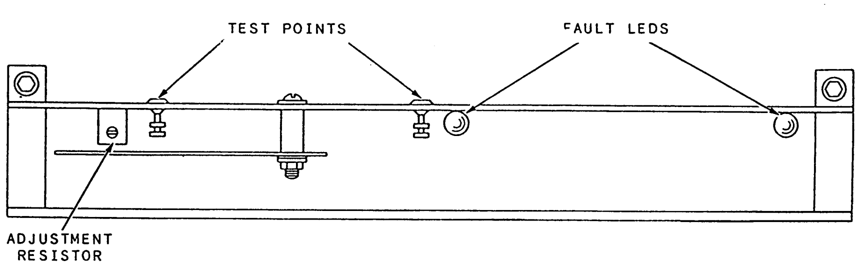


Figure 5-33.—Power supply dc/dc converter.

PUMP LOGIC TESTING

Testing the pump logic circuits is usually accomplished with PMS. The MRC gives you step-by-step instructions on how to set up your fuel oil and lube oil system to complete the test. You accomplish the test by disconnecting the transducer input from the system and hooking up a gauge comparator to the transducer. The comparator will simulate system pressure. Next, you pump up the comparator to reach normal system pressure, and then decrease the pressure to a predetermined level. Maintain this level for a required number of seconds, after which the pump or pumps will shift speed to maintain pressure. You are checking to see if the pump or pumps will shift up or down within the required time frame. You should continue this procedure until all specific operating points are tested. After completing the test, return the system to its normal configuration. If the test is not satisfactory, you will have to start troubleshooting to find the problem.

PUMP LOGIC TROUBLESHOOTING

When a console operator experiences a problem with pump logic, he or she will contact you, the GSE. One of your first steps in troubleshooting pump logic circuits is to open the console and check for any fault LEDs that may be lit. Examination of the circuit cards with lighted LEDs will be your next logical step. Upon identifying a malfunctioning circuit card, refer to the proper troubleshooting diagram to identify the faulted area.

If there are no faulted circuit cards, you will have to determine if a problem exists. If the ship is underway and the system has to be on line, you can not actually work on the problem. While waiting to work on the system, take the opportunity to look at how the system is operating under normal conditions. Take notes on how the system is functioning. Your notes should include pressures, times, and system configuration. When system operation is no longer required, you can use the gauge comparator to duplicate those conditions. Using the PMS card, test the pump logic circuits. If the test fails, you will need to refer to the manufacturer's technical manual.

There are several reasons the pump control logic could malfunction. The following list contains some of the problems that can cause the pump control logic to fall:

- Malfunctioning magnetic controller
- Faulty pump
- Faulty pump control logic card
- Faulty delay timer or time control card
- Faulty relay driver card or relay actuator
- Malfunctioning switches

If the problem lies within a particular console, you must take certain procedural steps to locate the faulty subassembly or circuit card. Use the following steps to troubleshoot console equipment malfunctions:

1. Energize the console and related equipment for troubleshooting.

2. Identify the faulting fictional area.

3. Refer to the technical manual to locate the signal flow diagram that relates to the faulting functional area.

4. Using the proper troubleshooting diagram, isolate the malfunction to the faulting subassembly or circuit card.

5. When you have isolated the fault to a particular circuit card or subassembly, perform corrective maintenance by replacing the faulty part.

When troubleshooting the pump control logic circuits, always use proper troubleshooting techniques and follow all applicable electrical safety precautions.

PROPULSION SYSTEM MAINTENANCE

Most maintenance tasks for the GSE will involve console upkeep and maintenance. The GSE must remove and replace various parts of the engineering plant consoles. Each gas turbine-powered ship has several control consoles, each with its own technical manual.

In this section, we will discuss the procedures you will use to perform maintenance on the consoles of several different classes of ships. The basic maintenance techniques are the same throughout the GSE rating. An extensive discussion of the maintenance required on control consoles is beyond the scope of this TRAMAN. Therefore, the procedures described in this section are basic in nature. Refer to the proper console technical manual for a detailed description of the maintenance required on your particular propulsion control consoles.

FUEL SYSTEM CONTROL CONSOLE

The FSCC is located in the CCS of DD-963, DDG-993, and CG-47 class ships. This console provides operator control and monitoring of the ship's fuel storage and transfer system. Maintenance of this console is the responsibility of the GSEs.

FSCC Testing

Testing the FSCC is a task you, the GSE, must perform daily. The daily tests consist of a hazard alarm test, fault alarm test, and lamp test.

You will use the hazard alarm test to make sure the hazard alarm circuits are functioning properly. Start the hazard alarm test by depressing the HAZARD ALARM TEST push button on the FSCC. This action will cause each hazard alarm circuit to start a hazard alarm, consisting of a 4-Hz flashing light and a 4-Hz tone.

You will use the fault alarm test to make sure the fault alarm circuits are functioning properly. Start the fault alarm test by depressing the FAULT ALARM TEST push button on the FSCC. This action will cause each fault alarm circuit to start a fault alarm, consisting of a 1-Hz flashing light and a 1-Hz tone.

The last daily test you must perform on the FSCC is the lamp test. Start the test by depressing the LAMP TEST push button on the FSCC. This action will cause all the indicator lights not checked by the alarm tests to light steadily, allowing you to locate burned out lamps on the console.

You will also test the meters on the FSCC, but not daily. In these tests, you must use the calibrate panel on the back of the FSCC. You will usually calibrate these meters before refueling and during PMS. You will use the calibrate panel to accomplish calibration of the storage tank level meters, the receiving tank pressure meters, and the high seawater and fuel overflow alarms.

FSCC Maintenance

Most of the maintenance required on the FSCC will stem from the failure of one of the tests we have just described. If an indicator fails to light or a meter fails to respond correctly, you must find the cause of the failure. Always refer to the manufacturer's technical manual whenever you perform maintenance on the FSCC.

When you are trying to locate a problem, there are several circuits in the FSCC you must investigate. There are a total of 32 printed circuit boards (PCBs) used in monitoring, alarm, and control functions. The FSCC also has eight power supplies located in the power supply drawers. Maintenance of power supplies was discussed earlier in this chapter.

TANK LEVEL MONITORING AND ALARM GENERATION.— One area of the FSCC that you should give particular attention is the tank level monitoring and alarm circuits. Individual tank levels are displayed by vertical panel meters. The tank level circuits convert analog information from a tank level transmitter to a meter display. Some of the circuits have associated hazard alarms for high- or low-level conditions.

Tank Level Transmitters.— Each level-monitored tank has a level transmitter. A typical transmitter section has a voltage divider resistor network extending the length of the section. Magnetic reed switches are tapped at 1-inch intervals along the resistor network. The reed switches are sequentially connected through series resistors to a common conductor. This network is enclosed in a stem that is mounted vertically in the tank. Afloat with bar magnets rides up and down the stem as the level changes.

Tank Level Monitoring Circuits.— Refer to the typical tank level monitoring circuit shown in figure 5-34. The signal from the level transmitter is sent to a level monitoring circuit in the FSCC. This circuit, in turn, drives the associated panel meter(s) and starts the visual and audible indications for a hazard alarm. This circuit also provides sensor circuit fault indication and meter and alarm calibration.

PRESSURE MONITORING AND ALARM GENERATION.— Another important area of the FSCC is the pressure monitoring and alarm generation circuits. Pressure is monitored and displayed for the fuel oil receiving tanks, transfer pump inlets and discharges, and purifier inlets and discharges. All but the purifier inlets have HIGH PRESS hazard alarms. These circuits are all functionally similar.

Pressure Transducers.— Pressure transducers are supplied with +24 volts dc. They regulate current flow between this +24 volts and common so that the current remains regulated proportional to the pressure input. The current is varied from 4 to 20 milliamps (mA) as the pressure changes from the low extremity of its range to the maximum. Current regulation is accomplished by circuits located within the transducer.

Pressure Monitoring Circuits.— Study the typical pressure monitoring circuit shown in figure 5-35. The pressure signal from the pressure transducer is sent to a pressure monitoring circuit in the FSCC. This circuit

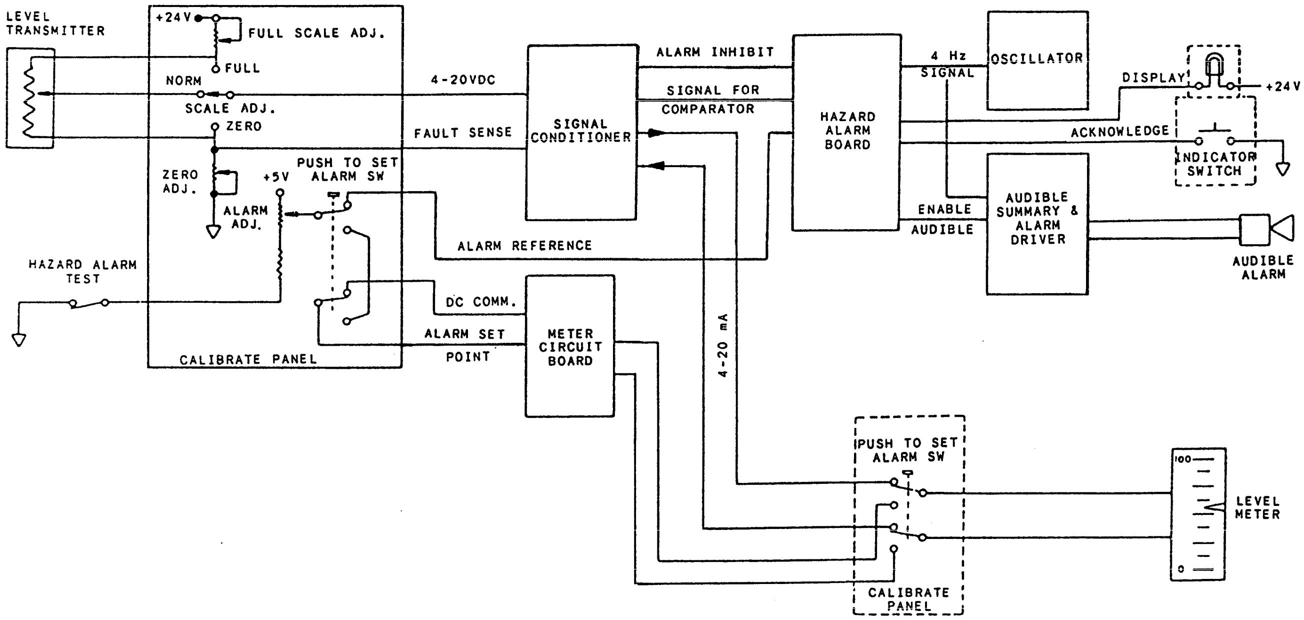


Figure 5-34.—Typical tank level monitoring circuit.

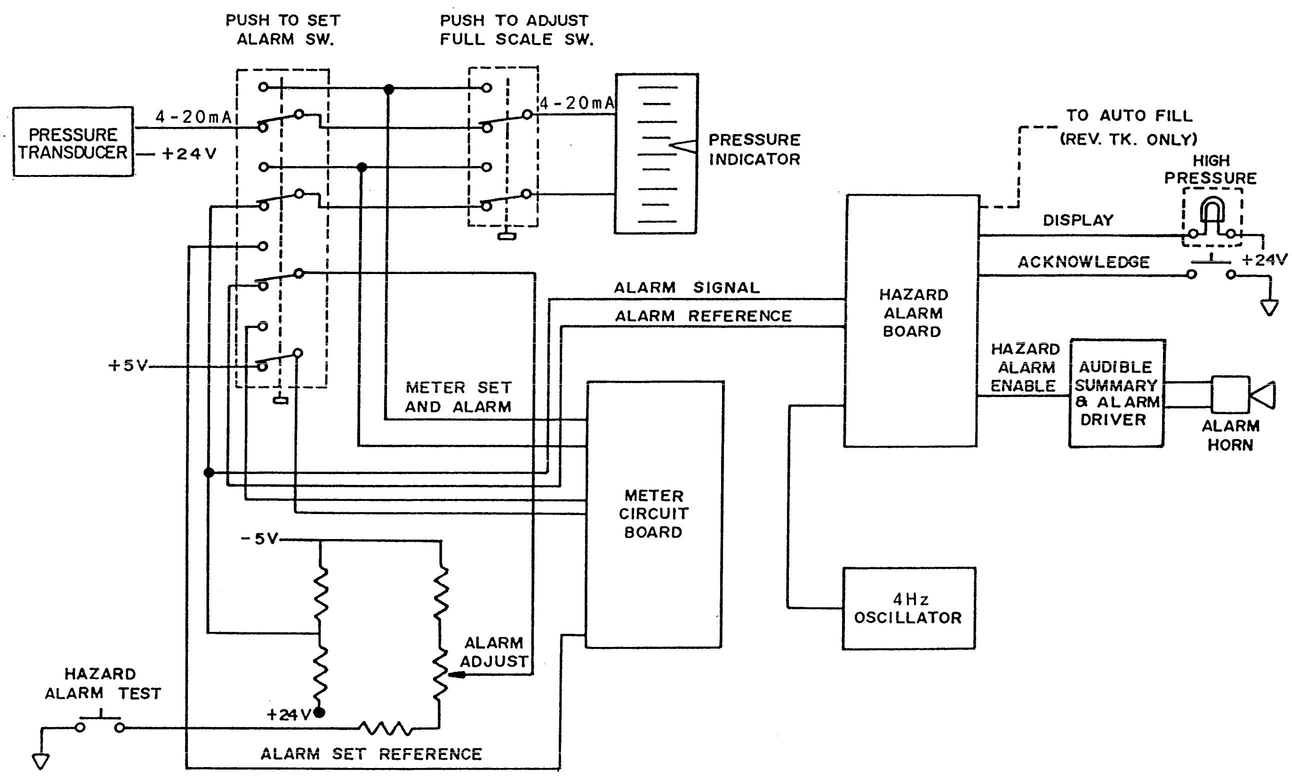


Figure 5-35.—Typical pressure monitoring circuit.

provides meter calibration, starts hazard alarms, and provides alarm point adjustment. It also gives fault condition indication.

TEMPERATURE MONITORING.– The final area that should be given attention is the temperature monitoring circuits. A typical temperature monitoring circuit is shown in figure 5-36. Temperature of the fuel oil discharge from the two fuel oil transfer heaters is monitored by this system. This temperature is displayed at the FSCC by a vertical meter. The meter circuitry is located in the fuel oil local control panels.

Temperature Sensors.– The temperature for the fuel oil is sensed by a resistance temperature detector (RTD). Associated with each RTD is a signal conditioner. It uses system 24 volts dc to regulate a 4- to 20-mA output at a value proportional to the RTD resistance.

Temperature Monitoring Circuits.– The monitoring circuit for fuel oil heater No. 1 is located in fuel oil transfer local panel No. 1. The circuit for fuel oil heater No. 2 is located in local panel No. 2. Each circuit has a remote display at the FSCC.

Since the temperature signal from the signal conditioner is at a 4- to 20-mA level, it is routed through the PUSH TO SET FULL SCALE switch to the panel meters. A mode switch allows selection of LOCAL AND REMOTE or LOCAL ONLY displays. The meter current return is through a fixed resistor to -5 volts.

When the PUSH TO SET FULL SCALE push button is depressed, a 20-mA signal is routed from the meter circuit board to the meter. You can adjust frill scale by using the mechanical full scale adjust screw on the meter.

When testing and performing maintenance on the FSCC, always follow the applicable electrical safety precautions. Use common sense when troubleshooting the console. It is not good practice to test, troubleshoot, or repair the console circuits while refueling or transferring operations are in progress. This is because the chance of damaging equipment or spilling fuel is increased during maintenance procedures.

PROPULSION AND AUXILIARY CONTROL CONSOLE/PROPULSION CONTROL CONSOLE

The propulsion and auxiliary control console (PACC) is located in the CCS of DD-963, DDG-993, DDG-51, and CG-47 class ships. On FFG-7 class ships, this console is called the propulsion control console (PCC) and is also located in the CCS. These consoles provide operator control and monitoring of the ship's main propulsion system. Ships that have the PACC also have the capability of monitoring and controlling some of the auxiliary systems. The PACC and PCC are the most carefully monitored consoles while the ship is underway. Therefore, improper operation of these consoles is immediately noticed. As a GSE,

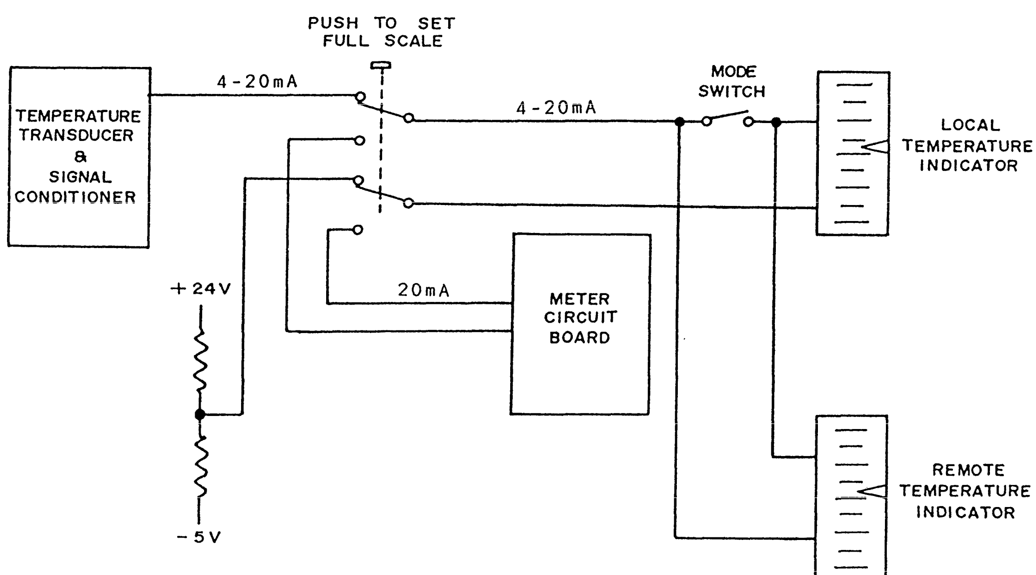


Figure 5-36.—Typical temperature monitoring circuit.

maintenance of the PACC and PCC is your responsibility.

PACC and PCC Testing

Daily testing of the PACC and PCC is normally performed by the console operator. On the PACC on DD-, DDG-, and CG-class ships, the daily tests consist of a audible test of the bell, horn, and siren. An audible test of the buzzer is included on the PACC on the DDG-51 class ship. The PACC and the PCC have lamp test circuits for testing the indicator lamps and LEDs.

You will use the audible alarm tests to make sure the audible alarm circuits are functioning properly. To start these tests, depress the appropriate test push button on the PACC. This action will cause each audible alarm circuit to sound an audible alarm.

The lamp test is conducted by depressing a LAMP TEST push button or activating the STATUS/ALARM switch on the PACC or PCC. This action will cause all the alarm and status lights to illuminate on the designated section, allowing you to locate the burned out lamps on the console.

PACC and PCC Maintenance

The PACC and PCC are complex electronic components. However, the basic troubleshooting and maintenance procedures used throughout your rating will still apply. Control and other electronic circuitry is packaged on circuit card assemblies located in card racks inside the consoles. Each circuit card is assigned its own designation to ease troubleshooting. The PACC and PCC also contain power distribution circuits and fuses.

Some of the maintenance required on the PACC or PCC will stem from the failure of one of the tests we have just described. If an indicator fails to light, you must find the cause of the failure. Most problems that occur to the PACC or PCC will happen during normal operation of the engineering plant. Imagine, for example, that during a GTE start, the main fuel valve fails to open. You, as the GSE, are called to investigate this problem. Always remember to refer to the manufacturer's technical manual when you are planning to perform maintenance on the PACC and PCC.

When a problem or fault occurs in the PACC or the PCC, you must know where to start troubleshooting. Using the technical manuals is essential in this step. The PACC and PCC contain so many circuits that it would be impossible for you to start your troubleshooting efforts without referring to the technical manual.

To use the technical manual correctly, however, you must first know what particular major circuit function is affected. A major circuit function area is a collection of circuits that are designed to achieve a certain function, such as starting a GTM, monitoring start air valve status, and so forth. Examples of major function areas in the PACC and PCC are as follows:

- Main reduction gear (MRG) monitoring and control circuits
- CRP/CPP monitoring and control circuits
- Fuel oil service monitoring and control circuits
- Lube oil service monitoring and control circuits
- Gas turbine module (GTM) monitoring and control circuits
- Air control and monitoring circuits

Recognizing and understanding the major function areas of the PACC and PCC will ease your maintenance and troubleshooting efforts.

ELECTRIC PLANT CONTROL CONSOLE

The electric plant control console (EPCC) is located in the CCS of DD-963, DDG-993, DDG-51, CG-47, and FFG-7 class ships. This console provides the operator with automatic and manual controls, displays of performance parameters, status indications, and alarm indications for remote operation of the ship's electric plant. Controls are provided for generator start/stop, generator paralleling, voltage and frequency raise/lower functions, and circuit breaker close/trip functions. Logic is provided for continuous monitoring of the electric plant operating configuration and supplying electric plant status information. The EPCC is continuously monitored while the ship is underway. Any malfunction of the console is immediately noticed. As a GSE, maintenance of the EPCC is also your responsibility.

EPCC Testing

Daily testing of the EPCC is normally performed by the console operator. The EPCC logic on some ships performs self tests at set intervals. The daily tests on the EPCC consist of a lamp test and an audible alarm test. On the EPCC on DD-963, DDG-993, and CG-47 class ships, the audible alarm test consists of a test of the horn and the siren. On the EPCC on the FFG-7 class ships, the audible alarm test consists of a test of the horn and bell. On the DDG-51 class ships, the audible alarm test on the EPCC consists of a test of the horn and the buzzer. The EPCC also has lamp test circuits for testing the indicator lamps and LEDs.

You will use these audible tests to make sure the audible alarm circuits are functioning properly. To conduct these tests, depress the appropriate test push button on the EPCC. This action will cause each audible alarm circuit to sound its audible alarm.

The lamp test is conducted by depressing a LAMP TEST push button or activating the STATUS/ALARM switch on the EPCC. This action will cause all the alarm and status lights to illuminate on the designated section, allowing you to locate the burned out lamps on the console.

EPCC Maintenance

The EPCCs on gas turbine-powered ships are also complex electronic components. Like the PACC, control and other electronic circuitry is packaged on circuit card assemblies located in card racks inside the consoles. The troubleshooting techniques you will use for the PACC are also those you will use with the EPCC. The EPCC also contains power distribution circuits and fuses.

Since the generators run at a constant speed, frequent changes to the electric plant are not common. Consequently, malfunctions to the EPCC are not as noticeable as those on the PACC or PCC. Most problems that occur to the EPCC will happen when the electric load is shifted or another generator is started. For example, after the generator is started, the voltage fails to increase. As a GSE, you will be called to investigate this problem. Always refer to the manufacturer's technical manual whenever you perform maintenance on the EPCC.

Your use of the technical manual is essential when you are troubleshooting a problem or fault in the EPCC. The EPCC has many circuits that interact with the circuits in the switchboards and other electric components. It would be impossible for you to troubleshoot the EPCC without using the technical manual. The EPCC technical manual, like the PACC technical manual, is arranged according to major circuit function areas. Examples of major circuit function areas in the EPCC are as follows:

- Generator start/stop control and status logic circuits
- Voltage and frequency control logic circuits
- Circuit breaker control logic circuits
- Electric plant status and alarm monitoring circuits
- Malfunction monitoring and display logic circuits
- Generator and shore power performance monitoring circuits

Having the knowledge of the major function areas of the EPCC will ease your maintenance and troubleshooting efforts.

SHIP CONTROL CONSOLE

The ship control console (SCC) is located on the bridge of DD-963, DDG-993, CG-47, and FFG-7 class ships. On the FFG-7 class ships, the SCC is different from the other SCCs but the primary function is the same. The SCC contains the principle controls and displays necessary to provide operator control of ship's speed and heading. It also contains circuits to control navigation lights, steering gear, and auto steering (auto pilot).

Control of the gas turbines and the CRP/CPP must be done in such a manner as to maintain safe operating conditions. The SCC is constantly manned while the ship is underway. Any malfunction that occurs to the SCC is immediately noticed by the SCC operator. As a GSE, you will also maintain the SCC.

SCC Testing

Testing of the SCC is normally performed by the console operator. The tests on the SCC consist of a lamp test and an audible alarm test. The SCC has lamp test circuits for testing the indicator lamps and LEDs.

The audible alarm test is conducted by depressing the buzzer push button on the SCC. This action causes the audible alarm circuit to sound. The console operator will use this test to make sure the audible alarm circuits are functioning properly.

The lamp test is conducted by depressing a LAMP TEST push button or activating the TEST switch. This action causes the alarm and status lights to illuminate on the designated section, allowing you to locate the burned out lamps on the console.

SCC Maintenance

The SCC on a gas turbine-powered ship has control and other electronic circuitry packaged on circuit card assemblies inside the consoles. The troubleshooting techniques you should use for the SCC are the same as those for the other consoles we have discussed.

Malfunctions to the SCC do not occur as frequently as they do to other control consoles. However, they do occur and you must be able to handle any problem that arises. Since this console is the responsibility of the GSEs, you will be called first to investigate a problem.

Since many different types of systems are controlled from the SCC, you must be able to work with other ratings to solve a problem. For example, if the navigation lights are causing a fault in the SCC, you must contact the EMs. If there is a malfunction with the ship's heading, a fault in the gyro signal to the SCC may have occurred. In this case, you should call the interior communication electrician (IC) to assist you.

Always refer to the manufacturer's technical manual when performing maintenance on the SCC. Use of the technical manual is essential when you are troubleshooting a problem or fault in the SCC. The SCC contains circuits that interact with the circuits in other electric and electronic systems. This is why it is impossible for you to troubleshoot the SCC without using the technical manual.

PROPULSION LOCAL CONTROL CONSOLE/LOCAL OPERATING PANEL

The propulsion local control console (PLCC) and the local operating panel (LOP) are located in the engine rooms of DD-963, DDG-993, FFG-7, and CG-47 class ships. The LOP is found on the FFG-7 class ships.

The PLCC contains the principal electronic equipment necessary for controlling the associated propulsion plant. Under normal conditions, the PLCC operator does not control the propulsion plant. Instead, the transfer electronics is designed to allow the PLCC operator to *take* control of the propulsion plant at any time. The PLCC normally acts as the receiver of propulsion commands from the PACC. The PLCC then processes these command signals and provides the appropriate output signal to the propulsion plant equipment.

On FFG-7 class ships, the LOP provides a means for manual operation for maintenance or emergency control and for monitoring each of the GTEs. The LOP also provides throttle control for each GTE and propeller pitch control. Under normal conditions, the LOP is not manned. However, under battle conditions, this console is manned and monitored. Since these consoles are either unmanned or not in control of the plant, any malfunction usually shows up on the PACC or the PCC. Maintenance of the PLCC and LOP is the responsibility of the GSEs.

PLCC and LOP Testing

Testing of the PLCC and LOP is performed by the console operator or maintenance person. On DD- and CG-class ships, the tests on the PLCC consist of a lamp test and audible test of the bell, horn, and siren. On FFG-7 class ships, the tests on the LOP consist of a lamp test and audible test of the horn and siren. Both the PLCC and the LOP have lamp test circuits for testing the indicator lamps and LEDs.

The audible alarm tests are conducted by depressing the appropriate test push button on the PLCC. This action will cause each audible alarm circuit to sound an audible alarm. You will use these audible tests to make sure the audible alarm circuits are functioning properly.

The lamp test is conducted by activating the STATUS/ALARM switch on the PLCC or depressing a LAMP TEST push button on the LOP. This action will cause the alarm and status lights to illuminate on the designated section, allowing you to locate the burned out lamps on the console.

PLCC and LOP Maintenance

The PLCC and LOP circuits are similar to those in the PACC and PCC. In fact, the troubleshooting and maintenance procedures used on the PLCC and LOP are the same. Control and other electronic circuitry is located on the circuit card assemblies. Each circuit card in the PLCC and LOP is assigned its own designation to ease troubleshooting.

Most problems that occur to the PLCC or LOP will happen during normal operation of the engineering plant. The PACC or PCC operator may experience a problem that arises from a fault in the PLCC or LOP. As a GSE, you will be called to investigate such a problem. Again, always refer to the manufacturer's technical manual when performing maintenance on the PLCC and LOP.

Troubleshooting a problem or fault in the PLCC or the LOP is the same as troubleshooting a fault in the PACC or PCC. In fact, the PLCC and LOP contain basically the same major circuit function areas as the

PACC and PCC. Once again, your use of the technical manuals is essential. The PLCC and LOP, like the PACC and PCC, contain many circuits. It would be impossible to begin troubleshooting without using the technical manual.

AUXILIARY CONTROL CONSOLE

The auxiliary control console (ACC) is located in the CCS on FFG-7 class ships. The ACC continually monitors the auxiliary equipment necessary for operation and support of the ship. For example, masker and prairie air or firemain pressure is monitored at the proper meter. The ACC interfaces with the data processor in the EPCC. Three primary interfaces are performed by this interface:

1. Processing of the discrete and analog data

2. Processing of data for output to the digital display indicator (DDI) at the ACC

3. Data logging through communications (with EPCC) with the data processor in the PCC

The interface between the EPCC and the ACC is considered to be another peripheral device to the EPCC processor. The ACC has signal conditioners, A/D converters, analog multiplexer, and alarm boards that function the same as those in the EPCC.

This console is not normally manned, but is the responsibility of the watch standers in the CCS. Any problem or fault that occurs on the ACC is usually found during operation of a system. Maintenance of the ACC, however, is the responsibility of the GSEs.

ACC Testing

Testing of the ACC is performed by the CCS watch stander or a maintenance person. The tests on the ACC consist of a lamp test and audible test of the bell and horn. The ACC has lamp test circuits for testing the indicator lamps and LEDs.

The audible alarm tests are conducted by depressing the appropriate test push button on the top panel of the ACC. This action will cause the audible alarm circuit to sound an audible alarm. You will use these audible tests to make sure the audible alarm circuits are functioning properly.

The lamp test is conducted by depressing a LAMP TEST push button on the ACC. The ACC has three LAMP TEST push buttons. Depressing one of these push buttons causes the lamps on the appropriate section to illuminate, allowing you to locate the burned out lamps on the console.

ACC Maintenance

On FFG-7 class ships, the ACC circuits are similar to those in the other consoles. The troubleshooting and maintenance procedures used on the ACC are the same. Control and other electronic circuitry is located on circuit card assemblies.

Although faults in the ACC are rare, they do occur. Most problems that occur to the ACC do so during normal operation of the ship's auxiliaries. As a GSE, you will be called to investigate any problems that occur in the ACC. Always refer to the manufacturer's technical manual when you perform any type of maintenance on the ACC.

ENGINEERING OFFICER OF THE WATCH/LOGGING UNIT

The engineering officer of the watch/logging unit (EOOW/LU) is located in the CCS on DDG-51 class ships. The EOOW/LU is manned by the engineering officer of the watch (EOOW) and provides data to the plasma displays in the pilothouse and combat information center (CIC). It also collects and logs data for the bell and data logging functions. The EOOW/LU provides a centralized location for accumulating, processing, and displaying the status of the machinery aboard the DDG-51 class ship.

The EOOW/LU includes several special operational capabilities that are not in the other consoles on the DDG-51 class ships. These capabilities are as follows:

- Bell logging using a high-speed printer
- Data logging using magnetic tape cartridges installed in an AN/USH-26 magnetic tape unit
- Software for loading bubble memories from the magnetic tape cartridges
- Computation and display of resource availability parameters
- Providing plasma display data to displays in the CIC and the pilothouse

Since this console provides vital information to the EOOW, it is carefully monitored. Any malfunction that occurs to the EOOW/LU is immediately noticed by the EOOW. Maintenance of the EOOW/LU is the responsibility of the GSEs.

EOOW/LU Testing

The EOOW/LU is tested by the console operator or maintenance person. The tests on the EOOW/LU consist of a lamp test of the indicators on the A2 panel and an LED and audible alarm test of the AN/USH-26 tape unit.

The lamp test of the A2 panel is conducted by depressing the LAMP TEST push button on the A2 panel. The CONSOLE TEMP HIGH and UPS IN USE indicators should light when the push button is depressed. The audible alarm and the LED test is conducted by setting a three-position toggle switch on the AN/USH-26 unit to the TEST position. When the switch is placed in the TEST position, the audible alarm circuits sound the audible alarm and illuminate the LEDs labeled HOT and OVERTEMP. You will use these tests to make sure the audible alarm and lamp circuits are functioning properly.

EOOW/LU Maintenance

The EOOWLU uses the machinery control system (MCS) to monitor the engineering systems. It also uses the data multiplex system (DMS) to communicate with the other consoles. Planned maintenance is conducted on the MCS according to the MRCs. Although the MCS and DMS are different from the control systems on other gas turbine-powered ships, the basic troubleshooting and maintenance procedures are the same. Control and other electronic circuitry is located on circuit card assemblies. Computer interface within the console is extensive. Therefore, the maintenance person must read the technical manual to thoroughly understand the interfaces.

Malfunctions that occur in the EOOW/LU are the responsibility y of the GSEs. As a GSE, you must handle any problems that arise. Since many different systems are monitored from the EOOW/LU, you will have to understand the problems that are presented. Always refer to the manufacturer's technical manual when you perform maintenance on the EOOW/LU.

Use of the technical manual is essential when you are troubleshooting any problem or fault in the EOOW/LU. The console contains circuits that interact with the circuits in other electronic systems and consoles. Consequently, it will be impossible for you to troubleshoot the EOOW/LU without using the technical manual. Troubleshooting a problem or fault in the EOOW/LU is the same as troubleshooting a fault in the MCS consoles.

SHAFT CONTROL UNIT

A shaft control unit (SCU) is located in each main engine room on the DDG-51 class ships. The SCU provides the interface between the propulsion plant and the ship's DMS. It also provides the interface between the propulsion plant and other control locations in the CCS and the bridge. The SCU controls the propulsion plant for its respective shaft, including auxiliary machinery such as bleed air, fuel service, propeller hydraulics, and lube oil. Signal conditioners and A/D converters are apart of the standard electronic modules (SEMs) that are located in the A2 section of the SCU. The SCU performs the same function as the PLCC on a DD-963, DDG-993, or CG-47 class ship.

The SCU is another important console on the DDG-51 class ships. Any malfunction that occurs to the SCU is immediately reported to the EOOW. Maintenance of the SCU is the responsibility of the GSEs; therefore, the EOOW will contact you, the GSE, to correct the problem.

SCU Testing

The SCU is tested by the console operator or maintenance person. The tests on the SCU consist of a lamp test of the indicators and an audible alarm test of the siren, horn, bell, and buzzer.

The audible alarm test is conducted by depressing each AUDIBLE ALARM TEST push button on the SCU. This action causes the audible alarm circuits to sound the appropriate alarm. The volume of the audible alarms is adjusted by a variable potentiometer located below the test push buttons. The operator or maintenance person uses this test to make sure the audible alarm circuits are functioning properly.

The lamp test of the SCU is conducted by depressing the LAMP TEST push button on the thrust/auxiliary panel. When the push button is depressed, all indicators will light, all LED meters segments will light to indicate frill scale, and the digital displays will indicate all 8s. You will use this test to make sure the lamp circuits are functioning properly.

SCU Maintenance

The SCU uses the MCS to monitor and control its associated engineering systems. It also uses the DMS to communicate with the other consoles. Planned maintenance is conducted on the MCS according to the MRCs.

Although the MCS and DMS are different from the control systems on other gas turbine-powered ships, the basic troubleshooting and maintenance procedures are the same. Control and other electronic circuitry is located on circuit card assemblies. As the maintenance person, you must read the technical manual to thoroughly understand the interfaces. Always refer to the manufacturer's technical manual when performing maintenance on the SCU.

Again, use of the technical manual is essential when you are troubleshooting a problem or fault in the SCU. This console contains circuits that interact with the circuits in other electronic systems and the propulsion equipment. It is therefore impossible for you to troubleshoot the SCU without using the technical manual. Troubleshooting a problem or fault in the SCU is the same as troubleshooting a fault in the other MCS consoles.

BRIDGE CONTROL UNIT

A bridge control unit (BCU) is located in the pilothouse on the DDG-51 class ships. The BCU provides control of the thrust of the port and starboard shafts from the SCC in the pilothouse. The BCU also provides the switches and indicators for transferring the propulsion control station location between the pilothouse, the CCS, and the engine rooms. The BCU also provides on and off control of the washdown countermeasures groups 1 through 4.

Several components mounted in the SCC are considered to be a part of the BCU. They are the +5 and ± 15 volt dc power supply, a tone generator, a speaker assembly, and a cable entry assembly. The power supply is used to supply +28 volts dc and +5 volts dc to the BCU assemblies. The tone generator and speaker are used to generate the audible alarms for the MCS at the SCC. The cable entry assembly provides the cable connectors for interfacing ship's cables with the BCU.

Since the SCC controls the operation of the ship, the correct operation of the BCU is essential. The malfunctions that occur to the BCU are immediately reported. Because maintenance of the BCU is also the responsibility of the GSEs, you, the GSE, will be called to correct the problem.

BCU Testing

The BCU is tested by the console operator or maintenance person. The tests on the BCU consist of a lamp test of the indicators and an audible alarm test of the bell.

The audible alarm test is conducted by depressing the BELL push button on the BCU. This action causes the audible alarm circuits to sound the bell alarm. The volume of the audible alarm is adjusted by a variable potentiometer located to the right of the test pushbutton. The operator or maintenance person uses this test to make sure the audible alarm circuit is functioning properly.

The lamp test of the BCU is conducted by depressing the TEST push button on the throttle control panel. When the push button is depressed, all lamps on the BCU light. You will use this test to make sure the lamp circuits are functioning properly.

BCU Maintenance

The BCU uses the MCS to monitor and control the propulsion system from the bridge. It also uses the DMS to communicate with other consoles. Planned maintenance is conducted on the BCU by using the proper MRCs. The troubleshooting and maintenance procedures used on the BCU are the same as those used on other MCS consoles. Always refer to the manufacturer's technical manual when performing maintenance on the BCU.

Use of the technical manual is essential when you are troubleshooting a problem or fault in the BCU. This console contains circuits that interact with the circuits in other electronic systems and the propulsion equipment. You can not effectively troubleshoot the BCU without using the technical manual.

GENERAL CONSOLE MAINTENANCE

The consoles on gas turbine-powered ships differ in style, construction, and operation. However, there are some general maintenance procedures that apply to all control consoles. As a GSE, you will have to recognize a symptom and associate it with the proper functional area. This technique will help you start your troubleshooting in the correct area. Although the fault might not be in that particular area, you will at least not overlook that possibility. For this reason, you must know the purpose of each circuit group and how it functions.

Console Circuits

Each control console contains several types of circuits that you must be familiar with before performing maintenance on them. Although these circuits contain the same components, they operate differently. The basic purposes of the circuits inside the consoles are described in the following paragraphs. As always, refer to the manufacturer's technical manual for a detailed description of the circuits in a particular control console.

CONTINUOUS DISPLAY CIRCUITS.— A continuous display circuit consists of the edgewise-reading meters and their related wiring. These meters continuously monitor and display parameters of the ship's propulsion and associated systems. Each console has meter-monitor functions that are displayed on a different number of meters on the console. Some meter-monitor functions are displayed on dual (side-by-side) scale meters, while others are displayed on single-scale meters. Whether dual- or single-scale, all meter movements are electrically the same. Each meter has a specific volts dc movement with a specific percentage of accuracy and internal resistance. The meters on the consoles of the DDG-51 class ships are LED-type meters and function differently from the meters on the other classes of gas turbine-powered ships. The signals to these meters are controlled by the AN/UYK-44 computer. The meter faces are marked and scaled for the parameter displayed. The meters can be mechanically or electrically zeroed.

STATUS DISPLAY CIRCUITS.– The status displays consist of various indicator lamps and switch-indicators on the console control and display panels. Each of the panels contains one or more indicators or switch-indicator assemblies. Regardless of the indicator type, each indicator lamp is operated on and off by the application or removal of a dc voltage. This dc voltage is applied or removed by some type of lamp driver circuit associated with the circuit. On the DDG-51 class ship, SEMs transfer data to the computer for status display. The indicators and switch-indicator lenses provide white and various colored backgrounds when lighted. This highlights the engraved legends of the lenses.

ALARM DISPLAY CIRCUITS.– The alarm display and associated audible warning circuits of each console are shown in the flow and schematic diagrams in the appropriate technical manuals. The alarm display circuits may consist of the following:

1. Alarm control logic cards or modules
2. Lamp driver cards or modules
3. Alarm indicator lamp assemblies
4. Alarm summary and audible alarm selection logic (horn, siren, or buzzer)
5. Alarm acknowledge and flasher/siren-bell inhibit (silencing) circuits
6. Audible alarm tone generator and associated speakers
7. SEM logic assemblies

Typically, signals originate at the sensors and transducers located at the device where the function is being monitored. From the sensors, some of the signals are wired directly to the consoles. Some signals are routed through other circuits for timing, signal conditioning, and threshold detection. Still other signals are routed through a computer. The results of these signals are then wired to the consoles.

DEMAND DISPLAY CIRCUITS.— The demand display circuits consist of the demand-display controls and indicators on the consoles. The circuits also include the interconnecting wiring and the interfaces with the serial data or MCS components. Demand display is accomplished through the plasma display unit on the DDG-51 class ships. Demand display on the other gas turbine-powered ships is accomplished through thumbwheel-type decimal display rotary switches.

CONTROL CIRCUITS.– The control circuits are those circuits that are operator initiated through switching devices, such as switch-indicators, push-button switches, and thumbwheel switches. Control signals initiated by switch-indicators are usually momentary in nature. These signals are applied through some type of debounce, latching, or control logic circuit before being sent through the serial data or DMS to the function to be controlled. Push-button initiated control signals are also momentary but are usually applied directly to the associated logic circuits. Rotary-switch-initiated control signals are usually discrete types and are buffered before being applied to the logic circuits. Thumbwheel-generated control signals are also buffered and are routed through the serial data system to the functions they control.

SERIAL DATA CIRCUITS.– The serial data circuits consist of a serial transmitter circuit, a serial receiver circuit, and an automatic self-test circuit. The serial transmitter circuit multiplexes parallel data, converts it into serial data, and transmits it via the serial data bus. The serial receiver circuit receives serial data from the serial data bus, converts it to parallel data, and buffers it to other console circuits. The self-test circuit performs a continuous automatic self-test of serial data cards.

REPAIR

This section contains basic information pertaining to the repair of console assemblies, components, and repairable parts. Basic repair procedures include the following:

- Removal of assemblies and components
- Disassembly, inspection, and cleaning of components
- Reassembly, calibration, and repair of components
- Replacement of assemblies and components

Removal of Assemblies

Most consoles on gas turbine-powered ships are constructed to ease maintenance and repair efforts. They have card cages, power supply drawers, buckets, assemblies, and bays. When performing repair work, you may find it necessary to remove complete assemblies or subassemblies to locate and repair a fault. Instructions for removing components and assemblies are listed in the manufacturer's technical manual. You should refer to the technical manual whenever you perform repair work on the consoles. The typical procedures for removing two of the most repairable components of consoles, a circuit card assembly and a power supply drawer, are listed in the following paragraphs.

CIRCUIT CARD ASSEMBLY.– To remove a typical circuit card assembly, you should proceed as follows:

1. Open the access door(s).

2. Release captive fasteners or screws and remove any card retainer devices.

3. Using circuit card extractor, remove the card from the assembly.

Depending on your class of ship and the specific console, there may be additional steps you must take to remove a circuit card. Again, make sure you refer to the appropriate technical manual.

POWER SUPPLY DRAWERS.— To remove a typical power supply drawer, you should proceed as follows:

1. Perform the console turn-off procedures, as specified in the technical manual.

2. Release any captive fasteners or screws.

3. Pull the drawer to its full open position. (Some power supply drawers are mounted on locking slide rails to prevent them from being pulled completely out.)

4. Disconnect any cable connectors from the power supply.

5. Release any slide stops, locks, or drawer retainers, and remove the power supply drawer.

Once again, depending on your class of ship and the specific console, there may be additional steps you must take to remove a power supply assembly. Always consult the technical manual.

Disassembly, Inspection, and Cleaning

After you remove the assembly or subassembly, you must disassemble it, inspect it, and clean it. These procedures are listed in the manufacturer's technical manual. The technical manual procedures will provide you with instructions for complete or partial disassembly. Usually, detailed disassembly, inspection, and cleaning procedures are included for maintenance of significant items.

To remove a discrete component, first tag and remove or unsolder the attached wires. Then, remove the parts and hardware listed in the procedure for that component.

When inspecting the assembly, you must know what faults or potential faults to look for. You should use the inspection procedures listed in the technical manual when repairing and replacing assemblies and components. A thorough visual inspection will allow you to identify any physically damaged parts and to prevent the obviously damaged parts from causing further damage.

Most electronic consoles on gas turbine ships have small fans that circulate air through the assemblies for cooling. This air causes the components to become extremely dusty. Dusty and dirty electronic components retain more heat and can overheat if they are not cleaned. The following list contains some of the common faults you should be aware of when inspecting assemblies of control consoles:

- Burned components, cracked or broken circuits, and chipped or broken connector pins on the circuit cards
- Bent or broken pins, cracked housings, damaged inserts, and loose attaching hardware on connectors

- Loose hardware, burned components, broken connections, and bent or broken pins on assemblies and subassemblies

You can clean the assemblies and subassemblies by wiping them with a dry cloth or brush. Use a water soluble detergent to clean the air falters on control consoles. For general cleaning of the consoles, use a general cleaning solvent. To remove corrosion and oxidation from the aluminum surfaces of the consoles, use trichlorotriflouroethane. Remember to observe all safety precautions when using cleaning solvents.

WARNING

Dangerous voltages exist in control consoles. Observe all safety precautions before performing any of the scheduled preventive maintenance.

Reassembly, Calibration, and Repair

When you replace a part, remember that the new part must be electrically and physically identical to the defective part. Identification of repair parts is given in the parts listing of the technical manual.

Unless otherwise specified in the detail repair procedures, use the following general rules when repairing the control consoles:

1. Remove and disassemble parts only to the extent necessary to inspect, clean, or replace a defective part.

2. When removing attaching hardware, note the number and arrangement of hardware at each attaching point. Be sure to replace hardware properly when reassembling the item removed.

3. Inspect all removed parts as specified in the technical manual. Install only parts that are serviceable.

4. Check to be sure that mating parts are properly engaged and aligned before tightening the mounting hardware.

Repair of circuit cards will, in most instances, consist of removal and replacement of detail parts. In some instances, however, the PCBs may be defective. You can make practical repairs of defective (open) printed conductors by installing jumper wires across the open circuit. Upon completion of any circuit card repair operation, calibrate and retest the circuit card. After calibration and retesting, apply a polyurethane coating to the reworked areas.

WARNING

Polyurethane materials are flammable and toxic. Do not smoke or permit sparks or open flames in the work area. The work area must be well vented. Wear eye protectors, protective clothing, and polyethylene or rubber gloves while working with the materials. Wash hands and exposed skin areas thoroughly with soap and hot water after handling.

Exercise care and observe the following precautionary measures during the handling and repair of circuit cards. These measures will help you to prevent further damage to the circuit cards and the replacement parts.

1. Ensure all leads of removed parts are tagged.

2. Make sure all hardware removed is replaced in the proper order.

3. Observe the polarity of the capacitors and diodes.

4. Observe the placement and height of the components.

5. Make sure the soldering iron you use for integrated circuits is 18 watts maximum (tip temperature between 450° and 550°F) and for other parts is 25 watts maximum (tip temperature between 750° and 850°F).

6. Ensure that the leads of the replaced parts are trimmed flush on the back of the circuit card.

7. Avoid accidental touching of the soldering iron or other heated instruments to the wire insulation.

CAUTION

Do not touch integrated circuits with your bare hands because of possible damage by static electricity. The hand tools you use must be properly grounded.

Replacement of Assemblies

After performing repair work, you must replace the assemblies or subassemblies. Instructions for replacing assemblies or subassemblies are listed in the manufacturer's technical manual. In most cases, replacement is the reverse of removal. Whenever special instructions are necessary, they are given in the technical manual. After replacing the assemblies, thoroughly check out the repair and replacement.

SUMMARY

In this chapter, we have discussed your primary role as a GSE in the maintenance of the electrical and electronic systems associated with your ship's main propulsion plant. We have discussed the troubleshooting, maintenance, and repair of electronic, electromechanical, and electrohydraulic control circuits and systems, motors and generators, controllers, jacks, plugs, multiconductor cables, and auxiliary systems. We have also discussed wire-wrapping techniques, pump logic calibration procedures, casualty inspection and reporting procedures, and important safety techniques and precautions you must observe whenever you are working with energized electrical equipment and systems.

As a GSE, you will be the backbone of electrical and electronic maintenance in your ship's engineering department. The information presented in this chapter covers some of the most important areas of your maintenance and repair responsibilities. If you have any questions or you are uncertain about any of the sections in this chapter, we recommend you review this important information before you begin the next chapter.

CHAPTER 6

PRESSURE, TEMPERATURE, AND LEVEL CONTROL DEVICES

The consoles on board gas turbine-powered ships monitor and control various systems and equipment. These systems are monitored with pressure, temperature, and level gauges and meters. Control devices are used to accomplish the monitoring functions. Control devices also generate the alarms that are displayed on the consoles. A control device, in its simplest form, is an electrical switching device that applies voltage to or removes voltage from a single load. In more complex systems, the initial device may set into action other control devices that govern pressures, temperatures, and liquid levels.

In this chapter we will describe the different control devices that you, the GS, must troubleshoot and repair. These include pressure, temperature, and level control devices. Upon completion of this chapter, you should be able to describe the types of control devices used on gas turbine-powered ships and their basic maintenance procedures.

PRESSURE CONTROL DEVICES

Pressure is one of the basic engineering measurements that must be monitored aboard ship. Pressure control devices control the operation of equipment. They stop and start motors, cycle ventilation dampers, and generate low- and high-pressure alarms to the propulsion control systems. Pressure control devices include pressure switches and pressure transducers. Pressure readings provided by these devices will allow you to determine the operating condition of your equipment.

PRESSURE SWITCHES

A pressure switch opens or closes a set of contacts at a preset pressure. Pressure switches can provide alarm indication or start an action, such as stopping an air compressor at a preset pressure. A typical pressure switch is shown in figure 6-1.

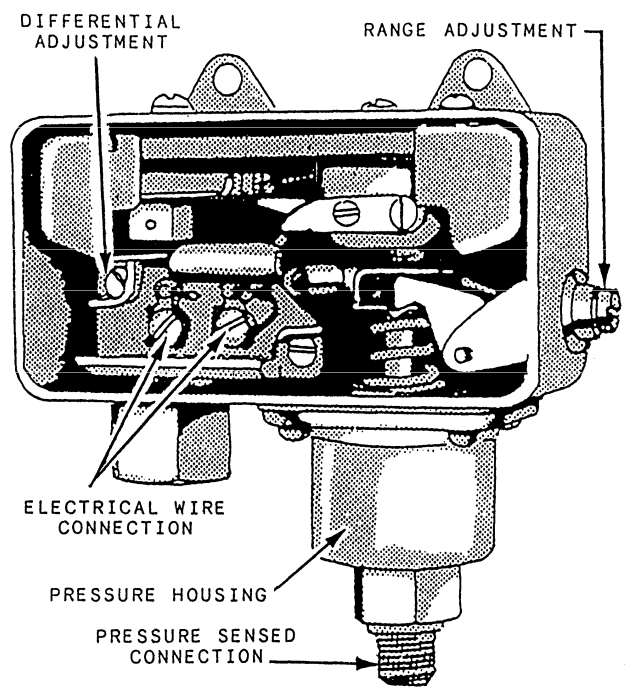


Figure 6-1.—Typical pressure switch.

The operation of the pressure switch is simple. When the pressure reaches the preset value, the pressure-sensing mechanism operates. The actuation of the sensing mechanism causes a light to illuminate, an alarm to sound, or a piece of equipment to stop or start. The switch is normally enclosed in a metal case with a removable cover. The metal case provides a pressure port and an electrical connection point. A pressure switch converts pressure energy into electrical energy. Pressure switches are used on pneumatic and hydraulic systems. The shapes, configurations, and sizes of pressure switches may differ but the functions basically the same. The type of switch used depends upon its application.

Construction

Pressure-operated switches are normally single-pole, single-throw, quick-acting switches. An individual pressure switch contains either a bellows or a diaphragm that works against an adjustable spring. The spring causes the electrical contacts to open or close automatically when the operating pressure rises or falls from a specified value. A permanent magnet in the switch provides a positive snap when the contacts are opened or closed. This snap action prevents excessive arcing at the contacts. The pressure at which the switch operates is adjustable within ranges, such as 0-15, 15-50, and 50-100. This adjustment is made by using the range adjustment screw.

Maintenance

Normal maintenance performed on pressure switches is accomplished by using the PMS. This maintenance includes inspecting the switch for damage, corrosion, and proper operation.

When you inspect a pressure switch, look for any physical external damage, such as loose-fitting covers, damaged pressure and electrical connectors, and missing parts. Check inside the metal case for corrosion and the presence of water or oil. If water or oil is present, check the condition of the rubber gasket in the cover and replace it if necessary.

During PMS, sometimes you must adjust the switch to bring the operating values back in tolerance. To set a pressure switch, you first have to set a known pressure in the working range of the switch. Normally, you do this by using a test setup, such as the one shown in figure 6-2. To set the operating range of the switch, turn the differential adjustment screw (see fig. 6-1) counterclockwise against the stop for minimum differential. Bring the pressure to the value at which the circuit is to be closed or opened. Turn the range adjustment screw slowly clockwise or counterclockwise until the contacts operate. This adjustment will set the open or closing pressure.

You have now brought the pressure to the point where the circuit will be activated. Since the differential adjustment screw is now set at minimum, the circuit will probably operate at a lower pressure than desired. Therefore, turn the differential adjustment screw clockwise to widen the differential until the desired activating pressure is obtained. Refer to the manufacturer's technical manual for detailed instructions on adjusting these switches.

Troubleshooting

After adjusting the operating range of pressure switches, check the operation through at least one complete cycle. If you find a variation from the desired operating values, go through the entire adjustment procedure again. In an emergency, you can use the pressure of the system in which the switch is installed instead of using the test setup. In this case, however, you should reset the switch as soon as possible using the test setup. After adjusting the switch, watch the operation through another complete cycle. If you cannot adjust the switch, you must troubleshoot it.

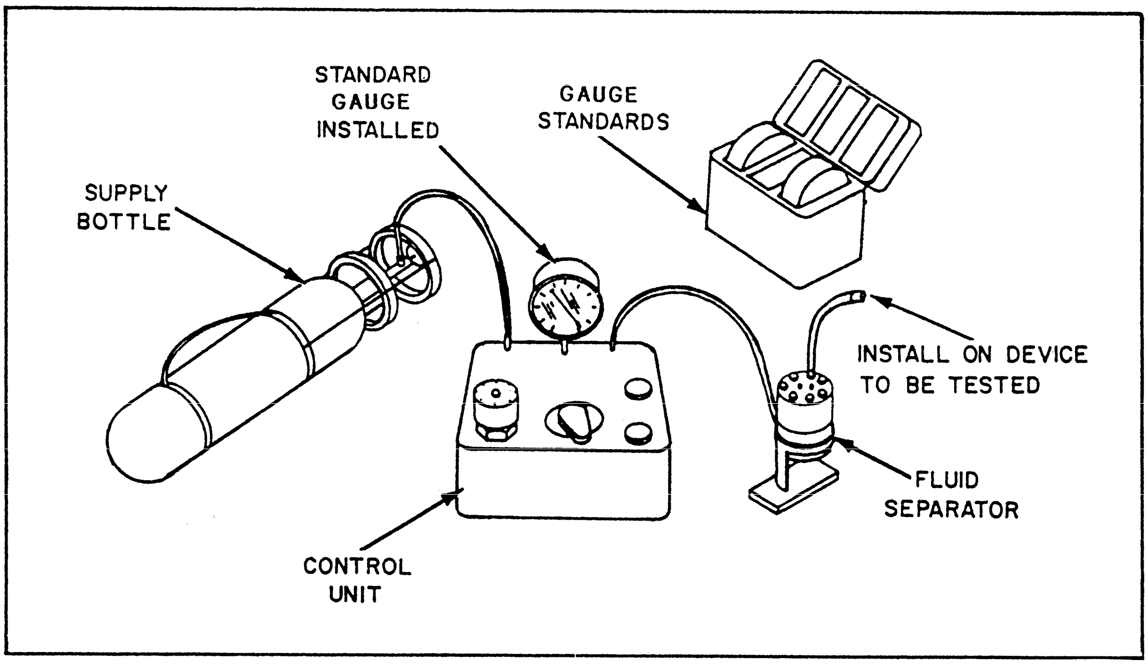


Figure 6-2.—Setup for calibrating a pressure device.

When troubleshooting a pressure switch that cannot be adjusted, you will normally find that it needs to be replaced. In most cases, the switching mechanism malfunctions and the switch cannot be repaired. Sometimes the bellows or diaphragm malfunctions. In this case, also, you will have to replace the switch. When you must replace a pressure switch, refer to the manufacturer's technical manual to make sure you have the proper replacement.

When replacing a pressure switch, you must remember that the switch is constantly energized even if the equipment is not actually running. It is the closing and opening of the contacts that energizes the entire electrical circuit. You must make sure that electrical power to the pressure switch is secured before you begin to replace the switch. Follow the basic troubleshooting techniques and all applicable electrical safety precautions whenever you repair or replace pressure switches.

PRESSURE TRANSDUCERS

A transducer is a device that receives energy from one system and retransmits it to another system. This retransmitted energy is often in a different form than it was received. A pressure transducer receives energy in the form of pressure and retransmits energy in the form of electrical current. A pressure transducer allows pressure monitoring at remote locations on gas turbine-powered ships. Pressure transducers provide the capability of sensing variable pressures and transmitting them in proportional electrical signals. Pressure transducers are widely used in ship propulsion and auxiliary machinery spaces. They are often used to monitor alarms. A typical pressure transducer is shown in figure 6-3.

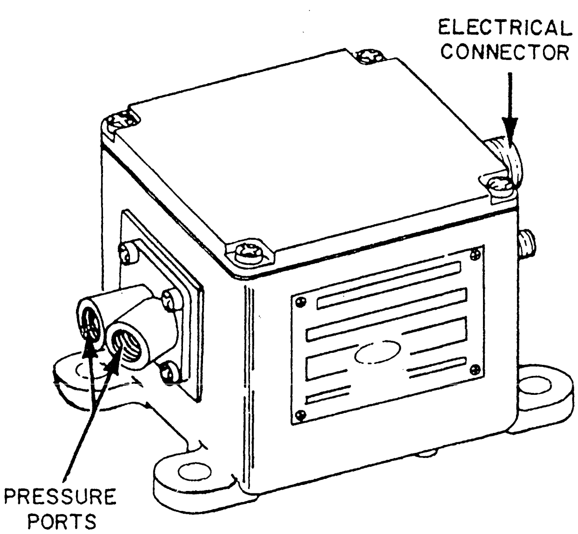


Figure 6-3.—Pressure transducer assembly.

Like the pressure switch, the operation of the pressure transducer is also simple. Pressure transducers sense absolute, gauge, or differential pressure. The transducer receives pressure through pressure ports. It sends an electrical signal, proportional to the pressure input, through the electrical connector. Pressure transducers are available in pressure ranges from 0 to 6 inches water differential to 0 to 10,000 pounds per square inch gauge (psig). Regardless of the pressure range of a specific transducer, the electrical output is always the same. The electrical signal is conditioned by signal conditioners before being displayed on an analog meter or digital display readout. The sensitive parts of the transducer are enclosed in a metal box with a removable cover. The metal box provides pressure ports and an electrical connection point. The range of the transducer used depends upon its application.

Construction

Pressure transducers are square metal boxes that contain one or two pressure ports, an electrical connector, and a circuit card. (See fig. 6-4.) A test jack and two variable resistors are located on the circuit card. One resistor is the span adjustment resistor and the other is the zero adjustment resistor. The transducer contains no moving parts; therefore, it is very reliable. The pressure applied to the transducer is converted to an electrical signal by the components on the circuit card

Maintenance

Maintenance performed on pressure transducers is accomplished also by PMS. This maintenance includes inspecting the transducer for damage, corrosion, and proper operation.

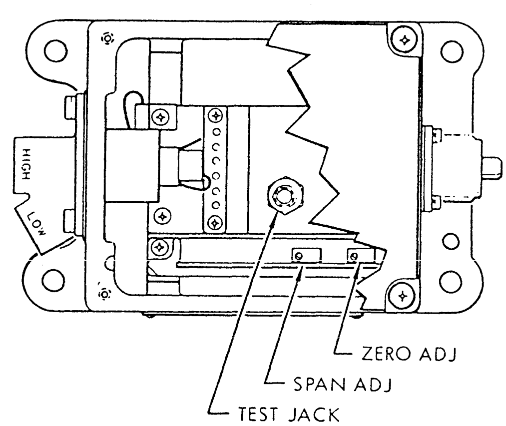


Figure 6-4.—Transducer construction.

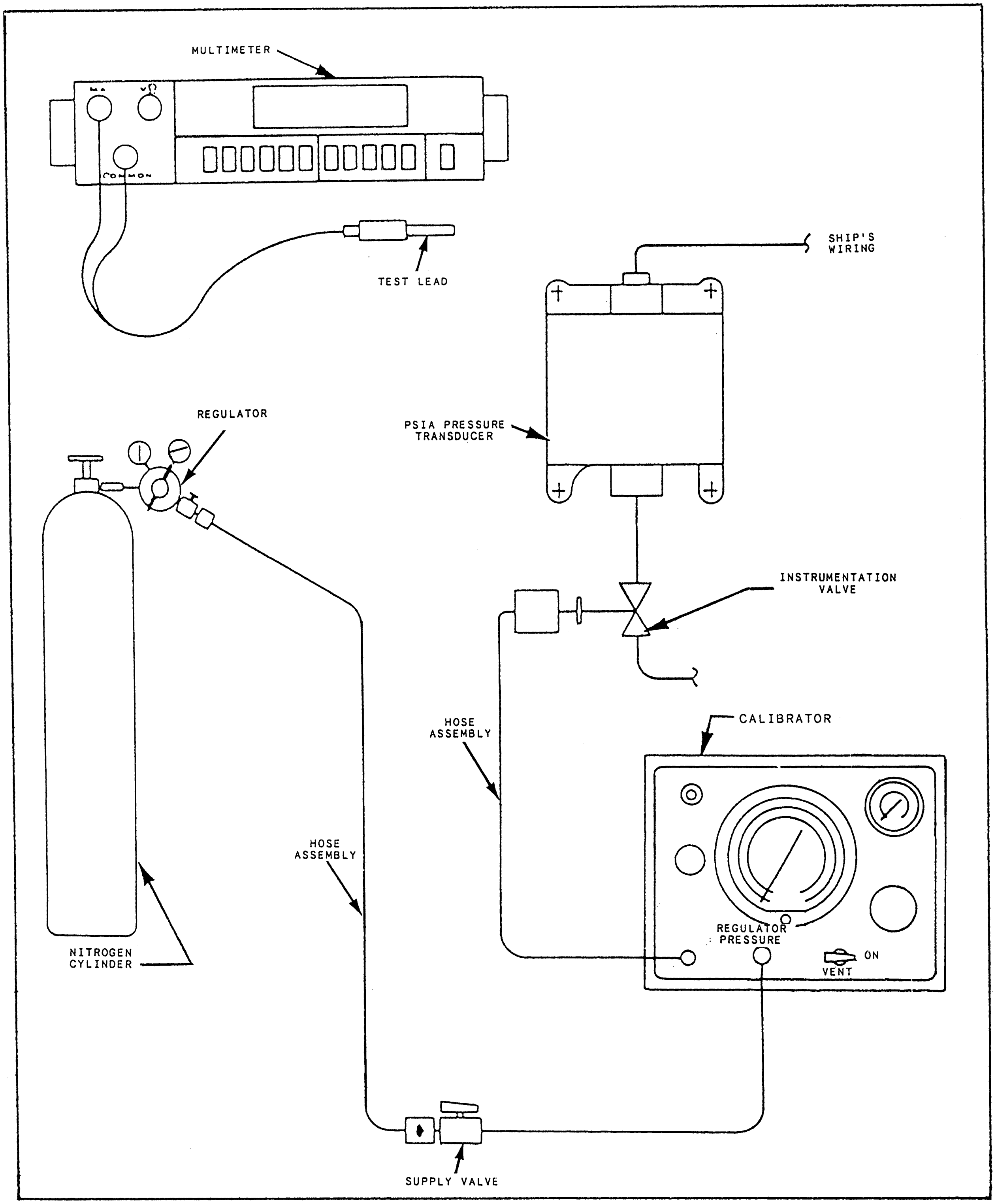


Figure 6-5.—Calibration setup for absolute pressure transducers.

When inspecting a pressure transducer, look for any physical external damage, such as loose-fitting covers, damaged pressure and electrical connectors, and missing parts. Check inside the metal case for corrosion and the presence of water or oil. If water or oil is present, check the condition of the rubber gasket on the cover and replace it if necessary.

While performing PMS, you may find it necessary to calibrate a transducer that is out of tolerance. Calibrate pressure transducers on a bench before installing them. This action will prevent damage to the transducer and the equipment served.

The equipment needed for the setup to calibrate a transducer is shown in figures 6-5 and 6-6. If your ship

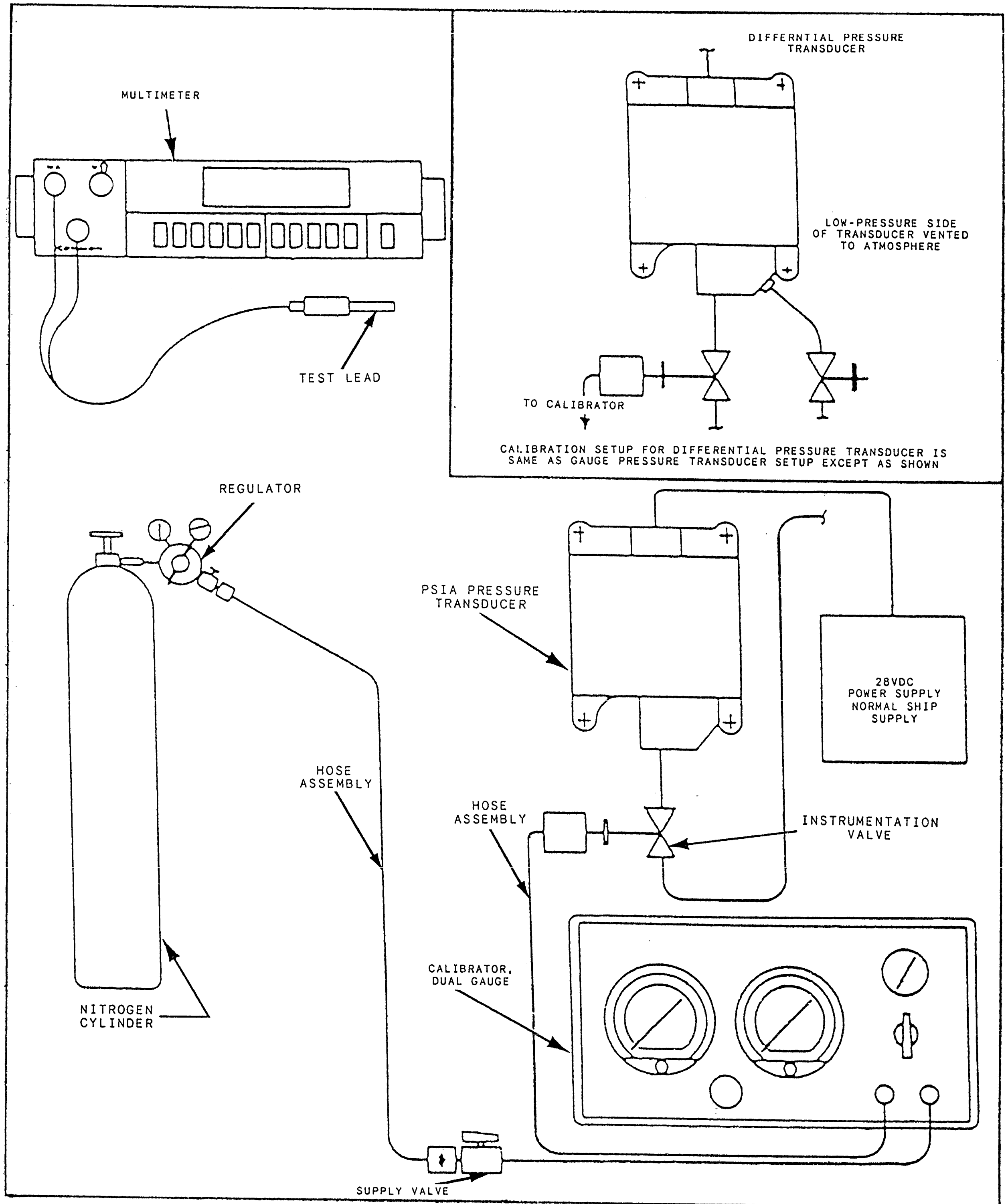


Figure 6-6.—Calibration setup for gauge pressure and differential pressure transducers.

does not have the equipment or is not qualified to calibrate transducers, send the transducer to a calibration facility. Some ships have their own calibration laboratories. If you have a problem with a pressure transducer or have to replace one, you can compare it with a known standard by using the calibration setup. The following paragraph describes the steps necessary to calibrate pressure transducers commonly found on gas turbine-powered ships.

Make sure you follow all applicable safety precautions while calibrating pressure transducers. There are three values to check when you calibrate transducers: low, high, and middle. To calibrate a pressure transducer, make sure the equipment served is tagged out of service. Close the instrumentation valve in the pressure line to the transducer, remove the cap, and connect the hose to the instrumentation valve. (The instrumentation valve is closed by turning it fully clockwise.) Remove the cover of the transducer and connect the multimeter to the transducer test jack. The multimeter should read 4 milliamps (mA) ±0.3. If necessary, adjust the ZERO ADJUST resistor to get the proper reading. This is the low reading of the transducer. Set the multimeter to the proper scale and apply pressure to the transducer that equals the high value. If necessary, adjust the SPAN ADJUST resistor as required to get the correct current output value. Recheck your first and last values whenever you adjust either the ZERO or SPAN resistors. Next, check the middle value of the transducer by applying pressure to the transducer that equals the middle value. Then check the transducer current output. Always refer to the manufacturer's technical manual to get the correct values for the low, middle, and high settings of the transducer. When calibration is completed, disconnect the calibration setup, replace the transducer cover, and return the equipment to service. For additional information on calibration of transducers, refer to *Propulsion Gas Turbine Module LM2500,* Volume 2, Part 3, NAVSEA S9234-AD-MMO-050.

Troubleshooting

If you suspect a transducer is faulty, start your troubleshooting procedures by making sure the same problem exists on another console or panel. This step will help you make certain that you are not just dealing with a faulty meter or indicator. After you verify that the transducer is in fact faulty, you must isolate the cause of the fault.

To troubleshoot a transducer, first disconnect the pressure transducer electrical connector and check for correct input voltage ±1 between pins A (+) and B (-). Next, check the electrical connections and cables for shorts, opens, or grounds. Check the pressure transducer according to the maintenance requirement card (MRC). Replace the transducer if it cannot be calibrated. If all

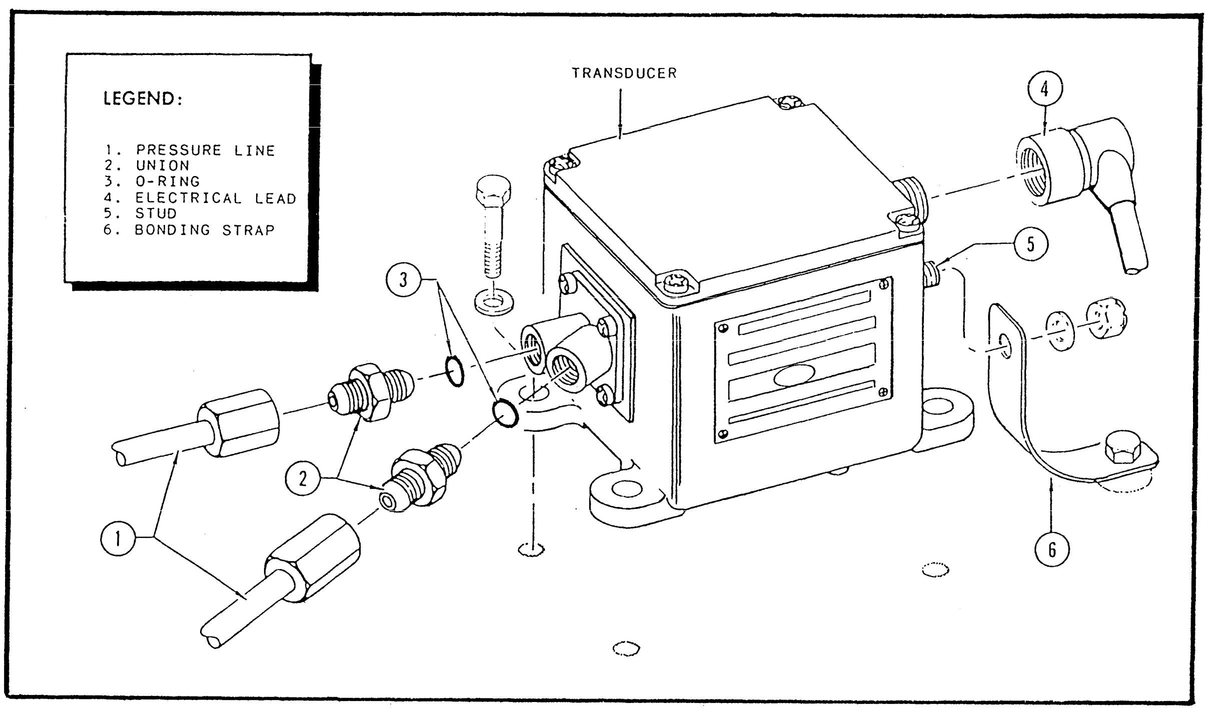


Figure 6-7.—Pressure transducer.

these checks prove satisfactory, check your ship's instrumentation or uplink signals. For more detailed troubleshooting procedures, refer to the manufacturer's technical manual.

When you must replace a transducer, read all applicable instructions, class advisories, and bulletins before removing the unit. All pressure transducers are removed and installed in the same manner. Differential pressure transducers, however, have two pressure lines. (See the detail block in fig. 6-6.) Refer to figure 6-7 as you read the description of the transducer removal procedures. The numbers in parentheses refer to the associated numbered parts in the figure.

To remove a transducer, first shut off the instrumentation valves in the pressure lines to the transducer. Secure and tag out the electrical power to the transducer and remove the electrical lead (4) from the unit. Next, remove the nut, washer, and bonding strap (6) from the transducer stud (5). Disconnect the pressure lines (1) from the transducer. Next, remove the bolts and washers that secure the transducer to the mounting plate. Remove the transducer. Finally, remove the pressure line unions (2). Remove and discard the O-rings (3) from the unions.

The following paragraph describes the procedures you should use to properly replace a pressure transducer. Again, follow along in figure 6-7 as you study this procedure.

First, install new O-rings (3) on the unions (2). Next, install the unions into the transducer and torque the unions to 135 to 150 inch pounds (in. lb). Place the transducer on the mounting plate so it is flat when the locator pin is inserted into the transducer flange. Next, install the bolts and washers to secure the transducer to the mounting plate. Torque these bolts to 40 to 60 in. lb. Connect the pressure lines (1) to the transducer and torque the fittings to 135 to 150 in. lb. Next, attach the bonding strap (6) to the stud (5) on the transducer with the washer and nut. Torque this nut to 70 to 110 in. lb. Make sure the seal is in the electrical lead (4) connector and attach the lead to the transducer. Finally, remove the tag and restore electrical power to the transducer. Calibrate the pressure transducer according to the applicable MRC. Follow the basic troubleshooting procedures and all applicable electrical safety precautions whenever you calibrate, remove, and replace pressure transducers.

TEMPERATURE CONTROL DEVICES

Temperature, like pressure, is one of the basic engineering measurements that must be monitored aboard ship. Like pressure readings, temperature readings also provide you with an indication of the operating condition of the equipment. Temperature control devices operate from changes in the temperature that take place in an enclosure or in the air surrounding the temperature-sensing element. Temperature control devices are used with high-temperature alarm systems, generator air temperature control circuits, and fire detection alarm systems. They are also used to stop and start ventilation motors and to control the heating of fuel and lube oil. Common temperature control devices include temperature switches and thermocouples.

TEMPERATURE SWITCHES

A temperature switch opens or closes a set of contacts at a preset temperature Temperature switches provide alarm indications or stop a piece of equipment if a high temperature condition develops. A temperature switch with two types of sensing elements is shown in figure 6-8. The main function of a temperature switch is to convert thermal energy into electrical energy. Although the shapes, configuration, and sizes of temperature switches may differ, their primary function is the same.

Construction

Temperature-operated switches are usually single-pole, single-throw, quick-acting, normally open

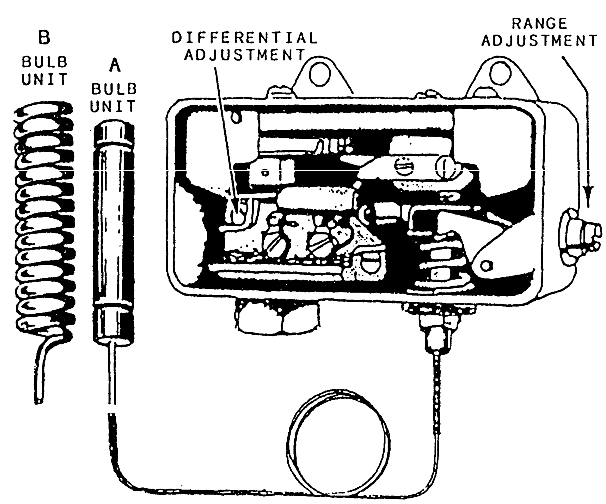


Figure 6-8.—Temperature switch with two types of sensing elements. A. Bulb unit. B. Helix unit.

switches. However, temperature switches can also be normally closed switches. A basic temperature switch contains a bellows or a diaphragm that works against an adjustable spring. The spring causes the electrical contacts to open or close automatically when the operating temperature exceeds a specified value. The bellows or diaphragm motion is produced by a sealed-in gas that expands with rising temperature. The sensitive element containing this gas may be built into the switch or located in a remote space and connected to the switch by a capillary tube. A permanent magnet in the switch provides a positive snap when the contacts are opened or closed. This snap action prevents excessive arcing at the contacts. The design of the switch allows movement of the contacts to determine whether the switch opens or closes on a temperature rise. The switch is normally enclosed in a metal case with a removable cover. The metal case provides a temperature-sensing port and an electrical connection point. The temperature at which the switch operates is adjustable.

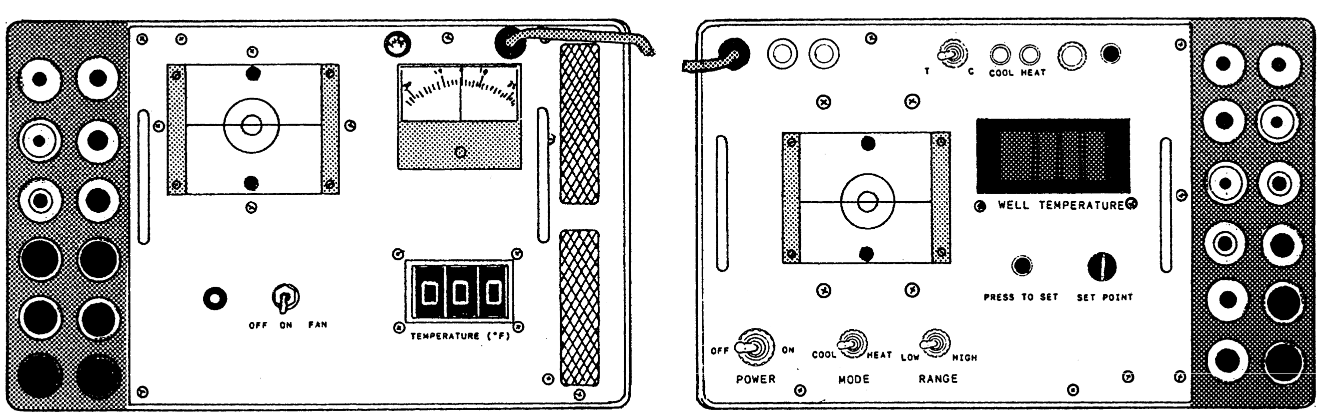
Operation

The operation of the temperature switch is basically the same as that of the pressure switch. In fact, temperature switches are actually operated by changes in pressure. The temperature element is arranged so a change in temperature will cause a change in the internal pressure of the sealed-gas or air-filled bulb or helix that is connected to the actuating device by a capillary tube. A temperature change will cause a change in the volume of the sealed-in gas. This, in turn, will cause movement of the bellows or diaphragm. The movement is sent by a plunger to the switch arm. The moving contacts are located on this arm. A fixed contact maybe arranged so the switch will open or close on a temperature rise.

Maintenance

Routine maintenance performed on temperature switches should be accomplished according to PMS. The routine maintenance procedures performed on temperature switches are the same as those discussed for pressure switches. Routine maintenance includes inspecting the switch for damage, corrosion, and proper operation. The procedures for adjusting the switch were discussed earlier in this chapter. The only difference is the test setup you will use to calibrate the switch.

The Navy uses several different pieces of equipment for calibrating heat-sensing devices. There are also several methods for calibrating temperature devices. The King Nutronics, models 3604 (fig. 6-9, view A) and 3605 (fig. 6-9, view B), are portable temperature comparators. These two units provide the latest in solid-state, digital technology for the Navy. The model 3604 is used to calibrate temperature control devices within a range of 100° to 1199°F. The model 3605 is used to calibrate temperature control devices within a range of -40° to +250°F. Usually, temperature switches on gas turbine-powered ships are calibrated at regular intervals by a calibration team. If a switch malfunctions, it is removed and sent to a calibration lab for testing.



A B

Figure 6-9.—King Nutronics. A. Model 3604. B. Model 3605.

Troubleshooting

After calibrating the temperature switch, check its operation through at least one complete cycle. If you find a variation from the desired operating values, have the switch recalibrated. In an emergency, you can adjust the temperature switch while it is in the system instead of sending it for calibration. You should, however, send the switch to the calibration lab as soon as possible for a thorough adjustment. If the switch cannot be adjusted, you must troubleshoot the switch or replace it.

Temperature switches, like pressure switches, normally require replacement if they cannot be adjusted. When you adjust temperature control devices, allow several minutes for the thermal unit to reach the temperatures of the surrounding air, gas, or liquid before setting the operating range. If replacement of a temperature switch is necessary, refer to the manufacturer's technical manual to be certain you have the proper replacement.

As with pressure switches, remember the temperature switch is constantly energized even if the system is secured. The closing and opening of the contacts energize the entire electrical circuit. You must make sure electrical power to the pressure switch is secured before you replace the switch. Follow the basic troubleshooting techniques and all applicable electrical safety precautions whenever you repair or replace temperature switches.

THERMOCOUPLES

The temperature of a body may be measured without any physical contact with it by use of an instrument that senses radiation. Such an instrument is known as a radiation pyrometer. This device is commonly called a thermocouple on gas turbine-powered ships. Thermocouples used aboard ship measure temperatures in the gas turbine engine.

Construction

Thermocouples are composed of two dissimilar metals joined at one end to produce a change in voltage that is proportional to a change in the temperature at the joined end. A voltmeter (calibrated in degrees) shows the temperature at the thermocouple.

Types of metals or alloys used in combination in thermocouples are (1) chromel-alumel, (2) copper-constantan, (3) iron-constantan, and (4) platinum-platinum rhodium. Other combinations also may be used for special purposes. The thermocouples found on gas turbine-powered ships are usually the chromel-alumel type.

Due to the high cost of thermocouple wire, a less expensive lead wire is often used to connect the thermocouple wires to the temperature-indicating instrument. However, to reduce errors, make sure you get lead wires with the same thermoelectric characteristics as the thermocouple wire. For chromel-alumel thermocouples, copper and constantan lead wires are often used. These lead wires are more rugged than thermocouple wires and may be solid or stranded.

Maintenance

Routine maintenance performed on thermocouples should be accomplished by PMS. Thermocouples should be checked regularly. If possible, they should be checked when they are in place. If it is necessary for you to remove a thermocouple, be sure to return it to the same insertion depth or deeper. This will prevent errors resulting from the irregular heating of different portions of the wire.

One prime requirement for a thermocouple to meet tolerance is that it must be unvarying. Remember, when thermocouples are handled they can be bent or contaminated. This is why you must use extreme care. Both bending and contamination will cause the thermocouple to become erratic, thereby affecting its operation and increasing the likelihood of error.

Troubleshooting

Normally, malfunctioning thermocouples are noticed during equipment operation. A console operator must know the correct operational parameters of the equipment he or she is monitoring. While taking readings on a GTE, if the turbine inlet temperature is incorrect or not consistent with previous readings, the operator should know something is wrong. The problem could be a malfunctioning thermocouple or thermocouple circuit. As a GSE, you will be called to investigate the problem.

When you are troubleshooting a thermocouple, several common faults can occur. Thermocouples, like other electrical equipment, can be grounded, open, or shorted. The thermocouples on most GTEs are connected in parallel. In troubleshooting this type of setup, you will have to isolate the thermocouples systematically to locate which particular thermocouple or thermocouple set is faulty. Some general troubleshooting procedures are discussed in the following paragraph.

Since thermocouples monitor temperature, you must allow them to cool before you begin troubleshooting. Thermocouples on GTEs can be cooled by motoring the engine. You can check the thermocouple and its leads by using a multimeter to take resistance readings. Take resistance readings between each pin and each pinto ground. Check the technical manual to determine if the readings are within the minimum acceptable limits. If the thermocouple resistance system measurements are within limits, troubleshoot the ship's instrumentation. As mentioned earlier in this chapter, always refer to the manufacturer's technical manual when you test, troubleshoot, and repair any electrical equipment.

LEVEL CONTROL DEVICES

In the engineering plant on a gas turbine-powered ship, operating personnel must know the levels of the various liquids in different locations in the ship. The level in the ship's freshwater tanks is an example of a liquid level that must always be known. There are other liquid levels that are also important. These include the levels in the fuel oil service tanks, fuel oil stowage tanks, lubricating oil sumps, and drain tanks.

A wide variety of devices, some of them simple and some complex, are available for measuring and controlling liquid levels. Without level control devices, engineering and operating personnel could not plan for their supply needs. GSEs are responsible for the repair, maintenance, and installation of these devices. Level control devices used aboard gas turbine-powered ships include liquid-level float switches and magnetic float devices.

LIQUID-LEVEL FLOAT SWITCHES

A relatively new development in indicating alarm and control functions is the liquid-level float switch. A liquid-level float switch is shown in figure 6-10. This type of switch is usually found in tank- and bilge-level alarm circuits.

The liquid-level float switch has a doughnut-shaped, floatable magnetic core operating over an encapsulated reed switch. The entire assembly is mounted at a predetermined level. The switch can be made normally open or closed by reversal of the core. Level conditions are shown as normal, above normal, or below normal. The switch can also be used to start and stop pumps, such as in a drain tank system. When the liquid level reaches a preset point, the float switch completes the circuit to the pump, signaling the pump to start to remove the liquid from the tank. When the level drops to the preset point, the pump secures.

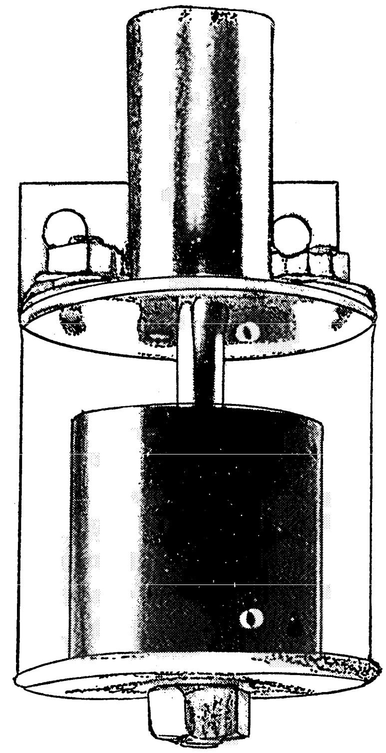


Figure 6-10.—Liquid-level float switch.

MAGNETIC FLOAT DEVICES

Each tank level indicator (TLI) system is made up of equipment and accessories that are necessary for the specific installation. The TLI system components can be divided into four general groups: (1) the liquid-level detection devices (transmitter), (2) the receiver devices (receiver panel or module), (3) the remote alarm or liquid-level indicating devices (alarm and gauges), and (4) the accessories (tubing and so forth). These components are shown in figure 6-11.

The purpose of the liquid-level detection devices installed in tanks is to convert the liquid level into an electrical signal. The two types of detection devices available are the transmitters and the level links. Transmitters provide a continuous level measurement, while level links provide a point or incremental measurement.

Study the transmitter shown in figure 6-12. The transmitter consists of a network of voltage divider resistors and magnetic reed switches contained in silicon

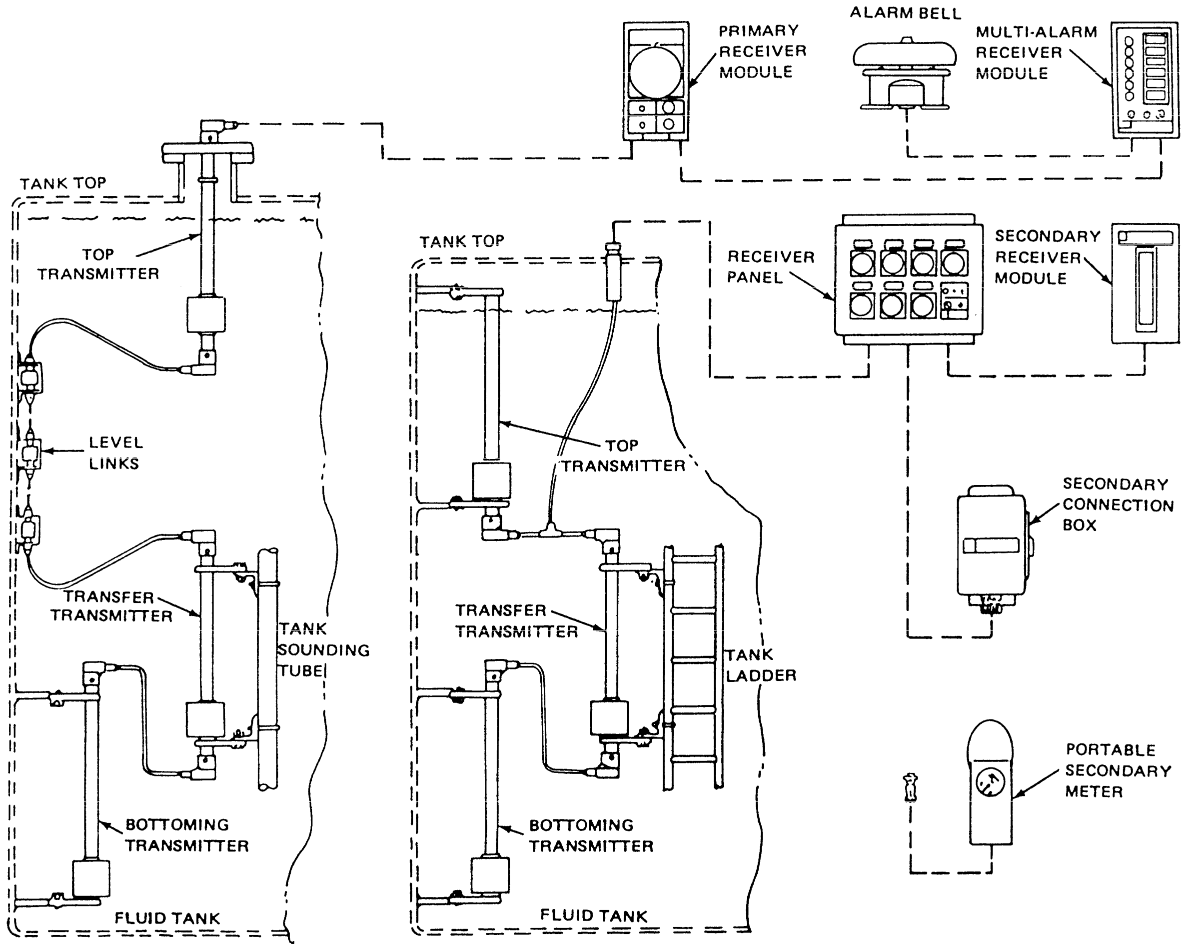


Figure 6-11.—Magnetic float systems.

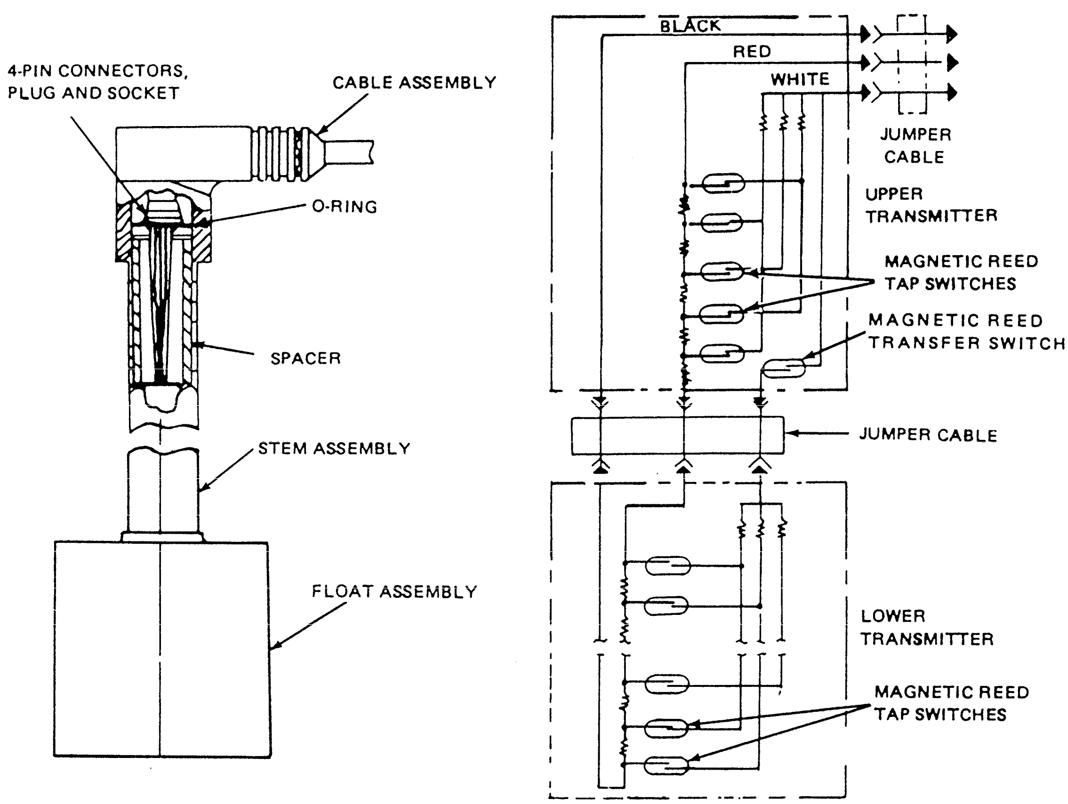


Figure 6-12.—Magnetic float liquid-level detector.

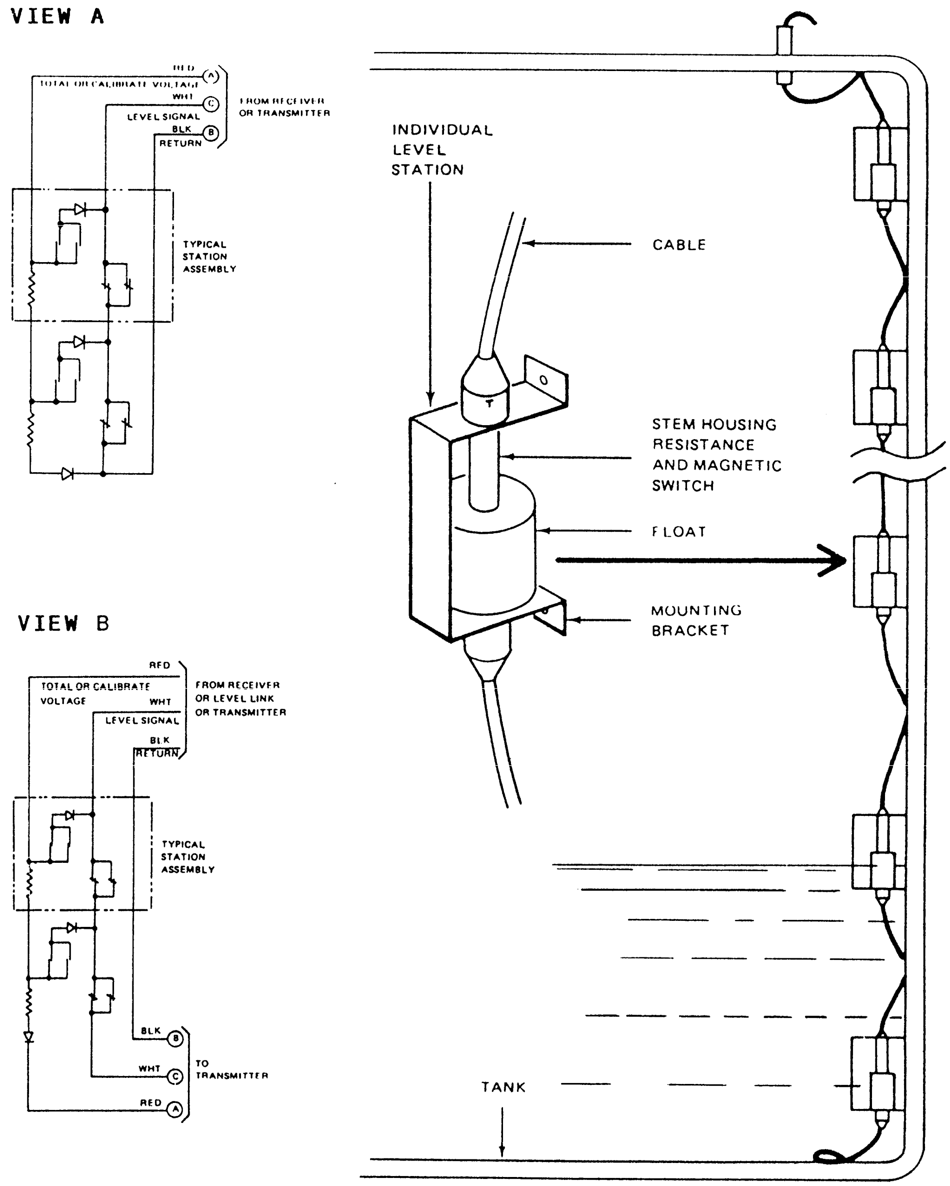


Figure 6-13.—Link transmitter float assembly.

rubber and potted in a mylar tube. The tube is surrounded by a neoprene tube and is mounted inside a stainless-steel tube. Electrical leads connect the resistors and magnetic reed switches to electrical connectors located either at the top, bottom, or both ends of the transmitter.

Now study the link transmitter float assembly shown in figure 6-13. The link system (views A and B) can be used alone or in combination with transmitter assemblies. Each level link system includes several cable-connected station assemblies. Individual station assemblies include magnet-equipped floats that ride up and down on stems. Each stem houses a resistor, magnetic reed switches, and a semiconductor diode. A mounting bracket is provided on the stem for individual mounting of each station assembly of the system.

Receiver devices are used to convert the electrical signals generated by the level detection devices into deflections of a pointer on a meter. The meter is usually marked in gallons. Primary receiver modules perform level indication, alarm generation, and alarm indication functions for one tank. A receiver panel provides the same function for several tanks.

The magnetic float system is operated by the changing liquid level in the tank. As the liquid level changes, the float moves up or down the transmitter. Figure 6-14 shows how bar magnets in the float operate tap switches in a two-at-a-time, three-at-a-time, two-at-a-time closing sequence as the float moves up the transmitter. When two adjacent tap switches are closed, the effective electrical tap point on the voltage divider network is halfway between the two switches. As the

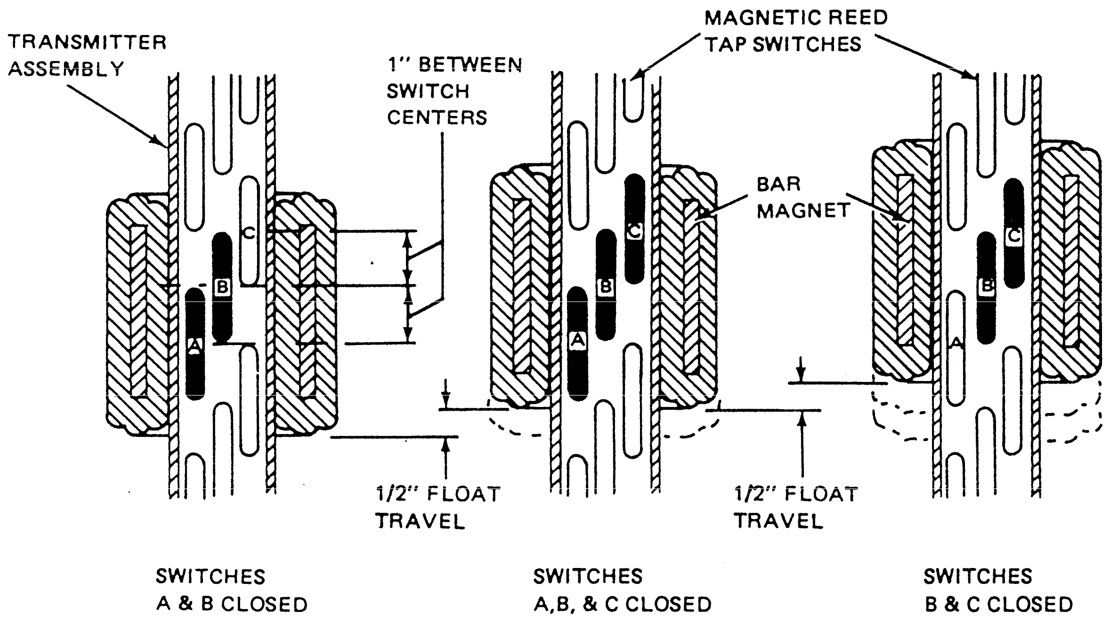


Figure 6-14.—Transmitter tap switch operational sequence.

float closes the next tap switch (the first two are still closed), the effective tap point is halfway between the first and third tap switches; that is, it is at the middle switch. This middle point is 1/2 inch from the effective tap point established when only two tap switches were closed. As a result, voltage drops are read in 1/2-inch increments of float travel.

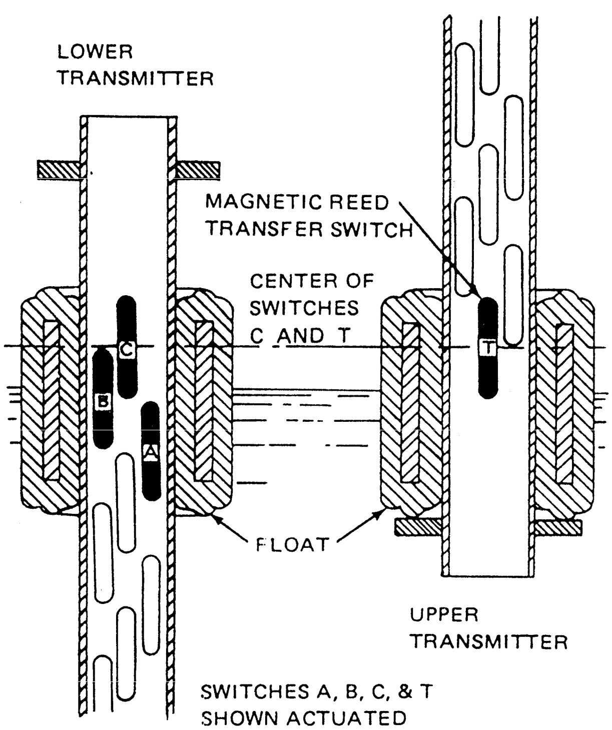


Figure 6-15.—Overlapped transmitter transfer switch operation.

When two or more transmitters are installed in a tank, each transmitter except the bottom transmitter has a transfer switch. These switches are of the type shown in figure 6-15. The transfer switch is a magnetically operated reed switch. It is connected between the common conductor (to the tap switch resistances) in one transmitter and the common conductor in the next lower transmitter. The transfer switch is held closed when the float on its transmitter is at the bottom limit. As the float level rises with the fluid level, the transfer switch opens and disconnects the tap switches in the lower transmitter.

The transfer switch action is required to open the common conductor circuit to the lower transmitter tap switches. The uppermost tap switch of the lower transmitter tap switches is held closed now, since the lower transmitter float is at its top limit of travel. The resulting voltage change produced by the changing tank level is processed by the receiver module, and the liquid level is indicated on the meter.

The liquid-level switches on board your class of ship may differ somewhat. However, the principle of operation will be similar to the one just discussed. For specific operational characteristics, refer to the manufacturer's technical manual for the system on your ship.

MAINTENANCE

Routine maintenance performed on most liquid control devices is accomplished by PMS. Routine maintenance includes inspecting the devices for damage and proper operation. To check for proper operation, you must lift some liquid control devices manually. You will check others, such as tank level sensors, through calibration circuits. Some difficulties that you may face in working with liquid control devices are inaccurate readings, units that are out of calibration, and malfunctioning floats. For specific maintenance and calibration procedures, refer to the applicable system technical manual.

The moving parts of liquid control devices should be inspected for smooth operation. They should also be lubricated at definite intervals. When spare parts are available, repairs and replacements should be made only by experienced GSEs. In several cases, it is best to replace the entire liquid control device and return the faulty one to the manufacturer (if required).

TROUBLESHOOTING

Most problems with liquid control devices are discovered during PMS. You may find that during calibration a meter might not indicate the level it is supposed to. You must find the problem by starting proper troubleshooting procedures. Troubleshooting procedures include reading voltages, resistances, and currents as well as performing calibration.

If you find a faulty liquid control device, you must replace it as soon as possible. Sometimes this is a simple process, while other times it will take the participation of many personnel. If the control device is a bilge level sensor, the replacement procedure is simple. Just tag out the circuit and replace it. However, if the control device is a fuel tank level sensor, the replacement procedures get a bit more complex. The fuel has to be pumped out of the tank, the tank certified gas free by a gas free engineer, and specific safety precautions observed. When replacing a liquid control device, take care in tagging the leads to assure proper replacement.

After you enter the tank, you may find the problem is a stuck float. To correct this problem, carefully clean and scrape the tube so it offers a smooth surface for the float. If you have to disassemble a liquid control device, be sure to clean all metal parts with a solvent.

Most liquid control devices are constantly energized even when the tank is empty or the system is secured. You must make sure that electrical power to the control device is secured before replacing it. Follow the basic troubleshooting techniques and all applicable electrical safety precautions when troubleshooting, repairing, or replacing liquid control devices.

SUMMARY

In this chapter, we have discussed your responsibility for the maintenance of pressure, temperature, and level control devices. We have discussed the troubleshooting, maintenance, and repair of pressure switches, pressure transducers, and temperature switches. We also described the different types of level control devices used aboard gas turbine-powered ships and the maintenance procedures you must use for them. We also talked about the safety precautions associated with the troubleshooting and maintenance of pressure, temperature, and level control devices.

These simple devices are vital to the operation of the engineering plant on a gas turbine-powered ship. As a GSE, the attention you give these devices will prevent several equipment malfunctions associated with your rating. The information presented in this chapter covers the basic operation and maintenance of control devices. If you have any questions about the pressure, temperature, and level control devices just discussed, we recommend you refer to the proper technical manual.

CHAPTER 7

LCAC AND PHM PROPULSION SYSTEMS

The GSEs assigned to landing craft, air cushion (LCAC) vessels and patrol combatant missile (hydrofoil) (PHM) class ships are responsible for the upkeep and maintenance of the propulsion electronic control systems. If you are assigned to an LCAC or a PHM, the watches you will stand will be different from those on the DD-963, DDG-993, DDG-51, CG-47, and FFG-7 class ships. In this chapter you will read about some of these differences and the associated responsibilities you may be expected to assume.

After reading this chapter, you should be familiar with the operation of the engineering plant equipment on the LCAC and PHM class ships. The information presented in this TRAMAN is designed only to familiarize you with the equipment on these ships. Remember, you should always use the appropriate EOSS and PQS to qualify for a particular watch station.

After reading this chapter and completing the associated self-study questions in the NRTC, you should have acquired enough knowledge to begin qualifying at the individual watch stations on board these ships. Even though you may never be assigned to an LCAC or PHM, the information in this chapter should familiarize you enough with the equipment to help you advance in the GSE rating. As you become more senior in the GS rating, you may find yourself assigned to an LCAC or PHM class ship, or to one of their maintenance depots. In either case, this indoctrination could help you begin your qualifications.

LANDING CRAFT, AIR CUSHION

The LCAC is a high-speed, ship-to-shore, over-the-beach vehicle that will deliver a 60-ton payload to the ground elements of a Marine amphibious force. It provides the Navy and Marine Corps with high-speed delivery capabilities to support amphibious operations.

The LCAC is an air cushion vehicle that is powered by four AVCO Aerospace TF40B marine gas turbines that provide a total of 15,820 horsepower (hp). Two shrouded reversible pitch propellers ‘provide forward and reverse motion. The air cushion on which the craft rides is created by four double-entry fans. These fans are 63 inches in diameter, providing the desired amount of airflow. The steering system consists of two rotatable bow thrusters and two aerodynamic rudders. Figure 7-1 is an illustration of an LCAC craft.

The LCAC engineering plant consists of propulsion, lift, and control systems. The plant is operated by the craft engineer/assistant operator while the craft is underway. There are no traditional watches as these limited endurance craft carry only enough personnel to man the operating stations. The crew consists of an operator, craft engineer/assistant operator, navigator, load master, and deck hand/engineer. This small crew is completely responsible for underway operations, and embarkation and disembarkation of troops and supplies. The only GS is the craft engineer/assistant operator.

In the following paragraphs, we will describe the basic physical and functional characteristics of the LCAC control systems. The LCAC control systems include all the systems and controls the operator needs to maneuver the craft. Maneuvering an LCAC basically consists of controlling the craft’s direction, speed, and cushion.

The LCAC control systems are divided into the following subsystems:

1. Steering control system
2. Propeller pitch control system
3. Lift fan control system
4. Lycoming TF40B engine control system
5. Command and control keyboard
6. Rate of turn system
7. Outside air temperature system
8. Speed/sideslip indicator

These subsystems are controlled by the operator in the LCAC operator station command module or the operator in the engineer control station. Figure 7-2 shows the physical arrangement of a typical LCAC operator station command module. Now, let’s take a brief look at each of these subsystems and how they are used. After we look at the control systems, we will discuss the electrical system that provides the electrical power for these units.

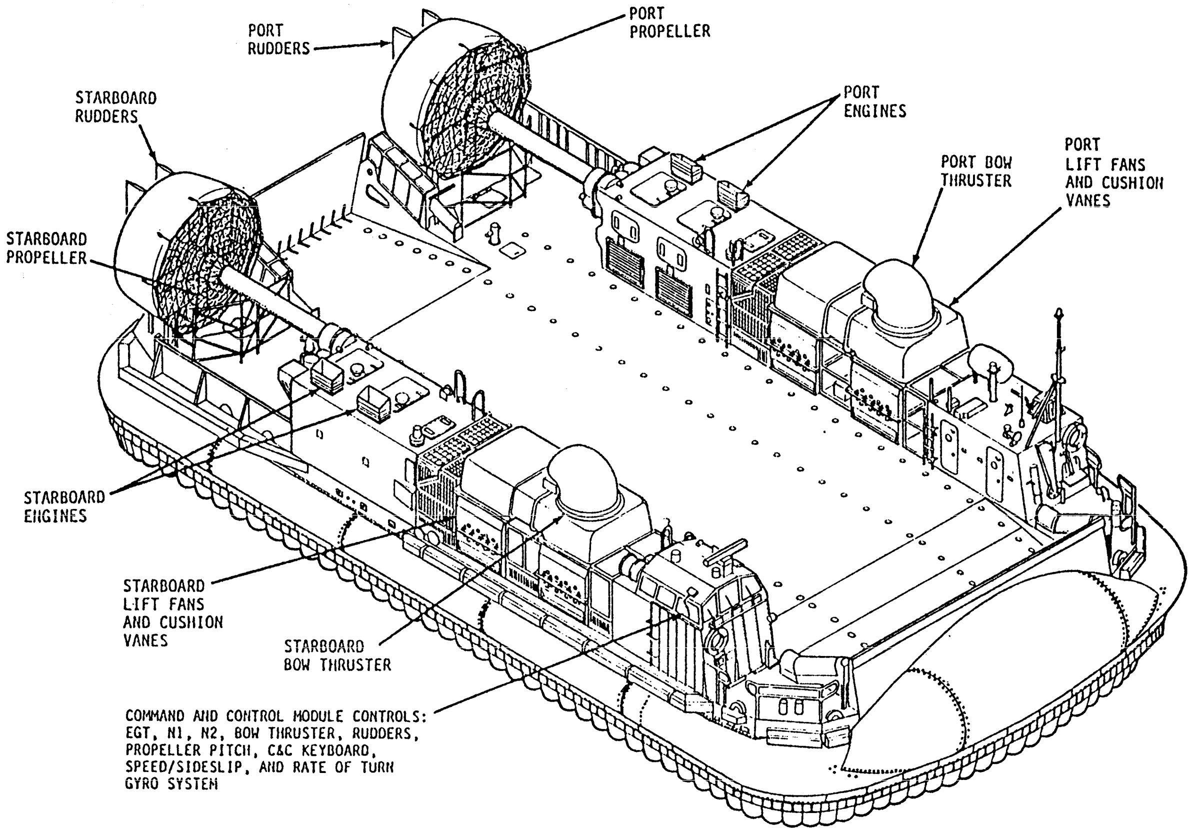


Figure 7-1.—Landing craft, air cushion (LCAC).

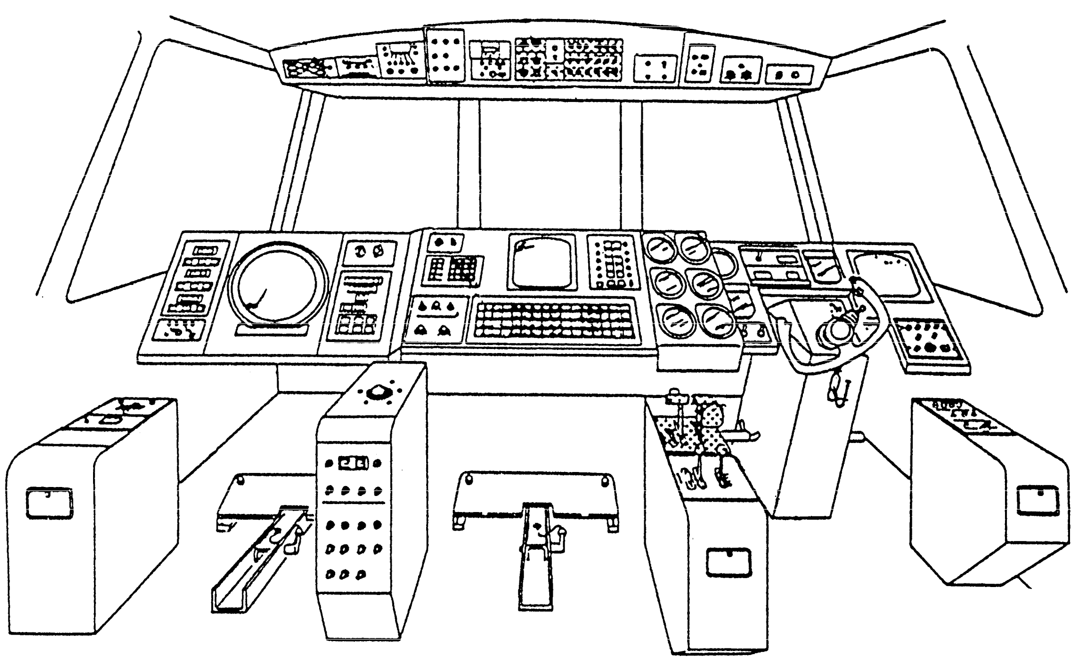


Figure 7-2.—LCAC operator station command module.

STEERING CONTROL SYSTEM

Just as its name implies, the steering control system allows the operator to steer the craft from the LCAC control station module. The steering control system is composed of both the rudder control system and the bow thruster control system and the associated operational controls, as shown in the shaded areas of figure 7-3. In the following paragraphs, we will briefly describe the major assemblies and components and their functions within the design and operation of the craft control system.

Rudder Control System

The function of the rudder control system is to provide the capability for turning power at the stern of the craft. Figure 7-4 shows the basic configuration of the rudder control system. (Study and compare figs. 7-1

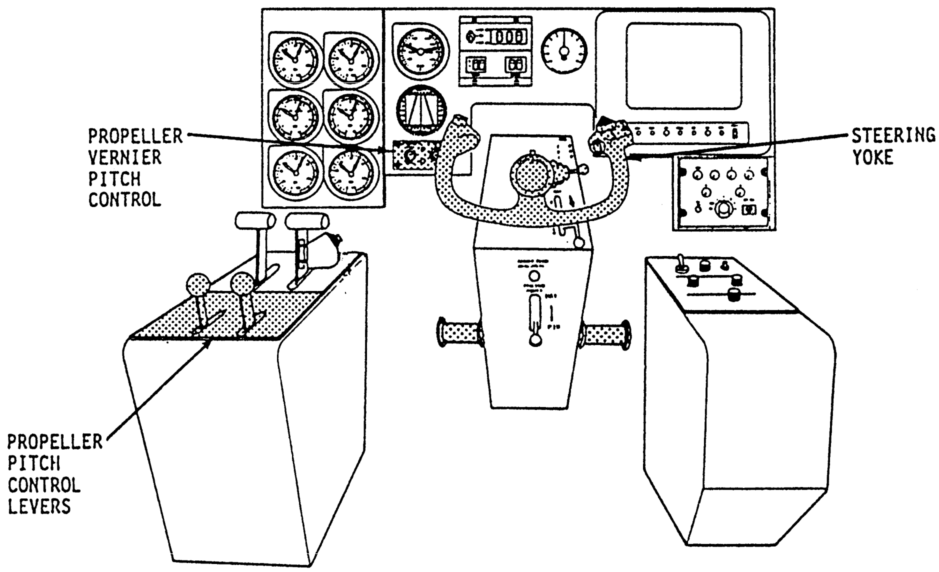


Figure 7-3.—Steering control station.

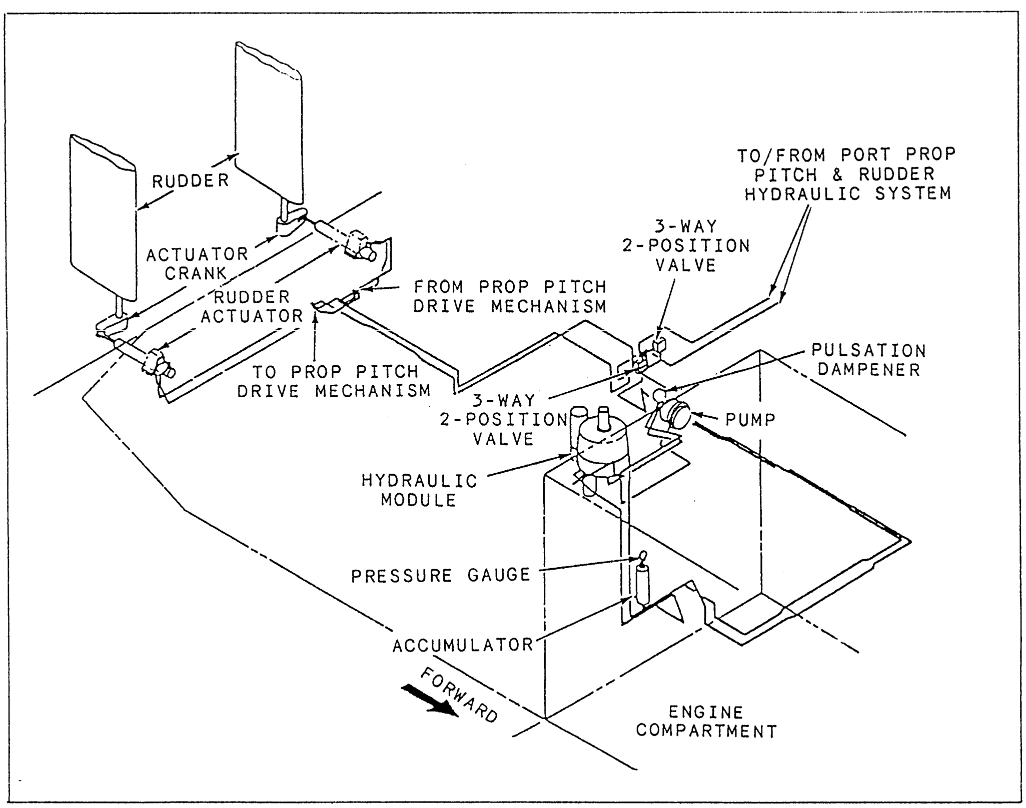


Figure 7-4.—Physical arrangement of the rudder control system.

through 7-4.) Study figure 7-4 as you read about the components and their functions.

There are two rudders mounted vertically across the trailing edge of each propeller duct. The rudders are used with the bow thrusters to provide turning capability. The function of the rudders is to deflect propeller slipstream which, in turn, provides a turning force at the stern of the craft.

Operation of the rudder control system is based on hydraulic pressure. In fact, a hydraulic pressure system supplies power to both the rudder control system and the propeller pitch control system. There is a separate hydraulic system for each side of the craft, consisting of pumps, valves, actuators, and piping. The control station operator controls the rudders by moving the rudder control pedals forward or aft, as required. Movement of a rudder control pedal is converted into an electrical signal. The electric signal, in turn, controls a hydraulic position actuator that moves the rudder for that side of the craft to the selected position. Figure 7-3 shows the location of the rudder control pedals at the steering control station. Figure 7-5 shows a side view of the rudder pedal assembly.

PEDAL CONTROLS.– The control station operator moves the rudders by operating the two pedals on the rudder control assembly. (See shaded areas of figs. 7-3 and 7-5.) The rudder pedals pivot on an axle to allow the operator to move the rudders in both directions. To move the rudders to full port or full starboard, the operator pushes the port or starboard pedal forward. This action causes a potentiometer to send a negative (port) or positive (starboard) electrical signal through the control system electronic package (CSEP) and to the rudder actuator, thereby causing the rudder to move left or right as directed. The pedal controls are spring-loaded to allow them to return to the neutral position after the rudder has moved to the commanded position.

CSEP AND RUDDER INTERFACE ASSEMBLY.— The function of the CSEP is to control and send the command signals initiated by the operator in the control station to the various components in the craft control system. The LCAC has two identical CSEPs, labeled CSEP A and CSEP B. Each CSEP has a single circuit specifically for rudder control. A rudder control signal initiated by the control station operator will be routed through one of these channels to the rudder control components. The operator can use either CSEP A or CSEP B to route a rudder control signal.

RUDDER POSITION DRIVE ASSEMBLY.— The rudder position drive assembly contains a valve coil, hydraulic drive servo motor, and feedback potentiometer. The CSEP sends an electrical drive signal to the electric drive servo motor through the valve coil to position the rudders. As the rudders are positioned, a feedback signal goes to the CSEP. When the feedback signal is equal and opposite to the drive signal, the rudders are in the desired position.

RUDDER BLADES.– The craft's two rudders are mounted vertically across the trailing edge of each propeller shroud. The rudder blades are broad, flat, aerodynamic, movable devices that measure 10.4 feet

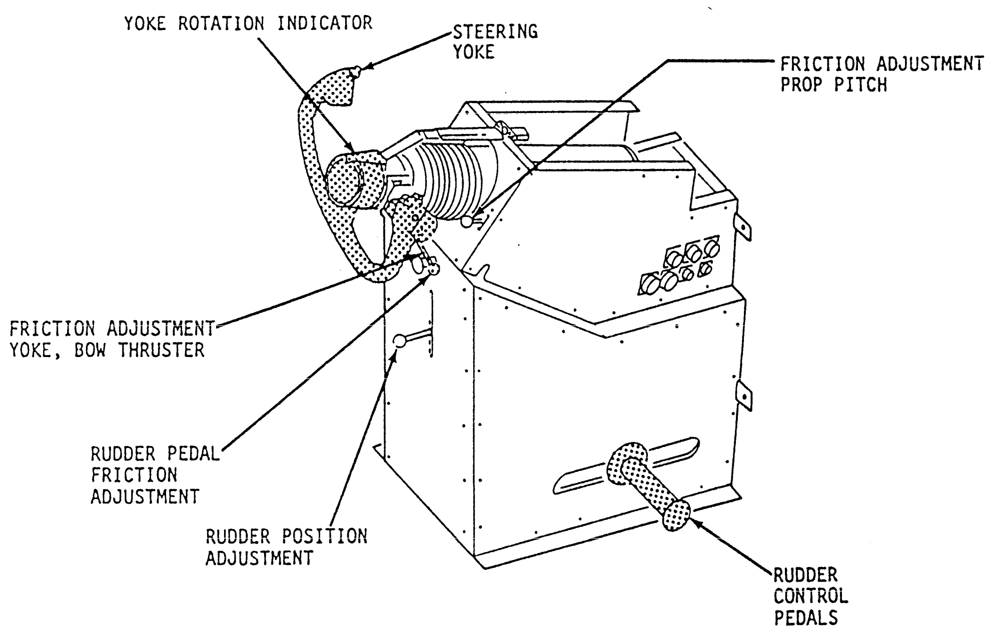


Figure 7-5.—Rudder pedals.

long and 2.3 feet wide. The rudder blades allow the operator to maneuver the craft by deflecting the propeller slipstream at various angles.

RUDDER CHANNEL SELECTOR SWITCH.— The rudder charnel selector switch is located on the command and control (C&C) keyboard at the engineer station. This switch, labeled RUDDER A/B, allows the operator to choose between channels of the CSEP in case of an emergency or system fault.

RUDDER CONTROL SYSTEM INDICATORS.– Indicators are provided on the alarm and monitor system (AMS) cathode ray tube (CRT) display monitor. The display monitor is located at the engineer control station. The indicators include the following:

- Rudder control failure
- Port and starboard hydraulic reservoir low
- Port and starboard hydraulic pressure low

Bow Thruster Control System

The purpose of the bow thruster control system is to allow the operator to turn the bow of the craft and to move the craft in close places. This system is extremely useful when the operator must dock and undock the LCAC in the dry well of the support ship.

The bow thruster control system and assembly consists of two bow thrusters (one port and one starboard), the steering yoke assembly, and the associated electrical and hydraulic operating mechanism. The physical arrangement of these components and assemblies is shown in figure 7-6. The bow thrusters provide thrust for the craft. The controls and operating mechanisms allow the control station operator to control the rotation of the bow thrusters to achieve the desired directional thrust. Basically, the control station operator uses the steering yoke in the steering control assembly to turn the craff right or left, respectively. Turning the yoke left causes the craft to turn left, while turning the yoke right causes the craft to turn right. The steering yoke contains potentiometers

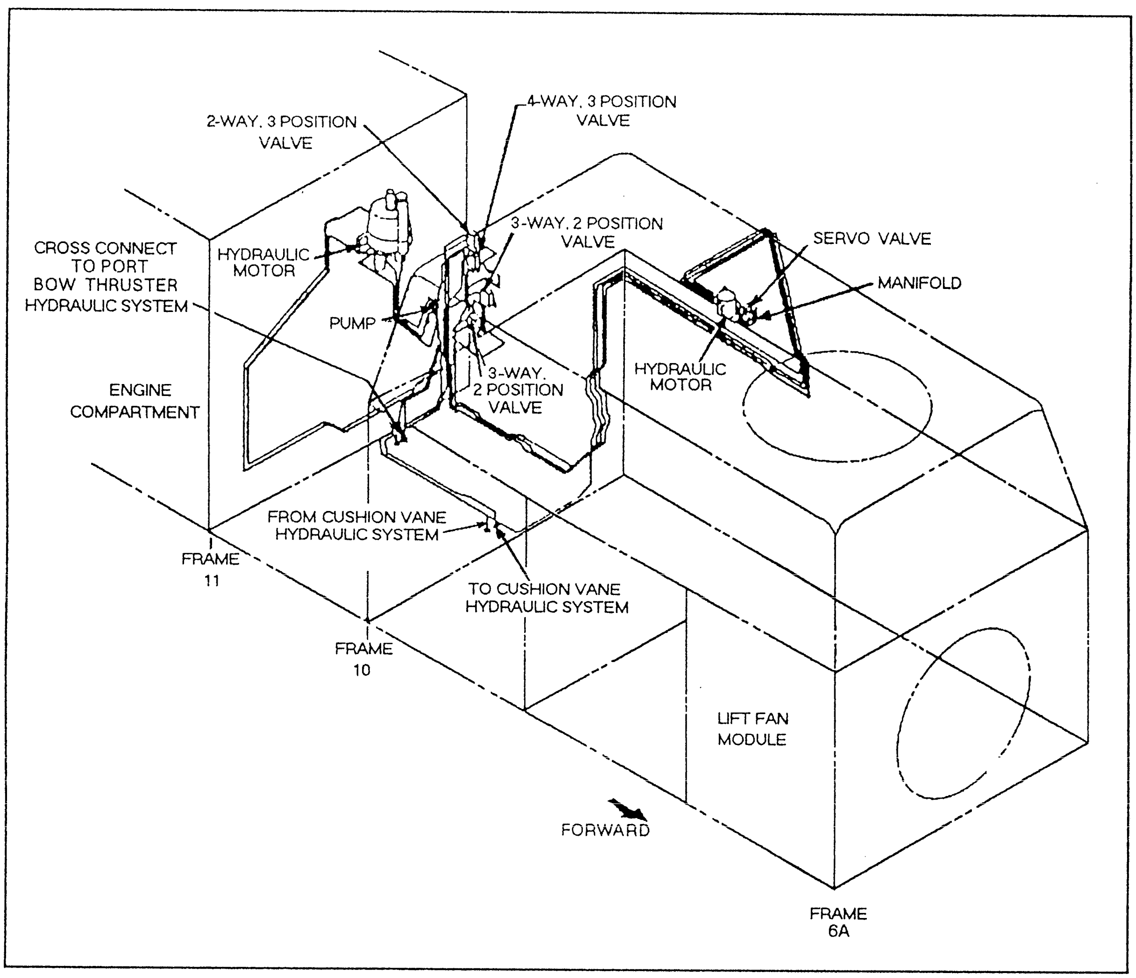


Figure 7-6.—Physical arrangement of the LCAC bow thruster control system.

that detect yoke movement and send electrical signals through the CSEP to the hydraulic operating mechanism.

Like the rudder control system, the bow thruster control system uses hydraulic power to turn the bow thrusters. A system of pumps, flow control valves, and piping supplies hydraulic power to the bow thruster wheel units and lift fan cushion vanes. When the operator turns the yoke, electrical signals are generated and routed through the CSEP to the bow thruster actuators. The basic components of the bow thruster control system are the steering yoke, forward/reverse switch, bow thruster drive mechanism, turning vanes, channel selector switch, and indicators.

STEERING YOKE.— The relative location of the steering yoke in the operator control station is shown in figure 7-3. The components and controls of the steering yoke are shown in greater detail in figure 7-7. The operator at the steering control station uses the steering yoke to control the direction of the bow thrusters. The steering yoke will turn 45° in either direction.

FORWARD/REVERSE SWITCH.— This switch allows the operator to select the direction in which the bow thrusters apply thrust. The switch is located on the steering yoke. (See fig. 7-7.) The switch allows an electrical signal to pass through the CSEP to the bow thruster drive mechanism to position the bow thruster as ordered.

BOW THRUSTER DRIVE MECHANISM.— The bow thruster drive mechanism works to move the bow thrusters to the position ordered by the operator. When the yoke is turned, it positions a potentiometer and sends an electrical signal to a mode and bias amplifier in the CSEP. The signal then goes to the bow thruster drive mechanism to position the bow thruster. The bow thruster turns, positioning a feedback potentiometer, and sends a feedback signal to the CSEP. When the feedback signal equals the command signal, the bow thruster is in the desired position.

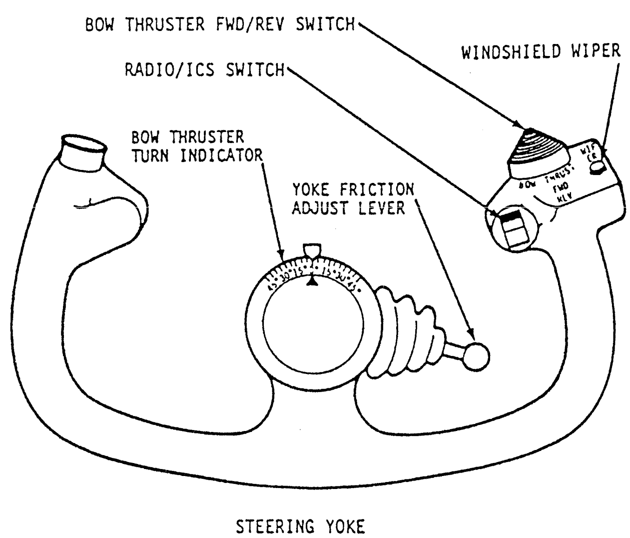


Figure 7-7.—Steering yoke and controls.

BOW THRUSTER TURNING VANES.— The purpose of the turning vanes is to direct airflow toward and out of the bow thrusters. Figure 7-8 shows the configuration of the bow thruster turning vanes. Notice how the fixed vanes are attached into the air duct of the lift fan module and into the bow thruster volute. This design allows the airflow to reach the bow thrusters with a minimum of turbulence inside the volute and air duct.

BOW THRUSTER CHANNEL SELECTOR SWITCH.— The bow thruster channel selector switch is located on the C&C keyboard at the engineer station. This switch, labeled BOW THRUSTER A/B, allows the operator to choose between channels of the CSEP in case of an emergency or system fault.

BOW THRUSTER INDICATORS.— The function of the bow thruster control system indicators is to inform the operator of existing operating conditions and alarm conditions concerning the following areas:

- Bow thruster control failure
- Port and starboard hydraulic reservoir low
- Port and starboard hydraulic pressure low

Now that you have read about the most important components of the steering control system, let's take a look at an associated system that is supplied by the same hydraulic power source–the propeller pitch control system.

PROPELLER PITCH CONTROL SYSTEM

The purpose of the propeller pitch control system is to allow the operator to control the speed and direction of the LCAC by changing propeller pitch. The LCAC propeller assembly is capable of both forward and reverse pitch. The greater the angle of pitch, the faster the craft will move.

The propeller pitch control system is composed of the yoke assembly, propeller pitch indicator, a control unit, propeller pitch control levers, potentiometers, and amplifiers. The control station operator controls the propeller pitch by using the two levers on the left-hand

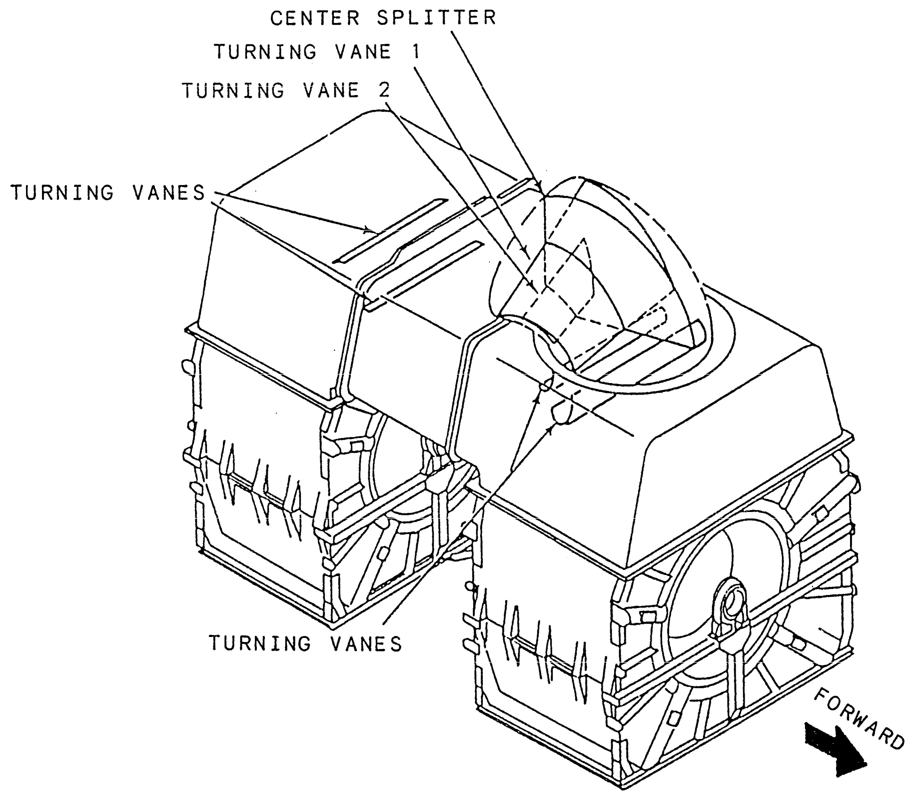


Figure 7-8.—Bow thruster turning vanes.

console and the in/out movement of the yoke. Pushing the yoke in or pulling it out will send electrical signals to the electrohydraulic servo valve and actuator, allowing the operator to control the pitch of the propellers. An indicator at the operator station provides an indication of propeller pitch. Figure 7-3 shows the physical location of the propeller pitch controls in the operator station. Let's talk about some of these controls and how they work.

Propeller Pitch Control Levers

The function of the propeller pitch control levers is to allow the operator to control the pitch of the propellers. By controlling the pitch of the propellers, the operator can control the speed and direction of the craft. Figure 7-9 shows a detailed view of the propeller pitch control levers. Each control lever has a detent stop at zero degrees of propeller pitch with adjustable mechanical stops at both ends. The propellers are adjustable from +40° to -30°.

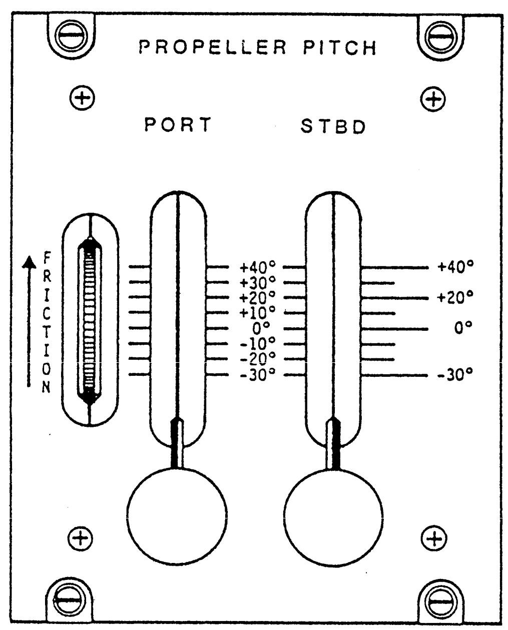


Figure 7-9.—Propeller pitch control levers.

Propeller Pitch Drive Assembly

The propeller pitch drive works to position the propeller to the position ordered by the operator. When the operator moves the control levers, an electrical signal range is produced and sent to the CSEP where it is amplified. From the CSEP, the amplified signal is sent to the propeller pitch drive mechanism. The propeller pitch drive mechanism turns the propeller, causing a feedback potentiometer to send a signal to the CSEP. When the feedback signal equals the command signal, the propeller is in the ordered position. The propeller pitch drive mechanism can also be triggered by the vernier pitch control circuit we will describe in the following paragraph.

Vernier Pitch Control Switch

The function of the vernier pitch control switch is to allow the operator to select the control source, or combination of control sources, to control propeller pitch. When the vernier pitch control switch is in the OFF position, the operator can control propeller pitch only by moving the control levers. When the vernier pitch control switch is ON, the operator can control propeller pitch by using both the control levers and the in-and-out movement of the yoke. The operator uses the control levers to set the midrange for the yoke propeller pitch control range.

Propeller Pitch Selector Switch

The propeller pitch channel selector switch is located on the C&C keyboard at the engineer station. This switch, labeled PROP A/B, allows the operator to choose between channels of the CSEP in case of an emergency or system fault.

Propeller Pitch Control System Indicators

The function of the propeller pitch indicators is to inform the operator of existing conditions. The operator uses this information to move the craft as effectively and safely as possible. This subsystem informs the operator of the following conditions:

- Propeller control failure
- Port and starboard hydraulic reservoir low
- Port and starboard hydraulic pressure low
- Propeller pitch

These indicators are provided at both the operator control station and the engineer control station.

You have just read about the steering control system and the propeller pitch control system. Now, let's take a look at another system that works with these two systems to allow the operator to maneuver the craft.

LIFT FAN CONTROL SYSTEM

The lift fan control system allows the engineer to control the airflow to the cushion of the craft. An emergency dump switch is provided at the operator control station to allow the operator to stop the craft in an emergency by taking it off the air cushion.

The structure of the lift fans and associated vane cushion assembly is shown in figure 7-10. The main components of this system are four double-entry centrifugal fans. A rectangular box structure containing two lift fans is located on each side of the craft. The fans

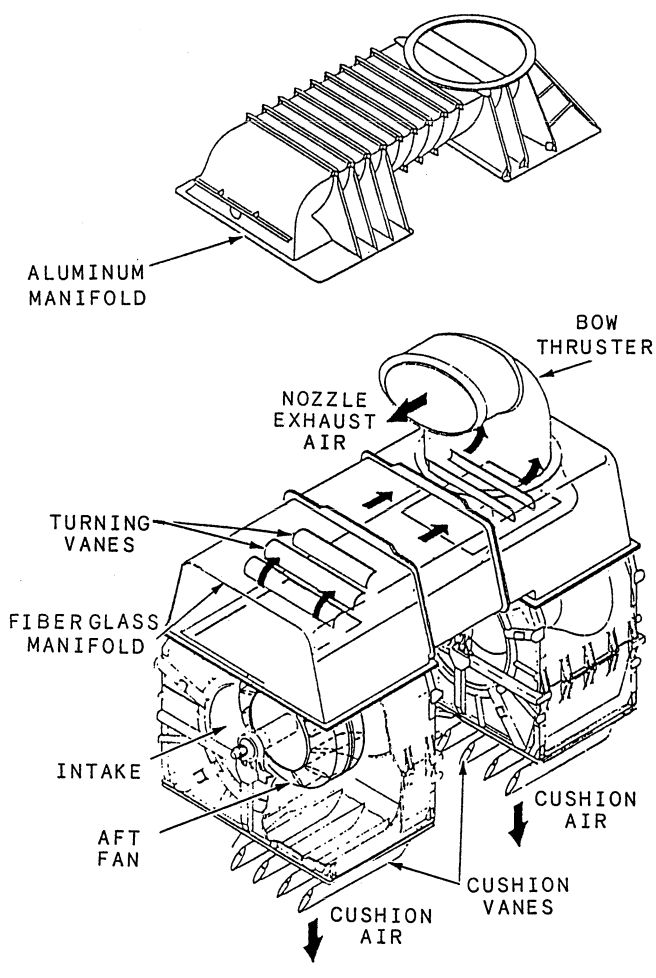


Figure 7-10.—Lift fans and cushion vanes assembly.

are driven by the TF40B gas turbine engines through right-angle gearboxes, as illustrated in figure 7-11. The lift fan control system uses the output of the TF40B engines, throughshafts, and reduction gears to turn the fans that provide air to the cushion and the bow thrusters.

Sixty percent of the air goes to the cushion and forty percent goes to the bow thrusters. The air going to the cushion can be increased or decreased by opening or closing the four sets of cushion vanes. Let's take a look at the components of this system and how they work

Lift Fans

As described earlier, there are two identical lift fan assemblies port and starboard. Each side has two double-discharge centrifugal fans, four air inlets, four discharge ducts, and eight flow control vanes. Each air inlet is protected by a foreign object damage (FOD) screen. Each fan is installed on an individual shaft. These shafts are connected to each other and then to the forward offset gearbox by flexible couplings. Each fan has one discharge volute directed upward to the bow thruster assembly.

Solenoid-Operated Valves

Four 4-way, 3-position solenoid-operated valves allow the engineer to control the cushion vanes. Momentary push-button switches located on the C&C keyboard allow the operator to control these valves. (See fig. 7-12.) Each valve has an A and a B solenoid. Solenoid A energizes when the VANE CLOSE push button is depressed. Solenoid B energizes when the VANE OPEN push button is depressed. Depressing the push button allows hydraulic pressure to be applied to the actuator, which causes the cushion vane to operate. These valves have manual overrides in case an emergency occurs.

Cushion Vanes

The function of the cushion vanes is to allow the engineer to control the amount of airflow going to the

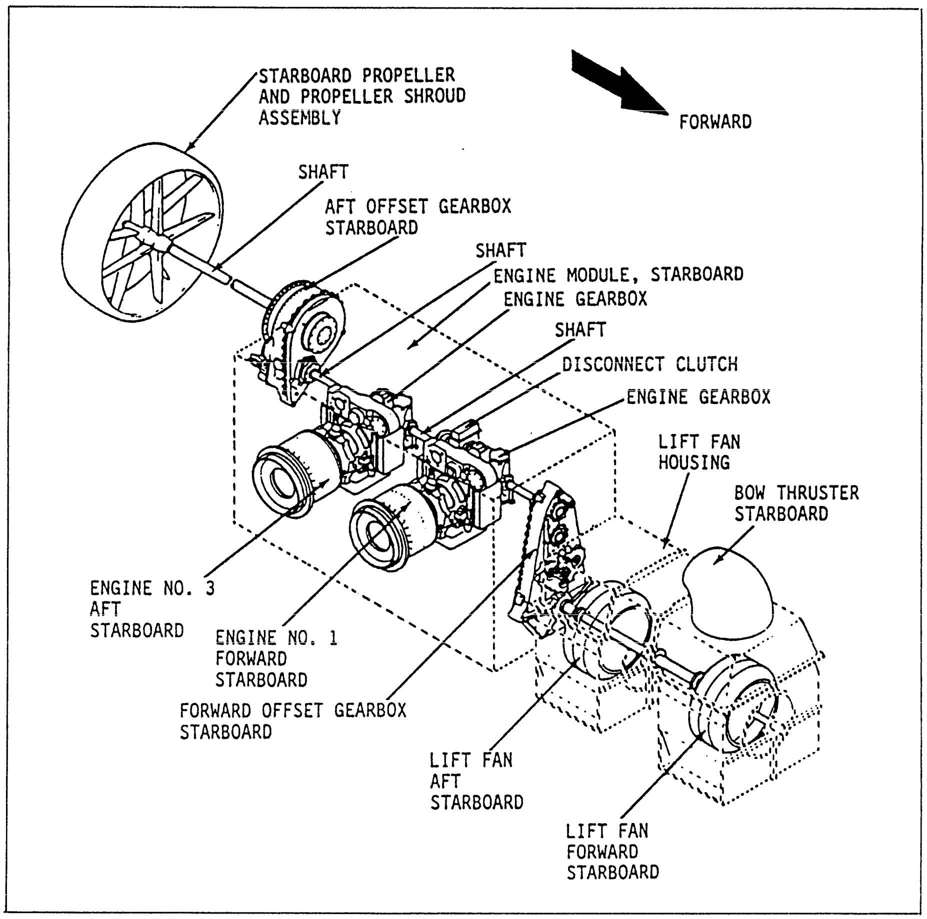


Figure 7-11.—TF40B propulsion and drive system arrangement.

cushion vanes and bow thrusters. Four switches on the C&C keyboard allow the engineer to control these vanes. The 16 vanes in the system are adjustable through any degree of rotation ordered by the operator.

OPERATING MECHANISM.— The purpose of the cushion vanes operating mechanism is to open and close the cushion vanes. Each mechanism consists of four bellcrank assemblies, four torque tubes, and one actuator. Hydraulic pressure supplied to the actuator, through the 4-way, 3-position, solenoid-operated valve, causes the bellcranks to turn and operate the cushion vanes.

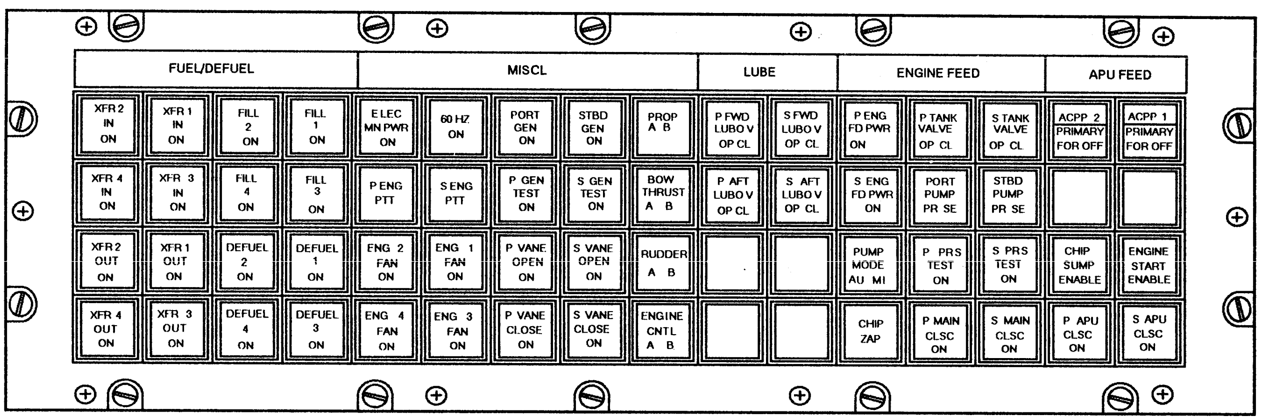
EMERGENCY CUSHION DUMP SWITCH.— The emergency cushion dump switch allows the operator to dump the craft air cushion during an emergency stop. When the switch is depressed, all four 4-way, 3-position, solenoid-operated valves are energized to supply adequate hydraulic pressure to the hydraulic actuators. The actuator movement closes all four cushion vanes and takes the craft off cushion.

SELECTOR SWITCHES.– Four momentary-contact push-button selector switches located on the C&C keyboard allow the cushion vanes to be opened and closed from the engineer station. These switches do not use power from the CSEP.

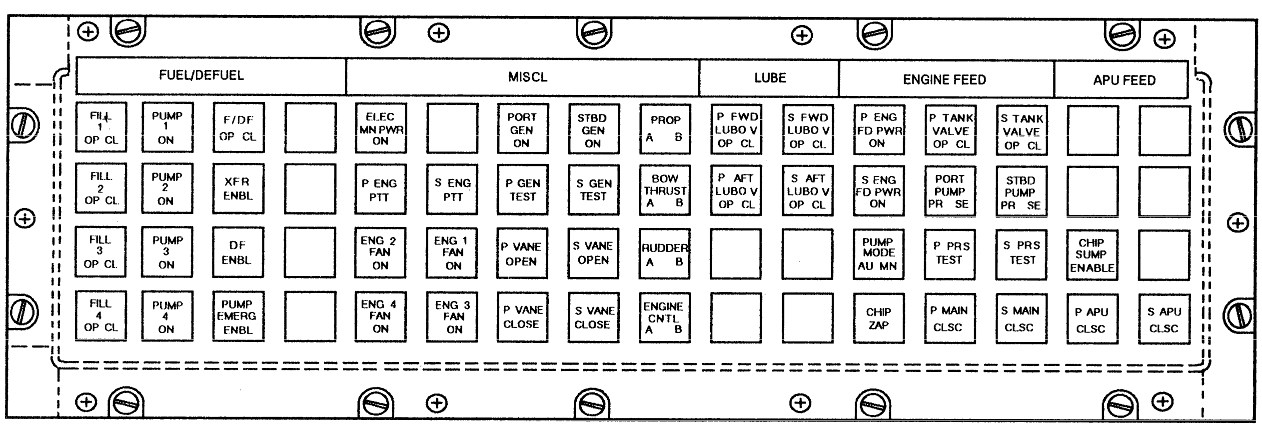
INDICATORS.— The following indicators are provided to inform the operator of the status of the cushion vanes:

- Port and starboard cushion vane position (bar graph)
- Port and starboard cushion vane digital position

The operator uses this information to achieve the most effective movement of the craft.



A. COMMAND AND CONTROL (C & C) KEYBOARD (LCACS 1 THROUGH 14 AND 24)



B. COMMAND AND CONTROL (C & C) KEYBOARD (LCACS 25 AND SUBSEQUENT)

Figure 7-12.—Command and control (C&C) keyboard.

LYCOMING TF40B ENGINE CONTROL SYSTEM

The TF40B engine control system provides the operator with controls and indicators to operate the engines and to move the craft effectively and safely. The engine control system consists of the following five control and indicator panels:

1. N_1
2. N_2
3. Engine balancing
4. Engine instrument
5. Engine start

The N_1 unit is the gas producer control unit. The N_2 unit is the power producer control unit. The engine balancing control unit is combined with the N_2 unit to balance the power outputs of the four TF40B engines. The engine instrument panel provides an analog indication of engine operating conditions. The engine start panel gives the engineer or craft operator control of the engine start and shutdown cycles.

The controls for the TF40B engine control system are powered from two de power panels and by signals from the CSEP. The N_2 and engine balance control signals are combined through the CSEP. The N_1 control signals are supplied with a positive-to-negative control voltage range from the CSEP.

Now that you have read about the control and indicator panels, let's take a look at the gas turbine engines and their associated controls.

Gas Turbines Engines

There are four direct-drive, high-speed TF40B gas turbine engines in the LCAC. Two are located on the port side and two are on the starboard side. The two-engine assembly for each side of the craft consists of a two-stage free-power turbine and a combination axial/centrifugal compressor driven by a two-step axial-flow turbine. (Compare figs. 7-1 and 7-11.) Each of these assemblies is the power source that drives the lift fans, propellers, and forward and aft gearboxes for that side of the craft. The lift fans and propellers are interconnected through the drive train by offset and engine gearboxes. There is a manual clutch provided on each power train to allow the forward engine to be disconnected from the aft engine.

Engine Start/Stop Switches

The function of the TF40B engine start/stop switches is to allow the operator to start and stop the engines from the control station. Each engine has a START/STOP switch and an OFF/IDLE/RUN master switch. The START/STOP switches send signals to the engine sequencing units, then to the respective engine control box, to carry out the ordered function.

Engine Balancing Control Potentiometers

The function of the engine balancing control potentiometers is to control the power output of each engine to make sure the engines are balanced.

Gas Producer Controls

The gas producer controls (N_1) are used by the engineer to set the speed of the engines. These controls are located in the engineer control station. The primary function of these controls is to allow the operator to control the speed of the gas turbine engines and move the craft.

Power Producer Controls

Like the gas producer controls, the primary function of the power producer controls (N_2) is to allow the operator to control the speed of the engines. When the operator uses the power producer controls, a signal goes to the CSEP and the correct engine control boxes to control that engine's speed.

Automatic Shutdown Normal/Override Switch

The automatic shutdown, normal/override switch allows the craft operator to inhibit all automatic shutdown features of the TF40B except an overspeed condition. This switch allows the operator to control the engines under battle conditions. This component was built into the engine control system to provide maximum safety for LCAC personnel.

Engine Control Channel Selector Switch

The function of the engine control channel selector switch is to select which CSEP will be used for engine control. The operator can select the desired channel by using the ENGINE CNTL A/B switch located on the C&C keyboard. This switch provides redundancy in case of a system malfunction or an emergency.

Alarm and Monitor System Indicators

The function of the TF40B engine control AMS indicators is to inform the operator of existing operating conditions, and any alarm condition that may affect craft movement. The TF40B AMS includes the following indicators:

- Engine intake air filter alarm
- Blow-in door open alarm
- Lube oil filter alarm
- Compartment hot alarm
- Chip sump alarm
- Chip bearing alarm
- Low oil quantity alarm
- Engines 1, 2, 3, and 4 ready to start
- Engines 1, 2, 3, and 4 sequence failure
- Engines 1, 2, 3, and 4 degradation alarm and percentage
- Engines 1, 2, 3, and 4 lube oil temperature
- Engines 1, 2, 3, and 4 lube oil pressure
- Engines 1, 2, 3, and 4 exhaust gas temperature
- Engines 1, 2, 3, and 4 inlet temperature
- Engines 1, 2, 3, and 4 inlet pressure
- Engines 1, 2, 3, and 4 compressor pressure
- N_1, Engines 1, 2, 3, and 4
- N_2, Engines 1, 2, 3, and 4

These indicators are provided at the engineer control station. Refer to the appropriate technical manual for a detailed fictional description of these indicators.

COMMAND AND CONTROL KEYBOARD

The function of the C&C keyboard is to provide the operator or engineer with a centralized means of control for various craft functions. Each control function is designated on an applicable keyboard switch. As shown in views A and B of figure 7-12, the LCAC C&C keyboard comes in two styles. The design represented in view A is found on LCACs 1 through 14 and 24. The design represented in view B is found on LCACs 25 and above.

The C&C keyboard is divided into the following five fictional areas:

1. FUEL/DEFUEL
2. MISC
3. LUBE
4. ENGINE FEED
5. APU FEED

In the following paragraphs, we will briefly discuss each of these functions. Refer to figure 7-12 as you read about these functional areas.

FUEL/DEFUEL Section

The FUEL/DEFUEL section contains the switches the operator or engineer can use to control the fuel transfer valves, defueling valves, and fuel transfer pump.

MISC Section

The MISC (miscellaneous) section contains switches that the operator or engineer can use to control the application of 60-Hz electrical power, battery power, and shore power to the craft. This section also has switches the engineer can use to test the generators. It also contains the CSEP channel switches for the bow thrusters, rudders, and engine control system. The cushion vanes and engine compartment ventilation fans are also controlled from this section of the C&C keyboard.

LUBE Section

The LUBE section contains the switches the engineer can use to control the lube oil system valves. There are four switches in this section, one for each lube oil system valve.

ENGINE FEED Section

The ENGINE FEED section contains the switches that control fuel flow to the engines. This section also contains the switches that control the fuel valves for the fuel tanks. The switches in this section allow the operator to select the primary or secondary fuel pump and control the main engine coalescer drains. Other switches in this section allow the engineer to test the automatic pump shifting routine. The CHIP ZAP switch in this section allows the operator to destroy small particles in the transmission system and main engine sumps.

APU FEED Section

The auxiliary power unit (APU) FEED section contains the switches that control the port and starboard APU coalescer drains. The sump chip detector alarm circuitry can be turned on and off from this section. Switches are also provided to bring 400-Hz power from the aft switchboards to the forward power panels.

Located to the left of the C&C keyboard are switches and knobs that control panel illuminations (not shown). A push-button switch is provided to test the AMS and C&C keyboard lighting.

RATE OF TURN SYSTEM

The function of the rate of turn system is to provide an indication in degrees of the craft's rate of turn. The components of the LCAC rate of turn system are shown in the shaded portions of figure 7-13. The system consists of a rate of turn directional gyro, an indicator, and a power transformer. The 400-Hz power panel or command module 400-Hz load center provides power through the power transformer to the correctional gyro. The output from the directional gyro is routed to the CSEP, where the signal is amplified and conditioned. The CSEP output is routed to the rate of turn indicator mounted on the operator console.

OUTSIDE AIR TEMPERATURE SYSTEM

The outside air temperature system provides an indication of the outside ambient air temperature for display on the AMS flight data display page. The temperature probe is mounted on the outside of the personnel and equipment module forward bulkhead. An illustration of the outside air temperature probe is shown in figure 7-14.

SPEED/SIDESLIP INDICATOR

The speed and sideslip indication is generated by the high-speed velocity log (HSVL). The HSVL system develops craft speed and sideslip (drift) angle data relative to the surface on which the craft is traveling. This information is provided to the data converter unit (DCU) where it is checked against calibration curves designed to reflect terrain characteristics. The output from the DCU is sent to the engineer AMS display and

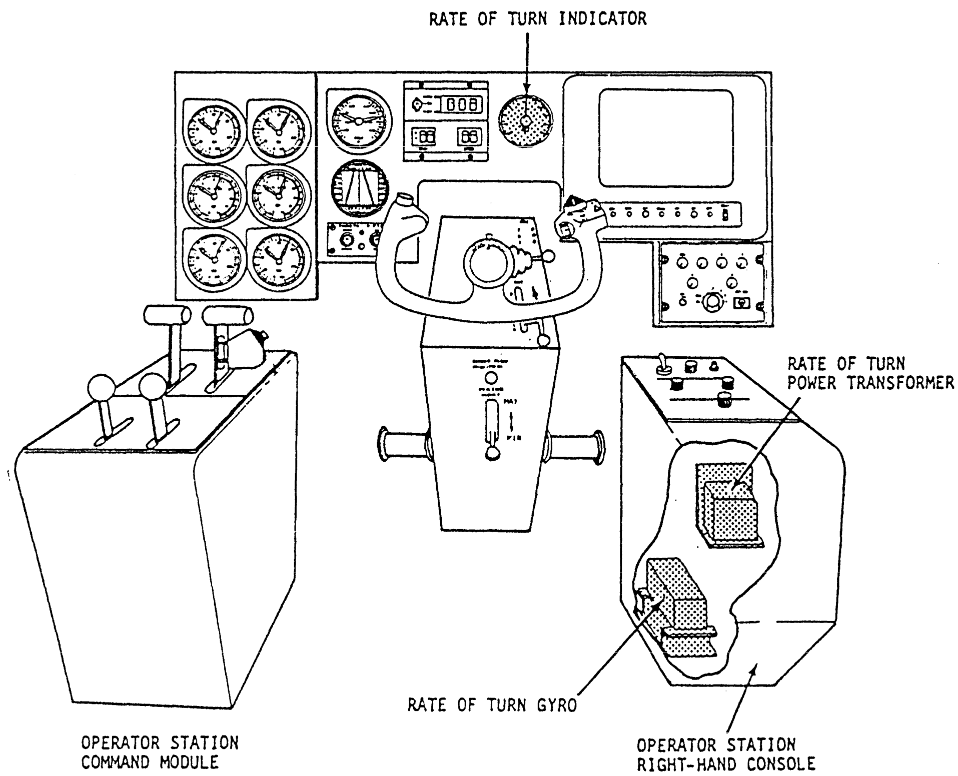


Figure 7-13.—Rate of turn gyro system.

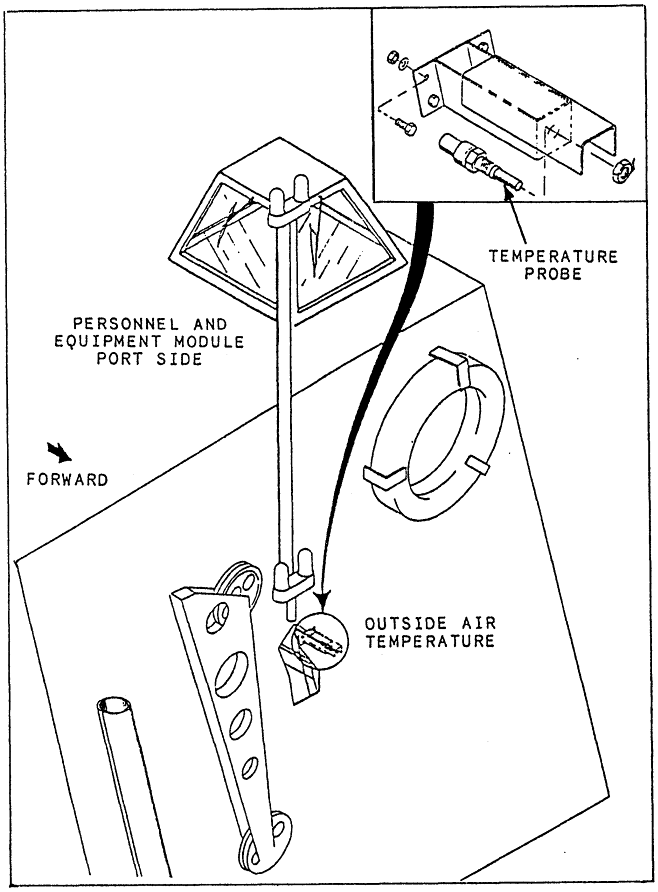


Figure 7-14.—Outside air temperature probe installation.

to the analog speed and sideslip indicator on the operator console.

The sideslip analog indication is displayed on the operator console as a left or right bar movement. (See fig. 7-15.) The bar movement has zero degrees at the center and a maximum travel of 60° to the left and right. The sideslip indication on the engineer AMS display is a digital numeric readout, with alpha characters showing PORT and STARBOARD.

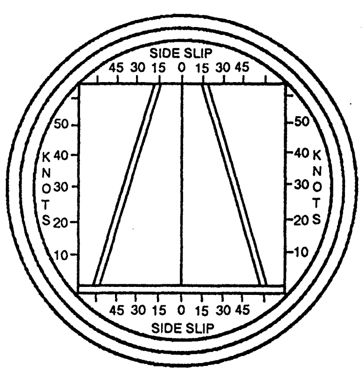


Figure 7-15.—Operator station sideslip indicator.

LCAC ELECTRICAL SYSTEM

The electrical power generation for the LCAC provides alternating and direct current requirements for power and lighting loads on the trail. The APU system, generator set, and its associated auxiliary control equipment are responsible for the generation of 120/208-Vac, 60-kW, 400-Hz, 3-phase power. The craft is organized into primary and secondary power distribution. Power is distributed over a common, redundant bus system in a manner that affords maximum protection form battle damage and equipment failure. Primary power consists of the craft generator 400-Hz ac power and the external shore 400-Hz ac power systems. Secondary power consists of the transformer rectifier unit (TRU) 28-V dc power system, the emergency power system, and 28-V dc tank power receptacle. The secondary 28-V dc system is also distributed over a common, redundant bus.

AUXILIARY POWER UNIT

As shown in figure 7-16, the gas turbine generator sets are mounted port and starboard on the LCAC. Each set consists of an ac generator, air inlet chamber, combustor assembly, turbine assembly, and reduction gear drive assembly. The gas turbine engine is a radial-flow, 150-hp, single-stage compressor, single-stage turbine. The APU is a Turbomach Model No. T-62T-40-7. Filtered air within the compartments is used for turbine inlet combustion air and generator cooling. An enclosure assembly houses each gas turbine engine and provides mounting of the turbine, exhaust connections, ship pipes, drain connections, and electrical connections. The access doors provided on the enclosure allow for inspection and maintenance of the gas turbine components.

APU Turbine Engine

The major components of the gas turbine engine are the generator, turbine, combustor and reduction gear drive. In addition, electrical control devices, accessories and associated plumbing and wiring are also part of the gas turbine assembly. The gas turbine incorporates an integral lubrication system. The lubricating oil is contained in an integral oil sump on the bottom of the reduction gear and accessory drive housing. A 24-V dc

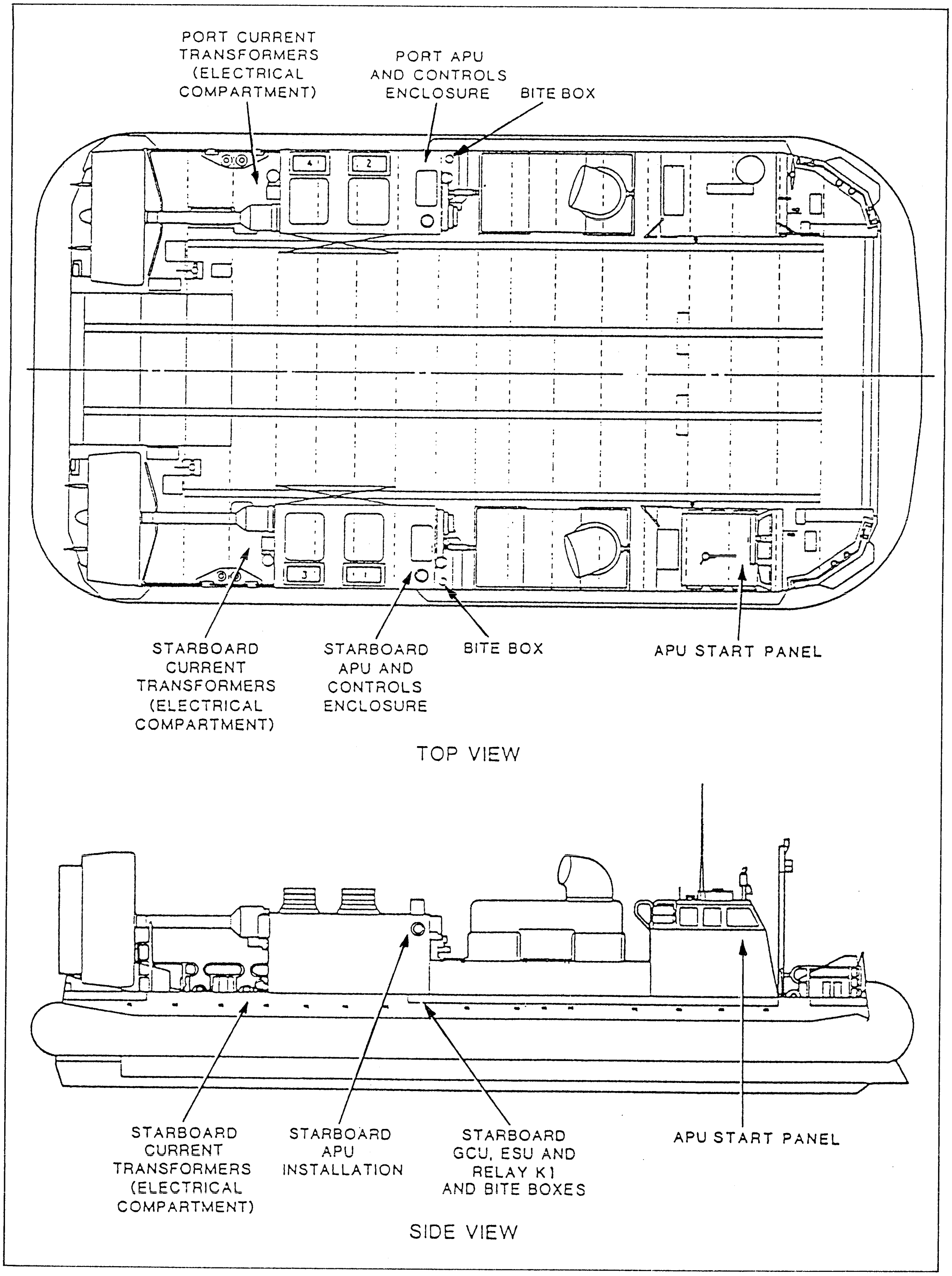


Figure 7-16.—Auxiliary powerunit (APU) locations.

electrical control system provides electrical energy for ignition and for operating the electrical components. Although a fuel system is integral to the gas turbine engine, a fuel supply must be connected to the engine.

The APU gas turbine assembly is shown in figure 7-17. The APU gas turbine consists of an air inlet assembly, rotor assembly, diffuser, turbine nozzle assembly, and input pinion. The air inlet housing is a contoured, cylindrical casting with forward and aft inlet flanges. The flanged forward end of the air inlet housing is bolted to an adapter. The adapter is bolted to the aft end of the reduction drive housing. The ail end of the air inlet housing is externally flanged to permit attachment of the combustor assembly. This configuration allows the air inlet housing to serve as a rigid member between the reduction drive assembly and the combustor assembly. An air inlet screen assembly covers the intake portion of the air inlet housing.

Gearbox Section

The reduction gear and accessory drive assembly reduces the output rotational speed (61,091 rpm) of the rotor assembly to the speeds necessary to drive the APU generator and accessories. The two-piece reduction drive housing is machined from aluminum sand castings. The reduction drive inlet pinion drives three planetary gears which, in turn, drive an internally splined ring gear. The ring gear is centrally splined to a short output shaft. The external gear of the output shaft drives the oil pump drive gear. The internal splines of the output shaft connect the driven equipment to the engine.

The upper portion of the reduction gear drive assembly contains the accessory drive. The output shaft transmits power through an intermediate gear to the fuel pump drive and starter gears, which convert the reduction gear output speed to 6,000 rpm. This is the speed required to drive the APU's accessories. The fuel pump gear operates at 4,200 rpm. With the starter disengaged, the starter gear is free to rotate with the intermediate gear. When the starter is engaged, the starter gear drives the accessory drive gear train to supply the necessary starting torque to the GTE.

The gears and bearings in the accessory drive are lubricated by an air-oil mist from the reduction drive assembly. To prevent the mist from leaking, seals are mounted in the reduction drive housing at the ends of the output shaft and the fuel pump drive and starter gears. The fuel pump and engine acceleration control assembly, which is mounted in tandem with the fuel pump, is mounted on the left forward pad of the reduction gear housing. The starter assembly is mounted on the right forward pad.

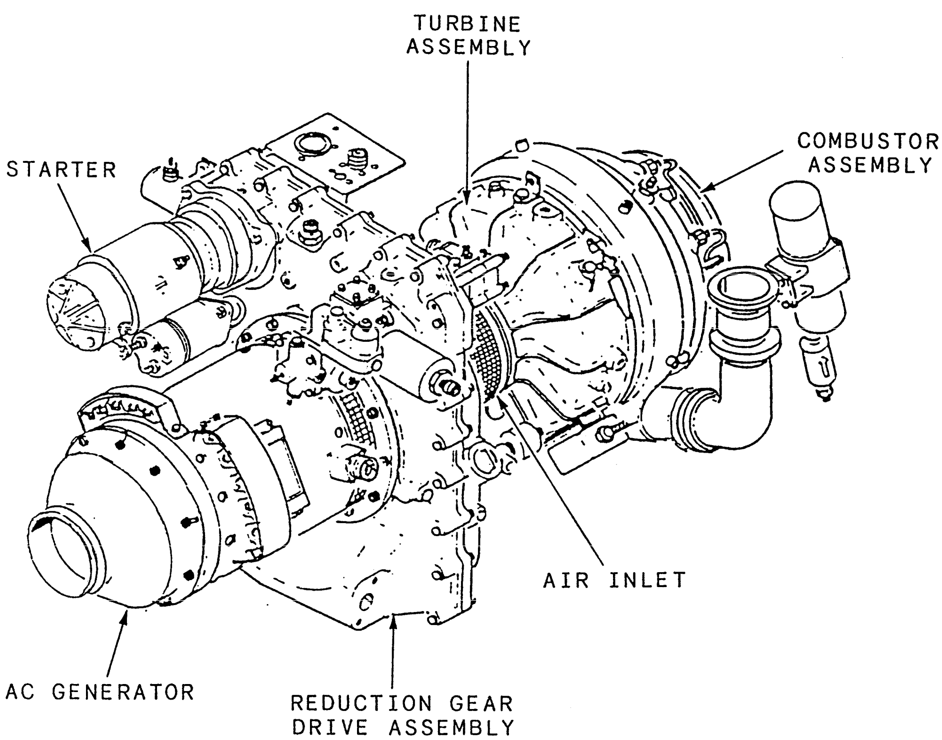


Figure 7-17.—APU gas turbine engine assembly.

APU Lubrication System

The APU lubricating oil system provides lubrication to the high-speed input pinion, the reduction and accessory gears, and the shafts and bearings. This integral lubrication system consists of an oil pump, a falter, a falter bypass relief valve, a pressure relief valve, an oil pressure switch, an oil distribution ring assembly, and an oil sump. All components of the APU lubrication system are contained within the reduction gear and accessory drive assembly.

A high oil temperature switch is installed in the reduction gear drive. The switch is electrically connected to the electronic sequence unit (ESU) to enable the ESU to monitor the oil temperature and shut down the APU when the oil temperature reaches 275° ±5°F.

APU Fuel System

The APU fuel system automatically provides proper engine acceleration and maintains a nearly constant operating speed under all operating conditions. Fuel is supplied to the GTE at 5 to 40 psig with a minimum flow capacity of 200 pounds per hour. The main components of this system are an inlet fuel filter, a fuel pump, an engine acceleration control assembly, start-fuel, main-fuel, and maximum-fuel solenoid valves, start-fuel nozzle, purge valve, and a manifold assembly.

During the APU start, the start-fuel solenoid valve opens. The resulting fuel pressure forces the piston in the purge valve to one side in the valve chamber to allow fuel to flow through the start fuel nozzle. At approximately 65 percent engine speed, the start-fuel solenoid valve closes to cut off the fuel pressure. A return spring transfers the piston in the purge valve to the purge position. In the purge position, compressor discharge air flows through the start-fuel nozzle to clear the nozzle of residual fuel. The residual fuel is then directed to the combustor to be burned.

Electronic Sequence Unit

The ESU is a control device that monitors APU speed, turbine exhaust temperature, low oil pressure, sequence failure, APU temperature, and APU underspeed. The ESU shuts down the APU if malfunctions occur in these circuits. Each 40 milliseconds, the ESU checks all functions and confirms that input data is greater or lesser than programmed values. In the event input data is outside the programmed values, an indication is provided in the built-in test equipment (BITE) box assembly and, if required, the engine is shut down.

Generators

The generators driven by the APUs produce a 120/208-V ac, 400-Hz, 60-kW, 3-phase current. The generator is a salient-pole, brushless, permanent-magnet type that incorporates a fan and generator air inlet adapter for cooling. The ac voltage generated by the permanent magnet rotor and stator is connected to an external voltage regulator where it is rectified and regulated. When both generators are operating, the load is divided, but either generator can supply total craft power requirements under normal operating conditions.

The control components consist of two governor control units (GCUs), ESUs, current transformers, BITE boxes, an APU start panel, and generator start boxes. The controls are used to monitor operating conditions for both the engine and generator. The control components for each gas turbine generator set are mounted in a control enclosure.

Generator Control Unit

A GCU is installed for each ac generator. The GCU circuits are functionally divided into the power supply, regulator, generator relay controls, contactor relay controls, feeder fault, overvoltage sensing, undervoltage sensing, underfrequency, and overfrequency sensing sections. Each GCU monitors and controls generator output parameters. The GCU provides voltage regulation, controls the generator output voltage, and protects the generator from frequency and current malfunctions. Generator input power application and output power regulation is accomplished by controlling the excitation applied to the generator by the GCU. The GCU also controls the excitation to the line contactor that distributes generator feeder lines to the load. The GCU also contains features that are used to establish a test mode of operation for the generator.

ELECTRICAL DISTRIBUTION

The electrical distribution system aboard the LCAC is composed of a 400-Hz/208-V ac system, and a 28-V dc system. The generators each supply separate 400-Hz switchboards which serve as central control points for power distribution. We will take a brief look at these two power systems in the following paragraphs.

400-Hz/208-V AC Distribution System

Primary power (400 Hz/208 V ac) is provided nom either external shore power or the two APU-driven generators. Generator power and shore power is distributed through the craft using the same busses. After the generators are started and power is available, the generators can be placed online by depressing the appropriate switch on the C&C keyboard. The power control relays are energized and route power to the main line contractors to energize the aft busses, port and starboard. The forward busses are controlled automatically through relay contacts of the line contractors. An isolation power supply wired between the battery switchboard and the switchboard control panels provides isolation between the ac and dc power distribution systems.

28-V DC Power Distribution System

All 28-V dc power is provided from two sources: (1) the storage batteries and (2) the transformer/rectifier (T/R) units. The storage batteries are made up of two 12-volt batteries connected in series. The T/R units convert 400 Hz/208 V ac to 28 V dc. The 400-Hz load centers are energized from the APU-driven generators or from 400-Hz external shore power. The No. 1 and No. 2 primary dc busses are cross connected through the emergency dc power panels. The reverse current relays function to prevent damage to the T/R units if a T/R unit should fail. When shore power or generator power is unavailable, the battery serves as the emergency dc power source.

Now that you have read about the LCAC propulsion control system and the associated components and systems, let's look at some important aspects involving the maintenance of these systems.

LCAC SYSTEMS MAINTENANCE

As with all equipment and systems, the propulsion control systems and related equipment on the LCAC must be monitored for effective and safe operation. Monitoring these systems is also a way of providing early warnings concerning potential trouble areas.

In this section, we will talk about the general maintenance and troubleshooting routines you will encounter with the LCAC control systems and equipment. For detailed information concerning the procedures you should use for removing and replacing specific parts, we recommend you consult the appropriate technical manuals.

SCHEDULED MAINTENANCE

Scheduled maintenance of the LCAC control systems includes the procedures you must perform for preventive maintenance and performance tests. You will discover that you must accomplish these procedures on a scheduled or condition monitoring basis.

You can find the appropriate scheduled maintenance actions in the technical manuals for the specific equipment items. Remember, the scheduled maintenance instructions in these technical manuals are not intended to duplicate the instructions furnished in the PMS. In the case of conflicts, the PMS documentation takes precedence.

MAINTENANCE REPAIR LEVELS

For the LCAC, the maintenance repair levels are divided into the following four categories:

1. Organizational
2. Enhanced organizational
3. Depot
4. Specialized repair facilities

These repair levels are part of the source, maintenance, and recoverability (SMR) codes for each part, subassembly, and module. The SMR codes are identified and explained in the Coordinated Shipboard Allowance List (COSAL) for the LCAC. Let's briefly look at each of these levels.

Organizational Maintenance

Organizational maintenance includes the type of maintenance actions that are performed on the LCAC craft, afloat. Organizational maintenance consists of all the maintenance actions required to maintain the operational status of the LCAC during deployment.

Enhanced Organizational Maintenance

Enhanced organizational maintenance includes the maintenance actions that are normally performed on the LCAC craft, ashore. This level of maintenance normally consists of craft system troubleshooting, component replacement, or part manufacturing. The LCAC craft unit, ashore, is normally a complete repair facility. The only maintenance actions that are not performed at this facility are those that require a depot or specialized facility maintenance.

Depot Maintenance

Depot maintenance is normally based at a shore facility. This level of maintenance involves the repair or disposition of components, modules, or assemblies that are sealed or require major overhaul. Depot maintenance also consists of repair procedures that are not available at the enhanced organizational level and those that are not cost effective at the lower levels.

Specialized Repair Facility

Specialized repair facility maintenance is normally accomplished at a shore facility that has the specialized capabilities required for specific parts that need maintenance actions beyond the scope provided by the depot maintenance level.

Now that we have talked about the different maintenance levels, let's look at some of the troubleshooting procedures you may need in maintaining the LCAC control equipment and systems.

TROUBLESHOOTING PROCEDURES

In troubleshooting the components and systems of the LCAC, you will use the basic troubleshooting methodology we discussed earlier in this TRAMAN. Sometimes, system analysis will allow you to go directly to a specific faulty component or cable. When you need to use a more comprehensive process, however, the half-split method of troubleshooting will provide you with the most logical approach to fault isolation.

To perform the half-split method of fault isolation, you should first pick a circuit midpoint on a specific wiring diagram. Your ability to gain access to this midpoint should be the determining factor. By taking a signal measurement at the midpoint, you will be able to determine which half of the circuit is defective. After you determine a midpoint, refer to the wiring diagram to identify the signal level or range required. If the signal is correct at the midpoint, then the defective part or circuit lies somewhere between that point and the end of the circuit. If the signal made at the midpoint is not correct, the problem lies somewhere between that point and the point at which the signal starts. Your next step is to continue to use the half-split method on the part of the original circuit you have found to be defective.

You should continue this process until you can isolate the defective part or area. In the last stage of the half-split method, you should be able to isolate the fault to a specific component or part of the circuit. At this point, you should use a voltage and continuity check to confirm the specific cause of the problem.

In the preceding sections of this TRAMAN, you have read about the design, control systems, and basic maintenance you will encounter in your duties and responsibilities aboard an LCAC. Now, let's look at the propulsion system of another type of landing craft, the patrol combatant missile (hydrofoil) or PHM.

PATROL COMBATANT MISSILE (HYDROFOIL)

The PHM is an advanced design, fast, highly maneuverable, foilborne warship. The mission of the PHM is to operate offensively against hostile, heavy-surface combatants and other surface craft and to conduct surveillance operations, such as screening coastal convoys or amphibious forces in the arrival and departure areas. This small, fast, and versatile ship provides the Navy with high-speed support capabilities.

The basic design of the PHM is shown in figure 7-18. This design offers the stability and ride comfort normally limited to much larger ships at a much lower cost. It also offers the high maneuverability and speed associated with smaller vessels. Its propulsion system consists of both a foilborne and hullborne system. This combination design offers the advantages of a diesel engine in its economical, long-range cruising and close-in, low-speed twin-engine maneuvering ability and those of a lightweight GTE in its immediate, high-speed foilborne capabilities. Its maximum hullborne range is greater than 1,200 nautical miles with a maximum speed of 11 knots. While the craft's takeoff speed is dependent on the loading, sea state, and power settings of its controls, its maximum foilborne speed is greater than 40 knots with a maximum cruising range of greater than 500 nautical miles.

As we discuss the PHM, we will provide you with a general description of the physical and functional characteristics of its propulsion systems and controlling stations. The basic control system includes the systems, controls, and equipment needed for direction, speed, and other maneuvering operations. Its propulsion and auxiliary systems include the following six subsystems:

1. Main propulsion (foilborne) subsystem
2. Main propulsion (hullborne) subsystem
3. Power train subsystem
4. Automatic control subsystem
5. Electrical subsystem (ship's service power unit)

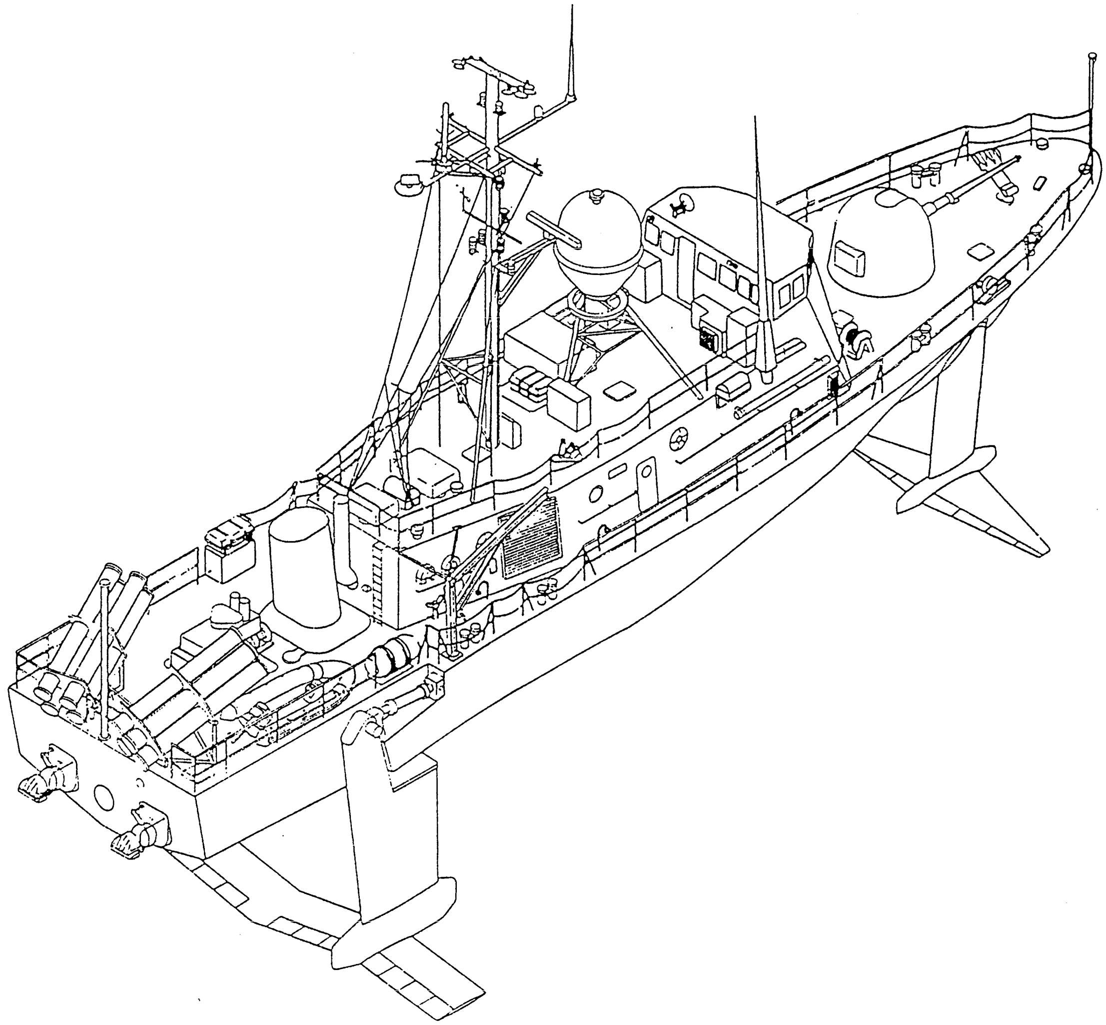


Figure 7-18.—Patro1 combatant missile (hydrofoil) (PHM).

6. Auxiliary subsystems

In the following paragraphs, we will briefly describe these systems and how they work to propel and control the craft.

PROPULSION SYSTEMS

The PHM has two complete and separate main propulsion systems: (1) the foilborne system and (2) the hullborne system. As its name implies, the foilborne propulsion system propels the ship in the foilborne mode. In addition, the foilborne system can propel the ship in the hullborne mode, either with the foils extended or retracted. The hullborne propulsion system, however, can propel the ship only in the hullborne mode, either with the foils up or down. The machinery arrangement for both the foilborne and hullborne propulsion systems is shown in figure 7-19.

Both foilborne and hullborne operations are controlled from a common helm. When the PHM is in the hullborne mode, a water jet nozzle pivots in response to an operator command from the helm to provide steering and reversing functions. A bow thruster provides for close-in maneuvering and docking. Consequently, the hullborne mode is used for any type of close maneuvering, such as docking or reversing the craft's direction. When the craft is in the foilborne mode, a control system consisting of the helm, throttle, and an automatic control system (ACS) provides continuous dynamic control during all foilborne operations. By providing trim and attitude control, automatic banking in turns, and seaway disturbance alleviation, the foilborne control system makes it possible for the PHM to achieve its desirable riding qualities and fast speeds. The foilborne control surfaces include the trailing edge flaps on each of the foils and the swiveled forward strut which acts as a rudder. (See fig. 7-19.) In the following paragraphs, we will get a closer look at both the hullborne and foilborne propulsion systems. Let's first look at the foilborne system.

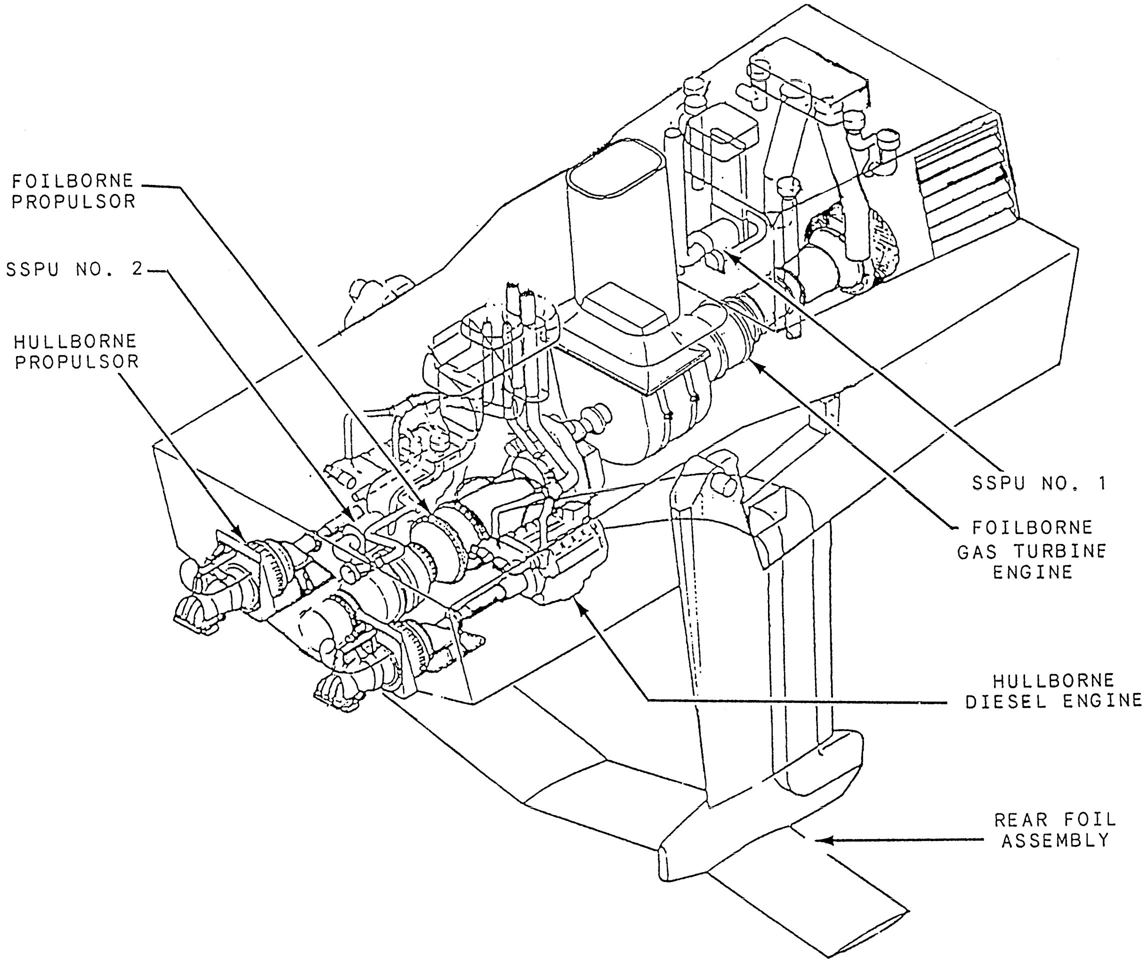


Figure 7-19.—Main machinery arrangement for foilborne and hullborne propulsion systems.

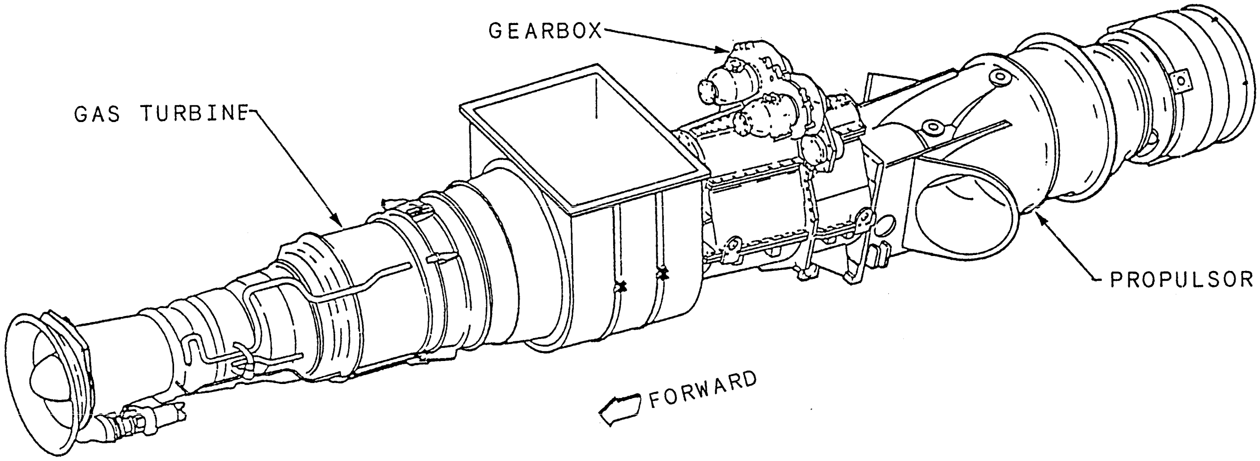


Figure 7-20.—Foilborne propulsion system.

MAIN PROPULSION (FOILBORNE) SYSTEM

The foilborne propulsion system provides the PHM with speed and stability. The basic components of the foilborne propulsion system are shown in figure 7-20. The foilborne power plant supplies the thrust required for takeoff and foilborne operations. Foilborne propulsion is created by a two-stage water jet pump powered by a gas turbine engine. The propulsion thrust occurs as seawater is pumped through the water jets and expelled through a nozzle at the stern. The reactive force resulting from the acceleration and expulsion of the seawater drives the ship forward. The main advantage of this system is its speed and efficiency in driving the craft forward. When foilborne, the PHM can attain speeds greater than 40 knots. A disadvantage, however, is that there is no provision for reversing the craft when the PHM is in the foilborne mode.

The basic foilborne propulsion system consists of the GTE (power plant), a power train assembly, and a propulsor assembly. In the following sections, we will examine the main components of the foilborne system, starting with its power plant, the LM2500 GTE.

LM2500 GTE ASSEMBLY

The power for the foilborne system is provided by a General Electric LM2500 GTE located in the gas turbine machinery room. This GTE is the same type that is used in the twin-shaft and single-shall ships. The gas turbine assembly consists of a gas generator, a power turbine, a high-speed coupling shaft, and an exhaust duct. At 100 percent power, this GTE is capable of delivering 16,767 hp to the gearbox assembly at about 3,100 rpm.

The LM2500 GTE draws combustion air through knit-mesh filters located on the weather deck. The combustion air flows through the demister panels and the air intake plenum, which interfaces with the forward end to the gas turbine machinery room. A barrier wall and seal prevent any air from the area surrounding the engine from entering the combustion air intake. The exhaust gases flow from the GTE exhaust duct through primary and secondary eductor nozzles, which create a flow of secondary cooling air through the gas turbine machinery room. Located in the aft end of the gas turbine machinery room is the foilborne engine exhaust collector. When the GTE is running, the exhaust works like an eductor to draw cooling air into this compartment from ventilation ducts through the auxiliary machinery room No. 1. When the GTE is secured, fans on either side of the combination air inlet finish cooling air for the engine and its compartment. The exhaust gases eventually exit through the foilborne engine exhaust stack located just aft of the superstructure.

In addition to the LM2500 GTE, the gas turbine machinery room contains other foilborne propulsion system equipment, including the foilborne engine lube oil supply and return falters, engine lube oil-to-fuel heat exchanger, engine fuel heater, propulsor gearbox lube oil-to-engine fuel heat exchanger for operating in cold areas, and propulsor gear lube oil-to-engine lube oil heat exchanger for operating in hot areas.

Lube Oil System

The LM2500 GTE lube oil system provides two main functions: (1) it supplies cool oil to the gas turbine bearings, gears, and splines to prevent excessive friction and heat, and (2) it supplies heat through the oil-to-fuel heat exchanger to heat the fuel for the gas turbine. The lube oil is stored in a 7.2-gallon oil tank located over the engine. The oil is gravity-fed from the storage tank to the lube and scavenge pump mounted on the gas turbine. The single-supply element of the pump forces the lube oil through tubes to the specific areas requiring lubrication.

A duplex filter mounted beneath the engine on the starboard side provides filtration for the supply oil. A duplex filter mounted beneath the engine on the port side provides filtration for the scavenge oil. The scavenge oil housing assembly contains a magnetic chip detector. The scavenge oil is filtered, cooled, and returned to the storage tank.

Fuel Oil System

The GTE fuel system on the PHM is essentially the same as the fuel systems on other gas turbine-powered ships. The PHM fuel system regulates and distributes fuel to the combustion section of the gas generator, providing a control over gas generator speed. Although the power turbine speed is not directly controlled by the GTE fuel system, it is established by the gas stream energy level produced by the gas generator.

Operation

The GTE is started by the operator in the engineer's operating station (EOS). Throttle control then is transferred to the helm (pilothouse) for foilborne operation. During foilborne operation, the monitoring of operating parameters continues to take place in the EOS. Before the GTE is shut down, control is transferred back to the EOS where the GTE is shut down by automatically controlled logic. Auxiliary functions, such as the GTE machinery room cooling, compressor washing, and engine waste drain pumping, are controlled by the operator in the EOS.

There is no local control at the GTE. The EOS operator normally starts and stops the GTE by using the automatically controlled sequencer. In case of system malfunction or damage to the GTE, however, manual starting and stopping of the engine can be accomplished at the EOS control console.

The GTE drives the propulsor assembly by means of the power train assembly. We have already talked about the LM2500 GTE that provides the power for the foilborne propulsion system. Now, let's take a look at the propulsor assembly for this system.

PROPULSOR ASSEMBLY

The foilborne propulsor consists of a two-stage Aerojet Liquid Rocket waterjet pump, a bearing, and a seal assembly. The Aerojet pump forces seawater up through the two ducts in the two aft foil struts into a single foilborne water jet nozzle that exhausts the seawater through a transom at the hullborne waterline. (See figs. 7-19 and 7-20.) The frost stage of the waterjet pump operates at a lower speed for good suction performance. The second stage runs at a higher speed to increase pressure and velocity. The propulsor assembly is driven by the GTE through the gearbox assembly or power train, which we will discuss next.

POWER TRAIN ASSEMBLY

The power train assembly consists of the gearbox, flexible coupling, and shaft assemblies. The GTE drives the gearbox through a high-speed flexible coupling shaft. This shaft is designed to accommodate any axial or radial movement between the GTE and gearbox that results from dynamic loads and thermal expansion. Because the GTE is directly coupled to the propulsor through the gearbox, there is no disengagement capability. This means that whenever the GTE is operating, the propulsor is being driven.

Gearbox Assembly

The gearbox assembly is a Western Gear lightweight, reduction transmission unit that sends power from the GTE to the foilborne propulsor through the bearing and seal assembly. The gearbox is split vertically into a high-speed assembly and a low-speed assembly and consists of main drive pinions that drive two coaxial output shafts through two sets of double helical reduction gears. This design allows it to provide speed reduction and power split to the two propulsor impellers. It does this by reducing the input speed from the GTE and providing separate output shafts to the propulsor first-stage inducer and the second-stage impeller, allowing these two sections to operate at different speeds. An access hole in the high-speed assembly and one in the low-speed assembly provide a means for inspection. The gearbox assembly also provides four hydraulic pump accessory drive pads as well as the drive pads for the lube oil supply and scavenge pumps. Eight thermocouples, one in each main bearing, monitor bearing temperatures.

Flexible Coupling and Shaft Assemblies

A double-diaphragm flexible coupling connects the low-speed and high-speed pinion shafts. Each coaxial output shaft consists of an inner high-speed quill shaft and an outer low-speed quill shaft. Splines in the high-speed and low-speed output gears drive the output shafts.

FOILBORNE CONTROL SYSTEMS AND OPERATING STATIONS

The foilborne control systems include all the systems that allow a PHM in the foilborne mode to respond to control commands. These systems include the ACS, foilborne engine control system (FECS), foilborne propulsor control system (FPCS), and the bulkhead-mounted electronics enclosure (BMEE). The foilborne control systems also include the foilborne equipment and systems found in the foilborne control stations, such as the EOS and the pilothouse.

Pilothouse

Foilborne operation is primarily controlled from the pilothouse. The pilothouse control console, which is shown in figure 7-21, is designed for a two-man operation under normal conditions. The helmsman is seated on the right with the primary maneuvering controls and displays arranged on the console within his or her reach. The displays necessary for conning and monitoring the ship are grouped on the left in front of the OOD seat. Overhead panels, which can be reached from either seat, contain the controls and indicator lights for critical ship's systems and the windshield washer/wiper controls.

Engineer Operating Station

The EOS is located on the port side of the platform deck adjacent to the gas turbine machinery room and turbine inner intake plenum. Although a seat is available for a second operator or for training purposes, the EOS is basically arranged for a one-man operation.

The EOS control panel arrangement is shown in figure 7-22. The power plant controls are on the main console. The electrical and fuel controls are on the inboard cabinet. The hydraulic panel is placed diagonally at the corner. A more detailed view of a

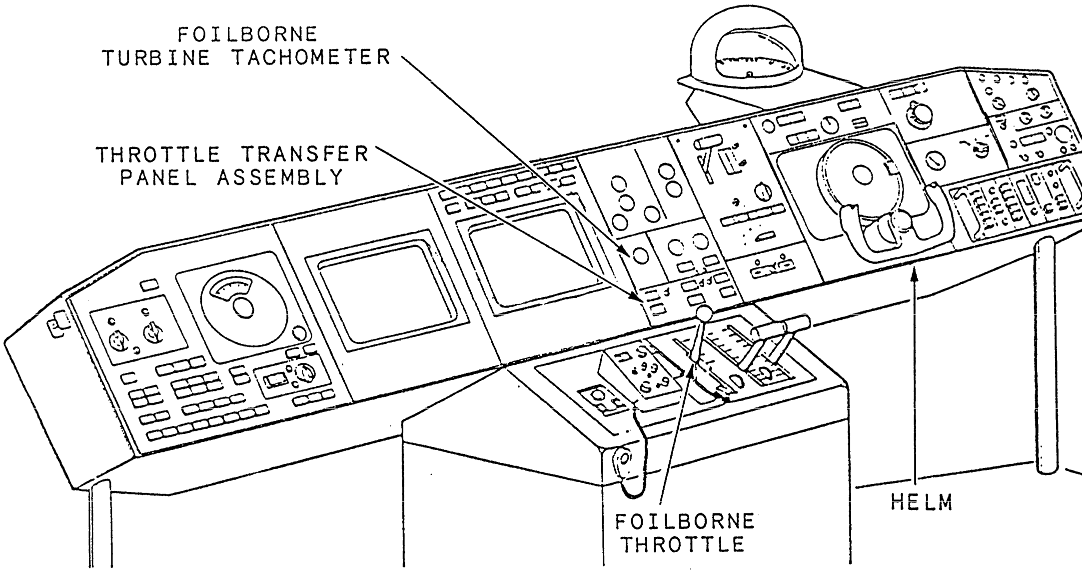


Figure 7-21.—FBCS controls at the pilothouse control console.

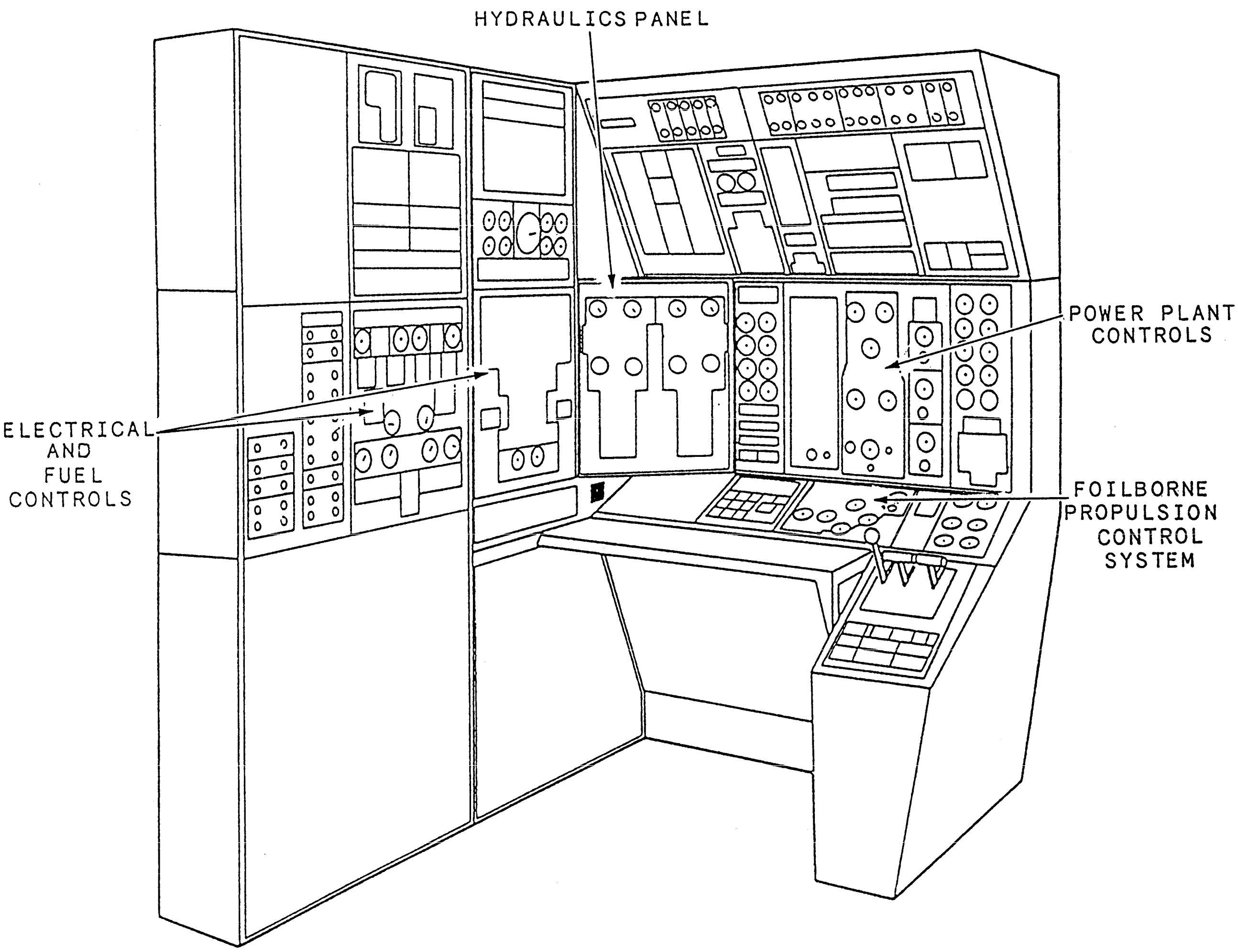


Figure 7-22.—Engineer operating station (EOS) showing panel arrangement.

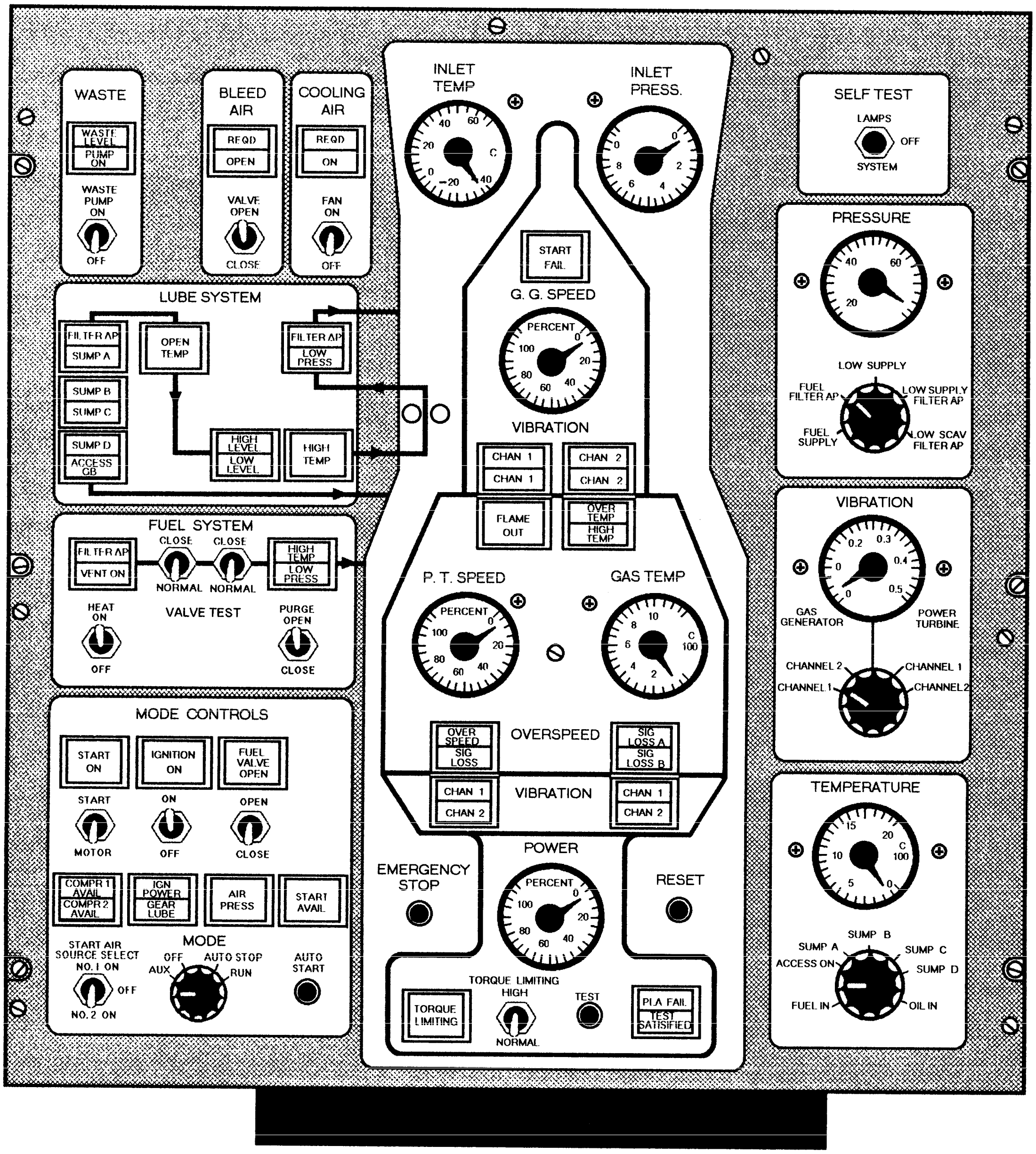


Figure 7-23.—Foilborne engine control system (FECS) panel at the EOS.

control panel is shown in figure 7-23. Notice that the 2-inch meters are front mounted and clamp held. The dial faces are white with black markings and the dials are configured to provide a normal operating pointer position at the 9 o'clock position. Flow lines are shown on the fuel, electrical, hydraulic, seawater, freshwater, and bilge flooding panels and are connected through certain annunciators as part of the display. Alarm annunciators flash in conjunction with an audible alarm when an alarm indication is received. When the operator presses the flashing annunciator, the audible alarm is silenced and the visual alarm becomes steady. Anytime the alarm indication becomes normal, the lamp is extinguished. Action cutout switches allow the operator to isolate short-circuited sensors or actuators.

Bulkhead-Mounted Electronics Enclosure

The BMEE is located in the EOS. The exterior and interior views of this unit are shown in figure 7-24. The BMEE contains the following gas turbine electronics that interface with the propulsion control system:

1. Power lever angle (PLA) actuator electronics

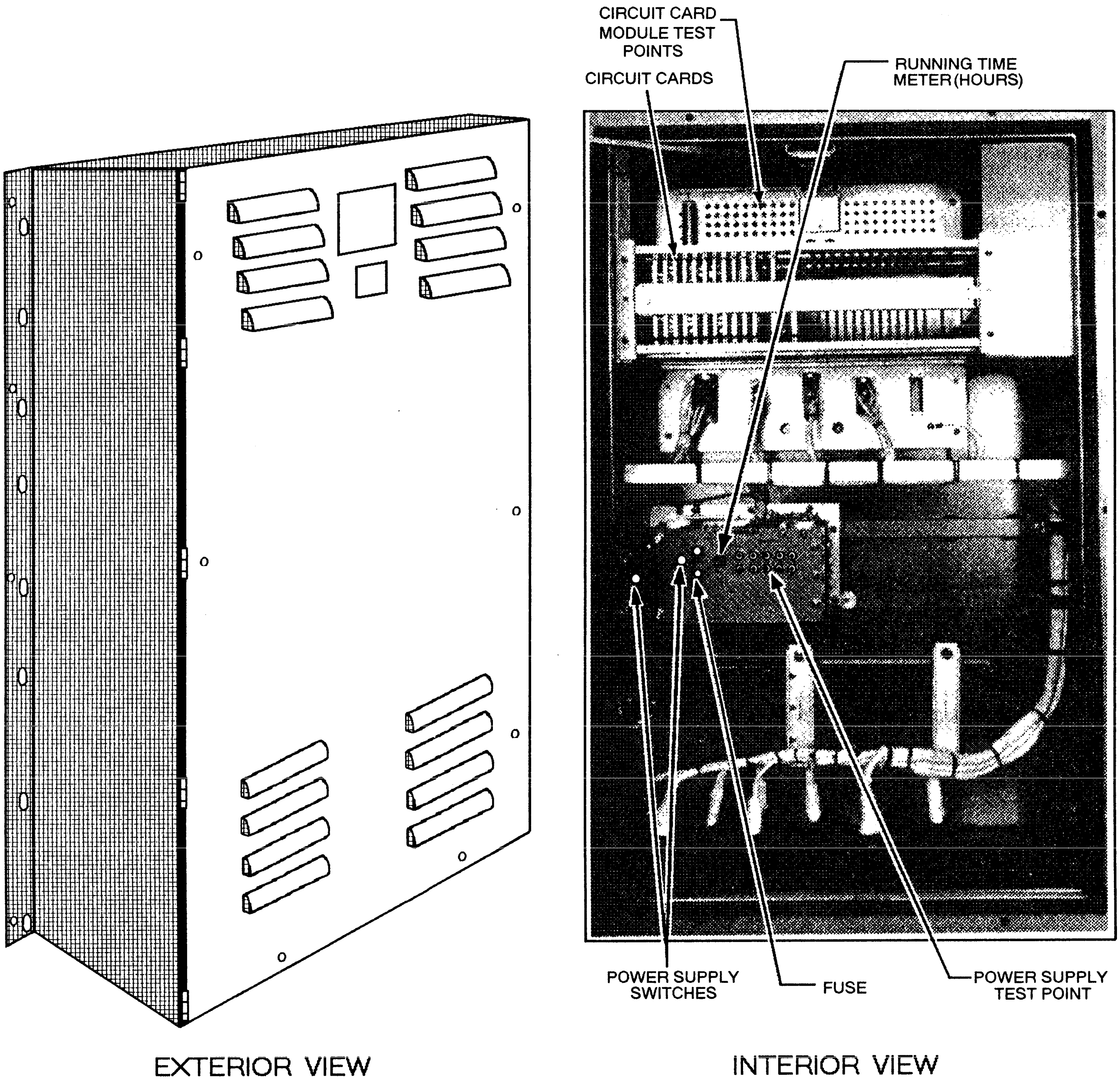


Figure 7-24.—Bulkhead-mounted electronics enclosure (BMEE).

2. Torque computer electronics
3. Speed and acceleration electronics
4. Overspeed switch electronics
5. Start/stop sequencer electronics

Let's take a brief look at how these electronics interface with each other and with the propulsion control system.

The PLA actuator, which is mounted on the main fuel control of the GTE, receives signals from the BMEE torque computer electronics. A voltage booster, which is mounted on the aft bulkhead of the EOS below the BMEE, maintains the ship's +28 V dc input at a constant potential under loads to 30 amperes. The ship's +28 V dc feeds the BMEE, FECS, and FPCS panels from a circuit breaker located on either one of the two dc distribution panels.

Foilborne Control System

The foilborne control system (FBCS) controls the PHM during foilborne operations and during transitions between foilborne and hullborne operations. The FBCS consists of the following equipment and systems:

1. Automatic control system (ACS)

2. Ready and warning system

3. Heading hold system

4. Foilborne throttle system

5. Forward and aft hydrofoils

6. Bow doors

The FBCS also monitors several critical parameters of the foilborne system and provides visual (and some audible) warnings of unsatisfactory conditions. A self-test feature is available in most sections of the FBCS. The major systems of the FBCS that allow the PHM helmsman to monitor and control foilborne operations are the ACS, the FECS, and the FPCS. In the following paragraphs, we will take a look at some examples of how these systems work.

AUTOMATIC CONTROL SYSTEM.— The ACS controls the PHM during takeoff, landing, and all foilborne operations. By automatically positioning the foilborne control surfaces, such as the forward flap, port and starboard flaps, and forward strut, in response to sensed ship motion and manual commands from the helm, the ACS provides attitude control, stability, and operation in rough water. The ACS also provides a self-test capability to allow the operator to perform system operational tests and fault isolation procedures.

The heart of the ACS is the control computer that receives command inputs and sensor inputs, performs the necessary logic, and processes the proper control signals to the proper control surfaces. It also receives feedback signals from the position transducer in the control surface actuators. Command inputs consist of heading change (turn) signals from the helm and foil depth command signals from the ACS control panel assembly. Sensor inputs are from attitude sensors (gyros), foil depth sensors (height sensors), and heave sensors (accelerometers).

The ACS electrical power assembly consists of an ACS power supply assembly, an ACS inverter, a dc line contactor, an ac line contactor, an isolation transformer, and blocking diodes. As shown in figure 7-25, these components are all mounted to the top shelf of the ship control electronics installation. The ACS power supply assembly input is 115 V ac, 400 Hz from either the ACS inverter, which is powered by +28 V dc (from two dc panels for redundancy) or from ship's 115 V ac, 400 Hz through an isolation transformer. The +28 V dc is the system's primary source with the ship's 115 V ac as the backup source. Circuits within the ACS power supply assembly monitor the incoming power at the changeover relay and provide for switching from

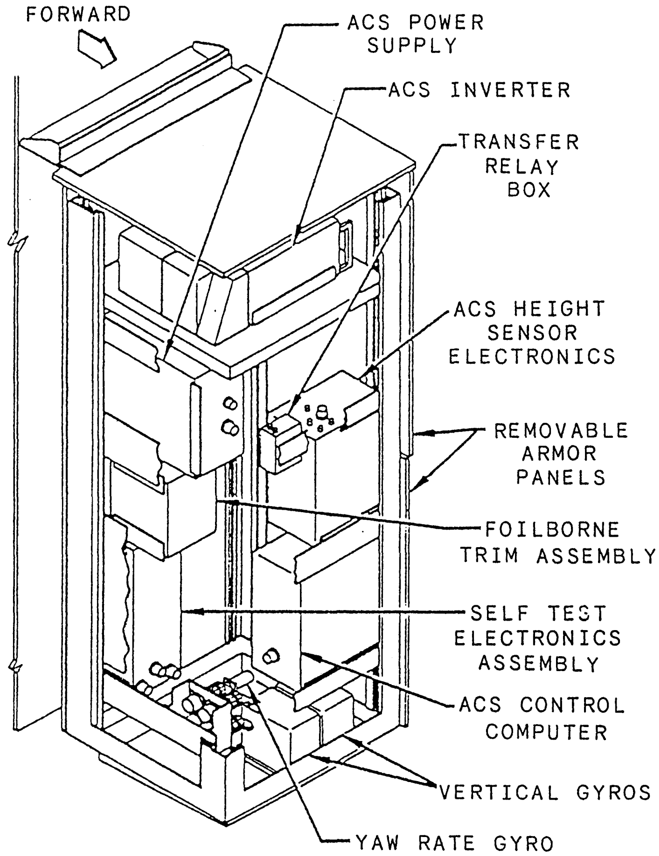


Figure 7-25.—Ship control electronics installation showing ACS.

primary to backup power when a loss of primary power occurs.

Let's look at how this system works. Once the helmsman sets the foil depth level command, the ACS maintains the appropriate depth during all ship maneuvers and throughout all sea conditions. As the helmsman rotates the helm for a heading change, the ACS adjusts the flaps and forward strut for a coordinated turn. When the helmsman adjusts the foilborne throttle to control the ship's speed, the ACS accommodates the resulting hydrodynamic forces that change during the ship's change in speed by adjusting the ship's pitch angle and the foil's angle of attack to maintain the required lift. The helmsman can set the ACS MODE switch at the helm station to STRUT STEERING. This will activate a portion of the ACS and the forward strut steering circuits, allowing the helmsman to steer with the forward strut while the craft is hullborne.

FOILBORNE ENGINE CONTROL SYSTEM.— The FECS provides for automatic starting and stopping of the GTE and the gearbox auxiliary lube oil pump. With the mode selector switch in the auxiliary

(AUX) position, the helmsman can obtain manual control of some of these functions by using the individual control switches. Functions that can be controlled manually are engine compressor washing, engine waste drain transfer, demister panel anti-icing, engine secondary cooling air, engine fuel shutoff valve test, engine fuel system purging, engine fuel heating, starting air compressor activation, gearbox lube oil heating, and system self-tests. The detailed view of the EOS panel shown in figure 7-23 is an FECS panel. Notice the dial faces and how the indicating and warning lights and temperature and pressure gauges are provided for monitoring foilborne operations. The circuit cards used in the FECS have LEDs and test points on the edges for troubleshooting.

As mentioned earlier, the GTE is started by the operator in the EOS. Then, throttle control is transferred to the helm for foilborne operation. Before shutdown, control is transferred back to the EOS where the GTE is shut down with automatically controlled logic.

FOILBORNE PROPULSOR CONTROL SYSTEM.– The FPCS consists of a GTE, a Western Gear gearbox, an Aerojet Liquid Rocket propulsor assembly, and an ELDEC propulsion control system. Interfacing support systems include the gas turbine inlet and exhaust air systems, secondary cooling air, air starting (pneumatic) system, and electrical power.

Although control for the gearbox auxiliary lube oil pump is contained in the FECS, manual control for the lube oil tank heater is provided on the FPCS panel, as shown in figure 7-26. Indicating and warning lights and temperature and pressure gauges are provided for monitoring propulsor system operation. Test points are provided on the edges of the FPCS circuit cards.

FOILBORNE OPERATIONS

From reading the preceding sections on the main components and control systems of the foilborne propulsion system, you have likely deduced how the equipment units and control systems work together to stabilize and propel the craft forward. Basically, foilborne propulsion is achieved through the interaction of hydrodynamic forces similar to the aerodynamic forces in flying. To understand the interaction of hydrodynamic forces involved in the propulsion of the PHM, let's take a look at some normal events.

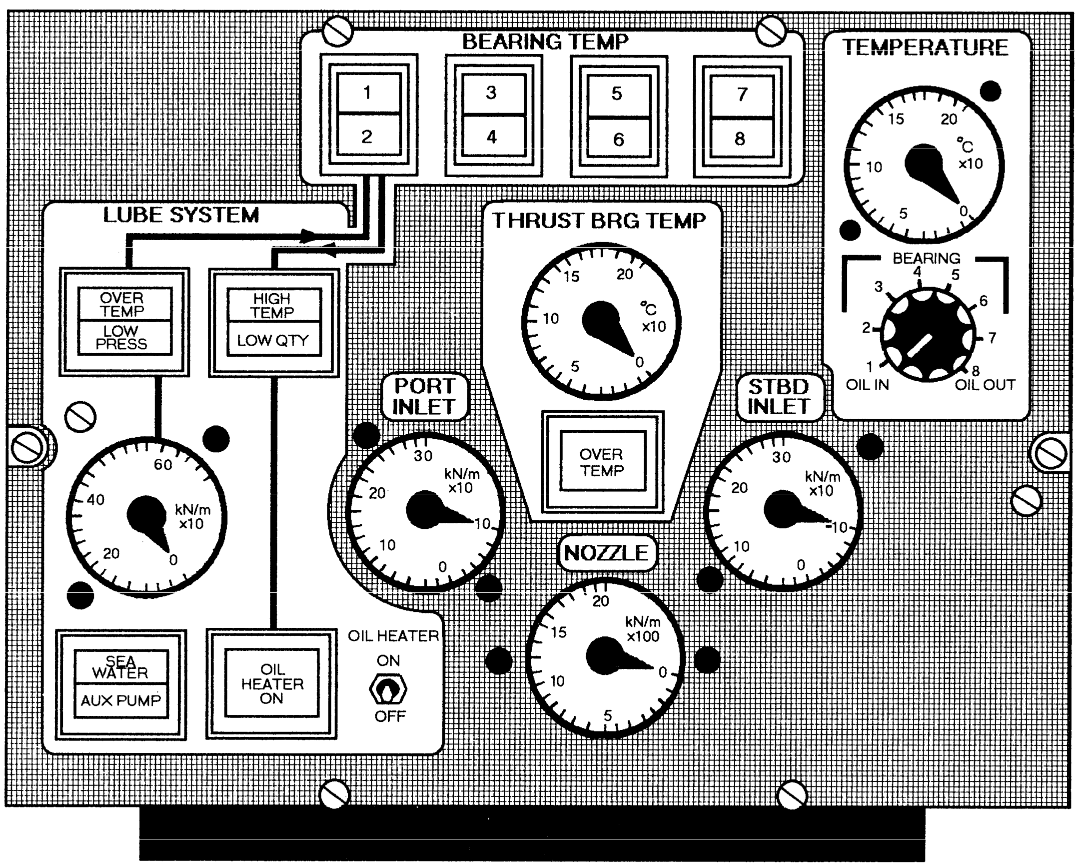


Figure 7-26.—Foilborne propulsor control system (FPCS) panel.

The FBCS senses the manual inputs from the helmsman (pilothouse) as well as those monitored by the ACS, such as roll, pitch angle, yaw rate, vertical acceleration, height of the bow above the surface of the water, and other measurements associated with the motion, direction, and weight of the ship and the sea conditions. The FBCS then converts these inputs to the appropriate control-surface deflections to provide continuous dynamic control of the ship.

In general, foilborne control is accomplished through operator and control system inputs, causing the FBCS to position the control surfaces, such as the trailing edge flaps on the forward and aft foils, and to swivel the forward strut. Each control surface and the forward strut are controlled by separate electrohydraulic actuators. For example, the port and starboard flap segments on each hydrofoil will operate simultaneously. The flaps on the forward and aft foils will move up and down differentially to give pitch and foil depth control. Differential movement of the flaps on the two aft foils will allow the craft to accomplish roll control (banking). For example, port flaps up and starboard flaps down will counter a ship roll to starboard. Along with roll control capability (banking), steering of the forward strut will provide the craft with directional heading control.

TROUBLESHOOTING THE FOILBORNE PROPULSION SYSTEM

In troubleshooting the foilborne propulsion system, you will be mostly concerned with isolating faults within the control systems. Let's look at some of the procedures you may be required to use when you are troubleshooting the different FBCSs.

ACS Procedures

We mentioned earlier that the foilborne ACS was equipped with self-tests. All ACS troubleshooting procedures are derived from test failures of the ACS operational self-tests. The BITE will enable you to fault isolate a high percentage of ACS failures within a high degree of probability.

Regarding ACS troubleshooting procedures, you should be especially aware of the ACS power supply and any special conditions you may encounter. For example, if another ACS component fails so that its power input is shorted, the microbuses for that specific power in the ACS power supply will be blown. This condition will result in a failure of the ACS power supply. Your use of the correct fault isolation procedures will likely prevent the possibility of a random double failure of this type. Nevertheless, you should be aware of this possibility whenever you are troubleshooting the ACS.

FBCS Procedures

In troubleshooting the FBCS, the best method you can use to perform fault isolation techniques is to use deductive reasoning, experience, instructions, panel indications, and the BITE. You should use the following procedures for troubleshooting the FBCS:

1. Identify the trouble symptom.
2. Locate the trouble symptom in the system fault directory.
3. Note the probable causes of failure.
4. Perform the specified corrective procedures.
5. Heed all precautions and warnings.
6. When a specified procedure recommends component replacement as a corrective action, refer to the removal/installation section of the appropriate technical manual.

You have just read about the foilborne propulsion system and how it provides for speed, handling, and propulsion of the PHM. In the following paragraphs, we will take a look at the other PHM main propulsion system, the hullborne system.

MAIN PROPULSION (HULLBORNE) SYSTEM

The hullborne propulsion system provides the PHM with the capability of steering, reversing, docking, and other operations requiring close-in maneuvering. The hullborne propulsion system consists of both a port and starboard unit.

The principles of operation for the hullborne system are very similar to those of the foilborne system. In each hullborne propulsion unit, the rotational speed of the diesel engine is reduced by the gearbox and transmitted to the propulsor assembly. Working together, both port and starboard hullborne propulsion units can propel the craft in the hullborne mode at speeds up to 11 knots.

MAJOR ASSEMBLIES

Each of the two hullborne plants is made up of three major components: (1) a diesel engine, (2) a speed reduction gearbox, and (3) a water jet pump that acts as the propulsor assembly. Let's take a brief look at the most important design features of these components.

Diesel Engine

Each hullborne propulsion unit is powered by its own Mercedes-Benz Model 8V331TC81 diesel engine. The diesel engine for each unit is located in the diesel pump and machinery room. Combustion air for the diesels and cooling air for the diesel pump and machinery room are drawn into the space through a screened compartment inlet located in the forward end of the air trunk. As the diesels draw combustion air from this compartment, the air goes through the screens and filters and enters the diesel engines. Diesel engine exhaust gases are collected and vented up and out through the inside of the compartment inlet.

Reduction Gear

The reduction gear assembly for each hullborne propulsion unit is built into the diesel engine for that unit. The speed reduction gearbox drives the propulsor assembly through an overrunning clutch assembly.

Propulsor

The hullborne propulsor assembly draws seawater from a sea chest, accelerates the water, and expels it through a nozzle at the stem. The hullborne propulsor inlet is a rectangular bellmouth type of penetration in the hull dead rise to which the propulsor is directly attached The propulsor and inlet ducts are located in the auxiliary machinery room.

Now that you have read about the main components of the hullborne propulsion system, let's take a look at its control system and subsystems.

HULLBORNE CONTROL SYSTEM

Whenever the PHM is in the hullborne mode, the craft is controlled by the hullborne control system

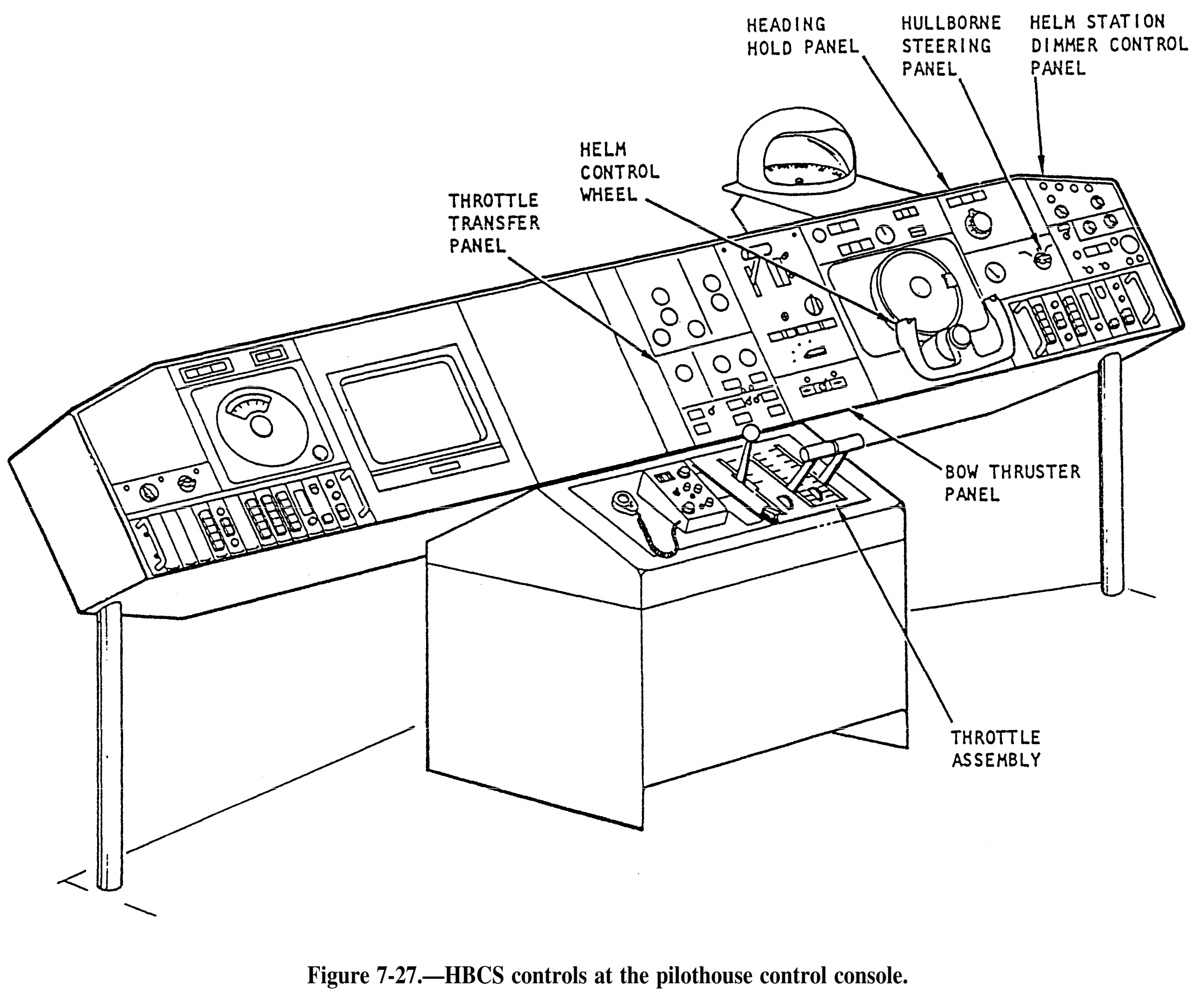


Figure 7-27.—HBCS controls at the pilothouse control console.

(HBCS). The HBCS consists of the following three subsystems:

1. Hullborne steering system
2. Heading hold system
3. Hullborne throttle system

Operation of the HBCS takes place almost entirely from the pilothouse, as shown in figures 7-27 and 7-28. The only HBCS controls located in the EOS are the throttle assembly and the throttle transfer module assembly. These assemblies are used in conjunction with the foilborne control system. Let's take a brief look at the three subsystems of the HBCS.

Hullborne Steering System

The hullborne steering system provides directional control and maneuvering capability while the PHM is in the hullborne mode. The location of each major equipment item in the hullborne steering system is shown in figure 7-28.

Primary steering control is provided by a hydraulic actuator that vectors the hullborne steering nozzles in response to position commands from the helm. Additional directional control is provided by the thrust reversers on the hullborne propulsory. A bow thruster is included in this system to allow for improved low-speed maneuverability and to assist in docking. The capability for strut steering is also included in this system. In the foils down mode, for example, the forward strut can be swiveled for hullborne steering.

Heading Hold System

The heading hold system provides the PHM with the capability of automatically maintaining a preset heading while the craft is in either the hullborne or foilborne propulsion mode. The helmsman establishes a preset heading command. A heading error signal is developed as a difference occurs between the craft's gyrocompass and the preset heading command from the helmsman. A steering correction signal is then applied to the ACS or hullborne steering system.

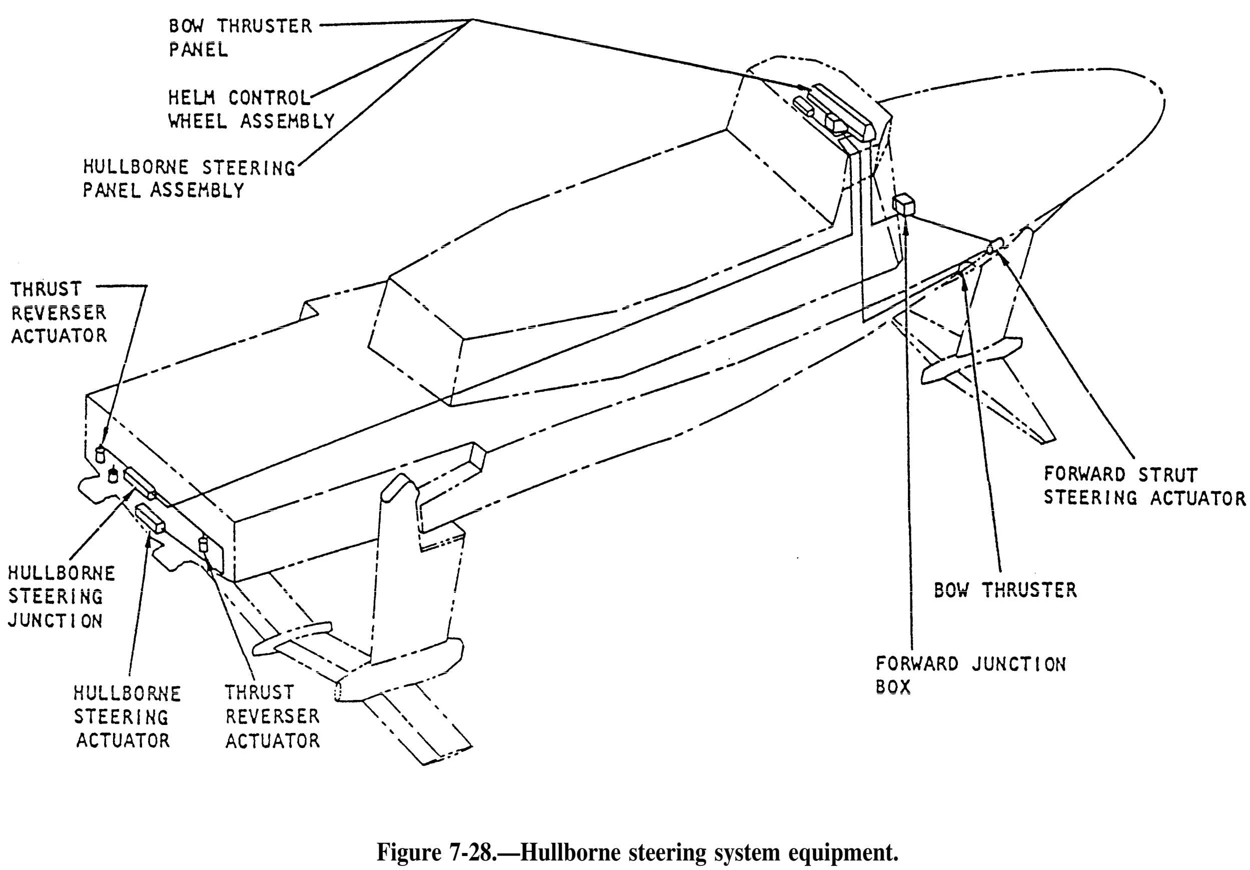


Figure 7-28.—Hullborne steering system equipment.

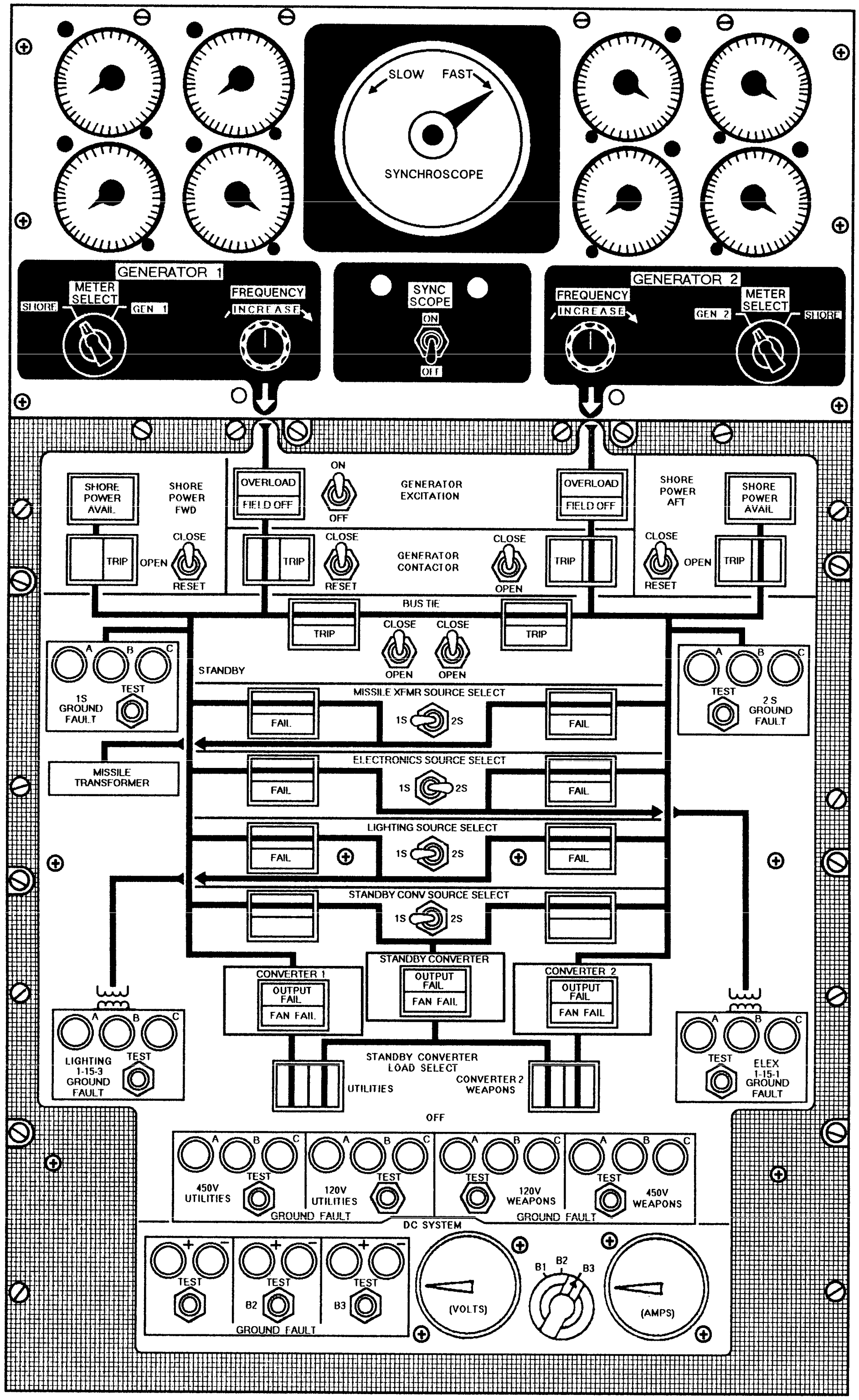


Figure 7-29.—Electrical system indicator and control panel.

Hullborne Throttle System

The hullborne throttle system allows for control of hullborne engine power and position of the thrust reversers to originate either from the pilothouse or the EOS. It also allows for the transfer of control between these stations when the throttle controls are placed in the idle position.

The hullborne throttle system consists of the throttle assembly, the throttle transfer panel assembly in the pilothouse, and the throttle transfer module assembly in the EOS. The throttle assemblies at each station are identical except for paint color and the guarded ENGINE-OFF switch, which is located only in the pilothouse unit. The throttle assemblies operate in conjunction with the throttle panel assemblies at each station. This feature allows the HBCS to transfer control of the engines between the helm station and EOS.

You have just read about the hullborne propulsion system. Earlier in this chapter, you read about the foilborne propulsion system. In the following section, we will discuss the PHM electrical system that allows both main propulsion systems to work.

PHM ELECTRICAL SYSTEM

The PHM electrical system generates, distributes, and controls the craft's onboard electrical power. Two 450-V ac, 400-Hz, 3-phase brushless generators supply power to the craft's electrical equipment. These generators are driven by power supplied by the ship's service power units (SSPUs). Switchboards and distribution panels distribute and control the electrical output. Transformers, converters, and inverters convert a portion of the generator output to lower ac and dc voltages to supply the lower voltage equipment needs. Four shore power receptacles, two for 400-Hz and two for 60-Hz power, are provided to receive power from shore installations or other ships upon need.

Basic control of the generators is at the EOS, with emergency controls and voltage/amp meters provided on each switchboard. As shown in figure 7-29, the EOS console contains the electrical system indicator and control panel that displays the voltage, amp, frequency, and kilowatt output of each generator. This panel also provides the switches to control and test the entire electrical system associated with the output of each individual generator. A dc voltmeter and dc ammeter for monitoring voltage and current are included on this panel. Ground fault detection lights and test switches on the panel provide a means of monitoring circuit condition.

Two battery chargers supply the normal dc power requirements for the craft. They also provide the voltage required to maintain the three emergency power battery sets at a specified charge level. Battery power is used for normal SSPU and diesel engine starts. The batteries also supply normal dc power for various control circuits, indicating circuits, and dc fuel pumps. The batteries are also used as an emergency power source to supply emergency loads after an ac voltage failure. For emergency power, the primary source is voltage supplied from the two battery chargers paralleled with the three battery sets. A secondary emergency power source is dc voltage supplied from two diesel engine alternators.

SHIP'S SERVICE POWER UNITS

The two SSPUs that supply power to the generators and other PHM electrical equipment are installed in nonadjacent auxiliary engine compartments. The major components of an SSPU are shown in figure 7-30. Each SSPU includes a turbine engine and a mechanical gearbox. Each SSPU must supply the power to drive an ac generator, two hydraulic pumps, and a load compressor, all of which are mounted on the gearbox. Each SSPU is installed by means of a 3-point suspension and is attached to the ship's structure by means of resilient mounts. These mounts are composed of bonded elastomer spool pieces secured in trunnion blocks.

Normal SSPU control is maintained from the SSPU panel located in the EOS. The PHM electrical system allows the SSPUs to operate individually or simultaneously. When both SSPUSs are operating, each 200-kVA, 400-Hz alternator shares the ship's electrical load. Each SSPU is capable of supplying the PHM's total electrical load. Reduction in electrical load, however, is necessary for an SSPU to start the LM2500 GTE.

Now that you have read about the general purpose and assembly of an SSPU, let's take a closer look at some of its main components.

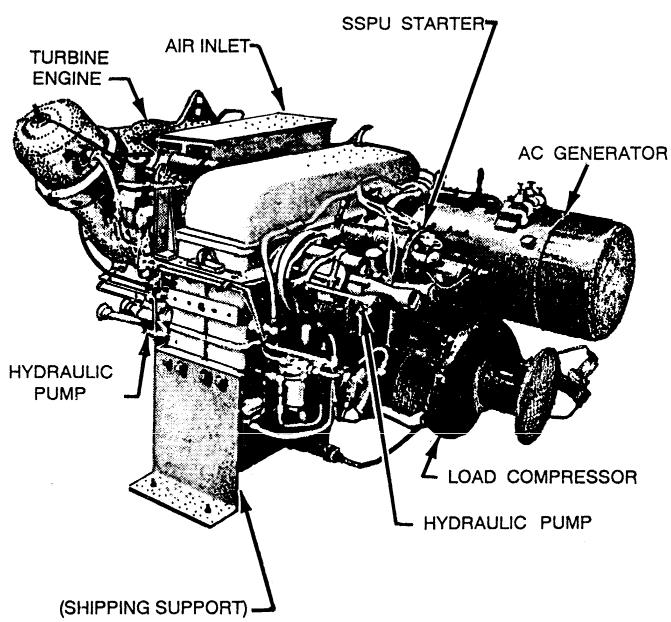


Figure 7-30.—Ship's service power unit (SSPU).

SSPU Turbine Engine

The SSPU turbine engine is composed of four major parts: (1) a 2-stage centrifugal-flow compressor, (2) a 3-stage axial-flow turbine, (3) an inlet plenum assembly, and (4) a combustion system. Figure 7-31 is a cutaway view of an SSPU turbine engine showing the relative position of each of these components.

The compressor impellers and three turbine wheels are locked together by means of curvic couplings. A tie bolt through the center of the wheels makes this assembly a single rotating unit. A floating ring journal bearing and seal assembly on each end of the shaft support this rotating unit.

Outside air is drawn into the compressor through the inlet plenum into the combustor where it is mixed with fuel. The fuelhir mixture is ignited by the igniter plug at 10 percent of engine speed. When the unit reaches 95 percent of engine speed, the ignition system is automatically de-energized because at this point combustion is self-sustained. The hot gases pass from the combustion chamber into the torus assembly. The torus assembly directs the hot gases onto the three turbine wheels. By imparting energy to the turbine wheels, the hot gases cause them to rotate and provide shaft power for operation of the compressor, gearbox assembly, and driven equipment. The spent gases are expelled through the tail pipe into the PHM exhaust duct.

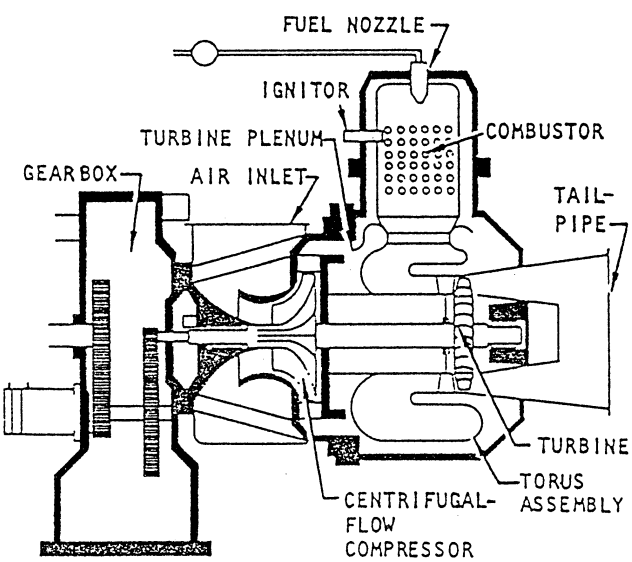


Figure 7-31.—Cutaway view showing main components of an SSPU turbine engine.

Gearbox Assembly

The external gearbox assembly provides for two of the SSPU's mount pads and the mounting area for the SSPU'S power section. The internal gearbox assembly contains the reduction gearing that enables the power section to drive the supporting accessories and the loading components at the proper speed. When the power section is operating at 100 percent speed (41,730 rpm), the unit's gears provide the following output speeds:

Generator	8,000 rpm
Load compressor	8,000 rpm
Hydraulic pumps	3,600 rpm

Lubrication System

The SSPU lubrication system provides lubrication for the engine and gearbox assembly, load compressor, and generator. It is a full pressure, wet sump system consisting of the oil pump assembly, oil falter assembly, oil pressure regulator, and a check valve. The system is also equipped with pressure and temperature switches and a temperature sensor for readouts on the PHM indicators. The oil sump is an integral part of the SSPU assembly. The oil sump has a capacity of 8 gallons and is equipped with a drain fitting, a dip stick, and a sight glass for monitoring oil quantity. The SSPU lubrication system is serviced through a filler cap. The filler cap should be removed only when the SSPU is shut down. The oil level should be checked daily.

Fuel System

The SSPU fuel system automatically regulates fuel flow to maintain constant engine speed and safe operating temperatures under varying conditions of starting, acceleration, and load application. If the fuel supply pressure decreases to 4 psig, a LOW FUEL PRESSURE indicator on the EOS panel will illuminate.

Control Panel

The control panel for each SSPU is located in the EOS. This panel is divided into three sections, as shown in figure 7-32. The top section provides switches for SSPU de-icing and engine wash functions. The center section provides meters to indicate the operating oil temperature, oil pressure, exhaust gas temperature, and percent speed of each SSPU engine. Filter assemblies, located on the side of the center panel, are used to filter electromagnetic interference (EMI) generated in the

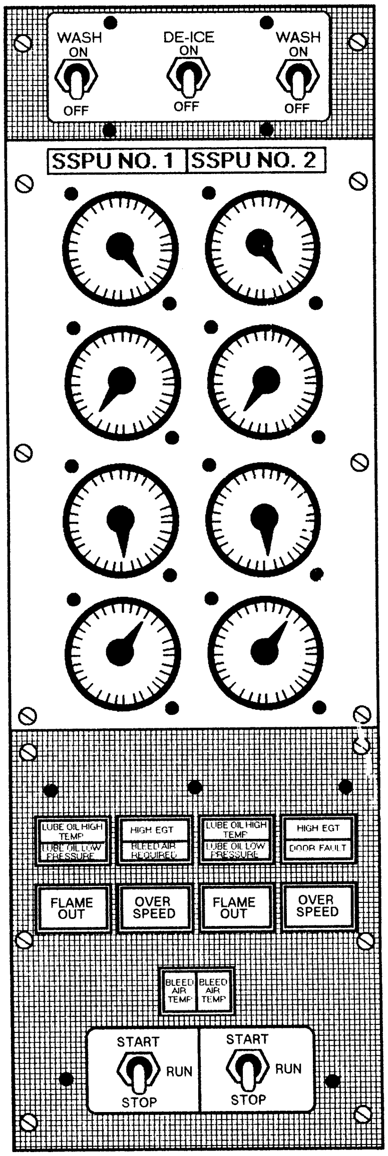


Figure 7-32.—SSPU control panel.

exhaust gas temperature meter transducers and transmission lines. The panel lower section provides switch controls to start, run, and stop both engines. This section also contains fault indicators that illuminate to display the cause of the fault if an operating fault should occur.

Local Control Panel

The SSPU local control panel is shown in figure 7-33. The local control panel is located in the same space as the SSPU and allows operation of the SSPU from that location under emergency conditions. The SSPU local control panel includes a LOCAL/EOS switch. The local operator can use this switch to select where SSPU operational control will take place. The SSPU local

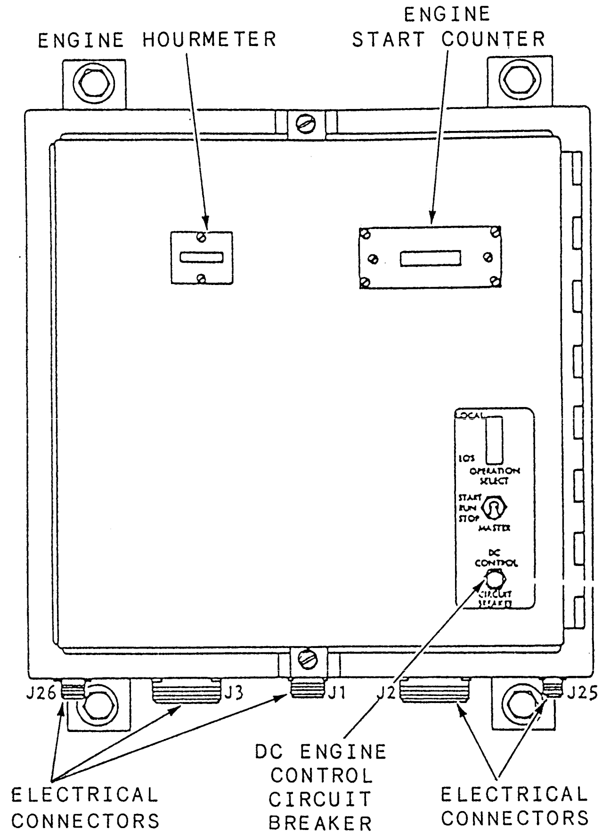


Figure 7-33.—SSPU local control (emergency) panel.

control panel also includes a master switch for START/STOP/RUN operations and a dc circuit breaker. Also located on the SSPU local control panel is an hour meter to record the elapsed time the turbine has been running. The start counter records the number of starts.

AC GENERATORS

Each SSPU drives its own ac generator. The two ac generators driven by the SSPUs are brushless, 250-kVA units that produce 450-V ac, 400-Hz, 3-phase power. Each generator consists of three machines (generators) in one housing. Two of these machines are 3-phase salient-pole synchronous units (alternators). The third machine is a permanent-magnet, high-frequency (4,800 Hz at 8,000 rpm), single-phase unit that provides a low power output used for initial excitation and control circuits.

The main generator is a rotating-field unit that develops the 400-Hz, 3-phase power supplied to the output terminals. Excitation of the main field of the main generator is received from the second 3-phase generator. The second 3-phase generator is an acting exciter that provides ac voltage. The ac voltage is rectified to dc voltage by rotor-mounted silicon diodes and capacitors. The generator is driven at a constant speed through a splined shaft that connects the unit to the SSPU gearbox.

The main generator provides its own internal cooling. Compartment air is drawn in at the generator outboard end. An external shroud collects the air and routes it out of the compartment.

GENERATOR CONTROL UNIT

A GCU is installed in each switchboard to monitor the corresponding ac generator output. The GCU monitors ac generator output to provide voltage regulation and control and to protect the generator and its electrical load. The GCU provides these functions through sensing, time delay, logic, and output control circuits. These functions are mostly contained on eight printed circuit boards (PCBs). The PCBs are mounted within a natural convection ventilated enclosure. They are connected to the switchboard wiring by means of two multiple pin connectors.

The GCU regulates the generator output voltage by controlling the amount of power delivered to the generator exciter field. It also protects the electrical load by monitoring the generator output for over/undervoltage, overcurrent, underfrequency, over/underexcitation, and differential phase currents for both single and parallel operation. In its monitoring function, the GCU activates control circuits to isolate the faulty output from the ship's electrical distribution system.

ELECTRICAL DISTRIBUTION SYSTEM

The generators each supply separate switchboards that serve as the central control points for the PHM's electrical distribution system. A bus tie between the main switchboard busses allows the generators to supply the ship's systems either individually, in the split-plant mode, or in the parallel mode. There are two switchboards used for power distribution: (1) the main deck switchboard and (2) the platform deck switchboard.

Main Deck Switchboard

The main deck switchboard (1S) is shown in figure 7-34. The main deck switchboard interfaces electrically with the 450-V ac, 400-Hz, 3-phase power output of generator No. 1 and shore power receptacle No. 1.

As shown in figure 7-34, the enclosure for this switchboard is equipped with hinged doors and

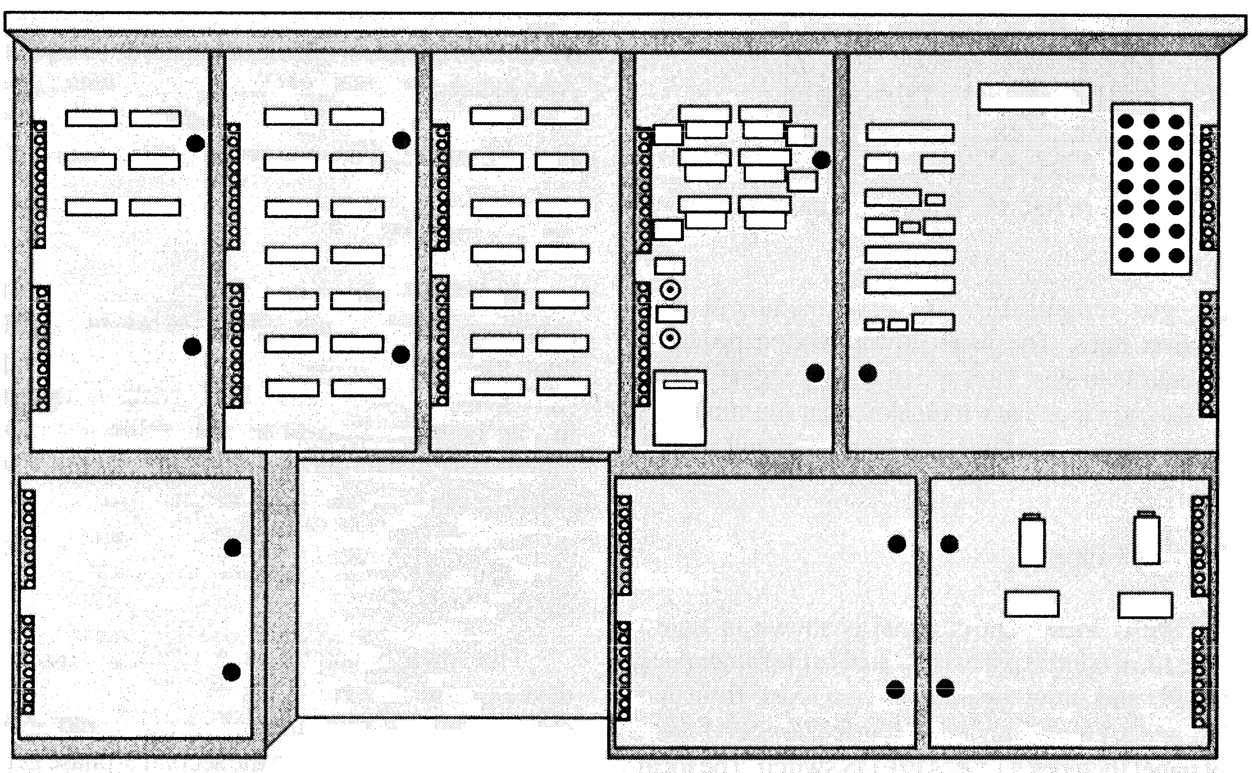


Figure 7-34.—Main deck switchboard.

removable faceplate panels. For operational access, the circuit breakers, switches, and fuses are mounted on these panels. Internally, the switchboard contains contractors, relays, fuses, transformers, control modules, and electrical busses.

Platform Deck Switchboard

The platform deck switchboard (2S) is shown in figure 7-35. The platform deck switchboard is essentially the same as the main deck switchboard, except that it serves generator No. 2 and shore power receptacle No. 2.

As shown in figure 7-35, the enclosure for the platform deck switchboard is equipped with hinged faceplate doors and removable front panels for maintenance access. Circuit breakers, switches, and display meters are installed on the panel doors. The electrical power busses, terminal strips, switching units, and control modules are mounted inside the enclosure.

SHORE POWER

A means of supplying electrical power to the PHM from an external source is known as shore power. This installation consists of shore power receptacles, a portable shore power cable, and a mobile electric power plant.

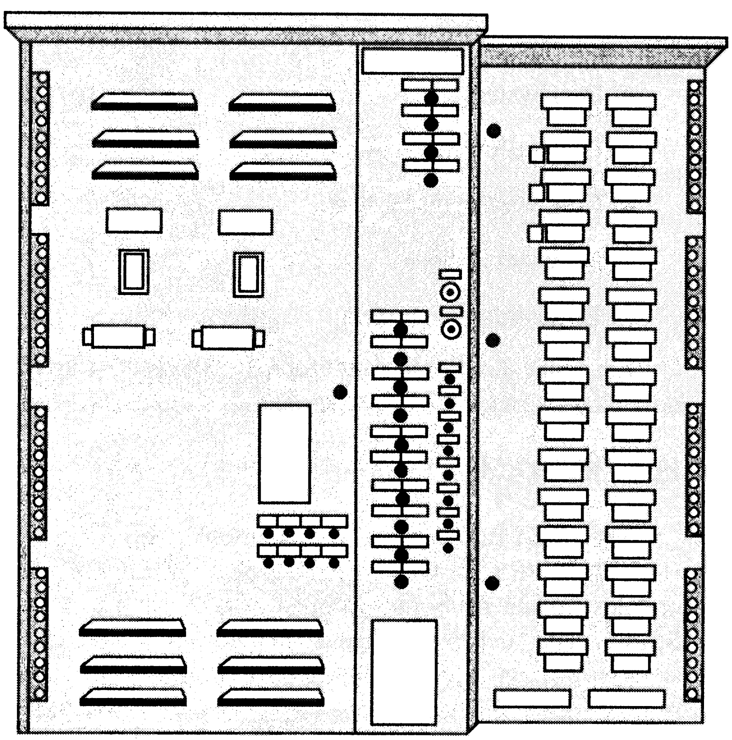


Figure 7-35.—Platform deck switchboard.

Shore Power Receptacles

The two shore power receptacles, shore power receptacles No. 1 and No. 2, are each capable of receiving 450-V, 3-phase, 400-Hz shore power. Each receptacle is rated for the shore power electrical load of the ship, plus a 30 percent growth margin.

Each receptacle is connected to its respective ship's electrical power system switchboards. Manual controls for the receptacles are provided both at the EOS console and the switchboards. Shore power monitors are installed in each switchboard to make certain the input voltage, frequency, and phase rotation are within the following limits before shore power is applied to the ship's electrical system:

- Voltage 410 to 471 V ac
- Frequency 365 to 435 Hz
- Phase rotation AB, BC, CA

The shore power receptacles also provide capability to supply 450-V, 3-phase, 400-Hz power to one or two sister ships, although feedthrough capability is not provided. Instead, a portable shore power cable assembly, 30 meters in length, is provided to connect the shore power receptacles to the sister ship.

Shore power of 60 Hz can also be connected to the PHM through two connectors on a common housing attached to the aft bulkhead of the deckhouse on the starboard side. One receptacle provides connection capability for 120-V, 3-phase power, while the other receptacle provides the same capability for 450-V, 3-phase power.

Mobile Electric Power Plant

Most piers where the PHM will dock cannot provide the special power required by the hydrofoil's electrical system. For this reason, mobile electric power plants are usually shipped to the ports where the PHM will be docked.

Each mobile electric power unit is composed of a motor generator and ashore power transformer. The unit is completely equipped with voltage regulator instruments, protective devices, and operating controls enclosed in a weatherproof, ventilated housing. The entire enclosure is mounted on a steerable, highway towable, 4-wheel trailer. (See fig. 7-36.)

The motor generator is a brushless, two-bearing, salient-pole unit. The unit is self-ventilated. The rotating brushless system consists of the salient-pole motor and generator rotor assemblies, fan assembly, rotating rectifier assembly and exciter armature assembly, all mounted on a common shaft and dynamically balanced.

The voltage regulator unit is a completely static, modular unit. It is provided with a plug-in connector for ease of removal and replacement. The regulator contains plug-in circuit modules for 3-phase voltage sensing, exciter field control, over/undervoltage monitoring, and underfrequency monitoring.

The control panel is hinged for easy access and provided with a weatherproof shield to prevent direct rainfall on the panel during operation of the controls or observation of the instruments.

The shore power transformer is a 3-phase, single-core, isolating type. It takes power from the power unit input terminals and provides two isolated, ungrounded output circuits. The shore power system is provided with both input and output circuit breakers, instruments, and indicators.

The mobile electric power unit is capable of continuous duty. It can maintain the electrical and physical performance characteristics required for the PHM under specified input and environmental conditions. The unit operates on a 480-V ac, 3-phase, 60-Hz power source with a continuous rating of 150 kVA(180 amperes). It will supply 450-V ac, 3-phase, 400-Hz power to the PHM at 125 kW continuous duty.

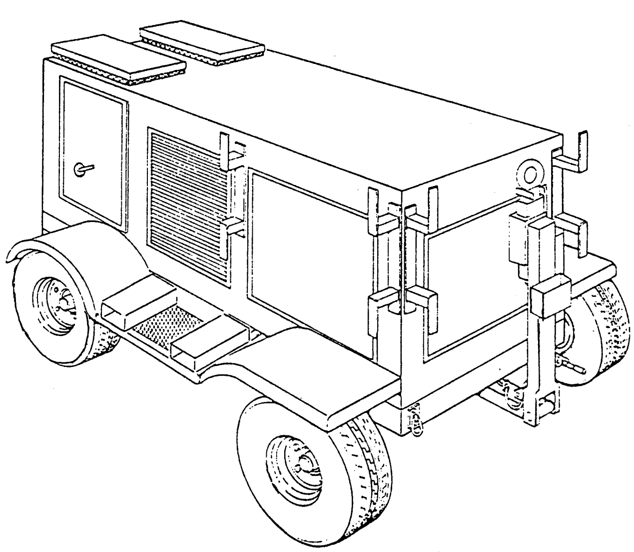


Figure 7-36.—Mobile electric power plant.

TROUBLESHOOTING PROCEDURES

In troubleshooting the PHMs electrical system, you should first use the fault or out-of-tolerance indications displayed on the electrical system control panel. You should then locate the associated fault directory and fault trees in the appropriate technical manuals.

Use the panel indications and the appropriate guidelines in the technical manuals to analyze the symptoms of the trouble, isolate them to a probable cause, and recommend corrective procedures to return the system to its operational condition. The information you can derive from the panel indications, the technical manuals, and the electrical power system one-line diagram should provide you with the information you will need to perform basic fault isolation procedures.

In the preceding sections, you read about the main propulsion, power train, control, and electrical systems of the PHM. In the following section, we will take a look at the auxiliary systems, their components, and the relationship of these systems to the engineering plant.

AUXILIARY SYSTEMS

The auxiliary systems of the PHM include the following systems:

- Fuel system
- Hydraulic power system
- Compressed air system
- Seawater system
- Bilge drainage system

Let's take a closer look at each of these systems and how they interface with the engineering plant.

FUEL SYSTEM

The PHM fuel system delivers diesel fuel, marine (DFM) or JP5 to the hullborne propulsion diesel engines, to the foilborne propulsion GTE, and to the SSPUs. The fuel is supplied from dockside or tender sources through the main deck port or starboard fuel replenishment fill stations. It is piped to four integral hull tanks at a rate of 250 gpm without spill or tank overpressure. From the tanks, the fuel is distributed to the engines or SSPUs through a cross-feed piping and controls system. The distribution system is serviced by one of three pumping systems. Each pumping system consists of the following units:

1. Four at-powered pumps
2. Two de-powered pumps, used as engine-starting fuel delivery pumps and standby pumps
3. One emergency operation hydraulic pump

For operation and underway replenishment operations, fuel system control is accomplished at the fuel system panel at the EOS console. Defueling operations are manually controlled by operation of local and manually-operated valves. The onboard fuel can be dewatered and the particulate removed by passing the fuel through an onboard fuel purifier. The fuel can be removed from any tank, passed through the purifier and returned to any tank, including the tank from which the fuel was originally removed. The fuel purification process is controlled from either the FUEL PURIFIER panel in the EOS or the FUEL PURIFIER LOCAL CONTROL BOX in auxiliary machinery room No. 2. The fuel purifier can process about 25 gallons of fuel per minute.

HYDRAULIC POWER SYSTEM

To operate, the foilborne and hullborne controls, foils, capstan, and foilborne emergency fuel pump all require hydraulic power. Normally, the 3,000-psi hydraulic power supply needed to meet these requirements is provided by four separate systems. The two forward systems provide hydraulic power to the bow. The two aft systems provide hydraulic power to the stem.

In the event of major damage, a dual hydraulic power supply can be provided for each system function with subsystem isolation forward and aft. If loss of hydraulic pressure from the primary hydraulic source should occur, hydraulic pressure for maintaining foilborne operations is automatically supplied from the standby source.

COMPRESSED AIR SYSTEM

The compressed air system provides pressurized air to various components and systems that require pressurization to work properly. For example, these units, components, and systems must receive pressurized air for the following purposes:

- Hydraulic power system for pressurization of the hydraulic reservoirs
- Foilborne ACS for pressurization of components and cabling
- Windshield washer system for pressurization of the window washing fluid storage tank
- Service outlets for varying maintenance requirements
- Seawater system, hullborne diesel engine seawater sea chest blowdown lines, and bilge drainage system for pressurized operation of air-actuating valves and valve-actuating solenoids

Pressurized air to the compressed air system is supplied from the following two sources:

1. Second-stage bleed air at a flow rate of 120 psi at 600°F from either of the two SSPUs. This is the primary source of compressed air. Passing through seawater-cooled condensers allows this air supply to cool down to 86°F.
2. Air compressor and tank assembly of the compressed air system at a flow rate of 60 to 90 psi. This is the secondary source of pressurized air. It should be used only when the SSPUs are not supplying a minimum airflow rate of 60 psi or are supplying bleed air to the ship's propulsion de-icing system.

Pressurized air from both sources must be dried, filtered, and pressure-regulated as required before entering into the various systems and components.

SEAWATER SYSTEM

The seawater system has two modes of operation: (1) foilborne and (2) hullborne. The PHM seawater system serves the following three primary purposes:

1. Cooling machinery
2. Lubricating propulsor bearings
3. Combating fires and other conditions involving overheating

The seawater system consists of four pumps. These pumps provide cooling seawater to the diesel engines, the SSPU heat exchangers, the SSPU bleed air coolers of the compressed air system, the heat exchangers of the hydraulic power system, the heat transfer chiller of the environmental control system condenser, and the gun assemblies. As indicated earlier, seawater is also supplied to the hullborne diesel engine propulsory for bearing lubrication and to the fire-extinguishing systems for fire-fighting purposes.

BILGE DRAINAGE SYSTEM

The bilge drainage system provides the PHM with a means for dumping fluids from the bilges and voids. This system also provides a method for storing these fluids until they can be off-loaded to a receiving facility.

The bilge drainage system consists of electrically driven fixed bilge pumps, a portable bilge pump, fluid storage tanks, a transfer pump for off-loading, and fluid level switches in the bilges, voids, and storage tanks.

PHM SYSTEMS MAINTENANCE

The PHM is supported by a progressive ship maintenance concept. This means that the individual PHM is designed so it will acquire significant maintenance support from external sources. This concept clearly conforms with the PHM's mission, physical characteristics, and specified manning levels that demand that onboard maintenance be kept to a minimum. As a result, the overall maintenance concept for the PHM gives primary consideration to the accomplishment of maintenance tasks while the ship is in port.

In other words, the basic concept of progressive ship maintenance for the PHM de-emphasizes corrective maintenance at the shipboard level and emphasizes the role of both the organizational and intermediate maintenance levels of the mobile logistic support group (MLSG). This concept also highlights the role of standard depot level maintenance.

MAINTENANCE REPAIR LEVELS

The maintenance repair levels for the PHM are organized into three groups. These three groups, arranged in increasing order of complexity are

- organizational level maintenance,
- intermediate level maintenance, and
- depot level maintenance.

In the following paragraphs, we will briefly describe the maintenance levels used on the PHM,

Organizational Level Maintenance

Organizational level maintenance is the routine maintenance that is performed by the MLSG with the help of the PHM ship crew. Certain organizational level tasks, such as daily preventive maintenance that cannot be scheduled for in-port periods and limited corrective maintenance, are performed at sea. Normally, the PHM crew will perform underway maintenance by using only the standard test equipment and tools that are carried aboard the PHM and the significant BITE. The onboard repair parts of the PHM are very limited in number and variety. Usually, they consist of fuses, bulbs, and critical modules and parts.

Most routine organizational level maintenance actions are accomplished in port during 2-day weekly upkeep periods that follow each PHM mission. During these upkeep periods, the PHM crew, with the MLSG, performs preventive maintenance scheduled for completion weekly. They also perform corrective maintenance required to restore systems and equipments to operational standards.

Intermediate Level Maintenance

Intermediate level maintenance is conducted in port by MLSG personnel. The MLSG facility consists of a complex of containerized mobile facilities. These facilities provide diagnostic skills, special tools, test equipment, technical manuals, and other maintenance resources not available aboard the PHM. The PHM is scheduled for a 7-day technical availability period each month to allow the completion of more extensive maintenance tasks. The ship is also scheduled for a 15-day restricted availability period each quarter to permit the installation of service changes and other maintenance actions requiring extended periods.

Depot Level Maintenance

Depot level maintenance is conducted at a ship repair facility, at a shipyard, or at the shipbuilder's facilities. The work accomplished at the depot level consists of major repairs, overhauls, modifications, rework, and maintenance tasks beyond the scope of the MLSG. The depot repair point for the PHM LM2500 gas turbine is NADEP, North Island, California. The Garrett ME 831-800 gas turbine receives depot level maintenance at the contractor's facilities.

SUMMARY

This chapter has provided you with a variety of information to help you become familiar with the propulsion systems and electrical systems on the LCAC and PHM class ships.

In the first part of this chapter, we discussed several of the control systems used on the LCAC. We also discussed the control console, the vessel's electrical system, and the APU. We briefly described the LCAC's maintenance system and the troubleshooting techniques used in isolating and repairing equipment malfunctions.

In the last part of this chapter, we described the propulsion and electrical control systems used on the PHM class ships. We covered the procedures used for foilborne and hullborne operations. We discussed the components of the main propulsion system and the ship's electrical system. We briefly described the troubleshooting procedures used to repair the foilborne and hullborne control systems. You were given a brief description of the electrical distribution system used on the PHM. You also read about how the PHM class ships receive shore power from a mobile electric power unit. We also discussed some of the auxiliary systems that interface with the main propulsion systems. Finally, we described the unique maintenance system associated with the PHM and the MLSG.

As a GSE, you may find yourself assigned to one of these classes of ships. This chapter should have provided you with a basic understanding of the engineering systems found on the LCAC and PHM class ships.

APPENDIX I

GLOSSARY

ALARM ACKNOWLEDGE.— A pushbutton that must be depressed to silence an alarm.

ALTERNATING CURRENT (ac).— An electrical current that constantly changes amplitude and polarity at regular intervals.

AMBIENT TEMPERATURE.— The surrounding temperature, such as the air temperature, that surrounds a conductor in a compartment or piece of equipment.

AMBIENT PRESSURE.— The surrounding pressure, such as the air pressure, that surrounds a conductor in a compartment or piece of equipment.

AMPERE (amp).— A unit of electrical current or rate of flow of electrons. One volt across 1 ohm of resistance causes a current flow of 1 ampere.

ANALOG SIGNAL.— A measurable quantity that is continuously variable throughout a given range and that is representative of a physical quantity.

ANALOG-TO-DIGITAL CONVERSION (A/D or ADC).— A conversion that takes an analog in the form of electrical voltage or current and produces a digital output.

ARMATURE.— The moving element in an electromechanical device, such as the rotating part of a generator or motor or the movable part of a relay.

AUTOMATIC BUS TRANSFER (ABT).— Normal and alternate power sources are provided to vital loads. These power sources are supplied from separate switchboards through separate cable runs. Upon loss of normal power supply, the ABT automatically disconnects this source and switches the load to the alternate source.

AUTOMATIC PARALLELING DEVICE (APD).— The APD automatically parallels any two generators when an auto parallel command is initiated by the EPCC.

AUXILIARY CONTROL CONSOLE (ACC).— The console in the CCS that is used to monitor the auxiliary systems on FFG-class ships.

AUTOMATIC CONTROL SYSTEM.— Controls the PHM during takeoff, landing, and all foilborne operations.

AUXILIARY POWER UNIT (APU).— The APU system provides ac power to the LCAC and also provides bleed airflow to start the main propulsion engines. The system consists of a gas turbine generator set, a GCU, an electronic sequencing unit, a relay, a current transformer, and built-in test equipment.

BATTERY.— A device for converting chemical energy into electrical energy.

BINARY SIGNAL.— A voltage or current that carries information in the form of changes between two possible values.

BIT.— Abbreviation for binary digit. A unit of information equal to one binary decision, or the designation of one of two possible and equally likely values or states (such as 1 or 0) of anything used to store or convey information.

BLEED AIR.— Air bled off the compressor stages of the GTEs. See BLEED AIR SYSTEM.

BLEED AIR SYSTEM.— This system uses as its source compressed air extracted from the compressor stage of each GTE or GTG. It is used for anti-icing, prairie air, masker air, and LP gas turbine starting for both the GTEs and GTGs.

BRIDGE CONTROL UNIT (BCU).— The console located on the bridge of the DDG-51 class ships that has equipment for operator control of ship's speed and direction.

BRIDGE WING DISPLAY UNIT (BWDU).— Part of the SCE. Displays actual port and starboard shaft rpm and standard orders. One BWDU is mounted on the port and one on the starboard bridge wing.

BUBBLE MEMORY.— A read-only device used sparingly and considered nonvolatile. This type of memory is found in the consoles on the DDG-51 class ships.

BULKHEAD-MOUNTED ELECTRONICS ENCLOSURE (BMEE).— Contains the gas turbine electronics that interface with the propulsion control system of the PHM. It performs the same functions as the FSEE on other gas turbine-powered ships.

BUS TIE BREAKER (BTB).— A device used to connect one main switchboard to another main switchboard.

BUS.— An uninsulated power conductor (a bar or wire) usually found in a switchboard.

CALIBRATION.— (1) The operation of making an adjustment or marking a scale so that the readings of an instrument conform to an accepted standard. (2) The checking of a reading by comparison with an accepted standard.

CASUALTY.— An event or series of events in progress during which equipment damage and/or personnel injury has already occurred. The nature and speed of these events are such that proper and correct procedural steps will only serve to limit equipment damage and/or personnel injury.

CENTRAL CONTROL STATION (CCS).— The main operating station from which a majority of the engineering plant machinery can be controlled and monitored.

CENTRAL INFORMATION SYSTEM EQUIPMENT (CISE).— The CISE is located in the CCS and is part of the PAMISE. It includes the general-purpose digital computer (ECU), S/CE No. 1, and supporting equipment.

CIRCUIT BREAKER (CB).— A device used to energize/de-energize an electrical circuit and for interrupting the circuit when the current becomes excessive.

CONTROL SYSTEMS ELECTRONIC PACKAGE (CSEP).— The CSEP acts as a signal conditioning interface between the commands generated and the execution by the equipment on the LCACs.

CONTROLLABLE REVERSIBLE PITCH (CRP) PROPELLER.— A propeller whose blade pitch can be varied to control the amount of thrust in both the ahead and astern directions. (Known as controllable pitch propeller (CPP) on FFG-class ships.)

CURRENT.— The movement of electrons past a reference point. The passage of electrons through a conductor. It is measured in amperes.

DAMAGE CONTROL CONSOLE (DCC).— This console is located in the CCS and provides monitoring for hazardous conditions (fire, high bilge levels, and so forth). It also monitors the ship's firemain and can control the fire pumps.

DATA MULTIPLEX SYSTEM (DMS).— A general-purpose information transfer system that provides data transfer for most of the major systems aboard the DDG-51 class ships.

DEMAND DISPLAY INDICATOR (DDI).— A numerical display that is used to read values of parameters within the engineering plant.

DIGITAL-TO-ANALOG CONVERSION (D/A or DAC).— A conversion that produces an analog output in the form of voltage or current from a digital input.

DIRECT CURRENT.— An essentially constant value electric current that flows in one direction.

DROOP MODE.— This mode is normally used only for paralleling with shore power. This mode provides a varying frequently for any varying load and droop mode inhibits the load sharing circuitry.

ELECTRIC PLANT CONTROL ELECTRONICS ENCLOSURE (EPCEE).— The EPCEE is part of the EPCE. It contains power supplies that provide the various operating voltages required by the EPCC on the CG- and DD-class ships.

ELECTRIC PLANT CONTROL CONSOLE (EPCC).— This console contains the controls and indicators used to remotely operate and monitor the generators and the electrical distribution system on the DD-, DDG-, CG-, and FFG-class ships.

ELECTRIC PLANT CONTROL EQUIPMENT (EPCE).— The EPCE provides centralized remote control of the GTGS and electrical distribution equipment. The EPCE includes the EPCC and EPCEE and is located in the CCS.

ELECTROLYTE.— A substance used in batteries in which the conduction of electricity is accompanied by chemical action.

ELECTRONIC GOVERNOR (EG).— A system that uses an electronic control unit with an electrohydraulic governor actuator (EGA) to control and regulate engine speed.

EMERGENCY.— An event or series of events in progress that will cause damage to equipment unless immediate, timely, and correct procedural steps are taken.

ENGINEERING CONTROL AND SURVEILLANCE SYSTEM (ECSS).— An automatic electronic control and monitoring system using analog and digital circuitry to control the propulsion and electric plant. The ECSS consists of the EPCE, PAMCE, PAMISE, PLOE, and SCE on the CG- and DD-class ships.

ENGINEERING OFFICER OF THE WATCH/LOGGING UNIT (EOOW/LU).— The EOOW/LU is located in the CCS on DDG-51 class ships. It provides a centralized station for accumulating, processing, and displaying the MCS status.

ENGINEERING OPERATING PROCEDURES (EOPs).— Technically correct written procedures, status charts, and diagrams required for the normal transition between steady state operating conditions.

ENGINEERING OPERATIONAL CASUALTY CONTROL (EOCC).— Technically correct, logically sequenced procedures for responding to and controlling commonly occurring casualties.

ENGINEER OPERATING STATION (EOS).— This station, located on the PHM, contains machinery controls, the fire detection and extinguishing panel, the flooding panel, and damage control central.

ENGINEERING OPERATIONAL SEQUENCING SYSTEM (EOSS).— A two-part system of operating instructions bound in books for each watch station. It provides detailed operating procedures (EOPs) and casualty control procedures (EOCC) for the propulsion plant.

ENGINE ORDER TELEGRAPH (EOT).— A nonvoice communication system provided between the command station (pilot house), CCS, and the main engine room.

EXCITER CONTROL PANEL (EXCOP).— Controls the generator output voltage by regulating generator field excitation. The EXCOP is enabled by the LOCOP on DDG-51 class ships.

EXECUTIVE CONTROL UNIT (ECU).— A computer (part of PAMISE) that is the nucleus of the information center of the ECSS. The ECU gathers data from the ship's propulsion, auxiliary, and electric plant equipment.

FEEDBACK.— A value derived from a controlled function and returned to the controlling function.

FEEDWATER.— Distilled water made in evaporators for use in boilers. Feedwater is purer than drinking (potable) water.

FILTER.— (1) A device that removes insoluble contaminants from the fluid power system. (2) A device through which gas or liquid is passed while dirt, dust, and other impurities are removed by the separating action.

FOREIGN OBJECT DAMAGE (FOD).— Damage as a result of entry of foreign objects into a gas turbine inlet.

FREE STANDING ELECTRONIC ENCLOSURE (FSEE).— The FSEE provides the supporting electronic and engine control interface between the GTE and the control consoles. One FSEE is located in each MER.

FREQUENCY.— The number of cycles (as in an alternating electrical current) completed per second.

FUEL SYSTEM CONTROL CONSOLE (FSCC).— Located in the CCS, the FSCC is the central station for monitoring and control of the fuel fill and transfer system on DD-, DDG-, and CG-47 class ships.

FUEL OIL SYSTEM.— This system provides a continuous supply of clean fuel to the GTEs.

FULL POWER.— The condition in which both engines (GTEs) in one engine room are engaged and driving the reduction gear and propeller shaft.

GAS TURBINE ENGINE (GTE).— A GTE consists of a compressor, a combustor, a turbine, and an accessory drive system. Many variations of GTEs exist.

GAS TURBINE GENERATOR SET (GTGS).— The GTGS has a GTE, a reduction gearbox, and a generator.

GENERATOR.— A rotating machine that converts mechanical energy into electrical energy.

GENERATOR BREAKER (GB).— The GB is used to connect a generator to its main switchboard.

GOVERNOR CONTROL UNIT (GCU).— A static GCU is supplied for each GTGS consisting of a static exciter/voltage regulator assembly, field rectifier assembly, motor-driven rheostat, and mode select rotary switch. It controls the output voltage of the generator.

GROUND.— (1) A metallic connection with the earth to establish ground potential. (2) The voltage reference point in a circuit. There may or may not bean actual connection to earth, but it is understood that a point in the circuit said to be at ground potential could be connected to earth without disturbing the operation of the circuit in any way.

HERTZ (Hz).— A unit of frequency equal to one cycle per second.

HORSEPOWER (hp).— A standard unit of power that equals 550 foot-pounds of work per second.

HYDRAULIC.— Conveyed, operated, or moved by water or other liquid in motion.

IMPELLER.— A blade or series of blades of a rotor that imparts motion.

INTERIM INTEGRATED ELECTRONIC CONTROL (IIEC).— The IIEC provides the supporting electronic and engine control interface between the GTE and the control consoles.

ISOCHRONOUS MODE.— This mode is normally used for generator operation. This mode provides a constant frequency for all load conditions. When two (or more) generators are operated in parallel, the isochronous mode also provides equal load sharing between units.

JP-5.— The primary type of fuel used for helicopters and small boats. The emergency source of fuel for the GTEs and GTGs.

KILOWATT.— A unit of electrical power equal to 1000 watts. (A watt is a unit of power equal to the rate of work represented by a current of 1 ampere under a pressure of 1 volt.)

LOAD SHEDDING.— Protects a generator from overloading by automatically dropping preselected loads when generator output reaches 100 percent.

LOCAL CONTROL PANEL (LOCOP).— The LOCOP is the local operating station for the SSGTG on the CG-, DD-, and DDG-class ships. It is located in the MER near the SSGTG.

LOCAL OPERATING PANEL (LOP).— The LOP is the local operating station for GTEs on the FFG-class ships. It is located in the MER and is used primarily for maintenance.

MACHINERY CONTROL SYSTEM (MCS).— Provides centralized and remote monitoring and control of propulsion, electrical, auxiliary, and damage control systems of the DDG-51 class ships.

MANUAL BUS TRANSFER (MBT).— Provides selection between normal and alternate power sources for selected equipment. This transfer switch is used for controllers with low voltage protection that requires manual restarting after voltage failure and for electronic power distribution panels.

MAIN REDUCTION GEAR (MRG).— A gear arrangement designed to reduce the rpm output of the GTE and drive the propeller shaft.

MAIN FUEL CONTROL (MFC).— A hydro-mechanical device on the propulsion GTE that controls N_{GG}, schedules acceleration fuel flow, deceleration fuel flow, and stator vane angle for stall-free, optimum performance over the operating range of the GTE.

MAINTENANCE INDEX PAGE (MIP).— A basic PMS reference document prepared and issued for each installed system/equipment for which PMS support has been established.

MAINTENANCE REQUIREMENT CARD (MRC).— A card that provides detailed procedures for performing maintenance requirements and tells who, how, and with what resources a specific requirement is to be accomplished.

MARINE GAS TURBINE SERVICE RECORDS.— A comprehensive equipment service record that provides a history of operation, maintenance, and configuration changes to gas turbine equipment.

MASKER AIR SYSTEM.— TMS system disguises the sound signature of the ship and alters transmission of machinery noise to the water by emitting air from small holes in the emitter rings on the ship's hull.

MEGGER.— A high-range ohmmeter having a built-in, hand-driven generator as a direct voltage source, used for measuring insulation resistance values and other high resistances.

MILLIAMPERE.— One one-thousandth (0.001) of an ampere. Abbreviated mA.

MOTOR.— A device that moves an object. Specifically, a machine that converts electric energy into mechanical energy.

MULTIPLEXING.— The process of combining several measurements for transmission over the same signal path.

OHM.— Symbolized by the Greek letter omega (Ω). The unit of resistance. One ohm is the value of resistance through which a potential difference of 1 volt will maintain a current of 1 ampere.

OIL DISTRIBUTION (OD) BOX.— This box is located at the forward end of each MRG assembly. It directs HP oil from the HOPM to the propeller hub through the shaft bore. The OD box also establishes propeller pitch by using control oil from the HOPM to position the valve rod, which extends through the shaft to the hub.

OPEN CIRCUIT.— A circuit that does not provide a complete path for the flow of current.

ORIFICE.— A circular opening in a flow passage that creates a flow restriction.

PARAMETER.— A variable, such as temperature, pressure, flow rate, voltage, current, or frequency that may be indicated, monitored, checked, or sensed in any way during operation or testing.

PERMANENT MAGNET ALTERNATOR (PMA).— The PMA is mounted on the generator shaft extension of each GTGS and supplies speed sensing and power to the electronic governor. The PMA also supplies initial generator excitation.

PHASE.— (1) The angular relationship between current and voltage in ac circuits. (2) The number of separate voltage waves in an ac supply (for example, single-phase and three-phase).

PHOTOELECTRIC.— Electricity produced by the action of light.

PITCH.— A term applied to the distance a propeller will advance during one revolution.

PLASMA DISPLAY UNIT (PDU).— An orange-colored backlit display screen mounted in the panel face of the MCS consoles. Typed data in alphanumeric format is printed on the interior plasma face of the unit. It is used to present equipment status data to operators for information or action.

PMS FEEDBACK REPORT.— A form ships use to notify the Naval Sea Support Center or the type commander of matters related to PMS.

POTENTIOMETER.— A variable resistance unit having a rotating contact arm that can be set at any desired point along the resistance element.

POWER.— The rate at which work is done. Units of power are the watt, the joule, and the kilowatt.

POWER LEVEL ANGLE (PLA).— A rotary actuator mounted on the side of the GTE fuel pump and its output shaft lever. It is mechanically connected to the MFC power lever. The PLA actuator supplies the torque to position the MFC power lever at the commanded rate.

POWER SUPPLY.— A unit that supplies electrical power to another unit. It changes ac to dc and maintains a constant voltage output within limits.

POWER TURBINE (PT).— The GTE turbine that converts the GG exhaust into energy and transmits the resulting rotational force via the attached output shaft.

PRAIRIE AIR SYSTEM.— This system emits cooled bleed air from small holes along the leading edge of the propeller blades. The resulting air bubbles disturb the thrashing sound so identification of the type of ship through sonar detection becomes unreliable.

PRESSURE.— Force per unit of area, usually expressed as psi.

PRESSURE SWITCH.— A switch actuated by a change in the pressure of a gas or liquid.

PRESSURE TRANSDUCER.— An instrument that converts a static or dynamic pressure input into the proportionate electrical output.

PRIME MOVER.— (1) The source of motion–as a GTE, (2) the source of mechanical power used to drive a pump or compressor, (3) or the rotor of a generator.

PROPELLER.— A propulsive device consisting of a boss or hub carrying two or more radial blades. (Also called a screw.)

PROPULSION AUXILIARY CONTROL CONSOLE (PACC).— This console is located in the CCS and is part of the PAMCE. It contains the electronic equipment capable of controlling and monitoring both propulsion plants and auxiliary equipment on a CG-47, DD-963, or DDG-993 class ship. (Also known as the PACC on the DDG-51 class ship but not a part of PAMCE.)

PROPULSION AND AUXILIARY MACHINERY CONTROL EQUIPMENT (PAMCE).— This equipment is located in the CCS, is part of the ECSS, and includes the PACC and PACEE. This equipment provides centralized control and monitoring of both main propulsion plants and auxiliary machinery on a CG- or DD-class ship.

PROPULSION AND AUXILIARY MACHINERY INFORMATION SYSTEM EQUIPMENT (PAMISE).— This equipment is located in the CCS and is part of the ECSS. This equipment receives, evaluates, and logs the engineering plant performance, status, and alarm state. The PAMISE contains the CISE and S/CE No. 1 on a CG-47, DD-963, or DDG-993 class ship.

PROPULSION CONTROL CONSOLE (PCC).— This is the main engine control console in the CCS on an FFG-class ship. It is used for starting, stopping, and controlling the GTEs and propeller shaft.

PROPULSION LOCAL CONTROL CONSOLE (PLCC).— The PLCC is located in each engine room and is part of the PLOE. It has controls and indicators necessary for operator control of one main propulsion plant and its supporting auxiliaries on a CG-47, DD-963, or DDG-993 class ship.

PROPULSION LOCAL OPERATING EQUIPMENT (PLOE).— The PLOE is located in each engine room and is part of the ECSS. It includes the PLCC and PLCEE. The PLOE provides for local control and monitoring of the main propulsion GTE and the associated auxiliary equipment on a CG-47, DD-963, or DDG-993 class ship.

PROPULSOR.— A waterjet pump that draws in seawater, accelerates the water, and expels it through a nozzle at the stern of a PHM. The PHM has one foilborne propulsor and two hullborne propulsory.

PUMP.— (1) A device that converts mechanical energy into fluid energy. (2) A device that raises, transfers, or compresses fluids or gases.

RECTIFIER.— A device that, by virtue of its asymmetrical conduction characteristic, converts an alternating current into a unidirectional current.

RELAY.— An electromechanical device in which contacts are opened and/or closed by variations in the conditions of one electric circuit and thereby affect the operation of other devices in the same or other electric circuits.

REPAIR STATION CONSOLE (RSC).— Provides centralized control of the damage control equipment on DDG-51 class ships. The RSC serves as the primary control station when the DCC is not available.

RESISTANCE TEMPERATURE DETECTOR (RTD).— A temperature sensor that works on the principle that as temperature increases, the conductive material exposed to this temperature increases electrical resistance.

RESISTOR.— A device possessing the property of electrical resistance.

RPM AND PITCH INDICATOR UNIT (RPIU).— Part of the SCE and is identical to the BWDU except that the RPIU also displays port and starboard CRP propeller pitch. Mounted in the pilothouse.

SALIENT-POLE GENERATOR.— A generator whose field poles are bolted to the rotor, as opposed to a generator whose field poles are formed by imbedding field windings in the slots of a solid rotor.

SCAVENGE PUMP.— A pump used to remove oil from a sump and return it to the oil supply tank.

SELECTED COMPONENT RECORD (SCR) CARD.— A card that provides for the recording of installation and removal data, technical directive status, and repair/rework history on selected accessories and components.

SENSOR.— The part of an instrument that first takes energy from the measured medium to produce a condition representing the value of the measured variable.

SHAFT CONTROL UNIT (SCU).— The SCU is located in each engine room. It has controls and indicators necessary for operator control of one main propulsion plant and its supporting auxiliaries on a DDG-51 class ship.

SHIP CONTROL CONSOLE (SCC).— This console is located on the bridge of CG-, DD-, and DDG-class ships. It has equipment for operator control of ship's speed and direction.

SHIP CONTROL EQUIPMENT (SCE).— The SCE provides a means of controlling and monitoring ship's speed, heading, plant propulsion status, and shaft performance. Most of the SCE assemblies are located on the bridge.

SHIP'S SERVICE DIESEL GENERATOR (SSDG).— The SSDG is the main source of electrical power for a ship. It uses a diesel engine as the prime mover for the generator.

SHIP'S SERVICE GAS TURBINE GENERATOR (SSGTG).— The SSGTG is the main source of electrical power for a ship. It uses a GTE as the prime mover for the generator.

SHIP'S SERVICE POWER UNIT (SSPU).— The SSPU is the main source of electrical power for a PHM. It consists of a gas turbine engine, a mechanical gearbox, an ac generator, hydraulic pumps, and a load compressor.

SHORT CIRCUIT.— Also called a short. An abnormal connection of relatively low resistance between two points of a circuit. The result is a flow of excess (often damaging) current between these points.

SIGNAL CONDITIONING ENCLOSURE (S/CE).— Part of the PAMISE and provides the major input interface between the propulsion plant machinery and the ECSS control consoles. The S/CE accepts inputs from the plant machinery and outputs normalized signals to the ECSS control consoles. Also has alarm detection and alarm output circuitry. One S/CE is located in each engine room and one is apart of the CISE (located in CCS).

SILICON CONTROLLED RECTIFIER (SCR).— A four layer PNPN semiconductor device that, when in its normal state, blocks a voltage applied in either direction. The SCR is enabled to conduct in the forward direction when an appropriate signal is applied to the gate electrode.

SOLDERING.— The joining of metallic surfaces (for example, electrical contacts) by melting a metal or an alloy (usually tin and lead) over them.

SOLENOID.— A coil of wire in the form of a long cylinder that resembles a bar magnet. When current flows in the wire, a movable core is drawn into the coil.

SOLID STATE.— (1) Pertaining to circuits and components using semiconductors. (2) The physics of materials in their solid form (for example, diodes and transistors).

SPLIT PLANT.— The condition in which only one engine in an engine room is driving the reduction gear/propulsion shaft.

STARTER AIR SYSTEM.— Takes both hot compressed bleed air from the bleed air collection and distribution system and cool compressed bleed air from the masker air system and distributes them to both the GTEs and GTGs for starting and motoring.

STARTING AIR COMPRESSOR (SAC).— The shaft-driven centrifugal compressor mounted on the end of a diesel engine on the FFG-7 class ships. It is used to supply compressed air to the GTEs for the purpose of starting.

STATOR.— The nonrotating part of the magnetic structure in an induction motor or a generator.

SUMMARY ALARM.— An indicator at a console that indicates to an operator that one of several abnormal conditions has occurred on a certain piece of equipment.

SWITCHBOARD.— A single large panel or an assembly of panels on which are mounted the switches, circuit breakers, meters, fuses, and terminals essential to the operation of electrical equipment.

TACHOMETER.— An instrument used to measure the speed of rotation of a device.

TEMPERATURE.— The quantitative measure of the relative hotness or coldness of an object.

THERMAL ENERGY.— The potential and kinetic energy of particles of a body that can be evolved as heat.

THERMOCOUPLE.— (1) A bimetallic device capable of producing an emf roughly proportional to temperature differences on its hot and cold junction ends. (2) A junction of two dissimilar metals that produces a voltage when the junction is heated.

TOLERANCE.— The allowable deviation from a specification or standard.

TRANSDUCER.— (1) A device that converts a mechanical input signal into an electrical output signal. (2) Generally, a device that converts energy from one form into another, always retaining the characteristic amplitude variations of the energy converted.

TRANSFORMER.— A device composed of two or more coils, linked by magnetic lines of force, used to step up or step down an ac voltage.

TURBINE OVERTEMPERATURE PROTECTION SYSTEM (TOPS) .— A system used on a CG- or DD-class ship to protect a surviving generator from overload if another generator fails.

TURBINE INLET TEMPERATURE (TIT).— The GTGS turbine inlet temperature on the Allison 501-K17. (Known as $T_{5.4}$ for an LM2500 GTE.)

ULTRAVIOLET (UV) DETECTOR.— A device that senses the presence of fire in the GTE and GTG enclosure and generates an electrical signal that is sent to the ECSS, MCS, or PCS.

UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM.— Critical ship control systems have a UPS as an emergency power source. The UPS is used to maintain operations during any interruption of the normal power source.

VOLT.— A unit of electrical potential.

VOLTAGE.— An electric potential difference, expressed in volts.

VOLTAGE REGULATOR.— A circuit that holds an output voltage at a predetermined value or causes it to vary according to a predetermined plan, regardless of normal input-voltage changes or changes in the load.

WASTE HEAT BOILER (WHB).— Each WHB is associated with a GTGS and uses the hot exhaust gases to convert feedwater to steam for various ship's services on CG-,DD- or DDG-51 class ships.

WATT.— A unit of electric power equal to the rate of work represented by a current of 1 ampere under a pressure of 1 volt.

APPENDIX II

ABBREVIATIONS AND ACRONYMS

This appendix is a listing of the abbreviations and acronyms used in this text. Although this is an extensive listing, it is not an all-inclusive list of abbreviations and acronyms used by the Gas Turbine Systems Technicians. However, this list will help form a basis for your qualification under the PQS system and allow for rapid access to terms used by Gas Turbine Systems Technicians.

A/D	analog-to-digital
A/C	air conditioning
ABT	automatic bus transfer
ACC	auxiliary control console
ACS	automatic control system
AMR	auxiliary machinery room
AMS	alarm and monitor system
APD	automatic paralleling device
APL	allowance parts list
APU	auxiliary power unit
BCU	bridge control unit
BIT	built in test
BITE	built-in test equipment
BMEE	bulkhead mounted electronics enclosure
BWDU	bridge wing display unit
C&C	command and control
CB	circuit breaker
CCS	central control station
CNO	Chief of Naval Operations
COSAL	coordinated shipboard allowance list
CO	commanding officer
CPP	controllable pitch propeller
CPR	cardiopulmonary resuscitation
CPU	central processing unit
CRP	controllable reversible pitch
CRT	cathode ray tube
CSEP	control systems electronic package
DCC	damage control console

DCU	data converter unit
DDI	demand display indicator
DMS	data multiplex system
DTG	date-time group
ECM	engine control module
ECSS	engineering control and surveillance system
ECU	executive control unit
EGL	equipment guide list
EIMB	Electronics Installation and Maintenance Book
EM	electrician's mate
EMI	electromagnetic interference
EOCC	engineering operational casualty control
EOOW/LU	engineering officer of the watch/logging unit
EOOW	engineering officer of the watch
EOPs	engineering operational procedures
EOS	engineer's operating station
EOSS	engineering operational sequencing system
EOT	engine order telegraph
EPCC	electric plant control console
EPCE	electric plant control equipment
EPI	electronic pitch indicator
ESM	electronic support module
EXCOP	exciter control panel
FBCS	foilborne control system
FBR	feedback report
FECS	foilborne engine control system
FOD	foreign object damage
FPCS	foilborne propulsor control system
FSCC	fuel system control console
FSEE	free standing electronics enclosure
GCU	generator control unit
GS	gas turbine systems technician
GSE	gas turbine systems technician (electrical)
GT	gas turbine
GTBs	gas turbine bulletins
GTCs	gas turbine changes

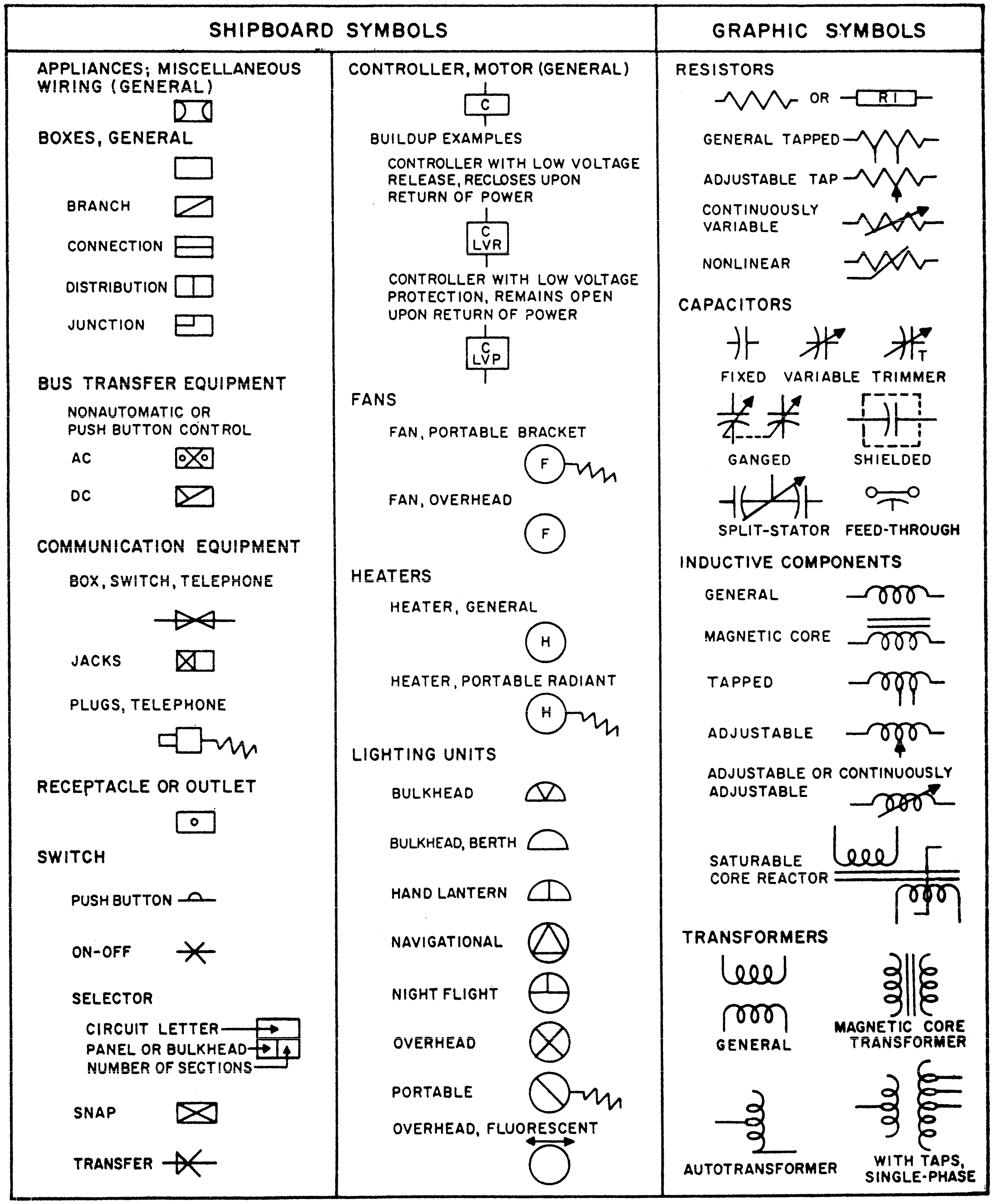
GTE	gas turbine engine
GTGS	gas turbine generator set
HBCS	hullborne control system
HOPM	hydraulic oil power module
HP	horsepower
HSVL	high-speed velocity log
Hz	hertz
I/o	input/output
IC	interior communication electrician
IIEC	interim integrated electronic control
IMAs	intermediate maintenance activities
in. lb	inch pound
in.H_2O	inches of water
ITC	integrated throttle control
kW	kilowatts
LCAC	landing craft, air cushion
LED	light emitting diode
LOCOP	local control panel
LOP	local operating panel
LVP	low voltage protection
LVR	low voltage release
mA	milliamps
MBT	manual bus transfer
MCS	machinery control system
MER	main engine room
MGT	marine gas turbine
MGTE	marine gas turbine engine
MGTESR	marine gas turbine equipment service record
MIP	maintenance index page
MLSG	mobile logistic support group
MRC	maintenance requirement card
MRG	main reduction gear
NAVSEACEN	Naval Sea Support Center
NRTC	nonresident training course
NSTM	Naval Ships' Technical Manual
OD	oil distribution

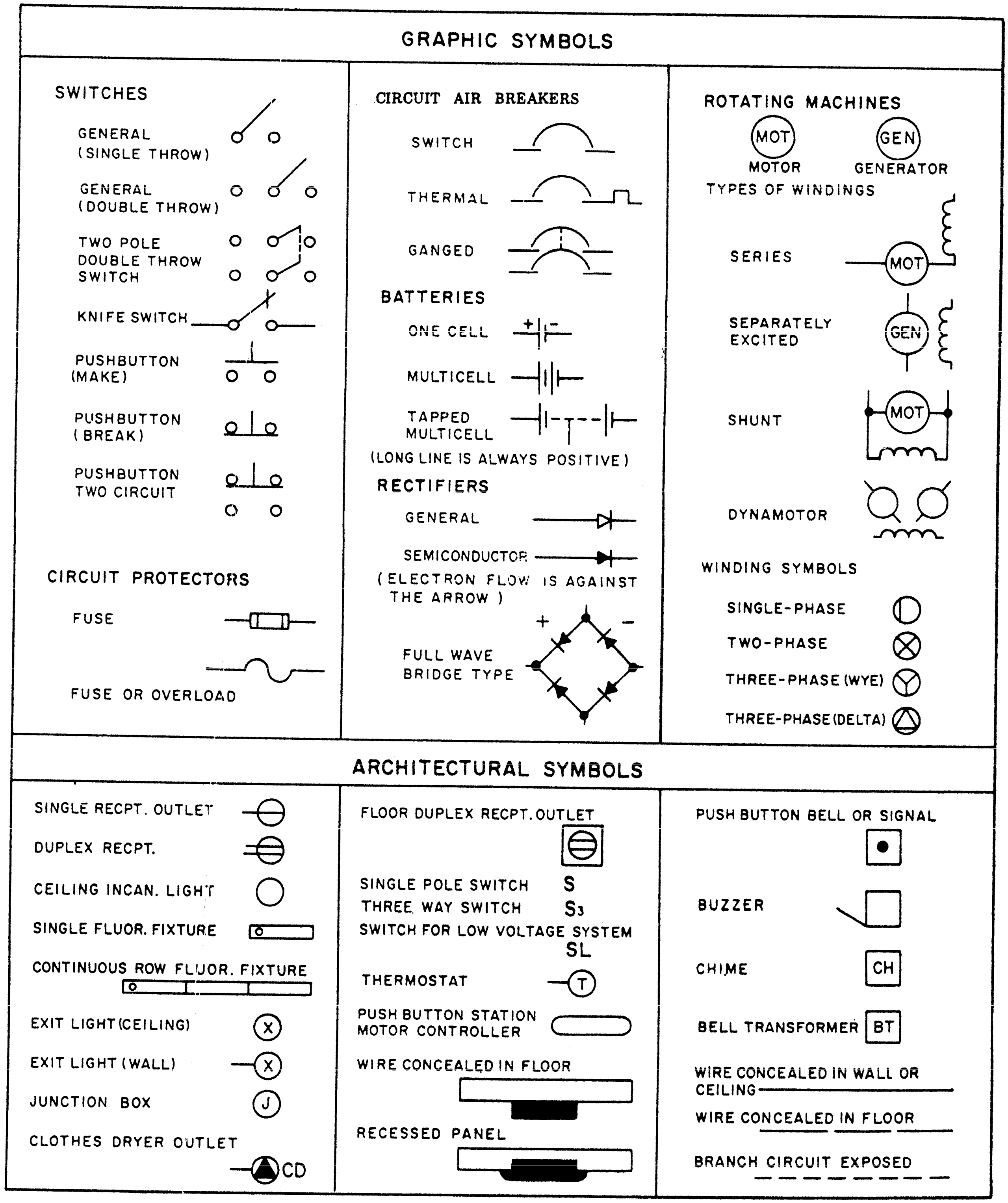
OOD	officer of the deck
PACC	propulsion and auxiliary control console
PAMCE	propulsion and auxiliary machinery control equipment
PAMISE	propulsion and auxiliary machinery information system
PCB	printed circuit board
PCC	propulsion control console
PCS	propulsion control system
PDU	plasma display unit
PHM	patrol combatant missile (hydrofoil)
PLA	power lever angle
PLCC	propulsion local control console
PLOE	propulsion local operating equipment
PMA	permanent magnet alternator
PMS	planned maintenance system
PQS	personnel qualification standard
psi	pounds per square inch
psia	pounds per square inch absolute
psid	pounds per square inch differential
psig	pounds per square inch gauge
PT	power turbine
PWB	printed wiring board
QA	quality assurance
QAO	quality assurance officer
RAM	random access memory
ROM	read only memory
RPIU	rpm and pitch indicator unit
rpm	revolutions per minute
RTD	resistance temperature detector
RTE	resistance temperature element
S/CE	signal conditioning enclosure
SAC	start air compressor
SCC	ship control console
SCE	ship control equipment
SCRs	silicon controlled rectifiers
SCS	supervisory control system
SCU	shaft control unit

SEM	standard electronic module
SMR	source, maintenance, and recoverability
SQCI	ship quality control inspector
SSDG	ship's service diesel generator
SSGTG	ship's service gas turbine generator
SSPU	ship's service power unit
TCPI	temperature compensated pitch indicator
TD	technical directive
TIT	turbine inlet temperature
TLI	tank level indicator
TOPS	turbine overload protection system
TRAMAN	training manual
TYCOM	type commander
UPS	uninterrupted power supply
WHB	waste heat boiler

APPENDIX III

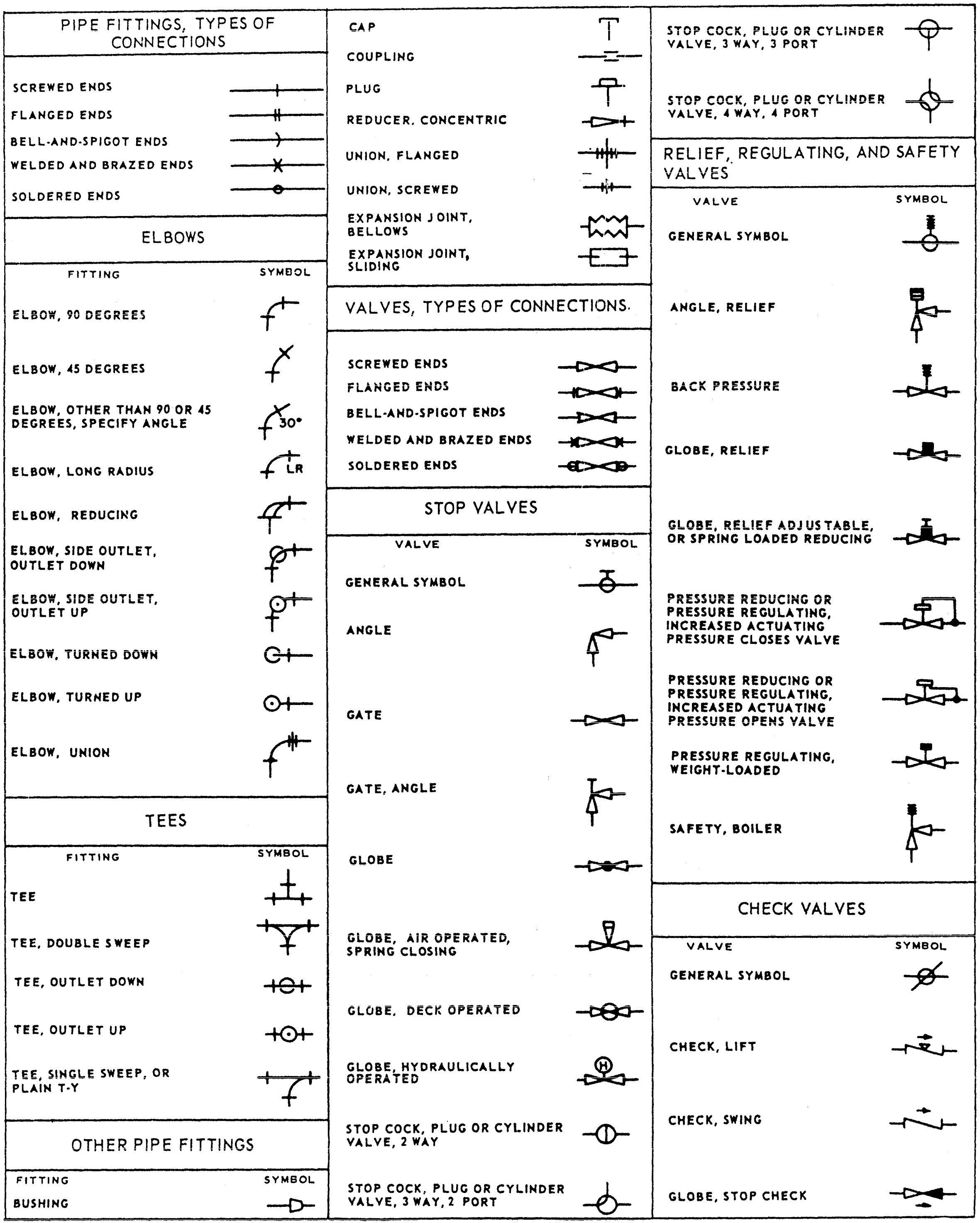
ELECTRICAL SYMBOLS

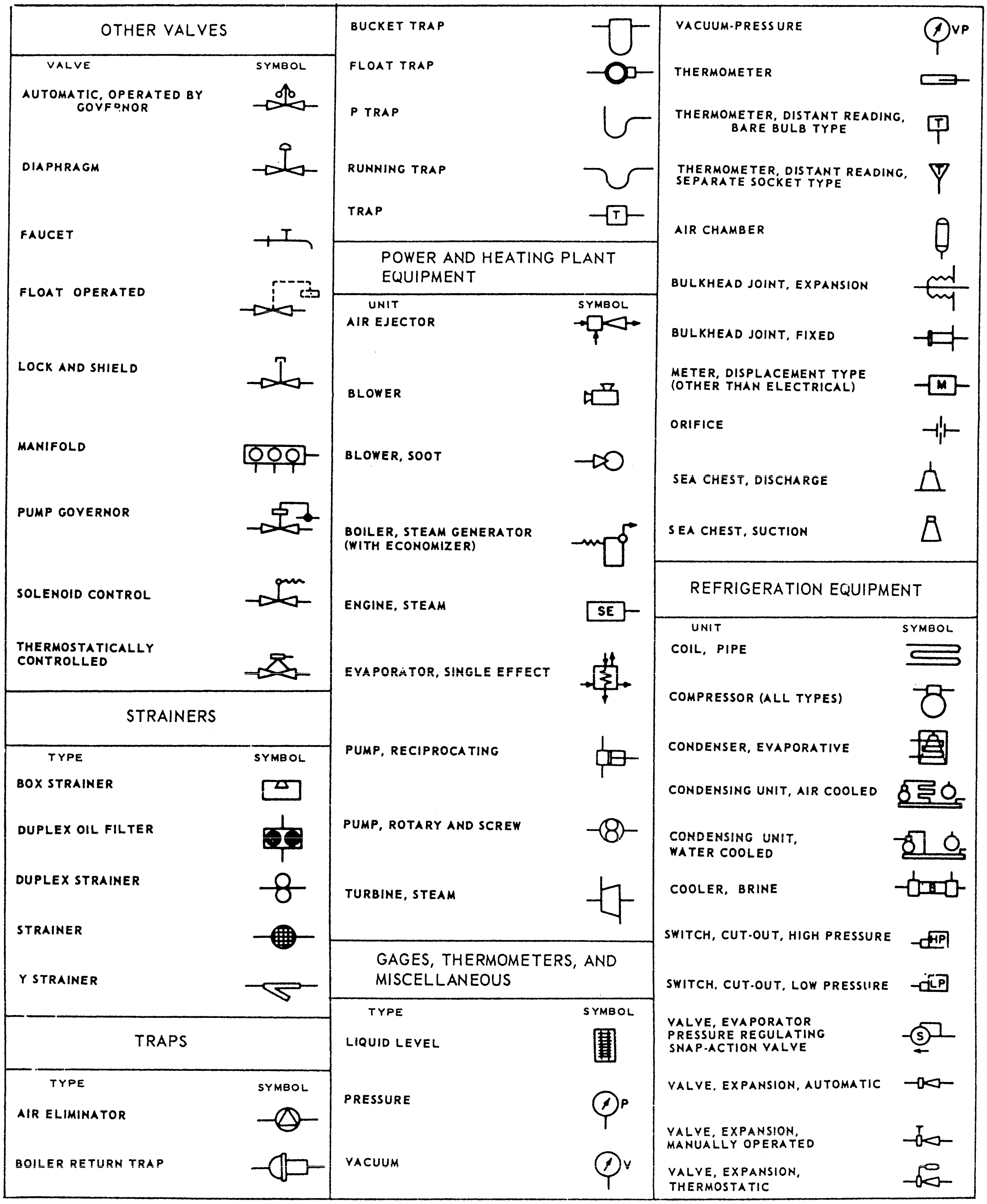

SHIPBOARD SYMBOLS
GRAPHIC SYMBOLS
APPLIANCES; MISCELLANEOUS WIRING (GENERAL)
BOXES, GENERAL
BRANCH
CONNECTION
DISTRIBUTION
JUNCTION
BUS TRANSFER EQUIPMENT
NONAUTOMATIC OR PUSH BUTTON CONTROL
AC
DC
COMMUNICATION EQUIPMENT
BOX, SWITCH, TELEPHONE
JACKS
PLUGS, TELEPHONE
RECEPTACLE OR OUTLET
SWITCH
PUSH BUTTON
ON-OFF
SELECTOR
CIRCUIT LETTER
PANEL OR BULKHEAD
NUMBER OF SECTIONS
SNAP
TRANSFER
CONTROLLER, MOTOR (GENERAL)
C
BUILDUP EXAMPLES
CONTROLLER WITH LOW VOLTAGE RELEASE, RECLOSES UPON RETURN OF POWER
C LVR
CONTROLLER WITH LOW VOLTAGE PROTECTION, REMAINS OPEN UPON RETURN OF POWER
C LVP
FANS
FAN, PORTABLE BRACKET
F
FAN, OVERHEAD
F
HEATERS
HEATER, GENERAL
H
HEATER, PORTABLE RADIANT
H
LIGHTING UNITS
BULKHEAD
BULKHEAD, BERTH
HAND LANTERN
NAVIGATIONAL
NIGHT FLIGHT
OVERHEAD
PORTABLE
OVERHEAD, FLUORESCENT
RESISTORS
OR
RI
GENERAL TAPPED
ADJUSTABLE TAP
CONTINUOUSLY VARIABLE
NONLINEAR
CAPACITORS
FIXED
VARIABLE
TRIMMER
T
GANGED
SHIELDED
SPLIT-STATOR
FEED-THROUGH
INDUCTIVE COMPONENTS
GENERAL
MAGNETIC CORE
TAPPED
ADJUSTABLE
ADJUSTABLE OR CONTINUOUSLY ADJUSTABLE
SATURABLE CORE REACTOR
TRANSFORMERS
GENERAL
MAGNETIC CORE TRANSFORMER
AUTOTRANSFORMER
WITH TAPS, SINGLE-PHASE


GRAPHIC SYMBOLS
SWITCHES
GENERAL (SINGLE THROW)
GENERAL (DOUBLE THROW)
TWO POLE DOUBLE THROW SWITCH
KNIFE SWITCH
PUSHBUTTON (MAKE)
PUSHBUTTON (BREAK)
PUSHBUTTON TWO CIRCUIT
CIRCUIT PROTECTORS
FUSE
FUSE OR OVERLOAD
CIRCUIT AIR BREAKERS
SWITCH
THERMAL
GANGED
BATTERIES
ONE CELL
MULTICELL
TAPPED MULTICELL
(LONG LINE IS ALWAYS POSITIVE)
RECTIFIERS
GENERAL
SEMICONDUCTOR
(ELECTRON FLOW IS AGAINST THE ARROW)
FULL WAVE BRIDGE TYPE
+
-
ROTATING MACHINES
MOT
MOTOR
GEN
GENERATOR
TYPES OF WINDINGS
SERIES
SEPARATELY EXCITED
SHUNT
DYNAMOTOR
WINDING SYMBOLS
SINGLE-PHASE
TWO-PHASE
THREE-PHASE (WYE)
THREE-PHASE (DELTA)
ARCHITECTURAL SYMBOLS
SINGLE RECPT. OUTLET
DUPLEX RECPT.
CEILING INCAN. LIGHT
SINGLE FLUOR. FIXTURE
CONTINUOUS ROW FLUOR. FIXTURE
EXIT LIGHT (CEILING)
EXIT LIGHT (WALL)
JUNCTION BOX
J
CLOTHES DRYER OUTLET
CD
FLOOR DUPLEX RECPT. OUTLET
SINGLE POLE SWITCH
S
THREE WAY SWITCH
S3
SWITCH FOR LOW VOLTAGE SYSTEM
SL
THERMOSTAT
T
PUSH BUTTON STATION MOTOR CONTROLLER
WIRE CONCEALED IN FLOOR
RECESSED PANEL
PUSH BUTTON BELL OR SIGNAL
BUZZER
CHIME
CH
BELL TRANSFORMER
BT
WIRE CONCEALED IN WALL OR CEILING
WIRE CONCEALED IN FLOOR
BRANCH CIRCUIT EXPOSED

APPENDIX IV

PIPING PRINT SYMBOLS


PIPE FITTINGS, TYPES OF CONNECTIONS
SCREWED ENDS
FLANGED ENDS
BELL-AND-SPIGOT ENDS
WELDED AND BRAZED ENDS
SOLDERED ENDS
ELBOWS
FITTING
SYMBOL
ELBOW, 90 DEGREES
ELBOW, 45 DEGREES
ELBOW, OTHER THAN 90 OR 45 DEGREES, SPECIFY ANGLE
30°
ELBOW, LONG RADIUS
LR
ELBOW, REDUCING
ELBOW, SIDE OUTLET, OUTLET DOWN
ELBOW, SIDE OUTLET, OUTLET UP
ELBOW, TURNED DOWN
ELBOW, TURNED UP
ELBOW, UNION
TEES
FITTING
SYMBOL
TEE
TEE, DOUBLE SWEEP
TEE, OUTLET DOWN
TEE, OUTLET UP
TEE, SINGLE SWEEP, OR PLAIN T-Y
OTHER PIPE FITTINGS
FITTING
SYMBOL
BUSHING
CAP
COUPLING
PLUG
REDUCER, CONCENTRIC
UNION, FLANGED
UNION, SCREWED
EXPANSION JOINT, BELLOWS
EXPANSION JOINT, SLIDING
VALVES, TYPES OF CONNECTIONS.
SCREWED ENDS
FLANGED ENDS
BELL-AND-SPIGOT ENDS
WELDED AND BRAZED ENDS
SOLDERED ENDS
STOP VALVES
VALVE
SYMBOL
GENERAL SYMBOL
ANGLE
GATE
GATE, ANGLE
GLOBE
GLOBE, AIR OPERATED, SPRING CLOSING
GLOBE, DECK OPERATED
GLOBE, HYDRAULICALLY OPERATED
H
STOP COCK, PLUG OR CYLINDER VALVE, 2 WAY
STOP COCK, PLUG OR CYLINDER VALVE, 3 WAY, 2 PORT
STOP COCK, PLUG OR CYLINDER VALVE, 3 WAY, 3 PORT
STOP COCK, PLUG OR CYLINDER VALVE, 4 WAY, 4 PORT
RELIEF, REGULATING, AND SAFETY VALVES
VALVE
SYMBOL
GENERAL SYMBOL
ANGLE, RELIEF
BACK PRESSURE
GLOBE, RELIEF
GLOBE, RELIEF ADJUSTABLE, OR SPRING LOADED REDUCING
PRESSURE REDUCING OR PRESSURE REGULATING, INCREASED ACTUATING PRESSURE CLOSES VALVE
PRESSURE REDUCING OR PRESSURE REGULATING, INCREASED ACTUATING PRESSURE OPENS VALVE
PRESSURE REGULATING, WEIGHT-LOADED
SAFETY, BOILER
CHECK VALVES
VALVE
SYMBOL
GENERAL SYMBOL
CHECK, LIFT
CHECK, SWING
GLOBE, STOP CHECK


OTHER VALVES
VALVE
SYMBOL
AUTOMATIC, OPERATED BY GOVERNOR
DIAPHRAGM
FAUCET
FLOAT OPERATED
LOCK AND SHIELD
MANIFOLD
PUMP GOVERNOR
SOLENOID CONTROL
THERMOSTATICALLY CONTROLLED
STRAINERS
TYPE
SYMBOL
BOX STRAINER
DUPLEX OIL FILTER
DUPLEX STRAINER
STRAINER
Y STRAINER
TRAPS
TYPE
SYMBOL
AIR ELIMINATOR
BOILER RETURN TRAP
BUCKET TRAP
FLOAT TRAP
P TRAP
RUNNING TRAP
TRAP
T
POWER AND HEATING PLANT EQUIPMENT
UNIT
SYMBOL
AIR EJECTOR
BLOWER
BLOWER, SOOT
BOILER, STEAM GENERATOR (WITH ECONOMIZER)
ENGINE, STEAM
SE
EVAPORATOR, SINGLE EFFECT
PUMP, RECIPROCATING
PUMP, ROTARY AND SCREW
TURBINE, STEAM
GAGES, THERMOMETERS, AND MISCELLANEOUS
TYPE
SYMBOL
LIQUID LEVEL
PRESSURE
P
VACUUM
V
VACUUM-PRESSURE
VP
THERMOMETER
THERMOMETER, DISTANT READING, BARE BULB TYPE
T
THERMOMETER, DISTANT READING, SEPARATE SOCKET TYPE
AIR CHAMBER
BULKHEAD JOINT, EXPANSION
BULKHEAD JOINT, FIXED
METER, DISPLACEMENT TYPE (OTHER THAN ELECTRICAL)
M
ORIFICE
SEA CHEST, DISCHARGE
SEA CHEST, SUCTION
REFRIGERATION EQUIPMENT
UNIT
SYMBOL
COIL, PIPE
COMPRESSOR (ALL TYPES)
CONDENSER, EVAPORATIVE
CONDENSING UNIT, AIR COOLED
CONDENSING UNIT, WATER COOLED
COOLER, BRINE
SWITCH, CUT-OUT, HIGH PRESSURE
HP
SWITCH, CUT-OUT, LOW PRESSURE
LP
VALVE, EVAPORATOR PRESSURE REGULATING SNAP-ACTION VALVE
S
VALVE, EXPANSION, AUTOMATIC
VALVE, EXPANSION, MANUALLY OPERATED
VALVE, EXPANSION, THERMOSTATIC

APPENDIX V

LIST OF NAVY ELECTRICITY AND ELECTRONICS TRAINING SERIES

Module 1	Introduction to Matter, Energy, and Direct Current
Module 2	Introduction to Alternating Current and Transformers
Module 3	Introduction to Circuit Protection, Control, and Measurements
Module 4	Introduction to Electrical Conductors, Wiring Techniques, and Schematic Reading
Module 5	Introduction to Generators and Motors
Module 6	Introduction to Electronic Emission, Tubes, and Power Supplies
Module 7	Introduction to Solid-State Devices and Power Supplies
Module 8	Introduction to Amplifiers
Module 9	Introduction to Wave-Generation and Wave-Shaping Circuits
Module 10	Introduction to Wave Propagation, Transmission Lines, and Antennas
Module 11	Microwave Principles
Module 12	Modulation Principles
Module 13	Introduction to Number Systems and Logic Circuits
Module 14	Introduction to Microelectronics
Module 15	Principles of Synchros, Servos, and Gyros
Module 16	Introduction to Test Equipment
Module 17	Radio-Frequency Communications Principles
Module 18	Radar Principles
Module 19	The Technician's Handbook
Module 20	Master Glossary and Index
Module 21	Test Methods and Practices
Module 22	Introduction to Digital Computers

APPENDIX VI

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Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

ASSIGNMENT 1

Textbook Assignment: "Engineering Administration," chapter 1, pages 1-1 through 1-25 and "Uninterrupted Power Supply Systems," chapter 2, pages 2-1 through 2-5.

1-1. Information and guidance necessary to manage a uniform policy of maintenance and repair of ships is provided by which of the following programs?

1. 3-M
2. QA
3. PMS
4. PQS

1-2. The QA manual for the surface fleet describes what level of QA requirements?

1. Maximum
2. Minimum
3. Detailed
4. Basic

1-3. The instructions in the basic QA manual are general in nature for which of the following reasons?

1. Because of the wide range of ship types
2. Because of the wide range of equipment types
3. Because of the number of resources available for repair and maintenance
4. All of the above

1-4. What are the two key elements of the Navy's QA program?

1. Administration and job execution
2. Administration and supervision
3. Job execution and supervision
4. Job execution and job training

1-5. Which of the following goals are NOT common to all Navy QA programs?

1. To improve the quality of maintenance
2. To cut unnecessary man-hour and dollar expense
3. To set up realistic material requirements
4. To eliminate the need for technical documentation

1-6. The QA program for COMNAVSURFLANT includes a total of how many levels of responsibility?

1. Five
2. Two
3. Three
4. Four

1-7. The QA officer (QAO) is responsible directly to which of the following officials?

1. TYCOM
2. SQCI
3. CO
4. XO

1-8. The QAO has which of the following responsibilities?

1. Coordinating the ship's QA training program
2. Conducting QA audits
3. Both 1 and 2 above
4. Controlling the force QA program

1-9. The ship quality control inspector (SQCI) has all of the following responsibilities EXCEPT which one?

1. Witnessing and documenting all tests
2. Inspecting all work for compliance with specifications
3. Ensuring failed test results are reported and recorded
4. Repairing the failed equipment

1-10. Which of the following terms are often misunderstood in the field of QA?

1. Level of assurance and level of availability
2. Level of assurance and level of essentiality
3. Level of essentiality and level of availability
4. Level of availability and level of nonavailability

1-11. QA consists of a total of how many levels of quality verification requirements?

1. One
2. Two
3. Three
4. Four

1-12. What QA level provides the least amount of quality control?

1. A
2. B
3. C
4. D

1-13. QA covers all events from the start of a maintenance action to its completion.

1. True
2. False

1-14. On board ship, what is the primary vehicle for record keeping?

1. PQS system
2. 3-M systems
3. QA system
4. 2-M system

1-15. Which of the following engineering logs are considered to be legal records?

1. Engineering Log and Electrical Log
2. Engineering Log and MRG Log
3. Engineering Log and Engineer's Bell Book
4. Engineer's Bell Book and MRG Log

1-16. An error in the Engineering Log is corrected in what way?

1. The error is erased completely and the correct entry is made
2. The error is overlined and initialed by the person who prepared the original entry
3. The error is overlined and initialed by the chief engineer
4. The error is scratched out and the correct entry is made to the right of the error

1-17. After the CO signs the Engineer's Bell Book, no changes can be made to the book without permission from what authority?

1. CO
2. XO
3. Engineer officer
4. Log custodian

1-18. On a gas turbine-powered ship, which of the following logs are commonly used for recording and maintaining data necessary for proper water conditions in d waste heat steam plant?

1. Cover Sheet and Monthly Boiler Data Log
2. Feedwater Chemistry Worksheet/Log
3. Waste Heat Boiler Water Chemistry Worksheet/Log
4. All of the above

1-19. Which of the following boiler water and feedwater logs should contain the boiler safety valve settings?

1. Cover Sheet and Monthly Boiler Data Log
2. Feedwater Chemistry Worksheet/Log
3. Waste Heat Boiler Water Chemistry Worksheet/Log
4. Reserve and Makeup Feedwater Test Log

1-20. For which of the following fuels are the fuel quality requirements more critical and extensive than for the other fuels?

1. JP-5
2. Naval distillate
3. F-76
4. NATO F-75

1-21. Which of the following activities must maintain marine gas turbine records?

1. Depots only
2. Ships only
3. All facilities having custody of gas turbine equipment
4. Shipyards only

1-22. Which of the following NSTM chapters includes the procedures for maintaining marine gas turbine equipment service records (MGTESRs)?

1. Chapter 220
2. Chapter 234
3. Chapter 244
4. Chapter 262

1-23. Which of the following activities starts the MGTESR?

1. The ship receiving the gas turbine engine
2. The shipyard
3. The manufacturer
4. The squadron receiving the gas turbine engine

1-24. When a GTE is removed from the ship, what happens to its associated MGTESR?

1. It is sent to an archives file
2. It is transferred with the GTE
3. It is returned to the manufacturer
4. It is destroyed

1-25. A standard MGTESR binder consists of what total number of separate sections?

1. 5
2. 8
3. 10
4. 12

1-26. In which of the following sections of the MGTESR binder can you find a chronological record of nonrepair activities where the GTE was installed?

1. MGTE Operating Record
2. MGTE Inspection Record
3. Cover Sheet
4. MGTE Miscellaneous/History

1-27. A GTE start should be recorded on the MGTE Operating Log for which of the following events?

1. The GTE successfully goes through the start cycle to idle
2. The GTE is motored
3. The GTE has a hung start
4. Both 2 and 3 above

1-28. Which of the following entries are NOT made on the MGTE Inspection Record?

1. Special inspections made on the gas turbine equipment
2. Conditional inspections made on the gas turbine equipment
3. Conditional inspections made on the gas turbine engine
4. Periodic inspections required by PMS

1-29. In what section of the MGTSR are engine lay-up procedures recorded?

1. MGTE Technical Directives
2. MGTE Record of Rework
3. MGTE Selected Component Record
4. MGTE Miscellaneous/History

1-30. What authority prescribes the required forms a ship must use to account for the daily fresh water and fuel usage?

1. TYCOM
2. CO
3. XO
4. Chief engineer

1-31. At what interval does the CO receive a fuel and water report?

1. Monthly
2. Weekly
3. Daily
4. Hourly

1-32. When verifying operating records, you should check for all of the following details EXCEPT which one?

1. That records are free from erasures
2. That out-of-limits entries are circled
3. That all readings and entries are legible
4. That out-of-limits entries are lined out

1-33. What is the quickest form of written communication used in the Navy?

1. Correspondence
2. Message
3. Tickler
4. Letter

1-34. What method should ships use to notify the NAVSEACEN or TYCOM of nonurgent matters pertaining to PMS?

1. PMS feedback report
2. Correspondence
3. Naval message
4. OPNAV 4790/2L

1-35. The instructions for preparing and submitting a PMS feedback report (FBR) located in what part of the report?

1. On the front of the first copy
2. On the back of the first copy
3. On the front of the last copy
4. On the back of the last copy

1-36. While performing PMS on a piece of equipment, you notice a specific tool is required that is not listed on the PMS card. What category block on the PMS FBR should you use to indicate this discrepancy?

1. A
2. B
3. Either 1 or 2 above, depending on the discrepancy
4. C

1-37. The number of entries allowed on a single EGL page is restricted to the number of work items that can be completed within what maximum number of work days?

1. 1
2. 2
3. 3
4. 4

1-38. Which of the following diagrams will show the individual connections within a unit and the physical arrangement of the components?

1. Pictorial wiring diagram
2. Schematic diagram
3. Wiring diagram
4. Block diagram

1-39. Which of the following diagrams will show the outlines of a ship and the location of connection boxes and cable runs?

1. Single line diagram
2. Isometric wiring diagram
3. Elementary wiring diagram
4. Pictorial wiring diagram

1-40. Because they represent more complex circuitry and systems than electronic prints, electrical prints are more difficult to read.

1. True
2. False

1-41. What are the two types of logic diagrams?

1. Basic and detailed
2. Basic and complex
3. Detailed and complex
4. Detailed and perplex

1-42. Which of the following logic diagrams will show specific pin numbers, socket locations, and test points?

1. Basic
2. Block
3. Schematic
4. Detailed

1-43. On gas turbine-powered ships, what is the purpose of a battery backup system?

1. To provide normal power to vital equipment
2. To provide alternate, long-term power to vital equipment
3. To provide constant ac power to vital equipment when normal power fails
4. To provide alternate, short-term power to vital equipment

1-44. How is the rapid method of transferring the load to the battery backup system accomplished?

1. By manual switching
2. By electronic switching
3. By mechanical switching
4. By electromechanical switching

1-45. On the CG-47 class ships, the UPS system can supply a nominal value of (a) how many volts dc for the duration of (b) how many minutes?

1. (a) 130 V (b) 30 min
2. (a) 130 v (b) 40 min
3. (a) 150 V (b) 30 min
4. (a) 150 v (b) 40 min

1-46. On DD-963 class ships, the UPS system consists of what type of storage batteries?

1. Lead-acid
2. Lead-calcium
3. Nickel-cadmium
4. Silver-zinc

1-47. On a CG-47 class ship, an alarm will sound at the EPCC when the UPS battery voltage drops below what minimum value?

1. 112 V dc
2. 122 V dc
3. 133 V dc
4. 145 V dc

1-48. On a CG-47 class ship, a discharged UPS battery bank can be recharged within what minimum number of hours?

1. 12
2. 2
3. 8
4. 4

1-49. On a DD-963 class ship, what is the input power to the battery charger?

1. 115-V ac, 60-Hz
2. 220-V ac, 60-Hz
3. 240-V ac, 60-Hz
4. 450-V ac, 60-Hz

1-50. On the CG-47 and DD-963 class ships, the UPS batteries are connected in what configuration?

1. 8 batteries in series, 1 spare
2. 8 batteries in parallel, 1 spare
3. 9 batteries in series
4. 9 batteries in parallel

1-51. On a CG-47 ship, noncritical loads are shed by the internal power supplies after the UPS system has been operating a total of how many minutes?

1. 1
2. 2
3. 3
4. 4

1-52. On the DDG-993 class ship, the battery charger circuit is electrically interlocked with the UPS battery room ventilation system for what primary reason?

1. To prevent the buildup of hydrogen when the ventilation is secured
2. To prevent the buildup of heat when the ventilation is secured
3. To prevent the buildup of oxygen when the ventilation is secured
4. To prevent the buildup of nitrogen when the ventilation is secured

1-53. The UPS system on which of the following ship classes contains a 120-V dc to 120-V ac inverter?

1. DD-963
2. DDG-993
3. CG-47
4. FFG-7

1-54. The UPS system on the FFG-7 class ships is located in what compartment?

1. MER
2. AMR 2
3. AMR 3
4. CCS

1-55. The UPS system on the FFG-7 class ships consists of (a) how many storage batteries rated at (b) how many volts each?

1. (a) 20 (b) 6 V
2. (a) 20 (b) 12 V
3. (a) 24 (b) 6 V
4. (a) 24 (b) 12 V

1-56. On the FFG-7 class ships, which of the following modes of the UPS system can be selected by using the mode switch?

1. Normal, alternate, automatic, and off
2. Normal, alternate, automatic, and on
3. Normal, emergency, automatic, and off
4. Normal, emergency, automatic, and on

1-57. On the FFG-7 class ships, to prevent damage to the UPS system inverter, 120 V dc must be applied to the oscillator before the 120 V dc is applied to the inverter.

1. True
2. False

1-58. On a DDG-51 class ship, which of the following consoles is NOT protected by the UPS system?

1. SCU-1
2. BCU
3. EPCC
4. PACC

1-59. On the DDG-51 class ships, the UPS battery cells will last what maximum period of time?

1. 15 min
2. 30 min
3. 45 min
4. 60 min

1-60. On the DDG-51 class ships, what are the power requirements for the MCS consoles?

1. Single phase, 115 V ac, 60 Hz only
2. 3 phase, 115 V ac, 60 Hz only
3. Single and 3 phase, 115 V ac, 60 Hz
4. Single and 3 phase, 450 V ac, 60 Hz

1-61. On the DDG-5l class ships, the UPS can supply a nominal value of how many volts?

1. 130 V dc
2. 130 V ac
3. 155 V dc
4. 155 V ac

1-62. On a DDG-51 class ship's UPS, the normal 3-phase voltage is rectified to the proper dc voltage in what component?

1. Power transformer
2. Power conditioner
3. Power rectifier
4. Silicon rectifier

1-63. Specific gravity of battery electrolyte increases during discharge and decreases during charging.

1. True
2. False

1-64. You can determine the state of charge of a sealed battery by using what method?

1. By measuring the battery's open-circuit voltage
2. By measuring the battery's closed-circuit voltage
3. By testing the specific gravity of the electrolyte of the battery
4. By checking the battery's vent indicator

1-65. What is the proper electrolyte level of an UPS storage battery?

1. 1/4 in. above the plates
2. 1/2 in. above the plates
3. 3/8 in. above the plates
4. 3/4 in. above the plates

1-66. To remove accumulated battery acid, you should wipe the case clean with a cloth moistened with which of the following solutions?

1. Diluted amnonia
2. Bicarbonate of soda
3. Either 1 or 2 above, depending on the ability of materials
4. Alcohol

ASSIGNMENT 2

Textbook Assignment: "Engineering Control System Operation," chapter 3, pages 3-1 through 3-38.

2-1. Which of the following gas turbine-powered ships use the machinery control system (MCS) to control and monitor its gas turbine equipment?

1. DD-963
2. DDG-993
3. DDG-51
4. FFG-7

2-2. The ECSS is found on which of the following classes of gas turbine-powered ships?

1. DD-963, DDG-993, and FFG-7
2. DD-963, DDG-993, and CG-47
3. DDG-51, DDG-993, and CG-47
4. DDG-51, FFG-7, and CG-47

2-3. Which of the following ECSS equipment is located in the CCS?

1. SCE, PAMCE, and EPCE
2. SCU, PAMCE, and EPCE
3. PAMCE, EPCE, and RCS
4. PAMCE, EPCE, and PAMISE

2-4. A digital computer, signal conditioning equipment, and two line printers are part of which of the following ECSS equipment?

1. PAMISE
2. EPCE
3. PAMCE
4. SCE

2-5. On a DD-963 class ship, what type of sensor is used in the engineering plant to read and display a constantly changing value, such as temperature?

1. Discrete
2. Analog
3. Mechanical
4. Photoelectric

2-6. What is the purpose of an S/CE?

1. To convert all sensory inputs into mechanical movements
2. To convert all sensory inputs into a common electrical range of 0 to 10 volts ac
3. To convert all sensory inputs into a common electrical range of 0 to 10 volts dc
4. To convert all sensory inputs into a common electrical range of 24 to 28 volts dc

2-7. Communication between ECSS consoles is accomplished through what types of signals?

1. Decimal
2. Octagonal
3. Hex
4. Binary

2-8. The number of data bits contained in a data word is specifically referred to by what term?

1. Word bit length
2. Data bit content
3. Data bit word
4. Word data length

2-9. In which of the following formats are data bits sent and received one at a time, using a single data line?

1. Series
2. Parallel
3. Complemented
4. Multiplexed

2-10. On a CG-47 class ship, if the computer halts because of a test failure, the GSE identifies the failure by using what information?

1. The data tape reader
2. The data display LEDs on the ECU
3. The DDIs on the S/CE
4. The DDIs on the PACC

2-11. The propulsion control system (PCS) on the FFG-7 class ships uses what type of sensed output signals?

1. Seasoned and unseasoned
2. Positioned and repositioned
3. Conditioned and unconditioned
4. Calculated and uncalculated

2-12. On the FFG-7 class ship, the discrete signal conditioner converts its sensed signal to what output signal level?

1. 0 to 10 V ac
2. 0 to 10 V dc
3. 0 to 5 v ac
4. 0 to 5 V dc

2-13. Digital computers are divided into which of the following basic units?

1. Input/output, control, memory, and buffer
2. Input/output, control, memory, and arithmetic
3. Memory, arithmetic, cache, and buffer
4. Memory, arithmetic, control, and cache

2-14. What true arithmetic function is performed by the arithmetic unit of a digital computer?

1. Multiplying two numbers
2. Dividing two numbers
3. Subtracting two numbers
4. Adding two numbers

2-15. What part(s) of a digital computer provide(s) temporary storage for processed data?

1. Control logic cards
2. ROM
3. RAM
4. Arithmetic unit

2-16. On the FFG-7 class ships, data and address bits CANNOT be entered at the processor maintenance panel.

1. True
2. False

2-17. The MCS on a DDG-51 class ship uses a total of how many AN/UYK-44(V) console computers to communicate over the data multiplex system (DMS)?

1. Seven
2. Six
3. Five
4. Four

2-18. All of the following MCS equipment units are located in the CCS EXCEPT which one?

1. EPCC
2. DCC
3. EOOW/LU
4. RCS

2-19. Which of the following input signals can be described as discrete?

1. An ON/OFF signal
2. An OPEN/CLOSE signal
3. Both 1 and 2 above
4. A speed signal in rpms

2-20. On the DDG-51 class ships, what is the voltage range of the interim integrated electronic control (IIEC) analog outputs?

1. 0 to 10 V dc
2. 0 to 10 v ac
3. 0 to 24 V dc
4. 0 to 24 V ac

2-21. On the DDG-51 class ships, what is the range of the LOCOP analog outputs?

1. 0 to 10 V dc
2. 0 to 10 V ac
3. 4 to 20 milliamps
4. 4 to 20 millivolts

2-22. A computer self-test is performed by the MCS console computers at all of the following times EXCEPT which one?

1. During unit initialization
2. During not-real operation
3. After a system reset
4. During system shutdown

2-23. On a DDG-51 class ship, input/output multiplexer self-tests are NOT performed at which of the following consoles?

1. SCU and EPCC
2. PACC and EOOW/LU
3. EPCC and RSC
4. DCC and RSC

2-24. On the DDG-51 class ships, which of the following computer self-tests checks the contents of its two RAMs?

1. Input/output multiplexer test
2. Availability test
3. Console status test
4. Panel distribution test

2-25. On the DDG-51 class ships, the console computer tests the analog signal inputs from the engineering plant to determine if these inputs are within what specific percentage of full scale range?

1. 7%
2. 9%
3. 15%
4. 17%

2-26. The MCS console status tests are initiated by the computer self-test function.

1. True
2. False

2-27. On gas turbine-powered ships, what is the main operating station from which the engineering plant is controlled and monitored?

1. MER
2. Pilothouse
3. CCS
4. AMR

2-28. On the CG-47 class ships, what are the two major engineering control consoles located in the CCS?

1. FSCC and PACC
2. FSCC and EPCC
3. EPCC and PCC
4. EPCC and PACC

2-29. On the DD-963 class ships, which of the following fuel oil service system functions are available at the PACC?

1. Fuel oil transfer system control
2. Fuel oil service control and monitoring
3. GTE fuel oil control and monitoring
4. Both 2 and 3 above

2-30. On the DDG-993 class ships, which of the following fuel service functions are available at the PACC and the PLCC simultaneously?

1. Monitoring only
2. Control only
3. Both 1 and 2 above
4. Defueling control

2-31. On the CG-47 class ships, which of the following methods will cause the GTE fuel purge valve to open?

1. Depressing the FUEL PURGE ON push button at the PACC
2. Depressing the FUEL PURGE ON push button at the PLCC
3. Either 1 or 2 above, depending on the operator
4. Automatic activation of the start/stop sequence control logic

2-32. On the DD-963 class ships, what are the two main air systems associated with the GTEs and GTGSs?

1. Bleed air and ship's service air
2. Bleed air and high-pressure air
3. Ship's service air and high-pressure air
4. Emergency air and high-pressure air

2-33. On a DD-963 class ship, when the start air mode on the PACC is in NORMAL and the motor air regulator valve is in the motoring position, start air pressure is regulated to what specific pressure?

1. 10 psig
2. 19 psig
3. 22 psig
4. 35 psig

2-34. On a DDG-993 class ship, all of the following GTE start/stop modes are available at the PACC EXCEPT which one?

1. Manual
2. Manual initiate
3. Auto initiate
4. Supervisory control

2-35. What type of throttle and pitch control system is used on a CG-47 class ship?

1. Analog
2. Digital
3. Discrete
4. Binary

2-36. On the CG-47 class ships, GTGS sensor information is sent to the EPCC in all of the following ways EXCEPT which one?

1. Through the PAMISE via S/CE No. 1
2. Directly from the alarm contact switches
3. Through the alarm detector circuits in the LOCOP
4. Through the alarm generator in the PLCC

2-37. On the DD-963 class ships, which of the following bus tie breakers have "Auto Trip" commands?

1. 1S–2S and 1S-3S
2. 2S–1S and 2S-3S
3. 3S-1S and 3S-2S
4. 3S-1S and 2S-1S

2-38. On the EPCC of a DD-963 class ship, what are the two modes of governor operation?

1. Normal and isochronous
2. Normal and droop
3. Normal and continuous speed
4. Normal and automatic

2-39. On the CG-47 class ships, the load shed relay is activated by what control power?

1. +5 v dc
2. -5 V dc
3. +28 V dc
4. -28 V dc

2-40. The TOPS prevents the loss of a GTGS resulting from which of the following abnormal conditions?

1. Overtemperature
2. Overspeed
3. Overload
4. Overvoltage

QUESTIONS 2-41 THROUGH 2-60 PERTAIN TO DDG-51 CLASS SHIPS.

2-41. The propulsion fuel controls available at the PACC are limited to all of the following primary functions EXCEPT which one?

1. Fuel cooling
2. Fuel purging
3. Closing the module fuel inlet valve
4. Opening the module fuel inlet valve

2-42. The solenoid-operated module fuel inlet valve assumes what position when it is electrically (a) energized or (b) de–energized?

1. (a) Open (b) open
2. (a) Open (b) closed
3. (a) Closed (b) closed
4. (a) Closed (b) open

2-43. The bleed air valve for the SSGTG can be controlled from which of the following locations?

1. SSGTG LOCOP or EPCC
2. SSGTG LOCOP or PACC
3. EPCC or PACC
4. EPCC or SCU

2-44. The engine fan control computer program function automatically operates the module cooling fan and damper in response to all of the following inputs EXCEPT which one?

1. Cooling air outlet temperature transducer
2. GTE start command
3. Halon release command
4. Compressor inlet temperature

2-45. What are the five possible engine states for a GTE?

1. OFF LINE, MOTOR, ON LINE, RUNNING, and SECURED
2. OFF, MOTOR, ON, ON LINE, and COOLDOWN
3. OFF, MOTOR, ON, RUNNING, and COOLDOWN
4. OFF, MOTOR, STANDBY, RUNNING, and COOLDOWN

2-46. What total number of the nine automatic GTE shutdowns can be inhibited by placing battle override on?

1. Five
2. Seven
3. Eight
4. Nine

2-47. What is the basic method of controlling ships's speed?

1. Manual control mode
2. Lockout manual control mode
3. Normal programmed control mode
4. Automatic control mode

2—48. The programed control computer program function of the MCS, is designed for which of the following purposes?

1. Ship maneuverability
2. Fuel economy
3. Speed
4. Flexibility

2-49. Which of the following independent auxiliary systems can be controlled from the PACC?

1. Freshwater service
2. Ship's service air
3. Air conditioning and chill water
4. Seawater cooling

2-50. Which of the following equipment features will allow the electric plant to remain operable if the EPCC computer fails?

1. The DMS signal transfer functions
2. The hardwired switch functions
3. The backup batteries
4. A reserve computer

2-51. Which of the following EPCC functions are lost when the EPCC computer fails?

1. Electric plant alarm detection
2. EPCC DMS communications
3. Display at the EPCC plasma display unit
4. All of the above

2-52. The generator field excitation is regulated by which of the following components?

1. EXCOP
2. LOCOP
3. Switchboard
4. EPCC

2-53. At what specific gas turbine speed does the LOCOP enable the EXCOP?

1. 2,200 rpm
2. 4,525 rpm
3. 8,455 rpm
4. 12,225 rpm

2-54. The EPCC automatically controls circuit breakers as a part of the standby generator start function.

1. True
2. False

2-55. The shore power breaker close control and phase monitoring devices are operated from what location?

1. Switchboard No. 1
2. Switchboard No. 2
3. Switchboard No. 3
4. EPCC

2-56. The output frequency of an SSGTG is controlled by an electronic governor located in which of the following components?

1. EXCOP
2. LOCOP
3. EPCC
4. Switchboard

2-57. All of the following circuit breakers opened during a load shed operation must be closed locally EXCEPT which ones?

1. Ventilation
2. Anti-icing heaters
3. Air-conditioning plants
4. Engine room nonvital panels

2-58. The bell log printer is a part of what MCS console?

1. EPCC
2. PACC
3. SCU
4. EOOW/LU

2-59. Which of the following signal data recorder-reproducer set tape drive units is the "Write Only" drive?

1. Drive 1
2. Drive 2
3. Drive 3
4. Drive 0

2-60. In the acronym AN/UYK-44(V), what does the letter "Y" indicate?

1. Computing
2. Data processing
3. General utility
4. Army/Navy

QUESTIONS 2-61 THROUGH 2-71 PERTAIN TO FFG-7 CLASS SHIPS.

2-61. Which of the following consoles is specifically used to control and monitor the auxiliary subsystems?

1. ACC
2. DCC
3. EPCC
4. PCC

2-62. What two modes of operation are available for the fuel oil service pumps?

1. MANUAL and LEAD
2. MANUAL and AUTO SPEED ADAVANCE
3. MANUAL and LEAD SPEED ADVANCE
4. MANUAL and AUTO LEAD

2-63. The gas turbine emergency supply valve fails to what position upon loss of electrical power?

1. Open
2. Closed
3. Diverted
4. Regulated

2-64. The lube oil coastdown pumps are driven by which of the following components?

1. Electric motor
2. Hydraulic actuator
3. Air motor
4. Piston actuator

2-65. The MRG contains a total of how many (a) gearbox bearings and (b) line shaft bearings?

1. (a) 1 (b) 28
2. (a) 1 (b) 29
3. (a) 28 (b) 1
4. (a) 29 (b) 1

2-66. Which of the following GTE control modes are available on FFG-7 class ships?

1. OFF LINE, MANUAL, and MANUAL INITIATE
2. OFF LINE, MANUAL, and AUTOMATIC
3. MOTOR, MANUAL, and AUTOMATIC
4. MOTOR, MANUAL INITIATE, and AUTOMATIC

2-67. A normal stop on a GTE can be initiated by the PCC operator in either the programed control mode or the manual control mode.

1. True
2. False

2-68. The stator temperature meter on the EPCC is graduated in what type of degree measurement units?

1. Fahrenheit
2. Celsius
3. Centigrade
4. Rankine

2-69. With the governor mode in droop, within what specific percentage range of bus frequency will the generator frequency vary as the load changes?

1. 0% to 6%
2. 7% to 10%
3. 11% to 17%
4. 18% to 25%

2-70. An alarm will be indicated on the EPCC when the SSDG'S fuel service tank level drops below what specific percentage of tank capacity?

1. 25%
2. 20%
3. 30%
4. 40%

2-71. The ACC interfaces with the data processor in which of the following consoles?

1. SCC
2. DCC
3. EPCC
4. PCC

2-72. Detailed information on the casualty control procedures used in the CCS can be found in which of the following manuals?

1. EOP
2. EOCC
3. ECSS
4. PMS

ASSIGNMENT 3

Textbook Assignment: "Engineering Support Systems Maintenance," chapter 4, pages 4-1 through 4-11 and "Electrical and Electronic Systems Maintenance," chapter 5, pages 5-1 through 5-57.

3-1. On gas turbine-powered ships, the ships's fuel service system is operated and monitored-by which of the following systems?

1. ECSS
2. PCS
3. MCS
4. Each of the above

3-2. On the CG-47 class ships, the fuel service system's controls and indicators are located on which of the following consoles?

1. PLCC and PACC
2. PLCC and SCU
3. PCC and PACC
4. SCU and PACC

3-3. On the DD-963 class ships, what type of motors are provided for the fuel service system?

1. Single-phase, 120-V ac, 60-Hz, fan-cooled
2. Single-phase, 440-V ac, 60-Hz, fan-cooled
3. 3-phase, 120-V ac, 60-HZ, fan-cooled
4. 3-phase, 440-V ac, 60-Hz, fan-cooled

3-4. On the DDG-51 and FFG-7 class ships, the fuel pump motors drive the fuel pumps through what component or unit?

1. Reduction gear
2. Belt drive-unit
3. Fluid coupling
4. Hydraulic lock

3-5. Electric motor failure is frequently the result of which of the following hazards?

1. Dirt
2. Debris
3. Both 1 and 2 above
4. Electrical short circuits

3-6. What is the purpose of the torque limiter on a motor-operated fuel valve?

1. To prevent the reverse flow of fuel through the valve
2. To protect the motor and valve from overload damage
3. To protect the fuel pump motor controller from overload damage
4. To adjust the fuel pressure through the valve

3-7. On gas turbine-powered ships, the fuel filter/coalescers serve all of the following functions EXCEPT which one?

1. To filter out solids from the fuel
2. To coalesce the suspended water in the fuel
3. To remove suspended water from the fuel
4. To remove lube oil from the fuel

3-8. Electrical fuel service heaters are installed on all ships in which of the following classes of gas turbine-powered ships?

1. DDG-51
2. DDG-993
3. DD-963
4. FFG-7

3-9. On the DDG-51 class ships, how is the fuel heater outlet temperature regulated?

1. By a pilot-operated steam control valve
2. By a steam regulator valve
3. By a solid-state heater controller
4. By an electromechanical heater controller

3-10. On the DDG-51 class ships, which of the following components prevent the fuel heater from being energized until a fuel pump is running?

1. Mechanical interlock
2. Electrical interlock
3. Pneumatic interlock
4. Hydraulic interlock

3-11. On the FFG-7 class ships, which of the following systems is NOT a part of the ship's bleed air system?

1. Masker air system
2. Gas turbine anti-icing system
3. Bleed air collection and distribution system
4. Gas turbine start/motor air system

3-12. Prairie air is cooled and distributed to which of the following areas?

1. The trailing edges of the propeller blades
2. The leading edges of the propeller blades
3. The outer ring of the propeller hub
4. The inner ring of the propeller hub

3-13. On the FFG-7 class ships, the bleed air controls and indicators are located on which of the following consoles?

1. EPCC
2. ACC only
3. PCC only
4. ACC and PCC

3-14. On gas turbine-powered ships, most of the bleed air control valves are what type?

1. Pneumatic piston-actuated, butterfly-vane, solenoid-controlled shutoff valves
2. Pneumatic piston-actuated, solenoid-controlled gate valves
3. Electric-actuated, remote piston-operated, shutoff valves
4. Electric-operated, globe-type, solenoid-controlled shutoff valves

3-15. In what configuration are the GTE fuel shutdown valves (a) piped hydraulically and (b) operated electrically?

1. (a) Series (b) series
2. (a) Series (b) parallel
3. (a) Parallel (b) parallel
4. (a) Parallel (b) series

3-16. The GTE fuel shutdown valves may be independently operated from which of the following consoles?

1. PACC and PLCC
2. PACC and PCC
3. SCU and FSEE
4. PLCC and LOP

3-17. Which of the following components are a part of the main lubricating oil system?

1. Service pumps, unloader valve, and duplex filter only
2. Duplex strainer, sump, and cooler only
3. Duplex strainer, unloader valve, and service pumps only
4. Sump, service pump, cooler, duplex filter, unloader valve and piping

3-18. The lube oil service pump motors are two-speed motors designed for what type of duty?

1. Continuous operation
2. Intermittent operation
3. Emergency operation
4. Alternative operation

3-19. What type of waste heat boilers (WHBs) are found on the CG-47 class ships?

1. Forced-recirculation, steam-tube
2. Forced-recirculation, water-tube
3. Forced-recirculation, U-tube
4. Forced-recirculation, air-tube

3-20. With the WHB control panel in AUTO, the feedwater pump will shut down if the feed pump discharge pressure does NOT reach what specific value within 10 seconds after receiving the auto start command?

1. 100 psig
2. 200 psig
3. 300 psig
4. 400 psig

3-21. All of the following voltage levels are present in the WHB control panel EXCEPT which one?

1. 28 V dc
2. 115 v ac
3. 220 v ac
4. 440 V ac

3-22. Which of the following basic groups are a part of preventive maintenance?

1. Testing, adjusting, and routine maintenance
2. Cleaning, replacing, and reporting
3. Routine maintenance, reporting, and replacing
4. Reporting, repairing, and scheduling

3-23. Inspections and tests are different because you must use (a) which of the following resources for an inspection and (b) what additional resource(s) for a test?

1. (a) A technical manual
   (b) your human senses
2. (a) Your human senses
   (b) an instrument
3. (a) Your judgment
   (b) your human senses
4. (a) An instrument
   (b) a technical manual

3-24. Symptom recognition, malfunction location, and repair operations are part of what type of maintenance action?

1. Preventive
2. Corrective
3. Operative
4. Reconstructive

3-25. Which of the following operations are the weakest link of corrective maintenance?

1. Recognizing the symptoms
2. Repairing the faulty part
3. Locating the malfunction
4. Locating the cause of the malfunction

3-26. What is the first logical operation in troubleshooting?

1. Localize the malfunction
2. Perform failure analysis
3. Identify the symptom
4. Locate the cause of the malfunction

3-27. What are the two classifications of relays?

1. Control and power
2. Control and sensing
3. Power and sensing
4. Power and assisting

3-28. Which of the following symptoms is the most common cause of relay failure?

1. A short to ground
2. An open coil
3. A shorted coil
4. A grounded coil

3-29. Which of the following materials or tools should you use to clean the contacts of relays?

1. An emery cloth
2. Sandpaper
3. A burnishing tool
4. A steel file

3-30. A precision snap-action switch is best known to the GSE as a

1. push-button switch
2. double-pole, double-throw switch
3. maintaining master switch
4. microswitch

3-31. When replacing an original microswitch with a substitute microswitch, which of the following characteristics should the replacement have before you use it?

1. A voltage rating lower than that of the original microswitch
2. A current rating lower than that of the original microswitch
3. A fewer number of poles
4. The same number of breaks

3-32. In the MS connector (cannon plug) designator MS3106K, what does the letter "K" indicate?

1. The connector is used in pressurized conditions
2. The connector is environment resistant
3. The connector is fireproof
4. The connector is of solid construction

3-33. Which of the following classes of cannon plugs should be used in areas where vibrations are likely to occur?

1. Environment-resistant
2. Pressurized
3. Split-shell
4. Solid-shell

3-34. When installing or replacing wire or wire bundles, you should make sure the slack deflection produced by your exerting normal hand pressure on the cable does not exceed what specific amount?

1. 1 in.
2. 3/4 in.
3. 1/2 in.
4. 1/4 in.

3-35. When you are installing or replacing wire or wire bundles, the bends in the individual wires should be limited to a minimum bend radius of how many times the diameter of the bundles?

1. 5
2. 10
3. 12
4. 15

3-36. What procedure should you use to attach the wires to the back planes of the ECSS control consoles?

1. Crimping
2. Soldering
3. Clamping
4. Wire wrapping

3-37. To perform the wire wrapping procedure correctly, what type of wire should you use?

1. Multi-stranded, uninsulated
2. Solid-conductor, insulated
3. Multi-stranded, insulated
4. Solid-conductor, uninsulated

3-38. The number of turns of wire used on a pin during wire wrapping is based on which of the following factors?

1. Wire gauge
2. Wire length
3. Wire color
4. Number of strands in the wire

3-39. Which of the following conditions can constitute a disadvantage. to using wire wrapping?

1. It is a complicated technique
2. Repair times are slower
3. Both 1 and 2 above
4. The likelihood of wire breakage is increased

3-40. When a solenoid is de-energized, what holds the plunger away from the core?

1. Magnetism
2. Spring tension
3. Electrical current
4. A mechanical pin

3-41. If the energizing voltage to the solenoid is too low, all of the following conditions can occur EXCEPT which one?

1. The solenoid will operate slower than normal
2. The solenoid will chatter
3. The solenoid will fail to operate
4. The solenoid will operate faster than normal

3-42. What is the most common electromechanical device used in the Navy?

1. Motor–operated valve
2. Electrical controller
3. Manual bus transfer switch
4. Automatic bus transfer switch

3-43. When you are troubleshooting a motor and there are no visual signs of circuit failure, which of the following components should you check first?

1. Motor brushes and line voltage
2. Line voltage and line fuses
3. Line fuses and motor brushes
4. Terminal voltage and motor brushes

3-44. When starting a 3-phase motor, the motor fails to start and gives a load hum. What do these symptoms usually indicate?

1. There is no power available to the motor
2. Two of the motor phases are reversed
3. One of the motor phases is missing
4. The main contactor is open

3-45. Manual bus transfer units are normally used for loads having what type of protection features?

1. LVP
2. LVR
3. LVRE
4. LVRP

3-46. What are the two basic parts or groups of components of the electrohydraulic pitch control system on the DD–963 class ships?

1. CRP electronic enclosure and OD box-mounted components
2. CRP electronic enclosure and variable pitch propeller
3. Hydraulic oil power module and OD box-mounted components
4. Hydraulic oil power module and variable pitch propeller

3-47. On a DD–963 class ship, what is the function of the shaped potentiometer mounted on the OD box?

1. To provide the pitch feedback signal to the servo valve controller card
2. To provide the pitch feedback signal to the A/D converter card
3. To generate the pitch readout signal used for DDI display on the ECSS consoles
4. To position the mechanical positioner along a calibrated scale

3-48. Differences between the CRP system installed on the DD-963 class ships and the system installed on the CG-47 class ships are described in all of the following statements EXCEPT which one?

1. The CG–47 class system has only one OD box-mounted potentiometer, whereas the OD-963 system has two
2. The A/D converter card in the OD–963 class system has been replaced by a slew rate controller card on the CG–47 class system
3. The CG–47 system has a separate CPP electronics enclosure, whereas the Dd-963 system does not
4. The controller card in the CG-47 class system sends signals for both indication and control, whereas the DD-963 system uses more than one component for these functions

3-49. On the FFG-7 class ships, the CRP electronics is located in buckets in the local operating panel.

1. True
2. False

3-50. What type of electrohydraulic servo control valve is used on the DDG-51 class ships?

1. A 3-way valve with a normally open center position
2. A 3-way valve with a normally closed center position
3. A 4-way valve with a normally open center position
4. A 4-way valve with a normally closed center position

3-51. On the LCAC, the put-pose of the propeller pitch control system is correctly described by all of the following statements EXCEPT which one?

1. To allow the operator to control the speed of the craft
2. To allow the operator to control the direction of the craft
3. To allow the operator to use both forward and reverse functions
4. To allow the operator to control the cushion lift fan

3-52. On the LCAC with the propeller V PITCH switch in the ON position, pushing the yoke inward causes the blade pitch to

1. increase only
2. decrease only
3. decrease, then increase
4. disengage from the propeller pitch control system

3-53. If your ship is experiencing slow, erratic, or no pitch response to normal commands, which of the following components should you suspect?

1. The hydraulic oil power module
2. The servo motor
3. The electrohydraulic servo control valve
4. The feedback potentiometer

3-54. During a ship overhaul or yard period, which of the following precautions should you take to prevent the nonoperating motors and generators from becoming damaged from dust, dirt, and debris?

1. Remove them from the ship until the work is complete
2. Seal their ventilation openings to prevent the entry of dirt and debris
3. Apply a thick coat of grease to the ventilation openings
4. Remove the ventilation screens

3-55. When you are using compressed air to clean the inaccessible areas of a 45-horsepower motor, your air pressure should not exceed what maximum psi?

1. 15 psi
2. 20 psi
3. 25 psi
4. 30 psi

3-56. When using sandpaper to seat motor brushes, in what direction should you pull the sandpaper to correctly seat the brushes?

1. In the direction of the normal rotation of the motor
2. In the direction opposite to the normal rotation of the motor
3. In a back-and-forth direction
4. At right angles from the brushes

3-57. If no other part of the system is grounded, a single ground in any winding of a motor will cause no particular harm to the machine.

1. True
2. False

3-58. What type of switchboard is used on gas turbine-powered ships?

1. Open-front
2. Live-front
3. Dead-front
4. Closed-front

3-59. On a gas turbine-powered ship, a ship's service switchboard should be de-energized, inspected, and cleaned at which of the following times?

1. Monthly
2. Annually
3. During each overhaul
4. Both 2 and 3 above

3-60. Which of the following personnel must grant permission before personnel can begin work on energized electrical equipment?

1. Chief engineer
2. Main propulsion assistant
3. Commanding officer
4. Safety officer

3-61. What type of voltage regulator is found on the FFG-7 class ships?

1. Brushless ac exciter
2. Static exciter
3. Direct-acting, rheostatic
4. Indirect-acting, rheostatic

3-62. On the FFG-7 class ships, a total of how many level switches are installed in the water-wash tank?

1. One
2. Two
3. Three
4. Four

3-63. On the LCAC class ships, what is the purpose of the level switch in the water-wash system?

1. To illuminate the TANK EMPTY indicator on the local console
2. To illuminate the FULL indicator at the fill connection
3. To automatically start the water-wash pump
4. To automatically stop the water-wash pump

3-64. In a basic power supply, what is the function of the rectifier section?

1. To convert the ac signal from the transformer into a pulsating dc voltage
2. To convert the pulsating dc voltage into a filtered dc voltage
3. To maintain the power supply output voltage at a constant level
4. To step up the power supply input voltage

3-65. Which of the following pieces of equipment is normally used to perform pump logic calibration?

1. Oscilloscope
2. Multimeter
3. Gauge comparator
4. Auxiliary oil pump

3-66. On the DDG-993 class ships, all of the following tests should be performed daily on the FSCC EXCEPT which one?

1. Hazard alarm test
2. Fault alarm test
3. Lamp test
4. Service tank calibration test

3-67. On gas turbine-powered ships, which of the following console tests are normally performed by the console operator?

1. Audible alarm test and power supply voltage test
2. Audible alarm test and lamp test
3. Lamp test and power supply voltage test
4. Lamp test and computer memory test

3-68. For troubleshooting the control consoles, which of the following items is the most essential thing you can use?

1. An oscilloscope
2. The manufacturer's technical manual
3. The DVOM
4. A power supply test set

3-69. On the DDG-51 class ships, which of the following consoles provides the interface between the propulsion plant and the ship's DMS?

1. SCU
2. PACC
3. BCU
4. EPCC

3-70. The audible alarm test of the SCU checks which of the following circuits?

1. Siren and horn only
2. Siren, bell, and buzzer only
3. Siren, bell, and horn only
4. Siren, bell, horn, and buzzer

3-71. Dusty electronic components retain less heat and should be cleaned less often.

1. True
2. False

3-72. When applying the polyurethane coating to the reworked areas of a circuit card, you should take all of the following precautions EXCEPT which one?

1. Do not smoke or permit any type of open flame in the work area
2. Wear eye protectors while working with the material
3. Wash your hands and skin thoroughly after working with the material
4. Wear leather gloves while working with the material

3-73. When soldering integrated circuits, what maximum wattage soldering iron should you use?

1. 5 W
2. 18 W
3. 22 w
4. 25 W

ASSIGNMENT 4

Textbook Assignment: "Pressure, Temperature, and Level Control Devices," chapter 6, pages 6-1 through 6-14 and "LCAC and PHM Propulsion Systems," chapter 7, pages 7-1 through 7-41.

4-1. Which of the following functions are performed by pressure control devices?

1. Alarm generation
2. Starting motors
3. Cycling ventilation dampers
4. All of the above

4-2. A pressure switch converts

1. pressure energy into electrical energy
2. pressure energy into mechanical energy
3. electrical energy into pressure energy
4. mechanical energy into electrical energy

4-3. Pressure-operated switches are normally of what type?

1. Single-pole, double-throw, quick-acting
2. Double-pole, single-throw, quick-acting
3. Single-pole, single-throw, quick-acting
4. Double-pole, double-throw, quick-acting

4-4. A pressure switch is constantly energized even when the equipment is not actually running.

1. True
2. False

4-5. Pressure energy received by a pressure transducer is retransmitted in which of the following forms?

1. Mechanical energy
2. Pressure energy
3. Electrical current
4. Hydraulic pressure

4-6. A pressure transducer is capable of sensing all of the following types of pressures EXCEPT which one?

1. Differential
2. Absolute
3. Gauge
4. Barometric

4-7. How many different values must you check when you are calibrating a pressure transducer?

1. One
2. Two
3. Three
4. Four

4-8. When you are checking the low reading of a pressure transducer with a multimeter, what should the measurement be?

1. 4 millivolts
2. 4 milliamps
3. 10 millivolts
4. 10 milliamps

4-9. When setting the high value of a pressure transducer, which of the following components should you adjust to get the correct current output value?

1. ZERO ADJUST resistor
2. SPAN ADJUST resistor
3. Instrumentation valve
4. Balancing transistor

4-10. When installing a pressure transducer, the fitting on the pressure lines should be torqued to what value?

1. 135 to 150 inch-pounds
2. 115 to 130 inch-pounds
3. 70 to 110 inch-pounds
4. 40 to 60 inch-pounds

4-11. What is the primary function of a temperature switch?

1. To convert pressure energy into temperature energy
2. To convert temperature energy into pressure energy
3. To convert thermal energy into electrical energy
4. To convert electrical energy into thermal energy

4-12. What component inside the temperature switch provides the positive snap action when the contacts activate?

1. The return spring
2. The solenoid
3. The permanent magnet
4. The relay

4-13. Temperature switches are actually operated by changes in what medium?

1. Temperature
2. Pressure
3. Voltage
4. Resistance

4-14. Which of the following temperature calibrators should you use to calibrate a 400°F temperature switch?

1. King Nutronics 3604
2. King Nutronics 3605
3. King Nutronics 3640
4. King Nutronics 3650

4-15. Which of the following instruments can measure temperature by sensing radiation?

1. Temperature switch and radiation pyrometer
2. Radiation pyrometer and thermocouple
3. Thermocouple and temperature switch
4. Radiation pyrometer and resistance meter

4-16. Thermocouples found on gas turbine-powered ships are usually what type?

1. Platinum-platinum
2. Iron-constantan
3. Chromel-alumel
4. Copper-constantan

4-17. The thermocouples on most GTEs are connected in what configuration?

1. Series
2. Parallel
3. Wye-wye
4. Delta-delta

4-18. What is the purpose of the liquid-level detection devices installed in tanks?

1. To convert a liquid level into mechanical energy
2. To convert mechanical energy into electrical energy
3. To convert electrical energy into mechanical energy
4. To convert a liquid level into an electrical signal

4-19. Replacing a liquid-level sensor in a fuel tank is an easier procedure than replacing a bilge sensor.

1. True
2. False

4-20. The LCAC is powered by which of the following types of GTEs?

1. LM2500
2. AVCO TF40B
3. Allison 501-K34
4. Pratt Whitney 1500TB

4-21. On the LCAC, which of the following personnel is of the GS rating?

1. Craft engineer/assistant operator
2. Load master
3. Deck hand/engineer
4. Navigator

4-22. Rudder pedal movement on the LCAC is converted into an electrical signal that controls which of the following components?

1. Pneumatic position piston
2. Electric motor positioner
3. Hydraulic position actuator
4. Steam actuator positioner

4-23. Which of the following components of the LCAC steering control system controls and sends signals to various electrical components?

1. Rudder position drive assembly
2. Rudder channel selector
3. CSEP
4. Pedal control

4-24. Each propeller pitch control lever on the LCAC has a detent stop at what specific degree of pitch?

1. 0
2. +15
3. -30
4. +40

4-25. The LCAC lift fan control system consists of which of the following components?

1. Two single-entry centrifugal fans
2. Two double-entry centrifugal fans
3. Four single-entry centrifugal fans
4. Four double-entry centrifugal fans

4-26. On the LCAC, what maximum percentage of air produced by the lift fan control system goes to the (a) bow thrusters and (b) cushion?

1. (a) 60% (b) 40%
2. (d) 70% (b) 30%
3. (a) 30% (b) 70%
4. (d) 40% (b) 60%

4-27. In the engine control system on the LCAC, which of the following units is the power producer control unit?

1. N1
2. N2
3. N3
4. N4

4-28. The power turbine section of the TF40B GTE consists of what total number of stages?

1. Eight
2. Two
3. Six
4. Four

4-29. On the LCAC, the automatic shutdown, normal override switch inhibits all automatic shutdowns of the TF40B GTE EXCEPT which one?

1. Undertemperature
2. Overtemperature
3. Overspeed
4. Underspeed

4-30. What section of the C&C keyboard contains the switches that control the main engine coalescer drains?

1. FUEL/DEFUEL section
2. MISC section
3. APU FEED section
4. ENGINE FEED section

4-31. Which of the following categories is NOT a maintenance repair level for the LCAC?

1. Depot
2. Routine repair facility
3. Organizational
4. Specialized repair facility

4-32. The mission of the PHM is described in all of the following statements EXCEPT which one?

1. To screen amphibious forces in the arrival and departure area
2. To conduct surveillance
3. To operate offensively against hostile surface combatants
4. To provide low-speed, air-cushion transport capability

4-33. The PHM has what total number of complete but separate propulsion systems?

1. One
2. Two
3. Three
4. Four

4-34. Foilborne propulsion on the PHM is provided by which of the following components?

1. A single-stage water jet pump powered by a diesel engine
2. A single-stage water jet pump powered by a GTE
3. A 2-stage water jet pump powered by a diesel engine
4. A 2-stage water jet pump powered by a GTE

4-35. On a PHM operating at 100 percent power, the GTE delivers a maximum of (a) how much horsepower to the propeller assembly at (b) how many revolutions per minute input speed to the propulsor gearbox?

1. (a) 16,767 hp (b) 3,100 rpm
2. (a) 15,541 hp (b) 2,900 rpm
3. (a) 13,821 hp (b) 2,500 rpm
4. (a) 12,780 hp (b) 2,100 rpm

4-36. In the PHM, the gas turbine electronics that interface with the propulsion control system are contained in what component?

1. FSEE
2. EOP
3. BMEE
4. FBCP

4-37. Which of the following systems of the PHM provides automatic starting and stopping of the GTE and gearbox auxiliary lube oil pump?

1. FECS
2. FPCS
3. HECS
4. HPCS

4-38. The gearbox assembly in the power train subsystem of the PHM consists of what type of reduction gear?

1. Single helical
2. Double helical
3. Single herringbone
4. Double herringbone

4-39. What total number of thermocouples is located in the power train subsystem gearbox assembly of the PHM?

1. Eight
2. Two
3. Six
4. Four

4-40. In the PHM, the GTE is directly coupled to the propulsor through the gearbox with no disengagement capabilities.

1. True
2. False

4-41. The FBCS provides dynamic control of the PHM by sensing which of the following ship motions?

1. Vertical acceleration
2. Yaw rate
3. Roll
4. All of the above

4-42. What is the input power to the ACS power supply assembly of the PHM?

1. 115 v ac, 60 Hz
2. 115 V ac, 400 Hz
3. 450 v ac, 60 Hz
4. 450 V ac, 400 Hz

4-43. On the PHM, the GTE is located in what area?

1. AMR No. 1
2. MER No. 2
3. Gas turbine machinery room
4. Propulsion gear room

4-44. Each hullborne power plant on a PHM consists of which of the following components?

1. Diesel engine, propulsor assembly, and water brake
2. Diesel engine, water jet pump, and speed reduction gearbox
3. Diesel engine, water jet pump, and water brake
4. Diesel engine, speed reduction gearbox, and water brake

4-45. The hullborne power plants can propel the PHM up to what maximum speed?

1. 5 knots
2. 11 knots
3. 22 knots
4. 40 knots

4-46. The hullborne propulsion system of the PHM consists of a total of how many diesel engines?

1. One
2. Two
3. Three
4. Four

4-47. On the PHM, what is the purpose of the bow thruster?

1. To provide improved low-speed maneuverability
2. To assist in docking
3. Both 1 and 2 above
4. To provide lift power to the forward strut

4-48. On the PHM, basic control of the electrical generators is provided at what station?

1. EOS
2. CCS
3. EPCC
4. Pilothouse

4-49. Emergency electrical power on the PHM is provided by what source?

1. An emergency ac generator
2. Two diesel engine alternators
3. Three battery sets
4. Either 2 or 3 above, depending on the source selected

4-50. What type of compressor is used in the SSPUs on the PHM?

1. Single-stage, axial-flow
2. Two-stage, axial-flow
3. Single-stage, centrifugal-flow
4. Two-stage, centrifugal-flow

4-51. During the start of a SSPU, at what percentage of engine speed does the ignition system automatically de-energize?

1. 10%
2. 50%
3. 95%
4. 100%

4-52. When the power section of the PHM SSPU is operating at 100 percent, what is its maximum speed?

1. 39,476 rpm
2. 41,730 rpm
3. 45,822 rpm
4. 49,630 rpm

4-53. With the power section of the PHM SSPU operating at 100 percent speed, the load compressor is running at what specific speed?

1. 3,600 rpm
2. 4,500 rpm
3. 8,000 rpm
4. 12,800 rpm

4-54. On the PHM, the SSPU lubricating system is what type?

1. Full-pressure, wet-sump
2. Full-pressure, dry-sump
3. Forced-fed, dry-sump
4. Forced-fed, open-sump

4-55. In the PHM, what is the capacity of the oil sump for the SSPUs?

1. 8 quarts
2. 4 quarts
3. 8 gallons
4. 4 gallons

4-56. In the PHM, the tilter assemblies located on the side of the SSPU meter panel serve what function?

1. To smooth out the pulsating dc provided by the rectifier
2. To filter out alit-t and dust
3. To filter the feedback signal from SSPU
4. To filter the EMI generated by the exhaust gas temperature meter

4-57. Which of the following statements best describes the ac generators on the PHM?

1. Brushless, 250-KVA, 450-V ac, 400-Hz, 3-phase
2. Brushless, 250-KVA, 450-V ac, 60-Hz, 3-phase
3. Brushless, 250-KVA, 450-V ac, 400-Hz, single-phase
4. Brushless, 250-KVH. 450-V ac, 60-Hz, single-phase

4-58. Initial excitation of the ac generator on the PHM is provided by which of the following components?

1. An external PMA
2. A 3-phase alternator
3. An internal single-phase generator
4. An internal 3-phase generator

4-59. On the PHM, where is the GCU located?

1. Adjacent to each switchboard
2. Adjacent to each generator
3. Inside each switchboard
4. Inside each generator

4-60. The generators on the PHM can be operated in all of the following modes EXCEPT which one?

1. Individually
2. Series
3. Split-plant
4. Parallel

4-61. The shore power receptacles on the PHM are rated for the shore power electrical load for the ship plus what percent growth margin?

1. 10%
2. 20%
3. 30%
4. 40%

4-62. Before the shore power monitor will allow power to be applied to the PHM, all of the following conditions must be met EXCEPT which one?

1. AB, BC, or CA phase rotation
2. 410 V ac to 471 V ac
3. 365 Hz to 435 Hz
4. 57 Hz to 63 Hz

4-53. Which of the following statements best describes the motor generator of the mobile electric power unit used to provide shore power to the PHM?

1. Two-bearing, salient-pole, brushless
2. Two-bearing, squirrel-cage, brushless
3. Single-bearing, salient-pole. brushless
4. Single-bearing, squirrel-cage, brushless

4-64. The mobile electric power unit used to provide the PHM with shore power operates from what power source?

1. 450-V ac, 3-phase, 400-Hz
2. 450-V ac, 3-phase, 60-Hz
3. 480-V ac, 3-phase, 400-Hz
4. 480-V ac, 3-phase, 60-HZ

4-65. The PHM fuel system delivers what types of fuels to the diesels. GTEs, and SSPUs?

1. JP-5 and DFM
2. DFM and MOGAS
3. MOGAS and JP-5
4. Gasoline and MOGAS

4-66. The fuel purifier on the PHM can process a maximum of how many gallons of fuel per minute?

1. 15 gal/min
2. 25 gal/min
3. 35 gal/min
4. 45 gal/min

4-67. On the PHM, what is the primary source of compressed air?

1. A compressed air system air compressor
2. SSPU 2nd-stage bleed air
3. A high-pressure air compressor
4. LM2500 16th-stage bleed air

4-68. The primary source of compressed air is cooled to what temperature before it is used?

1. 86°F
2. 75°F
3. 60°F
4. 54°F

4-69. The seawater system on the PHM serves all of the following purposes EXCEPT which one?

1. Combating fires
2. Machinery cooling
3. Propulsor bearing lubricating
4. Turbine aft bearing cooling

4-70. On the PHM, the seawater system consists of a total of how many pumps?

1. One
2. Two
3. Three
4. Four

4-71. The maintenance repair levels for the PHM are organized into what three groups?

1. Organizational, training, and depot
2. Intermediate, training, and depot
3. Intermediate, training, and organizational
4. Organizational, intermediate, and depot

4-72. On the PHM, routine maintenance is categorized under which of the following maintenance levels?

1. Training
2. Organizational
3. Intermediate
4. Depot

4-73. What level of maintenance is conducted at sea by the PHM crew?

1. Training
2. Organizational
3. Intermediate
4. Depot

4-74. On the PHM, major modifications is categorized under which of the following maintenance levels?

1. Training
2. Organizational
3. Intermediate
4. Depot

4-75. Depot level maintenance is normally conducted at all of the following facilities EXCEPT which one?

1. Ship repair facility
2. Shipyard
3. Shipbuilder's facility
4. MLSG