NONRESIDENT
TRAINING
COURSE

February 1993

Gas Turbine Systems Technician (Mechanical) 2

NAVEDTRA 14115

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
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10 Aug 1999

ERRATA #1

Specific Instructions and Errata for
Training Manual (TRAMAN)

GAS TURBINE SYSTEMS TECHNICIAN (MECHANICAL) 2

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)
   c. Change *Blueprint Reading and Sketching,* NAVEDTRA 10077, to *Blueprint Reading and Sketching,* NAVEDTRA 12014.
   d. 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. Delete all references to "Patrol combat missile hydrofoils" and "PHM" throughout the TRAMAN.
   b. In all cases where "AEL Mk I/Mk II" appears, change to read "Free Water Detector (FWD)."
   c. In all cases where "AEL Mk III" appears, change to read "Contaminated Fuel Detector (CFD)."
   d. Page 2-8, at the end of the paragraph just before the heading "Flash Point Tester," add a new sentence to read "The combined features of the FWD and CFD are found in the combined contaminated fuel detector (CCFD)."
   e. Page 2-12, under the heading "Refueling Evolution," to the end of the first sentence add "if sediment is present."
   f. Page 2-12, under the heading "BS&W TEST," delete procedural steps 1- 8 following " two 100-milliliter (mL) centrifuge tubes, and a centrifuge. Replace with "Perform the BS&W test by following the procedures in NSTM Chapter 541."
   g. Page 2-13, under the heading "API Gravity Test," delete the last sentence of the second paragraph and replace with "Perform the API Gravity Test by following the procedures in NSTM Chapter 541." Delete all information in procedural steps 1-5.
   h. Page 2-13, under the heading "FLASH POINT TEST," delete the last sentence of the second paragraph to replace with "Perform the Flash Point Test by following the procedures in NSTM Chapter 541." Delete all information in procedural steps 1-8 up to "Water Contamination Test" on page 2-14.

i. Page 2-14, under the heading "Service Tank Replenishment," change the last sentence of the third paragraph to read "If the service tank remains idle for over 48 hours, perform a visual sample and recirculate the fuel if sediment or water is present." Under the heading "AEL Mk III" (which now is changed to Contaminated Fuel Detector (CFD)), after the sentence "All the equipment and parts you will need are stored in the unit," delete the remainder of the paragraph and all information in procedural steps 1-11 up to "With a little practice..." on page 2-15. Add "Perform the Contaminated Fuel Test by following the procedures in NSTM Chapter 541."

j. Page 2-16, under the heading "AEL Mk II" (which now is changed to "Free Water Detector," delete the last sentence of the first paragraph and add "Perform the Free Water Test by following the procedures in NSTM Chapter 541." Also delete all information in procedural steps 1-10.

k. Page 2-17, under heading "Testing," change the last sentence of the third paragraph to read "Perform the FSII test by following the procedures in NSTM Chapter 542." Also delete all information in procedural steps 1-11.

l. Page 2-19, under heading 'Thief Method," change last sentence of first paragraph to read "Perform a thief sample by following the procedures in NSTM Chapter 262." Also delete all information in procedural steps 1-6.

m. Page 2-20, under heading "Standards," change second paragraph to read "After the haze has settled out, invert the sample bottle and look for sediment or water particles. If you observe any particulate matter or water, your sample has failed the clear and bright criteria. Additional testing will be required to determine the suitability of the oil. The additional tests required depend on the type of oil and the equipment it lubricates."

n. Page 2-20, under the heading "BS&W Test" in the first paragraph, change the first sentence to read "You will perform the BS&W test on all 2000 series oils."

o. Page 2-21, under the heading "Mineral Oil Contamination Test," change the last sentence of the first paragraph to read "To perform the Mineral Oil Contamination Test, use the procedures in NSTM Chapter 234." Also delete all information in procedural steps 1-4.

p. Page 2-21, under the heading 'Oil Acidity Test," change the last sentence of the first paragraph to read "Perform the Oil Acidity Test by following the procedures in NSTM Chapter 233." Also delete all information in procedural steps 1-5.

q. Page 2-21, under the heading "Fuel Dilution and Oil Thickening Test," change the last sentence of the first paragraph to read "Perform the Fuel Dilution and Oil Thickening tests by following the procedures in NSTM Chapter 233." Also delete all information in procedural steps 1-6 and information up to the paragraph starting with "The standards of the test are logical..." on page 2-22.

r. Page 2-24, under the heading "STEAMING BOILERS" in item #6, change "1 hour" to "90 minutes."

s. Page 2-25, in Table 2-1 in the last row under the second column titled "Test Frequency," change "Within 2 hours after light off and daily thereafter" to 'Within 2 - 3 hours after light off and daily thereafter." In the last row under "Maximum Limit or Range," change "5 ppb" to "15 ppb." Also in the fifth row, "Distiller Air Ejector Drains," under the column titled "Test Frequency," change "As required*" to "Daily."

t. Pages 2-36 through 2-38, Figures 2-15, 2-16, and 2-17, add "Note: See NSTM Chapter 220, Volume 2, Section 27, for sample entries utilizing these forms."

u. Page 3-4, under the heading "Starter Air System" in the second paragraph, change the third sentence to read: "This valve is controllable at the PLCC or PACC and can provide either one of two functions :..."

v. Page 3-18, under the heading "Gas Turbine Control" in the third paragraph, change the second sentence to read: "When the operator depresses the ON push button, the signal is combined with the HIGH PRESS or BLEED indication signal in the input/output multiplexer hardware."

w. Page 3-23, under the heading "Fuel Oil Service System" in the third paragraph, change the first sentence to read: "The suction and return electric-operated valves are electrically connected so when the tank suction valve is opened, the return valve also opens."

x. Page 4-21, under the heading "Deaerating Feed Tank," change "within 2 hours after start-up and daily thereafter" to ‘within 2 - 3 hours after start-up and daily thereafter."

y. Page 6-1, change Chapter 6 title from "LCAC AND PHM PROPULSION SYSTEMS" to "LCAC PROPULSION SYSTEMS." Delete all references to "patrol combatant missile (hydrofoil)" and "PHM."

z. Page 6-7, under the heading "Air Bleed System," change combustor to compressor.

aa. Page 6-47, under the heading "SUMMARY," change the entire text to read:

"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 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.

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

bb. Page 7-1, under the heading "PRIME MOVERS," in the second paragraph, delete "The Garrett ME 831-800A GTE is installed on the PHM class ships."

cc. Page 7-9, under the heading "Hand Pump Assembly," rewrite the third paragraph to read ‘Now that we have discussed the important design differences in the Allison 501-K17 and K34 models, let's look at the Sunstrand T-62T-40-7 auxiliary power unit (APU) found on the LCACs. In chapter 6, you were given an overview of this prime mover. In the following section, we will present additional information that you, the GSM, should be aware of concerning this important engine."

dd. Pages 7-9 through 7-25, delete the entire text from the heading "GARRETT ME 831-800A" through and including "BLEEDAIR (DE-ICING) SYSTEM."

ee. Pages 7-9 through 7-22, delete Figures 7-5 through 7-22.

ff. Page 7-32, under the heading ‘Start Fuel Solenoid Valve," change "At 90 percent" to "At 65 percent."

gg. Page 7-47, under the heading "Water Washing," in the third paragraph, delete "For example, let's look at the differences between the water wash system installed on the Allison and the one installed on the Garrett."

hh. Page 7-47, change the heading "ALLISON AND GARRETT" to "ALLISON." Delete the existing paragraph test and replace with "The water wash system for the Allison is permanently piped, and the ship's low-pressure air system provides the required pressure."

ii. Page 7-48, under the heading "CUSTOMER BLEED AIR VALVE," in the first sentence, delete the word ‘Garrett."
jj. Page 7-49, delete the headings "Garrett" and associated paragraphs in both columns on the page.
kk. Page 7-49, under the heading "COMBUSTION LINER," delete "Garrett" from the text. Under the subheading "Sunstrand," delete ‘Like the Garrett" and "Also like the Garrett."
ll. Page 7-49, under heading "COMBUSTOR DRAIN VALVES" and under the subheading "Allison," delete "Garrett."
mm. Page 7-50, delete the word "Garrett" in all sentences or paragraphs on the page. Under the heading "Cables," delete the last sentence in paragraph. Under the heading "FUEL MANIFOLD DRAIN VALVES," delete the first sentence and delete the heading ‘Allison." Delete the heading "Garrett." and the sentence associated with the heading "Garrett."
nn. Page 7-56, delete the heading "PHM-Class Ships" and its associated paragraph.
oo. Page 7-56, under the heading "Lubricating Oil System," delete the following sentence: "On the PHM-class ships, the SSPUs use 23699 oil for lubrication."
pp. Page 7-59, under the heading "Cooling System," in the first paragraph, delete "and the SSPU found on the PHM-class ships."
qq. Page 7-61, under the heading ‘SUMMARY," delete "the Garrett found on the PHM-class ships."

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

a. Page AI-l, delete "BULKHEAD-MOUNTED ELECTRONICS ENCLOSURE (BMEE)" and its definition.
b. Page AI-3, delete "ENGINEER'S OPERATING STATION (EOS)" and its definition.
c. Page AI-E, in the definition for "WASTE HEAT BOILER (WHB), "delete "DDG-51."
d. Page AII-3, delete "PHM" and its definition.

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: general engineering administration; oil laboratory procedures and administration; engineering control system operation; engineering support and auxiliary equipment and systems; propulsion plant systems and drive train equipment; LCAC and PHM propulsion systems; and an overview of electric plants found aboard gas trubine-powered ships.

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.

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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
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Address: COMMANDING OFFICER
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For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
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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 8 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 (Mechanical) 2*

NAVEDTRA: 14115 **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 (Mechanical) (GSM) 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 GSM 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 GSM2, 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 IMAs. The QA program for COMNAVSURFLANT 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* essentialy 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 GSM 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 ship 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 GSM rating. A more detailed description and examples of the logs that are maintained by the oil lab will be discussed in chapter 2 of this TRAMAN.

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

This log is a locally prepared document that includes spaces for recording the results of all shipboard fuel tests. 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. Whenever test results exceed maximum parameters, the entries should include notations that corrective actions have been taken.

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.

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 1-1.

The manufacturer of the equipment starts the MGTESR. The MGTESR is later maintained by the activity having custody of the equipment. The

MARINE GAS TURBINE EQUIPMENT SERVICE RECORD

NAVSEA 9400/1(10-74)

NOMENCLATURE OF EQUIPMENT		
GAS GENERATOR		
MODEL	SER. NO.	AUTHORIZED OPERATING INTERVAL (IF APPLICABLE)
LM2500PB101	GGA-999	ON-CONDITION

SECURE HERE

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 1-1.—MGTESR Cover Sheet.

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
2. Marine Gas Turbine Engine (MGTE) Custody and Transfer Record
3. MGTE Operating Log
4. MGTE Inspection Record 5. MGTE Record of Rework
5. MGTE Technical Directives
6. MGTE Miscellaneous/History
7. MGTE Selected Component Record
8. MGTE Selected Component Record (SCR) Card
9. 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

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 1-2.—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

REMARKS COLUMN IS LEFT BLANK WHEN OPERATIONS ARE NORMAL.

HOURS, TENTHS, AND NO. STARTS COLUMNS ARE LEFT BLANK ON LINES ON WHICH SIGNIFICANT EVENT INFORMATION HAS BEEN ENTERED IN THE REMARKS COLUMN.

TOTAL NUMBER OF STARTS OCCURRING DURING A REPORTING INTERVAL IS LOGGED IN THE NO. STARTS COLUMN.

AFTER ACCEPTANCE OF SHIP BY NAVY, FREQUENCY OF ENTRIES IS OPTIONAL BY COMMAND, PER S9086-HC-STM-000/CH234.

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 1-3.—MGTE Operating Log.

MGTE INSPECTION RECORD

NAVSEA 9400/4(10-74) (FRONT) CHECK ONE: ( )Special ( )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 1-4.—MGTE Inspection Record.

Custody and Transfer Record is completed before the transfer. (See fig. 1-2.) 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 1-3. 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 transfer of an equipment item. The MGTE Inspection Record, shown in figure 1-4, 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 RECORD OF REWORK

(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-AR-MMO-020/LM2500	NAVAVNDEPOT NORIS	John Doe

DEPOT REPAIR MANUAL WITH APPROPRIATE SECTION CITED.

(Continue on Back)

Figure 1-5.—MGTE Record of Rework.

MGTE TECHNICAL DIRECTIVES

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.

THE AUTHORIZING SIGNATURE FOR TD RECORDS CONSOLIDATED DURING REWORK IS CONTAINED IN THE RECORD OF REWORK ENTRY.

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

(Continue on Back)

Figure 1-6.—MGTE Technical Directives.

MGTE MISCELLANEOUS/HISTORY

NAVSEA [illegible] (FRONT)

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

DATE	REMARKS
10/5/91	TS.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

(Continued on back)

Figure 1-7.—MGTE Miscellaneous/History.

MGTE Record of Rework.– The MGTE Record of Rework, shown in figure 1-5, 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. 1-6.) A separate form is used for each type of TD, and all applicable directives are recorded. Gas turbine TDs are issued as gas turbine bulletins (GTBs) or gas turbine changes (GTCs). All gas turbine TDs, including their revisions and amendments, should be recorded by number in this section of the MGTESR.

MGTE Miscellaneous/History.– The Miscellaneous/ History sheet, shown in figure 1-7, is used in the MGTESR to record pertinent information for which no other place has been provided. This information includes significant details that might be of 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

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		DATE	TOTAL EQUIP COUNT	TOTAL COUNT ON ITEM	
						SINCE NEW	SINCE REWORK			SINCE NEW	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 1-8.—MGTE Selected Component Record.

figure 1-8, maintains a current inventory and installation and 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 1-9, provides for the recording of installation and removal data, TD status, and repair/rework history on 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

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-EM01-1274

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 OF 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 1-9.—MGTE Selected Component Record Card.

MGTE TURBINE ROTOR DISC ASSEMBLY SERVICE RECORD

NAVSEA 9400/10(10-74) (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.

MGTE COMPRESSOR ROTOR ASSEMBLY SERVICE RECORD

NAVSEA 9400/11(10-74) (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	ASSEMBLY DATE 1/25/88: SERIAL NO.	TIME: DISC	TIME: BLADE	ASSEMBLY DATE 6/28/92: SERIAL NO.	TIME: DISC	TIME: BLADE	ASSEMBLY DATE: SERIAL NO.	TIME: DISC	TIME: BLADE	ASSEMBLY DATE: SERIAL NO.	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)	MPOJ3268	0.0	MPOJ3268	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. stal:

Figure 1-10.—Supplemental Record.

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. FRIGATE (FFG-1000) | TIME ZONE DESCRIPTION -14 Q | CLOCKS SET – BACK OR AHEAD HRS. MINUTES AT | LOCATION [X] AT SEA [ ] IN PORT | DATE 12/6/92

CHECK ONE [ ] PROPULSION [X] AUXILIARY ENGINE NO. 1 | * Preferred to 30" Barometer

TIME	TACHOMETER	GENERATOR ELECTRIC LOAD AMPS.	VOLTS	GENERATOR TEMPERATURE AIR TO CLR.	FWD. BRG.	AFT. BRG.	TEMPERATURES SALT WATER INJECTION	OVERBD.	FRESH WATER TO ENG.	FROM ENG.	TO OIL CLR.	LUBE OIL TO ENG.	FROM ENG.	HOTTEST CYLINDER NO.	TEMP.	SCAV. ENG-ING AIR	PRESSURES SEA WATER AT PUMP	FRESH WATER TO ENG.	LUBE OIL AT PUMP	AT ENG.	FUEL OIL TO FLT.	FROM FLT.	SCAV. ENG-ING AIR	BACK PRES-SURE (IN.)	VAC-UUM* (IN.)	CRANK-CASE MA-NOM-ETER (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
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2200																											
2300																											
2400																											

DISREGARD WHEN NOT REQUIRED

CLUTCH AND REDUCTION GEAR

TIME	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	–	–	–	–	–	–

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

0000-0400

2345 – Assumed the WATCH

0345 – Properly Relieved By A.B.Seaman

0400-0800

0345 – Assumed the WATCH

0745 – Properly Relieved By P.T. Boat

0800-1200

Figure 1-11.—Diesel Engine Operating Record—All Ships.

figure 1-10. 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 GSM2 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.

The Diesel Engine Operating Record, shown in figure 1-11, 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.

OPERATING DATA LOG SHEET

USS Destroyer (DD-1000) HPAC NO. 2 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	43	34	34	34	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	1050	1060	1060	1060	1060																		
4th STAGE h	5200 [b] 4200 [a]	4200	4200-4675*	5100	4500	4500	4500	4500	4500	4500																		
TEMP 1st STAGE-suct		49	84	122	83	83	83	83	83	82																		
(°F) 1st STAGE-disch	430 [a]		336	415	340	340	340	340	340	340																		
2nd STAGE-suct			122		120	120	120	120	120	120																		
2nd STAGE-disch	430 [a]		374	415	375	375	360	370	370	360																		
3rd STAGE-suct			119		110	130	130	130	130	125																		
3rd STAGE-disch	430 [a]		356	415	370	370	370	370	370	370																		
4th STAGE-suct			119		125	125	125	125	125	125																		
4th STAGE-disch	430 [a]		376	415	400	400	400	400	400	400																		
FINAL DISCH TEMP		115		125	120	120	118	118	118	119																		
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 PRGSS		25		175	120	150	130	130	140	150																		
CLG WTR INLET TEMP				95	80	80	80	80	80	80																		
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	13	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.-8 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, 13.8 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^2g AND RELIEF VALVE SETTING MAY BE DUE TO DESICCANT PLUGGING OF FILTERS.

Figure 1-12.—Compressor Operating Data Log Sheet.

AIR COMPRESSOR RECORDS.– A typical air compressor Operating Data Log Sheet is shown in figure 1-12. 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.

DISTILLING PLANT OPERATING RE-CORD.– 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

5. 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 1-13, is a guide for the continued analysis of operating conditions and operating results found in the equipment. Notice that

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 (NTR) of the refrigerated space (do not include comfort air-conditioned compartments).

DATE 10/2/92

MAKE	SIZE/MODEL	REFRIGERANT	APPLICATION	PLANT NO.	LOCATION
YORK	150T	R-114	Air Condition	1	AMR1

TIME	MACH. SPACE AMB. TEMP. °F	COMPRESSOR						CONDENSER (Water cooled)			LIQUID LINE			OPERATING TIME METER READING	INITIALS
		SUCTION		DISCHARGE		LUBRICATING OIL		WATER SUPPLY		DISCH.	TEMP. °F	CONDITION AT SIGHT FLOW INDICATOR	CONDITION AT MOISTURE INDICATOR		
		PRESS. PSIG	TEMP. °F	PRESS. PSIG	TEMP. °F	PRESS. PSIG	BULL'S-EYE LEVEL	PRESS. PSIG	TEMP. °F	TEMP. °F					
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		NTR	NTR	NTR	NTR	NTR	NTR	NTR	
0200	35	44	37	43		-	-	-	-	-	-	-	
0400	35	50	37	43		-	-	-	-	-	-	-	
0600													
0800													
1000													
1200													
1400													
1600													
1800													
2000													
2200													
2400													

GENERAL REMARKS

B. BACK

Figure 1-13.—Refrigeration/Air-Conditioning Equipment Operating Record.

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 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 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 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 GSM 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 GSM 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 may be 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 GSM, 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 be 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 GSM2, you will likely be assigned to maintain a variety of tiles. Most routine tiles 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.

REPORT SYMBOL OPNAV 4790-4

SEE INSTRUCTIONS ON BACK OF GREEN PAGE

FROM (SHIP NAME AND HULL NUMBER)	SERIAL # 2596-89
U.S.S. MIDWAY (CV-41)	DATE

TO

[XX] 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	CATEGORY B
[XX] MIP/MRC REPLACEMENT	[ ] 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	DIV. OFFICER
EX00	
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) ACTION COPY PAGE ____ OF ____
S/N 0107-LF-007-8000
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 correct 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 4790/78 (Back)

B. BACK

Figure 1-14.—PMS Feedback Report.

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 1-14. The front side, shown in view A, is used for 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 GSM 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.

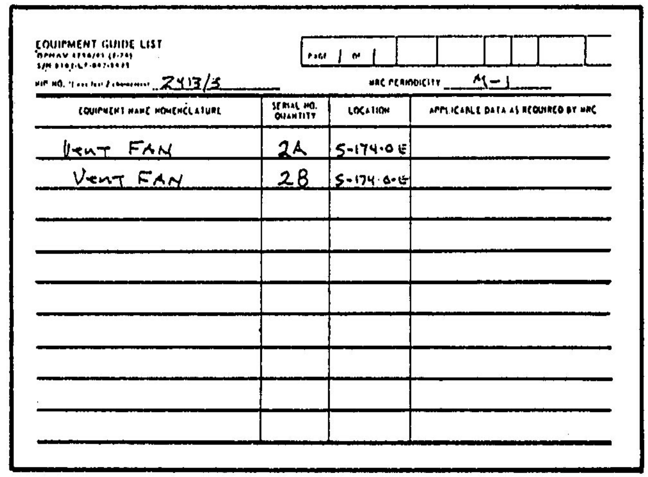

Figure 1-15.—Standard Equipment Guide List.

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 (fig. 1-15) that is used with a controlling MRC. 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. 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.

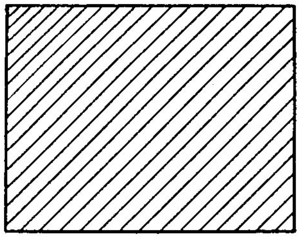

Figure 1-16.—Simplified all-purpose material symbol.

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 GSM must be able to read and understand various types of machine (equipment) and piping drawings and system diagrams. To read any machine or piping drawings or system diagrams, you must be familiar with the common terms and standard symbols used for these drawings and diagrams.

COMMON TERMS AND SYMBOLS

GSMs use drawings and diagrams in the installation, maintenance, and repair of shipboard equipment and systems. The following sections will provide a brief description of these common terms and symbols. For more detailed information, refer to *Blueprint Reading and Sketching,* NAVEDTRA 10077-F1.

Tolerances

Tolerances represent the total amount by which a specific dimension may vary. Tolerances may be shown on drawings by several different methods. The unilateral method is used when variations from the design size is permissible in one direction only. In the bilateral method, a dimension figure will show the plus or minus variation that is acceptable. In the limit dimensioning method, the maximum and minimum measurements are shown.

Fillets and Rounds

Fillets are concave metal corner (inside) surfaces. In casting, a fillet normally increases the strength of a metal corner. A rounded corner cools more evenly than a sharp corner, thereby reducing the chance of a break. Rounds or radii are edges or outside corners that are rounded to prevent chipping and to avoid sharp edges.

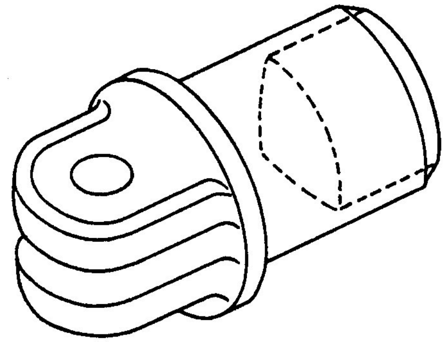

Figure 1-17.—Isometric drawing of a clevis.

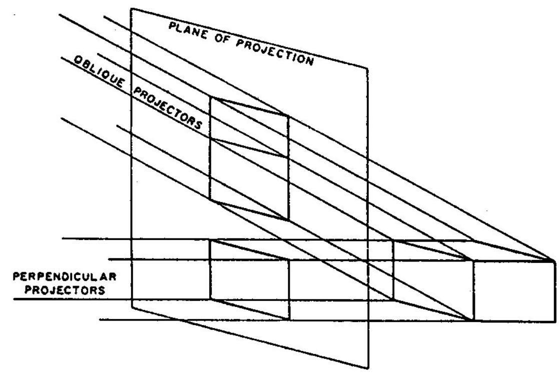

Figure 1-18.—Oblique and orthographic projections.

Slots and Slides

Slots and slides are for the mating of two specially shaped pieces of material. Though secured together, the pieces can still move or slide.

Casting

Casting refers to the process of making an object by pouring molten metal into a mold (normally of sand) of the desired shape and allowing it to cool.

Forging

Forging is a process of shaping metal while it is hot or pliable. The hammering or forging process is done either manually (blacksmith) or by machine.

Key

A key is a small wedge or rectangular piece of metal inserted in a slot or groove between a shaft and a hub to prevent slippage.

Keyseat

A keyseat is a slot or groove into which the key fits.

Keyway

A keyway is the slot or groove within a cylindrical tube or pipe into which a key fitted into a keyseat will slide.

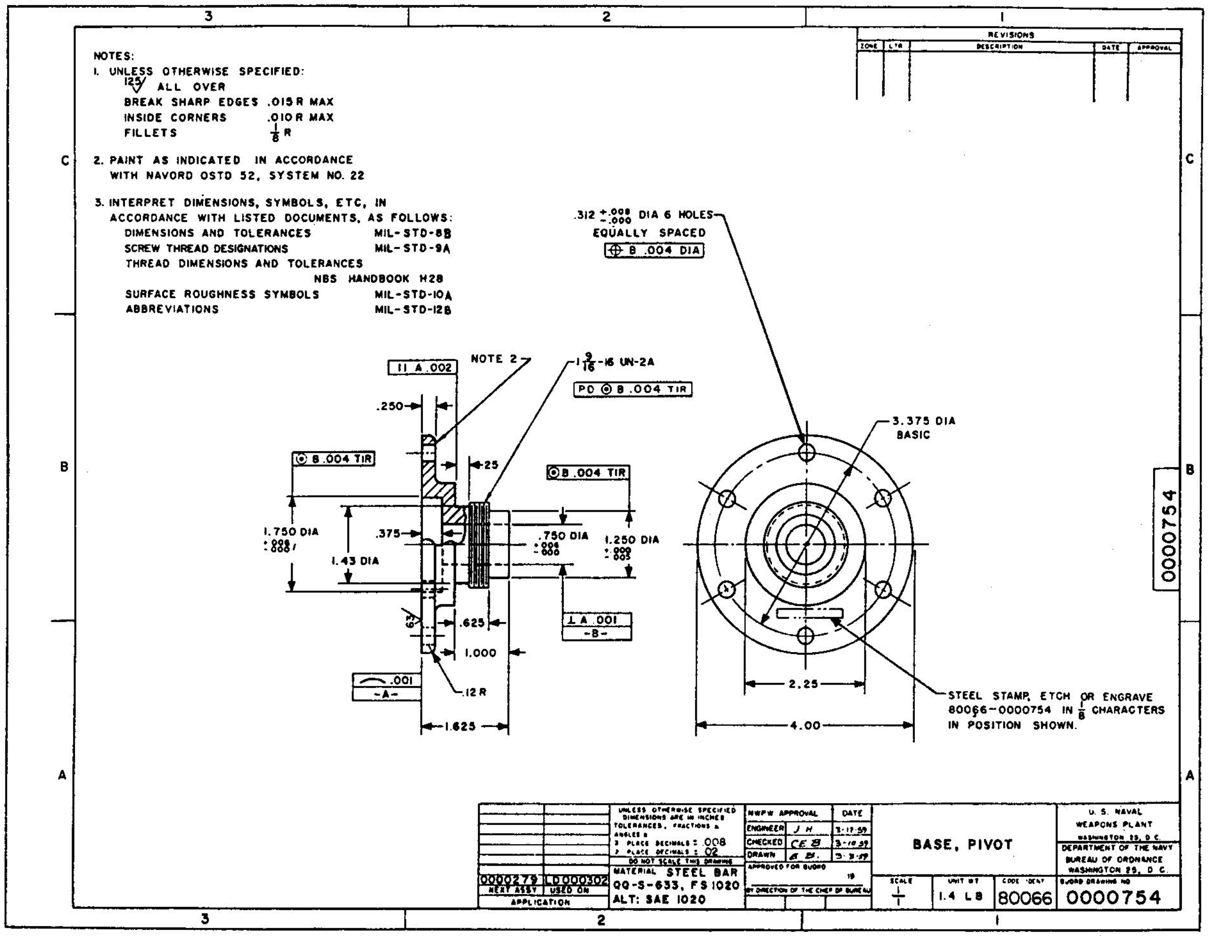

Figure 1.19.—Detail drawing of a base pivot.

Tempering

Tempering is the method for hardening steel by heating it and then suddenly cooling it by immersion in oil, water, or another coolant.

All-Purpose Material Symbol

An all-purpose material symbol is shown in figure 1-16. In drawings, this symbol represents materials of all types.

MACHINE DRAWINGS AND SYSTEM DIAGRAMS

Once you grasp a good understanding of the terms and symbols, drawings and diagrams will become less complex and easier to use. This section will provide descriptions and illustrations of the most commonly used drawings and diagrams.

Isometric Drawings

An example of an isometric drawing is shown in figure 1-17. An isometric drawing is a set of three or more views of an object that appears rotated. This gives the appearance of viewing the object from one corner. All lines are shown in their true length, but not all right angles are shown as such.

Oblique Drawings

A sample of an oblique drawing is shown in figure 1-18. Notice that an oblique drawing shows an object in three dimensions. It is a projection of an object's front and top surfaces, which shows the viewer the length, width, and height.

Orthographic Drawings

Figure 1-18 is also an example of an orthographic drawing. It is a drawing that provides a two-dimensional view; that is, it shows only the object's height and width.

Detail Drawings

Refer to the detail drawing shown in figure 1-19. A detail drawing is a print illustrating a single component or part. It shows a complete and exact description of the shape and dimensions of the part and how it is made (its construction).

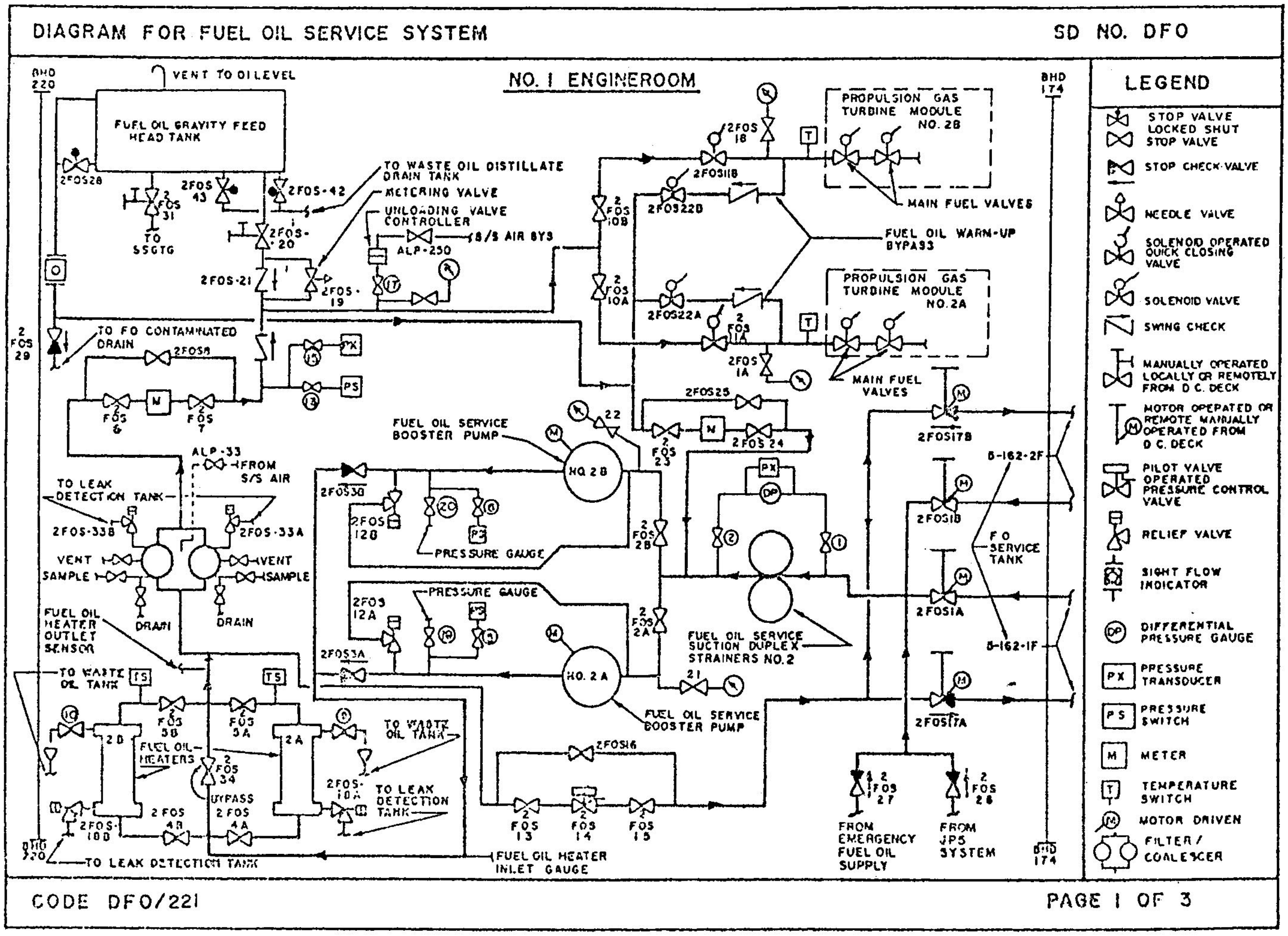

Figure 1-20.—Single-line diagram for fuel oil service system.

Single-Line Diagram

Figure 1-20 is an example of a single-line diagram. A single-line diagram uses lines and graphic symbols to simplify a complex circuit or system. Contained in the Engineering Operating Procedures (EOP) section of EOSS, these types of diagrams are the ones that you will use everyday. They will aid you as you are maintaining, repairing, or aligning shipboard systems.

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.

Figures 1-20 and 1-21 are examples of equipment layouts. On a gas turbine-powered ship, you will primarily find equipment layouts in the EOP and propulsion plant manuals (PPMs). The equipment layouts in the EOP are used mainly for training new personnel. The use of 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 GS.

This chapter described the Navy's QA program and how you, a work center supervisor, will become

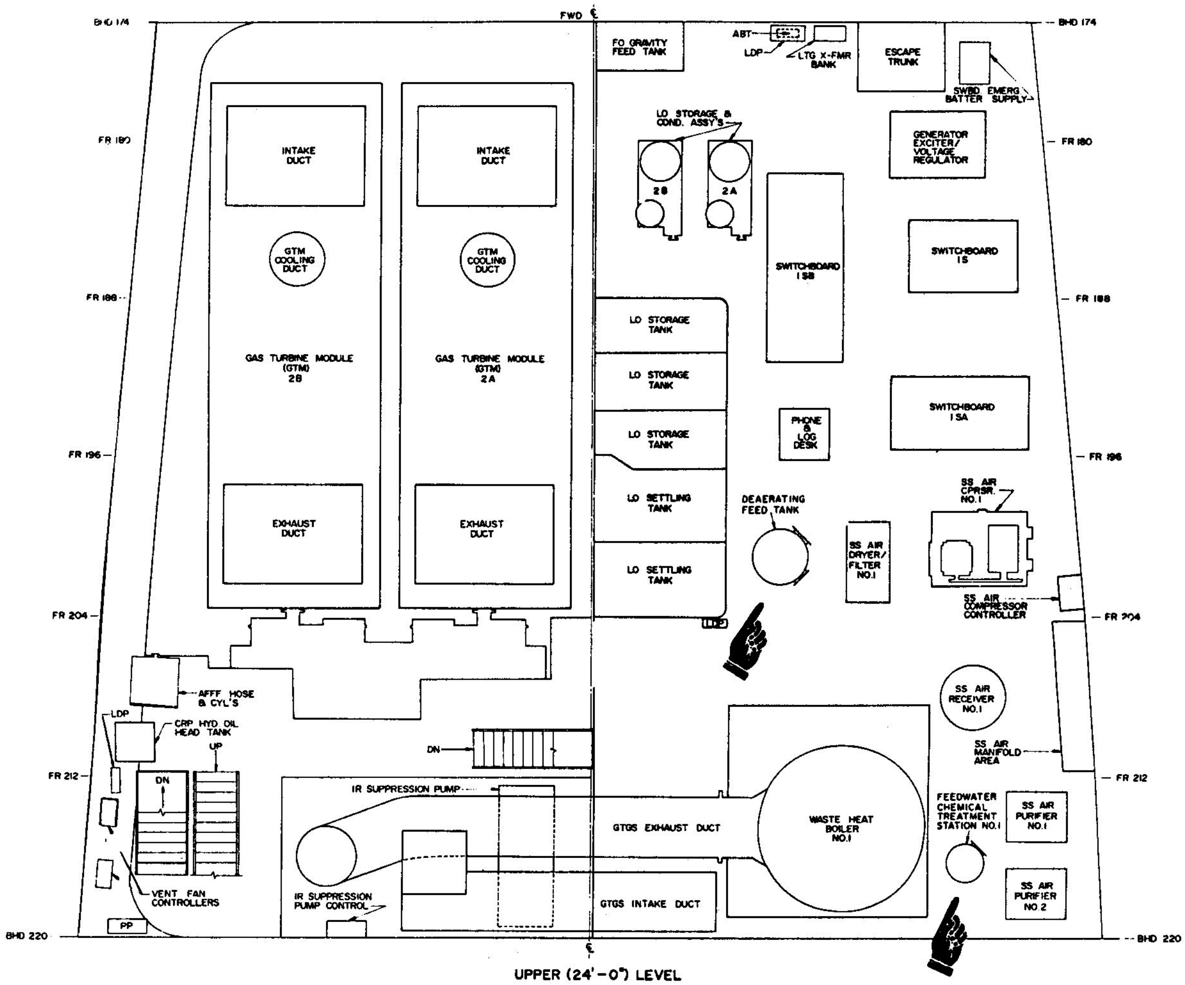

Figure 1-21.—Engine-room equipment layout.

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 GSM.

CHAPTER 2

OIL LABORATORY PROCEDURES AND ADMINISTRATION

In your career as a GSM, you may be assigned to your ship's oil laboratory. If you have already been assigned to the oil lab, you are likely aware of the significance of your role as a middle manager. In the oil lab, your most important job will be to maintain the quality of your ship's fuels, oils, and water supplies. The efficient operation of your ship's engineering equipment and systems directly depends on the quality of these products.

This chapter will discuss the safety precautions you will need to know whenever you are handling, testing, stowing, or disposing of hazardous fluids, chemicals and materials. It will also discuss the proper way to perform certain sampling and testing procedures, record the results, and review and maintain the logs related to the operations of the engineering plant and the oil laboratory. After studying the information in this chapter, you should have a good understanding of the inner workings of the oil laboratory and the important role it plays in the everyday operations of your ship.

SAFETY PRECAUTIONS

No matter where you are assigned, the responsibility for safety goes with you. As a GSM, you are already familiar with many of the job-related safety hazards you can face every day and the safety precautions you must observe.

Good safety habits are especially important when you are working in the oil laboratory. On a day to day basis, you may be required to handle, test, transfer, and dispose of the most hazardous and toxic liquids and materials on board your ship. No matter what you already know or where you are assigned, it is vitally important for you to understand and adopt good safety habits in your daily work routines and responsibilities.

The following sections will discuss some of the safety precautions you should take. These precautions are specifically related to the materials and equipment you will handle in your routine responsibilities in the oil lab.

HANDLING AND MONITORING HAZARDOUS MATERIALS

Fire and other potential disasters can occur whenever you must handle, test, transfer, stow, or dispose of hazardous solutions and materials. In the following sections, we will explain the specific safety precautions you must take whenever you are handling or monitoring the hazardous solutions and materials you will have to work with in the oil lab. Because they are the most dangerous materials on your ship, we will discuss petroleum products first.

Petroleum products

As you have been frequently reminded, a shipboard fire is the most dangerous mishap you and your shipmates can experience. You should consider all petroleum products to be potential fire hazards.

In your everyday work in the oil lab, you may be required to handle or monitor petroleum products. Most petroleum products fall into two basic categories: fuels and oils. Because they are the most dangerous petroleum products carried on your ship, we will discuss fuels first.

FUELS.– Fuels are the most dangerous products aboard ship not only because they ignite easily but also because your ship must stow them in such large quantities. To minimize these hazards, the fuels on your ship must meet applicable safety precautions for flammables. While assigned to the oil lab, you must be aware of these safety precautions for characteristics such as flash points, vapors, spontaneous ignition temperatures, wicking, and mist formation. In the following paragraphs, we will explain the required safety standards for each of these characteristics.

Flash Points.– The flash point of a fuel is the lowest temperature at which the fuel will give off sufficient vapor to form a flammable mixture with the air above the surface of the fuel in its liquid state. In other words, to be able to form a flammable vapor-air mixture, evaporation of the fuel must take place at or above its flash point. The required minimum flash point for naval distillates (F-76) and JP-5 (F-44) is 140°F (60°C).

Fuel Vapors.– Fuel vapors form when a liquid fuel undergoes the process of evaporation. When F-76 and JP-5 are mixed with air in certain proportions, flammable vapors result.

Fuel vapors are heavier than air. This is important for you to understand because fuel vapors will tend to collect in the lowest levels of your ship's compartments, such as the bilges. Fuel vapors can travel rapidly from compartment to compartment through existing openings. You may not be aware of these vapors until they ignite by an unsuspected source. Some sources that can cause fuel vapors to ignite are open flames, electric sparks, sparks produced from striking metals, heat from exposed hot piping, and smoking.

Spontaneous Ignition Temperatures.– The spontaneous ignition temperature (SIT) is also called the autoignition or autogenous ignition temperature (AIT). The SIT or AIT is the minimum temperature at which a fuel or fuel blend will ignite spontaneously in air without the aid of a spark or flame. The importance of the SIT or AIT is that it identifies the lower limit of fire hazard whenever you are handling fuels near hot surfaces. In other words, to conform with prescribed military standards and safety guidelines, you must not handle fuels in areas in which temperatures exceed the SIT or MT.

For both F-76 and JP-5 fuels, the SIT values can be as low as 450°F (232.2°C). For this reason, you should consider these two fuels to be equally hazardous. General specifications for the building of naval ships require that any surface that might exceed a temperature of 400°F (204.4°C) must be suitably insulated so that temperatures of the exposed surface will not exceed this critical level.

The procedure by which the SIT or AIT rating of a fuel is determined is very complex. To do your part in preventing fire hazards, you must respect and accept the established laboratory SIT values. In your oil lab duties, always consider the SIT value of any fuel you must handle and try to take every precaution to prevent the fuel from dripping onto a hot surface.

Wicking and Mist Formation.– Normally, fuels do not form flammable vapor-air mixtures at temperatures below their flash points. There are two exceptions to this rule: (1) wicking and (2) mist formation. Both of these conditions provide the means by which fuels can ignite even at temperatures below their flash points.

Wicking occurs when a fuel is drawn onto an absorbent solid material that can be ignited locally. When a flame is applied to a wick, a hot spot forms on the wick. The hot spot will continue to give off sufficient vapors to sustain the flame.

Candles and kerosene lamps are good examples of wicking. Rags soaked with fuels also make excellent wicks. For this reason, you should always consider fuel-soaked rags to be potential fire hazards.

Fuel mists can form when a rupture or small leak occurs in a pressurized fuel line. Fuel mist formation can also be caused by fuel vapor condensation that results from sudden cooling. Mists from fuel droplets mix with air, forming a flammable mixture. When exposed to an ignition source, these mists can ignite. Once ignited, the fuel mists will continue to bum because the fuel spray droplets entering the flame zone will continue to vaporize as long as they are exposed to the heat of the flame.

It is vitally important for you to understand the fuel characteristics we have just described and the prescribed safety guidelines and precautions you must use whenever you come in contact with these products. Remember, these characteristics are always present wherever fuels are handled, tested, stowed, transferred, or used aboard ship. They will always be dangerous sources of potential fire hazards.

OILS.– Even though oils have a much higher flash point than fuels, they are still dangerous if they are not properly handled. The potential for fire always exists, Like fuels, oils operate in some systems under high pressure. This is why strict attention must be paid to system integrity (prevention and control of leaks). The policy of no leaks in any system carrying flammable liquids is a good one. If oil should be forced out of a system in the form of a fine mist, the results could be disastrous.

Fire hazards are not the only danger associated with petroleum products. They can also be harmful to personnel by irritating the skin and eyes. Aboard ship, fuel and oil products are handled daily. To most people, the vapors from these products are irritating. To some people, physical contact with these products can cause severe skin disorders. This is why you must use protective clothing, such as rubber gloves, a face shield, and an apron whenever you handle these products.

Although the oil used in the gas turbines is not a petroleum-based product, you need to be aware of certain safety precautions. This oil is an synthetic ester-based product that can cause dermatitis after prolonged contact with the skin. If you come into contact with this oil, wash your skin thoroughly and remove any saturated clothing immediately.

Chemicals

Sampling and testing can be dangerous if you do not follow the procedures carefully, if your equipment is faulty, or if you carelessly handle or stow the testing chemicals. In the oil lab, you will use specific chemicals and chemical solutions for testing fuel, oil, and water samples. In the next sections, we will identify these chemicals and explain their associated safety precautions. Material safety data sheets (MSDSs) are available for all hazardous materials used by the Navy. You should review the MSDSs for each chemical before use. To be able to perform your fuel, oil, and water testing procedures correctly, you must know how to use these chemicals safely.

FUEL AND OIL TESTING.– There are only two chemicals you will normally use for fuel and oil testing. These chemicals are dry-cleaning solvent, better known as P-D-680 type II, and absolute methanol. You will use very small quantities of these chemicals in the oil lab. Since both chemicals are flammable, bulk quantities should be stowed in a flammable liquid store room.

WARNING

Take extra care when you are handling absolute methanol. It is irritating to the skin, respiratory tract, and eyes. It is moderately toxic by skin absorption and highly toxic to the central nervous system and optic nerve by ingestion. Always use absolute methanol in a well-ventilated area to avoid the accumulation of vapors.

WATER TREATMENT CHEMICALS.– Trisodium phosphate (TSP) and disodium phosphate (DSP) are the only two treatment chemicals authorized for use in waste heat boilers. You and all other oil lab personnel should take care when either one of these chemicals is used. In its concentrated form, TSP will cause burns to the skin, eyes, and body tissues. If you get TSPor its solution on your skin or in your eyes, flush the affected area with cold, potable water for 15 minutes and obtain medical attention.

For both TSP and DSP, the safety dispensing bottle must be clearly marked and used for these boiler treatment chemicals only. The type of dispensing bottle used for both TSP and DSP is made from linear polyethylene, a material that has a maximum use temperature of 176°F (80°C). As they dissolve, both TSP and DSP will generate heat. Do not use hot water to dissolve these chemicals in their dispensing bottles. The heat of the solution may exceed the maximum safe dispensing temperature.

When mixing TSP with feedwater, you can either add the TSP to the water or add the water to the TSP without difficulty. When you are using large quantities of DSP, however, you should add the DSP to the water because DSP tends to cake when water is poured over it.

Another water treatment chemical you may have to handle is Nalcool 2000. This corrosion and rust inhibitor is used in the jacket water systems of SSDGs, and it is very hazardous.

Nalcool 2000 is hazardous because it contains strong alkalies. Do not mix alkalies directly with acids because the heat generated may cause the chemicals to spatter. If alkalies come into contact with your skin, flush the affected area with cold, potable water until the slippery feeling disappears. If the burning or itching sensation persists, seek medical attention. If alkalies come into contact with your eyes, flush with cold, potable water for 15 minutes at an eyewash station and seek immediate medical attention.

WATER TEST CHEMICALS.– During feedwater and boiler water testing, you will come in contact with several chemicals that require special handling and disposal. If they are not properly handled, these chemicals are hazardous both to personnel and to the environment.

Most of these chemicals come in concentrated form (stock solutions) and contain either caustic soda, nitric acid, or mercuric nitrate. These chemicals can cause burns to the skin and eyes and can be fatal if they are ingested. To protect yourself, always wear goggles or a face shield and either plastic or rubber gloves whenever you are handling these solutions.

Now that we have discussed some of the potential hazards you should be aware of when you are handling or stowing the materials and solutions you will be using or testing in the oil lab, let's talk about the methods you should use to dispose of these and other hazardous products safely.

Hazardous Wastes

The discharge of oils or oily wastes into our aquatic environment is a serious worldwide pollution concern. These discharges (effluents) can cause significant and long-lasting effects on marine life and the quality of shoreside beaches. Oily discharges can also be a potential hazard for fires and explosions. Because of these concerns, U.S. Navy vessels must comply with existing federal, state, local, national, and international laws.

LAWS.– U.S. Public Law 96-478, Act to Prevent Pollution from Ships, replaced the Oil Pollution Control Act and implements the International Convention for the Prevention of Pollution from Ships and the Clean Water Act. Without impairing DOD operational capabilities, U.S. Navy ships must comply with the following basic standards of these laws and with the applicable Status of Forces Agreement (SOFA) and OPNAVINST 5090.1A:

1. If operating in navigable waters of the United States or within 50 nm from the U.S. coastline, your ship is prohibited from discharging oil in quantities that will cause a sheen or discoloration on the surface of the water or deposits of sludge or emulsion beneath the surface or on the adjoining shorelines. This means that all oily discharges must be less than 10 ppm of effluent within 12 nm of shore and less than 100 ppm beyond the 12 nm limit. Basically, this means your ship is prohibited from directly discharging any oily bilge water at sea before processing it through an effective oil-water separator (OWS).

2. If your ship is operating in coastal waters or territorial seas up to 12 nm from the shoreline of a foreign country, you must abide by the oily waste discharge regulations of the applicable SOFA. In the Mediterranean Sea, for example, your ship is restricted to an effluent discharge rate of less than 15 ppm. If no SOFA exists, your ship must operate according to the standards of the host country's military forces until a satisfactory agreement with the host country can be reached. Unless otherwise provided by a SOFA, U.S. Navy vessels operating temporarily within a foreign jurisdiction are subject to that country's standards to the extent specified by the clearance for a visit. If no standards exist, your ship is prohibited from discharging unprocessed oily wastes within 50 nm from land. Ships that are not equipped with OWS units must retain all oily wastes for proper disposal at a shore reception facility.

EQUIPMENT.– Because of the severity of the oil pollution problem, the Navy is giving high-level attention to the prevention of oily discharges from its ships and crafts. Special equipment for monitoring and controlling shipboard effluents is currently being installed throughout the fleet. To operate this equipment effectively and comply with the laws and regulations, consult OPNAVINST 5090.1A, Environmental and Natural Resources Protection Manual, and *Naval Ships' Techical Manual (NSTM),* chapter 593, "Pollution Control." As a GSM, you should be aware of the following oil pollution abatement equipment/systems that are scheduled for installation on U.S. Navy vessels:

1. Oil-water separators, oil content monitors, oily waste holding tanks, and waste/used oil tanks that will allow the ship to separate and collect shipboard waste oil and to process oily wastes before discharging them

2. Bilge pumps (oily waste transfer pumps), piping risers, and weather-deck connections that will allow safe and convenient ship-to-shore transfer of oily wastes

3. Two and one-half inch cam-lock discharge connections (MS27023-14) for oily waste discharge that will allow for rapid connect/disconnect functions with shoreside offloading hoses

4. Oily waste discharge adapters to accommodate hoses with international-standard flanges when Navy vessels visit foreign and non-Navy ports

5. Mechanical seals on shipboard pumps to minimize the quantity of oily waste water collected in the bilges

6. Improved tank level indicators to reduce overboard spills during fueling and oily waste handling and transfer operations

7. Contaminated fuel settling tanks to receive and assist reclamation of fuel tank strippings which might otherwise be discharged overboard

PROCEDURES.– For detailed procedural instructions concerning shipboard oil pollution abatement, you should consult *NSTM,* chapter 593, "Pollution Control." In the following sections, we will discuss some of the highlights of these procedures and other important information that you, as a GSM, should be aware of when your ship must dispose of bilge water and oily wastes, waste/used oils, and waste water test chemicals.

Bilge Water and Oily Wastes.– You should be aware of the procedures your ship will need to use for the careful disposal of bilge water and oily wastes. As a GSM in the oil lab, you can use the information in the following list as a guideline.

1. Your ship must reduce oil contamination of its bilge water to a minimum. Use of carefully maintained mechanical seals in oil and water pumps and the proper segregation of oily and nonoily waste water will help your ship reduce generation of oily wastes. Your ship's efforts to segregate bilge water from oil are important steps in pollution control.

2. Your ship should minimize use of any bilge cleaners or chemical agents, such as detergents and surfactants, that will promote chemical emulsion. This step will enable the OWS units to work more effectively.

3. In port, your ship should off-load oily wastes to a shore receiving facility. The use of shoreside donuts (oil disposal rafts) is being phased out. Ships will be charged an analysis fee for a laboratory analysis of contaminated bilge water.

4. In port, your ship can use any of the following methods to dispose of oily bilge water:

a. Oil-water separator (OWS) system–Your ship should use its OWS system unless state standards or local port authorities prohibit its use. This is one of the most important steps in pollution control.

b. Oil-ship waste offload barges (O-SWOBs)–Ships that are not equipped with bilge OWS systems should use the O-SWOB system for treating and collecting oils and oily wastes.

c. Permanent shore reception facilities–Where adequate oily waste collection lines are provided, your ship may pump oily bilge wastes directly ashore.

5. Your ship may be equipped with oily waste holding (OWH) tanks instead of an OWS system. In this case, your ship must direct all shipboard oily wastes to the OWH tanks. In the tanks, the oil will be separated from the water. This step will allow your ship to recover and transfer ashore valuable reusable waste oil and reduce pollution. Ensure this OWH tank is never contaminated with synthetic oils.

6. In normal operations, your ship must not use eductors to dewater bilges containing oily wastes. In emergencies when the OWS or OWH system cannot handle flow requirements, your ship is permitted to use eductors. In these cases, your ship must be underway, should try to be at least 12 nm from land, and should have the proper notations entered into the engineering logs.

Waste/Used Oil.– Before your ship departs from port or after it returns, you and other shipboard personnel must make every effort to use the available port facilities to dispose of waste/used oil products. These facilities include O-SWOBs, pier-side collection tanks, tank trucks, bowers, and contaminated fuel barges.

In the case of used lube oils, your ship must collect these products separately, store them, and label them for eventual shore recycling. Your ship must not discharge these products into the bilge or into the OWH or waste oil tanks.

In the case of synthetic lube oils and hydraulic oils, your ship must also collect these products separately from other used/waste oils. If your ship does not have a system dedicated to collection of synthetic oils, you must use 5- or 55-gallon steel containers, properly labeled, for eventual shore recycling. All personnel who must handle synthetic oils must wear protective clothing, such as impermeable gloves, coveralls, and goggles.

Your ship will receive all oil products in the original packaging or containers, such as drums or cans. Your ship should retain these containers and keep them properly labeled for storing used oil products and transferring them ashore.

Waste Water Test Chemicals.– You must place the waste from each chemical product in the original or in its own properly marked container. Never pour these products into shipboard drains. For example, you must store bottles containing mercury wastes (mercuric nitrate) on board until you can turn them over for disposal to the public works officer or public works center at a naval installation (base or shipyard) or an industrial facility.

Whenever you are handling the flammable or hazardous materials we have just described, always follow the prescribed safety guidelines. Now, let's take a look at some of the safety guidelines you should follow when you are operating and monitoring laboratory test equipment.

OPERATING AND MONITORING LABORATORY TEST EQUIPMENT

While assigned to the oil lab, you will be required to use a variety of sampling and testing equipment items. In the following paragraphs, we will briefly describe this equipment and the precautions you should take to operate, monitor, and maintain these items safely.

All the equipment we will describe must use some sort of electrical power device to obtain the power to operate. As with all types of electrical equipment, you should periodically check the casing of the equipment and the power cords for damage. Remember to keep countertops and decks free of liquids whenever you are operating this equipment. If you have an electrical problem or you realize that electrical safety checks need to be performed, always make sure the electricians are promptly informed.

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Figure 2-1.—Centrifuge.

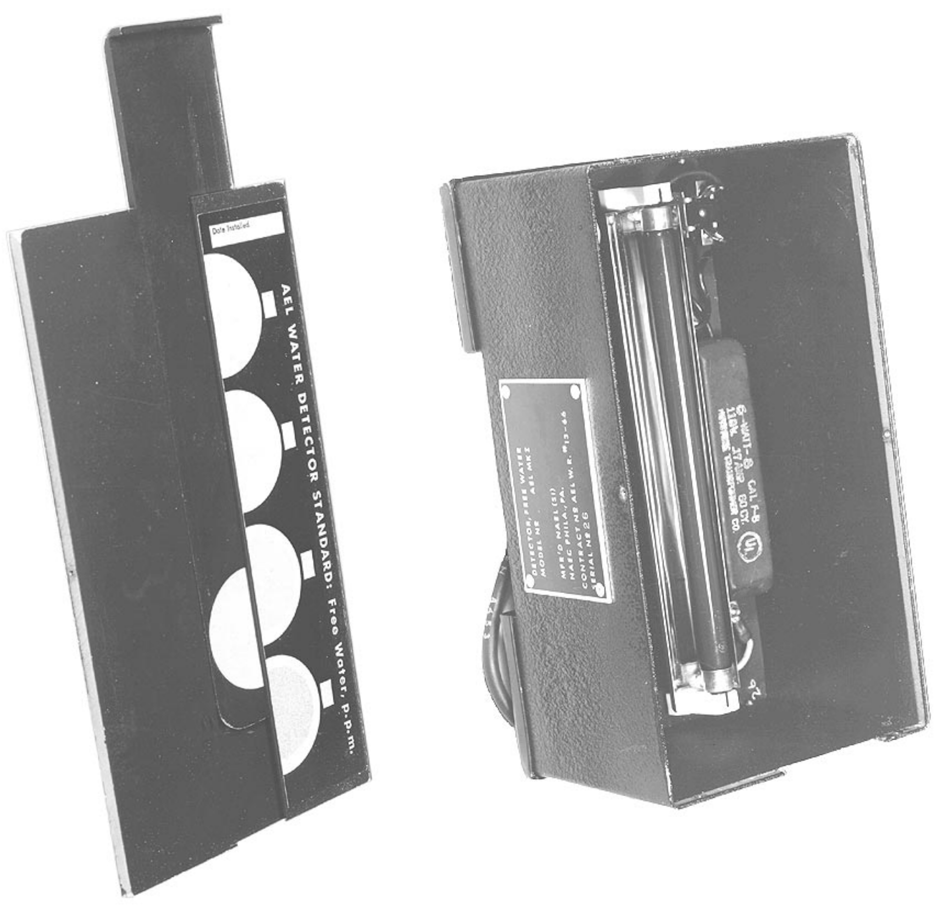

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Figure 2-2.—Free water detector (AEL Mk I/Mk II)

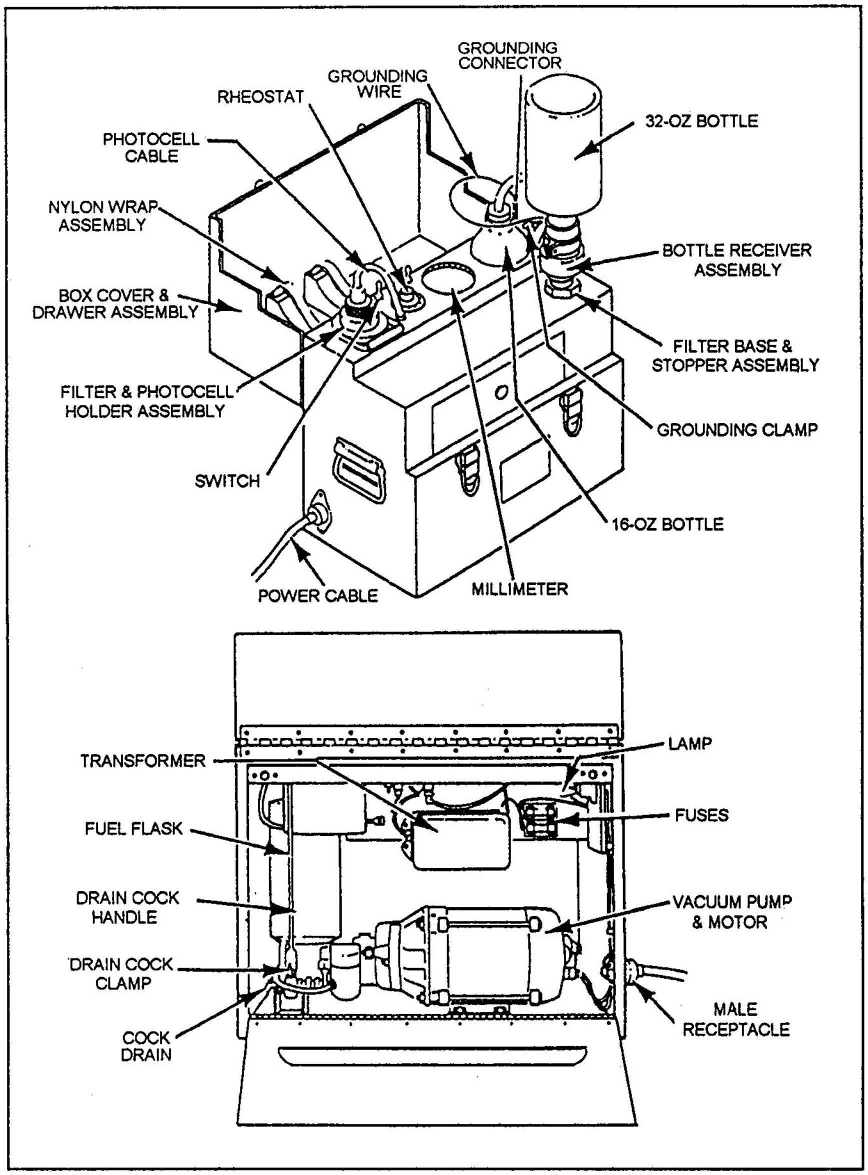

Figure 2-3.—Contaminated fuel detector (AEL Mk III).

Centrifuge

You will use a centrifuge to test fuels and lubricating oils for bottom sediment and water (BS&W). The centrifuge you use must be capable of holding at least two 100-milliliter pear-shaped tubes. The type of centrifuge you will likely use is shown in figure 2-1. It is capable of holding four tubes at one time. It also has an adjustable speed control rheostat, which will allow you to raise and maintain the rotational speed between 1,400 to 1,500 rpm.

To operate this unit safely, remember it is a rotating piece of equipment. Always keep your hands and all objects away from the unit while it is operating. Never open the unit while it is operating. Before you operate the centrifuge, always make certain the tubes are free from cracks and they are properly capped. Also, make sure the unit is sitting on a level surface and the tubes are equally spaced to maintain proper balance.

AEL Mk I/Mk II

The AEL Mk I/Mk II free water detector is shown in figure 2-2. You will use this instrument to measure the amounts of free or mechanically suspended water in diesel fuels, naval distillate, and JP-5. To operate the unit safely, follow the precautions mentioned earlier for the safe operation of electrically powered equipment.

AEL Mk III

The AEL Mk III contaminated fuel detector is shown in figure 2-3. It is the most extensively used unit

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Figure 2-4.—Flash point tester.

for fuel testing. Like the AEL Mk I/AEL Mk II, you will use the AEL Mk III to test diesel fuel, naval distillates, and JP-5. If this unit is not operational, you will not be able to determine the quantity of solid contaminates or free water content in the fuel. The reason for this is the AEL Mk I/Mk II requires the fuel to be drawn through its detector pad by the AEL Mk III pump.

Although it is portable, the AEL Mk III should be mounted in a permanent location so it will stay within its proper calibration requirements. Every time this unit is moved, it must be recalibrated. It should only be moved if it is being replaced or repaired.

The primary safety factor you must consider is to make sure the grounding probe is in good working condition and that you, and other oil lab personnel, use it properly. You must use the grounding probe to ground the metal filter holder to the unit case. The grounding function transfers the static electric charge that is created as the fuel is drawn from the plastic bottle through the filter holder.

Flash Point Tester

The flash point tester shown in figure 2-4 is the only type of flash point tester that is authorized for shipboard use. It is classified as a closed-cup tester because the liquid being tested is heated by an electric element and not an open flame.

You will use this tester to determine the flash point of a specific petroleum product. Before you use it, however, always thoroughly clean and dry all parts of the cup and its accessories. Be sure to remove any solvent that was used to clean the equipment. These steps will help you make certain the solvent will not contaminate the fuel or come in contact with the heating element.

Figure 2-5.—Boiler water testing cabinet (inside view).

As shown in figure 2-4, bottled propane is used with the tester to supply gas to the test flame. When the tester is not in use, you should make certain the propane bottle is properly stowed. Because the thermometer in the unit contains mercury, it must be audited by the hazardous materials officer (usually the supply officer). Use and store this thermometer carefully to avoid breaking it. If it should break be sure to contact your ship's hazardous materials spill team.

Boiler Water Testing Cabinet

A typical boiler water testing cabinet is shown in figure 2-5. This portable, steel cabinet contains the primary equipment and chemicals you will need to perform approximately 90 percent of all water chemistry testing. It is equipped with an internal light and a door that can be locked for safety purposes. Although the cabinet is portable, for shipboard use it is normally bolted to the workbench.

Conductivity Meter

With the removal of carbon steel steam-generating tubes and the installation of stainless-steel ones, the WHB water chemistry testing program has undergone several changes over the years. One of these changes was the deletion of pH level testing and the start of conductivity testing. To implement this change, U.S. Navy ships have been equipped with conductivity meters. There are two types of conductivity meters currently in use. The older meter requires a warm-up

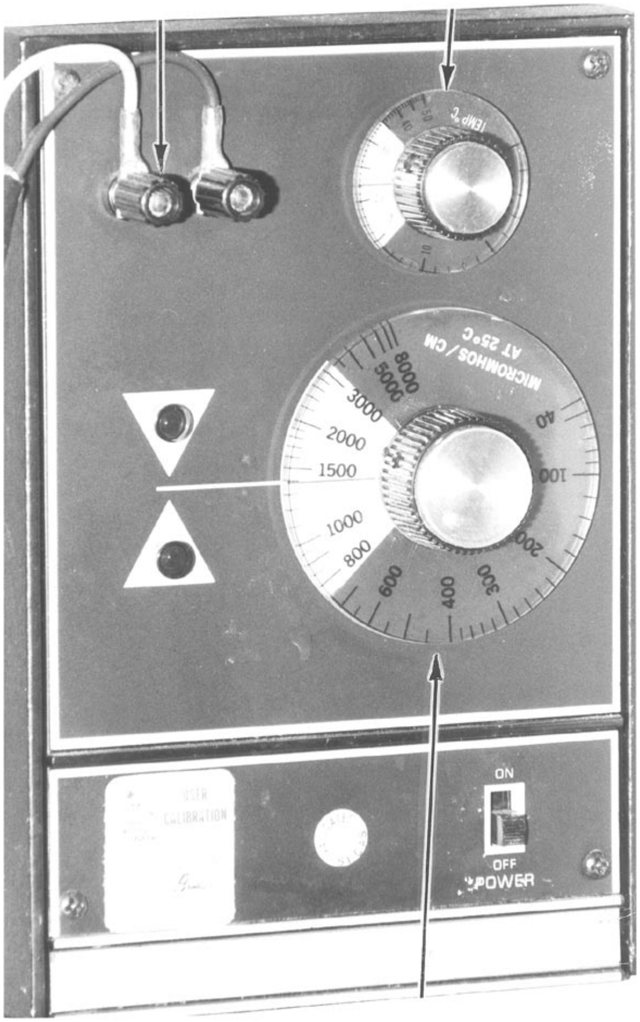


Figure 2-6.—Conductivity meter.

period. The newer meter does not require a warm-up period. The newer model is shown in figure 2-6.

SAMPLING AND TESTING FUELS, OILS, AND WATER

Fuels, oils, and water are essential products for the operation of your ship. Your most important concern will be maintaining the quality of these products. By using the proper sampling and testing procedures, you will play an important role in keeping your ship's engineering equipment and systems in top operating condition. In the preceding section, we have focused on the safety precautions you must use. In this section, we will discuss the basic procedures you should follow to sample, test, and analyze the quality of your ship's fuels, oils, and water supplies.

Sampling and testing are two separate processes, each with its own set of required tasks for a particular product. For this reason, we will discuss each of these processes in terms of the basic tasks involved for each product. Just as with any other set of procedures or tasks, you should never rely solely on your memory. Every task we will discuss has a specific written procedure in either the EOSS, the PMS, or an *NSTM*. You should always use the specific procedures and guidelines authorized for your ship. In the following sections, we will briefly describe some of the most important tasks and procedures. We will also point out some common mistakes. Understanding this information and remembering the safety precautions you have just read should help you become a more proficient and productive engineer.

FUELS

Sampling and testing are continuous tasks that allow you to make certain your ship receives the best quality fuel and that contamination levels remain within the acceptable specified military standards. Fuel contamination can originate from a variety of sources. Fuel tanks can be contaminated by rust particles. Rust particles can be caused by moisture from air vents, condensation on tank surfaces, and the settling of solids and residues picked up during fuel transfers. Consequently, you may have to perform some type of sampling or testing procedure each time your ship prepares to receive, move, stow, or use fuel products. In the following paragraphs, we will discuss some of the methods you will use to sample fuels. We will begin our discussion with F-76 (naval distillate) because you will need to sample this fuel frequently.

F-76 (NAVAL DISTILLATE)

You will sample F-76 (naval distillate) more than any other fuel product. The information in the following paragraphs will introduce you to some of the more commonly used methods, equipment, sampling locations, and standards for naval distillate.

Sampling

Simply stated, sampling is a visual inspection. It is the first, simplest, and most frequent procedure you will perform on fuels. A fuel sample is a small part or quantity of fuel that is drawn for visual or laboratory

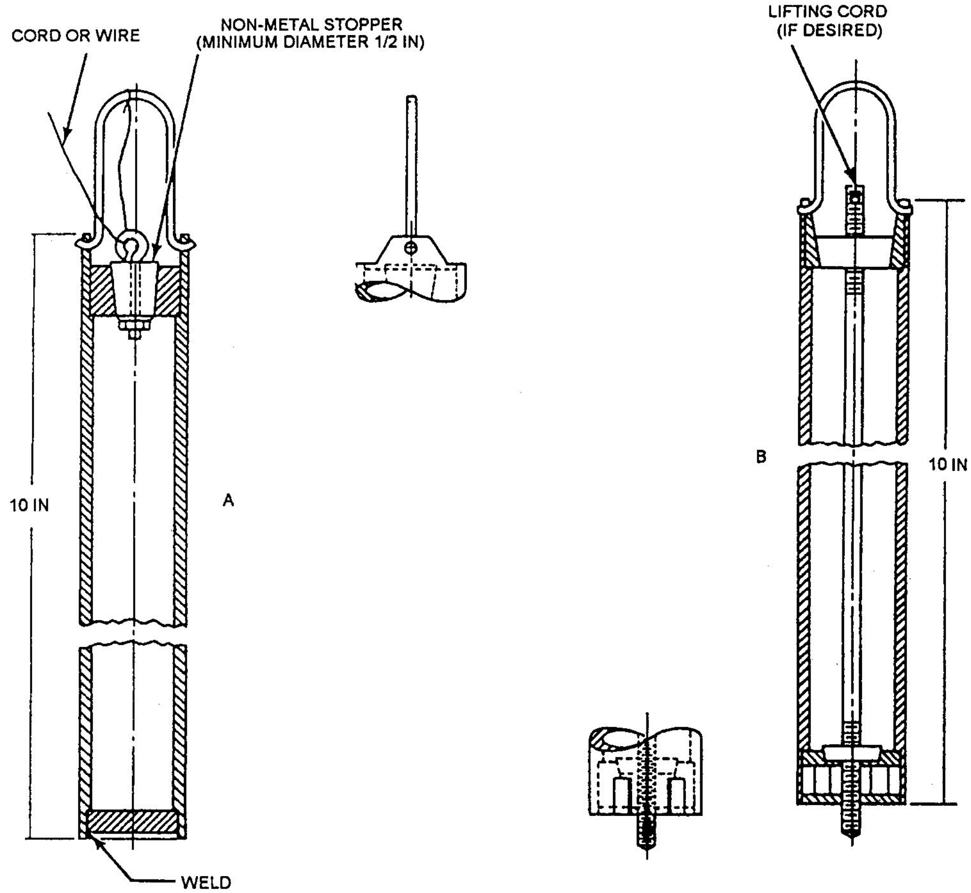


Figure 2-7.—Sounding tube oil samplers.

inspection because it is representative of the quality and condition of the total quantity of that fuel.

METHODS AND EQUIPMENT.– The methods you will use to obtain F-76 samples include tank bottom sampling and pressurized sampling. To perform tank bottom sampling, you will use a common thief sampler, such as one of those shown in figure 2-7. To perform pressurized sampling, you will need standard equipment items, such as a sample bottle, a bucket, rags, and the required personal protective equipment.

LOCATIONS.– Regardless of the type of fuel system on your ship, your ship must be equipped with valve connections at certain locations. As a minimum requirement, your ship should at least have required valve connections in the following areas:

- Each deck fill connection
- Each centrifugal purifier clean-fuel discharge
- Each filter/separator (coalescer) clean-fuel discharge
- Each stripping pump discharge
- All sounding tubes

For you to obtain a representative sample, the sounding tubes in your ship's fuel tanks must be perforated along the entire length of the tube.

Regardless of the location and method you use to take fuel samples–whether it is from a deck riser at a fueling station, a thief bottom sample, or a sample from the system piping–remember to follow the safety precautions we have discussed and the guidelines in *NSTM,* chapter 541, "Petroleum Fuel Stowage, Use, and Testing" and chapter 542, "Gasoline and JP-5 Fuel Systems."

STANDARDS.– After you take an F-76 sample, you must visually inspect it. In some cases, you must determine quickly if the fuel is suitable for use or if another form of testing is required. All fuels should have a clear and bright appearance. Your sample will have a clear appearance when solids are not present. Your sample will have a bright appearance if there is no free water present.

CONDITIONS AND FREQUENCY.– There are many conditions for which you will be required to take F-76 samples. During a refueling evolution, for example, you must sample F-76 from the deck connection at the beginning, middle, end, and every 15 minutes until the evolution is completed. After sampling F-76, you may determine that additional tests are needed. Any time you prepare to test F-76, of course, you must first obtain a sample. For this reason, we will continue our discussion of sampling requirements in the following section on fuel testing.

Testing

You will routinely use the following tests to check the quality of your ship's fuels:

- BS&W test
- API gravity test
- Flash point test
- Water contamination tests

We will describe these tests in the following paragraphs. First, however, let's look at some of the conditions that will require you to perform these tests. After we explain the requirements, we will describe each of the tests, using F-76 as a typical fuel sample.

REQUIREMENTS AND CONDITIONS.– As a GSM assigned to the oil lab, you should be able to recognize when you will need to perform routine tests and when you will need to use additional tests to check the fuels your ship receives. You will perform routine tests during a refueling evolution. You must, however, recognize the different requirements for when your ship receives fuel from a contracted U.S. government supply source or a non-U.S. government source. In the following sections, we will explain these requirements.

Refueling Evolution.– In addition to the visual sampling requirements previously mentioned, you must also perform a BS&W test on the samples taken at the start, midpoint, and end of the refueling evolution. The sampling procedures and BS&W tests are routine testing requirements. If at any time during refueling you discover free water in any of the samples, stop receiving the fuel until you can locate the source of the contamination and correct it.

U.S. Government Supply Source.– If your ship is receiving fuel from a U.S. government supply source, the only required tests you must perform are the visual inspections (samples) and the three BS&W tests discussed in the preceding paragraph.

Non-U.S. Government Supply Source.– If your ship is receiving fuel from a non-U.S. government supply source, you must send a representative (if possible) to the supplier to witness the gauging, sampling, and laboratory analysis of the fuel. At a minimum, your ship's representative should observe while the fuel is being tested for flash point, API gravity, and BS&W. The flash point, especially, must be determined before your ship can be authorized to receive the fuel. You must determine the API gravity and BS&W of the transferred fuel.

BS&W TEST.– You will routinely perform the BS&W test to determine the sediment and water content in your ship's fuels. Sediment and water are often present in heavy fuels. Too much water and sediment in a fuel can cause blockage in the spray nozzles and poor combustion of the fuel. In a fuel sample, the maximum allowable percentage of BS&W is 0.1 percent.

To determine the BS&W, you will need a standard sample bottle, two 100-milliliter (mL) centrifuge tubes, and a centrifuge. Use the following steps:

1. Use the standard sample bottle to obtain the sample. The temperature of your sample must not be below 60°F (15.5°C).
2. Thoroughly agitate the sample. This is an important step for accurate readings. You must thoroughly agitate your sample <u>before</u> you continue to the next step.
3. Measure exactly 100 mL of the sample into each of the two centrifuge tubes and tightly cap both tubes.
4. Place the tubes on opposite sides of the centrifuge and whirl for 10 minutes at approximately 1,500 rpm.
5. After the unit has completely stopped, remove each tube, read the volume of water and sediment at the bottom, and record the results.
6. Place the tubes back in the unit and centrifuge for 10 more minutes.
7. Again, remove the tubes (when the centrifuge has stopped rotating) and read and record the results.

8. Repeat steps 6 and 7 until the volume of water and sediment in each tube is the same (for that tube) for two consecutive readings. (You can usually obtain these readings within four repetitions.)

Your readings will indicate a direct percentage of water and sediment. (You will not have to make conversions because you are using 100 mL of fuel in each tube.) By using two tubes, you are checking the samples against each other for accuracy, Therefore, when you are determining your final reading and both tubes have an equal amount of sediment and water, use only the results of one tube to record the final reading. If the tubes should have different amounts of sediment and water, add the readings of both tubes together and divide by 2 to get the proper total.

API GRAVITY TEST.– You will use the API gravity test to check the actual weight (volume) of a fuel that is transferred to your ship from a non-U.S. government supply source. This test will allow your ship to have a more accurate account of the actual amount of fuel your ship will receive.

For this test, you will use a clear, smooth glass container, a stirrer that will reach the bottom of the container, a hydrometer, a temperature standard of 60°F (15.5°C), and the conversion charts in *NSTM,* chapter 541, "Petroleum Stowage, Use, and Testing." Use the following steps:

1. Fill the container with a fuel sample. Make certain the temperature of the fuel sample is approximately the same as the temperature of the surrounding air.

2. Use the stirrer to agitate the sample thoroughly.

3. Check the hydrometer to make sure it is clean, dry, and at about the same temperature as your fuel sample. Gently lower the hydrometer into the fuel sample, release it, and allow it to sink into the sample slightly beyond the point where it floats naturally. Allow the rise and fall of the sample to cease and the hydrometer to reach equilibrium before you continue to the next step.

4. Read the scale. Make certain your eyes are on the same level as the surface of the sample. Read the hydrometer scale at the point that appears to coincide with the top of the sample.

5. Convert your reading to the petroleum industrial standard of 60°F (15.5°C) by referring to the conversion tables in *NSTM* chapter 541. Use one table to find the corresponding industrial standard for your reading. Refer to the next table to find the volume correction factor. Take the volume correction factor and multiply it with the amount of fuel volume in the tank you are testing. The result should provide you with the actual weight or volume of the sampled fuel according to the industrial standard and should represent the actual weight of the fuel your ship will receive from the non-U.S. government source.

FLASH POINT TEST.– You will use the flash point test to determine the flash point of a fuel your ship has received on board. The minimum flash point for all fuel on Navy ships is 140°F (60°C).

For this test, you will need a closed-cup flash point tester and a 90 millimeter (mm) paper filter. Use the following steps:

1. Thoroughly clean and dry all parts of the cup and its accessories. Make sure there are no traces of cleaning solvent on the unit or its accessories.

2. Filter the fuel sample through the filter paper to remove all traces of water.

3. Fill the test cup with the fuel sample to the level indicated as the filling mark. Place the lid on the cup.

4. Set the cup in the oven. Be sure you have the locking device properly engaged. Insert the thermometer.

5. Light the test flame and adjust it to 5/32 inch (4 mm) in diameter. Adjust the oven heat so the rate of temperature rise for the fuel (as indicated by the thermometer) is 9°F (5°C) to 11°F (6°C) per minute.

6. Turn the stirrer 90 to 120 rpm in a downward direction. Now, turn the stirring unit off before you continue to the next step.

7. Making sure the temperature of the sample is not any higher than 30°F (17°C) below the expected flash point, use the cover mechanism that controls the shutter and test flame burner to lower the test flame into the fuel cup. (Lower the flame into the vapor space of the cup in 0.5 second, leave the flame in its lowered position for 1 second, and quickly raise it back up.) Reapply the test flame at every 2°F (1.1°C) interval.

8. When the test flame causes a distinct "flash" in the cup, record the temperature indicated. Do not

confuse the true flash point with the bluish halo that may surround the test flame until the real "flash" occurs.

WATER CONTAMINATION TEST.– If you happen to be aboard a ship, such as an FFG, that has noncompensated fuel oil storage tanks, you must perform a water contamination (water cut) test. You should perform this test 24 hours after the receipt of fuel. If water is present, the tank must be stripped. You must retest the tank until the fuel meets the requirements set forth in *NSTM* chapter 541. Use the procedures in the following paragraphs.

Service Tank Replenishment.– Noncompensated fuel oil storage tanks contain the fuel products that will be used to replenish the main and auxiliary service tanks of your ship. For this reason, you must test noncompensated storage tanks for water contamination and strip them as necessary <u>before</u> the fuel transfer takes place.

Five minutes after the start of the fuel transfer and every 30 minutes thereafter, you must sample and visually inspect the purifier discharge. Your sample should meet the clear and bright criteria. If the sample fails, you need to inspect the tank and clean the purifier.

Once the service tank is replenished, you should recirculate the fuel. If your ship is equipped with self-cleaning purifiers, recirculate the fuel in the service tank for at least 3 hours and as long as possible after this period. Even if your ship is equipped with manual purifiers, you should still try to recirculate the fuel for at least 3 hours after replenishment. A properly working purifier can remove 10 to 50 percent of contaminants in a single pass. If you operate the purifier for multiple passes (3 hours), you can remove as much as 90 percent of the total contaminants. By reducing the level of contamination in the service tank, you are also reducing use of the coalescer, separator, and prefilter elements. As an additional precaution, you must make sure the purifier bowl is cleaned regularly. If the purifier bowl is not clean, recirculating the fuel will be of little value. If the service tank remains idle for over 48 hours, recirculate the fuel for at least 3 hours.

Your ship can minimize the entry of pollution-laden harbor water into the compensated fuel tanks by topping off the service tanks before entering port and by not transferring fuel between groups. In the same way, your ship should never use harbor water as tank ballast for noncompensated fuel stowage tanks.

Service Tank Operations.– Before placing the auxiliary (standby) service tank in use, you must test the tank bottom for water contamination and strip it as necessary. When the service tank is suitable for use, sample and test the filter/separator discharge 5 minutes after you place the tank in service and at least once every 4 hours during system operation. To test the fuel, you will use the AEL Mk I/II and AEL Mk III testers. You will use the AEL Mk III first.

AEL Mk III.– The AEL Mk III is a portable fuel detection unit. It consists of a fuel sample container, a fuel millipore filtration system (with the filter), and a light transmission system that will determine the quantity of solids contamination trapped on the millipore filter. All the equipment and parts you will need are stored in the unit. Before you begin the test, however, there are two things you must check: (1) Make sure the calibration chart is up to date, as it must be updated quarterly according to the PMS, and (2) make sure the fuel flask is empty. If you have to drain the flask, turn the drain handle to allow the fuel to drain through the tygon tubing to the waste fuel container. Once the fuel has drained, close the drain cock Now take the following steps:

1. Disassemble the filter holder and bottle receiver assembly by turning the center locking ring in a counterclockwise direction and pulling apart the two components. Insert the filter holder (the equipment with the rubber stopper) into the opening in the fuel flask.
2. Using the forceps, place two millipore filters on the rubber stopper side of the assembly (filter screen). Do not touch these filters with your hands!
3. Reassemble the filter assembly and temporarily place it in the opening of the fuel flask. Now, turn on the light switch so the unit can warm up.
4. Fill the plastic bottle with 200 mL of the fuel sample.
5. Remove the filter assembly from the fuel flask opening and install it on the plastic sample bottle. Make sure the entire threaded portion of the sample bottle is inserted into the filter assembly.
6. Insert the ground wire into the receptacle next to the fuel flask opening. Quickly invert the sample and place it into the fuel flask opening. Now, turn on the pump.
7. After all the fuel has drained from the sample bottle, carefully remove the bottle from the

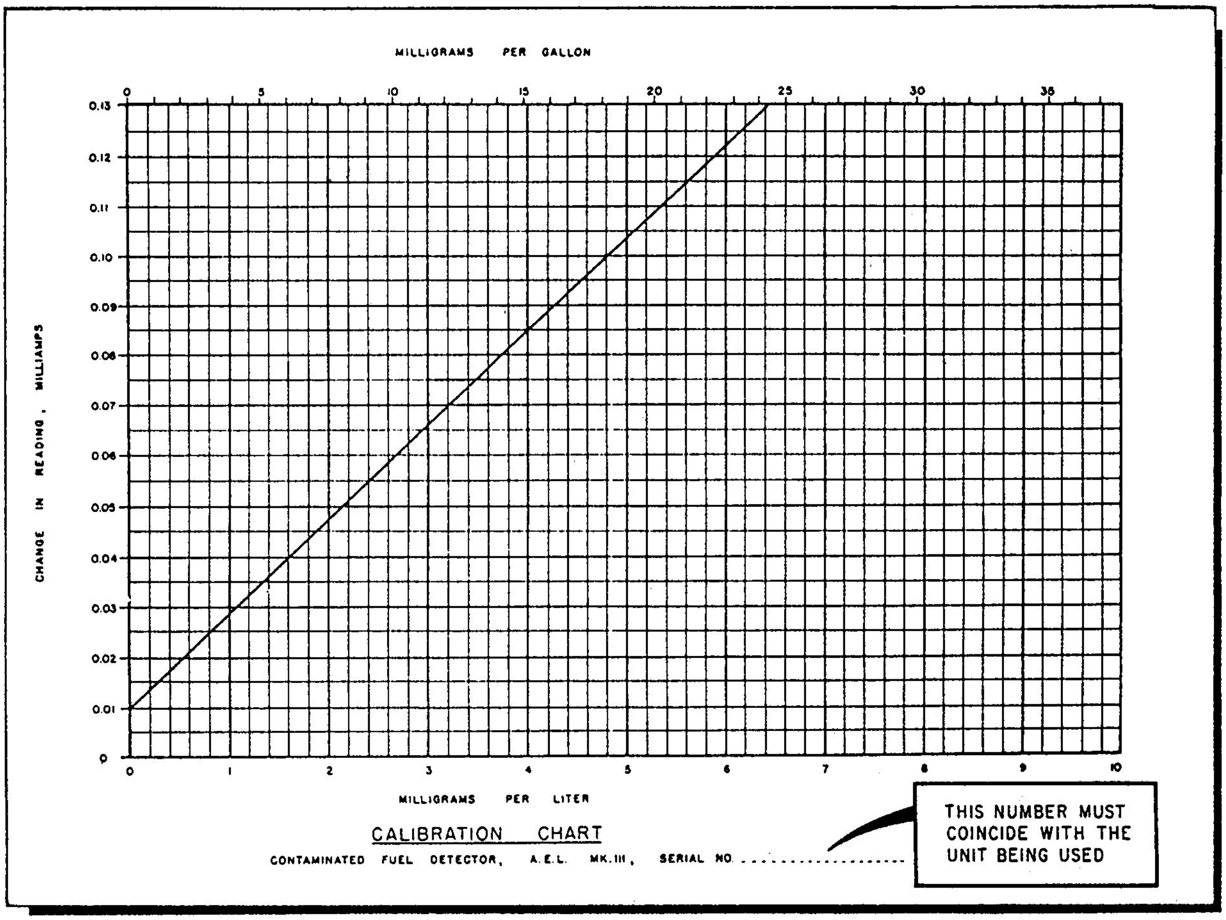


Figure 2-8.—Calibration chart.

filter assembly. Watch to make sure all the fuel drains through the filters. Next, turn off the pump. By now, the light should have had sufficient time to warm up and you can proceed with the calibration process, starting with the next step.

11. Making sure there is no filter in the receptacle and the photocell is clean, swing the photocell into the measuring position. Use the rheostat knob to adjust the millimeter until you get a reading of 0.6.

12. Using the forceps, pick up the contaminated filter. Wet the filter completely by pouring a small amount of clean F-76 on the working surface and laying the filter in it. Make sure you get the entire filter wet with fuel.

13. Using your forceps, place the wet filter in the measuring receptacle under the photocell. Record the reading on the millimeter and remove the filter. Now, repeat the process with the second filter.

14. Subtract the contaminated filter reading (filter No. 1) from the clean filter reading (filter No. 2). Find the corresponding contamination value in milligrams per liter (mg/L) on the calibration curve chart, such as the one shown in figure 2-8. Calibration chart readings of 5 mg/L or less are acceptable and equate to 2.64 mg/L or less. You will not need to make corrections for sample size.

With a little practice, you will have no difficulty using the calibration curve chart. For example, take the following numbers and plot them on the chart in figure 2-8: Filter No. 1 (contaminated) equals 0.02 milliamps. Filter No. 2 (clean) equals 0.06. Subtract the reading for filter No. 1 from that of filter No. 2 . Your answer should equal 0.04 milliamps. To find the mg/L reading, look on the left side of the chart and locate 0.04 milliamps. Draw a straight line across the chart until you intersect the calibration line. At this point, move your pencil straight down to find the fuel contamination level. If you have done these steps correctly, you should have a reading of 1.6 mg/L.

Now that you have determined the contamination level of your fuel, you can proceed with the free water test. For this test, you will use the AEL Mk II free water detector as well as some parts of the AEL Mk III.

AEL Mk II.– The AEL Mk II free water detector consists of three main parts: (1) a view box containing an ultraviolet light source; (2) a set of printed standards, indicating 0, 5, 10, and 20 ppm; and (3) some water detector test pads. To maintain detector accuracy, you must replace the printed standards every 6 months. The water detection pads are extremely sensitive to moisture in the air. To avoid false readings, avoid drawing air through these pads at times other than when your fuel sample has passed completely through the pad. Keep these precautions in mind as you take the following steps:

1. Using the same fuel sample bottle you used with the AEL Mk III, fill the bottle to the 200 mL mark with F-76.
2. Open a free water detector envelope. Using the forceps, pick up the detector pad and place it, orange side up, on the contaminated fuel detector filter base. Attach the bottle receiver to the filter base and plug in the ground wire jack.
3. Check to make certain the fuel flask is empty and the drain valve is closed.
4. Shake the sample bottle vigorously for at least 30 seconds. Immediately turn on the vacuum pump. Unscrew the bottle cap and place the bottle receiver and pad holder assembly firmly over the end of the sample bottle, making sure the entire threaded portion of the bottle top is inserted into the bottle receiver.
5. Pick up the entire assembly, invert it, and insert the pad holder end into the fuel flask of the AEL Mk III. Do steps 4 and 5 quickly to keep the free water in suspension.
6. Observe the filtration process. Once the entire sample has passed through the detector pad, turn off the vacuum pump. Remove the bottle and the bottle receiver.
7. Using your forceps, remove the detector pad from the filter base and place it, orange side up, in the free water detector slide depression.
8. Hold the light switch in the ON position and insert the slide containing the test pad.
9. Look through the view port of the box. To determine the amount of free water, compare the brightness of the fluorescence of the test pad with that of the standards. The numbers located directly above the standards will indicate the free water content in ppm. If the chart reading is 5 ppm or less, then the level of free water is acceptable. A chart reading of 5 ppm or less equates to an actual limit of about 40 ppm or less. You will not need to make corrections for sample size.
10. Your last step is to drain the fuel from the flask of the AEL Mk II through the tygon tubing.

Up to now, we have discussed sampling and testing requirements and procedures for F-76. In the following sections, we will discuss the procedures you will need to use for F-44, commonly called JP-5.

F-44 (JP-5)

Although most of your fuel sampling responsibilities will involve F-76, you also will be involved with maintaining the quality of F-44. F-44 has two principal uses on board gas turbine-powered ships. Its primary use is for the service of aircraft. Its secondary use is for the ship's boats. Maintaining a high quality of this product is very important. As you read about the sampling and testing procedures for F-44, notice how the quality requirements for F-44 are much more stringent than those for F-76.

Sampling

In sampling F-44, you will use the same visual sampling criteria (clear and bright) as you would for F-76. The main difference in the sampling requirements is that you must sample F-44 fuels more frequently, The conditions under which you must sample F44 and the frequency with which you must take these samples are listed in *NSTM*, chapter 542, "Gasoline and JP-5 Fuel Systems." As we are unable to cover the multitude of conditions and circumstances within the scope of this TRAMAN, we recommend you consult *NSTM*, chapter 542, for detailed instructions.

Testing

You will basically use the same tests and testing procedures for F-44 as you would for F-76. The main difference is that the testing requirements for F-44 are stricter than those for F-76. The stricter requirements for F-44 apply mainly to the following maximum allowable contamination limits:

- Solids contamination must not exceed 2.0 mg/L.
- Free water content must not exceed 5 ppm.

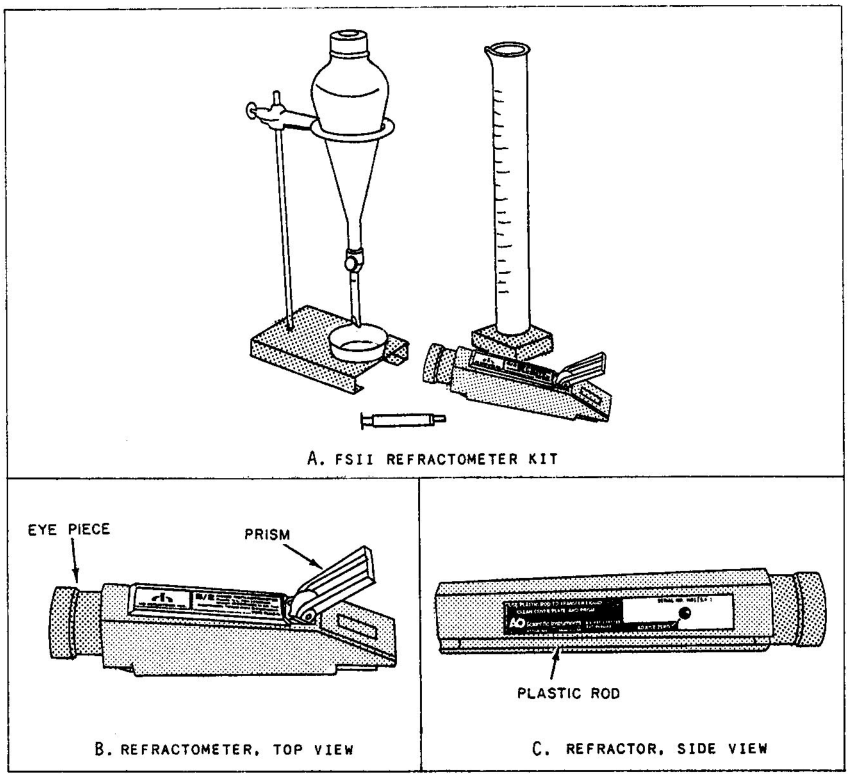


Figure 2-9.—FSII refractometer.

The methods you will use to test F-44 are the same ones we just described for F-76 fuels.

In addition to the tests you will perform on both F-76 4. and F-44 fuels, you must perform one other test on F-44. In this test, you will check for fuel system icing inhibitors (FSII). For this test, you will use the FSII refractometer kit, as shown in figure 2-9. View A of figure 2-9 shows the components of the test kit and the 5. set up. Views B and C show front and side views of the refractometer.

As the name implies, the refractometer uses light to 6. indicate inhibitor levels. You must handle the refractometer with care. It is delicate and can be damaged easily. You can use either a fluorescent or an incandescent light source, but the area in which you perform test, must be well lighted. To perform the test use the following steps:

1. Set up the refractometer ring stand assembly, as shown in view A of figure 2-9.
2. Using a clean sample bottle, take a 1-quart sample of the F-44 you will test.
3. Fill the aluminum dish that comes with the kit one-half full. (If the dish that comes with the kit is damaged or missing, you can use any clean dish.)
4. Fill the graduated cylinder and the separator funnel about one-third full of the test fuel. Swish the fuel around in both the cylinder and the funnel to clear away any foreign material, then toss it out.
5. Fill the graduated cylinder with exactly 160 mL of the fuel sample. (Make sure the drain cock on the separator funnel is closed.)
6. Pour the fuel from the graduated cylinder into the separator funnel.
7. Using the piston pipets or an eye dropper, add exactly 2 mL of water from the aluminum dish to the separator funnel. Place the cap on the funnel.
8. Shake the funnel for at least 3 minutes, then place it on the ring stand.
9. Open the hinged plastic cover on the window of the refractometer. Make sure the window and cover are clean. Place several drops of water on the window. Close the cover and look through the eyepiece. Observe the shadow line.

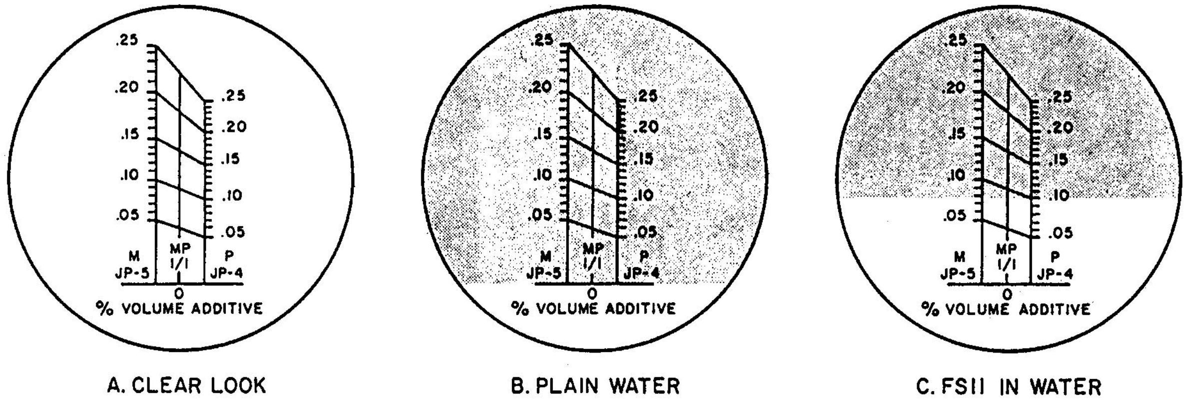


Figure 2-10.—Views through a refractometer.

Remove the black plastic rod from the bottom of the refractometer. Using the rod (or a screwdriver), adjust the setscrew until the shadow line meets the zero line of the scale, as shown in figure 2-10. (Study views A and B.)

NOTE

What you have done is added water to the fuel. By shaking the sample, you have allowed the icing inhibitor to leach into the water. By adjusting the setscrew until you read zero, you have made the refractometer ready to compare the FSII in the fuel to the scale inside the instrument.

10. Open the plastic cover and wipe the water from the window and cover. Carefully turn the drain cock so several drops of water can trickle into a clean, dry aluminum dish. Open the hinged plastic cover and place two or three drops of water from the funnel on the window. Close the cover. Look through the eyepiece and read the point where the shadow line is on the scale. This reading should give you the percentage of FSII by volume. (Study view C.)

NOTE

Remember to put only water on the refractometer, no fuel. Use clean water or water with additives only. If fuel is in the sample you put on the refractometer, you may get a false reading.

11. Upon completion of the test, empty the funnel and properly dispose of the fuel. Clean the equipment with soap and water, then thoroughly rinse it with water.

OILS

In the oil lab, your job of sampling and testing oils (lubricants) will be extremely critical to the effective operation of your ship's engineering equipment and systems. Oils reduce friction, dissipate heat, and prevent corrosion. In addition, they conduct friction-generated heat away from bearings, act as a seal to protect lubricated areas from contamination, and act as a carrier for materials such as rust preventatives, anti-friction agents, and extreme-pressure additives.

Contamination of oils can seriously harm equipment. Contamination occurs in oils much in the same manner as it does in fuels. Whereas fuels are really used only once, oils are purified and used over and over again. This is where a good sampling and testing program comes into play.

In the following sections, we will discuss typical sampling and testing procedures for oils. In most of our discussions, we will use 2190 TEP as a typical oil because you will come into contact with this oil more than any of the others. Later in this section, we also will tell you about the other types of oils and the sampling and testing procedures you will be required to perform on them. Because you will perform sampling more frequently than testing, let's talk about oil sampling first.

SAMPLING

Oil sampling will always be your simplest, most frequently used, and first-line procedure of defense against equipment failure. While assigned to the oil lab, you will need to know the conditions for which you should take oil samples and the frequency with which you should perform sampling procedures.

Conditions and Frequency

You should take oil samples for shipboard testing at the intervals specified by the PMS, the EOSS, or the applicable technical manuals for your ship. Unless otherwise specified in these documents, you should sample all equipment at the following times:

- Before start-up
- 30 minutes after start-up
- Daily thereafter

In addition, you must sample idle equipment weekly. Be sure to check all equipment for proper oil levels before and after sampling.

You also should sample when unusual conditions occur, such as abnormal changes in temperature, pressure, vibration, or noise levels. You should always sample whenever you observe an abnormal symptom, such as a sudden oil color change, foaming in the sight glass, and excessive leakage, venting, or oil consumption.

NOTE

Normal lube oil sampling and testing requirements do not apply during engineering casualty control drills. For equipment involved in casualty control drills, test the oil 1 hour before the beginning of the drills and 1 hour after the completion of the drills.

Methods

The three oil sampling methods you will commonly use aboard ship are: (1) thief, (2) static, and (3) pressurized. In the following paragraphs, we will discuss these methods and the equipment you will need.

THIEF METHOD.— Thief sampling is the method you will use primarily to sample the bottom of the equipment sump (like that on the main reduction gear) before the lube oil service pumps are started. You will use a thief sampler (sounding tube sampler) similar to one of those shown in figure 2-7. If the sump has a sounding tube, you must use a pail, a clean 8-ounce sample bottle, rags, and a thief sampler. (If the sump does not have a sounding tube, you will be required to use the pressurized sampling method, which we will discuss later.) Use the following steps:

1. Clean the area around the sounding cap and remove the cap.
2. Attach the thief sampler to the sounding tape and lower it into the sump. Do this slowly so the sampler will gently hit the striker plate at the bottom. You can damage the sampler if you let it hit the striker plate too hard. If you are not familiar with the depth of the tank, measure it first. Then, you can use the sounding tape to measure the distance from the top of the sounding tube to the striker plate before you attach the sampler. Remember, the sounding tape plumb bob is approximately 4 inches shorter than the sampler.
3. Once the sampler is at the bottom of the tank, you can take a sample. However, you will not keep this sample. You will use it to flush out the sample bottle. Remember to keep the sample bottle capped or closed promptly after you take the sample to prevent contamination.
4. After flushing the sample bottle, dump the oil into a pail for disposal.
5. Fill the sample bottle. You will have to send the sampler down several times to obtain enough oil to fill the bottle.
6. Label the filled sample bottle with the following information:
   - Equipment name
   - Oil type
   - Date
   - Time

STATIC METHOD.— You will use the static method to take samples on equipment items that have sample connections installed on the equipment sump. The equipment items with this type of sample connection are usually auxiliary equipment, such as air compressors, line shaft bearings, and lube oil storage and settling tanks.

For static sampling, you will use the same basic procedures you would use for thief sampling. The only difference in static sampling is you must flush the sample connection. The amount of oil you must use to flush the connection must beat least equal to or greater than the amount of stagnant oil already in the connection.

PRESSURIZED METHOD.— You will be able to perform pressurized sampling on most of the operating equipment in the engineering plant. In fact, when you use the pressurized method, you will be taking samples on equipment that is already in operation. The main problem with taking pressurized samples is that you must take additional precautions, such as wearing protective clothing (rubber gloves, an apron, and chemical splash goggles), and taking extra care to avoid an excessive loss of oil. Be very careful when you take these samples. Try to avoid accidentally dumping the oil from either the sump or the tank. Sound the sump on small equipment both before and after you take the samples because flushing and sampling can both cause a low sump condition.

Standards

No matter what method you use, all your samples must meet the visual inspection requirements. These requirements, the clear and bright criteria, are basically the same as those you would use for fuels. The only difference is you must allow an oil sample that has a hazy appearance to settle for 30 minutes to allow any entrained air a chance to dissipate. If the sample clears from the bottom to the top, you can assume the haze was the result of entrained air. If the haze clears from the top to the bottom, however, it is likely the result of solids or free water contamination.

After allowing the haze to clear, you must visually inspect the sample to determine if it is clear. Start by inverting the sample bottle and observing the particulate matter as it settles. Be sure to hold the bottle in the inverted position for at least 1 minute. Then, turn the bottle in its right-side-up position for 1 minute, and then invert it again for an additional minute. Invert the sample bottle at least three times. If you still see any particulate matter in the oil, the sample has failed your visual inspection for clear and bright oil and you must perform additional testing. The additional tests will be based on the type of oil and the type of equipment.

TESTING

The oil testing procedures we will discuss in this section are for transparency, BS&W, mineral oil contamination, acidity, and fuel dilution. These tests are usually performed either as a PMS maintenance requirement or under special conditions. In the following sections, we will describe each of these tests. Later, we will tell you about each oil type, its testing requirements, and whether the tests are routine or conditional.

Transparency Test

Systems without online purification capability sometimes have difficulty maintaining a clear and bright oil condition. In such equipment, frequent oil changes to maintain a clear and bright condition are time consuming and costly. In these cases, you should perform the transparency test.

First, place a PMS card behind the sample bottle in a well-lighted area. Be sure to hold the card directly against the sample bottle. Try to read the printed words on the card. If you can read the words, the oil passes the transparency test. If you can not read the words, the oil fails the test. If the oil passes the transparency test, it is satisfactory for use. If it fails the test, your next step is to perform the BS&W test.

BS&W Test

You will perform the BS&W test on all types of oils. The BS&W test you will perform on oils is very similar to the one we described for fuels. Since the procedure is basically the same, we will just discuss the differences. The only differences in the procedure for oils are that you must (1) dilute the oil sample, and (2) add the water and sediment readings of both tubes to get the final readings.

To dilute the oil sample, add exactly 50 mL of a water-saturated mixture of dry-cleaning solvent (P-D-680, type II) to each of the two 100 mL tubes. After vigorously agitating the oil sample, pour the oil into each of the 100 mL tubes. Pour enough oil into each tube to make up the remaining 50 mL. Agitate each tube to make sure the oil and dry-cleaning solvent are completely mixed. Invert each tube at least five times. Allow the liquid to drain thoroughly from the tip of the tube each time you invert it. Now check your readings against the following standards:

1. If the sediment is less than or equal to 0.1 percent and the combined BS&W is less than or equal to 0.2 percent, the oil is satisfactory for use.

2. If the sediment is less than or equal to 0.1 percent and the combined BS&W is somewhere between 0.2 and 0.4 percent, the equipment is in a warning condition. In this case, you need to identify the cause of the contamination and correct it. Either purify the oil or replace it with clean oil when the equipment is secured. Do not operate the equipment longer than 7 days after

you identify the contamination unless you obtain written authorization from the commanding officer. For secured equipment, have the oil either purified or changed before the equipment is readied for operation.

3. If the combined BS&W exceeds 0.4 percent or if sediment exceeds 0.1 percent at any BS&W level, the oil is at the condemning limit. In this case, you must secure the equipment unless the commanding officer authorizes its continued use in writing.

Mineral Oil Contamination Test

You will use the mineral oil contamination test on synthetic oils. In fact, you must routinely test synthetic oils for mineral oil contamination. Mineral oil contamination is always a possibility because of the configuration of the synthetic oil cooling systems. According to the PMS, you will routinely perform the test for mineral oil contamination every month. Use the following steps:

1. Mix 25 mL of synthetic oil with 75 mL of absolute methanol in a 100-mL graduated cylinder that you can cap.
2. Seal the container and shake it vigorously.
3. Observe the liquid. If the liquid appears cloudy, it is contaminated with mineral oil. If the liquid remains clear, it is not contaminated with mineral oil.
4. If the oil is contaminated, find the cause and correct it. Then, thoroughly flush the oil system before you add new oil.

Oil Acidity Test

You will be required to perform oil acidity tests on series 9000 (diesel) oils. You will normally conduct the oil acidity test at least every 24 hours of engine operation or once a week, whichever is more frequent. To perform this test, use the following steps:

1. Remove the reaction vial from the test kit and fill it to the 25-mL mark with the preprepared reaction indicator solution.
2. Add the engine oil to raise the liquid level to the 40-mL level.
3. Screw on the top and shake the vial vigorously for 15 seconds.
4. Allow the reaction vial to stand for 5 to 10 minutes until the oil and indicator separate.
5. Remove the reaction indicator card from the kit and compare the color of the separated indicator (lower level in vial) with the card. If the indicator is blue, the oil is satisfactory. If the indicator in the vial is either green or yellow, the oil is unsatisfactory and should be changed.

Fuel Dilution and Oil Thickening Test

Like the oil acidity test, you will perform the fuel dilution and oil thickening test on series 9000 (diesel) oils. For the fuel dilution and oil thickening test, you will need a sample of clean (new) lube oil as well as the sample from the engine (used oil). Take the comparator from its storage case and set it up on a level, stable work area. Make sure it is firmly supported and at a slight angle from the vertical position. Take the following steps:

1. Using the thermometer from the test kit, measure the temperature of the new and used oils to make sure the difference is not greater than 1°F (-17.2°C).
2. Fill tube A of the comparator to the gallery (the enlargement of the diameter) with new oil and place it in the comparator. Fill tubes 1 and 2 to the same level with used oils and place them also in the comparator.

NOTE

You can place samples from two different engines in the individual comparator tubes (tubes 1 and 2) at the same time. You will run the test only on one used sample tube and tube A at a time.

3. Use the end buttons to lift the three rod markers to 100 on the scale. Do not let your fingers touch the rods. Set the comparator aside for at least 10 minutes to equalize the temperatures.
4. Run rods A and 1 up and down in their tubes at least twice. Looking squarely at the markers and the start line, set the markers of rods A and 1 at the start line. Place the rod of the other sample tube in the down position.
5. Push in the reset button. Start the rods down by pushing and holding the release button. Then release the button when one of the rod markers reaches 100 on the scale.

6. Record the rod A reading in column 3 of the diesel engine lube oil testing log. (We will examine this log later in this chapter.) Record the used oil rod reading in column 4 of the oil test log.

You can now repeat the process if you are using another used oil sample in tube 2. When you have completed the tests, wipe the rods and the balls and drain the tubes thoroughly. You must make certain to do this between each test. Place the comparator back in its storage case.

The proper analysis of the test results depends upon the design and size of the engine from which you took the sample. You can generally use the following standards:

- The normal range of fuel dilution will be within 0.5 to 2.0 percent.
- Fuel dilution in the range of 2.0 to 5.0 percent indicates either a fuel jumper line leak or faulty injection equipment.
- Fuel dilution greater than 5.0 percent should cause you to be seriously concerned about the fitness of the engine. In addition to checking for jumper line leaks and faulty injection equipment, inspect several of the engine bearings for abnormal or excessive wear. If the bearings are worn, you will need to make further inspections to determine both the extent of bearing damage and the proper repair actions.

The standards of the test are logical if you just think about how the test works. In the case of fuel dilution, the higher the fuel dilution (oil thinning), the faster the rod will move down in the used oil than it will in the new oil. Oil thickening, however, is just the opposite. The carbon and sediment picked up by the oil will cause the oil to become thicker and will cause engine damage if the oil is not changed.

TYPES OF OILS

We have just discussed the basic tests you will be required to perform on oil samples. We will now talk about the different oils you will test and how the characteristics and testing requirements will differ depending on the type of oil and the type of equipment using it. Since they are the most commonly used oils on your ship, we will discuss mineral oils, or 2190 TEP, first.

Mineral Oils

Mineral oils, commonly called 2190 TEP, are extensively used throughout naval engineering plants. These oils are commonly used in your ship's main reduction gears, controllable pitch propeller systems, and generators.

Earlier in this section, we discussed the procedures you should use for sampling oils. If a mineral oil sample fails your visual inspection or remains hazy after settling, you will need to perform additional tests. The tests you will perform on mineral oils are for transparency and BS&W.

In sampling and testing mineral oils, you should be aware of some special characteristics. Sometimes the chemical makeup of a mineral oil will cause a good oil not to be clear and bright at 77°F (25°C). This usually happens when the oil is contaminated with trace amounts of water. After the oil is heated, it becomes clear and bright. Consequently, if you are sampling a MIL-L-17331 (2190 TEP) lube oil and your oil sample is not clear and bright at 77°F (25°C), use a water bath to heat the oil to 120°F (48.8°C). For the water bath, you will need a container of water and a heat source, such as a hot plate. You can also use a deep sink or pot filled with hot water. Place the sample bottle in the water and heat the oil until it reaches 120°F (48.8°C). Observe the oil sample periodically. If the oil becomes clear and bright when it reaches 120° (48.8°C), it is satisfactory for use. If the oil fails to become clear and bright after it reaches 120°F (48.8°C), use the following guidelines:

1. If the equipment has online purification capability, have the oil purified. If the oil is still not clear and bright after three passes through the purifier, change it.

2. If the equipment does not have online purification capability and you discover particulate matter in the sample, perform the BS&W test. If the sample is not clear and bright, perform the transparency test.

Synthetic Oils

Synthetic oils are found in shipboard cooling systems. You will routinely make visual inspections of synthetic oils during sampling. In addition to transparency and BS&W tests, there is one other shipboard test you will need to be familiar with for synthetic oils, the test for mineral oil contamination. In performing this test, you should use the procedure we described earlier.

Series 9000 Oils (Diesel)

In addition to the transparency and BS&W tests, you will need to perform two other tests on 9000 series oils (diesel), the oil acidity test and the fuel dilution and oil thickening test. In performing tests on 9000 series oil samples, follow the steps we described for each of these tests in the preceding paragraphs.

WATER

You will sample and test water products almost as frequently as you will fuel products. In sampling and testing water, the primary contaminant you will deal with is chloride. Chloride is the direct result of seawater contamination, but other contaminants are also produced when seawater contamination occurs. Rust formation (corrosion) and scaling can occur in boilers, feed tanks, piping, and diesel engines. This is why you must frequently sample water products and provide prompt and correct treatment for contamination levels. The only way you can detect these contaminants is through a program of diligent sampling and testing. Once you detect the contaminants, you can devise a treatment plan to control and eliminate the problem.

In the following sections, we will tell you about various sampling locations, basic testing guidelines, and fundamental treatment procedures for water products. We will use different terms to refer to the water you will sample and test at specific locations in the shipboard water cycle. These distinctions are necessary because water quality standards will vary throughout the system. We will use the following terms to identify water at various points in the system:

- Distillate—The distillate is the evaporated water that is discharged from a ship's distilling plant. The water in a shipboard water cycle normally begins as distillate. The distillate is stored in the feedwater tanks. The chief engineer will designate one of these tanks as the online feed tank and the others as reserve feed tanks. The distillate will be stored in the reserve feedwater tanks until it is needed as makeup feedwater.

- Feedwater—Very simply, feedwater is the water (distillate) stored in the feedwater tanks. In its broad sense, feedwater refers to all waters of the feed system, including the reserve feedwater, makeup feedwater, condensate, and deaerated feedwater systems. In its narrow definition, feedwater can include different types, depending on the location of the feedwater in the system.

- Reserve and makeup feedwater–The distillate while stored in the feedwater tanks is called reserve feedwater. Because gas turbine-powered ships that have waste heat tillers do not have demineralizers, the water in all tanks (including the tank on makeup) is termed reserve feedwater. The water flowing to the condensate system is referred to as makeup feedwater.

- Deaerated feedwater–Deaerated feed water is produced from the condensate that flows from the condenser to the deaerating feed tank (DFT) where dissolved oxygen and other gases are removed. The resulting deaerated feedwater then goes to the tillers. Deaerated feedwater specifically refers to that water contained between the DFT and the boilers.

- Condensate–Condensate is the water that results when used steam is cooled in a condenser. After the steam has done its work, it is coded in a condenser and returned to its liquid state. The condenser is a heat exchanger that uses seawater to cool the steam and turn it into water. The liquid condensed from steam is called condensate. Water from other sources, such as makeup feedwater and low-pressure drains, mixes with and becomes part of the condensate. The condensate goes to a condensate cooler, and back to the feedwater tank.

- Boiler water–If a DFT is installed, the deaerated feedwater, as it enters the boiler separator, becomes boiler water. Boiler water specifically refers to the water in the separator, headers, and generating tubes of the boiler.

- Fresh water–Fresh water can refer either to a ship's potable water or to water from certain steam drains that is returned to the condensate system.

You should routinely be able to recognize and use these terms. Keep these terms and their definitions in mind as you read the following sections.

SAMPLING

Sampling of water products is just as important as sampling of fuels and oils. The primary difference is that water products will rarely show any visible signs of contamination. Because of this, you will draw water samples primarily for chemical testing.

You will draw water samples from various locations in the plant. These locations will differ according to whether the system you are testing is operating under normal conditions or casualty conditions. In the following paragraphs, we will discuss when you must take samples under normal operating conditions and the sampling locations you should use.

Boiler Water

For your ship's boilers to operate safely and efficiently, you must pay careful attention to the quality of the boiler water. Your responsibilities for sampling boiler water will vary based upon the condition and operation status of each boiler. In the following paragraphs, we will talk about some of the more common conditions you will encounter.

STEAMING BOILERS.— You should sample boiler water from a steaming boiler at the following times:

1. Within 30 minutes after the generator is started.
2. As often as you need to maintain the chemical limits, or at least every 8 hours. The time between samples should not exceed 8 hours.
3. Within 1 hour before starting blowdowns.
4. Between 30 to 60 minutes after blowdowns.
5. Between 30 to 60 minutes after batch chemical treatment.
6. Within 1 hour before the generator is secured.

When taking samples from a steaming boiler, keep the design of the system in mind. The water and steam mixture you will sample originates from the boiler. The water then passes through a cooler which lowers the water temperature to 100°F (37.7°C) or below. Each boiler has its own cooler. For this reason, you must designate and maintain a separate sample bottle for each boiler. You should also follow all the safety precautions listed at the beginning of this chapter.

IDLE BOILER.— In sampling boiler water from an idle boiler, you will use the same locations you would use for a steaming boiler. For an idle boiler, however, you will only be required to sample 1 hour before a blowdown, usually after the boiler is secured. Even if an idle boiler has been blown down, you will not be required to sample it either after the blowdown or before the subsequent start-up.

Feed water

The sampling requirements and standards for feedwater will vary based upon each specific type of water, contaminant, or test, and the associated standards, limitations, and required intervals. Many of the sampling and testing requirements for feedwater are shown in table 2-1. Notice how the table shows you the water type, the required sampling intervals, the contaminate for which you are testing, the type of test you should use, and the maximum limit or range. Notice also that some of the test frequencies say "as required." This means the affected sampling locations have individual salinity/conductivity indicators. In testing the feedwater at these locations, you will compare the chemical test results with the meter reading. The required sampling frequently for each of these locations will depend upon the chemical test comparison results. For example, if the chemical chloride test result is more than 0.02 epm higher than the meter reading, the test is unsatisfactory and the meter is faulty. If the chemical chloride test result is less than the meter reading by more than 0.02 epm, then the water must be tested for hardness. If hardness is less than 0.02 epm than the meter reading, then once again the meter is faulty. In this case, you must sample at that location at least once every 4 hours until the indicator is brought back into service. Remember, many waste heat boilers are not equipped with a sample connection at the condensate cooler or the control condenser. In these cases, you should compare the applicable standards to a feedwater tank sample.

Ship's Service Diesel Generator and Waste Heat System (FFG-Class Ships)

Let's shift gears from waste heat boilers and look at the water sampling requirements for an FFG-class ship's service diesel generator and waste heat system. First, let's talk about the treatment chemical you will be sampling and testing, Nalcool 2000.

NACOOL 2000.— Nalcool 2000 consists of a blend of corrosion-inhibitor chemicals in a water solution. The major components of Nalcool 2000 are sodium nitrite, sodium borate, sodium silicate, and an organic copper inhibitor. Sodium nitrite helps to forma protective oxide layer on ferrous metal surfaces. Sodium borate is an alkaline buffer that reduces corrosion by neutralizing the acidic by-products that result from combustion blow-by gases leaking into the coolant. Sodium silicate forms a silicate film on metal surfaces and provides effective corrosion protection for mixed metal systems. The organic copper inhibitor chemically bonds with the copper in copper alloys, resulting in a protective layer on the surface.

DIESEL JACKET WATER SYSTEM.— To monitor the diesel jacket water system of an FFG-class ship, you should take samples at the following times:

- After freshly filling and treating the system
- After adding water to the cooling system
- After adding chemicals to the cooling system

Table 2-1.—Waste Heat Boiler Feedwater Requirements

Type of Water	Test Frequency	Constituent	Test	Maximum Limit of Range
Distillate	Continuously monitored automatically	Conductivity Chloride	SI CC	0.065 epm 10 µmho/cm
	As required*	Chloride	CH	0.07 epm
Feedwater Tank	Daily on standby tank	Chloride Hardness	CH CH	0.10 epm 0.10 epm
Feedwater	Monitored	Conductivity	CC SI	8 µmho/cm 0.05 epm
	As required*	Chloride Hardness	CH CH	0.05 epm 0.02 epm
Condensate/Drains	Monitored	Chloride Conductivity	CC SI	0.05 epm 8 µmho/cm
	As required*	Chloride Hardness	CH CH	0.05 epm 0.02 epm
Distiller Air Ejector Drains	Monitored	Conductivity	CC SI	10 µmho/cm 0.065 epm
	As required*	Chloride	CH	0.05 epm
Deaerated Feedwater	Within 2 hours after light off and daily thereafter	Oxygen	CH	5 ppb

SI = Salinity Indicator CH = Chemical Test CC = Conductivity Indicator

* Sample and test as required for the daily indicator comparison test and to locate the source of contamination.

- At least once a month

Remember, these frequencies can change according to circumstances and if any changes are made to the PMS. The location where you will usually take these samples is the jacket water expansion tank. For additional information, you should consult *NSTM,* chapter 233, "Diesel Engines."

WASTE HEAT SYSTEM.— You must sample the waste heat system of an FFG-class ship according to the PMS. In addition, you must sample and test the waste heat water for nitrite levels daily whenever the waste heat system is used to operate the distilling plant. You can obtain water samples from a convenient location in the line upstream of the supplemental electric heater. Now that we have discussed the basic sampling locations and frequencies, let's talk about the tests you will perform on these samples.

TESTING

As stated in the sampling section, water products rarely show visible signs of contamination. This is why chemical testing of these products is so important. All the test and treatment procedures we will discuss can be found in the PMS, the EOSS, or *NSTM,* chapter 220, volume 2, "Boiler Water/Feedwater Test and Treatment," and chapter 233, "Diesel Engines." In the following paragraphs, we will describe some of the testing procedures you will use. We will discuss these

Table 2-2.—Waste Heat Boiler Control Limits

Alkalinity	0.05 to 0.25 epm
Phosphate	25 to 75 ppm
Conductivity	500 µmho/cm maximum
Chloride	1.0 epm maximum

procedures according to the type of water you will be testing.

Boiler Water

The boiler water testing and treatment procedures you will use are based on the coordinated phosphate program. The Navy uses this program to prevent acid corrosion, caustic corrosion, and scale formation in boiler water. Table 2-2 contains the Navy's standard boiler water control limits. If you study this table carefully, you will see what compounds you will test for and their acceptable concentration limits.

CHEMICALS.— The first thing you need to learn about boiler water testing is the treatment chemicals you will use and how these chemicals work to control the contaminants you are monitoring. Trisodium phosphate (TSP) and disodium phosphate (DSP) are the chemicals you will use to treat the waste heat tiller water. TSP provides alkalinity and some of the phosphate. DSP provides additional phosphate while contributing little to the alkalinity. Maintaining alkaline boiler water prevents acid corrosion and provides the necessary environment for the phosphate to react with the scale formers. The additional phosphate prevents the formation of free caustic in the boiler water, an undesirable condition that could lead to caustic corrosion. The propulsion boilers measure the pH of the boiler water rather than the alkalinity. The corresponding pH range is about 9.7 to 10.4. The relationship of the waste heat boiler water treatment to the coordinated phosphate curve is shown in figure 2-11.

In the next few paragraphs, we will discuss some of the highlights of the boiler water testing procedures you will use. We will also warn you about some of the mistakes that are commonly made during the performance of these procedures.

PROCEDURES.— Accurate test results are essential for an effective boiler water treatment program. To get accurate test results, the most important thing you can do is to use the correct procedures. In testing and treating boiler water, you will use a different set of procedures for different parts of the boiler water system. When testing for chloride and conductivity, for example, you must use the procedures for propulsion boilers. When testing for alkalinity and phosphates, you must use the procedures for auxiliary boilers. Both procedures are explained in detail in *NSTM,* chapter 220, volume 2, "Boiler Water/Feedwater Test and Treatment." In routine testing you will actually be shifting from one procedure to the other. The reason for this is based on the natural order in which you should perform the testing. For a detailed description of all procedures, we recommend you consult *NSTM,* chapter 220, volume 2. At first this process maybe confusing, but the more familiar you become with this *NSTM* chapter, the easier these procedures will become. We will explain the highlights of both tests in the following paragraphs.

Boiler Water Conductivity Test.— Let's go to the propulsion boiler section for the boiler water conductivity test. Because it is easy to perform and does not require much time, this test should be done first. (It should also be done first because the test results can be affected by the absorption of CO_2.)

To perform this test, you will use the conductivity meter, a dip-type conductivity cell (2.0 cell constant), a thermometer, an 8-ounce square bottle, and distilled water. As easy as this test procedure is, there are still two important steps that are sometimes overlooked: (1) You must move the cell up and down in the bottle to remove trapped air bubbles, and (2) you must move the cell up and down in the bottle during the measuring phase until the movement no longer affects the meter readings. Keeping the cell clean is another important task that is sometimes overlooked. The most common mistake, however, is forgetting to change the distilled water in the cell storage bottle on a daily basis. For accurate results, you must make sure the distilled water in the storage bottle containing the cell is changed daily.

Alkalinity and Phosphates Test.— A common mistake in boiler water testing is the use of outdated test chemicals. Before you perform the alkalinity and phosphates test, you should check your test chemicals to make certain they are still active. To do this, check the dates on the containers to make certain the chemicals are not outdated. You can avoid using outdated chemicals by taking the following steps:

1. Do not overorder your test chemicals.

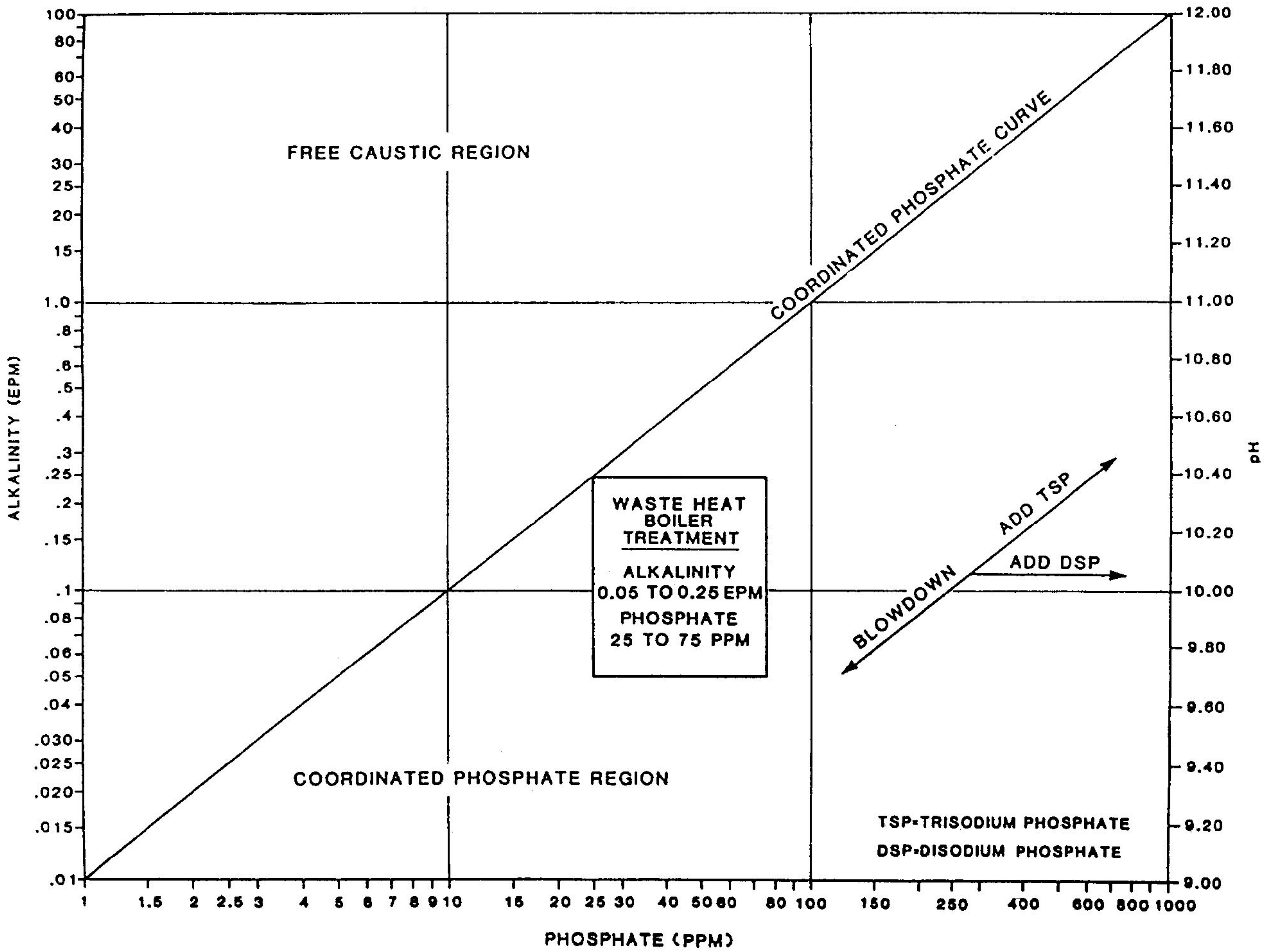


Figure 2-11.—Coordinated phosphate curve (waste heat boilers).

2. Periodically check the dates of the chemicals you have in stock.

3. Dispose of the outdated stock and rotate the rest to get optimum use of the good stock.

Another precaution you should take is to test your samples within a reasonable amount of time. Do not allow your samples to sit for long periods of time before you test them.

Chloride Test.— The chloride test will be the last test you will perform. Although this test is not difficult to perform, you must take care to avoid two things: (1) adding reagents too quickly during titration and (2) attempting to test discolored water. Adding the reagents too quickly will cause a high chloride reading. Many of the color changes in this test are very subtle. If you are not careful, you may add too much reagent before you notice the color change.

Now that the testing is complete, we need to know how to interpret our results and develop a treatment plan. In the following paragraphs, we will discuss how to control contamination under normal and abnormal situations. We will also describe some key symptoms and factors you must be able to interpret so you can determine what type of contamination has occurred.

CONTAMINATION CONTROL

To monitor your ship's water for contaminants, you must first be able to recognize the standards for normal operating conditions for both the boiler water and the feedwater systems. Next, you must be able to recognize when contaminant levels start to exceed normal control limits and threaten to become a hazard to your ship's engineering equipment and systems. First, let's talk about the contamination control procedures you will use for boiler water.

Boiler Water

In monitoring and maintaining the quality of your ship's boiler water, you will follow routine procedures for normal operating conditions. At times, however, contamination levels will present hazards to engineering equipment and systems. In these cases, you must use special procedures to correct the problems. In the following paragraphs, we will discuss the procedures you will use for both normal and abnormal contamination levels. First, let's look at the normal routines.

ROUTINE PROCEDURES.— Using the correct routine chemical treatment procedures will help you keep boiler water contamination levels under control. During normal boiler operations and when a normal depletion of treatment chemicals has occurred, you should follow the steps in the logic chart shown in figure 2-12. Study these steps and pay particular attention to the options associated with each step.

For normal operations, you can generally provide the recommended control limits by using two methods: (1) the continuous chemical injection system and (2) the batch chemical injection system. First, let's talk about the preferred method, the continuous chemical injection system.

Continuous Chemical Injection System.— For Navy ships, the continuous chemical injection system is the preferred treatment method. You should check this system to make sure it is operating properly. When the system is operating properly and outside contamination has not occurred, you should have very few cases requiring batch chemical injections. Normally, the continuous injection pump stroke setting is 60 percent (1 gallon per hour of treatment chemical). This setting can be changed if two consecutive samples show low levels of alkalinity and phosphates. In this case, you can increase the injection pump stroke in 10 percent increments until the proper levels are maintained. If the alkalinity and phosphates are continually over the upper limit, then reduce the pump stroke in 10 percent increments until proper levels are maintained.

Remember, the continuous injection system does not operate automatically when the generator is started. You must start the system within 30 minutes after the generator is started and secure it as soon as the generator is stopped. You must also monitor the tank level to make sure the treatment solution is entering the boiler. Record the tank level and the pump stroke in the boiler water log within 30 minutes after start-up and at least every 8 hours thereafter. Refill the injection tank when the level drops to between 10 and 20 gallons.

Batch Injection System.— In certain occasions, you will need to use the batch injection system. You should use this system if the continuous injection system is inoperative, if the system needs additional chemicals to compensate for an improper pump stroke setting, or during a casualty. The procedure for batch injecting chemicals is described in the EOSS (WHBP). You must strictly adhere to this procedure.

SPECIAL PROCEDURES.— You can control low levels of seawater contamination by using the normal dosage tables and blowdowns as long as you first identify the source of contamination and correct it. There are times, however, when contamination levels may exceed the normal control limits. At these times, you may need to use special treatment procedures. While assigned to the oil lab, you must be able to recognize the symptoms of excessive contamination and the steps you need to take to correct them. Some of the abnormal conditions you may face are excessive seawater contamination, chemical hideout, and chemical carryover. For some of these problems, you must use special chemical treatment plans; for others, you must use blowdowns. Before you start to treat a problem, however, you must first identify the condition or agent that caused it.

Seawater.— You can recognize serious seawater contamination by the following symptoms:

- Alkalinity of 0.00 epm
- Chloride greater than 2.0 epm

This condition is serious. You should recognize these symptoms and realize that this condition requires special treatment. When serious contamination occurs, inject only TSP according to the following formula:

CONSECO TSP = 60 x chloride

CE TSP = 30 x chloride

where: TSP = grams trisodium phosphate, dodecahydrate chloride = tiller water chloride, epm

NOTE

Do not inject more than 500 grams (18 ounces) of TSP at one time.

Chemical hideout and carryover also contribute to chemistry control problems. These two conditions, if not properly handled, can also cause boiler damage.

Chemical Hideout.— The chemical hideout seen in waste heat boilers is caused by concentration of boiler water chemicals. The symptoms of chemical

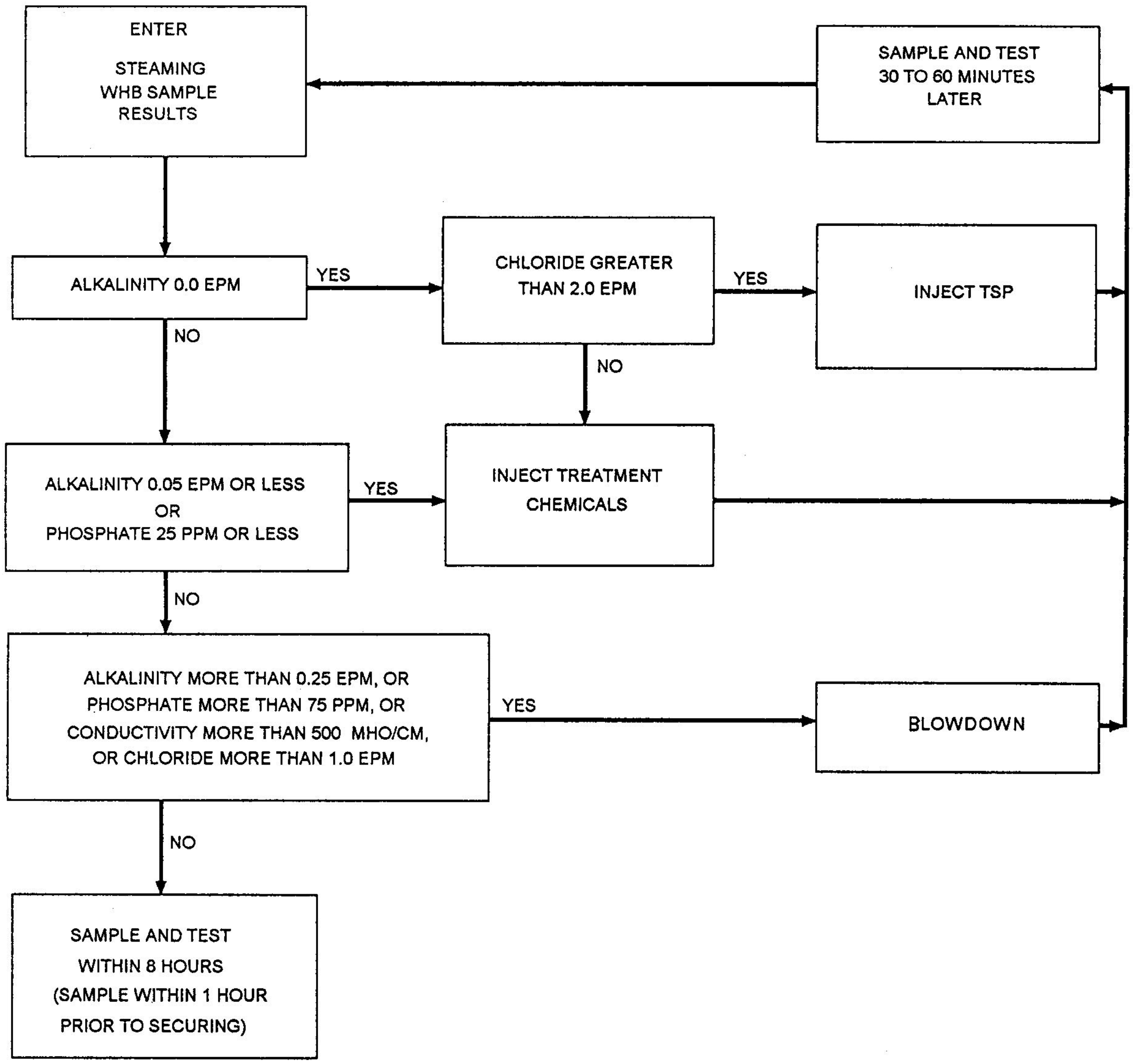


Figure 2-12.—Treatment logic chart for steaming waste heat boilers.

hideout are a decrease in all of the boiler water parameters. These symptoms are usually associated with an increase in generator load. When the load is reduced, the chemical levels increase. Another symptom is a large increase in the alkalinity or the phosphate after the boiler is secured.

Do not mistake the symptoms of carryover for hideout. If you suspect chemical hideout, secure the boiler and allow it to cool. Recirculate the boiler water for about 5 minutes and then obtain a boiler water sample. If the chemical level more than doubles, then hideout is confirmed.

Occasional incidents of hideout are normal when the generator is operating at high load. Reducing the generator load will stop the hideout. Do not continue to batch inject treatment chemicals if hideout has been confirmed. Maintain a minimum of at least 0.025 epm alkalinity and 5 ppm phosphate. When the boiler is secured, make sure it is drained and flushed repeatedly until a sample of the flush water shows the chemical levels to be within limits. Continual hideout that occurs at all generator loads may be caused by excessive waterside deposits. When this happens, inspect the boiler watersides to see if there is a need for chemical cleaning.

Chemical Carryover.— With waste heat boilers, a certain amount of boiler water carryover is a common occurrence. Waste heat boilers are supposed to have less than 1 percent carryover. In reality, however, many waste heat boilers have much higher levels. When high levels of carryover treatment chemicals and contaminants enter the steam condensate system, deposits can form in the steam lines, causing deterioration of the piping. As long as only one boiler is steaming, the effects of chemical carryover on the boiler water chemistry will be minimal. This is because most of chemicals leaving the boiler will be washed to the feedwater tank and then returned to the boiler. In this case, it will be easy for you to recognize excessive carryover by the entries in the boiler water logs. When two boilers are steaming, however, an increase in the chemical levels can occur in one boiler while a loss of chemicals can occur in the other. This is an indication of carryover. The problem is complicated by the fact that each of the boilers may carry over at different rates. When a different set of boilers is steaming, the boiler that was losing chemicals may start gaining them. Excessive carryover will cause the salinity/conductivity indicators to read higher than normal for the chemical chloride test. Another sign of carryover is any detection of alkalinity in the condensate or feedwater (feedwater sample pink to phenolphthalein).

You will need to use specific treatment procedures designed to compensate for chemical carryover. The batch dosage will not increase the alkalinity or the phosphate to the upper limits to allow for some increase in the chemicals. The low treatment levels reduce the amount of chemicals that leave a boiler having excessive carryover. When you discover that one boiler carries over more than another, secure the continuous treatment system to the boiler that is collecting the chemicals. Adjust the continuous treatment to the boiler that is carrying over to maintain the chemical levels as low as possible. Excessive carryover may cause the indicator alarms to activate. If this happens, just bypass the alarm. When contamination occurs, the boiler water chloride will carry over and cause high chloride test results in the feedwater. To reduce the contamination, it is more effective to blow down the boiler than to dump the feedwater. If the carryover is so severe that it is impossible to maintain the water chemistry, a problem with the steam separator may be indicated.

Slowdowns.— Once you have identified contaminants and additional chemicals in boiler water, how do you remove them? To remove the contaminates and excess chemicals, you must blow down the boiler. You must use either a separator blowdown for CONSECO boilers or a surface blowdown for combustion engineering (CE) boilers. You must use either a separator or surface blowdown any time your test results indicate the need. You must also perform periodic bottom blowdowns to control sludge buildup. You do these weekly, or as needed, to make sure the time between blowdowns does not exceed 168 steaming hours. You must perform a bottom blowdown daily if the boiler water sample contains sediment. In this case, the time between blowdowns should not exceed 24 hours. You will not have to secure a waste heat boiler before you perform a bottom blowdown.

If you follow the procedures for separator or surface blowdowns, you can reduce the alkalinity, phosphate, conductivity, and chloride of a steaming boiler by about 10 percent. If you need more than a 10 percent reduction, repeat the blowdown cycles as necessary. Wait 1 minute between blowdown cycles to allow the water to circulate.

CAUTION

Do not blow down a steaming boiler more than 50 percent at one time. This time period equates to five 3-inch blowdowns on the CONSECO or 5 minutes on the CE. If you overlook these precautions, an excessive chemical loss occurs. Sample and test as needed, and base further actions on the test results.

You are required to record the percentage of blowdown on a steaming boiler in the boiler water treatment log. To determine the percentage of blowdown, use the following formula:

$$\%\ blowdown = \frac{(C_B - C_A)}{C_B}$$

where: C_B = Conductivity before blowdown

C_A = Conductivity after blowdown

Remember, the conductivity is proportional to the concentration of all of the dissolved solids present in the boiler water from treatment chemicals and contaminants. The conductivity will remain within limits as long as the other test results are within the proper ranges.

The chloride level will provide you with an overview of the level of contamination entering the boiler. You can maintain an acceptable chloride level of less than 1.0 epm by maintaining good distillate quality and correcting any in-leakage of seawater or potable water.

Now that we have discussed the testing and treatment of boiler water, let's talk about where the boiler water comes from–the feedwater.

Feedwater

Feedwater is extremely important to the overall operation of the steam plant. After all, the feed tank is where the water that supplies the boilers comes from and where the water will return after it is condensed. This is why the quality of your ship's feedwater is so important. The quality of feedwater can ultimately affect the efficiency of your ship's engineering equipment and systems.

In a properly operating waste heat boiler system, the distillate (evaporator supply) contains the highest level of contaminants. Therefore, the makeup feedwater rate will determine the contaminate level that will enter the boiler. High makeup rates will cause the boiler water chloride and conductivity to increase. This condition will lead to higher use of treatment chemicals. Both conditions will cause greater sludge formations and an increase in the deposits on the watersides. To keep the makeup rate at a minimum, make sure all system leaks are corrected. In a properly maintained system, the makeup feedwater rate should be less than 900 gallons per day.

CONTAMINANTS.— There are four primary feedwater contaminants you will need to monitor: (1) seawater, (2) shore water, (3) oil, and (4) dissolved oxygen. In the following paragraphs, we will briefly discuss the origin, detection methods, effects, and corrective actions in regard to these contaminants.

Seawater.— Seawater is the most common contaminant found in marine boiler water/feedwater systems. The most routine source of intermittent seawater contamination in feedwater is the distillers, especially during start-up of the distillers. Contamination from the distiller air ejector drains can ultimately cause a rapid and large increase in boiler water chloride. The source of this contamination, of course, is from concentrated seawater, more commonly called brine.

Another source of seawater contamination in feedwater that will ultimately cause an increase in boiler water chloride are leaks in the condensate system. Small condenser leaks can cause a continual, low level increase in boiler water chloride. Tube leaks in a condensate cooler or control condenser can cause varying levels of contamination, depending on the amount of leak-by. The most common methods of detection you can use are the salinity/conductivity indicators or the chemical chloride test. You should readily notice the effects of condensate system leaks on the boiler water chemistry. There will be a noticeable decrease in alkalinity and phosphate and usually a somewhat large increase in conductivity and chloride.

You must locate, isolate, and correct the source of the contamination. You must continue to monitor (sample and test) the water, add chemicals, and blow down as needed to maintain these contaminants within their specified control limits. To remove high levels of contamination, however, the most effective method you can use is to secure, cool, dump, and flush the system.

Shore Water.— The second most common contaminant is shore water. Shore water contamination originates from a potable water supply from shore. Shore water can enter the feedwater system through a leaking steam coil in a hot water heater or by the use of contaminated shore source feedwater or steam.

You can detect contaminated shore water by monitoring the condensate cooler salinity indicator or by performing a feedwater hardness test. By reviewing the logs, you should also notice an effect on water chemistry, as indicated by a decrease in phosphate and increase in alkalinity. In most cases, you will also see an increase in conductivity and chloride. The corrective actions you should take are the same ones you should take for seawater contamination.

Oil.— The third major contaminate is oil. Steam, as well as feedwater, can become contaminated by oil if a leak develops in either a fuel oil or lube oil heater. Oil contamination can be indicated in the feedwater or boiler water sight glass, in feedwater or boiler water samples, or by oily condensate in the inspection tank. The effect oil contamination can have on boiler water chemistry is that it can induce carryover with no effect on alkalinity, phosphate, conductivity, or chloride. The corrective actions you should take are to find, isolate, and correct the source of the contamination. Surface blow the CE boiler to remove the contamination. If the boiler is steaming, treat the water as needed to keep the alkalinity and phosphate levels within the limits. You may have to secure, dump, and flush the boiler water to remove the oil contamination. If contamination levels are severe, clean the boiler with an alkaline boilout according to the procedures in *NSTM*, chapter 221, "Boilers."

Dissolved Oxygen.— The last contaminant we will discuss is dissolved oxygen. Dissolved oxygen in the feedwater as it enters the boiler will cause corrosion of the nonstainless-steel coils.

On the CE boilers and on some of the CONSECO boilers, a DFT is installed to reduce the oxygen level and minimize the corrosion rate. A DFT is not required on a boiler that has stainless-steel coils. You will need to check the DFT to make sure it is working properly. You will use the feedwater dissolved oxygen test to detect a malfunctioning DFT. In the case of a malfunctioning DFT, you must find the cause of the malfunction and have it corrected immediately. Dissolved oxygen contamination can often be traced to the following mechanical failures:

1. Improper operation of the DFT spray valves or steam atomizing valve
2. Inadequate venting of the DFT
3. Excessive water level in the DFT, flooding the steam atomizing valve
4. A fluctuating steam supply pressure as a result of a malfunction of the steam control valve

CONTROL METHODS.— For a brief review of the methods you should use for feedwater contamination control, look again at the chart in table 2-1. Again, notice that some of the test frequencies say "as required." All of these areas are monitored by an individual salinity/conductivity indicator. The test frequency will be based on the chemical test comparison results.

To perform salinity indicator comparison tests correctly, there are two things you must keep in mind:

1. Do not perform a comparison test on a feedwater tank sample within 1 hour of adding distillate to the feed tank.
2. Do not perform comparison tests within 1 hour after starting or securing a waste heat boils. During start-up and securing, the water level in the steam drum/separator will increase and boiler water will overflow into the steam/condensate system. This contamination will cause the indicators to read higher than the chemical chloride test.

Jacket Water

You must test the jacket water system for nitrite and chloride concentration levels. For proper protection of the jacket water cooling system, you should maintain the nitrite (NO_2) concentration level at a minimum of 1,000 ppm and the chloride level below 100 ppm. If the nitrite level is below 1,000 ppm, the Nalcool 2000 will not provide adequate corrosion protection. Chloride levels above 100 ppm indicate that seawater has leaked into the coding system. Another characteristic you should know about seawater is that it contains "hardness." The hardness in seawater will cause scale formation on hot metal surfaces in which the temperature is 130°F (54.4°C) or above. In dealing with these characteristics, let's first briefly describe the test for chloride.

CHLORIDE TEST.— To perform the chloride test, you should add two dippers of cupric sulfate to a 10 mL sample of Nalcool 2000 treated coolant. Allow it to stand until the sample is filtered. Then, immerse the end of a quantab chloride test strip in the sample. After an exposure period, remove the quantab and read the scale. Use the conversion chart included in the quantab test strip bottle to convert the scale reading to ppm chloride.

NITRITE TEST.— For the nitrite test, take 1 mL of Nalcool treated coolant and dilute it with 100 mL of distilled water. Dip a nitrite test strip into the diluted sample. After a brief development time, compare the color on the stick with the color chart on the side of the test stick container to determine the nitrite content.

When chloride and nitrite tests are performed, there are some important steps that are frequently overlooked. You can avoid these mistakes by taking the following precautions:

1. Always check the expiration date on the quantab and nitrite test stick bottles. Do not use the test sticks if the date has expired.
2. Do not try to use another quantab conversion chart if the one for the bottle you are using is missing. Because the quantabs are produced in batches, the conversion chart with each quantab bottle is specifically for use with the quantabs in that bottle.
3. Always keep the quantab and nitrite test stick bottles tightly closed when they are stored.
4. Never immerse the entire quantab test strip beneath the level of the solution you are testing; otherwise, the test will give you a false low result.

By taking these precautions and preforming the tests correctly, you can obtain reliable test results that will help you monitor and maintain the jacket water system.

Waste Heat Water

The nitrite test is the only test you will need for the waste heat water system. To perform this test, dip a nitrite test stick directly into a sample of waste heat water. After a brief development time, compare the color on the stick to the color chart on the container to determine the nitrite concentration level. Ideally, the nitrite concentration should he zero. From time to time, 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 2-13.—Suggested fuel management log.

however, leaks can develop in the waste heat exchanger and jacket water will enter the waste heat water system. If a leak develops, you must have it repaired as soon as possible. The nitrite concentration level must not exceed 25 ppm for any reason. There is a good reason for this concern. Both nitrites and berates are poisonous. Both of these toxins could enter the ship's potable water system through the heat exchangers of the distillers.

To summarize, we have discussed the basic procedures you should use to sample, test, and analyze the quality of the fuels, oils, and water supplies received, stored, and prepared for use aboard your ship. In the next section, we will tell you about some of the responsibilities you will have for documenting the quality of these important supplies.

LOGS AND RECORDS

The logs and records you will maintain in the oil lab are apart of the Navy's record system. This system will help you improve your record keeping through standardization, automation, speed, and efficiency.

Accurate, legible, and up-to-date logs and records plus the timely submission of accurate and legible reports reflect efficient administration of the oil laboratory. Remember, the logs and records maintained by the oil laboratory 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 oil laboratory logs, records, and reports system requires the regular and conscientious attention of all oil lab personnel. The person filling out the log or record must have knowledge of both the material recorded or reported and the correct method of documentation. Your engineer officer has a record reference file containing complete information on the methods of maintaining these important records.

FUEL OIL TEST 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 oil (FO) test log system helps the engineering department to achieve these requirements.

Fuel Management Log

An example of a fuel management log is shown in figure 2-13. This log is a locally prepared document that includes spaces for recording the results of all shipboard fuel tests. Whenever test results exceed maximum control limits, 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, including:
   a. visual inspections,
   b. shipboard analyses, and
   c. laboratory 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 important part of shipboard maintenance. It aids in the prevention of delivery of contaminated fuel to the gas turbine engines.

JP-5 Fuel Sample Log

Since most gas turbine ships can support helicopters, an aviation fuel (JP-5) system is installed. As we mentioned earlier, fuel quality requirements are more critical and extensive for JP-5 fuel than for 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 must 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
- Name of the person drawing the sample
- Fueling station number or filter/separator sampled
- Heading: Aviation Fuel Sample – Sediment and Flash Point

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

LUBE OIL TEST LOGS

Because of the importance of good quality lubricating oil, the Lube Oil Management Program was developed. The guidelines 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 (LO) 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.

Naval Oil Analysis Program Logs

The Naval Oil Analysis Program (NOAP) was developed for off-ship analysis. Under the computerized NOAP, special oil sampling techniques, sample equipment, sample markings, and shipping instructions are prescribed for shipboard machinery systems assigned to this program. All NOAP oil samples must be handled exactly as prescribed in the existing NOAP directives. These directives can be found in your current type commander's instructions.

Diesel Oil Log

For each shipboard diesel engine, the viscosity and reaction (acidity) test results must be recorded in the diesel engine oil test log, such as the one shown in figure 2-14. The oil lab must maintain a separate oil test log for each shipboard diesel engine.

WATER TREATMENT LOGS

The importance of maintaining accurate 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. Remember, the decision-making process involved in an effective water chemistry program aboard your ship will be supported by the information in these logs.

DIESEL ENGINE LUBE OIL TESTING LOG

ENGINE NO. 1 MONTH JUNE 19 92

1 DATE	2 TIME	3 ROD A READING	4 USED OIL ROD READING	5 [1] % THICKENING	6 [2] % FUEL DILUTION	7 REACTION (ACIDITY TEST)
6/1	1015	95	100	—	<1%	SAT

1. If column 3 reading is 100, subtract 100 from column 4 reading and enter result in column 5 (% oil thickening).

2. If column 4 reading is 100, calculate the percent of fuel dilution present from Chart A and enter in column 6 (% fuel dilution).

CHART A [3]

ROD A READING*	FUEL DILUTION
90%	1%
75%	3%
65%	5%

*Rod A readings that fall between these values shall be adjusted to the nearest value in the table. Any rod A reading below 65% is automatically cause for oil replacement.

3. If the lube oil sample exceeds the condemning limits of table 233-4, the engine lube oil is to be resampled and tested two additional times. If it still exceeds the limits, the condition is to be reported to the Engineer Officer for resolution.

Figure 2-14.—Diesel Engine Lube Oil Testing Log.

The engineering department of your ship will need both the engineer officer and the commanding officer, specific data to maintain the proper water conditions in the waste heat steam plant. The three logs you will use to record and maintain these data are:

1. Cover Sheet and Monthly Boiler Data Log

2. Feedwater Chemistry Worksheet/Log

3. Waste Heat Boiler Water Chemistry Worksheet/Log

4. Reserve/Makeup Feedwater Tests Log

5. Fuel and Water Report

6. Boiler Water/Feedwater Test and Treatment Chemical Inventory Log

To be an effective engineer, you should be familiar with the purpose, content, and general procedures for each of these logs. Let's take a brief look at each of them.

Cover Sheet and Monthly Boiler Data Log

You must prepare a cover sheet and Monthly Boiler Data log sheet, such as the one shown in figure 2-15. Notice in view A that the log contains the signatures of 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

The Feedwater Chemistry Worksheet/Log contains the daily chemical condition of the waste heat boiler feedwater system. The information you will record in this log includes the results of chemical tests, salinity indicator comparisons, shore steam and shore feedwater chemical test data, and remarks.

A sample of the Feedwater Chemistry Worksheet/Log is shown in figure 2-16. 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).

You must start a Feedwater Chemistry Worksheet/Log 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, just use

A. FRONT

WATER TREATMENT LOG

MACHINERY PLANT NO._____

USS G. TURBINE (DD-999)

MONTH DECEMBER , 19 92

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.B. SUP-1, PARA. 9510(1). TRANSCRIPT(S) WILL BE FURNISHED TO NAVSEASYSCOM WHEN REQUIRED.

NAVSEA 9255/6 (8-88)(FRONT)

B. BACK

NAVSEA 9255/6 (8-88)(BACK)

MONTHLY BOILER DATA

BOILER NO.			
STEAMING HOUR DATA			
TOTAL LAST MONTH			
HOURS THIS MONTH			
TOTAL STEAMING HOURS			
HOURS RUN DRY			
INSPECTIONS			
SCPI			
DATE LAST INSPECTED			
INSPECTED BY			
STM. HRS. SINCE INSP.			
CHENG			
DATE LAST INSPECTED			
INSPECTED BY			
STM. HRS. SINCE INSP.			
CLEANINGS			
WATER JET, WIREBRUSH OR EDTA WATERSIDE CLEANING			
DATE LAST CLEANED			
TYPE OF CLEANING			
STM. HRS. SINCE CLN.			
HYDROCHLORIC/SULFAMIC ACID WATERSIDE CLEANING			
DATE LAST CLEANED			
STM. HRS. SINCE CLN.			
FIRESIDE CLEANING			
DATE LAST CLEANED			
STM. HRS. SINCE CLN.			
CONTAMINATION			
STM. HRS. MODERATE			
% STM. HRS. MODERATE			
STM. HRS. SERIOUS			
% STM. HRS. SERIOUS			
CHEMICAL AND BLOWDOWN DATA			
TOTAL oz/g TSP			
TSP/1000 STM HR/1000 GAL			
TOTAL oz/g DSP			
DSP/1000 STM HR/1000 GAL			
TOTAL OUNCES C.S.			
NO. OF SURFACE BLOWS			
TOTAL % SURFACE BLOW			
NO. OF BOTTOM BLOWS			

BOILER SAFETY VALVES SET	DATE	PRESSURE LIFT	PRESSURE RESEAT
BOILER NO.			
PILOT			
SUPERHEATER			
#1 DRUM			
#2 DRUM			
#3 DRUM			
#4 DRUM			
BOILER NO.			
PILOT			
SUPERHEATER			
#1 DRUM			
#2 DRUM			
#3 DRUM			
#4 DRUM			
BOILER NO.			
PILOT			
SUPERHEATER			
#1 DRUM			
#2 DRUM			
#3 DRUM			
#4 DRUM			

WATER CHEMISTRY STANDARDS RUN		
TEST	DATE	RESULT
CONDUCTIVITY		
CHLORIDE		
ALKALINITY		
HARDNESS		

HYDROSTATIC TEST DATES		
BOILER NO.		
LAST 150% HYDRO		
LAST 135% HYDRO		
LAST 125% HYDRO		

DATES OF IMPORTANT EVOLUTIONS			
BOILER NO.	PSI/DATE	PSI/DATE	PSI/DATE
SOOT BLOWER HDE			
BOTTOM BLOWDOWN PIPING HDE			
AIR CASING TEST			
SATISFACTORY BOILER FLEXIBILITY TEST			

GOVERNOR SETTINGS									
NUMBER									
FORCED DRAFT BLOWERS	DATE / STNG								
NUMBER									
FUEL OIL SERVICE PUMPS	DATE / STNG								
NUMBER									
MAIN FEED PUMPS	DATE / STNG								
NUMBER									
MAIN FEED BOOSTER PUMPS	DATE / STNG								

Figure 2-15.–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 NITRATEx0.1= EPM CHLORIDE		INDICATOR READING		COM-PARISON	HARDNESS mL EDTAx0.2= EPM HARDNESS		OIL KING INITIAL
		mL	EPM	μMHO/CM	EPM	SAT/UNSAT	mL	EPM	
0115	CNTL COND		.01		.01	SAT		02	
0130	COND CLK		.02		.02	SAT			
0321	COND CLK		.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	INDICATOR READING EPM	CHLORIDE mL MERCURIC NITRATEx0.1= EPM CHLORIDE mL	CHLORIDE EPM	HARDNESS mL EDTAx0.2= EPM HARDNESS mL	HARDNESS EPM	OIL KING INITIAL

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		MORPHOLINE TREATED SYSTEM	
PFB	PRIOR TO FEEDING THE BOILER	AOL	60 TO 90 MINUTES AFTER ON LINE
AOL	WITHIN 3 HOURS AFTER BOILER ON LINE	RTE	CARRIERS EVERY 4 HOURS OTHERS EVERY 12 HOURS
RTE	WITHIN 24 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	11 MAY 92	DR	11 MAY 92	W.T. DOOR	11 MAY 1992

B. BACK

Figure 2-16.—Feedwater Chemistry Worksheet/Log.

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/EDO 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	JK	AA
1645	RTE	0.8	0.2	2.4	55	25°	205	0.7	0.28	MK	LO
2000	PTS	0.8	0.2	2.4	55	25°	205	0.7	0.28	BC	EN
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 | TOTAL DSP INJECTED

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) PAGE 41

TIME	REMARKS

	STEAMING HOURS	STEAMING HOURS UNDER CONTAMINATION: MODERATE	SERIOUS
PRIOR HOURS STEAMED THIS MONTH	12206.7	305.7	22.5
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
ADD 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
AA	20 DEC 92	CG	20 DEC 92	W. T. DOOR	31 DEC 92

B. BACK

Figure 2-17.—Waste Heat Boiler Water Chemistry Worksheet/Log.

the front of a single log sheet to record the dates that testing was not needed. You should also include a remark stating why testing was not necessary.

Waste Heat Boiler Water Chemistry Worksheet/Log

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

A sample of a Waste Heat Boiler Water Chemistry Worksheet/Log is shown in figure 2-17. Notice in views A and B that both the front and back sides of this log contain sections for data on chemical test results, chemical treatments, blowdowns, steaming hours, and remarks.

Reserve/Makeup Feedwater Tests Log

A sample of the Reserve/Makeup Feedwater Tests Log is shown in figure 2-18. The front and back of this log, displayed in views A and B, contain sections for chemical test results for salinity indicator comparisons and shore source feedwater (steam condensate or processed feedwater) quality. This log is normally prepared daily unless all of the feedwater tanks are empty. If all of the tanks are empty and no testing is required, enter the inclusive dates on the front of the log and give the reason in the remarks section.

Fuel and Water Report

The Fuel and Water Report, shown in figure 2-19, is a daily report of the fuel and water status the oil lab must prepare to reflect these conditions at 0000 hours. The commanding officer receives this report daily. The report contains data, such as total fuel and 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 12 o'clock reports. The OOD retains the copy.

Boiler Water/Feedwater Test and Treatment Chemical Inventory Log

The Boiler Water/Feedwater Test and Treatment Chemical Inventory Log shown in figure 2-20 provides a record and monthly inventory of test and treatment chemicals. As shown in views A and B of the log, each standard, treatment chemical, and stock chemical must be accounted for monthly. This log, when properly maintained, is a valuable asset the oil lab can use to keep the test and treatment chemical stocks properly rotated and as fresh as possible.

Jacket Water Log

An example of a Diesel Engine Jacket Cooling Water System/Treatment Log is shown in figure 2-21. As shown in views A and B, you will use both the front and the back to record data.

This is a monthly log, consisting of the following sections:

1. Chemical Test Results: You must maintain this section on a 2400-hour clock basis. You should enter the date and time for the following actions:

   a. Completion of jacket water sampling

   b. Completion of draining a portion of jacket water

   c. Completion of dumping the entire jacket water system

   d. Completion of freshly filling

   e. Completion of water additions

Make sure you use the appropriate codes listed on the back of the log for all entries. Both the tester and the EOOW/EDO must enter their initials when the tests are completed.

2. Chemical Treatment: Make appropriate entries for the following information:

   a. Amount of Nalcool 2000 required

   b. Date and time of completion of the chemical addition

Circle all out-of-limits readings. Make sure the person who performed the chemical treatment calculations has initialed the results.

3. Remarks: This section should describe significant events related to the jacket cooling water

RESERVE/MAKEUP FEEDWATER TESTS LOG

(FILL IN APPLICABLE COLUMNS)

NAVSEA 9255/10 (8-88)(FRONT)

SHIP U.S.S. G. TURBINE (DD-999) DATE 10 MAY 92

TANK NO.	TIME	CODE	SALINITY INDICATOR, EPM	CONDUCTIVITY INDICATOR, µMHOS/CM	CHLORIDE LIMIT: 0.10 EPM MAX		HARDNESS LIMIT: 0.10 EPM MAX		DEMINERALIZER CONDUCTIVITY		OIL KING INITIAL
			LIMIT: 0.10 EPM	LIMIT: 15 µMHO/CM	mL MERCURIC NITRATE	mL x 0.1= EPM	mL EDTA	mL x 0.2= EPM	INLET MAX 15 µMHO/CM	OUTLET MAX 1.0 µMHO/CM	
5-220-1	Ø800	DAY			.4	.Ø4	.1	.Ø2			OK
5-300-1	Ø810	DAY			.2	.Ø2	Ø	Ø			OK
5-220-1	1645	PPS			.2	.Ø2					WO
5-220-1	165Ø	AOS	.Ø2								WO
5-220-1	2045	AOS	.Ø1								OK
5-220-1	2355	AOS	.Ø1								OK

LEGEND/TEST CODE

DAY	DAILY	AOS	AFTER ON SUCTION	PPS	PRIOR TO PLACING ON SUCTION	OTH	OTHER

A. FRONT

RESERVE/MAKEUP FEEDWATER TESTS LOG

NAVSEA 9255/10 (8-88)(BACK)

TIME	REMARKS:

INIT.	LCPO	DATE	INIT.	MPA	DATE
PR		11 MAY 92	JD		11 MAY 92

REVIEWED (ENGINEER OFFICER) Joe Engineer DATE

SHORE SOURCE FEEDWATER CHEMICAL TEST DATA

CONSTITUENT OR PROPERTY	STEAM CONDENSATE SUPPLIER	STEAM CONDENSATE SHIP	PROCESSED FEEDWATER SUPPLIER	PROCESSED FEEDWATER SHIP
pH RANGE	8.0–9.5	> 5.4	NOT REQ.	5.4–8.2
HARDNESS EPM LIMIT	0.10	0.10	NOT REQ.	0.10
CONDUCTIVITY µMHO/CM LIMIT	25	< 40	2.5	< 40
SILICA PPM LIMIT	0.2	0.2	0.2	0.2
ACTIVITY				

B. BACK

Figure 2-18.—Reserve/Makeup Feedwater Tests Log.

FUEL AND WATER REPORT

NAVSEA 9255/9 (1-87) (FRONT)
(FORMERLY NAVSEA 9510/1)

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		
PERSONNEL ON BOARD	GALLONS USED PER PERSON	STANDARD
243	26	27

FEEDWATER CONSUMPTION	
NOT UNDERWAY (GALLONS PER HOUR)	UNDERWAY (GALLONS PER HOUR)
	357

REMARKS:

* STRIPPED 200 GALS FROM JP-5 SERVICE TK
* GAINED 150 GALS Sounding Tanks During Heavy seas

Figure 2-19.—Fuel and Water Report.

system of that particular diesel engine. You may need to insert additional pages for remarks. Make sure all remarks are accompanied by the date and time. If you have a doubt whether or not you should make a certain entry, go ahead and enter it. You should record the following types of information:

a. The reasons for out-of-limits conditions and the actions taken to correct the problem

b. The source of water used for filling or topping off the cooling system

c. The reason for partially draining or dumping a cooling system

The LCPO/MPA must review and initial this log. The log must then be reviewed and signed by the engineer officer.

Waste Heat Water Log

This locally prepared log is recommended, but it is not required by NAVSEA. Remember, although a log is not required by NAVSEA, your ship or type commander may have different requirements. Even if you do not use a log, the test results must still be entered in the engineering log.

BOILER WATER/FEEDWATER TEST AND TREATMENT CHEMICAL INVENTORY LOG

NAVSEA 9255/16 (8-91)(FRONT)

Ship__________ Date__________ Page__________

Item	NSN	Qty with less than 6 months shelf life remaining	Qty with 6 months or more shelf life remaining	Qty required for 6 month deployment	Sufficient onboard stock? Yes/No
Standards					
Chloride (2.0 epm)	9G 6810-01-129-3762				
Conductivity (1,400 μmho/cm)	9G 6810-00-945-7652				
Hardness (0.2 epm)	9G 6810-01-125-5234				
Methyl purple alkalinity (6.0 epm)	9G 6810-0[illegible]-259-8231				
pH 7.00 ± 0.05 at 25°C	9G 6810-01-239-7562				
pH 10.00 ± 0.05 at 25°C	9G 6810-01-239-7563				
Treatment Chemicals Caustic soda (lye, sodium hydroxide)	9Q 6810-00-270-8177				
Disodium phosphate anhydrous (sodium phosphate, dibasic, O-S-639)	9G 6810-00-584-4298				
Hydrazine, 7%	1H 6810-01-304-5373				
Ion exchange resin	1H 6810-01-029-4217				
Morpholine, 40%	9G 6810-00-419-4298				
Nitrogen (chelant treatment)	9G 6830-00-656-1596				
Sodium Nitrite	9G 6810-00-270-3254				
Trisodium EDTA, trihydrate	1H 6810-01-312-4076				
Trisodium phosphate dodecahydrate (sodium phosphate, tribasic, dodecahydrate, O-S-642, Type II)	9G 6810-01-082-5415				

A. FRONT

BOILER WATER/FEEDWATER TEST AND TREATMENT CHEMICAL INVENTORY LOG

NAVSEA 9255/16 (8-91)(BACK)

Ship__________ Date__________ Page__________

Item	NSN	Qty with less than 6 months shelf life remaining	Qty with 6 months or more shelf life remaining	Qty required for 6 month deployment	Sufficient onboard stock? Yes/No
Stock Chemicals Amino acid reagent pillows	9G 6810-01-169-1770				
Ampoules, 0-40 ppb oxygen	9L 6630-01-068-5210				
Ampoules, hydrazine	1H 6810-01-312-4075				
Chloride indicator capsules	9G 6810-00-753-4907				
Citric acid reagent pillows	9G 6810-01-169-6568				
Dimethylglyoxime	9G 6810-01-082-5414				
Hardness buffer	9G 6810-01-072-1977				
Hardness indicator	9G 6810-01-072-1979				
Hardness titrating solution	9G 6810-01-072-1978				
Isopropyl alcohol (isopropanol, 2-propanol)	9G 6810-00-227-0410				
Mercuric nitrate	9G 6810-00-281-4163				
Methyl purple indicator capsules	9G 6810-00-142-9290				
Nitric acid	9G 6810-00-270-9978				
Phenolphthalein indicator	9G 6810-00-223-7612				
Potassium chloride crystals	9L 6810-00-136-1004				
Silica-1 reagent	9G 6810-01-169-1773				

LCPO INIT.	LCPO DATE	MPA INIT.	MPA DATE	REVIEWED: (ENGINEER OFFICER)	DATE:

B. BACK

Figure 2-20.—Boiler Water/Feedwater Test and Treatment Inventory Log.

DIESEL ENGINE JACKET COOLING WATER SYSTEM

NALCOOL 2000 TREATMENT LOG

PAGE____

ENGINE NO.________SHIP____________________MONTH__________,19__

CHEMICAL TEST RESULTS

DATE	TIME	CODE	CHLORIDE DIVISIONS ON QUANTAB	CHLORIDE PPM CHLORIDE (from chart) limit: 100 ppm	NITRITE minimum required: 1000 ppm	INITIALS tester / / EOOW

CHEMICAL TREATMENT

NALCOOL 2000 GALLONS	DATE	TIME	INITIALS

A. FRONT

DIESEL ENGINE JACKET COOLING WATER SYSTEM

NALCOOL 2000 TREATMENT LOG

PAGE____

DATE	TIME	REMARKS:

CODES

FF FRESHLY FILLED
ACA AFTER CHEMICAL ADDITION
DRN PORTION OF COOLANT DRAINED
WA WATER ADDITION
AWA AFTER WATER ADDITION
RTE ROUTINE SAMPLE
D DUMPED
OTH OTHER

LCPO INIT.	LCPO DATE	MPA INIT.	MPA DATE	REVIEWED: (ENGINEER OFFICER)	DATE

B. BACK

Figure 2-21.—Diesel Engine Jacket Cooling Water System Nalcool 2000 Treatment Log.

SUMMARY

As an oil king, you will be responsible for one of the most important operations in the engineering department, the maintenance of the fuels and lubricating oils. This chapter has pointed out the importance of having clean fuel reach the gas turbine engines and the necessity of maintaining a high quality lubricating oil product. The knowledge you gained from this chapter concerning safety, test requirements, and record keeping should provide you with a foundation you can use to ensure the sound operation of the propulsion plant.

This also holds true if you are assigned waste heat boilers (WHBs) or diesel generators. The proper testing and treatment of the WHBs and SSDGs will ensure their proper operation and provide for a longer life-span for the equipment. As a GSM assigned to the oil lab, you hold an important and necessary job within the engineering department structure.

CHAPTER 3

ENGINEERING CONTROL SYSTEM OPERATION

One of the most remarkable design features of a gas turbine-powered ship is that the engineering plant can be controlled from a central area located away from the actual equipment and systems. This central location, known as the central control station (CCS), is your ship's primary control watch station for operating nearly all the equipment in the engineering plant. Any of your ship's engineering systems that are not controlled in the CCS can at least be monitored there. The CCS system not only allows for efficient watch standing but also permits the engineering officer of the watch (EOOW) and the propulsion, electrical, and damage control watch standers of your ship to have a quicker and more comprehensive look at the vital parameters of all engineering equipment and systems. In all gas turbine-powered ships, the foundation of the CCS is the engineering control system.

The engineering control systems on gas turbine-powered ships come in three major designs. The design of the control system is based on the class of ship. The DD-963, DDG-993, and CG-47 class ships use the engineering control and surveillance system (ECSS) to operate their gas turbine equipment. The FFG-7 class ships use the engineering plant control system (EPCS) to both operate and monitor their gas turbine equipment. The relatively new DDG-51 class ships use the machinery control system (MCS) to both control and monitor their gas turbine equipment. In your career as a GSM, you may not be directly involved with all of these control systems. You should, however, be aware of each of these systems and how they relate to the engineering plant. Of course, as you advance in the GS rating, you should also be aware of certain watch-standing requirements associated with these systems.

After reading this chapter, you should have a good understanding of the function and operation of the three major engineering control systems used on gas turbine-powered ships. You should also be able to discuss how each of these control systems interacts with the equipment and systems of the ship's engineering plant. Although you may not work on all these systems, the knowledge you gain from this chapter should help you to both study for advancement and prepare for your watch-standing qualifications as you become senior in the GS rating.

Remember, the information in this chapter is intended for training and advancement study only. It is not intended to replace the engineering operational sequencing system (EOSS) or the appropriate technical manuals for your ship's equipment and systems. In this chapter, we will provide you with an overview of the consoles of the three major engineering control systems used on gas turbine-powered ships. We will not discuss these consoles in depth. For a detailed description, we recommend you review *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical)* 3, Volume 2, NAVEDTRA 10564.

CENTRAL CONTROL STATION OPERATIONS

In all gas turbine-powered ships, the CCS is the main operating station from which the engineering plant can be monitored and controlled. The specific control consoles located in the CCS will vary, however, depending on the class of ship. On the DD-963, DDG-993, and CG-47 class ships, the propulsion and auxiliary control console (PACC), electric plant control console (EPCC), fuel system control console (FSCC), and damage control console (DCC) are located in the CCS. On the DDG-51 class ships, the PACC, EPCC, engineering officer of the watch/logging unit (EOOW/LU), and DCC are located in the CCS. On the FFG-7 class ships, the propulsion control console (PCC), EPCC, auxiliary control console (ACC), and DCC are located in the CCS. In this chapter, we will briefly discuss some basic operations performed from the major control consoles located in the CCS. We will begin our discussion with the CCS control consoles found on the DD-963, DDG-993, and CG-47 class ships. Next, we will describe those found on the DDG-51 class ships. Last, we will talk about the ones on the FFG-7 class ships. We will provide you with a fundamental overview of these consoles. For a detailed description of operating procedures for specific control consoles, we recommend you refer to the EOSS, engineering operational procedures (EOP), and appropriate technical manuals for your ship's equipment and systems.

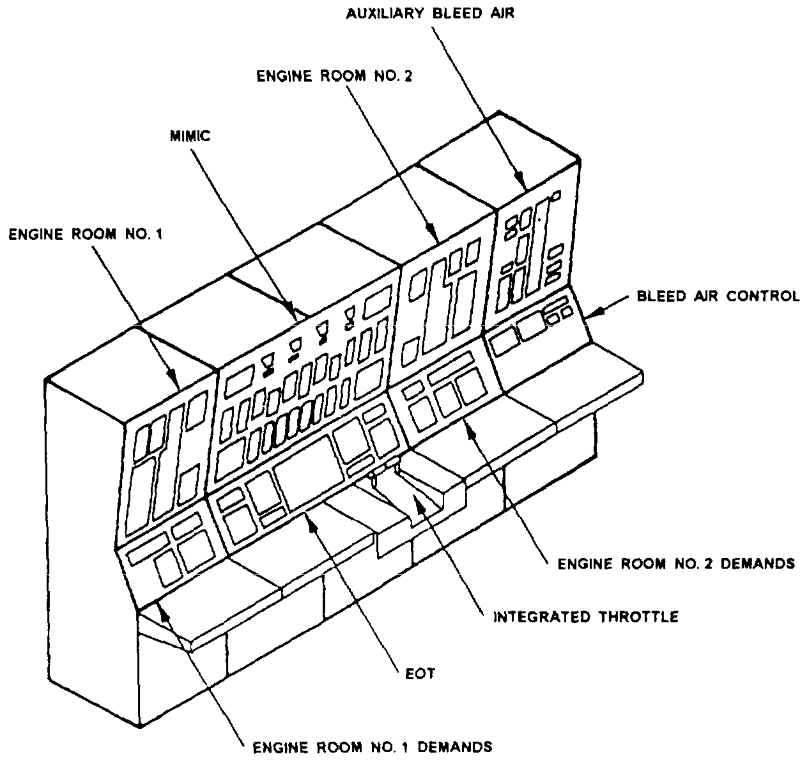


Figure 3-1.—PACC layout.

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

On DD-963, DDG-993, and CG-47 class ships, the CCS is located remotely from the ship's machinery spaces. This design allows the engineering plant to be monitored and controlled with a minimum of personnel.

The two major consoles that control the engineering plants on these 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 these two consoles in the following paragraphs.

PACC

The PACC is the central control point in the propulsion plant's control system. The PACC monitors and controls the operation and performance of the ship's main propulsion equipment and systems by sending commands that will operate specific controls to sequence the operation of equipment or control subsystem operation.

The PACC contains electrical equipment that is capable of controlling and monitoring both propulsion plants and most of the ship's auxiliary systems. Notice in figure 3-1 how each panel of the PACC is dedicated to particular types of control and monitoring. In this section, we will briefly discuss the following control and monitoring systems that are operated from the PACC:

1. Fuel oil service system
2. Lube oil system
3. Air system
4. Gas turbine module (GTM) control
5. Engine order telegraph (EOT) control
6. Throttle and pitch
7. Plant mode
8. Auxiliaries

In the following paragraphs, we will provide a basic overview of these systems. For detailed information, consult the appropriate EOSS, EOP, and technical manuals.

Fuel Oil Service System

For the fuel oil service system, the control and monitoring functions at the PACC can be divided into two major categories: (1) fuel oil service control and monitoring, and (2) GTM control and monitoring. Together they function to deliver fuel oil at the proper pressure and temperature to the individual propulsion gas turbines. In the following paragraphs, we will describe the monitoring and control functions available at the PACC for these two categories. Let's first talk about those for the fuel oil service.

FUEL OIL SERVICE.— For fuel oil service monitoring and control, the following nine 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

For all nine functions, monitoring is continuously available at both the PACC and the propulsion local control console (PLCC), but control is available only at one console at a time.

At the PACC, control of the fuel oil service system consists of remote manual control of the suction and recirculating valves in the two service tanks and remote automatic or manual control of the two fuel oil service pumps. For valve control, the PACC sends open or close commands to the valve motor controllers. Because both valves in a service tank must be in the same state (either open or closed) to operate properly, the PACC can send these commands simultaneously to both the suction and the recirculating valves. For service tank control, separate control switches at the PACC allow the operator to control each service tank independently. At the PACC, service tank monitoring consists of tank temperature high and low alarms.

From the PACC, the operator can operate the two fuel oil service pumps in either the manual or automatic control mode. By setting the pump mode switch to MANUAL, the operator can control each of the pumps individually by using the push buttons on the PACC. Setting the pump mode switch to either the A LEAD or B LEAD position sets up the automatic control circuits, allowing the operator to select a lead pump and a standby pump. From this point, pump control becomes a function of header pressure and time.

GTE FUEL OIL SERVICE.— For gas turbine engine (GTE) fuel oil monitoring and control, the following five functions are available at the PACC:

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

The primary function of the GTE fuel oil controls available at the PACC is to control the GTE fuel shutdown valves and the emergency trip valves. Some controls are also provided for fuel purging. By closing either of the two main fuel valves, the operator can prevent fuel from flowing to the engine fuel manifold. The operator's control of these valves, however, depends on whether the GTE control mode is manual, manual initiate, or auto initiate. With the GTE in the manual control mode, the operator can use the push-button indicator on the PACC to generate main fuel valve control signals to the freestanding electronics enclosure (FSEE). With the GTE in either the manual initiate or auto initiate control mode, the fuel valve control signals are automatically generated by the start/stop sequence control logic.

The other GTE fuel oil controls at the PACC are related to fuel purging operations. A common condition requiring fuel purging is when an engine has been shut down for over 15 days. The fuel will likely have to be purged before the engine is started. This can be done by motoring the GTE with the fuel purge valve open. At the PACC, the operator opens the fuel purge valve by depressing the FUEL PURGE ON push button. This allows the fuel oil to flow through the engine fuel lines and into the leak detection tank. In fact, the only way the fuel valve can open is if an operator pushes the FUEL PURGE ON push button at either the PACC or PLCC.

Now that we have described the fuel oil service controls located at the PACC, let's talk about the controls for the lube oil system.

Lube Oil System

Each main engine room (MER) has its own separate and independent lube oil system that can be monitored and controlled from the PACC. Monitoring is available continuously at both the PACC and the PLCC, but control is available only at one of the consoles at a time. At the PACC, lube oil control consists of either manual or automatic control of the two lube oil service pumps. The function of these pumps is to provide additional oil to the lube oil pump that is attached to the main reduction gear.

For the operator to be able to enable the pump controls at the PACC, the local control switches on the pumps must be in the REMOTE position. Then, the operator can obtain individual manual control of each of the two pumps by using the three push-button indicators on the PACC. Setting the pump mode auto/manual logic switch to MANUAL allows the operator to control pump speed. When the operator depresses the push-button indicator at the PACC, the associated command goes 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, allowing the operator to select a lead pump and a standby pump. From this point, pump control becomes a function of header pressure and time.

Lube oil control can be transferred from the PLCC to the PACC by depressing the control transfer switch at the PLCC. Then, the control commands can go from the PACC 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 GTMs and the gas turbine generator sets (GTGSs): (1) the bleed air system, and (2) the high-pressure air system. These two air systems are interconnected by piping and valves. Both systems are monitored and controlled at the PACC. Control for both systems is available continuously and simultaneously at both the PACC and the PLCC. Let's now look at each of these systems separately, starting with the bleed air system.

BLEED AIR SYSTEM.— There is a separate bleed air line to each GTM. Located in each of these lines is a motor-operated bleed air valve. The position of the valve can be controlled manually at the PACC as long as GTM control is transferred to the PACC. The valve can also be controlled automatically by the start/stop sequence logic circuits. The status indicator lights on the PACC will show the position of each bleed air valve.

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 bleed air system. The ISOLATE push button, located on the PACC, will illuminate when the valve is closed and the No. 3 GTGS has been isolated. On the CC-47 class ships, the GTGS solenoid-operated bleed air valves can be controlled from a bleed air valve control panel next to the EPCC in the CCS.

Now let's examine the bleed air system in terms of its four distinct subsystems:

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

We will briefly discuss each of these subsystems in the following paragraphs.

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

Normal start air is used during a normal start sequence. The start air for the GTM is controlled by the motor air regulator valve. This valve is controllable at the PACC and can provide either one of two functions: a valve-opened, nonregulated (start) position or a valve-opened, regulated at 22 psi (motoring) position. In the GTM, the last valve in the start air flow is the starter air valve. The operator at the PACC can control this valve either manually or automatically as long as GTM control has been transferred to the PACC. The last valve in the GTGS start air flow is through one of the two starter air valves, either high pressure or low pressure, depending on which is selected. Once the valve is selected, then the start air control is maintained by the GTGS's system throughout the start sequence.

The operator at the PACC can start the emergency start air by depressing the EMERGENCY push button. This action allows air from the high-pressure storage flasks to be made available for GTM starts. The exception to this is in the case of the DDG-993 class ships, which do not have a high-pressure/low-pressure (HP/LP) air reducing station for GTM starting. The high-pressure air is reduced and enters the GTM start air system upstream of the motor air regulator valve.

Masker Air System.— The operator can align the masker air system from the PACC. The masker air system causes the valves of the start air system to line up to either one of two possible positions, depending upon whether the masker air is ON or OFF and whether the air system is in the automatic control mode. With the masker air ON after a start sequence, the start air system valves will automatically align to allow masker air to flow to the masker air belts. With the masker air in the OFF condition after a start sequence, the masker transfer valve will remain in the start position. The operator can perform both of these valve alignments manually from the PACC.

Prairie Air System.— The prairie air system consists of the prairie air supply valve. At the PACC, the operator can use the ON/OFF push-button indicator to operate and control prairie air in both engine rooms. If one of the prairie supply valves should fail to respond to a command, both sections of the push-button indicator will fail to illuminate.

Anti-Icing Air System.— The anti-icing air system includes a bleed air injection system and an electrical intake heater system. For both the GTMs and GTGSs, the bleed air injection system is used to increase the intake combustion air temperature. The electrical heater in this system is used to prevent ice formation of the stack intake louvers and the blow-in doors. For the operator at the PACC to be able to use the pushbuttons to control the heaters, the intake heater controllers must be in the ON position.

For each GTM and GTGS, monitoring for the bleed air injection system and the anti-icing system is available at the PACC. The operator at the PACC can control the bleed air injection system manually.

High-Pressure Air System.— The high-pressure air system is used for emergency starting of the gas turbine generators (GTGs) and the main propulsion GTEs through an HP/LP air reducing station (except on DDG-993 class ships). It is also the primary means to start the first GTG, because bleed air is not available. The two HP air compressors provide the system air to the five air flasks in each MER and to the four air flasks in the No. 3 GTG room.

GTM Control System

Most of the GTM control and monitoring circuitry is used primarily for normal start-up and shutdown of the propulsion gas turbines. All four GTM control and monitoring functions can be accomplished at the PACC. At the PACC, there are three possible start/stop modes for each GTM: (1) manual, (2) manual initiate, and (3) auto initiate. We will describe the auto initiate mode in the plant mode control section of this chapter. For now, let's take a brief look at the manual and manual initiate modes.

In the manual mode, the operator must generate the start or stop commands at every step of the sequence. This means the operator must make sure each step is accomplished at the proper time. The sequencing of these manual controls is the same as those shown in the time sequential flow charts found in the EOSS and appropriate technical manuals.

In the manual initiate mode, the starting and stopping of the GTE is 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 required start-up and shutdown steps. This mode is semiautomatic because operation of the brake and clutch (the brake only on the CG-47 class ships) must be done manually. Now, let's shift from the GTM control system and take a look at the EOT control system.

EOT Control System

The EOT control system controls the rpm and pitch signals for both engine rooms. This system is used when the PACC is in control of the throttles.

To generate propulsion command information, the ECSS uses the three following types of EOTs:

1. Standard order–EOTs consisting of standard engine commands, such as 2/3 back, 1/3 back, stop, 1/3 ahead, 2/3 ahead, and so forth

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

3. Plant mode–EOTs consisting of commands for secured, split-plant, and full-power operations

These three EOT's are at the SCC and the PACC. All three communicate via the command and control serial data bus.

STANDARD ORDERS.— For standard orders, the operator initiates the commands at the SCC by moving the integrated throttle control (ITC) lever to the standard order position and depressing the stand order ALERT push button. This sends the order to the PACC and the PLCC for that particular shaft. If the PACC has control, the operator can acknowledge the order by using either one of the two following procedures:

1. Pushing the STD ORDER switch indicator, which silences the EOT bell, and moving the ITC to match the command from the bridge, as displayed by the

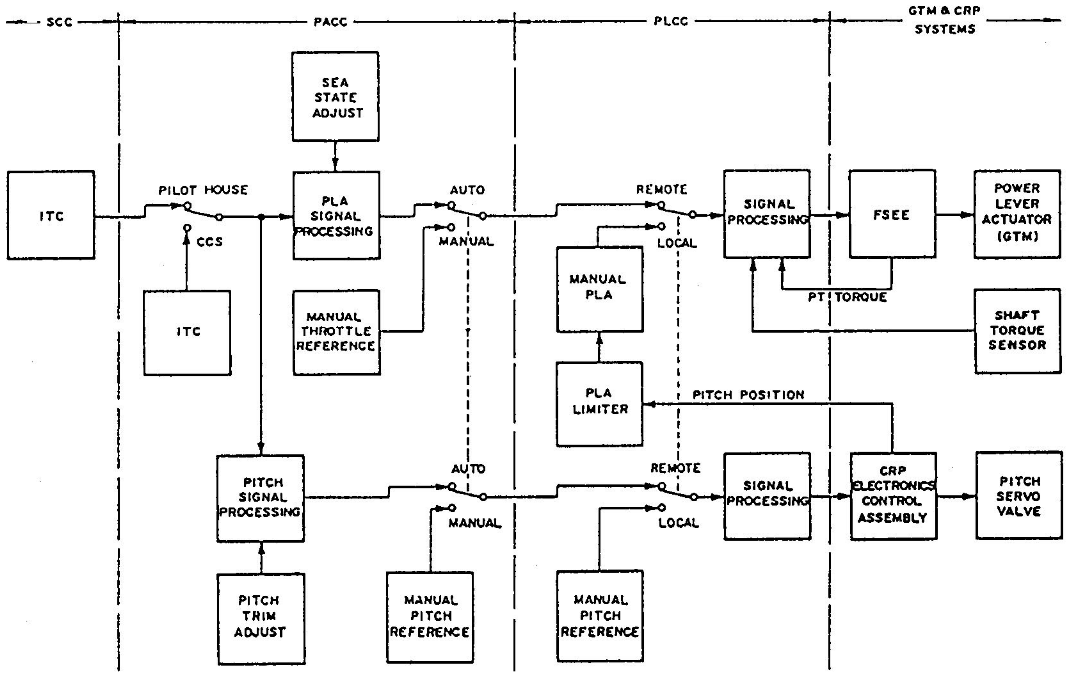


Figure 3-2.—Throttle and pitch control block diagram.

flashing ITC indicator. This will cause the indicator to illuminate steadily.

2. Moving the ITC lever to the new indicated command. This will silence the bell and cause the indicator to illuminate steadily.

DIGITIZED ORDERS.— 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 ORDERS.— The plant mode EOT consists of three possible orders: secure, split plant, and full power. When the plant mode is activated, the signal is sent to the PACC. The signal causes the indicator for the given order to flash and the bell to sound. The operator acknowledges the order by depressing the flashing indicator. When the new plant condition is achieved, the indicator will illuminate steadily. Now, let's move from the EOTs to the throttle and pitch control system.

Throttle and Pitch Control System

The throttle and pitch control system provides control of shaft speed and propeller pitch. This 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 3-2 shows an overall control block diagram of the throttle and pitch control system.

We have briefly mentioned the plant mode control system earlier in this chapter. We will now tell you how it works.

Plant Mode Control System

The plant mode control electronics is located in the PACC. This control works with the start/stop logic at the PACC. As we mentioned earlier, the auto initiate mode is a part of the plant mode control logics. In plant mode control, the operator can start up or shut down the 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

2. Throttle

3. Brake

4. Air

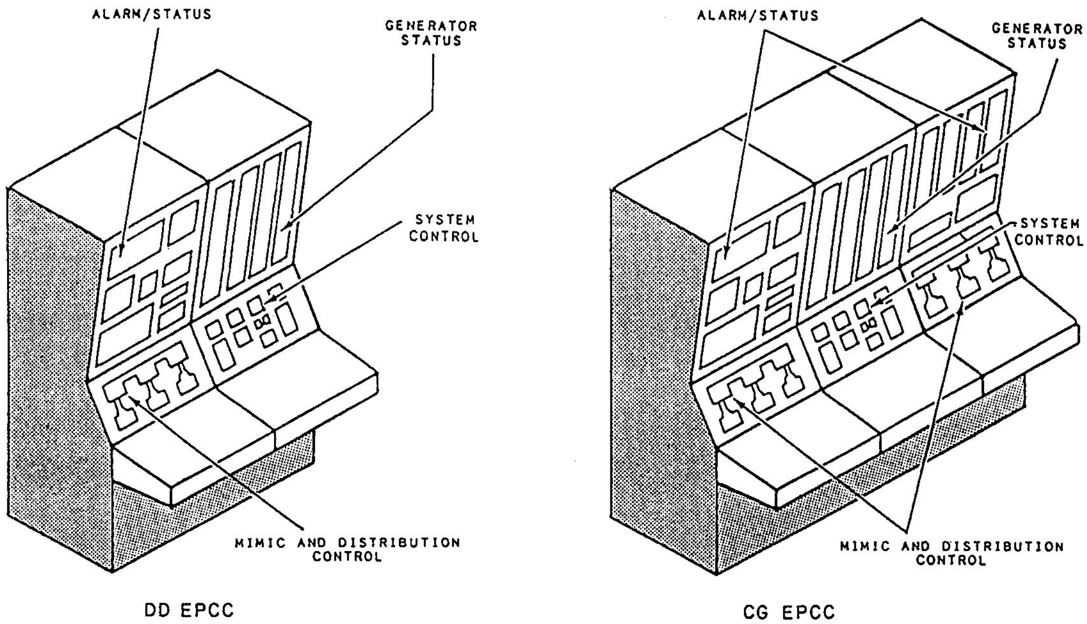


Figure 3-3.—EPCC layout.

As long as these systems are in AUTO and the propulsion plant is in one of the three propulsion configurations (either secure, split plant, or full power), the plant mode system control is enabled. With plant mode control enabled, the operator can perform the following mode changes at the PACC:

1. Secure to split plant (CG-47 class ships only)
2. Split plant to full power
3. Full power to split plant
4. Full power or split plant top secure
5. Change engine

Now let's shift from the plant mode control system to the remaining system that can be controlled at the PACC, the auxiliaries.

Auxiliaries Systems

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

1. Waste heat boiler (WHB) (emergency stop only)
2. Seawater service (start/stop)
3. Freshwater service (start/stop)
4. Refrigeration plant
5. Sewage and waste system 6.
6. Distilling plant
7. Air-conditioning (A/C) plant
8. High-pressure air system
9. Ship's service air system
10. Chilled-water expansion tank system (CG-47 class only)
11. Combat dry-air system (CG-47 class only)
12. AEGIS pump system (CG-47 class only)

You have just read about the eight control systems available at the PACC in DD-963, DDG-993, and CG-47 class ships. Now, let's take a look at the control systems at the EPCC for these ships.

EPCC

The electric plant control systems monitor and control the performance and operation of the equipment associated with the ship's electrical systems. The EPCC contains the controls and indicators that are used for remote operation and monitoring of the ship's service power generation and distribution systems. Remotely produced commands from the EPCC operate controls to sequence the operation of equipment or control subsystem operation. In fact, the operation of the equipment associated with the electrical distribution systems is normally controlled from the EPCC.

Figure 3-3 shows a typical layout of an EPCC. Notice how each panel is dedicated to particular types of control and monitoring. Notice also that the EPCC on the CG-47 class ships has an additional section for the 400-Hz system.

We will briefly discuss the following control systems operated from the EPCC:

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. Turbine overload protection system (TOPS)
9. 400-Hz power system

We will provide only an overview of these systems. For a detailed description of the operation of these systems, we recommend you consult the EOSS, EOP, and specific technical manuals for the equipment and systems of your ship.

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 any 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 propulsion and auxiliary machinery information system equipment (PAMISE) via the signal conditioning enclosure (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 two alarms that are not initiated by the contact sensors are the vibration high alarm and the high turbine inlet temperature (TIT) alarm. The vibration high 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 use and depressing the START push button.

The EPCC STOP push button is not affected by the control transfer switches. When this button is depressed, a signal is sent to the turbine stop relay at the

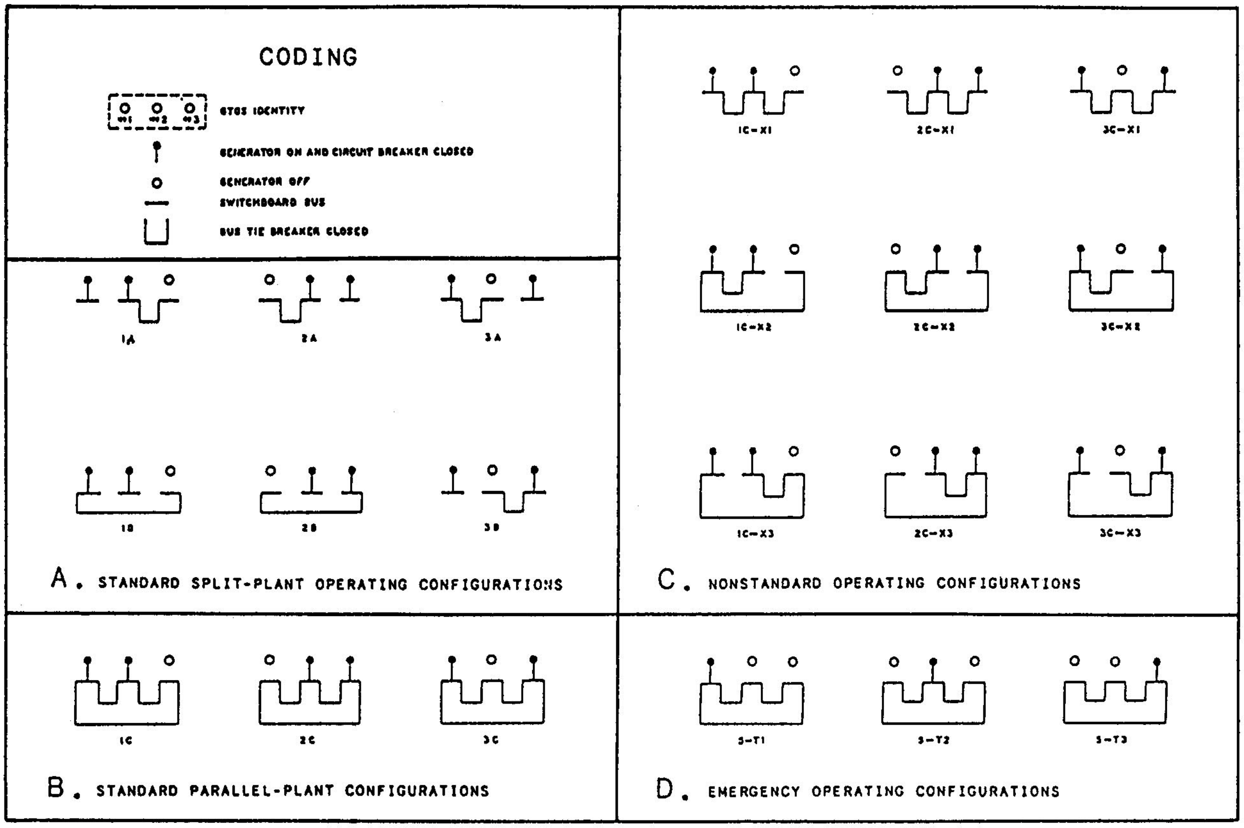


Figure 3-4.—Electric plant configurations.

switchboard. The stop relay sends a stop signal to the generator control panel to initiate a normal stop.

The 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. The operator can make the frequency adjustment 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

For a GTGS, control of generator field excitation is accomplished by its voltage regulator. There are two modes of voltage regulator operation available at the 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 voltage regulator mode, excitation current from the is set by a motor-driven rheostat located at the switchboard. The operator can make the voltage adjustment 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. Just as for the generator, there are two modes of operation for the voltage regulator: normal and droop.

System Configurations

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

STANDARD SPLIT-PLANT CONFIGURATION.—Standard split-plant operation requires two generators to be on line 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. 3-4, 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 CONFIGURATION.— In standard parallel-plant operations, two generators are on line and paralleled. Additionally, all bus tie breakers are closed so that the three main switchboards are connected in a loop system. Configuration status logic at the EPCC identifies the on-line generators for auto recovery logic. (See fig. 3-4, view B.)

NONSTANDARD PLANT CONFIGURATIONS.— The open-loop paralleled generator configuration, as shown in view C of figure 3-4, energizes all three switchboards with two generators. These configurations are either operator selected or 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 to be either in the parallel or split-plant configuration. In an emergency with two generators inoperative, one generator must energize the three switchboards. (See fig. 3-4, view D.) 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.

At the EPCC, the operator can engage manual load shedding by depressing the LOAD SHED push-button indicator. This switch transfers +28 volt dc power to a load shed relay.

The operator can start automatic load shedding by using 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 push button at the EPCC. Closing these contacts energizes the same load shedding control relay as in manual load shedding.

When the operator energizes the load shedding control relay, its contacts pickup tripping relays in each main switchboard. The tripping relays complete the power circuits to the trip coils on selected 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 as tripping relays are actuated by their load shedding control relays.

TOPS

The TOPS is an automatic protection system designed to prevent the loss of a GTGS because of overtemperature. An example of the TOPS control panel is shown in figure 3-5. This panel receives analog inputs, such as GTGS inlet temperature, rpm, kilowatt, and so forth. 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.

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, however, are used on CG-47 class ships. On the DD-963 and DDG-993 class ships, the 60/400-Hz converters 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, operators at the EPCC can control the converters only when the CCS IN CONTROL indicator is illuminated. Starting as well as paralleling and stopping of 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.

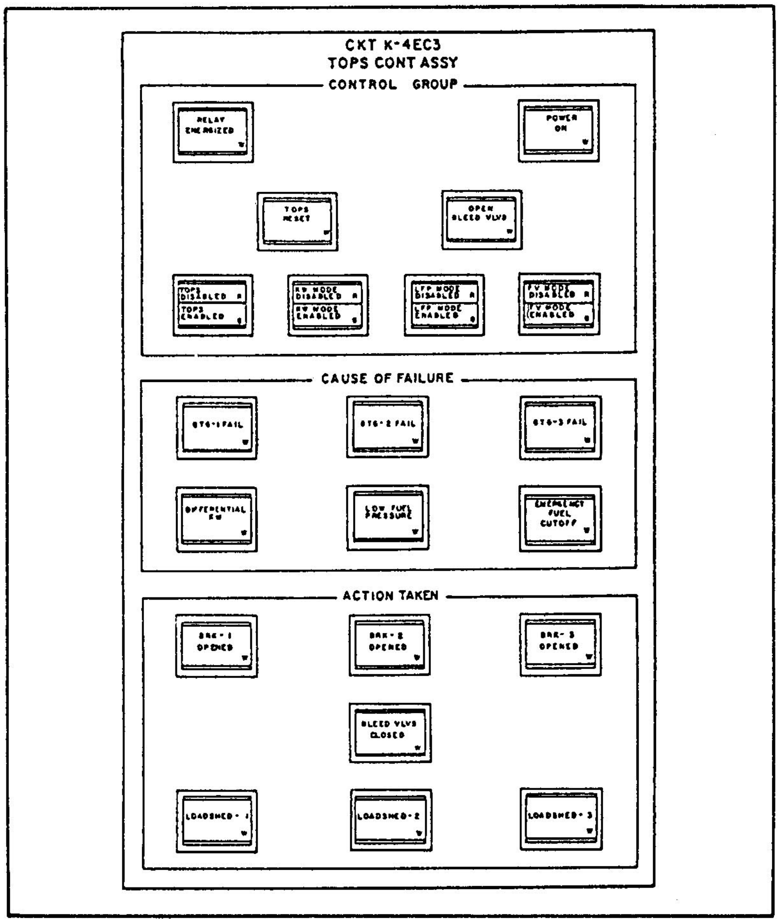


Figure 3-5.—TOPS control panel.

1. BUS TIE ENABLE - The converters' synchronized parallel operation is enabled. Closure of bus tie breaker is enabled.

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

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

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

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

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

7. CURRENT - A meter shows the converter amperage to a maximum of 481 amps.

For a detailed description of the operation of the static converters, we recommend you consult the appropriate technical manual for the 60/400-Hz converter.

You have just read about the two major control consoles in the CCS on the DD-963, DDG-993, and CG-47 class ships: the PACC and the EPCC. In the following section, we will talk about CCS monitoring and control operations for the DDG-51 class ships. As you study this section, try to recognize the similarities and differences in the design and operational characteristics of the CCS consoles for the DD-963, DDG-993, and CG-47 class ships and those of 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, can be controlled and monitored. On the DDG-51 class ships, the three major consoles of the engineering plant are the PACC, the EPCC, and the EOOW/LU. The PACC can

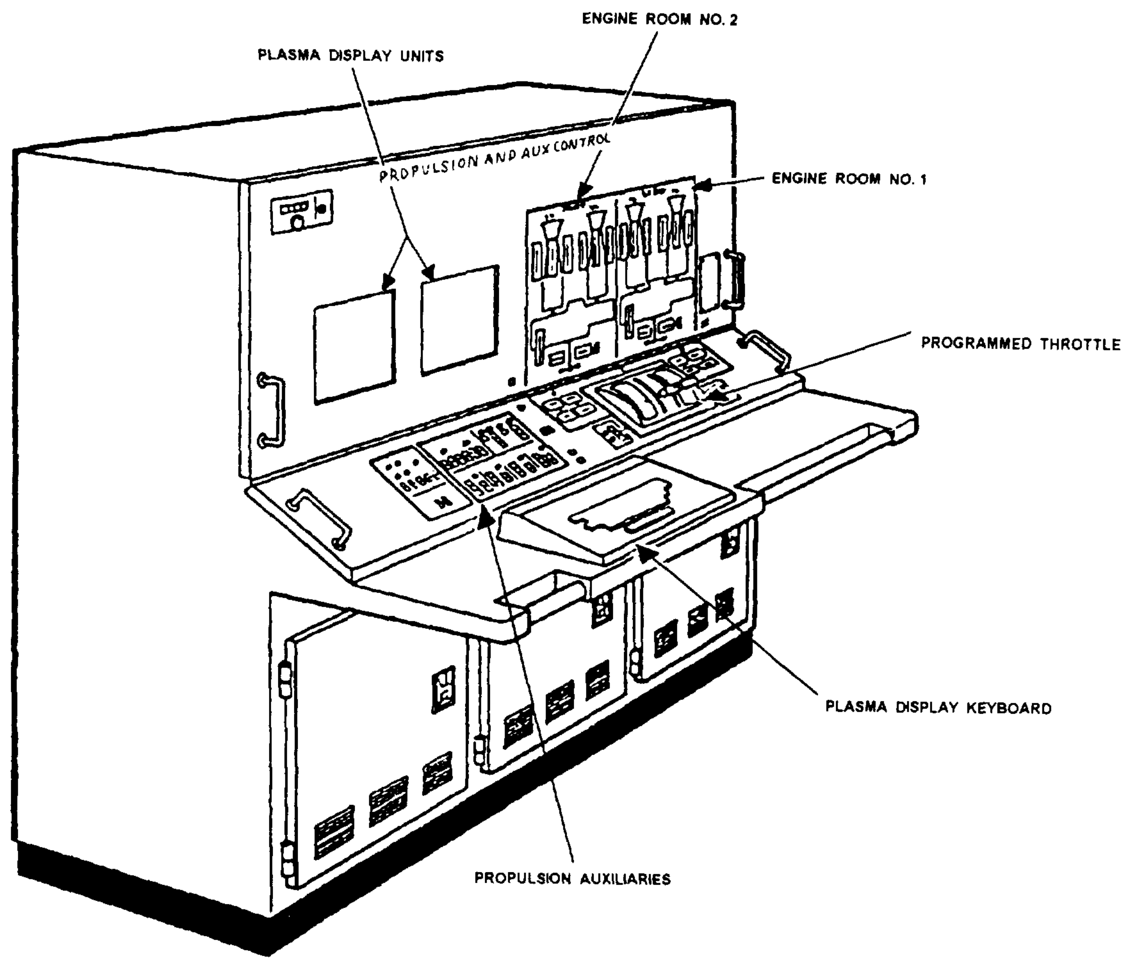


Figure 3-6.—Overall view of the PACC.

control and monitor all systems and components that interface with the shaft control units (SCUs). This includes the propulsion machinery, propulsion auxiliaries, and independent auxiliaries. The EPCC controls and monitors the ship's service gas turbine generators (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 data multiplex system (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 3-6 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 service and (2) propulsion fuel. The fuel service and propulsion fuel controls deliver fuel oil at the proper pressure and temperature to each GTE. The fuel service system may also be operated locally. The monitoring functions for both parts of the fuel oil service system are continuous y available at both the PACC and the SCU, but control is available at only one console at a time. Let's take a look at both parts of this system, starting with the fuel service system.

FUEL SERVICE SYSTEM.— The following six monitoring and control functions of the fuel service system are available at the PACC:

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

PACC control of the fuel 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 service pumps.

The computer program for the fuel suction and return valves allows the operator to open or close both service tank valves simultaneously. Separate control push buttons are available so the operator can operate the pair of valves in one service tank independently of the pair of valves in the other service tank. 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 the fuel service pumps automatically when their respective motor controllers are aligned for remote operation. The push-button indicators at the PACC allow the operator to assume manual control of the computer function program for the fuel service pumps. The operator can depress the OFF, LOW SPEED, or HIGH SPEED push button whenever the 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 service pumps OFF at any time. When a fuel service pump is in the OFF state, the automatic mode of the computer program function is inhibited for that pump. If the PACC is in the automatic mode before a fuel service pump is started, the operation of that pump is controlled by the computer function program. The computer program controls the fuel pumps with respect to fuel header pressure and time.

PROPULSION FUEL SYSTEM.— The following four functions are available at the PACC for propulsion fuel monitoring and control:

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

The propulsion fuel 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.

The one solenoid-operated module fuel valve external to the module is located in the fuel supply piping near each GTE. This valve isolates the module fuel system from the fuel service system. Push-button indicators on the PACC allow the operator to control the valve. From the PACC, the operator either can electrically energize the valve closed or de-energize it open. The operator has separate controls for each GTE. By depressing the MODULE VALVE CLOSE push button, the operator energizes the valve. This prevents fuel flow to the GTE regardless of its operating status. If the operator should depress the MODULE VALVE CLOSE push button while a GTE is either ON LINE, ON, or in a cool down, an automatic shutdown recurs.

At the PACC, the operator can initiate the fuel purging function. The fuel purging function allows the operator to drain the GTE manifold of any cold or contaminated fuel before starting. Purge control is available for each GTE through the PURGE ON and PURGE OFF push-button indicators at the PACC. The operator starts a fuel purge by depressing the PURGE ON push button. This action energizes (opens) the solenoid-operated purge valve in the GTE. The operator depresses the PURGE OFF push button to de-energize (close) the valve when fuel temperature and purity are satisfactory. The position of the purge valve 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 plasma display unit (PDU). Now let's move onto the lube oil system.

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. At the PACC, the operator can control the lube oil service system pressure through the computer program function of the lube oil service pumps. The operator initiates these commands by depressing the push-button indicators in the reduction gear lube section of the propulsion mimic panel.

The 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. The MANUAL mode allows the operator to select pump speed with OFF, LOW SPEED, and HIGH SPEED push-button indicators. The AUTO LEAD mode 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 before the computer can control pump operation. Three push-button indicators at the PACC allow the operator to assume control of the lube oil pumps individually. Automatic and manual pump operation are enabled when the operator depresses an AUTO LEAD push button. AUTO LEAD prevents the operator from commanding pump speeds that contradict the lube oil service pumps automatic mode logic. When pump control is in AUTO LEAD, the pumps cycle as a function of the main reduction gear (MRG) hydraulically most remote bearing pressure. Now that we have described the lube oil system, let's go on to the air system.

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. Let's look at the bleed air system first.

The bleed air system contains the following four distinct subsystems:

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 local operating panel (LOCOP) or the EPCC.

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.

At the PACC, the operator selects the starting air source 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 may be 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 it is in the motor position. At the PACC, the operator can start the motor sequence for a GTM in the OFF state by depressing the MOTOR push button.

The masker air system is aligned by the HULL MASKER ON and OFF push-button indicators at the PACC. These push buttons 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.

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.

The anti-icing 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.

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 the appropriate SCU at any one 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 three inputs: (1) the GTE cooling air outlet temperature transducer, (2) a GTE start command, or (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 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 EMER STOP, PRI OR RSV HALON RLSE, or MODULE VALVE CLOSE. Depressing a HALON RLSE or MODULE VALVE CLOSE push button indirectly causes the SCU to send an emergency stop command to the interim integrated electronic control (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 tire 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. At the PACC, the operator can activate Halon by depressing the PRI OR RSV HALON RLSE push button. AHALON SYSTEM ACTUATED alarm is then 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 bridge control unit (BCU). Throttle/pitch control is unified under the programmed control and order difference computer program functions when the NORMAL PROGRAMMED MODE is selected. Throttle and pitch controls are separated, and only available at the SCU, when the 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. The LOCKOUT MANUAL MODE places unit control at the SCU and inhibits control station transfers.

Programmed control is the normal method of controlling a DDG-51 class ship's speed. Programmed control allows the operator to use a single lever to position the controllable pitch propeller (CPP) blades and GTE power lever angle (PLA) for a propulsion shaft. TWO programmed control levers are available at the PACC. The port and starboard programmed control levers at the PACC maybe 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: (1) the modulate transmission mode used for slower ahead and astern thrust settings, and (2) the modulate engine mode 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 following independent auxiliaries are associated with the MCS system:

1. Seawater cooling system
2. Sewage and drainage system
3. Freshwater service system
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 controls available at the PACC, let's take a look at the ones available at the EPCC.

EPCC

The EPCC provides centralized control of the ship's electric plant. The electric plant on the DDG-51 class ships consists of the SSGTGs and the 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 will cause a loss of electrical plant alarm detection, EPCC and DMS communications, and any displays at the PDU.

The EPCC contains the controls and indicators that the operator can use for remote operating and monitoring of the ship's service power generation and distribution systems. Figure 3-7 shows the locations of the control and indicator panels of the EPCC. We will briefly discuss the following control systems that are operated from the EPCC:

1. SSGTG control and monitoring
2. Electrical distribution monitoring and control
3. Circuit breaker operation
4. Gas turbine control
5. Generator control
6. Load shedding system operation
7. A/C plant operation
8. 400-Hz power system operation

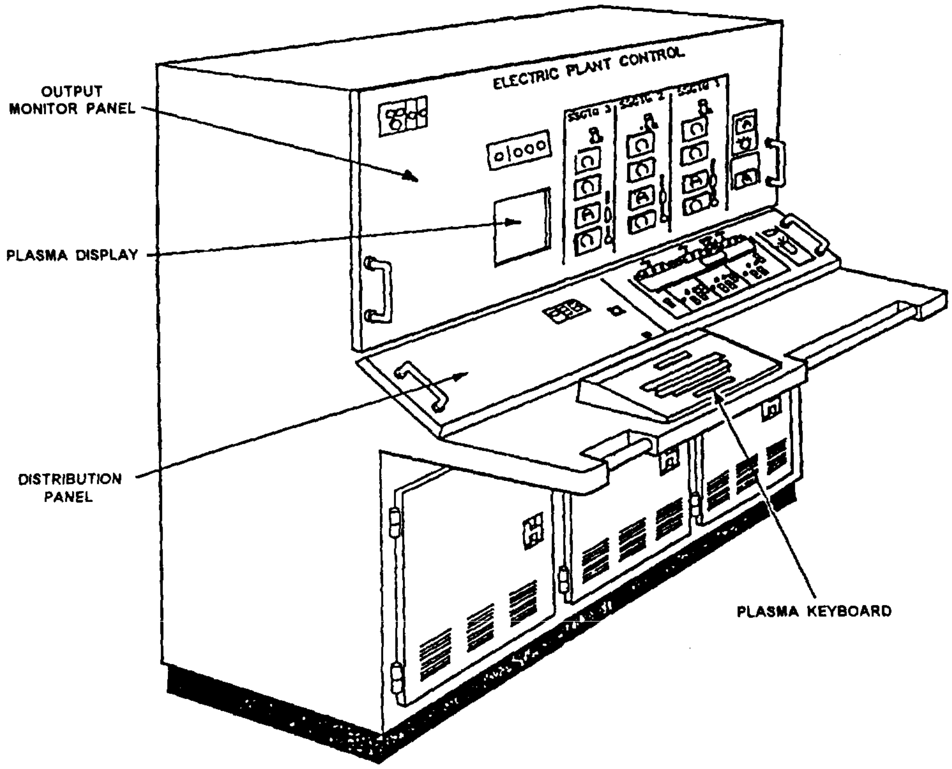


Figure 3-7.—EPCC panel locations.

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

SSGTG Control and Monitoring

Most SSGTG control systems reside in the 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 any 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 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. At the EPCC, eight alarm conditions for each SSGTG are displayed by specific alarm indicators. All other alarms are indicated by the appropriate SSGTG summary alarm light above the PDU.

At the EPCC, there is one SSGTG summary alarm LED for each SSGTG. The summary alarm light for SSGTGS No. 1 and No. 2 operate when at least one of 22 alarm conditions occur. The summary alarm light for SSGTG No. 3 operates when at least 1 of 25 alarm conditions occur.

Any inputs to the EPCC that do not originate 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 a SSGTG support system. Direct analog inputs are received from resistance temperature elements (RTE) or tank level receivers associated with a SSGTG.

Electrical Distribution Monitoring and Control

An electrical switchboard has both 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. 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 system output LED meters. These signals are also sent to the computer for alarm generation and the PDU's demand display. The operator can select the voltage displayed on the system output panel meter by positioning 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. The switchboard relay logic and the LOCOP sequencer generator breaker trip command are the only automatic breaker controls.

Shore power breaker control from the EPCC is limited to the operator's sending a trip command to each breaker simultaneously by depressing the ALL CB OPEN push button. 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 and Control

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 these circuit breakers from the EPCC is enabled only when the operator extinguishes the LOCAL CONTROL alarm light for a switchboard.

EPCC operation of circuit breakers is accomplished through the same circuits used by the switchboard controls. Depressing an EPCC push-button indicator allows the operator to energize 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 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, an operator at either the switchboard or the EPCC can start the SSGTG. When the switchboard GTG START TRANSFER switch is in LOCAL, operators at both the switchboard and the EPCC can start the SSGTG. When the switchboard GTG START TRANSFER switch is in REMOTE, an operator only at the EPCC can start the SSGTG.

The manual SSGTG start controls at the EPCC are the ON, HIGH PRESS, and BLEED push buttons. When the operator depresses the ON pushbutton, the signal is combined with the HIGH PRESS or BLEED indication signal in the 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. Depressing 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, such as slow start, module fire, and so forth, occur.

The output frequency of each SSGTG is controlled by an electronic governor in the LOCCP. The electronic governor regulates the 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 the frequency to decrease or increase, respectively. At the EPCC, the operator selects the mode by depressing either the ISPO or DROOP push button. 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 either manually or automatically. One manual mode and two automatic modes are available at both the switchboard and 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 general 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. The DROOP mode is basically the DIFF mode without cross-current compensation.

Load Shedding System Operation

A load shedding operation can be started manually or automatically. An operator can start manual load shedding by depressing the appropriate INIT push-button indicator at the EPCC or the spring-loaded LOAD SHED switch at the switchboard. An operator can start automatic load shedding by energizing either an overpower relay in a switchboard or an overcurrent relay on a shore power breaker.

When one overpower relay is energized, its contacts operate tripping relays in each switchboard. The tripping relays complete the 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. This completes the power circuits in the switchboards to trip the 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 an existing overpower or overcurrent condition is cleared.

Air-Conditioning Plant Operation

The normal and alternate supply circuit breakers for the air-conditioning (A/C) plant can be closed from the EPCC. At the EPCC, all four A/C plants have a remote restart capability to bring a plant that was operating before a power interruption back online. 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 the switchboard LOCAL CONTROL alarm status, to energize each A/C plant controller.

400-Hz Power System Operation

The 400-Hz power systems consists of two 60/400-Hz static converters that feed separate 400-Hz switchboards. On the DDG-51 class ship, the EPCC cannot control or monitor 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.

Now that you have read about the monitoring and control functions available at the PACC and EPCC, let's look at some of these controls available at the EOOW/LU.

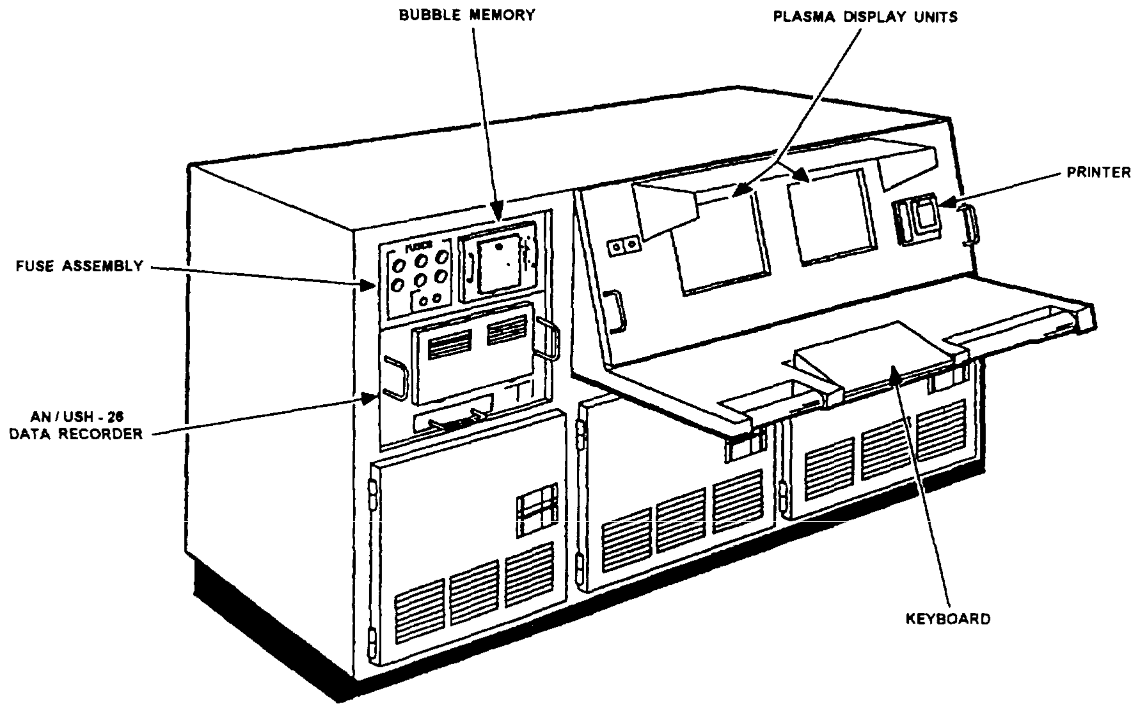


Figure 3-8.—Overall view of the EOOW/LU.

EOOW/LU

The EOOW/LU provides a central location for the EOOW to monitor the status of the DDG-51 class machinery plants. The EOOW/LU, shown in figure 3-8, provides a centralized station for the basic functions of accumulating, processing, and displaying the MCS status. Additional functions of the console are to provide the data for display on the console displays on the PDUs on the bridge and in the combat information center (CIC). This console also provides the means of loading the bubble memories used by the other MCS consoles. An operator can also use this console 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 following five principal operating units are furnished with this console:

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/UYH-44(V) computer

In the following paragraphs, we will briefly describe the units of this console. Again, for detailed information, we recommend you consult the EOSS, EOP, and appropriate technical manuals.

Plasma Display Units

The EOOW/LU panel has two PDUS with a single keyboard. The panel CONTROLLED DISPLAY switch connects the keyboard to either the left or right unit. The keyboard CONTROLLABLE PLASMA/WORK-STATION SELECT key swaps the PDU controllable assignments for those of the workstation. This arrangement separates the housekeeping and operation functions. It also eases the PDU casualty operations for the EOOW. The controlled PDU assignments include the automatic alarm and status unit and the summary group and demand display unit. The PDU workstation capabilities include manual entry, log tape read, alarm acknowledgement, bubble memory loadng, and edit operations.

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

Bubble Memory Unit

When the EOOW/LU is first energized, the operator must install bubble memory cassettes in the drive unit. The computer's start-up program will then cause the console's operating program software on the cassettes to be loaded into the computer's memory. Anytime the computer is rebooted with the cassettes installed, the operator must repeat the loading operation.

Each bubble memory for the MCS has unique console software programming. When software changes are required, a new AN/USH-26 master tape cartridge is provided. The operator inserts the new cartridge in tape drive O. Bubble memory cassettes are then loaded into the EOOW/LU bubble memory drive unit. The EOOW/LU console transcribes the new master tape program to the cassettes. New programs are set in motion after the cassettes are installed in their MCS console and the console's initialization and bootstrap procedure is run.

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 the 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 drive 0 through 3. Only two tape drives are used, however, and 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. If a status error exists and may result in a local tape error alarm, additional operations can be entered.

EOOW/LU Computer

Embedded in the EOOW/LU, the AN/UYK-44(V) 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, a control and maintenance panel, and power supplies. The basic modules are standard electronic modules (SEMs), 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 principle unit in the interchange of information for the EOOW/LU. It works with the DMS to accomplish these tasks. 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. The control and alarm input capabilities, however, will vary within the program functions assigned to each console computer. The computer enters a bootup process at power turn-on. (It may also be rebooted from the control panel whenever this is required.) During the boot process, the operating program is loaded from the bubble memory cassettes installed in a tape drive unit in

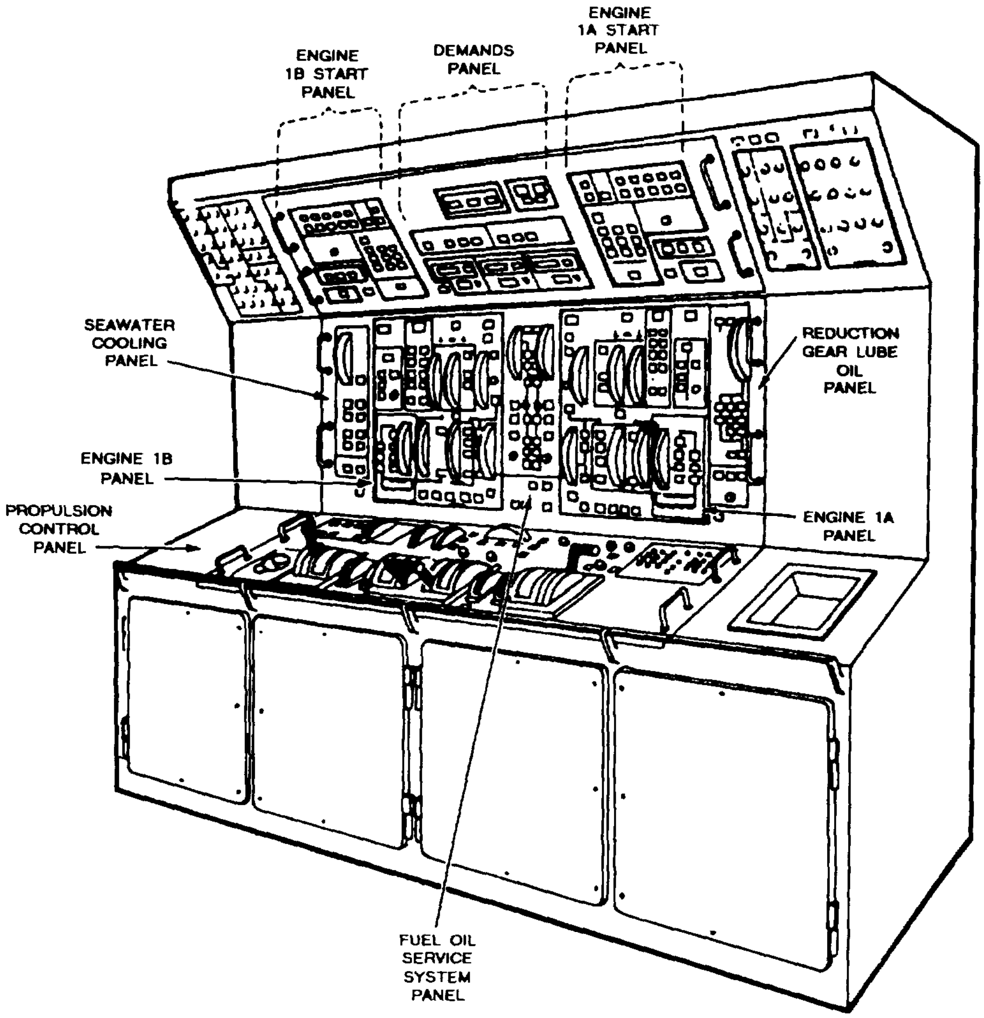


Figure 3-9.—Overall view of PCC.

the console. The program is unique to each console housing a computer.

You have now read about CCS operations on the DD-963, DDG-993, CG-47, and DDG-51 class ships. Let's now look at these operations for 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 the FFG-7 class ships are the PCC, EPCC, and 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 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 propulsion control system (PCS) in the programmed control mode or the remote manual control mode. The PCC contains the signal conditioning, logic, and multiplexing circuits, and the processor for the PCS. Notice in figure 3-9 how each section of the PCC is dedicated to particular types of control and monitoring. In the following paragraphs, we will briefly discuss some of the major control and monitoring systems.

Fuel Oil service System

The fuel oil service system supplies fuel to the GTEs. The control and monitoring functions available at the PCC can be divided into two major categories: (1) fuel oil service and (2) GTM fuel oil. Together they function to deliver fuel oil at the proper pressure and temperature to the individual propulsion GTEs.

The following eight fuel oil service monitoring and control functions are available at the PCC:

1. Fuel oil service tank level monitoring
2. Fuel oil service tank suction and return valves monitoring and control
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

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

1. Emergency fuel supply valve monitoring
2. Supply cutoff valve control and monitoring
3. Fuel supply 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 the 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 operator must manually reset the pump to low speed.

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. his switch is inoperative when local lockout is in affect. 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 on the PCC 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 at the PCC 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 mode 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 the 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, however, to reduce the speed or stop either pump. Reducing the 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 shall bearing. All the bearing temperature alarms are set at 20 degrees above the maximum full power builder trial data specified for each 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 (SACs). The SACs are driven by the diesel generators.

The bleed air system provides air for starter air, masker air, prairie air, and anti-icing air. 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. The operator at the PCC can open and close this valve by using the BLEED AIR VALVE OPEN/CLOSE push-button indicating switch. The bleed air lines will direct the bleed air to both the anti-icing system associated with the respective GTE 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. At the PCC, the operator can use the control alternate-action push-button switches and split-legend indicators to control the solenoid-operated bleed air shut-off valve and the motor-operated anti-icing valve. 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

At the PCC, the operator can use a three-position switch to select the following three modes: (1) OFF LINE, (2) MANUAL, and (3) 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. In the off-line mode, the fuel and ignition cannot be enabled simultaneously. 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: (1) normal stop, (2) manual stop, and (3) emergency stop. The engine will also be shut down automatically either during a start sequence or while running if certain faults are detected.

To initiate a normal stop, the operator can use either the programmed control mode or the manual control mode. The operator must use the manual stop, however, if control was transferred from the local operating panel (LOP) to the PCC after the engine was started. The operator initiates a normal stop 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.

The operator can initiate a manual stop in either the programmed control mode or the remote manual control mode. Before initiating a manual stop, the operator should make sure the gas generator is run at idle speed for 5 minutes. This precaution allows the engine parts to cool evenly. A manual stop uses the circuitry in the start/stop sequencer to stop the GTE. To provide the manual stop command, the operator depresses the MANUAL STOP push-button switch. This action causes both automatic fuel shutdown valves to close.

The operator can initiate an emergency stop at any time, in any control mode, and without regard as to which console has GTE control. The EMERGENCY

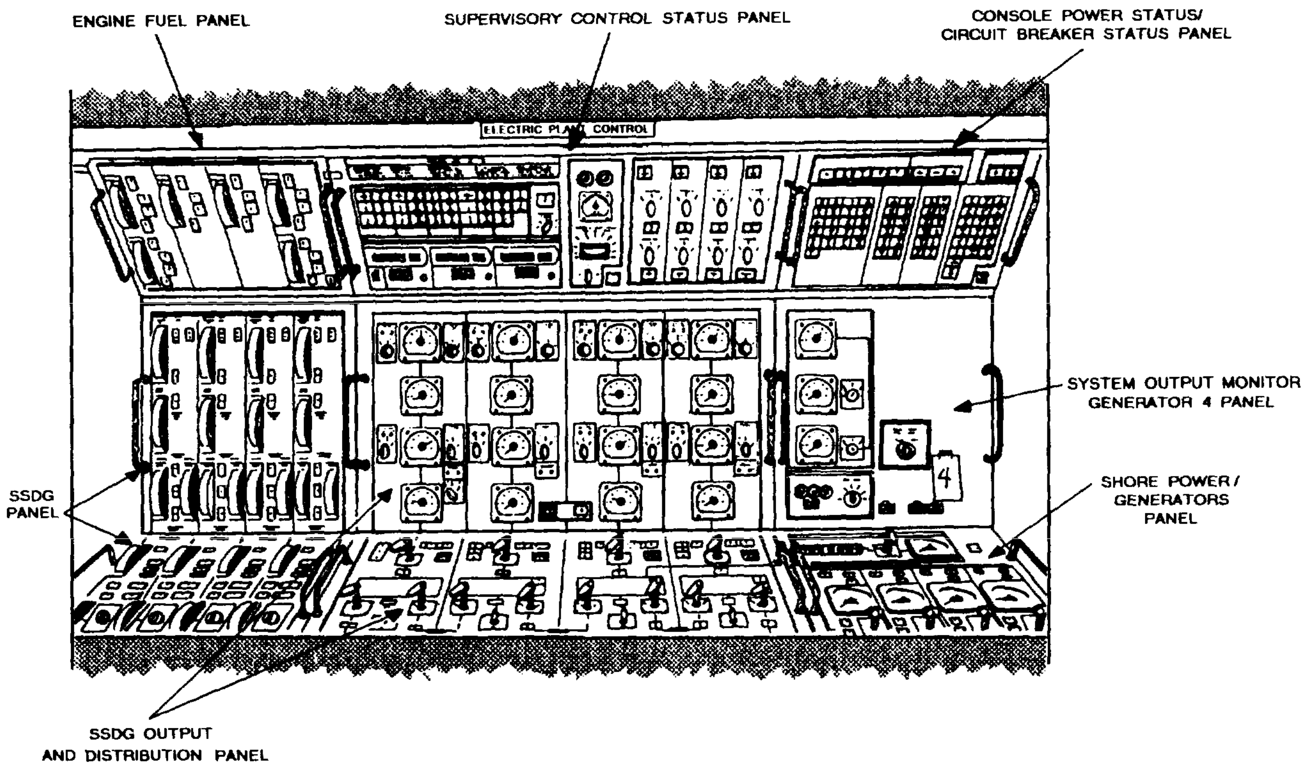


Figure 3-10.-EPCC panel locations.

STOP OVERRIDE switch at the LOP must not be used 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 will cause 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 ships 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: (1) local manual control, (2) remote manual control, and (3) 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.

You have just read about the controls available at the PCC. Now, let's look at the controls 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 3-10, each panel incorporates a variety of control and monitoring devices. These are 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 service system
6. Auxiliary fuel service system
7. Jacket water system
8. Supervisory control system (SCS)

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

Diesel Control and Monitoring

Each ship's service diesel generator (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 these signals.

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; they sound an alarm and light a lamp. The operator can cancel the sound by depressing the ALARM ACKNOWLEDGE push button. There are two levels of audible alarms at the EPCC. The first level is a horn that signifies a problem that requires immediate 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 start-up and shutdown. The SSDG can be shut down either under normal or emergency conditions. 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 EPCC can be automatic or manual. As engine speed builds up, a fuel pressure switch opens and de-energizes a pilot cracking relay. Once the engine is started and engine speed starts to pick up, 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. Although 115-volt ac power is required for this start sequence, the start can be accomplished manually.

Under normal conditions, the operator can stop the engine 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.

The operator can initiate an emergency stop 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 operator must manually reset the air intake solenoid. 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, the SCS, and alarm circuits and gauges.

At the EPCC, the operator can obtain current, voltage, frequency, and power readings by dialing in the appropriate address on the DDI or by 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 generators and to 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 0 to 6 percent of the bus frequency. The operator can control the frequency of a generator manually from the front panel of the EPCC. Using 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 controlled from the respective switchboards, except 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 potentiometer on switchboard No. 4 at the EPCC gives 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 procesor software programs.

The circuit breaker status of each SSDG is monitored for the generation, 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 shedding, and bus ties are monitored on the EPCC. Other circuit breakers can also be monitored, such as those in the radar room or seawater pump. These circuit breakers are monitored but not controlled from the EPCC. Power supplies, including the uninterruptible power supplies (UPSs) and the console heaters, can also be monitored. The total output for the ac generation system is monitored for frequency, voltage, and current. Individual bus ties can be monitored for current loads. The operator uses the rotary switch on the EPCC to select each bus tie.

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

The manual voltage control for the No. 4 switchboard is on the EPCC since the switchboard and 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 can monitor the seven breakers connected to shore power. At the EPCC, the operator can trip all seven breakers by using the TRIP lever. Current from the shore power source is monitored on a meter that reads up to 3,000 amperes. Each of the seven breakers can handle 400 amperes. The status of each breaker is indicated at the EPCC by an illuminated blue light indicator. The EPCC only controls the transfer of shore power to ship's power. 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. Alarms at the EPCC activate when the fuel tank level is beyond the high level of 90 percent of tank capacity or lower than 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 SCS provides a 16-second delay on the level indicating alarms. We will take a closer look at the SCS later in this chapter.

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 each have two tanks. The SSDGs No. 2 and No. 3 share two day tanks; therefore, the EPCC operator can only open or close the tanks. The EPCC operator cannot transfer fuel to the day tanks. This transfer must be 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 a part 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 the control and monitoring functions associated with this discharge.

Supervisory Control System

The program module for the SCS monitors the electric plant for failures or degradation of performance. The program 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, i f the supervisory control mode is off, or if all SSDGs arc 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. You should refer to the appropriate technical manual for a detailed discussion on the SCS.

Now that you have read about the PCC and EPCC controls for FFG-7 class ships, let's take a look at the controls at the ACC.

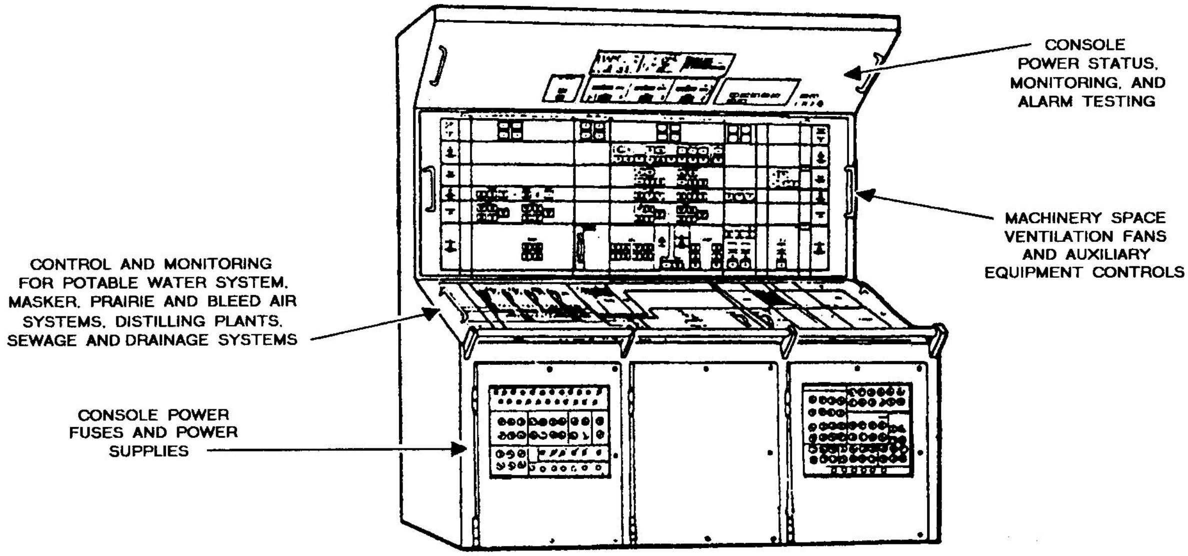


Figure 3-11.-Auxiliary control console.

ACC

The ACC, shown in figure 3-11, 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 the logging of data on the data logger. Controls and indicators are arranged on the ACC in a logical manner to help the operator relate the panel control and monitoring functions to the location of the auxiliary systems in the ship.

There are 15 specific auxiliary subsystems interfacing with the ACC. These 15 subsystems are as follows:

1. Machinery space ventilation

2. Fuel fill, 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

In this chapter, we will only mention these systems. For a detailed description of these systems and the associated controls and indicators, refer to *GSE3/GSM3*, Volume 2, NAVEDTRA 10564.

The parameters that are considered critical are continuously displayed on the ACC for operator monitoring. The parameters that are not considered to be critical are available to the operator. For these parameters, the operator uses the thumbwheel switch assembly to enter a specific code for the desired parameter. 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. Three of the primary functions performed by this interface are as follows:

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. This EPCC output data consists of address information for both input and output data transfers and digital data that drives the DDIs on the ACC.

We have now discussed the CCS operations for DD-963, DDG-993, CG-47, and FFG-7 class ships. If you have questions concerning the basic operation of any of the consoles, we suggest you review the appropriate sections. For detailed information on any of these consoles, you should consult the appropriate EOSS and technical manuals.

ENGINEERING CASUALTY CONTROL

The mission of engineering casualty control is to maintain engineering services in a state of maximum reliability under all conditions of operation. In the CCS, casualty control includes both machinery and electrical casualty control. Efficient CCS casualty control is the result of effective personnel organization and training. Remember, your ability to detect and identify signs of initial trouble in your ship's engineering equipment is based on how well you have familiarized yourself with engineering plant operations.

The details on specific casualties that can occur in the CCS of a gas turbine-powered ship are beyond the scope of this TRAMAN. For detailed information on casualty control, you should refer to the engineering operational casualty control (EOCC) portion of the EOSS. The EOCC contains information you can use to recognize casualty symptoms and identify their probable causes and effects. The EOCC contains information on the actions you can take to prevent a casualty and the specific procedures your ship should use to control single- and multiple-source casualties. The EOCC manuals are available at each watch station in the CCS for self-indoctrination. These manuals contain official 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 a corrective action can be applied to an engineering casualty is frequently of paramount importance. This is particularly true when casualties might affect propulsion power, steering, or electrical power generation and distribution. If casualties associated with these functions are allowed to increase, 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 casualty conditions.

Although speed in controlling a casualty is essential, corrective actions should never be undertaken without accurate information; otherwise, the casualty may be mishandled, and irreparable damage and possible loss of the ship may result. Speed in the handling of casualties can be achieved only by a thorough knowledge of the equipment and associated systems and by thorough and repeated training in the routines your ship requires to handle specific predictable casualties.

SUMMARY

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

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. In this chapter, we also referred you to other publications that will give you a more in-depth explanation of the material we have covered. You should study them to become a more proficient and reliable technician.

CHAPTER 4

ENGINEERING SUPPORT AND AUXILIARY EQUIPMENT AND SYSTEMS

As a GS or even an engineer, you should know the important role the engineering auxiliary equipment and systems play in the overall operations of the ship. Even though most of the support and auxiliary equipment are located in the engineering spaces, their systems extend throughout the ship. For the most part, you and your shipmates may forget what services this equipment and these systems provide until your telephone rings and the captain is on the line telling you he has soap in his eyes and hair and no water to rinse with. As a GS, you are not directly responsible for the making and distribution of fresh water. You are, however, responsible for the production of the steam or electricity that is needed to operate the distilling plants.

This chapter will provide you with some basic component descriptions for support and auxiliary equipment and their systems. It also will discuss operations, system interaction, and maintenance requirements. Because of the similarities in the equipment, system designs, and service requirements, all the topics in this chapter will be discussed in general terms.

OPERATION AND MAINTENANCE OF SUPPORT AND AUXILIARY EQUIPMENT

The proper operation of and good maintenance practices for the support and auxiliary equipment should be high on your list of priorities. Your attention to these priorities should minimize the need for telephone calls like the one we just described. In this section, we will highlight some of the operational and maintenance requirements that are crucial to the efficient performance of the support and auxiliary equipment.

LOW-PRESSURE AIR COMPRESSORS

Basically, the reciprocating and helical screw are the two types of low-pressure air compressors (LPACs) used on gas turbine-powered ships. The helical-screw type is the most widely used. It is rated at 100 cfm and is installed on the CG-47, DDG-51, and FFG-7 class ships. The reciprocating type is rated at 200 cfm and is installed on DD-963 and DDG-993 class ships.

There are two LPACs installed on the DD-963, DD-993, and FFG-7 class ships. Because of the ship size, lower compressor capacity, and air volume demand, there are three LPACs installed on the CG-47 and DDG-51 class ships.

Normal Operation

Gas turbine-powered ships will normally have at least two LPACs aligned for operation to provide low-pressure air for maintenance, service, control, pneumatic power, and other utility purposes. For those ships with only two compressors, the normal alignment is to have one unit in constant run and the other in standby. However, if one unit is out of commission, then only one unit will be available.

For those ships with three compressors, normal operations will have the cutout pressure switches set at 125 psig, 120 psig, and 115 psig. The compressor run status will depend on the pressure cutout selection. For example, the compressor set at 125 psig will be in constant run. The unit set at 120 psig will be designated as intermittent. The third unit, set at 115 psig, will be in emergency standby.

Even though multiple units are installed on gas turbine ships, they may not all be needed during routine operations. During normal operations, one compressor will usually provide sufficient air to supply the system.

Each LPAC has its own low-pressure air subsystem. Each subsystem consists of the LPAC, a dehydrator, and a main receiver. When in operation, each LPAC system supplies air to a common vital air piping header. This header usually runs longitudinally near the centerline of the ship. The mission-essential equipment services are isolated from the nonessential services by two priority valves, which actuate at 85 psig. These priority valves do not operate very frequently–only when they are needed. For example, if a large leak develops in the air system, the priority valve will activate to maintain sufficient operating air pressure to mission-essential equipment. If the leak becomes too large for the priority valve to handle, HP air can then be aligned through a reducing station to supplement the LP air system.

Maintenance

Because of the wide range of use, proper maintenance of the LPACs is extremely important. All of the maintenance requirements are really very easy to accomplish. Even though these requirements may seem easy and almost insignificant, you should not underestimate their importance. If these procedures are not performed correctly and in a timely manner, long-range detrimental effects on the equipment will result. Always use the PMS when accomplishing maintenance on LPACs. Remember, the PMS is only sufficient to meet the minimum requirements. As a GS, you must be aware of the more extensive requirements that may be required by your type commander.

Troubleshooting

Generally, as the operator you will not be equipped to correct all malfunctions; however, you should be able to identify them when they occur and make a preliminary diagnosis of the probable cause. There are occasions when a malfunction can be caused by one or more possible faults. Using fault logic diagrams and flow charts, you should be able to investigate, isolate, and correct a malfunction with a minimum amount of compressor downtime. When you encounter troubles for which the possible causes are not readily adaptable to a fault logic diagram, you can usually find specific explanations in the applicable manufacturer's technical manual.

In the following paragraphs, we will discuss some common problems that may occur to both types of LPACs and some key points to help you identify them and minimize equipment downtime. If we state a problem or possible cause that refers to a specific LPAC type or model, we will indicate the type of model in parentheses.

COMPRESSOR WILL NOT START IN MANUAL MODE.– Check the following components for the possible cause of this malfunction:

1. Power switch–Is it operational?
2. Fuses–Are they blown?
3. Last shutdown–Was the last shutdown an automatic safety shutdown?
4. Control panel–Do the failure indicating lights illuminate when start-up is initiated
5. Air receiver pressure–Is it below the falling pressure set point, as it should be?

COMPRESSOR RUNS ONLY FOR A SHORT PERIOD.– Examine the following conditions as the possible cause:

1. Compressor runs for 5 seconds or less—Is the water in the separator holding tank too low? (Screw-type LPAC)
2. Compressor runs for only 5 to 12 seconds–Check for the following conditions (screw-type LPAC):
   a. Oil pressure–Is it too low?
   b. Injection water pressure–Is it too low?
   c. Compressor–Is it running in the wrong direction?
3. Compressor runs for only 12 to 15 seconds-Is the oil pressure 100 low? (Reciprocating-type LPAC)

COMPRESSOR DOES NOT AUTOMATICALLY UNLOAD OR STOP.– Check the following components for the possible cause:

1. Receiver air pressure switch-Is it operating? Is it at the proper setting?
2. Compressor air intake butterfly valve–Is it closing properly? (Screw-type LPAC)
3. Ten-minute unloaded run timing relay–Is it operational? (Screw-type LPAC)
4. Unloading solenoid valve–Is it operational? (Reciprocating-type LPAC)

COMPRESSOR DOES NOT AUTOMATICALLY START OR LOAD.– Check these components:

1. Receiver pressure switch–Is it operational? Is it at the proper setting?
2. Compressor air intake butterfly valve–Is it opening properly? (Screw-type LPAC)
3. Unloading solenoid valve–Is it operational? (Reciprocating-type LPAC)

AIR PRESSURE IS TOO HIGH AND RECEIVER RELIEF VALVE IS OPENING.– Check the following conditions:

1. Relief valve–Is it set incorrectly? Is it defective?

2. Valve alignment–Are the valves properly aligned? Could the receiver discharge valve be closed?

AIR PRESSURE IS TOO LOW.– Check for the following conditions:

1. Excessive usage or system leaks–Are system leaks causing excessive use of air?

2. Relief valves–Is there evidence of premature opening or leak-by?

3. Automatic blowdown valves–Is there evidence of leak-by?

4. Injection water pressure–Is it low? (Screw-type LPAC)

ABNORMAL NOISE.– Check for the following conditions:

1. Compressor air inlet–Is there insufficient air? Is the filter blocked?

2. Compressor–Is it rotating properly?

3. Drive coupling–Is it defective? (Screw-type LPAC)

4. Drive belts–Are the drive belts hose? Are they defective? (Reciprocating-type LPAC)

5. Bearings–Are the bearings defective in either the motor or compressor?

LOW OIL PRESSURE.– Check the following components and conditions:

1. Oil pump suction piping–Are there loose connections?

2. Oil pressure gauge–Is it faulty?

3. Oil level dipstick–Is the oil level below the low mark on the dipstick?

4. Oil pump relief valve–Is this valve faulty?

5. Oil pump–Is it defective?

Even though the problems we listed are not all-inclusive, they are probably the most reoccurring problems you will face.

Overhaul and Repair

The overhaul and major repair of an LPAC is usually performed by a ship's repair facility. An emergency situation, however, may require your ship to perform major repair work on the compressor. Normally, the compressor will be replaced from a pool of reconditioned units. The old units will be removed and replaced during a ship repair availability (SRA) or overhaul. As a GSM, you will be limited primarily to the performance of general maintenance (PMS) and minor repairs. In the following sections, we will take a look at some of the components you will need to maintain.

AUTOMATIC CONTROL VALVES AND ASSOCIATED COMPONENTS

Even before the conception of the gas turbine-powered ship, the Navy was using automatic control valves and automated components. The need to develop better and more reliable automatic systems came into play with the introduction of the unmanned engine room concept to be implemented on gas turbine-powered ships.

In every gas turbine-powered ship, automatic control valves and their associated components play a very important role in the operations of the engineering plant. There is at least one automatic control valve installed in every system in the engineering plant. There arc so many different types of automatic valves, however, we must limit our discussion to some of the most prominent valve types and their various applications, such as controlling a tank liquid level, LO temperature, and LO pressure. For the remainder of this section, we will discuss some of the uses, operations, and maintenance of these valves and their associated components.

Normal Operation

In any system, the type of valve used is normally determined by the needs of the system. We will talk about some of the more commonly used valves and their design and normal operating characteristics.

AUTOMATIC TEMPERATURE CONTROL VALVES.– An automatic temperature control valve is installed in the MRG LO system of a gas turbine-powered ship to maintain the oil temperature within safe operating limits. The type of valve used for this purpose is of the same basic design for all classes of gas turbine-powered ships. The valve is pneumatically operated via an externally mounted air pilot controller. To function properly, the valve must first receive the proper command air signal from the air pilot controller. In fact, without the proper command air signal from the controller, the valve is worthless.

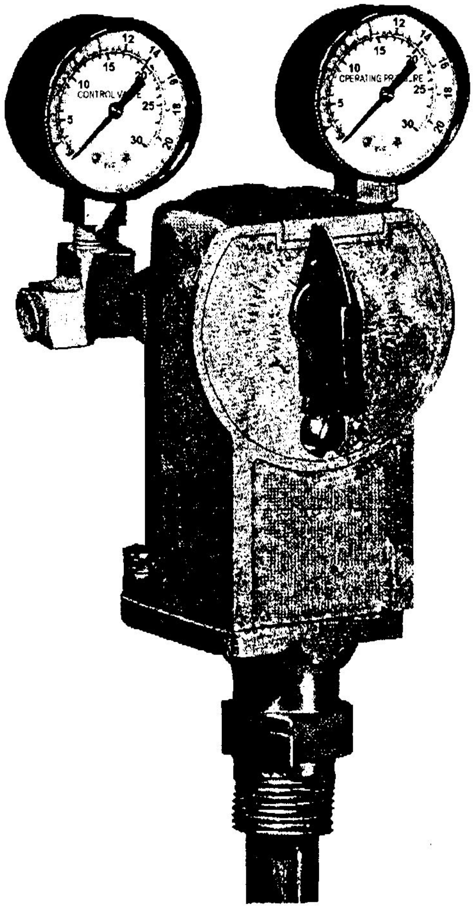


Figure 4-1.-Bimetallic temperature pilot controller.

The externally mounted temperature pilot controller shown in figure 4-1 is used in most gas turbine MRG LO systems. It receives inputs from the increasing or decreasing length of the bimetallic sensing element, as shown in detail in figure 4-2, The sensing bulb is installed in the MRG LO cooler outlet piping where it senses the oil temperature before the oil enters the MRG. The tube, which is fixed at one end, expands and contracts with temperature changes. Since there is a difference in the coefficient of expansion between the tube and the Invar rod, temperature changes at the tube will create movement of the rod. The movement of the rod is transmitted and amplified by a lever that contacts the diaphragm assembly. As the rod moves, it regulates the amount of air pressure that is sent to or bled off the automatic control valve. For example, if the controller shown in figure 4-2 should sense an increase in liquid temperature, it will cause the tube to lengthen, allowing a downward movement of the rod, which, in turn, will increase airflow to the automatic control valve. Consequently, a temperature increase will cause the automatic control valve to open, thereby increasing the cooling medium or the oil flow (depending on system design) through the cooler.

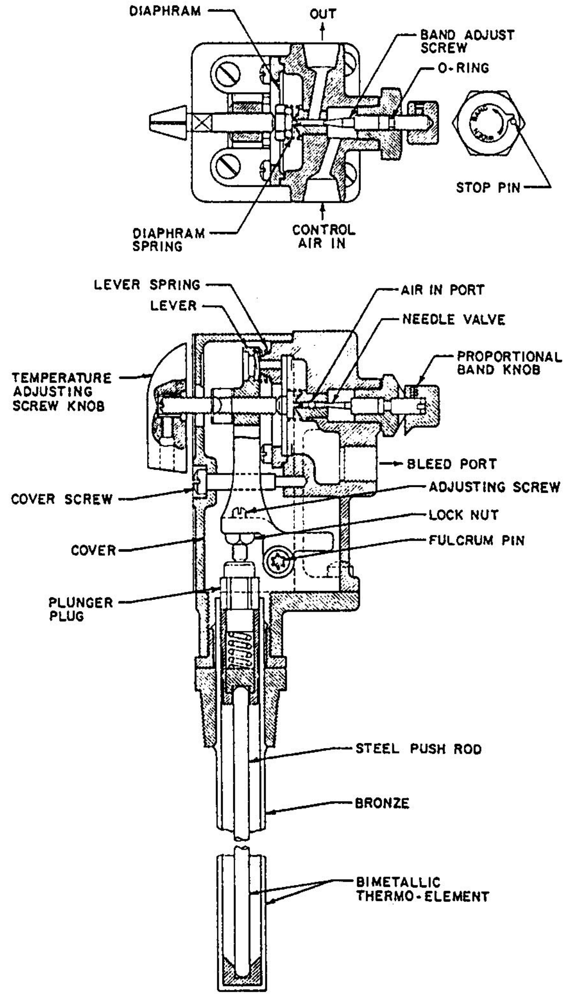


Figure 4-2.-Detail drawing of a bimetallic temperature pilot controller.

NOTE

Remember, our description of this operation pertains only to the controller shown in figure 4-2. Normally, most automatic temperature control valves used for cooling will fail to the open position. Our description and the controller shown in figure 4-2 are intended to provide you with a basic example of controller operation.

VALVE ACTUATORS.– As well as automatic control valves, there are several types of valve actuators. Many actuators are pneumatic, such as the one in the automatic temperature control valve we just described. Some valve actuators are mechanical. A large number of valve actuators you will encounter are electrical (solenoid type).

The mechanical actuators, either spring-loaded or manual, are stand alone operators or are sometimes used to override a pneumatic or electrical type of actuator in the case of an actuator or control valve failure. For example, the steam diverting valve used on the CG-47 and DD-963 class ships has a valve handwheel. The handwheel is coupled directly through the diaphragm to the valve stem to allow for manual operation of the valve.

MECHANICAL LINKAGES.– The purpose of valve operator mechanical linkages is to connect remotely positioned valves with an operator handwheel by a series of rods (linkages) or a flexible cable. Valve operator mechanical linkages are needed to control hard-to-inch valves, such as those located in the bilge area or the overhead. With proper maintenance and upkeep, these mechanical operators serve as real time savers.

Now that we have discussed some of the automatic control valves in terms of their basic operations and components, let's talk about how you will be required to test, inspect, and maintain them.

Tests and Inspections

In this section, we will briefly discuss some of the tests and inspections you may be required to perform on the various types of control valves and other associated components. Normally, you will conduct periodic tests and inspections when the component is operating or according to approved maintenance procedures, such as the PMS.

LEVEL CONTROL VALVES– In testing and inspecting level control valves, you will sometimes require the assistance of a GSE. If the test or inspection pertains only to the valve itself or if the sensing features of the system are mechanical, such as those on the WHBs, then you will be able to complete the checks on your own. If the operation of the tank level sensing system you must test or inspect is electrical, however, then you will need the assistance of a GSE.

Frequently, you will inspect the operation of a level control valve during normal operation. You will normally perform tests on this valve during a training evolution or a propulsion plant inspection, or when you are planning to perform general maintenance. Regardless of the circumstances, you must perform your inspections and tests of these valves according to the PMS or other authorized procedures just as you would for any other test or inspection you are required to accomplish.

Basically, the two most popular types of level control valves you will need to be familiar with are the solenoid-operated, needle type and the pneumatic-operated globe type.

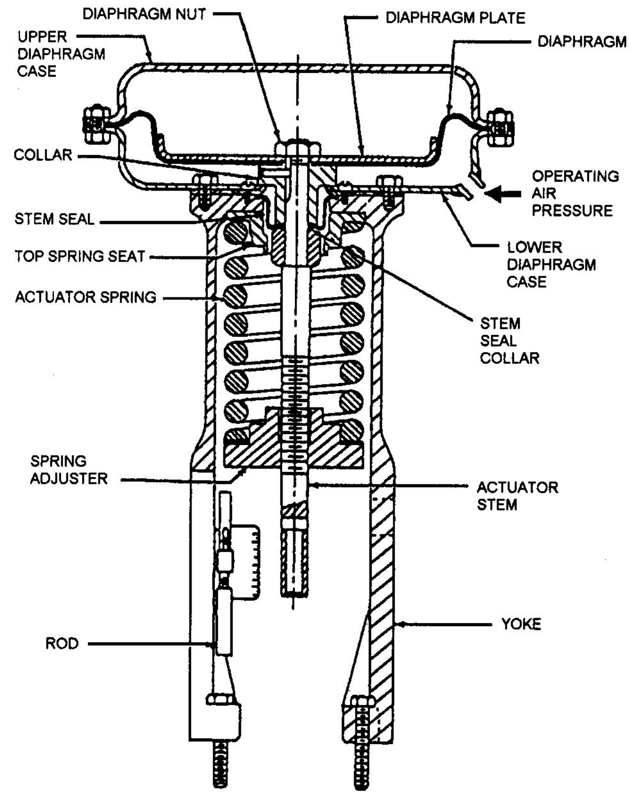


Figure 4-3.-Diaphragm control valve actuator.

Solenoid Valves.– Solenoid valves are used extensively throughout the engineering plant of any gas turbine-powered ship. The solenoid valve we will discuss as our typical example is the one that is used as a level control device in the FO service system on DD-963 class ships. These valves do not have any specific tests or inspections as per PMS. According to the *NSTM,* Chapter 505, "Piping Systems," however, extensive damage may occur if these valves are not exercised periodically. This is particularly true if the valves are located in areas that are difficult to keep clean, such as the bilges in main engine room (MER) No. 1.

Solenoid valves should always be cycled before the system is placed in operation. For proper operation, they should also be cycled at least once per month. You can perform an operational test on a solenoid valve by using the thumbwheel override built into the side of the valve. When performing a test or inspection, you should be checking for proper operation of the valve and leaks around the stem or associated fittings and flanges.

Pilot Operated Valves.– Pilot operated valves are normally tested and inspected according to the PMS. In performing a normal test, you will check the full travel range of the valve stem and match it with the scale mounted on the control valve actuator yoke, as shown in figure 4-3. To perform this test, you must use an

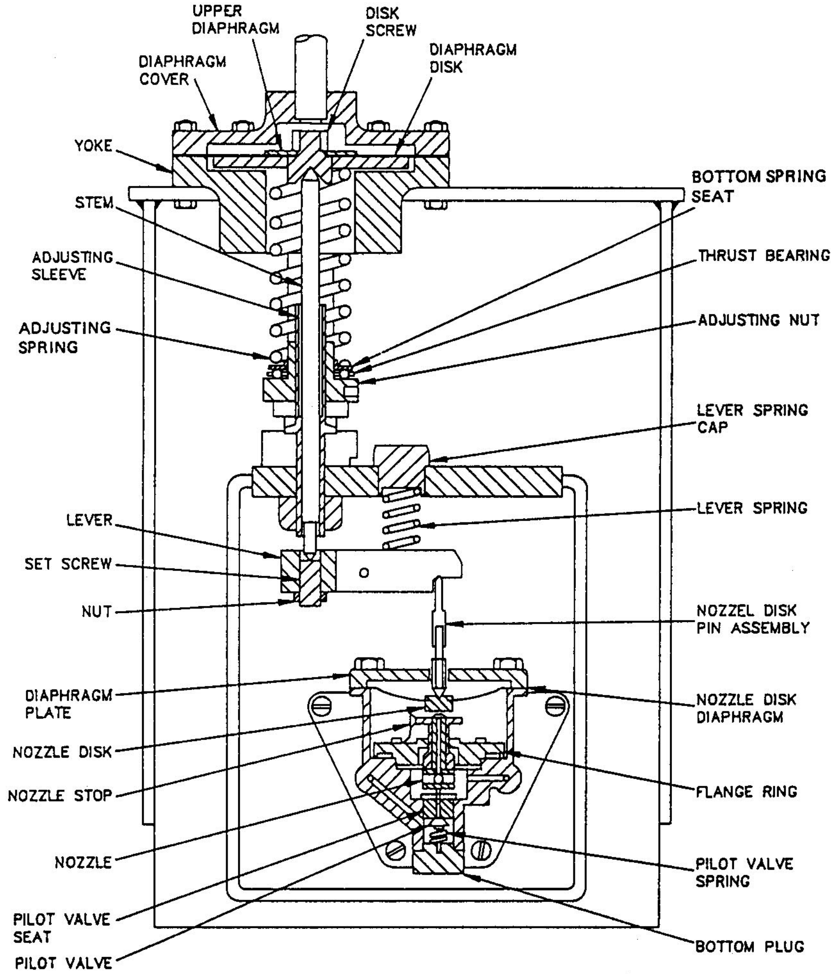


Figure 4-4.-External control pilot.

external air source with an in-line pressure regulator that is connected to the diaphragm inlet air connection. With the air pressure regulator set at zero psi, the valve position indicator should be pointing at zero percent on the position scale, indicating a normally closed valve. As you apply air pressure to the diaphragm, the valve should begin to open. The amount of air pressure you apply to the valve will determine the percent of valve opening, depending on the valve spring pressure. Normally, all of these valves will require approximately 5 psi of air pressure to start valve stem movement. At 20 to 22 psi, the valve should be fully open. If more air pressure than 22 psi is required to move the valve stem, there is a good possibility the diaphragm has a hole in it, the stem seal is leaking, or the valve is binding. Any one of these problems can seriously affect the responsiveness of the valve, so you should investigate these conditions as soon as possible.

Generally, you will perform an inspection of a pilot operated valve during normal valve operation. During the inspection, you will need to check the packing gland for leakage, watch the stem cycle for smooth operation, examine the diaphragm telltale hole and stem collar seal for air leakage, and check the externally mounted pilot controllers, such as the one shown in figure 4-4, for proper supply air pressure settings.

TEMPERATURE CONTROL VALVES.– The types of temperature control valves we normally use are either the air pilot operated valves, such as the one we described earlier, or the spring-loaded, bellows-actuated valves. These two valves are used in almost every system in the engineering plant. You will find either one located near every heat exchanger in the plant.

Pilot Operated Valves.– The tests and inspections you will use for the pilot operated valves are the same as those we previously described for the level control valves.

Spring-Loaded Bellows Actuated Valves.– A typical spring-loaded bellows actuated valve is shown in figure 4-5. For this valve, you will normally conduct

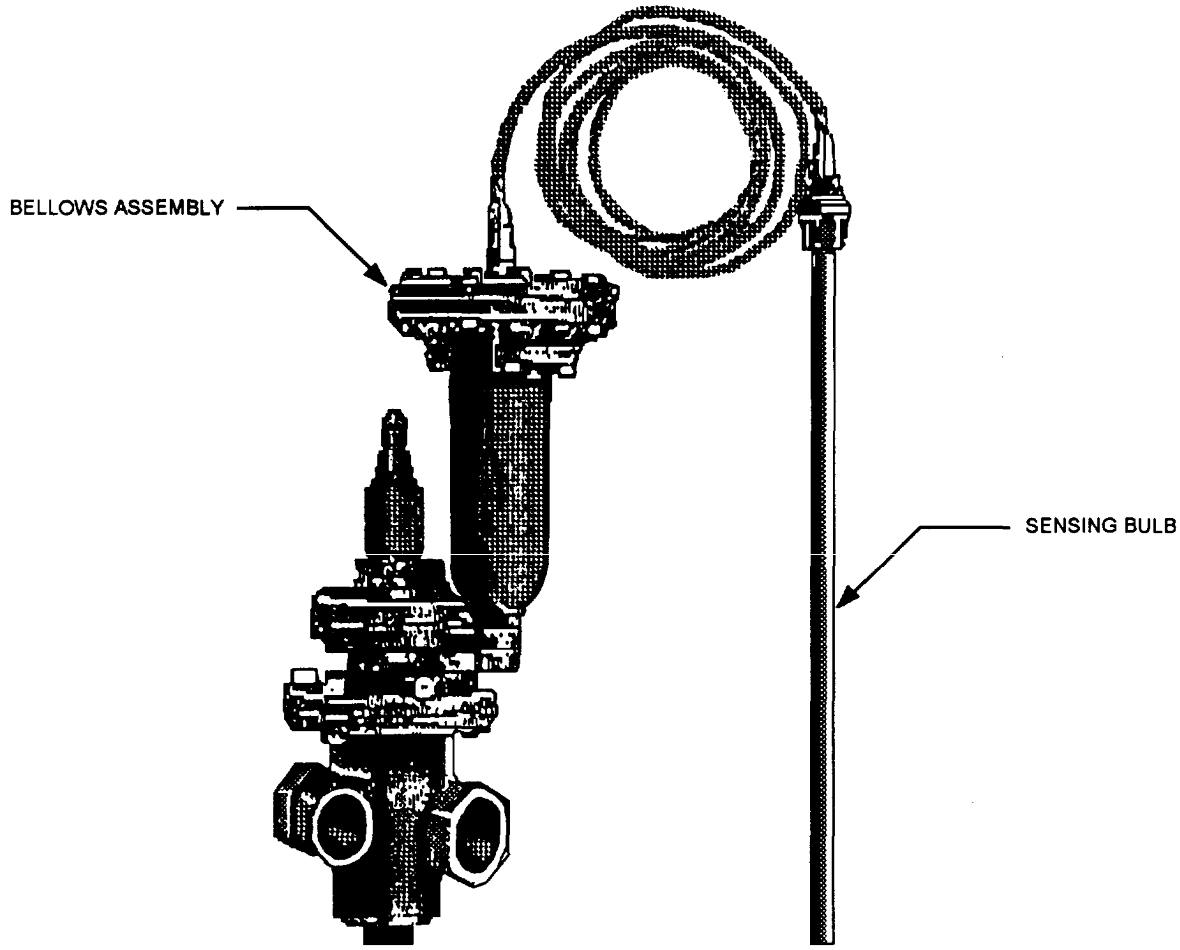


Figure 4-5.-Spring-loaded bellows actuated valve.

inspections during equipment operations and according to the PMS.

You can test this type of valve by using either of two methods: (1) by monitoring the valve during normal operations to ensure it is maintaining the desired temperature of the liquid or gas, or (2) by removing the sensor bulb, artificially raising the temperature, and monitoring the valve movement. Although you can raise the temperature by using either calibration equipment or a hot plate to heat the water, it is recommended that you use the calibration equipment because it will provide you with a better means of temperature control.

NOTE

The ability to control temperature during a test is crucial. Using a hot plate will not give you that flexibility.

PRESSURE CONTROL VALVES.– There are several different types and models of pressure control valves. For example, pressure control valves include relief, reducing, and regulating valves. Because of the large selection of pressure control valves, we will limit our discussion to regulating valves.

There are two basic types of MRG LO pressure regulating valves used on gas turbine-powered ships: (1) pneumatic pressure regulating valves and (2) self-contained pressure regulating valves.

Pneumatic Pressure Regulating Valves.– In several sections of our discussion of automatic control valves, we have already described the normal operation and components of the basic pneumatic pressure regulating valve. For this reason, we will limit our discussion to the following paragraphs on the self-contained pressure regulating valves.

Self-Contained Pressure Regulating Valves.– A typical example of a self-contained pressure regulating

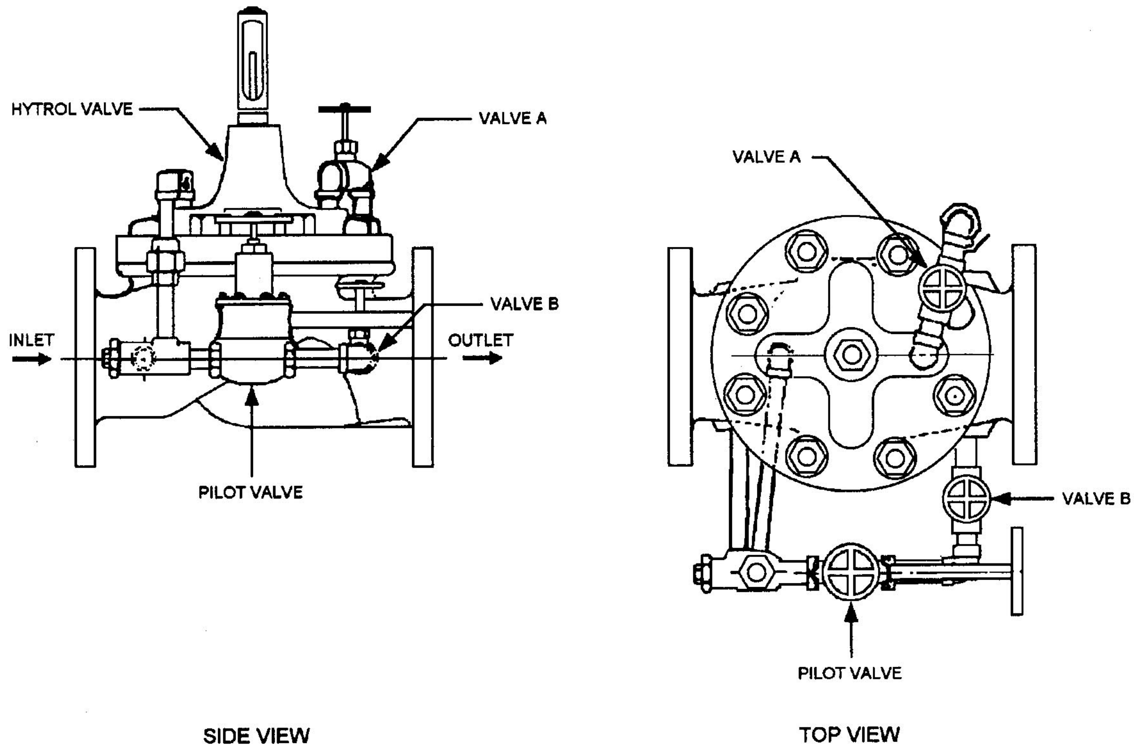


Figure 4-6.-MRG LO unloading valve.

valve is the MRG LO unloader valve shown in figure 4-6.

Normally, you will perform inspections of the MRG LO pressure regulating valves while the MRG LO system is in operation. Valve integrity (leaks) and proper pressure regulation will be your key concerns. Engine-room personnel can use visual inspections to check for valve integrity. Pressure regulation can be monitored locally and at the operating console in the central control station (CCS).

Self-contained pressure regulating valves have two modes of operation: (1) automatic and (2) manual. You can test both modes of operation locally. You should perform these tests according to the PMS or other authorized maintenance procedures. In the following paragraphs, we will briefly describe the sequence of steps you should use for testing both modes of operation. Please refer to figure 4-6 for proper component identification and location.

Automatic Operation.– To test a self-contained pressure regulating valve for automatic operation, use the following steps in sequence:

1. Be sure globe valve A is closed and globe valve B is open.
2. Vary the system pressure by any convenient method and observe LO pressure at the remote sensing point. The valve should modulate to hold this pressure within 1 or 2 psi of the setting. If the valve is out of adjustment, adjust the pilot valve until the proper pressure is achieved.
3. Lower the LO system pressure to below operating level. The hytrol valve should close tight, as indicated by the stem in the indicator assembly going to the bottom of the sight tube.
4. Return the LO system operating pressure to the normal operating level. If the valve is functioning properly, proceed with manual operational testing. If the valve fails to operate properly, perform a complete inspection of the valve at the earliest possible time.

Manual Operation.– To test a self-contained pressure regulating valve for manual operation, use the following steps in sequence:

1. Close globe valves A and B with the system under pressure. The hytrol valve should stay closed regardless of fluctuations in the system pressure.
2. Open globe valve A with the system under pressure. The hytrol valve should open

completely and stay in that position. This will be indicated by the stem rising to the top of the sight tube.

3. Close globe valve A. The indicator stem should drop, indicating that the hytrol valve is closed. (The speed of this closure is controlled by the size of the orifice in the strainer and orifice assembly. This small hole prevents excessively fast closing.)

4. Open globe valve B. The unloading valve should resume automatic operation.

VALVE OPERATOR MECHANICAL LINKAGES.– Valve operator mechanical linkages, as we previously stated, are used to connect a remotely positioned valve with an operator (handwheel). In this section, we will discuss the tests and inspections for the two types of mechanical linkages used on gas turbine-powered ships: (1) the rods and universal joint type and (2) the cable type.

Rod-Type Linkage.– In the design of the rod-type linkage, a series of rods is connected together by universal joints. The number of rods is determined by the distance between the operator and the valve. The number of joints is determined by the number of rods used and the number of bends that are less than 90 degrees. If a bend of 90 degrees is needed, then a gearbox assembly should be used.

Cable-Type Linkage.– In the design of the flexible cable type of linkage, a wire woven cable is housed in a flexible metal tube. In this type of linkage, gearbox assemblies should also be used when 90-degree bends are required.

The methods you will use for testing and inspecting these two types of mechanical linkages are very similar. These requirements are normally covered under the PMS. When testing these operators, your primary concern will be to check the freedom of movement. If difficulty in operation occurs, there are several areas you should inspect as possible causes of the problem. Use the following sequence of steps:

1. Determine if the problem is the operator or the valve. To do this, disconnect the operator from the valve and retest the operator. If it is still hard to operate the operator, then the problem is the operator.

2. Next, you must determine where the operator is binding. The first and easiest method you can use is to visually inspect the entire length of the operator. The following are some key things to look for:

   a. Positive signs of lubrication

   b. Loose or improperly positioned hold down brackets

   c. Excessive bending in the cable or individual universal joints

   d. Improperly positioned packing gland or a packing nut that is too tight on the deck or bulkhead penetration fittings

   e. Rusted or corroded fittings

In testing and inspecting automatic control valves, mechanical linkages, and their components, you may find that many of the problems will be obvious. In the following paragraphs, we will discuss the more common problems and tell you how to determine the required repairs.

Maintenance and Repair Procedures

Most maintenance will be covered by the PMS or maintenance procedures described in an appropriate manufacturer's technical manual. Therefore, we will briefly discuss some preventative maintenance and focus primarily on repair and component replacement. Because they are the most important preventive maintenance actions, we will start with cleaning and lubrication procedures.

CLEANING AND LUBRICATION.– The cleaning and lubrication of automatic control valves and mechanical linkages is extremely important. You may not realize how important it is until you are told to operate a valve and you cannot get the valve to move (open or close). Valves and operators located in high moisture systems or in the bilge areas are extremely susceptible to corrosion and will require more attention than any other propulsion plant valves. A key thing to remember is all valves do not use the same lubricants or solvents.

High-pressure Air System Valves.– High-pressure (HP) air system valves require a nonpetroleum-based lubricant. This type of lubricant must be used because of the static electric charge that is developed as the air moves through the piping.

WARNING

Use of a petroleum-based lubricant can create a very explosive condition.

CAUTION

Use of an inappropriate solvent can cause damage to the components of the valve.

For these reasons, you should always follow an approved materials listing on the PMS card or in the manufacturer's technical manual.

Automatic Control Valves.– The cleaning and lubrication of automatic control valves and their actuators is vital to the proper operation of every system in the engineering plant. Electric solenoid valves and the self-contained LO unloader valves we have already described are the only automatic control valves that will require cleaning but not lubrication. All the other types will require continuous care involving both cleaning and lubrication.

You must pay very close attention to the control valve and actuator stem area. The stem and surrounding area is where most of the dirt will collect. If the packing gland has any leakage, corrosion will start in that area.

Valve Operator Mechanical Linkages.– Proper cleaning and lubrication of valve operator mechanical linkages is very important to maintain ease of operation. These mechanisms are designed to be helpful and timesaving because they allow you to operate valves that are located in hard-to-reach places. Remember, if you want to avoid waking three compartments over and five decks down, you must properly maintain these operators.

The rod or rigid type of operators with universal joints and gear cases will require more attention than the flexible cable operators. This is because the universal joints in the rod-type operators are not enclosed and are constantly exposed to the environment. Being exposed, these valves will require more frequent cleanings. After cleaning, you must also apply a fresh coat of lubricant. To maintain the gear cases, you should periodically open them (if a cover is provided), remove the old grease, clean them, and repack them with new grease.

The flexible cable valves are similar to a speedometer cable in design, except each end of the cable has a bearing installed. Each bearing housing is fitted with a grease fitting, so you can use a grease gun to provide lubrication.

OVERHAUL, REPAIR, AND REPLACEMENT OF COMPONENTS.– Depending on the age of the equipment and the availability of parts, it is usually more cost effective to overhaul or repair the equipment rather than replace it. Try to avoid complete replacement whenever possible. In the following paragraphs, we will discuss some tips concerning component repairs that should save your ship money and your equipment downtime.

Automatic Control Valves.– Automatic control valves are very versatile and, if properly maintained, they will provide long periods of service before complete replacement is necessary. The air-operated type of valve, however, will require more repair attention than the other valve types.

Air-operated valves use a rubber diaphragm and stem collar seal to operate. These rubber components have a much higher failure rate than the valves that operate without them. The main factor that causes diaphragm failure is the system in which the valve is installed. For example, the rubber diaphragm in a steam system valve will have a much higher failure rate than one on an LO system valve. Heat transfer from the system piping through the valve body is one of the primary factors that will contribute to the diaphragm's failure. Another factor is the amount of moisture and foreign material (rust) in the air supplied by the ship's service air system. Over a period of time, any moisture in the air system can cause the diaphragm to rot. Moisture in the air system will also cause rust to form in the piping. Eventually, the rust particles will flake off and be carried downstream to the diaphragm area, causing wear and holes in the rubber.

As maintenance goes, these rubber components are inexpensive and easy to replace. When replacing the stem collar seal, you must remember to treat it in the same way as you would a bicycle tube. The seal is delicate and can be easily damaged or punctured. To avoid damage to the seal, you must clean the housing thoroughly and make sure it is free of abrasives. You must also be careful during assembly to avoid pinching the seal between the metal surfaces.

Your ability to make shipboard repairs to the valve body will also be a time-saver. You can perform minor repairs, such as repacking and lapping the valve disk and seat, with minimal effort. Occasionally, however, according to the PMS or because of component failure, you will have to remove the valve and have it delivered to an IMA for an overhaul.

In the case of the air pilot controllers, all repairs will have to be performed by an IMA. Sometimes the larger IMAs will maintain a pool of controllers. If this is the case, you need only to send a faulty air pilot controller in and pickup an already reconditioned unit that is ready for installation.

Electric solenoid valves will usually require component replacement instead of repair. The whole assembly is divided into two parts, the solenoid and the valve. The diaphragm in the valve is the only minor part in the whole assembly that can be replaced to effect a minor repair. In most cases, you will have to replace either the solenoid or the whole valve.

Valve Operator Mechanical Linkages.– Mechanical linkages are designed to provide years of trouble-free service when properly maintained. Probably the leading cause of operator failure is negligence. This statement pertains to both types of operators we have discussed. For example, an operator will work fine until it has to be detached from the valve or component it is operating. Then, during reassembly, a bracket bolt may be missing. Instead of finding a replacement, you might think "Oh well, one bolt will hold it." The problem is there are usually two bolts per bracket. Using one bolt will definitely cause a misalignment in the operator. If both bolts are missing and you are tempted to install bolts of the wrong size, you will still cause the operator to be out of alignment.

Shipboard repairs to rigid rod-type operators will normally consist of freeing up a binding universal joint or gearbox, replacing the packing, and tightening or replacing any loose or missing support bracket bolts. Binding universal joints are usually caused by excessive bends or operator misalignment, as we have already discussed. Depending on the operator's age, however, the joint may be worn out and you will need to replace it. In most cases, the joint will be attached to the operator rod end by a removable pin. If necessary, you can drive out the pin with a punch. You can then remove the joint and install a new one.

Gearbox repairs will be more difficult and in some cases impossible to perform. Many of the gearboxes are sealed units and repairs cannot be made. Even if the gearboxes can be opened, you must call on your machinery repairman to manufacture the new gears. If the materials and equipment are available, you might be successful. In most cases, however, it is easier to order a new part.

Even though the flexible valve operators have fewer parts than the rigid operators, shipboard repairs to flexible valve operators are usually limited by the availability of parts. This means most repairs must be accomplished by outside activities. Depending on the problem, sometimes the repair personnel can make the repairs while leaving the operator in place. If this is not possible, the whole operator should be removed and sent to an outside repair facility.

OPERATION AND MAINTENANCE OF SUPPORT AND AUXILIARY SYSTEMS

Up to now, we have talked about some of the components associated with the support and auxiliary systems. You should realize, however, that these components are just a small portion of the total design and operation of these systems. In this section, we will tell you how these components interact to make the support and auxiliary systems work. Although we will briefly describe how the systems operate, we will focus primarily on their maintenance and repair.

SHIP'S SERVICE AIR SYSTEMS

The ship's service air system (SSAS) on a gas turbine-powered ship is used extensively everyday. It supplies air for maintenance, service, control, pneumatic power, and other utilities. All of these services come under one or more of the four subsystems we will describe in the following paragraphs.

Electronics Dry Air System

The electronics dry air system is a vital system in which the air is dried twice. Before entering the system, the air passes through a condenser filter and then a type 11 dehydrator. The electronics dry air system services all electronic systems, AC plants, and gun and missile control panels that require dry air.

Ship's Vital Air System

The ship's vital air system produces air that is dried only once. The only difference between the vital and nonvital air systems is the equipment serviced. The ship's vital header services the sonar dome, ammo elevator, close-in weapon system (CIWS), No. 3 GTG signal air, and many others.

MER Vital Air System

Like the ship's vital air system, the MER vital air system is tapped off the main header just before the priority valve. This tap location ensures that all vital equipment will have air if there is high air use or a leak occurs in the nonvital subsystem. This air is for vital propulsion equipment. It is also the receiving piping for emergent y air from the HP/LP air reducing station. On the CG-47, DD-963, DDG-993 class ships, there is one HP/LP air reducing station located in MER No. 1. On the DDG-51 class ships, there are two HP/LP air reducing stations, one in each MER.

Ship's and MER Nonvital Air Systems

These two subsystems, the ship's nonvital air system and the MER nonvital air system, are used for all of the same types of service. Both systems are designed to service all nonvital equipment, such as the pilothouse window washer, tool outlets, and several other nonvital equipment units.

The number of compressors needed to support these four basic subsystems will vary according to the class of ship. It does not matter, however, how many compressors are available because all these subsystems can be cross-connected or isolated from each other with the proper valve confikguration. An occasion may arise when none of the LPACs may be available. If this occurs, then the SSAS can be cross-connected with the HP air system (HPAS). For this configuration, you must make sure all nonvital systems are isolated. Isolating the nonvital system will help you make certain the depletion of the HPAS is minimal.

Tests and Inspections

Tests and inspections for the SSAS are normally scheduled according to the PMS, with the primary emphasis on the individual components, such as the compressors, driers, dehydrators, and reducing valves.

For the driers and dehydrators, you can accomplish many of the required tests and inspections during normal operation. Technically, you are performing an inspection of each unit every time you take hourly equipment readings.

For the system piping, you can accomplish a complete inspection for leaks and any other problem during the normal watch routine and while you are performing valve maintenance. While you are inspecting the air system, some of your major concerns should be damaged or rusted piping, broken or missing pipe hangers, and even painted or missing rubber isolation mounts.

Troubleshooting

In troubleshooting the SSAS, using common sense is your best tool. For example, visualize a situation in which you discover a large leak in the air system. Because the leak is very large, you must use the priority valve to isolate air to the nonvital header. The air pressure, however, still does not completely restore. Where should you look first for the cause of this problem?

Your first step is to narrow down the possible sources of the problem by isolating each of the three remaining SSAS subsystems, one at a time. The first subsystem you should check is the MER vital air, Identify the operating equipment supplied by the MER vital air subsystem. If practical, secure these equipment units. Once you have isolated the MER header and air pressure is restored, then you have narrowed down the location of the leak to this area. If air pressure does not restore, however, then you will need help from outside the MER. Before proceeding, you must check with all other divisions who receive service from the MER vital air system and have them inspect their equipment and piping until the problem is isolated.

Maintenance

Upkeep of the overall SSAS will consist of two main areas: (1) valve maintenance and preservation and (2) maintenance of the compressors and their associated driers and dehydrators. Valve maintenance will include maintaining and preserving the reducing station assemblies and all the manual valves. Maintenance of the manual valves will normally be limited to general cleaning and lubrication. Shipboard maintenance for the reducing stations will include adjusting, lubricating, and cleaning the air inlet strainers.

Like tests and inspections for the air driers and dehydrators, the maintenance of valves should be carried out according to the PMS.

BLEED AIR SYSTEMS

As you work toward becoming a GSM2, you will need to be familiar with the major equipment, basic operations, and general maintenance of the ship's bleed air system. You can find a detailed discussion of this system in *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* Volume 2, NAVEDTRA 10564,

In this section, we will give you only a brief overview of the following five major bleed air systems:

- Bleed air collection and distribution system
- Masker air system
- Prairie air system
- Start air system
- Anti-icing air system

For each of these systems, we will describe the major equipment, maintenance, and system similarities or differences among the ship classes.

Bleed Air Collection and Distribution System

The bleed air collection and distribution system collects compressed air extracted from the compressors of all propulsion turbines and SSGTGs. It then distributes the air to the four other systems as needed. This is the primary system and contains the bulk of the hardware, consisting of regulating valves, isolation valves, collection piping, the main header, distribution piping, and relief valves.

The bleed air collection and distribution system extracts compressed air from the customer bleed piping of the turbines through a bleed air shutoff valve. To prepare the air for use throughout the system, a regulating valve reduces and regulates the extracted air to 75 psi. Once regulated to 75 psi, the air enters the main bleed air header and is distributed to the start air, masker air, prairie air, or anti-icing air system, depending on the valve configurations of these individual systems.

TESTS AND INSPECTIONS.– Your responsibilities for testing the components of the bleed air collection and distribution system will be minimal. For example, if you are stationed on a twin-shaft ship, there are only 13 valves outside of the main engine enclosures that will require some kind of testing. These valves include the three 14-stage bleed air valves, seven bleed air regulating valves (three GTG valves and four GTM valves), the bleed air isolation valve, and two relief valves. If you arc stationed aboard an FFG-7 class ship, only two valves will require testing, one relief valve and the pressure regulator and flow control valve. For the most part, all testing for these valves will be covered under the PMS or as part of the Engineering Operational Procedures (EOP). According to the PMS, you will test the operation of the 14-stage bleed air valves and the relief valves. The PMS for the 14-stage bleed air valve must be conducted quite frequently and usually in conjunction with a major propulsion plant inspection (safety checks). According to the PMS, the relief valves must be periodically tested for proper lifting and reseating pressure.

Other tests and inspections will be more frequent. For example, you must test the bleed air isolation valves whenever the No. 3 SSGTG is started. You must test the other isolation valve (header) daily according to the EOP to ensure proper operation.

As for inspections, the bleed air regulating valves and the overall system must be inspected and monitored continuously by engineering personnel while it is in operation.

TROUBLESHOOTING.– Troubleshooting a problem in the bleed air collection and distribution system is usually fairly easy to accomplish. Remember, the movement of air follows the same principles as electricity: Air always takes the path of least resistance. In the following paragraphs, we will describe a few of the more common problems and some of the steps you can take to isolate their probable causes.

Bleed Air System Pressure is Too High.– When the bleed air system pressure is too high, use the following steps, in sequence, to isolate the problem:

1. Check and compare pressure readings throughout the plant to verify gauge accuracy.
2. Check the bleed air regulating valves. For CG-, DD-, and DDG-class ships, if more than one GTG is operating, you will need to alternate the securing of the bleed air regulating valves to pinpoint which one is faulty. Also, because bleed air from the main engines is not used very often, the regulating valves tend to overpressurize the system. For FFG-class ships, check the bleed air regulating and flow control valve. If a start air compressor (SAC) is operating, you should check the start air system's isolation check valve for leak-by into the main bleed air header.

Relief Valve is Lifting.– When this condition occurs, check the following two areas:

1. System pressure is too high–Follow the guidelines in the preceeding paragraph for high system pressure.
2. System pressure is normal–Is the relief valve faulty? Is it improperly set?

System Pressure is Too Low.– If the system pressure is too low, take the following steps:

1. Verify the accuracy of the gauge.
2. Check the relief valves for blowby.
3. Check the system for leaks.
4. Check the pressure regulating valve for proper operation.

MAINTENANCE.– You must perform the maintenance of all valves (electric or air operated) in the bleed air collection and distribution system according to the PMS. Except for the module bleed air cutout valves, you may in some cases use a type of planned maintenance program. You will also maintain the valves in the remaining subsystems of the bleed air system according to the PMS and possibly a planned maintenance program. The planned maintenance programs are usually contractual agreements between the Navy and the manufacturers of the valves. In some cases, valve manufacturers may keep a rotational pool of valves that will allow the ship to remove and replace all of the system valves with new or rebuilt ones during an SRA. Plans, such as these, will significantly reduce system downtime and increase reliability for months. Because all the bleed air system valves are basically maintained in the same manner, this is the last time we will discuss their maintenance requirements.

Masker and Prairie Air Systems

Both the masker and prairie air systems take the hot bleed air from the bleed air collection and distribution system. These two systems cool the air in independent coolers before sending it to the masker emitter belts or leading edge of the propeller blades. The purpose of masker air is to muffle or modify the ship's machinery noises that are transmitted into the water through the ship's hull. Prairie air is then used to disguise the propeller noise signature. We will discuss the basic design and operational characteristics and maintenance requirements of both systems in the following paragraphs.

MASKER AIR SYSTEM.– The number of valves used and the direction of airflow through the masker air system will depend on the ship's class. Because of the differences in masker air system designs, we will discuss the system installed on the CG-47, DD-963, and DDG-993 class ships. After we discuss this system, we will then point out the differences in the systems installed on other gas turbine-powered ships.

CC-47, DD-963, and DDG-993 Class Ships.– For the masker air system in these ships, the air is first extracted from the bleed air header and then piped to the masker air valve (masker cooler valve). The masker air valve is located between the header and the masker air cooler. When the operator selects the ON position for this valve, the hot bleed air flows through the cooler to an air/water cyclone-type separator and then to the masker transfer valve. The masker transfer valve is a two-way directional flow valve. The valve position selected by the operator will determine the direction of airflow, either to the start air system or to the masker air system. As the air is directed to the masker air system, the bleed air pressure is then reduced by a pressure regulating valve before the air is sent to the masker air distribution manifold. The air then enters the distribution manifold where it can be directed manually to any of the desired emitter belts.

DDG-51 Class Ships.– The basic masker air system installed on the DDG-51 class ships is the same as the one installed on the CG-47, DD-963, and DDG-993 class ships. The only difference worth mentioning is the way in which the masker air (cooler) valve operates. The type of masker air valve installed on the DDG-51 class ships is manually operated. The type installed on the CG-47, DD-963, and DDG-993 class ships is an electric solenoid-controlled valve that is operated from the PACC or the PLCC.

FFG-7 Class ships.– The masker air system installed on the FFG-7 class ships has only two characteristics in common with the masker air systems installed on the other ship classes: (1) where the masker air comes from and (2) the basic principles of operation.

In the FFG-7 class ships, the air is piped from the bleed air cooler through a normally open, manually operated cutout valve and then to the masker air pressure regulating valve. The air pressure is reduced and the air is then piped to the two masker air supply cutout valves. These two solenoid-controlled valves are then operated from the auxiliary control console (ACC) in the CCS to send air to one or both emitter belts.

PRAIRIE AIR SYSTEM.– Now let's discuss the prairie air system. The prairie air systems installed on all gas turbine-powered ships have the same basic design. They all have a solenoid-controlled valve that is operated from the control consoles, a cooler, and the associated piping that supplies air to the rotary air seal on the OD box for distribution to the propeller blades. Because these valves are operator selected either open or closed, the airflow and pressure are not reduced or regulated by these valves before the air is required for use.

TESTS AND INSPECTIONS.– For both the masker and prairie air systems, all tests and inspections must be carried out according to the PMS.

There are two primary tests that are normally conducted on these systems. In the first test, you will use a portable air flowmeter to check for the proper airflow. For the other test, you will check the operational effectiveness of these two systems against an acoustical range. In most cases, you can perform the two tests at the same time unless all flow rates arc set correctly before you make the required passes over the range.

TROUBLESHOOTING.– Neither the masker or prairie air system will have a vast number of components to cause the system to fail. This means troubleshooting a problem with either system should be fairly simple. Let's take a look at some problems that may occur and their possible solutions.

Incorrect Masker Air System Pressure.– In the masker air system, when the air pressure is either too high or too low, use the following steps:

1. Check the pressure gauge for accuracy.
2. Check the bleed air header pressure.
3. Check the regulating valve for the proper setting.

Incorrect Prairie Air System Pressure.– If the air pressure in the prairie air system is too high or too low, take the following steps:

1. Check the pressure gauge for accuracy.
2. Check the bleed air header pressure.

If there is no air pressure in the prairie air system, take the following steps:

1. Check the pressure gauge for accuracy.
2. Check the system supply cutout valve to make sure it is open. Sometimes this valve will indicate OPEN and will actually be closed if the pin connecting the actuator to the valve should shear. A sheared pin will allow the actuator to move, but not the valve.

Incorrect Masker or Prairie System Airflow.– Incorrect airflow in either system can be caused by the following conditions:

1. Improper system pressure–Is the regulating valve faulty or improperly set?
2. Misaligned manual belt cutout valves
3. Blocked holes in the masker belts or propeller

High Masker or Prairie System Air Temperature.– If the air temperature is too high in either the masker or prairie air system, take the following steps:

1. Check the gauge for accuracy.
2. Check the masker or prairie air coolers.
   a. Is the seawater cooling system pressure insufficient?
   b. Are the cooler tubes clogged?

Any of these conditions could be the cause of high air temperatures in either system.

Start Air Systems

The start air systems installed on all gas turbine-powered ships serve the same purpose: To start all the ship's propulsion or electric plant turbines. Even though the start air systems have the same goal, the start air system in each ship class will accomplish this goal in its own individualized way. Except for the DDG-993 class ships, all gas turbine-powered ships have two methods of starting each propulsion or electric plant turbine: (1) LP start air and (2) HP start air. In the DDG-993 class ships, the start air system has only LP start air capabilities for the propulsion turbines.

Because there are several differences in the start air systems installed in the different ship classes, we will first discuss the basic system installed on the CG-47, DD-963, and DDG-993 class ships. We will then discuss the differences.

CG-47, DD-963, AND DDG-993 CLASS SHIPS.– The start air systems installed on the CG-47, DD-963, and DDG-993 class ships use hot bleed air from the bleed air header and cool masker air from the masker air system to provide each turbine with LP starting air. These start air systems were designed to use a bleed-air/masker-air combination because the propulsion turbine and GTG starters consume a lower amount of air when the air temperature is increased.

There are three modes of operation for the starter air system: (1) normal, (2) motor, and (3) emergency. With the bleed air system in the automatic mode, the normal position for starter air is the primary method of operation for GTM starting and the motor position is the primary method of operation for GTM motoring. Also, with the bleed air system in the automatic mode, the ECSS logics for the start air system valves will automatically align for either starting or motoring the GTM. When a GTG is started, however, its start air system does not interface with the ECSS logics. This is why a manual air valve alignment must be used for GTG starting.

GTM Starting and Motoring.– In the start air system for a GTM start, there are five valves that must be aligned before the GTM start air valve can open:

1. MASKER XFR
2. MASKER CLR
3. HI TEMP BLEED
4. MOTOR AIR REG
5. MIXING BYPASS

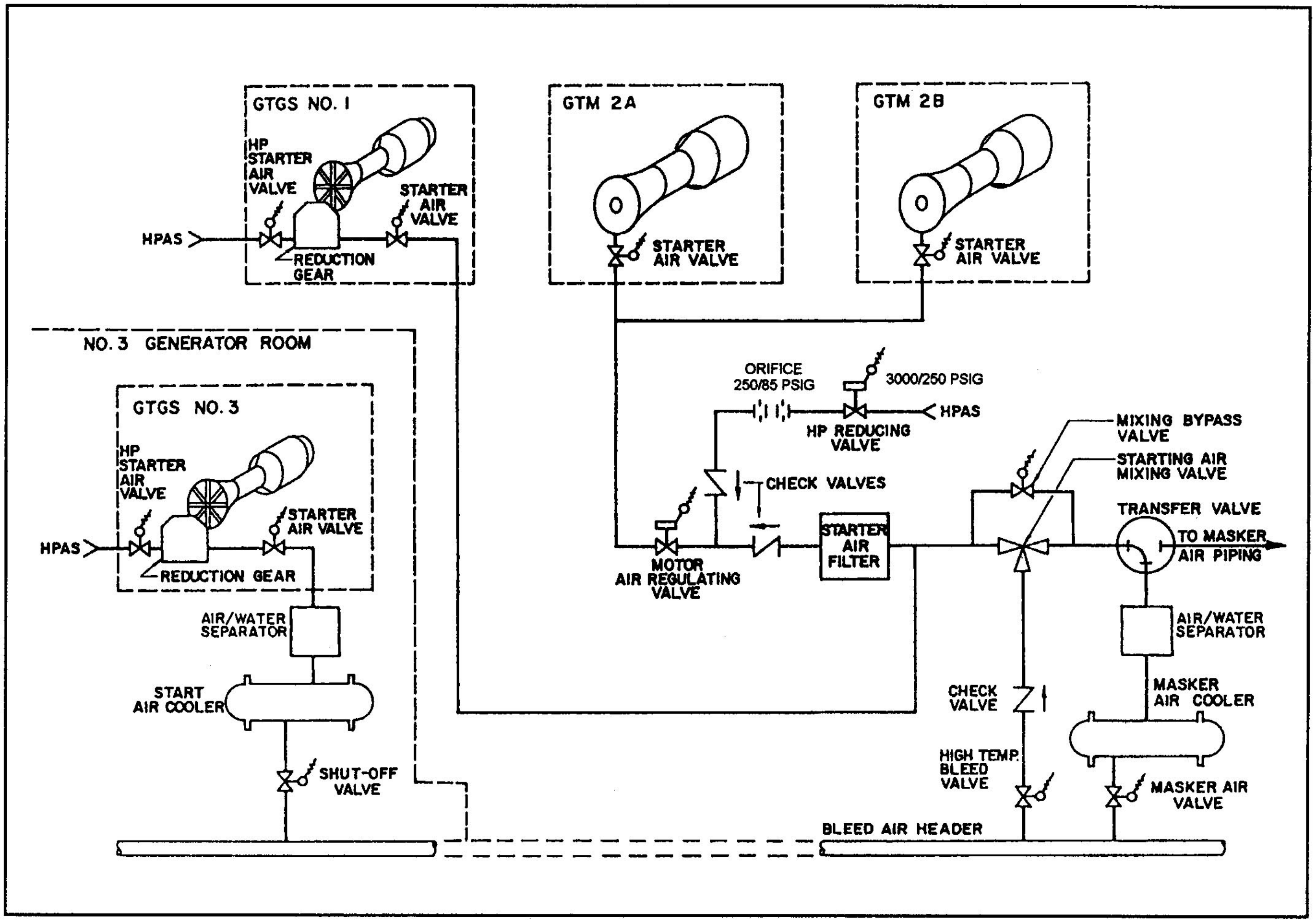


Figure 4-7.-DD-963 start air system (simplified).

If you trace the system shown in figure 4-7 and compare it with the following listing of the five valves and their positions, you will see the proper valve alignment for GTM LP starting and motoring.

VALVE TYPE	VALVE POSITION FOR: STARTING	MOTORING
MASKER XFR	START	START
MASKER CLR	OPEN	OPEN
HI TEMP BLEED	OPEN	CLOSE
MOTOR AIR REG	OFF	ON
MIXING BYPASS	CLOSE	OPEN

Now that you have seen the valve alignment for GTM LP starting and motoring, let's discuss the valve alignment for GTG starting.

GTG Starting.– If you reexamine figure 4-7, you can see that the valve alignment for a GTG start or motor should be same as for a GTM motor. The only exception is that it does not matter what position the motor air regulating valve is in.

HP and LP Starting.– As we mentioned at the beginning of this section, there are two methods of starting—using either HP or LP air. Again, if you study figure 4-7, you can see that the HP air system interfaces with the start air system just before the motor air regulating valve. Notice also in figure 4-7 that the HP-to-LP air reducing valve pressure and the orifice are configurations that only apply to DD-963 ships.

The CG-47 ships share this basic system design, but the CG-47 HP/LP reducing station has a lower outlet pressure (45 psig), which eliminates the need for the orifice pack. Because of the location at which the HP air enters the system, there is only one valve that must be aligned, the motor air regulator.

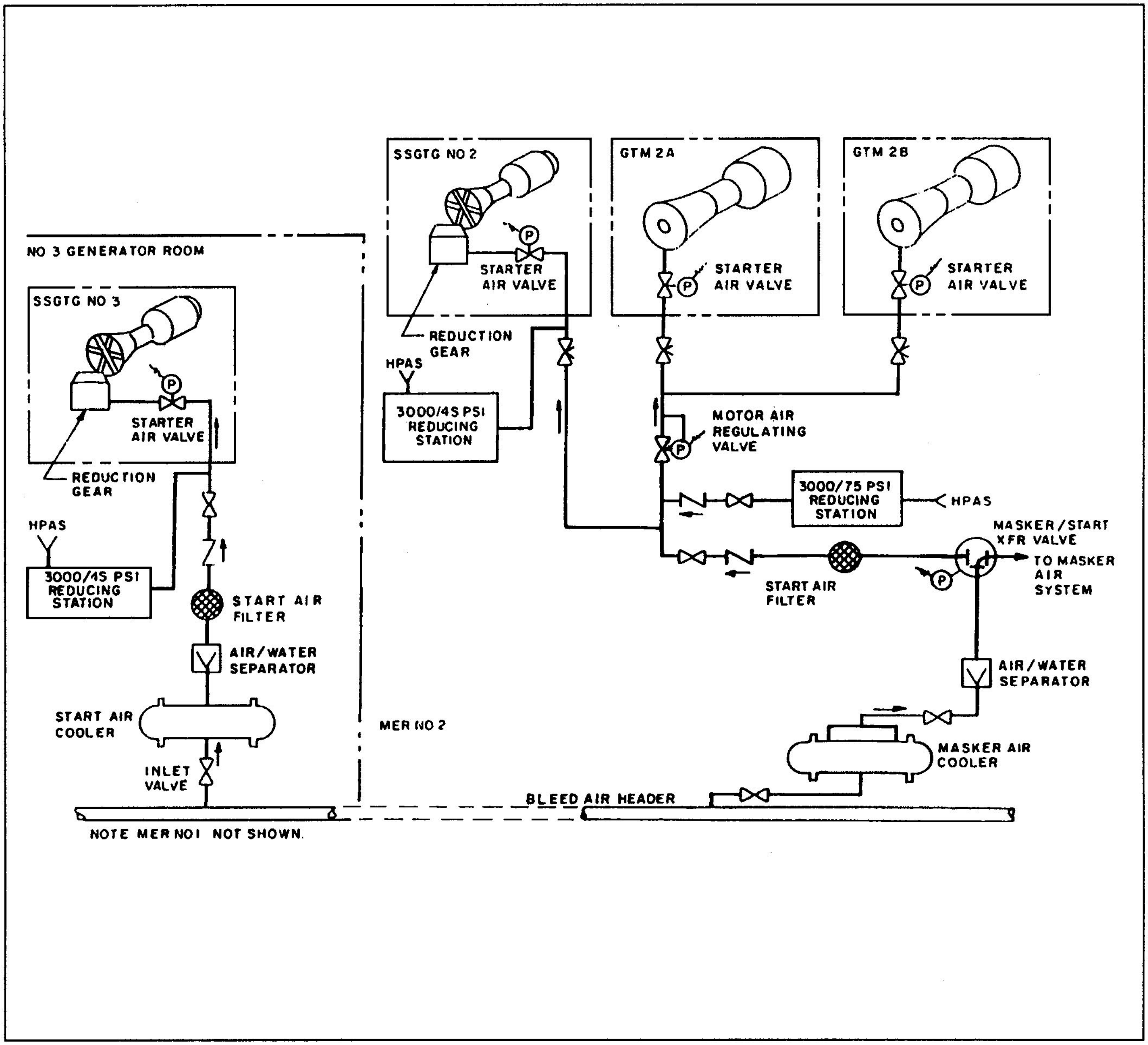


Figure 4-8.-DDG-51 start air system (simplified).

As we indicated earlier, the start air systems we have just discussed are found on the CG-47, DD-963, and air DDG-993 class ships. In the following paragraphs, will point out the differences found on the two remaining systems installed on the DDG-51 and FFG-7 class ships.

DDG-51 CLASS SHIPS.– The start air system on the DDG-51 class ships shares some basic similarities with the systems we have already described. If you study figure 4-8 and compare it to figure 4-7, you can see the start air system for the DDG-51 class ships performs the same functions as the DD-963 system with fewer valves. Instead of using five valves, the DDG-51 start air system does the same job with only two valves. The console controls are also much simpler in design. At the DDG-51 console, you will have only one of two choices to make–to use HP air or bleed air to start the engine.

In the DDG-51 start air system, another design difference is that the HP-to-LP air reducing station outlet that is 75 psig. In the DDG-51 system, an orifice pack is not installed because additional air pressure reduction is simply not necessary.

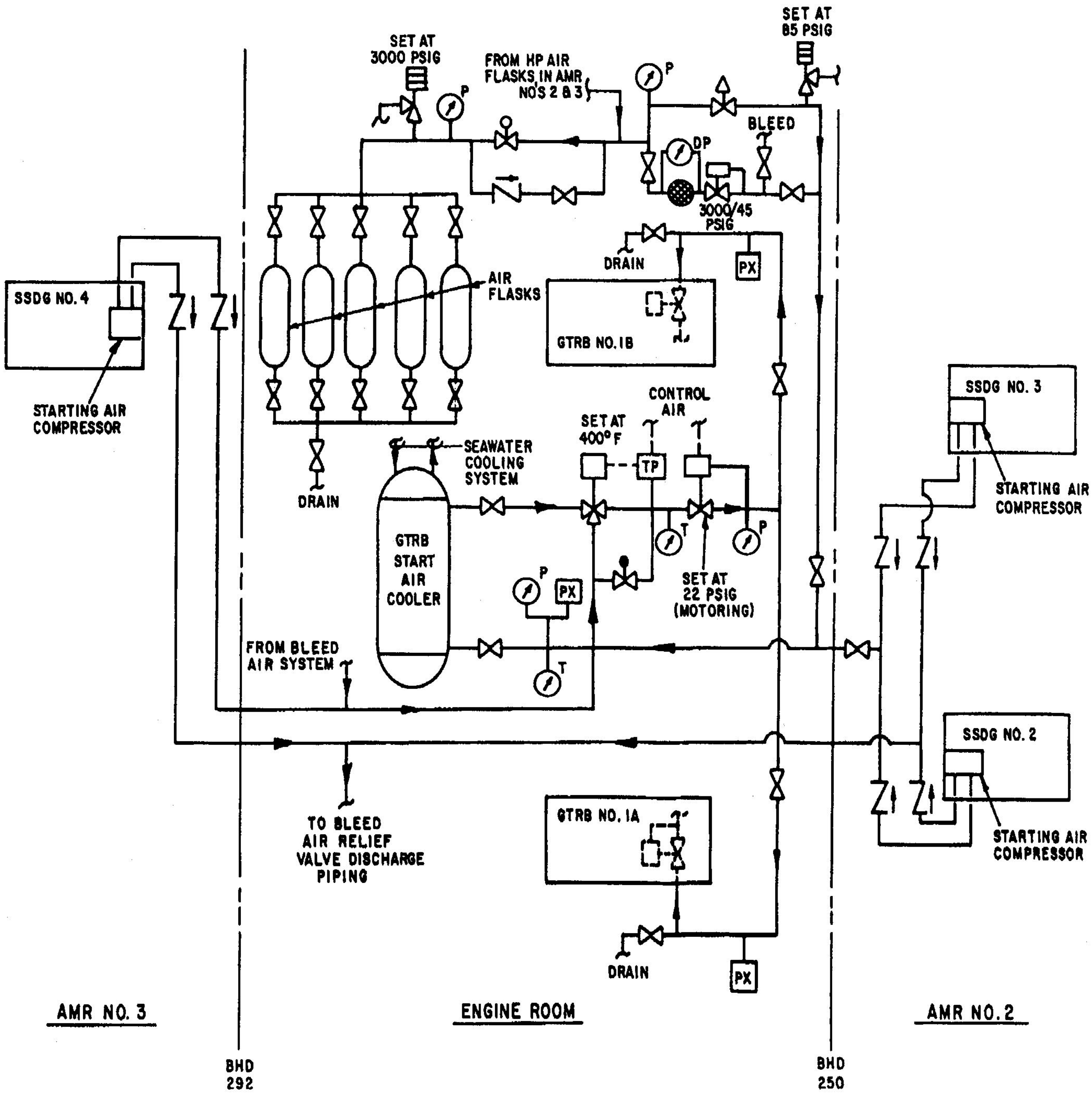


Figure 4-9.-FFG-7 start air system (simplified).

FFG-7 CLASS SHIPS.– The last start air system we will discuss is the one installed on the FFG-7 ships. This system is shown in figure 4-9.

If you look closely at figure 4-9, you should notice there are three methods or sources of air for starting the GTMs: (1) HP air, (2) LP (bleed) air from the start air compressors, or (3) LP (bleed) air from the cross-bleed piping from the online GTM. You can use any of the three methods, depending on the circumstances. In most cases, HP air will be available and will be the primary means of starting the GTMs during a casualty. As you can see in figure 4-8, the air pressure is reduced to a workable pressure by the HP/LP air reducing valve, which alleviates the need for further pressure reduction. This design is very similar to the one used on the CG-47 class ships.

The second method is using LP (bleed) air from the start air compressors. In this method, two start air compressors (SACs) provide LP air for GTM starting. The two SACS are attached to the front end of the SSDG. One is installed in the No. 2 SSDG enclosure. The other one is installed in the No. 4 SSDG enclosure. In this system, the air is treated in much the same way as it is in the DD-963 system. Hot compressed air is supplied by one of the SACs. The air is then split into two flow paths before reaching the starter. Part of the air will remain hot; the other part will be routed through a cooler. The hot air will then be mixed with the air that was routed through the cooler. The mixing of air takes place in the temperature regulating valve (similar to the DD-963 mixing valve), which will regulate the start air temperature to 400°F.

The third method, referred to as cross-bleed starting, is not very frequently used. In fact, you will use it only when performing the PMS or during a casualty. Remember, this method can only be used if the other GTM is already running with a gas generator (GG) speed of 7,500 rpm or greater. The reason the GG speed has a specific set point is because at a lower GG speed, sufficient air volume cannot be supplied to the GTM for starting.

TESTS AND INSPECTIONS– You must carry out all tests and inspections for all the start air systems according to the PMS. Generally, there are two tests you will conduct on these systems. The first test is checking for the proper operation of the HP/LP start air reducing stations installed on the CG-, DD-, and DDG-51 class ships. Because the reducing stations are not used very frequently, they must be tested periodically.

Another periodic inspection you must make is on the SACs installed on the FFG-7 class ships. Even though the SACs on the FFG-7 class ships are used and tested more frequently than the reducing stations installed on the CG-, DD-, and DDG-51 class ships, you must still inspect them periodically. As a GSM, you should keep in mind that the air produced by these compressors may be used to start your turbines, but the maintenance and upkeep of these compressors may not be your responsibility. As a watch stander, however, you will be responsible for reporting any discrepancies you might observe during the operation of these units.

TROUBLESHOOTING.– At times, your procedures for troubleshooting a start air system can be quite difficult. If all the problems that might arise were mechanical, then solving those problems would not be that difficult. Unfortunately, a start air system is highly reliant on electronic interfacing with the control consoles. With so many different variables associated with the control consoles and the start air system, such as FO, LO, air permissive, and so forth, in most cases you will need to call upon a GSE to assist you in troubleshooting this system. Occasionally, however, you may get lucky and encounter a problem that is strictly mechanical. With this in mind, we will discuss some of the mechanical and minor electrical problems you might encounter in ‘the start air system and some methods you can use to identify the faulty components.

Air Valve Will Not Cycle.– If the air valve will not cycle, perform the following checks:

1. Check the valve's actuating air supply. On the DD-963 and DDG-993 class ships, the actuating air is supplied from the bleed air system. In all the other ship classes, the activating air is supplied from the ship's LP air system. If activating air is available, check the pilot air inlet fitting and its filter to see if they are clogged.

2. Check the pilot actuator assembly. Most of the valves for this assembly are equipped with a manual override device. First, activate the override. If the valve operates, you have narrowed the problem down to a faulty solenoid, a faulty or loose cannon plug, or loss of the command signal. If the valve still does not operate, it may be jammed or the actuating piston seal may be leaking by and the resulting pressure may be insufficient to overcome the spring pressure.

3. Check the cannon plug connection. If the connection is clean, dry, and tight, then have a GSE check the solenoid and the control circuit.

Faulty Air Valve Appears to Operate Properly.– This situation will occur occasionally when the pin that connects the pilot actuator with the valve stem shears. When this occurs, the actuator will move properly but the valve stem will not. For a good example of this situation, visualize attempting a start on a DD-963 class ship. During the start attempt, monitor the start air manifold pressure. It will likely read normal. Notice, however, that once the GTM start valve opens, the air pressure drops to zero. When this occurs, you will need to either replace the valve or, if time permits, disassemble the valve and install a new pin.

Air Valve Opens and Closes Slowly.– As a GSM, you must watch for the valve's performance. The valve may open and close, but it will take an abnormally long time to do so. When this occurs, you should immediately check the system's filters and low-point drains for excessive amounts of water and debris.

Anti-Icing Air System

The last bleed air subsystem we will discuss is the anti-icing system. Even though this system is not used very often, it is still an important part of the overall bleed air system.

The function of the anti-icing air system is to use hot bleed air to prevent the formation of ice on the gas turbine cooling air inlet moisture separators on the FFG-class ships and the combustion air intakes on all the ship classes. Among the different classes of gas turbine ships, the ice detectors will be installed in critical locations to warn the operators when an icing condition exists. If an icing condition should occur, the operators in the CCS will always inform the engine-room personnel and direct them to open the anti-icing valves manually. These valves will control the pressure and flow of air that will be required to raise the intake air temperature to a level that will eliminate the icing condition. Except for the FFG-7 class ships, all classes of the gas turbine-powered ships are equipped with this anti-icing valve system. Although the anti-icing air system on the FFG-class ships is equipped with a manual cutout valve, the pressure is automatically regulated.

TESTS AND INSPECTIONS.– On all classes of gas turbine-powered ships, tests and inspections of the anti-icing air system will not be performed very often. The tests will mainly pertain to the operational capability of the system's valves. You will perform these tests according to the PMS. Your main concerns will be to test these valves for freedom of movement and check the console indicator lights for proper valve position indications.

The inspections you will perform on the components of the anti-icing air system are very important. You must use great care whenever you conduct these inspections and handle these components. You must be so careful because the primary component for this system is located inside the turbine's combustion air intake. You must regard any work inside the combustion air intake with the same care and concern you would any work on the main reduction gear. To protect the safety of personnel and equipment, you must adhere strictly to all security and safety guidelines. While inspecting the bleed air manifold, your primary concern will be not so much the manifold itself but its fasteners. In inspecting the fasteners, you must make certain that all the bolts are made of the proper material (stainless steel) and that they are properly tightened and safety wired. You must check every bolt for tightness, corrosion, and the presence of properly installed safety wire.

TROUBLESHOOTING.– As a GSM, you should have very little difficulty troubleshooting a problem in this system. Because the majority of the system's valves are manually operated, most of the system's problems will be related to improper alignment. The only exception to this is the anti-icing air system installed on the FFG-class ships, which has a pressure regulating valve installed. If you should identify this valve as the source of a problem, you should approach its repairs and testing the same way as you would any of the other bleed air system automatic control valves we have discussed. The most important thing to remember about the pressure regulating valve in the FFG anti-icing air system is that it is not used very often and may have a tendency to stick.

MAINTENANCE.– In all gas turbine-powered ships, your maintenance of the anti-icing air system will be fairly limited to valve maintenance and the required repairs you will determine after performing the previously mentioned tests and inspections.

WASTE HEAT RECOVERY SYSTEMS

As a GSM, there is a good chance you will encounter one or both types of waste heat recovery systems we will discuss in this section. The first type of waste heat recovery system we will discuss is installed on the CG-47, DD-963, and DDG-993 class ships. The other system we will describe is installed on the FFG-7 class ships.

In this section, we will briefly discuss the role of the waste heat recovery system during routine operations. We will focus on some of the maintenance and upkeep requirements for this system.

CG-47, DD-963, and DDG-993 Class Ships

The CG-47, DD-963, and DDG-993 class ships use waste heat boilers (WHBs) that are installed in the ship's service gas turbine generator (SSGTG) exhaust stream. The WHB is positioned so it can effectively capture the hot exhaust gases from the turbine before they are exhausted from the ship.

On the CG-47, DD-963, and DDG-993 class ships, there are two different styles of WHBs. One is a horizontal straight tube style manufactured by Combustion Engineering (CE). The other style, manufactured by Conseco, has a horizontal coiled tube bundle. Even though these boilers are different in design, they serve the same purpose-to generate steam for cooking, laundry services, and heating the water, FO, and LO. These boilers also function according to the same principles, with only small differences in their operating parameters. Since the design differences are minimal, and a complete description can be found in each unit's applicable propulsion plant manual, we will only discuss the differences.

The first and probably the most obvious difference is in the design of the steam generating unit (boiler). The CE boiler is square and has straight tubes. The Conseco boiler is round and has coiled tubes. The second design difference is that the CE boiler system uses a deaerating feed tank (DFT) to remove excess oxygen from the water. The last difference is not as obvious as the others. The steam drum (separator) has steam connections installed to enable the operator to perform a surface blow. Surface blowing is an additional method commonly used on propulsion steam plants to maintain proper water chemistry limits.

TESTS, INSPECTIONS, AND FUNCTIONAL CHECKS.– All steam system tests, inspections, and functional checks are either covered in the PMS or in the EOSS. Some of the equipment items on which you will perform tests, inspections, or functional checks are briefly discussed in the following paragraphs.

Boiler Control Panel.– The tests or inspections associated with this piece of equipment are usually conducted before the boiler is placed in operation. When performing the preoperational EOSS procedure (WHBP), check all of the indicating lamps and alarms for proper operation.

Water Level Controller.– Most tests or inspections performed on this equipment are accomplished during boiler operations. The best time to pinpoint a problem is during normal operations. There is a specified time, however, when you will need to remove the gauge for calibration, unless an onsite calibration team can perform the adjustments with the instrument in place.

Safety Valves.– These valves are routinely inspected during normal boiler operation. They should also be periodically tested according to the PMS. During these tests, you should check for proper lifting and reseating pressures. Periodically, these safety valves must be removed so they can be bench tested according to the PMS and the requirements in *NSTM,* chapter 221, or if they fail the installed PMS tests.

Pilot Operated Valves.– Tests and inspections performed on these valves should be handled in the same manner as those for the valves described earlier in this chapter.

Steam Drum.– The steam drum is primarily a reservoir and is usually only inspected in conjunction with a boiler inspection.

Deaerating Feed Tank.– The DFT is similar to the separator in that it serves as a reservoir, but that is the only similarity. When the DFT is in normal operation, you should test its ability to remove dissolved oxygen within 2 hours after start-up and daily thereafter. There are also some internal components that will periodically require maintenance according to the PMS or as a result of an unsatisfactory dissolved oxygen test.

Boiler.– The boiler should be tested continuously while it is in operation. Inspections, however, should be accomplished periodically according to the PMS; *NSTM,* chapters 220, Vol. 2 and 221; and any other applicable NAVSEA technical directive. These inspections are normally driven by the number of boiler operating hours and performance.

TROUBLESHOOTING.– The two most common problems you will encounter with the WHB steam system are (1) maintaining the proper steam pressure and (2) maintaining the proper steam drum water level. The most frequent of these problems will be maintaining a proper water level.

Maintaining the Proper Water Level.– Maintaining the proper water level is very crucial. Failure to maintain the proper water level can lead to some very serious problems. When this problem occurs, a quick diagnosis is needed to restore the water level to normal before the boiler tubes run dry. The

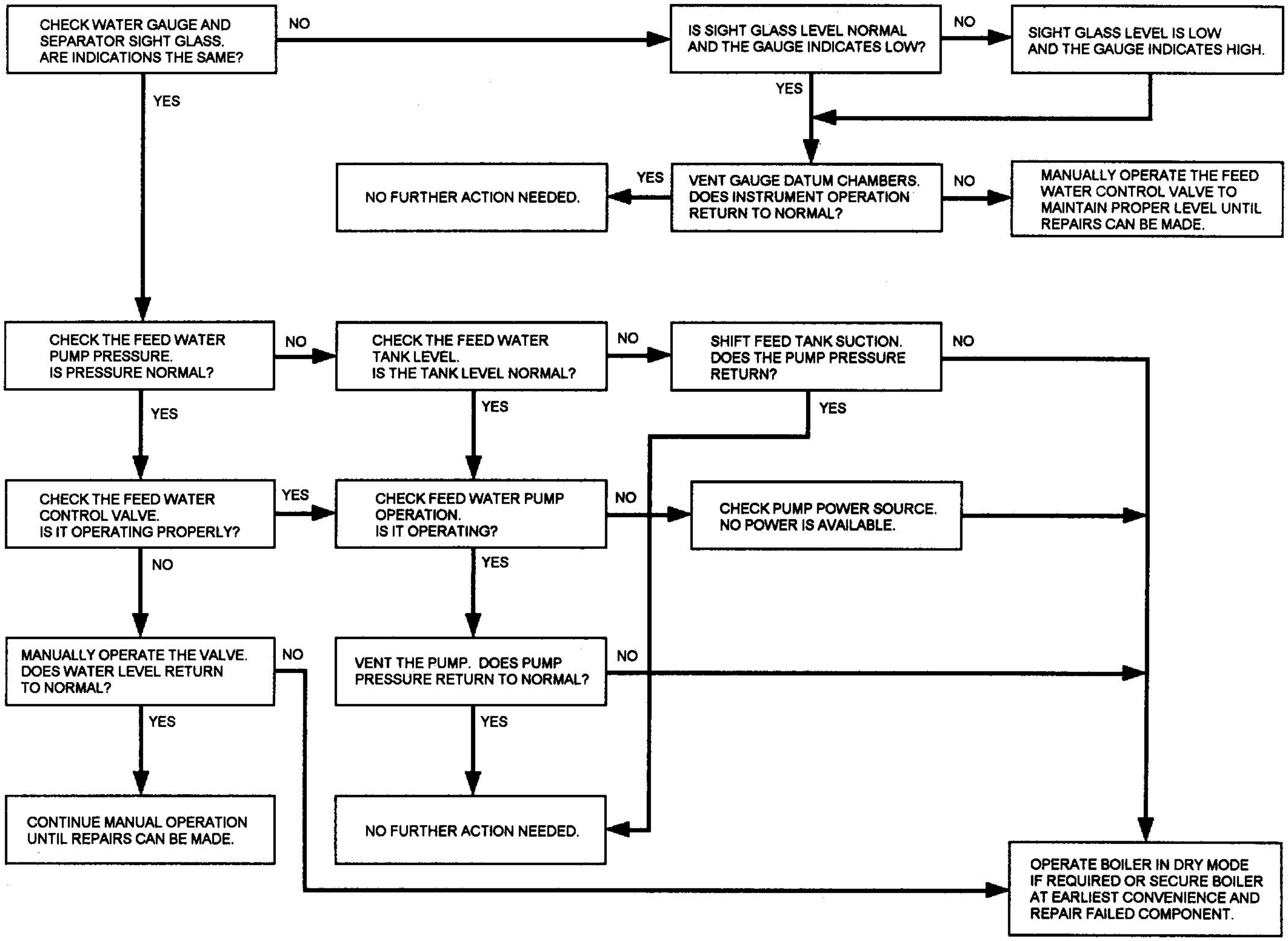


Figure 4-10.-Troubleshooting chart for low boiler water.

troubleshooting chart in figure 4-10 explains some key items you can check to help pinpoint the source of the problem.

NOTE

The troubleshooting chart shown in figure 4-10 contains general information only and should not take the place of the EOSS or approved manufacturer's technical guide.

Maintaining the Proper Steam Pressure.– The second most common problem that we will discuss is maintaining a proper steam pressure. The following list contains the components or conditions that are most likely to cause this problem:

1. Low boiler water - Review figure 4-10 of this chapter and the procedures in the EOSS or approved technical manuals.

2. Faulty diverting valve - If this valve fails open or the pneumatic pilot valve malfunctions, most of the steam pressure will be diverted back to the condensate system. Remember, this valve has manual override capabilities.

3. Faulty or airbound recirculating pump - If the recirculating pump stops operating, no water can be moved from the separator to the boiler coils. Also, if the pump becomes airbound, you should try to vent the pump casing to restore water flow. Remember, if either of these two problems cannot be resolved quickly, the boiler will run dry. A quick way to determine if the boiler tubes are dry is to watch the inlet and outlet exhaust gas temperatures. The closer or more equal they are, the more likely the boiler is approaching or is already in dry operation.

MAINTENANCE.– In this section, we will discuss some of the maintenance you as a GSM will either be required to perform or expected to know. We will only provide a brief discussion of these procedures that will pertain mostly to the major components of the WHB system.

Cleaning.– Most of the cleaning you will be involved in will pertain to the exterior of the system's components. For example, valve maintenance (PMS) procedures contain cleaning as one of the first steps you will perform.

Unless you are extremely lucky, however, there will come a time when you will be required to assist or perform the exhaust path cleaning of the boiler. This procedure is normally performed according to the PMS, during an extended repair availability, or as deemed necessary as a result of a boiler inspection or a casualty.

Cleaning the exhaust gas path is an extremely dirty and time-consuming job. In this procedure, you will be required to clean the external surfaces of the boiler tubes. Soot blowing during boiler operation is the only way you can perform this procedure without entering the boiler. Unfortunately, soot blowing is more of a preventive measure to lessen soot buildup. It is not as thorough a cleaning measure as entering the boiler and cleaning the tubes.

Another painstaking cleaning procedure is cleaning the tubes in the heat exchangers (condensate cooler or control condenser). Technically, the work is not difficult but it is heavy and time consuming. It is heavy because you must remove the end caps of the heat exchangers to allow access to the steam or water lance. It is time consuming because you must be very thorough to make sure all of the tubes are cleaned. Also, each end cap gasket must be hand made.

The last and most difficult procedure we will discuss is cleaning the internal surfaces of the boiler tubes. This procedure is normally scheduled and performed according to the PMS, as directed as a result of a boiler inspection, or according to instructions in *NSTM,* chapter 221. Normally, this is a chemical type of cleaning that must be performed by an outside activity (repair facility).

Removal of Components.– The need for the removal and replacement of waste heat system components depends on the PMS, NAVSEA instructions, and the condition of the components. For example, the boiler's safeties will probably need to be removed and replaced more frequently than any other component. The safeties come under two guidelines for maintenance and repair. The first guideline is the PMS; the other one is *NSTM,* chapter 221.

Most of the other components are usually removed or replaced out of necessity because of a failure. The only other component that will be removed according to an established time table is the boiler itself. The boiler is usually replaced during a ship's major overhaul period.

FFG-7 Class Ships

The FFG-7 class ship's waste heat recovery system does not use a WHB to supply heating for LO, FO, potable water, and distilling. Instead it uses the waste heat produced by the ship's service diesel generators (SSDGs) jacket water system.

The FFG-7 waste heat circulating system contains a total of four heat exchangers (one for each SSDG) and four hot-water circulating pumps. The waste heat system is pressurized by a compression tank that maintains sufficient pressure (about 5 psig) to prevent cavitation on the suction side of the circulating pump. Although high circulating water temperatures up to 195°F can occur when the heating demand is light, the normal operating temperature range is between 170° to 175°F. Sometimes there are conditions when the demand for waste heat will exceed the available waste heat. When this condition occurs, there are two 300-kilowatt supplementary electric heaters to assure a minimum temperature of 170°F in the system regardless of the available waste heat. Normally, at sea these heaters will not be needed because two or three SSDGs will be in operation. When a SSDG is put on the line, the associated hot-water circulating pump starts automatically. Each pump also has a manual mode and can be started or stopped manually without harming the system or its equipment.

Now that we have given you a brief overview of the waste heat recovery system's purpose and operations, let's discuss some of the tests, inspections, and functional checks that you will be required to perform.

TESTS, INSPECTIONS, AND FUNCTIONAL CHECKS.– Like the steam system in other gas turbine-powered ships, the tests, inspections, and functional checks for the FFG-7 waste heat circulation system are either covered in the PMS or EOSS. Some of the equipment items in the FFG-7 waste heat circulating system on which you will perform tests, inspections, or functional checks are briefly described in the following paragraphs.

Temperature Control Valves.– All the temperature control valves that service the waste heat circulation system are air pilot operated valves. The tests and inspections for these valves are the same as the ones we described earlier in this chapter. Remember, the temperature of the water in the waste heat circulation system is maintained by the SSDG jacket water temperature regulating valves. This means that most of your tests and inspections will require the operation of the SSDG jacket water system and waste heat water system.

Supplementary Heaters.– As mentioned earlier, the supplementary heaters are used to boost the waste heat water temperature to its normal operating range when there is an large demand on the system or the SSDGs are secured. Heaters should be frequently inspected while in operation. Perform all tests and functional checks according to the PMS and applicable manufacturer's technical manual.

Relief Valves.– There are only three relief valves installed in the FFG-7 system. One is installed on each of the two supplementary heaters and one is installed on the compression tank. These valves must be periodically tested in place. They should also be removed annually and delivered to a repair facility for testing and inspection. Remember, no matter where the tests are performed or who performs them, they all must be accomplished according to the PMS.

TROUBLESHOOTING.– Sometimes, tracking down a problem in the FFG-7 waste heat circulation system can be very easy. Other times, it can be very difficult. Never attempt to make adjustments to this system unless you are extremely knowledgeable of the system's operation or troubleshoot a failure without using an approved troubleshooting guide contained in the appropriate manufacturer's or NAVSEA technical manual. Remember, the operation of this system depends on the proper operation of the SSDG jacket water system and the supplementary heaters.

MAINTENANCE.– In this section, we will be discussing some of the maintenance you will need to perform or will be expected to know as a GSM2. For the most part, the maintenance topics discussed in this section will be brief and will pertain primarily to the FFG-7 system's major components. All maintenance discussed in this section normally will be covered under the PMS.

Cleaning.– The cleaning requirements for this system are no different from those for the steam systems we have already discussed. Most of the cleaning you will be involved in will pertain to the exterior of the system components. For example, valve maintenance (PMS) procedures contain cleaning as one of the first steps you will perform. In this system, valve cleaning will be approximately 90 percent of all your maintenance responsibilities.

Removal and Replacement of Components.– You will probably remove and replace the relief valves in the FFG-7 system more frequently than any other component. Just like the safeties in the steam system, the relief valves must be periodically tested in place and removed annually to be tested and repaired as needed.

All other components of this system, such as the supplementary heating elements, temperature control valves, and circulating pumps, will only be removed or replaced because of component failure or as part of the ship's overall planned maintenance program.

SUMMARY

In this chapter, we have provided you with an overview of the engineering support and auxiliary equipment and systems used on gas turbine-powered ships. We discussed some of the equipment and system similarities and differences you will encounter among the various ship classes. We also discussed some ways in which you can properly operate and use your ship's support and auxiliary equipment and systems. If you properly maintain this equipment and their systems, they will continue to provide your ship with a high level of efficient service. With the information provided in this chapter and the recommended technical publications, you should become a more effective gas turbine systems technician.

CHAPTER 5

PROPULSION PLANT SYSTEMS AND DRIVE TRAIN EQUIPMENT

As a GSM, you will primarily operate and maintain the GTEs. You will also be tasked with the maintenance and repair of other major equipment and their related systems, such as the fuel oil, lube oil, and controllable pitch propeller systems.

This chapter will focus on the maintenance and repair of these main propulsion systems needed to support the operations of the main propulsion gas turbine engines.

After studying the information in this chapter, you should have a basic understanding of the propulsion plant systems and drive train equipment in gas turbine-powered ships in terms of normal operations, some common malfunctions, and the general maintenance responsibilities that you, the GSM, may encounter.

PROPULSION PLANT SYSTEMS

The main propulsion plant could not operate without fuel oil for the engines and lube oil for the main reduction gears. These systems and others are part of the overall main propulsion plant and are in your areas of responsibility. You will likely be assigned to perform or supervise the PMS and repairs and to maintain the equipment and components associated with these systems.

As you advance in the GSM rating, you may be assigned as a work center supervisor. At this level, it will become increasingly important for you to be able to identify reoccurring system and equipment problems and be able to initiate timely repairs. You should also be proficient at troubleshooting so you can also identify less common malfunctions. In this chapter, we will tell you about some of the common problems you may encounter during system operations. We will also give you some troubleshooting and maintenance tips that should help you handle these problems more effectively.

SHIP'S SERVICE FUEL OIL SYSTEM

As you are likely aware, your ship's fuel oil (FO) service system is vital to propulsion plant operations. Care and maintenance of this system is equally important for the effective operation of propulsion plant equipment and systems. All of the FO service systems you will encounter on gas turbine-powered ships are basically the same. For this reason, we will discuss the normal operations, common malfunctions, and general troubleshooting and maintenance procedures associated with a basic FO service system. This information is designed to help you to recognize normal operations and to identify and handle some of the more common problems you may encounter in the operation and maintenance of a typical FO service system.

NORMAL OPERATIONS

A typical FO service system on a gas turbine-powered ship has one or more service tanks that are replenished from the ship's FO storage tanks via the FO transfer system. From the FO service tank, the fuel passes through a suction strainer (in some cases) immediately before entering the FO booster pump. The pump then delivers the fuel to a heater. In most cases, the fuel flows from the heater, through a prefilter, and then to the filter/coalescer. From the filter/coalescer, the fuel reaches its final delivery point-the engines.

Normally, the fuel is delivered to the engines at a nominal pressure of 45 to 55 psi. To deliver or maintain the fuel at the ideal pressure, however, several different pieces of equipment must work in harmony. These equipment units cannot always perform as designed without routine maintenance, some repairs, or even component replacement. As a GSM, you should be able to recognize some of the basic problems and understand the steps you will need to take to solve them.

MAINTENANCE AND TROUBLESHOOTING

From studying the information in *GSE3/GSM3,* volumes 1 and 2, on FO service systems, you should have already learned about basic system layouts, local operations, and remote console operations from the CCS. If you do not remember the basic design and operation of a typical FO service system, we recommend you take time to review these references and the earlier sections of this TRAMAN. In the following paragraphs, we will discuss FO service system maintenance and repair. We will provide you with some helpful hints for both preventive and corrective maintenance of your ship's FO service system. Remember, propulsion plant equipment and systems will vary among the different classes of ships. For this reason, we will discuss the tests, inspections, and maintenance procedures in general terms. For specific guidelines, you should consult the EOSS and other authorized technical publications for your ship. Now, let's talk about some general aspects of preventive maintenance.

Preventive Maintenance

Simply stated, preventive maintenance is taking the necessary planned steps so you can remove or reduce the possibility y of equipment failure. These actions will help prolong the useful life of your ship's equipment. All the preventive maintenance actions or steps you will need to perform can be grouped into the following three basic categories:

1. Routine maintenance
2. Testing
3. Adjusting

In the following paragraphs, we will briefly discuss each of these categories. To acquire a more in-depth knowledge of preventive maintenance, including the planning and scheduling of routine maintenance, testing, and adjusting of equipment, we recommend you review the discussion of the Planned Maintenance System (PMS) in *GSE3/GSM3,* Volume 1, NAVEDTRA 10563. We also recommend you review the *Ships' Maintenance and Material Management* (3-M) *Manual,* OPNAVINST 4790.4.

ROUTINE MAINTENANCE.– Routine maintenance is carrying out the special procedures you must use for inspecting, cleaning, and lubricating equipment. These procedures are special because you must use the approved and standard methods to perform the required maintenance actions. For example, you must use certain approved methods for cleaning and lubricating ball bearings. When a ball bearing needs lubricating, you must first clean it and then use the proper lubricant to lubricate it. Included in the instructions you must use for lubricating ball bearings are charts specifying the approved lubricants and their uses. These approved methods are considered to be routine because (1) they are the authorized procedures for lubricating ball bearings, and (2) they must be performed at specified intervals.

Routine inspections include checking equipment ground straps, screws, nuts, and bolts. They also include such tasks as checking oil reservoirs for proper levels and checking front panel indicators and bulbs for proper operation. These inspections require you to perform a direct analysis as you are doing the check To perform an inspection, you will use only your human senses-especially sight, touch, and hearing-to make a direct examination and judgment concerning the operating condition of a system or piece of equipment. To perform a test, however, you must also use an instrument to make a determination.

TESTING.– Testing of mechanical or electrical equipment usually 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 device or circuit is operating properly.

The difference between a test and an inspection is that a test requires the use of an instrument (portable or installed) to indicate 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 mechanical or electrical equipment is a broad area that encompasses all phases of the following actions:

- Rearranging or changing a function or characteristic
- Aligning circuits by adjusting two or more sections of a circuit or system so their functions are properly synchronized
- Calibrating 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

Anytime you change, align, or calibrate the mechanical or electrical equipment you are checking for operational effectiveness, you are performing preventive maintenance.

Remember, all categories of preventive maintenance are designed to help you to avoid mechanical and electrical problems before they start. In spite of the best preventive maintenance program, however, you will eventually be called upon to correct a problem. In the following section, we will tell you about some of the actions you can take to correct the more common malfunctions in a typical FO service system.

Corrective Maintenance

Corrective maintenance of mechanical or electrical equipment consists of the actions and operations you must perform to restore an improperly operating piece of equipment to a fully operative condition. Some examples of corrective maintenance actions are repairing a piece of equipment after a tire or locating and replacing a faulty part. Corrective maintenance actions are also needed to locate a faulty function and adjust its circuit for an output that is within specifications. Common to each corrective maintenance action is a sequence of three basic operations that are always performed. These are

1. symptom recognition,
2. malfunction location, and
3. repair.

We will briefly discuss each of these operations. As you read the following sections, try to envision the ways that you, the GSM, maybe called upon to correct a problem.

SYMPTOM RECOGNITION.– Symptom recognition is the weakest link in the three basic operations. Many incidents occur where malfunctioning equipment is operated for hours, days, and even months without notice of a failure. This can occur because the symptoms of many malfunctions are subtle and are not easily recognized. This makes the need for trained operators and technicians in the methods of symptom recognition even more important.

To be a good technician, you must first know the proper equipment operation and the function of each operating control. Very often, a qualified console operator can detect a malfunction in an operating unit of equipment and may even be able to make some minor adjustments to the equipment. The console operator is, however, still responsible for reporting any symptoms of a malfunction to a GSM or GSE.

Not all equipment will produce symptoms that are easily recognized. In fact, some symptoms may be detected only when you are performing preventive maintenance on the affected equipment item or system. For these reasons, you must be able to recognize the not so apparent as well as the apparent troubles. Once you realize a malfunction exists, your next step is to locate the source of the trouble,

MALFUNCTION LOCATION.– In the language of the GSM, the process of malfunction location is better known as troubleshooting. The process of troubleshooting begins after you recognize a symptom of a malfunction and ends when you locate and correct the cause of the malfunction.

As a GSM, you are aware that other GSMs, the GSEs, the equipment or console operators, and your other shipmates who have worked with mechanical or electrical equipment readily understand what the term *troubleshooting* means. If that is so, then why does so much downtime occur? The answer is simple. The amount of downtime resulting from a malfunction in a piece of equipment or a system will be directly proportional to: (1) the complexity of the system or equipment with the problem, (2) the lack of knowledge concerning the affected system or equipment, and (3) the proper troubleshooting methodology on the part of the people who are actually trying to locate the problem.

Troubleshooting is not an easy job. Modern mechanical, electrical, and electronic equipment and systems are extremely complex. The complexity results from the multitude of interfacing and interacting components and circuitry that can exist in a single system or piece of equipment. The complexity of a system or piece of equipment can make troubleshooting a difficult and frustrating job. As a GSM, you will discover that the complexity of a system or equipment item will be your biggest challenge in troubleshooting. Your troubleshooting efficiency will depend on the knowledge you have of the operation of the equipment. In troubleshooting any equipment or system, the greatest tool you can use is your knowledge of the equipment or system in terms of its normal operational characteristics. his is very important: *You must first know what the equipment or system should do under normal operating conditions before you can determine what it is not doing or what it is doing incorrectly.*

In addition to a thorough knowledge of the affected equipment or system, you must know how to troubleshoot effectively. To troubleshoot efficiently and effectively, you should perform the following five logical operations in sequence:

1. Identify the symptom.
2. Identify the malfunction.
3. Localize the malfunction.
4. Locate the cause of the malfunction.

5. Perform failure analysis.

In the following paragraphs, we will briefly describe each of these operations. Again, try to envision your responsibilities as a GSM in each of these steps.

Identifying the Symptom.– After recognizing an equipment malfunction, a good technician will then use all available aids designed into the equipment to elaborate on the symptom. As a GSM, you have several available aids. By using the front panel controls, indicators, and other testing aids, you can obtain a better description of the symptom. Once you identify the symptom, your next step is to identify the malfunction.

Identifying the Malfunction.– In this step in the troubleshooting process, you must determine some logical choices for the basic cause of the symptom. Your determinations will be based on your knowledge of equipment or system operation and a full description of the symptom. The overall functional description of the equipment or system in the appropriate technical manuals can help you outline some 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 troubleshooting flow charts and block diagrams in the technical manuals. 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 the Malfunction.– After localizing the malfunction, you must make additional choices to find which component or circuit is at fault. If the trouble is not immediately apparent, use the proper test methods to further isolate the fault. Continue this process until you locate the specific cause. Defective components, vibration, misalignment, improper wiring, and improperly soldered components are all examples that might be specific causes of an engine problem.

Performing Failure Analysis.– After you have located the fault, review your troubleshooting procedures before you make 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 and not the *result* of the malfunction. For example, excessive vibration may have caused a component failure. Upon analysis, you may have determined that equipment misalignment caused the vibration, which, in turn, caused the component to fail. The real culprit could simply be loose equipment foundation bolts that allowed the vibration. In addition to replacing the faulty component, you must realign the equipment and make certain the foundation bolts are torqued to the proper values.

Following the five troubleshooting operations in their logical sequence will help you to be more efficient and effective in your troubleshooting responsibilities. Remember, your most important tool in troubleshooting is your thorough knowledge of the equipment or system in terms of its normal operational characteristics. The next most important tool is to follow the correct troubleshooting procedures or operations in their proper sequence.

TESTS AND INSPECTIONS

The operational performance of the FO system on board your ship should be constantly monitored. Good maintenance habits and the proper use of the PMS as a scheduling tool for routine tests and inspections will ensure the optimum performance from your ship's FO system. In the following paragraphs, we will describe some components of the FO system and the most common tests and inspections. As you advance in the GSM rating, you will be required either to perform these inspections and tests or to make certain they have been done.

Fuel Pump Coupling

Inspection of the fuel pump coupling similar to the one shown in figure 5-1 is usually performed semiannually. The normal steps of this inspection are disassembling the coupling cover, cleaning out the old grease, and inspecting the coupling grid and hub teeth. If your inspection shows that the fuel pump coupling is satisfactory for operation, then your next steps are to reinstall the grid, apply the specified grease, and reassemble the coupling cover.

In inspecting the fuel pump coupling, there are some key points you should look for during the disassembly and inspection steps. We will describe these points in the following sections. Remember, you should consider both the symptoms of the malfunctions and the signs of normal operation when you are checking the components.

COVER SEAL.– A symptom of deterioration of the coupling cover seal or a bad seal is the collection of grease on the inside of the coupling guard or on the pump base, depending on the type of pump installation. You can perform a check of the cover seal at any time, even with the pump in operation. If a seal is bad, the natural thing for you to do is to replace it. Before you replace

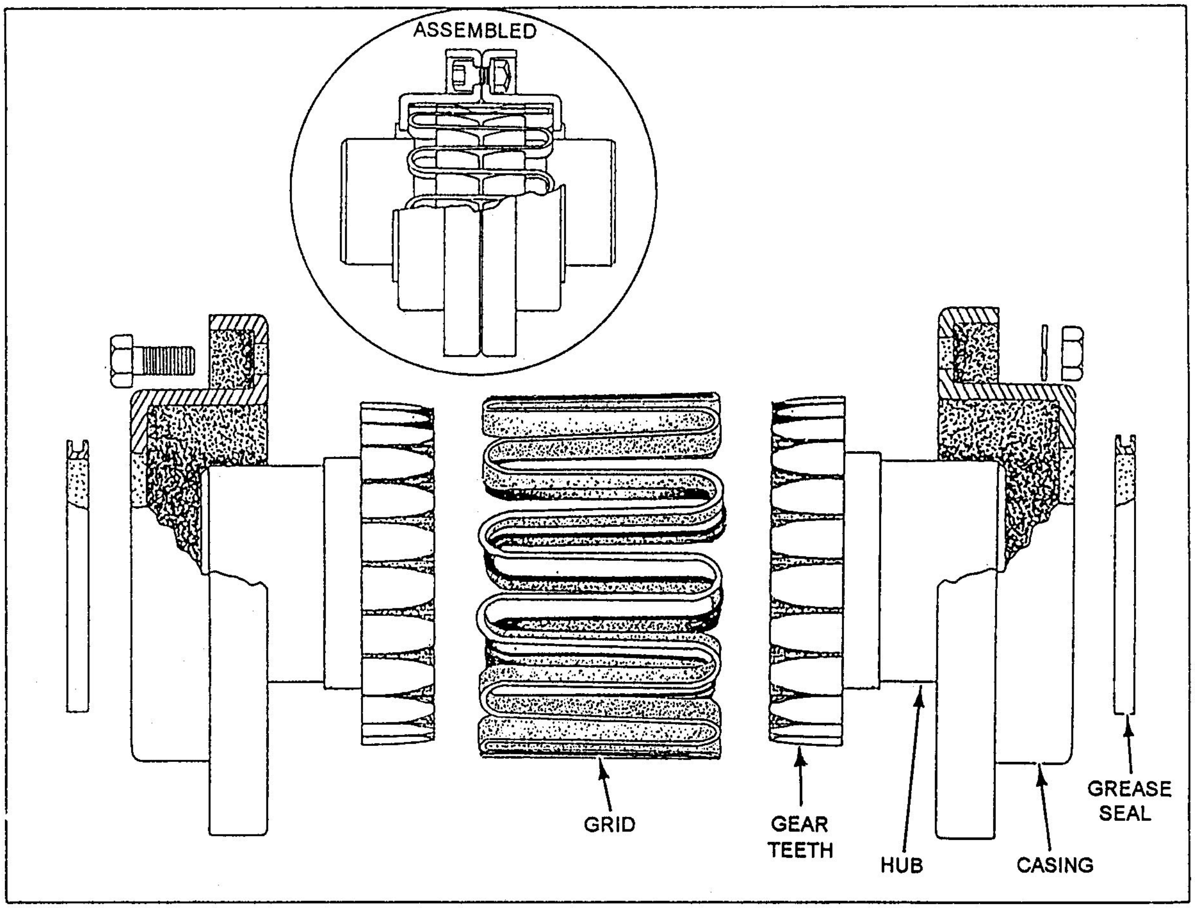


Figure 5-1.-Grid-type flexible coupling.

it, however, the most important thing you should do at this point is to ask yourself this question: How long has this coupling been operated with an insufficient grease supply? Improper lubrication can easily cause a fuel pump coupling to become damaged because of the heat that is generated during normal operation.

GRID.– The coupling grid is a shaped spring steel band that interlocks the coupling hub gear teeth. The grid is usually coated or painted. You should check the grid for deterioration or wearing of the coating or paint. The condition of the coating or paint can provide you, at a glance, with a clue to the condition of the coupling. If the coupling has been operated with insufficient grease, the coating or paint may be worn off and the metal will have a bluish appearance. The bluish color on the metal means that the metal was allowed to become too hot. This is a good indication that the component is possibly fatigued and requires replacement. The coating or paint can also provide you with an indication of coupling misalignment. If you detect an uneven wear pattern, there is a good possibility the coupling is misaligned.

HUB.– You should check for damaged or worn teeth on the coupling hub. Normally, the coupling hub teeth will not show symptoms of damage or wear unless the hub was improperly installed on the pump or motor shaft. (This usually happens when a hub has been hammered onto the pump or motor shaft.) The hub teeth can, however, become damaged if they become fatigued or overheated. As in the case of the grid, you will notice a bluish tint on the metal when these conditions occur. Each coupling hub is attached to its respective shaft by a key. Although the key does not fail very often, you should check to make certain the hub fits snugly on the shaft. If the hub moves at all on the shaft, then you should check the hub inside diameter, the shaft key way, and the hub outside diameter for wear.

Fuel Pump Logic

Normally, the logic circuits of a ship's fuel pumps are tested semiannually or during scheduled propulsion plant inspections (safety checks). During this maintenance check, you will test the pump logic circuit to see if the pump will cycle up in speed with increased pressure demands or stop in the event of a large leak in the system. All of these functions are controlled by means of cooperating system components, consisting of a timing circuit card, pressure transducer, and detroit-type pressure switch. In most cases if the timing is off, you will have to replace the circuit card. (This is because you cannot adjust the circuit card.) If the transducer or detroit switch should activate the pressure alarms or pump control signals at the wrong pressure, however, you can adjust these components for proper operation.

Relief Valves

All relief valves in a ship's FO service system are usually inspected and tested annually. These valves are normally removed and carried to an intermediate maintenance activity (IMA) for bench testing. You can, however, test these valves while they are installed in the system and you can inspect them every time the system is placed in operation. Remember, most of the low pressure problems in a FO service system can usually be traced to a faulty pressure relief or unloader valve.

Prefilter Δ P Alarm Operation

Normally, you will test the alarms associated with the FO prefilter during system start-up, propulsion plant inspections, and filter element changeout. Your inspection procedure, however, will be limited to a lamp status check.

Separator/Coalescer Δ P Alarms and Changeover Valve Operation

Depending on the class of ship, these two tests will likely be performed either according to the PMS or according to the authorized procedures for a particular ship. The tests you will be required to perform will depend on the design of the FO equipment and system on your ship. Although FO equipment and systems may differ among gas turbine-powered ships, the testing procedures and alarm set points are almost identical. These tests are usually performed as required or for a propulsion plant inspection.

Unloader Valve

The unloader valve does not have a specific test or inspection. The only maintenance that you will normally perform will coincide with the valve maintenance program (lubrication). Normally, you will inspect the operation of this valve during system start-up and normal operation, and when you are troubleshooting for system pressure problems.

In any inspection or test of the FO system, your most important tools are (1) your knowledge of the system and its normal operating characteristics, and (2) your understanding and ability to detect the signs and symptoms of abnormal operation. Once you detect the problem and trace the cause of abnormal operation, your next logical step is to remove and replace the faulty components.

REMOVAL AND REPLACEMENT OF COMPONENTS

Normally, you will need to remove and replace components because of component failure. At times, however, you may be required to perform a partial or complete removal of a component to satisfy the guidelines of a required maintenance procedure. To perform an inspection of a FO flexible coupling, for example, you will need to perform a partial disassembly or removal of the coupling components to complete the task. If you must test a FO pump relief valve, however, you must completely remove the relief valve from the system so it can be properly tested. The removal and replacement procedures you will perform will be based on the specific inspections, tests, troubleshooting, and preventive and corrective maintenance required for the FO system of your ship.

MAIN REDUCTION GEAR LUBE OIL SERVICE SYSTEM

On any gas turbine-powered ship, the primary function of the main reduction gear (MRG) lube oil (LO) service system is to supply oil to the MRG and its accessories. In the majority of the gas turbine ship classes, there are three LO service pumps–two are electric and one is either gear or air driven for each MRG. In the case of the LCACs, however, each gearbox has its own pump or pumps. No matter how big or complex the MRG service system maybe on your ship, you will need to know the primary components and functions of this system and what your responsibilities as a GSM will be to maintain them. In maintaining any system, your most important tool will be your thorough knowledge of normal operational characteristics. Because of this, let's briefly discuss these systems and how they work under normal operating conditions.

NORMAL OPERATIONS

In the case of most gas turbine ships, the LO system supplies oil to the MRG through one of the two electric pumps. The electric pumps supply oil to the system when the propulsion shaft is stopped and augment the attached pump at low shaft speeds. After the oil leaves the pumps, it fills the main header piping where it will travel toward the LO unloader valve and the LO cooler. One exception to this design is the LO service system on the DDG-51 class ships in which the oil goes to the main LO filter assembly before it goes to the cooler.

Unloader Valves

On the DD-963, DDG-993, and FFG-7 class ships, the unloader valves are pneumatic pilot-type valves. On the CG-47 and DDG-51 class ships, the unloader valves are the hydraulically operated (Cla-valve) design. Although the unloader valves are of different designs for the different ship classes, they all perform the same job. They maintain proper design oil pressure throughout the system by maintaining the required pressure as sensed at the most remote bearing. Depending on the ship class, the oil will pass through the unloader valves to either the oil cooler or the oil filter assembly. As we mentioned earlier, most ships have the cooler as the next component in the line. Because of this, we will discuss this configuration first.

Lube Oil Coolers

All the LO coolers used on gas turbine ships are basically the same. The only differences exist in the way in which the oil temperature is regulated. On the DDG-51 and FFG-7 class ships, the oil flow is regulated at the inlet of the cooler to maintain the oil temperature. On the CG-47, DD-963, and DDG-993 class ships, however, the seawater flow is regulated to maintain the oil temperature. The placement of the seawater regulating valve, however, is different for each of these ship classes. On the CG-47 class ships, for example, the regulating valve is installed on the inlet side of the cooler. On the DD-963 and DDG-993 class ships, the regulating valve is placed on the cooler outlet. Regardless of the class of ship, after the oil leaves the cooler, it enters a duplex filter or strainer assembly.

Filter Assemblies

On the CG-47, DD-963, and DDG-993 class ships, the filter assembly consists of a single wire mesh strainer basket in each tower. On the DDG-51 and FFG-7 class ships, the filter assembly consists of multiple filter elements in each tower. After the oil leaves the filter assembly or the cooler, depending on the ship class, it is then sent to the MRG.

Headers

Lubrication and cooling is provided to the MRG and its accessories through the main LO headers. The headers are located at the top of the gear case. Gear and pinion teeth are lubricated and cooled by spray nozzles arranged to direct oil across the full face width at the gear mesh. Oil flow to the journal bearings and main thrust bearings is controlled by orifice plates. When the lubrication and cooling process is complete, gravity then drains the oil back to the sump where the cycle starts over again.

MONITORING AND TROUBLESHOOTING PROCEDURES

Now that we have discussed some of the basic design features of the MRG LO systems of the different ship classes, let’s talk about some general monitoring and troubleshooting procedures.

Monitoring equipment performance is the key to identifying early equipment failures. As a GSM, you will be the primary technician and watch stander. You should be knowledgeable in the normal operating parameters of this system and be able to identify most abnormalities. Once you have identified a problem, you must use sound troubleshooting procedures to isolate the faulty component or components before you can make the appropriate repairs. In troubleshooting the MRG LO service system of your ship, you can use the same general procedures we described earlier for troubleshooting the FO service system. In the following paragraphs, we will provide you with some additional guidelines you can use as tools to help you maintain the MRG LO system of your ship effectively.

TESTS AND INSPECTIONS

The safe operation and performance of the LO system on board your ship must be constantly monitored. By consistently using good maintenance habits and the PMS as a scheduling tool for routine tests and inspections, you can ensure the optimum performance from your system. In the following paragraphs, we will describe some of the components in the LO system and the most commonly performed tests and inspections. As a GSM, you will be responsible for either performing these tests and inspections or making sure they are completed correctly.

Lube Oil Strainer/Filter Assembly

Of all the components in the MRG LO service system, the strainer or filter assembly will probably receive the most attention. On CG-47, DD-963, and DDG-993 class ships, the filter/strainer assemblies are frequently cleaned and inspected. In inspecting and cleaning your ship's LO strainer/filter assembly, always remember to follow the requirements listed in the EOSS. You should also follow the requirements listed in NSTM, chapter 262, "Lubricating Oils, Greases, Hydraulic Fluids and Lubricating Systems." The requirements listed in *NSTM,* chapter 262, may exceed those listed in your ship's EOSS. In this case, you should follow all the requirements in your EOSS and those described in *NSTM,* chapter 262, that are not included in your EOSS. In the following paragraphs, we will tell you about the requirements set forth in *NSTM,* chapter 262, as they pertain to your responsibilities for maintaining the components of the MRG LO service system on CG-47, DD-963, and DDG-993 class ships.

Normally, you should shift and inspect the main propulsion LO strainer baskets once a day. Under the following circumstances, you must shift and inspect these baskets once each watch:

- When you detect any indication that pressure differential has shifted from normal or when any other symptom of abnormal operation (such as high bearing temperatures) is seen
- For the first 24 hours of operation following a shutdown in excess of a week, after rough weather, or any time you notice an abnormal pressure differential (in excess of 1.5 lb/in^2) through the strainer
- For the first 48 hours of operation after repairs to the LO system or to any equipment serviced by the LO system have been made
- When the propulsion plant is operating at more than 85 percent full power

These inspection requirements are for the LO filter/strainer assemblies installed in the CG-47, DD-963, and DDG-993 class ships. The inspection requirements for the LO filters installed on the DDG-51 and FFG-7 class ships are different. That is why you should always strictly follow the requirements listed in the EOSS and PMS for your ship.

Lube Oil Pump Logics

On most gas turbine ships, the LO pump logics are routinely tested semiannually. In reality, however, this test is usually performed more frequently because your ship will perform safety checks for various training and inspection evolutions throughout the year. These checks and inspections will include tests of the LO pump logics.

The LO pump logics test is fairly simple to perform. It does, however, require two people and communication lines between the LO pressure switch or pressure transducer and the control console. The performance of this test is almost the same as that for the FO pump logics test. For the LO pump logics test, however, the desired results are different because the operational design of the LO system is different from that of the FO system. During a continuous loss of pressure, for example, the FO system will stop, whereas the LO pumps will continue to operate. Analysis has shown that a continuous small amount of oil provided to a multimillion dollar MRG is less likely to cause massive damage than no oil at all.

CLEANING AND LUBRICATION

Cleaning and lubrication of the MRG LO service system are continuous tasks. Proper lubrication of the components of this system is vital for system performance and safety. Let's take a look at some of the components that will need frequent cleaning and lubrication.

Valves

Most of the components in the MRG LO service system that will require frequent cleaning and lubrication are valves. In cleaning and lubricating these valves, you must pay close attention to details because most of this system's piping and valves are located in the bilge area. Being in the bilge area means that the valves are constantly exposed to corrosive elements.

Pump Couplings

Other components that require cleaning and lubrication are the LO pump couplings. Even though the couplings will not need as much attention as the valves, frequent cleaning and lubrication are still very important.

The procedures for cleaning and lubricating LO pump couplings are the same as those we described earlier in this chapter for the FO pump couplings. The alignment procedures for LO pump couplings are also the same as those we described for FO pumps. The main difference is that the LO system has three pumps, whereas the FO system has two pumps. Because the third LO pump is driven by the MRG, the alignment procedure is much more difficult than the one for the electric pump. For the MRG LO service systems found on the CG-47, DD-963, and DDG-993 class ships, the alignment procedures for the third pump require a special short shaft assembly. This special shaft is not normally kept on board these ships. You must acquire this tool and special assistance to use it from a SIMA or tender. On DDG-51 class ships, however, the attached LO pump is mounted on a pedestal in the horizontal position and will not require any special tools for coupling alignment.

REMOVAL AND REPLACEMENT OF COMPONENTS

All relief valves in the LO system are usually inspected and tested annually. Just like the relief valves in the FO system, these valves are normally removed and carried to a SIMA or tender for bench testing. They can, however, be tested while they are being installed in the system and they can be inspected every time the system is placed in operation. As in the FO system, most of the low pressure problems in an MRG LO service system can usually be traced to a faulty pressure relief or unloader valve.

You may need to remove and replace components because of component failure. Whether you are partially or completely removing a component for inspection, testing, cleaning, or lubrication, you should always follow the EOSS and other specific procedures required for your ship.

CONTROLLABLE PITCH PROPELLER SYSTEMS

Depending on the class of ship, your ship's propulsive thrust is provided by a hydraulically actuated propeller system. Each propeller is driven by one or two GTEs through a reduction gear assembly and line shaft.

NORMAL OPERATIONS

The controllable reversible pitch (CRP) or controllable pitch propeller (CPP) systems installed on all gas turbine-powered ships perform the same basic duties. For this reason, we will confine our discussion of the CRP/CPP systems to the major differences in the design features and operational characteristics found on the different ship classes. If you require additional information on the fundamental design and operation of these systems, we recommend you consult the applicable sections of *GSE3/GSM3,* volumes 1 and 2.

The CRP/CPP systems were designed to maximize the ability of the ship's propulsion GTE to accelerate and decelerate rapidly and to enhance its maneuverability. To further enhance the systems' performance and to make them more "user friendly," some subtle changes were made. These changes have been installed on the newest gas turbine ship platform, the DDG-51 class ship. In the following sections, we will tell you about some of these changes and the contributions they make to system performance.

After studying this section, you should have a good understanding of the design, operation, and major system differences in the CRP/CPP systems installed on the different classes of gas turbine-powered ships. You should also have a basic understanding of your responsibilities for caring for and maintaining these systems properly.

DDG-51 Class Ships

As an operator or technician, you should be aware of the changes incorporated in the CRP/CPP systems installed on the DDG-51 class ships and the advantages they offer in the performance and operation of these systems. Let's take a look at some of the components that have changed.

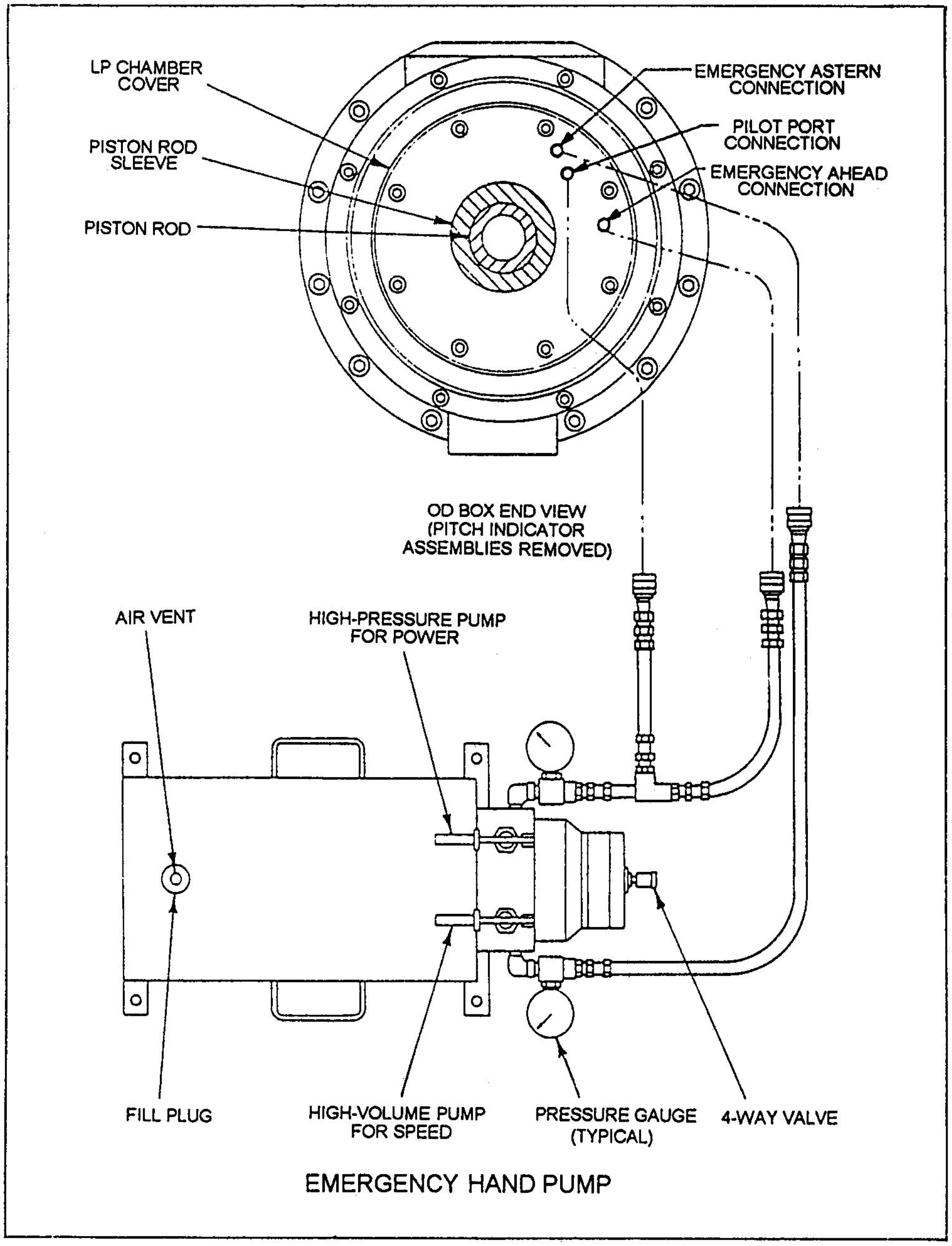


Figure 5-2.-Emergency pitch arrangement.

OIL DISTRIBUTION BOX.– On the DD-51 class ships, the configuration of the oil distribution (OD) box has undergone several changes. First, the emergency pitch pump hose connections have been moved from the bottom of the OD box to the low pressure chamber cover, as shown in figure 5-2. These changes make it easier for the operator to make the connections during testing or in case of an emergency.

PITCH INDICATING SYSTEM.– Another significant change was made to the pitch indicating system. Now there are two types of pitch indicating systems installed on the DDG-51 class ships. One system is temperature compensated while the other is electronic. Because these two systems operate independently, the DDG-51 class ships have both a normal and alternate means of measuring propeller pitch. Let's take a brief look at both systems.

Temperature-Compensated Pitch Indicator System.– On the DDG-class ships, the temperature-compensated pitch scale platform is rigidly connected to the OD box. The scale platform holds the feedback

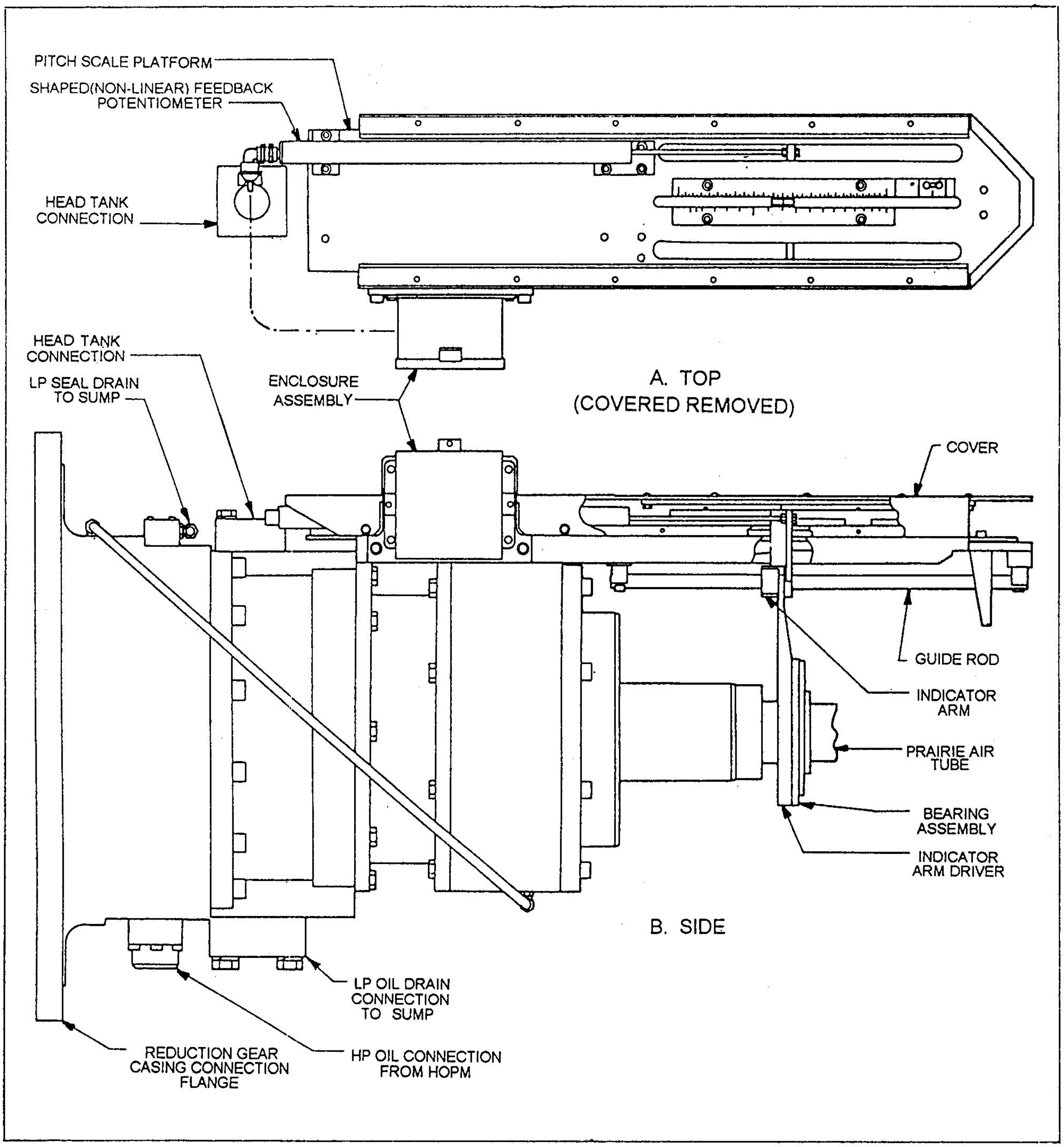


Figure 5-3.-Pitch scale platform showing temperature-compensated pitch indicating system.

potentiometer and local pitch indicator, as shown in views A and B of figure 5-3. This indicator is defined as temperature compensated because the indicator arm is connected to the prairie air tube. (See view B.) The prairie air tube is normally pressurized with air at a controlled temperature, and will have a fixed amount of thermal growth. Hence, the indicator arm is provided with a thermally stable (temperature compensated) surface and a primary means to sense and indicate propeller pitch and to relay that information to the machinery control system (MCS).

Electronic Pitch Indicator System.– In addition to the temperature-compensated pitch indicator installed on the OD box of DDG-51 class ships, an electronic pitch position transducer is installed behind a cover

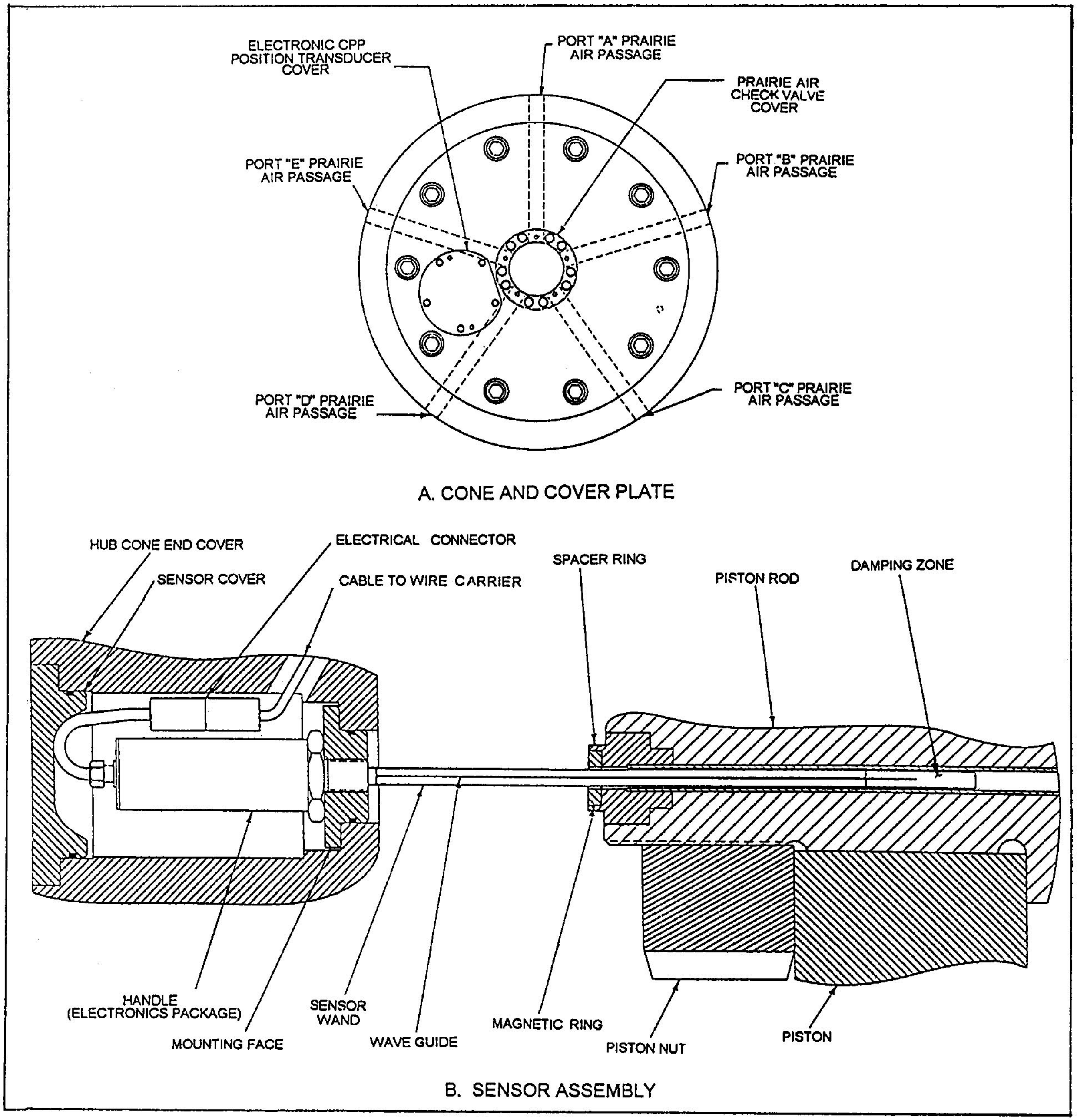


Figure 5-4.-Hub-mounted electronic pitch position transducer.

plate on the propeller hub, as shown in view A of figure 5-4. The electronic pitch indicator receives an input from a sensor assembly mounted inside the propeller hub, as shown in detail in view B of figure 5-4. The sensor (wand) extends from the small electronics package (handle) located in the hub cone and cover into an axial hole drilled into the piston rod. The hole contains a magnetic ring that allows the sensor to measure CPP position.

The electronic pitch indicator system also contains a stationary electronics cabinet, rotary transformer, and rotating electronics cylinder. The stationary electronics cabinet is mounted adjacent to the OD box. It contains the circuitry to provide a 10-kHz excitation signal to, and receive a CPP position feedback signal from, the rotary transformer. The cabinet also has two light emitting diode (LED) displays that show propeller pitch in both feet and percent of design ahead pitch. The rotary transformer contains both the transducer excitation and output coils. The rotating electronics rectifies the rotary transformer excitation to 24 V dc for powering the hub-mounted transducer and receives the transducer output. The rotating electronics is attached to the prairie air tube extension at the end of the OD box. It regulates the transducer output to 3 kHz for the rotary transformer. For a more detailed description of this system's operation, consult the DDG-51 propulsion plant manual or the CPP system technical manual.

CG-47, DD-963, DDG-993, and FFG-7 Class Ships

With the exception of the previously mentioned modifications to the CPP system on the DDG-51 class ships, the basic design of the CRP/CPP systems on all gas turbine-powered ships is generally the same. The basic operational characteristics are also fundamentally the same. If you need to review the basic design and operational characteristics of these systems, we recommend you consult *GSE3/GSM3,* volumes 1 and 2. Because of the similarities among these systems, we will describe in general terms some of the troubleshooting and maintenance tips you can use to monitor and maintain these systems effectively.

TROUBLESHOOTING AND MAINTENANCE PROCEDURES

Even though the CRP/CPP systems installed on a gas turbine-powered ship use the same types of pumps and fluids as the MRG lube oil system, they are much more sophisticated. Paying close attention to system operating pressures is your most important step in successfully troubleshooting any problems and making the appropriate repairs. The following paragraphs will describe some of the common problems associated with system pressure and the methods you can use to identify the component or components that might be causing the problems. Let's first look at two of the most common casualties that you can identify just by noting variations in the system pressure–loss of pitch control and loss of hydraulic oil pressure.

Loss of Pitch Control

A loss of pitch control can be caused by either a mechanical or an electrical failure. Mechanical failures will tend to occur more frequently. You should be aware, however, that electrical problems can occur that will occasionally produce a loss of control. Normally, an electrical problem, such as a broken or loose cannon plug or loss of feedback position, will require the system to be shifted to manual control. In the case of the DDG-51 class ships, however, the CPP system has both a normal and an alternate system by which the pitch position can be monitored. If the normal system should fail to provide command or feedback data, the CPP system can be shifted to the alternate system. In investigating a loss of pitch control on any gas turbine-powered ship, you must be aware of the components in the CRP/CPP systems that are most likely to fail. Let's take a look at some of the components you will have to monitor most frequently.

ELECTROHYDRAULIC SERVO VALVE.– The most common component failure is the electrohydraulic servo valve. This valve is the primary component for remote operation and control. If this valve were not installed, all operations would require personnel to be stationed at the OD box at all times.

You can easily identify a faulty electrohydraulic servo valve. Any of the following symptoms should alert you as to the possible failure of this valve:

1. The pitch fails to respond to a desired change of the integrated throttle control (ITC).
2. Pitch changes (fluctuations) occur without a pitch change command.
3. There is a steady increase in hub servo pressure without a change in system demands.

AUXILIARY RELIEF VALVE.– A faulty auxiliary relief valve will also cause a loss of pitch control. If the valve fails in the open position, all of the control oil will be ported back to the sump. As you should know, pitch cannot be changed without control oil to position the auxiliary servo piston in the OD box. In addition to the loss of pitch control, you should investigate any loss of pressure. You should be able to spot a pressure loss by checking the HOPM pressure gauges. This should be one of your first steps in checking the system.

REDUCING VALVE.– A faulty reducing valve is another cause for a loss of pitch control. If this valve happens to fail in the closed position, the flow of control oil will be cut off to the auxiliary servo piston and pitch will fail to respond. Again, this loss of pressure will have to be viewed at the HOPM during initial system investigation.

Loss of Hydraulic Oil Pressure

Usually, a loss of hydraulic oil pressure will cause an alarm to be generated at the PACC/PCC. The generation of this alarm, of course, will immediately alert the operator of a problem. The alarm will sound when casualties occur either to the main relief valve or to a sequencing valve. The alarm will not sound, however, when a major leak occurs. Let's look at the methods you can use to identify failure of these components.

MAIN RELIEF VALVE.– A faulty main relief valve can be identified by a low-pressure alarm at the console, but the actual answers can be found at the HOPM. This component failure can be easily identified by the operator. The operator simply looks at the HOPM pressure gauges and notes that all pressures are extremely low or nonexistent.

SEQUENCING VALVE.– You may suspect that a sequencing valve is faulty by detecting a loss of pitch control as well as a loss of hydraulic oil pressure, depending on how the valve fails. For instance, if the valve fails in the open position, then all the oil would become high-pressure oil and the low-pressure alarm would not sound. In this case, the auxiliary servo supply (control oil) pressure would be drastically low and system control would fade. On the other hand, if the sequencing valve were to fail in the closed position, a low-pressure alarm would sound and alert the operator. In this instance, the operator would also be able to see an extremely sluggish pitch response time.

MAJOR LEAK.– A major leak can provide the same symptoms as a loss of hydraulic oil pressure, depending on the location of the leak.

We have just told you about some of the components you should check for failure when you detect a loss of pitch control or a loss of hydraulic oil pressure. Now, let's talk about some of the most common maintenance procedures you will be expected to perform.

Cleaning and Lubrication

Cleaning is an continuous task. As a GS, you are likely already aware that good housekeeping practices must be maintained at all times. Your responsibilities for cleaning and lubricating the components of the CRP/CPPsystems are very similar to those we discussed for the MRG LO system. This is because the majority of the components that require cleaning in both the MRG LO system and the CRP/CPP systems are valves. In cleaning the valves of the CRP/CPP systems, you must pay close attention to detail. This is because most of the valves and piping of the CRP/CPP systems are located in the bilge area. Being in this area, these valves are constantly exposed to corrosive elements.

Other components that require cleaning and lubrication are the two CPP pump couplings. Even though the couplings are not cleaned and lubricated as frequently as the valves, cleaning and lubricating are still very important responsibilities. The procedures for cleaning and lubricating CPP pump couplings are the same as those we described earlier in this chapter for the FO and LO pump couplings.

Alignments and Adjustments

You will routinely make alignments and adjustments to couplings and other components. You will usually perform these tasks after you have cleaned and lubricated the components. Alignments and adjustments are either scheduled or conditional. During the cleaning process, for example, you may discover that a coupling requires an alignment check or adjustment. To Perform an alignment check you can follow the same guidelines you would use for checking the alignment of a FO or LO pump. These guidelines were described earlier in this chapter.

The CPP system is one of the few systems that you as a technician will be required to check for proper operating pressures. You will also be required to make some of the necessary mechanical adjustments. You will periodically perform these procedures through your ship's PMS. Remember, you must first monitor the operation of the CPP system as a whole, and then isolate individual components (one at a time) to ensure they are functioning properly. Let's take a look at some of the components you may be required to adjust and the functions they are designed to perform when the system is operating properly.

UNLOADING VALVE.– The unloading valve unloads the pressure of the attached pump back to the sump if the electric pump is operating and functioning properly.

SEQUENCING VALVE.– The sequencing valve serves two purposes: (1) It maintains a back pressure on the system to ensure that a minimum of 400 psi is supplied to the inlet side of the reducing valve, and (2) it provides high-pressure oil to the OD box.

REDUCING VALVE.– The reducing valve provides control oil to the OD box.

AUXILIARY SERVO RELIEF VALVE.– The auxiliary servo relief valve relieves excess control oil pressure back to the sump.

MAIN RELIEF VALVE.– The main relief valve relieves excessive pump pressure, either from the electric pump or attached pump, back to the sump.

REMOVAL AND REPLACEMENT OF COMPONENTS

This system seldom requires the removal or replacement of components. However, there is one component that you will be required to replace–the electrohydraulic servo valve. As previously discussed, this valve is in constant use and its probability of failure is much higher than any other component in the system.

There is only one other set of components that you will need to remove frequently–the system's filters. In fact, you will need to remove these components even more frequently than the electrohydraulic servo valve. This is because you will need to remove the filters for periodic cleaning according to the PMS. Of course, you will also need to remove them in the event of a casualty.

Now that we have discussed the maintenance and repair of the major propulsion plant systems, let's take a look at the machinery that these systems support.

DRIVE TRAIN EQUIPMENT

Next to the propulsion turbines, the drive train equipment is probably the most significant equipment unit in the engineering plant. In this section, we will discuss the operation and care of the equipment that transmits the GTEs' power to the propeller.

MAIN REDUCTION GEAR

The MRG is probably the most significant component that we will discuss in this section. The MRG reduces the GTEs' high rpm to a workable speed for the propellers. The workable speed is that rpm range below the cavitation point. The speed reduction capacity of an MRG must be correctly proportioned according to the size of the ship, the desired speed range, and the size of the propeller. Since all MRGs on gas turbine-powered ships are similar in design, we will discuss the operational and maintenance requirements in basic terms.

NORMAL OPERATIONS

The MRGs on the larger gas turbine-powered ships have multiple engine inputs. To allow for multiple engine inputs, each engine must be coupled to the MRG through a special type of clutch assembly: There are two types of clutch assemblies capable of accommodating multiple engine inputs. Each larger gas turbine-powered ship will be equipped with one of these two types of clutch assemblies.

The MRGs with multiple engine inputs are all rated at approximately a 21 to 1 gear reduction ratio (where 3,600 PT speed equals 168 srpm). As the rotation of the GTEs cannot be reversed and the MRGs are identical on twin-shaft ships, the MRGs are installed to "mirror image" each other to allow for opposite shaft rotations.

MAINTENANCE OF COMPONENTS

The amount of MRG component maintenance you will encounter on gas turbine-powered ships will depend on the type of MRG installed on your ship. The variations in maintenance routines will depend on the type of brake assembly installed on your particular class of ship. For example, on a DDG-51 or FFG-7 class snip, an externally mounted PT brake is installed on the interface between the output shaft of the GTE and the input shaft of the MRG. In CG-47, DD-963, and DDG-993 class ships, the PT brakes are internal and part of the clutch/brake assembly. The systems with the externally mounted braking systems will normally require more maintenance than those that are internal.

In addition to the brake assemblies, there are other components in the MRG system that will require maintenance. As a GSM, you will likely be required to perform maintenance on the following components:

1. Sight flow indicators
2. Shock mounts and snubbers
3. Attached pump angle drives
4. Vent fog precipitator
5. Dehumidifier

For these components, your specific maintenance duties will include cleaning, inspecting, and testing.

Cleaning

Cleaning the MRG is extremely important. The MRG is equipped with numerous removable inspection covers and maintenance access plates. Remember, the cleaner you maintain the MRG, the easier it will be for you to identify new leaks.

SIGHT FLOW INDICATORS.– Keeping the sight flow indicators clean is an especially important requirement. The sight flow indicators must be clean so bearing oil flow can be properly monitored. Even though there is not a specific maintenance procedure for cleaning the sight flow indicator glass, this component can become covered with an oil film and dirt. By periodically cleaning the sight flow indicator glass, you can prevent oil and dirt accumulation.

SHOCK MOUNTS AND SNUBBERS.– The cleaning of shock mounts and snubbers is covered by the PMS. For this maintenance requirement, you will need to keep the rubber portions of the mounts and snubbers free of paint, dirt, and oils, and to coat them with a silicone type of lubricant.

ATTACHED PUMP ANGLE DRIVES.– You must also clean the attached pump angle drives. This requirement coincides with the overall external cleaning of the MRG. Remember, each drive unit has two access/inspection covers, and they can develop leaks.

VENT FOG PRECIPITATOR.– You can also clean the external portion of the vent fog precipitator at the same time you perform the overall external cleaning of the MRG. Normally, all other maintenance will be performed by the GSEs. Because the MRG casing will be open when the vent fog precipitator is removed, you may be called upon to be a safety or security observer.

DEHUMIDIFIER.– Even though the dehumidifier is not physically attached to the MRG, its cleanliness is an important requirement. Technically, the cleanliness of the air filters is what is so important. For the unit to operate efficiently and to provide the MRG with the maximum protection from moisture, make sure the cleaning requirements listed in the PMS are consistently performed.

TURNING GEAR.– Cleaning the turning gear is usually a part of the overall cleaning of the MRG. Keeping the turning gear clean will make it easier for you to identify any leaks that might develop from the various flanges and inspection cover plates.

Inspections and Tests

The MRG and its components should be inspected and tested quite frequently. While in operation, the MRG and its components are inspected hourly. Remember, almost all inspections and tests of these components are requirements of the PMS. Let's take a look at some of these components and the most important points you should watch for while you are inspecting and testing the MRG.

MAIN REDUCTION GEAR.– The MRG inspection is the most important inspection you will perform. Generally, an MRG internal inspection will take place at the following times:

1. At least once a quarter
2. When a casualty or other unusual conditions exist
3. When the engineer officer is relieved of his or her duties

Remember, it is extremely important for all persons involved in an MRG inspection to adhere strictly to the prescribed safety and security guidelines. Safety is an extremely important factor in this inspection. You or another technician may be required to climb around on the MRG while accompanying the engineer officer on this inspection. Another important factor is security. While the MRG covers are open, all other work that might possibly interfere with the MRG inspection must be stopped. A controlled area must be set up around the MRG. A watch, consisting of E-5 personnel or above, must be posted to check all personnel and equipment entering and leaving this area.

ATTACHED COMPONENTS.– In addition to the MRG, you must also inspect the attached components for proper operation. In the following paragraphs, we will look at a few of these components.

Sight Flow Indicators.– Although it is simple in design, the sight flow indicator will be a very valuable tool for you in your responsibilities as watch stander. This small, installed component will allow you to check the oil flow and oil temperature coming from the bearing. While the MRG is operating, you must check the bearing oil flow and oil temperature at least once an hour.

Shock Mounts and Snubbers.– Although they are often ignored because they are out of sight, the shock mounts and snubbers not only maintain the proper mounting and alignment of the MRG but also reduce the noise signature of the MRG, which would otherwise be transferred to the hull. The noise reduction feature is especially significant in antisubmarine warfare (ASW). Because shock mounts and snubbers play such important roles, they should not be ignored. As a good technician, you should avoid the "out of sight, out of mind" thinking you may encounter in other technicians regarding the maintenancc of these components. While inspecting these components according to the PMS, pay close attention to details. By giving proper attention to details, you are doing your job to make certain these components do not fail prematurely.

Attached Pump Angle Drive.– According to the PMS, you will occasionally be required to inspect the attached pump angle drive. Because you must open the MRG casing to perform this inspection, you are required to follow the same safety and security guidelines used during an MRG inspection.

Vent Fog Precipitator.– While the MRG is in operation, the vent fog precipitator should be inspected hourly. Check the indicator light installed on a side panel of the power plant. This light serves two purposes: (1) to show that supply power is available, and (2) to indicate that the unit is operating. If the light is out, first check the unit's circuit breaker to make sure the unit is on, then check the indicating light bulb to make sure it is not loose or burned out. If the circuit breaker is on and the indicating light bulb is not loose or burned out, then have a GSE check the unit for proper operation.

Dehumidifier.– The dehumidifier is used whenever the MRG is in an extended layup of 8 weeks or longer. During this period the dehumidifier should be checked daily for proper operation and to ensure the relative humidity of the gear casing remains below 35 percent.

Turning Gear.– As far as inspections go, special inspections of the turning gear will be limited to those times when the equipment fails. Consistent performance of the PMS should allow you to keep this equipment in good working order and to limit any special inspections resulting from equipment failures.

During any inspection, it is important for you to be thorough, especially if you are performing an inspection after a casualty. In the following section, we will tell you about some of the important steps you should take and the conditions you should check when you are troubleshooting the failure of an MRG component.

Troubleshooting

The MRG itself is not very complex. To identify a problem in the MRG, you can use the prescribed inspection procedures contained on the PMS maintenance requirement card and those for troubleshooting contained in *NSTM,* Chapter 9420, "Propulsion Reduction Gears, Couplings, and Associated Components," to help you pinpoint the problem. The attached components, however, make the MRG more complex to deal with.

As we explained earlier, the attached MRG components include the sight flow indicators, shock mounts and snubbers, pump angle drive assembly, and turning gear. In the following paragraphs, we will tell you about some important troubleshooting lessons learned by experienced technicians that you can use to deal with these attached components.

SIGHT FLOW INDICATORS.– As we mentioned earlier, you will use the sight flow indicators to monitor the oil flow of the MRG bearings. If the oil flow is reduced or if it disappears, this mayor may not indicate a serious problem. In any event, you should investigate the condition immediately according to your ship's EOCC. In the following paragraphs, we will describe some of the problems that could cause these symptoms to appear and some methods that can help you to isolate them.

Restricted or Reduced Oil Flow.– This condition can be caused by a blockage (dirt) in the sight flow indicator itself, a partially unseated oil supply tube, a small hole in the oil supply tube, or a blockage in the bearing oil passage. Of these conditions, blockage in the bearing oil passage is the only one that might indicate a serious problem.

A blockage in the bearing oil passage can result from the introduction of a foreign object, such as a rag, into the LO system. Dirt, or even the babbit of a damaged bearing can also cause a blockage. Whichever of these problems has occurred, the process of identification is the same. To help identify the problem, you can use the following steps, keeping in mind that these steps are not meant to replace other already approved troubleshooting procedures for your ship:

1. First, you must determine if the reduced oil flow remains unchanged at various speeds. For example, if the oil flow increases at a slower speed, you can eliminate a blocked sight flow indicator, an unseated oil supply tube, or an oil tube with a hole in it as the probable cause. With these conditions, the reduced oil flow would remain unchanged. An increase in oil flow at slower speeds could signify a bearing problem. A damaged bearing, for example, could possibly have moved because of the changing thrust requirements during speed changes. A moved bearing could have, in turn, covered or uncovered the bearing oil passage. If the bearing appears to be the problem, the engineer officer must determine if he or she wants ship's force to continue the investigation or call for outside assistance.

2. Now, with the engineer officer present, you can determine if the problem is associated with the sight flow indicator or its supply tube. You can do this by carefully removing the sight flow indicator. First, inspect the sight flow indicator for a blockage. If you detect no blockage, remove and inspect the oil supply tube for damage or shrinkage. If you detect no problems in these areas, then you must seriously consider a full MRG inspection to determine if a foreign material has

entered the oil system. The condition must be resolved before it damages any other components on the MRG.

No Oil Flow Evident in an Individual Sight Flow Indicator.– If there is no oil flow detected in any one of the sight flow indicators, this may or may not be a serious problem. According to the EOCC, however, you should always treat this symptom as if it were an indication of a loss of LO pressure to the entire MRG. Once the MRG is stopped, you can begin troubleshooting by using the approved procedures. In most cases, you will find the casualty was caused by one of the previously mentioned problems we discussed in the section concerning restricted or reduced oil flow.

SHOCK MOUNTS AND SNUBBERS.– A typical shipboard technician would have trouble identifying a problem with the MRG shock mounts and snubbers unless the problem were obvious. You will likely discover the more obvious problems, such as severe MRG vibration, loose, missing, or broken mounting bolts, or large cracks in the shock mount or snubber isolation material, during your operation or PMS inspections. The repair work will be accomplished by a ship repair facility under the direct supervision of the Naval Sea Systems Command (NAVSEASYSCOM).

PUMP ANGLE DRIVE ASSEMBLY.– Determining a problem in this area is not very difficult. Symptoms such as excessive noise, difficulty in engaging or disengaging the drive, and a high failure rate of the attached pump flexible couplings are all good indications of a damaged drive assembly. If the problem is caused by a failed bearing, the ship can usually make the repairs. In most cases, however, the drive shaft will be damaged and machine work will probably be required. If this is the case, assistance from a repair activity will be needed because your ship is not likely to have the experienced personnel or the required materials for this type of work.

TURNING GEAR.– If the problem with the turning gear is mechanical, then you would probably approach troubleshooting the problem in much the same manner as you would a problem with the pump angle drive assembly. Just remember the turning gear is driven by an electric motor and not by the MRG. If the problem is electrical, you will need to call upon a GSE to assist in the troubleshooting.

Removal and Replacement of Components

Remember: Before you remove or replace any components that require the MRG casing to be opened, the engineer officer must be present. In most cases, if the casing covers must be opened for any reason other than inspections, such as bearing removal, the work will be performed by an outside activity. While the repairs are being made, however, ship's company may be allowed to assist in the repairs and will be required to provide the security watches.

There are a few components that you may be authorized to remove and repair. These components are the attached pump angle drive assemblies and the clutch/brake assemblies, with we will discuss in the next section.

CLUTCH AND BRAKE ASSEMBLIES

Depending on the type of ship to which you will be assigned, you will encounter either one or both of the two types of clutch assemblies currently in use on gas turbine-powered ships. The first and most widely used clutch assembly is the syncro-self-shifting (SSS) type. This type of clutch assembly is installed on all CG-47, DDG-51, and FFG-7 class ships. The other is a pneumatically operated, forced-synchronization type of clutch assembly, which is installed on DD-963 and DDG-993 class ships.

Along with the two types of clutch assemblies, there are two types of PT brake assemblies installed on gas turbine-powered ships. One ship class has a separate shaft brake assembly, The type of brake assembly used depends not only on the ship class but also on the type of clutch assembly installed.

In this section, we will briefly discuss the normal operation and the maintenance related to both types of clutch assemblies and all the brake assemblies. Because of its complexity, its elaborate control system, and the large number of labors hours required for its maintenance, the Navy is gradually phasing out the forced-synchronization type of clutch. For this reason, we will focus our discussion mostly on the maintenance practices associated with the SSS type of clutch.

NORMAL OPERATIONS

Both types of clutch assemblies perform the same function-they connect a GTM or the GTMs to the MRG to drive the propulsion shaft. However, the method of clutch engagement varies drastically between the SSS and forced-synchronization clutches.

Forced-Synchronization Clutch

The forced-synchronization type of clutch requires ship's service air and MRG LO to be available before normal engagement can occur. The clutch is made up of a friction pack and dental clutch assembly. The friction pack is needed to bring the GTM input shaft speed to within 11 rpm of the first reduction pinion. Once the speed permissives are met, air pressure is applied to the dental clutch to complete engagement. When the dental clutch is engaged, all torque is transmitted from the GTM input shaft to the MRG's first reduction pinion. This clutch assembly also houses a friction-type PT brake that serves two purposes. The primary purpose of the PT brake is to stop and hold the PT stationary. If the PT brake is used in conjunction with an engaged clutch, the PT brake also acts as a shaft brake. The forced-synchronization clutch is being phased out of Navy service in favor of the SSS clutch.

Synchro-Self-Shifting Clutch

The SSS clutch system performs the same functions by transmitting engine torque through the input shaft to the MRG first reduction pinion. It does not, however, require any external controls to perform the engagement sequence. For clutch engagement to occur, the SSS clutch requires only that the input shaft speed be greater than the speed of the first reduction pinion. The SSS clutch is fully automatic, and by design, centrifugal force causes the main sliding member to move and engage with the output assembly.

Depending on the ship class, the SSS clutch system uses two different types of PT brake assemblies. The CC-47 class ships have a PT brake assembly similar to those installed on the DD-963 class ships. It is an internally housed friction clutch design that is mounted to, but operates independently of, the SSS clutch assembly. The main difference between this brake and the one installed on the DD-963 class ships is that it cannot be used as a shaft brake. Because of the SSS clutch design, even if the brake is applied with the clutch engaged, the clutch will disengage once the PT input speed drops below the speed of the first pinion.

The other type of PT brake assembly is the one installed on the DDG-51 and FFG-7 class ships. This is a single-disc caliper brake assembly that is externally mounted to each PT input shaft. These brakes are also used in conjunction with the SSS type of clutch in which their only purpose is to stop and hold the PT stationary when required.

The last type of brake assembly we will discuss is the shaft brake assembly. Shaft brake assemblies are installed only on the FFG-7 class ships. The shaft break assembly is also a single-disc caliper brake assembly, such as the PT brake assemblies we just described. Consisting of two complete units, a shaft break assembly is mounted on each starboard first reduction quill shaft. Once all permissive are met, the single purpose of this break is to stop MRG rotation.

MAINTENANCE OF EQUIPMENT AND COMPONENTS

The maintenance of the clutch and brake assemblies and associated equipment and components will normally be accomplished according to the PMS. General cleaning, tests, and inspections will be your primary concern. Because of the good operational track record associated with the SSS clutches, troubleshooting and repairs should be minimal. This is the main reason the Navy is phasing out the forced-synchronization type of clutch.

In the following paragraphs, we will discuss some general maintenance and repair practices associated with clutch and brake assemblies that you, the GSM, may be required to perform or supervise.

Cleaning

The cleaning of clutch and brake assemblies will primarily be accomplished when the MRG is cleaned. Cleaning the clutch assembly will be limited to external cleaning with attention to the areas around the inspection and access cover plates and the clutch position indicating ports.

The cleaning of externally mounted brake assemblies will require a little more effort. To properly and thoroughly clean any of the external brake assemblies, you must remove the guard screen. Once you remove the screen, pay particular attention to removing any dust accumulation on the brake and to the cleanliness of the disc. It is important for you to keep dust accumulation to a minimum. Once the dust mixes with oil, it can be deposited on the brake disc or absorbed into the pads. Excessive dust and/or oil accumulation can seriously degrade the brake's operation.

Tests and Inspections

Unless a casualty occurs to either the clutch or brake assemblies, all tests and inspections will be performed according to the PMS. For all practical purposes, there are no tests or inspections related to SSS clutch assemblies, unless you are assigned to a CG-47 class ship. Remember, that particular type of SSS clutch has an internal PT brake assembly. The ship's maintenance action plan periodically requires that an inspection of the disc assembly be made and the clearances between the discs measured.

Additionally, the externally mounted PT and shaft brake assemblies must be checked on a regular basis according to the PMS. These inspections will normally include checking the brake pad thickness measurements, rotor condition, proper operation of air or hydraulic actuators, and proper lubrication of vital moving parts.

TROUBLESHOOTING

Because the SSS clutches are reliable, problems that require troubleshooting should be minimal. Like all other gear-driven assemblies, the SSS clutches have a tendency to wear and produce noise with age. Normal failures, however, are usually limited to faulty position indicator switches and failures related to the PT brake assemblies. For these reasons, we will not dwell on the clutch assemblies. Let's move on and discuss some of the problems related to the installed brake assemblies and look at the ways in which you, the GSM, can better identify them.

The basic operation of both the PT and shaft brakes are the same as the disc brake system installed in most automobiles. They all require some type of medium (air, oil, or air and oil) to force the caliper piston against the brake pad which, in turn, is pushed against the disc. This action slows the rotation of the disk until the disk stops. Let's talk about some common malfunctions that may occur in this system and the ways you can isolate the cause.

Failure to Engage

There are several problems that can cause a brake to fail to engage, Let's go back to the operating principles associated with this system. First, check to see if there is sufficient air or oil pressure for operation. Its pretty obvious that if the activating medium (air or oil) is missing, this condition should produce an alarm at the console.

Once you determine that the activating medium is available, then you should try the manual control. If the manual control works, then you should consider an electrical fault as the source of this problem. If the manual control does not work, then you should continue troubleshooting. If the pressure regulator is not working, then the supply cutout valve (if installed) may be closed, or there may be a blockage or leak in the supply line. These are all possible causes for the failure. The last part to check is the electrical control. Did the brake actually engage? If the brake engages, but you do not receive a brake engaged indication, just look at the PT speed to verify if it is slowing down or has already stopped. If the FT has stopped, then your indicator light maybe out or the indicator switch may be bad. If the PT does not stop, then you probably need to contact a GSE to help locate where the command signal is lost.

Failure to Release

When a brake fails to release, the most common causes are a command problem, a bad position indicator switch, or a bad indicator light, If these conditions are not the cause, then you should check for a binding caliper and weak or damaged return springs.

Failure to Stop Rotation

When the brake applies but does not stop rotation, the most common causes are insufficient actuating pressure, contaminated brake pads, a damaged rotor (disc), or a binding caliper piston.

ALIGNMENTS AND ADJUSTMENTS

Basically, the only components that have any type of an adjustment or alignment check are the PT and shaft brake systems. Normally, all of these adjustments or alignments are performed as requirements resulting from a PMS inspection.

REMOVAL AND REPLACEMENT OF COMPONENTS

The removal and replacement of a clutch may be performed by your ship's personnel if there is sufficient time or if a casualty occurs. Most of the time, however, the engineer officer will opt to have an outside activity perform the work.

On the other hand, the brakes and their subsystems can be easily maintained by your ship's maintenance technicians and personnel.

PROPULSION SHAFTING AND BEARINGS

Now that wc have discussed the MRG and propeller assemblies, we need to tie the MRG assemblies together with a discussion of the shafting.

The size and class of a ship will dictate the number of required propulsion shafts, bulkhead seals, and support bearings. Because of the similarity in shafts, bulkhead seals, and support bearings among the various classes of gas turbine-powered ships, our discussion will be in general terms.

Normally, the propulsion shaft operations and maintenance you will encounter will be related to the main engine room (MER) to which you are assigned. For example, if your MER drives the port shaft, then the shaft, all bulkhead and stern tube seals, and support bearings on that shaft will be your responsibility,

NORMAL OPERATIONS

We know that when the GTE is coupled to the MRG, it transmits its rotation and torque through a series of gears to reduce its speed. This rotation and torque is then relayed to the propeller through the propulsion shafting. But, as this power is transmitted, another force develops. This force is referred to as thrust. The propeller generates this thrust that pushes the ship through the water. To react to this thrust, a thrust bearing is required on the propeller shaft to prevent the shaft from being pushed into the hull of the ship. As we described in detail in GSE3/GSM3, volume 1, the main thrust bearing transmits thrust to the hull and properly positions the shaft axially relative to the hull.

Without all of the complexity and to a lesser degree, the line shaft bearings perform many of the same functions as the main thrust bearing. The line shaft bearings maintain the shaft in axial alignment and guide the workable rotational speed to the propeller. The bulkhead seals do not assist in shaft alignment. In fact, they have quite the opposite effect because they are aligned to the shaft to maintain a watertight seal between machinery spaces to prohibit progressive flooding. The stern tube seal is also aligned to the shaft so it can maintain a watertight seal where the shaft penetrates the ship's hull.

MAINTENANCE OF EQUIPMENT AND COMPONENTS

As we mentioned earlier, there may be more than one work center involved in the maintenance of the propulsion shafting, depending on the class of your ship. Whenever more than one work center is involved, team work and coordination are critical. All work centers involved should get together to plan all maintenance related to the propulsion shafting and to make arrangements to provide each other with assistance as needed.

Remember, even though more than one work center may be involved, your own work center is ultimately responsible for the readiness of the propulsion shafting. In the following paragraphs, we will describe some of the key maintenance requirements and helpful hints you can use to maintain the propulsion shafting in peak operational condition.

Cleaning

Depending on the delegation of responsibility on your ship, the responsibility for cleaning the propulsion shafting and its components could be assigned to the MER personnel or to the personnel in the machinery space through which the shaft passes. The external parts of the shaft, bulkhead and stern tube seals, and line shaft bearings only require general cleaning, such as wiping down, and preservation against rust and corrosion. The internal cleaning of the line shaft bearings and bulkhead and stern tube seals, however, will be required occasionally according to the PMS. As a GSM, you may be assigned the responsibility for cleaning these components.

LINE SHAFT BEARINGS.– The line shaft bearing sump may need to be cleaned periodically for the following reasons:

1. If the oil is contaminated and requires changing either by the results of a visual inspection or an off-ship analysis.
2. If a temperature sensor fails, the oil must be drained and the inspection covers removed.
3. If a casualty has occurred and an inspection is required.
4. When major work has been completed on the bearing.
5. Any time cleaning is required by the PMS.

BULKHEAD SEALS.– The bulkhead seals should be periodically cleaned according to the PMS. This procedure includes the complete disassembly of the seal for cleaning, lubricating, and inspecting. The only other reason for seal disassembly would be a condition caused by a casualty.

STERN TUBE SEALS.– The stern tube seal and its components are normally cleaned as part of a general cleanup in the space where this assembly is installed. Other cleaning requirements may have to be performed to the internal parts of this assembly as apart of the PMS or when a casualty occurs.

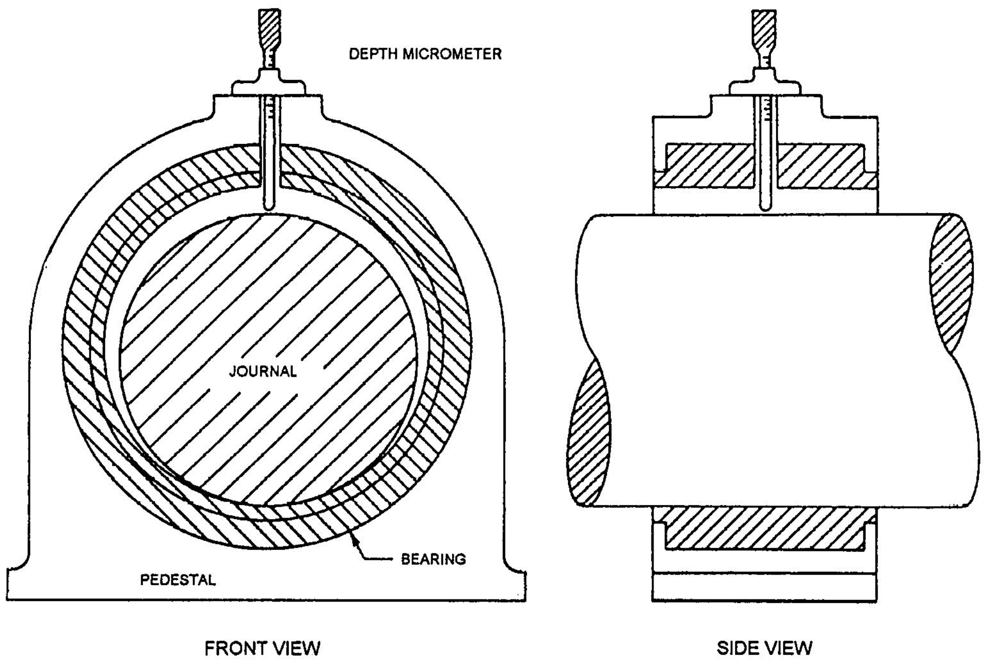


Figure 5-5.-Depth micrometer readings.

MAIN THRUST BEARING.– The main thrust bearing does not require any special cleaning. Its cleaning is usually performed as part of the MRG cleaning. You should follow the cleaning tips we described earlier for the components of the MRG.

Inspections and Tests

Most of the tests and inspections we will discuss are accomplished according to the PMS. Because of casualties, however, you may be required to participate in some unscheduled inspections. We will now discuss some of the most common tests and inspections performed on the components we just discussed in the preceding paragraphs.

LINE SHAFT BEARINGS.– The task you will perform the most frequently on the line shaft bearing (LSB) will be a visual inspection while the propulsion shaft is in operation. You should perform this inspection once an hour to check for proper oil flow, oil temperature, and leaking seals and covers.

The other inspection that you as a technician could be required to perform will be a bearing wear measurement. This procedure is covered under the PMS, but here are some important tips you should remember:

1. All of the line shaft bearings installed on gas turbine ships have a machined flat surface and a removable plug for micrometer access on the top of the upper bearing shell cap. This flat surface must be kept clean and free of nicks so correct depth readings can be taken.

2. A depth constant (installation reading) is inscribed on or near this flat surface. You must use this reading every time you perform a depth measurement, as shown in figure 5-5. You must make sure you give the same care to acquiring depth micrometer readings as you would give to the measuring flat surface.

BULKHEAD SEALS.– You will usually inspect the bulkhead seals at the same time you clean them. This inspection will require the complete disassembly of the seal to expose those parts shown in figure 5-6. Once the seal cover is removed, pay particular attention to the condition of the compression and garter springs and the surfaces of the two (segmented) carbon sealing rings. These springs should not be cracked or distorted. The sealing rings must have an even wear pattern and should be free of nicks and scratches. An uneven wear pattern on the face of the sealing rings is an indication of improper garter or compression spring pressure or possibly the binding of a ring segment. Remember, the condition of a sealing ring is only as good as the condition of the journal surface on the propulsion shaft.

You should also inspect the surfaces of the two sealing discs to make sure the discs have not slipped from their correct position. (Remember, these discs are stationary.) Scoring on the sealing surface of either

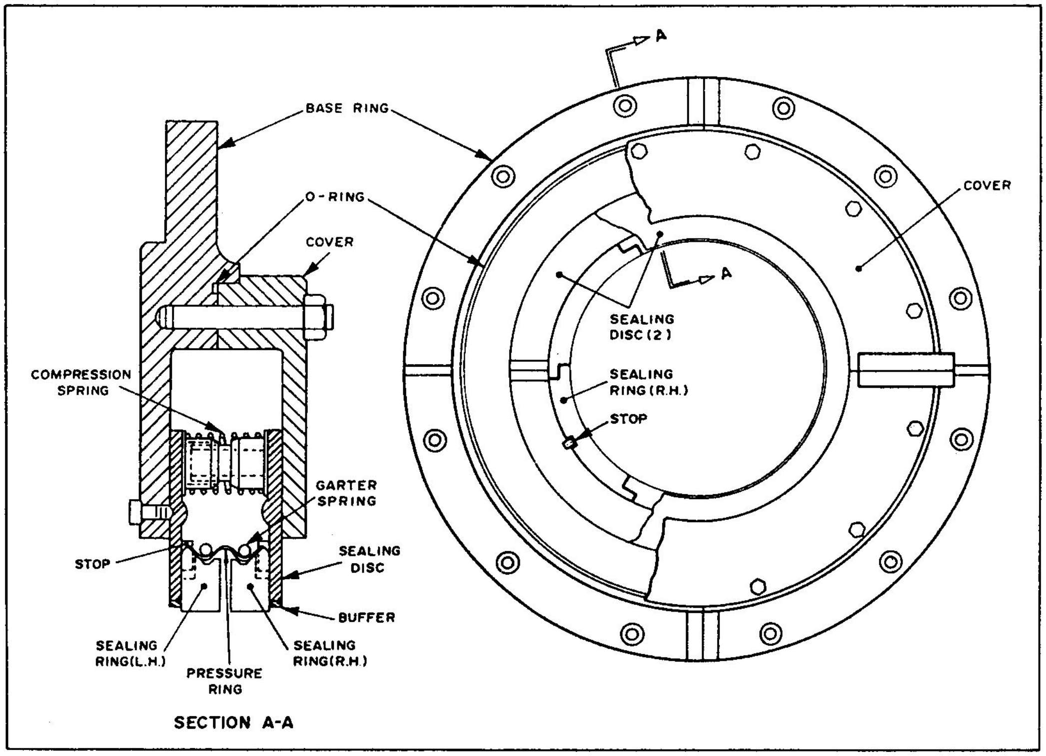


Figure 5-6.-Cutaway view of a typical bulkhead seal.

sealing disc is a good indication that you have a few weak compression springs that have allowed the disc to rotate with the shaft.

Another key point to look for is signs of wear on the buffers installed on the bottom of the sealing discs. If you detect wear and the pattern of wear is not uniform, then the shaft to bulkhead seal alignment is most likely incorrect.

STERN TUBE SEALS.– Your inspection of an individual stem tube seal should consist of the seal and its support systems. There are two support systems you should check: (1) the seawater service system, which provides cooling; and (2) the ship's service air system, which provides the air for seal inflation.

You should check both subsystems for proper operation as they pertain to the operation of the stern tube seals. For example, you should check the inflatable seal operation at least every 6 months. Remember, the proper operation of the inflatable seal is crucial to safety and your ship's ability to survive. Check both the ship's service air system, which provides air pressure under normal operation conditions, and the compressed air bottles, which supply emergency air pressure to the seals, to make certain the inflatable seal is always supplied with the required air pressure. Next, you should check the seawater cooling system. Check both the ship's seawater cooling system, which provides cooling seawater during normal operations, and the firemain system, which provides emergency cooling seawater, for proper pressure and flow. If a seawater strainer is included in your ship's seawater cooling system, check it also and clean it as required. Then, you should check the stem tube seal itself for leakage. Even though the sealing assembly is mechanical, you can adjust the spring pressure to maintain a proper seal. We will explain this adjustment procedure later in this chapter.

MAIN THRUST BEARING.– The main thrust bearing will normally be inspected as frequently as the MRG when the propulsion plant is in operation. During a normal inspection, you should check for the proper oil flow and oil temperature and for leakage. You should also periodically inspect the main thrust bearing according to the PMS for excessive thrust. Like the LSB, you should use a depth micrometer to measure the thrust. Normally, the measurement plug is located on the propulsion shaft side of the MRG casing. By moving the shaft first in the ahead and then in the astern direction, you can measure the actual movement of the second reduction gear (bull gear). Use these readings in the same reamer as you would the thrust readings for a LSB.

Troubleshooting

All of the propulsion shaft components we have described demonstrate similar symptoms when a casualty occurs. These symptoms include unusual noise, excessive vibration, and overheating. Unusual noise and excessive vibration can be especially tricky to detect, identify, and trace. That is why whenever you detect one of these symptoms, it is extremely important that you make a thorough inspection of all propulsion shafting components. Let's take a closer look at each of these symptoms.

UNUSUAL NOISE.– This symptom may be accompanied by vibration and can have several causes. Since the most common causes are already listed in the EOCC, we will keep our description brief.

If the sealing disc in a bulkhead seal begins to rotate against the inside of the cover plate, a squeaking or squealing noise will be produced. Another cause could be an object that has fallen or is improperly stowed against the propulsion shaft. The type of noise can vary, depending on the position of the object and the material from which it is made (cardboard, wood, or steel, for example).

EXCESSIVE VIBRATION.– Internal damage to one of the drive train components or propeller damage are the usual causes of this symptom. Broken or damaged MRG teeth may cause internal damage. A fouled or damaged (unbalanced) propeller blading can also cause excessive vibration.

OVERHEATING.– Of the three major symptoms, this is the one you will encounter the most often. A lack of lubrication, such as a low oil level in a LSB or insufficient cooling water to the stem tube seal, is normally the first thing you should check. If overheating becomes too severe, another symptom, such as unusual noise, may occur. That is why a quick response and proper identification of the casualty are so important.

Alignments and Adjustments

The alignment or adjustment of the bulkhead and stern tube seals arc the only propulsion shaft components that shipboard personnel will normally be able to perform. If an IMA is making the repairs, shipboard personnel will be required for quality assurance inspections and in most cases called upon to help in the repair effort.

If an alignment (or even checking the alignment) of the propulsion shaft is required, then a ship repair facility must be called in. Remember, the alignment of the shafting and bearings is not permanently fixed but changes with every dry docking, in keel blocking, and throughout temperature variations.

The alignment of the struts and stern tubes must be in relation to each other as well as to the main propulsion machinery. These alignments will undergo a natural change if the propeller, propeller shaft, LSBs, or all of these parts are temporarily removed.

The temporary removal of any machinery attached to shafting, bearings, or their immediate surrounding areas can redistribute weight and stresses in the system. This can result in misalignment. Furthermore, alignment is not the same when the vessel is waterborne as it is when the vessel is in dry dock. Remember, the final alignment and bolting up of the main propulsion shafting of any vessel should always be done when the vessel is waterborne.

There is really only one component of the propulsion shafting to which you may have to perform an adjustment–the stern tube seal. There are only two times when you should adjust this component: (1) when the seal is leaking, and (2) when emergency packing must be installed and you must compress the packing to maintain a proper seal and leakage rate. Always take special care when you are adjusting the seal seating pressure. If overcompression occurs, the seal will overheat. If the spring is undercompressed, the seal will leak.

Removal and Replacement of Components

Believe it or not, there will be occasions when you will be required to remove and replace components on the propulsion shaft. There is one type of component that is subject to failure and is installed in all of the previously mentioned components-a seal. In the following paragraphs, we will briefly discuss some of the key points for seal removal and replacement.

LINE SHAFT BEARINGS.– The line shaft bearings have a double sealing system in which there is a combination of two seals installed at each end of the bearing. All four seals are identical in design and can be easily removed and replaced by the ship's company. An important thing to remember, however, is that the sealing lip of each seal must face in opposite directions, as shown in figure 5-7. The innermost seal faces inward to keep the oil from leaking out of the bearing and the outer seal faces outward to keep water from entering the bearing if the space becomes flooded.

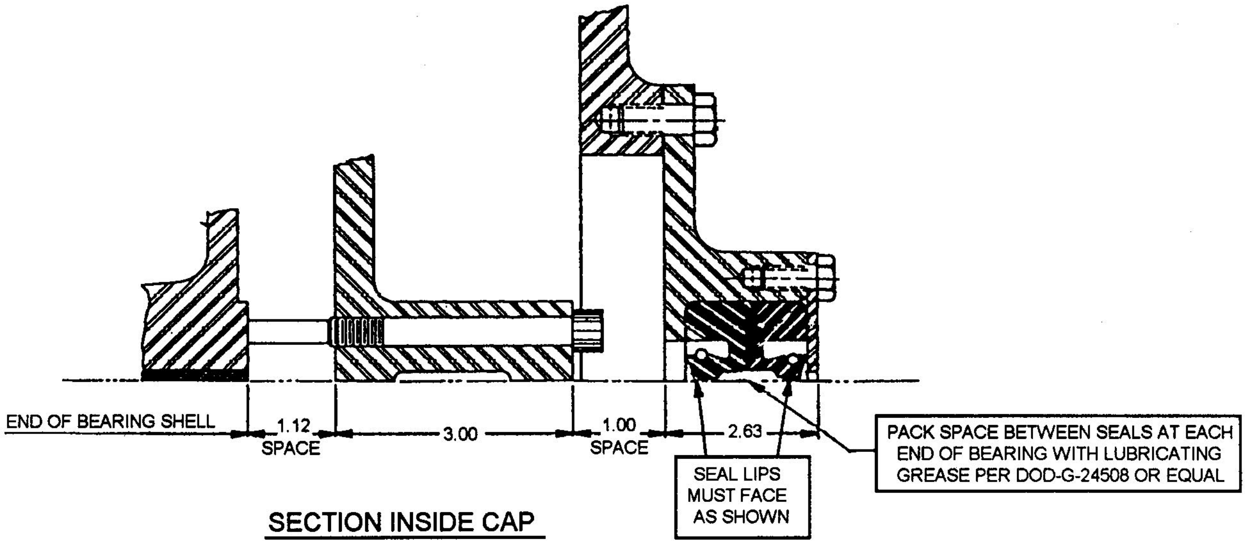


Figure 5-7.-Cross-sectional view of LSB oil seals.

The procedure for seal installation is usually included in the package containing the seal. If the instruction sheet is missing, you can find the installment procedure in the NAVSEA technical manual for the model of the line shaft bearing installed on your ship. A couple of key points for you to remember are (1) make sure you use only an approved adhesive to join the butt ends of the seal together and that you pack the space between the two seal faces as described in figure 5-7, and (2) make sure you properly space the seal split lines.

BULKHEAD SEAL.– The bulkhead seal is another component that can easily be maintained by ship's force personnel. Because the bulkhead seal does not support the shaft, virtually every part of the seal assembly can be removed and replaced without disturbing the shaft alignment. Normal wear and tear will require periodic replacement of the sealing rings and garter springs. Sometimes, as the result of an inspection, the replacement of the compression springs or the sealing discs may be necessary. One key point to remember: Always handle the sealing rings with care. These rings are made of carbon and they can be damaged or broken easily.

STERN TUBE SEAL.– The replacement of the stern tube seal assembly can be accomplished by the ship's force if the ship has all the tools required to perform the job. The person assigned to perform this procedure must be experienced. Because a seal must be placed around the shaft at the hull penetration point, a qualified diver is necessary. Once all of these precautions are taken, seal replacement can commence. Always, you should carefully follow the procedures provided in the manufacturer's technical manual.

MAIN THRUST BEARING.– Even though seal replacement can be and has been accomplished by ship's force personnel, many engineer officers prefer to have an outside activity make the repair. The reason for this is because the bearing cap must be removed. It is extremely heavy and awkward. Few ships have the necessary rigging experience to handle this piece.

Removing the bearing cap is very dangerous. The cap must be properly rigged for lifting. If, because of limited space, it cannot be moved clear of the working area, it could possibly be left hanging directly over your head while you arc working on the seal. Because of these potential safety hazards, make sure all precautions and instructions are followed to the letter.

SUMMARY

In this chapter, we have provided you with an overview of the propulsion plants systems and drive train equipment and systems used on gas turbine-powered ships. We discussed some ways in which you can properly operate and use your ship's propulsion plant. If you properly maintain your propulsion plant and its equipment, the plant will provide your ship with a high level of efficient service. With the information provided in this chapter and the recommended technical publications, you should become a more effective gas turbine systems technician.

CHAPTER 6

LCAC AND PHM PROPULSION SYSTEMS

The GSMs 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 and electric plant 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 FPG-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. (In chapter 7, we will discuss the electric plants for 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 NRTV, 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 GS 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 Lycoming 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 6-1 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 dis-embarkation of troops and supplies. The only GS is the craft engineer/assistant operator.

AVCO LYCOMING TF40B GAS TURBINE ENGINE

The AVCO Lycoming TF40B gas turbine engine is the major propulsion plant for the LCAC. As a GSM, you will come into contact with the TF40B if you are assigned to an LCAC or to one of its maintenance depots.

There are four TF40B engines on the LCAC, two on the port side and two on the starboard side. These engines are the power sources that drive the lift fans, propellers, and forward and aft gearboxes. In the following paragraphs, we will take a look at the TF40B in terms of its design and normal operating characteristics. Later in this chapter, we will take a look at the control and other systems for its functions.

DESIGN AND OPERATION

The TF40B is a direct-drive, high-speed turbine consisting of a 2-stage, free-power turbine and a combination 7-stage, axial-centrifugal compressor driven by a 2-stage, axial-flow turbine. It also incorporates a reverse-flow, annular-type atomizing combustor chamber assembly, oil cooler assembly, topmounted accessory gearbox module, and an integral lubrication system. The major sections of the TF40B are shown in figure 6-2.

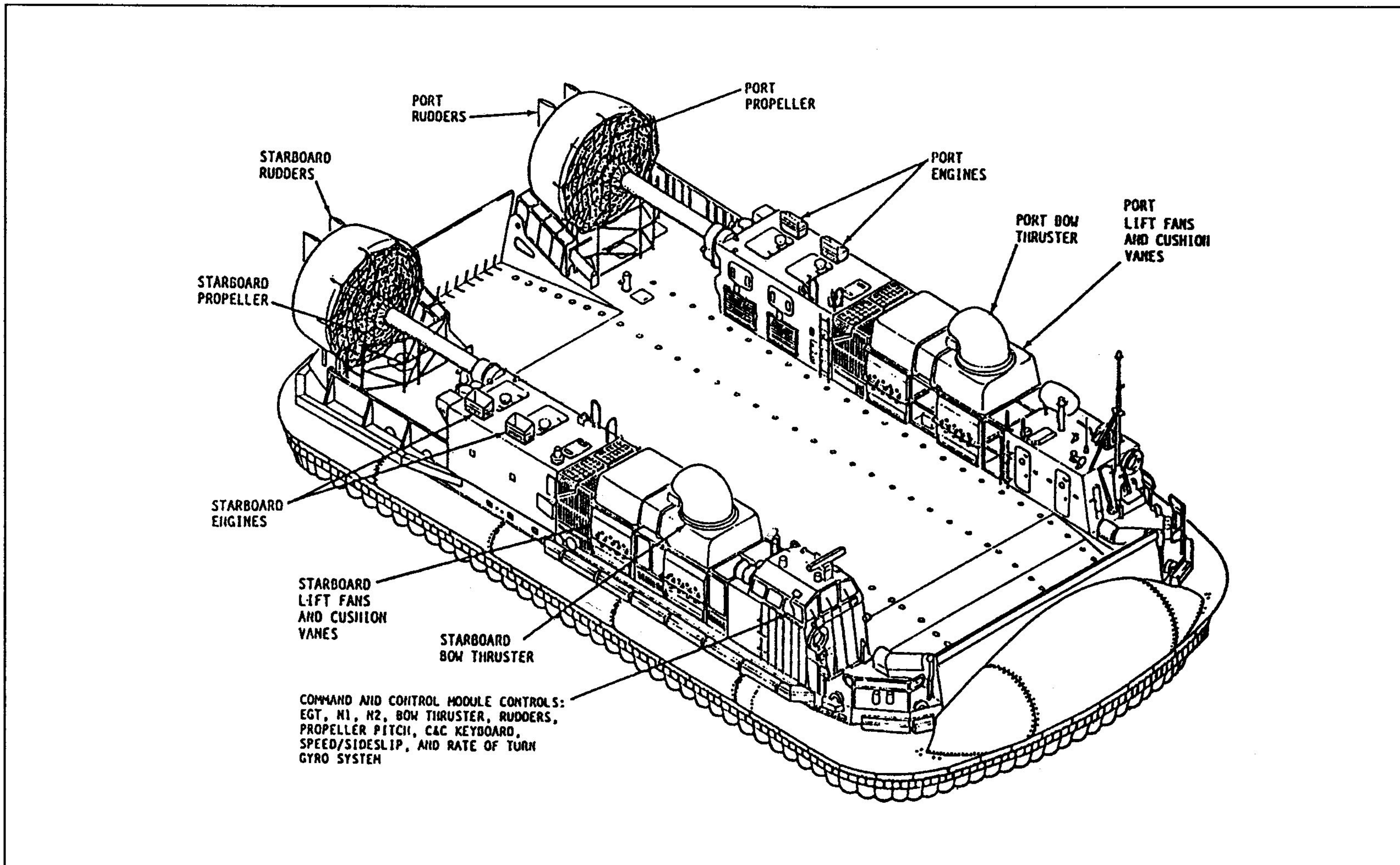


Figure 6-1.–Landing craft, air cushion (LCAC).

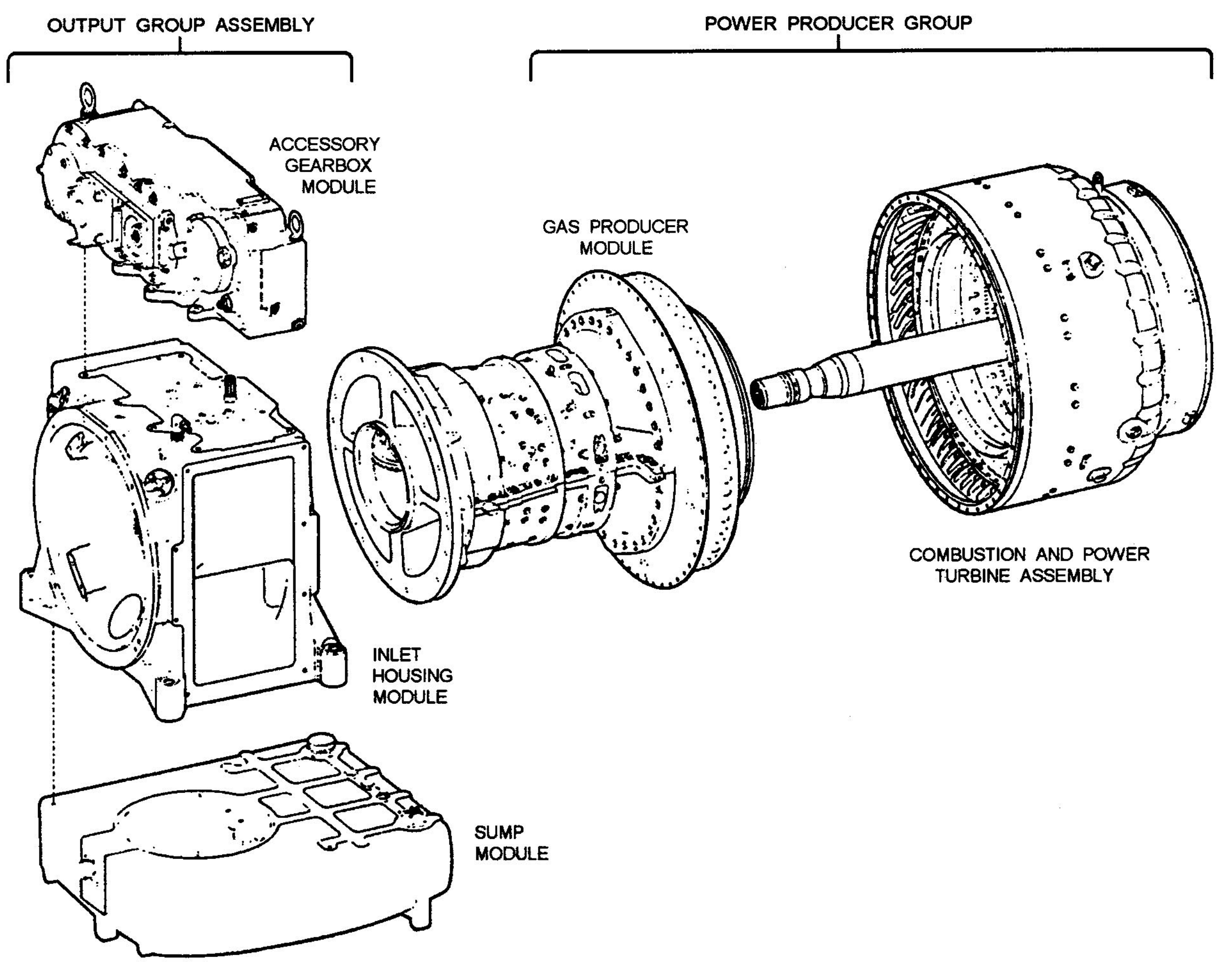


Figure 6-2.–Major sections of the Lycoming TF40B (LCAC).

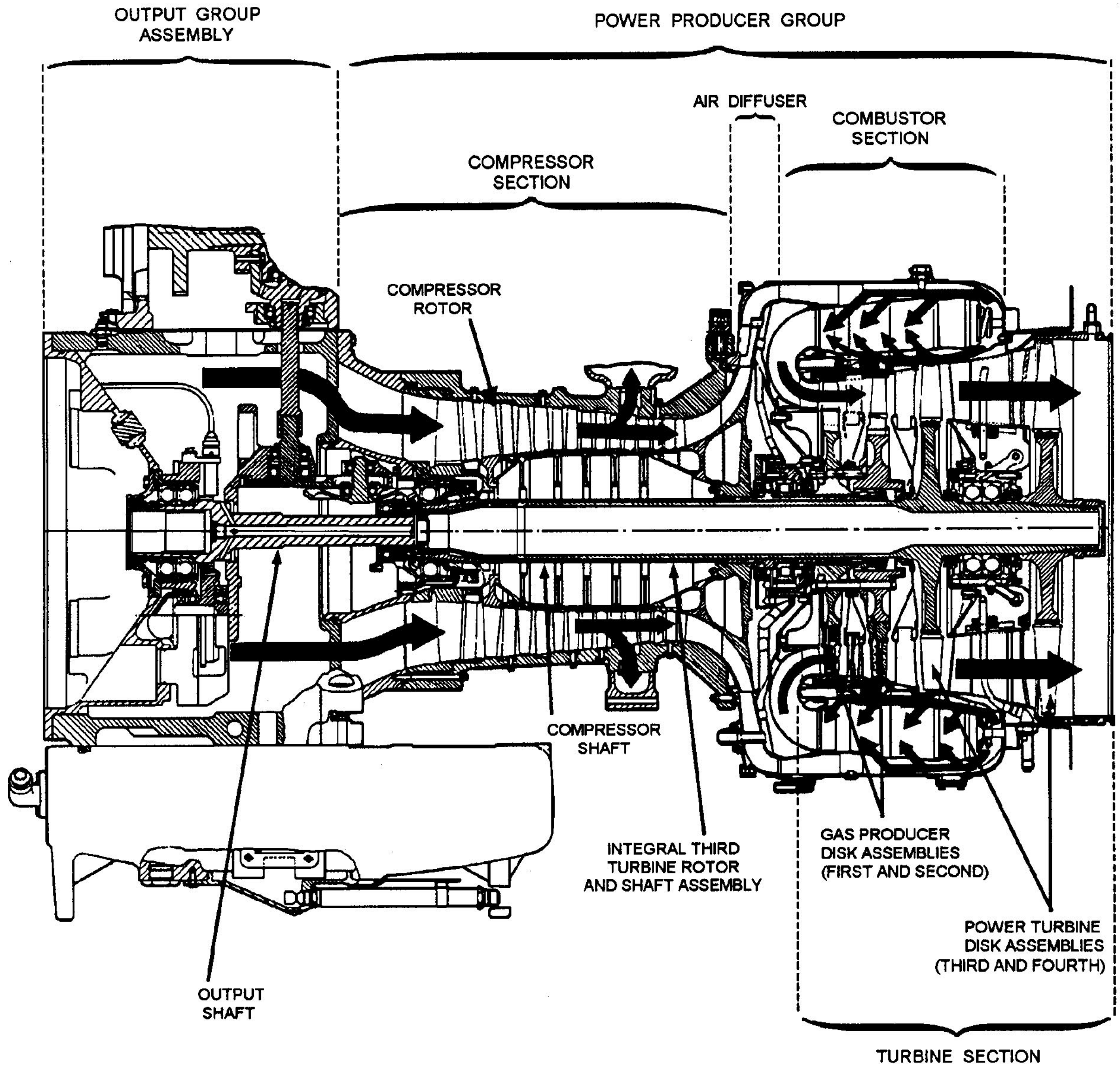


Figure 6-3.-Operation and primary airflow of TF40B gas turbine engine (LCAC).

Components and Assemblies

As you study figure 6-2, notice how the TF40B is basically composed of two major sections: (1) the output group assembly and (2) the power producer group. The power producer group includes the gas producer module and the combustor and the power turbine assembly. The output group assembly includes the accessory gearbox module, inlet housing module, and sump module. The power producer group provides a reverse annular flow path for air and hot gases. (See fig. 6-3.) The compressor rotor assembly is directly connected to the first and second gas producer disk assemblies. The fourth turbine rotor disk assembly is directly connected to the power turbine integral third turbine wheel disk shaft assembly. This assembly, which runs inside of the compressor shaft, is splined to the power output shaft assembly. The power output shaft assembly is located at the forward end of the engine. Its speed is equal to power turbine speed. Externally, the power output group assembly provides mounting pads for several accessories and components required for engine operation.

Notice how the two major sections of the TF40B are structurally interdependent. Working together as an operating unit, they provide an annular flow path for the air or hot gases, support internal rotating systems, and provide external attaching capabilities for components and accessories required for engine operation. An important advantage of this design is that it allows for the removal and installation of engine modules. This means you are able to make repairs and replace a variety of engine-related components without having to ship the complete engine to a depot repair facility.

Operation

Study figure 6-3 as you read about the operation of the TF40B. The compressor rotor assembly is turned by the air starting system as air enters the inlet housing module. The inlet air is directed into the compressor rotor assembly and is compressed. The compressed air then flows through the air diffuser assembly and into the atomizing combustor chamber assembly. When the engine reaches 2,246 rpm, the fuel valve assembly and fuel flow divider allow metered main fuel to flow to the 28 main fuel injection nozzles. The air mixes with fuel from the fuel injection nozzles to form a combustible mixture. Two igniter assemblies provide spark and ignite the mixture, creating the hot, expanding gases which are discharged through the turbine section. Some energy from the hot gases drives the two gas producer disk assemblies which, in turn, drive the compressor rotor assembly. The remaining energy from the hot gases drives the integral third turbine wheel shaft assembly and fourth turbine rotor disk assembly which, in turn, drive the power output shaft assembly.

Systems

The operation of the TF40B is supported by the following major systems:

1. Electrical control system
2. Ignition system
3. Engine gas temperature (EGT) system
4. Speed sensing system
5. Fuel system
6. Lubrication system
7. Electronic control system
8. Air system

In the following paragraphs, we will give you a brief overview of these systems. You will need to become familiar with the fundamental systems of this engine before you read about your general maintenance responsibilities. For detailed descriptions of these systems, you should consult the appropriate technical manuals.

ELECTRICAL CONTROL SYSTEM.– The electrical control system is energized by a separate 24- to 28-V dc ungrounded two-wire power source. The system consists of engine-mounted accessories and sensors, an electronic control system, and panel-mounted controls and indicators. AU engine harnesses are designed to withstand salt spray, sand, dust, fungi, vibrations, immersion during washdown and steam cleaning, and fuel and oil residues. The connector ends are molded for wiring integrity and suitable strain relief. The cable assemblies provide electrical continuity between the engine accessories and engine interfaces. All molded ends of the harness assemblies are stamped with their respective plug numbers, making it easier for you to locate and identify these assemblies in the appropriate engine electrical control system wiring schematic.

CAUTION

System ground is isolated and should not be connected to frame ground.

IGNITION SYSTEM.– The ignition system is used for start procedures only. It consists of a single-box, high-energy, capacitor-discharge ignition exciter that is used with two ignition leads and two shunted surface gap-type igniter assemblies.

Ignition Exciter.– The ignition exciter is designed to operate in ambient temperatures of -30° to 250°F (-34° to 121°C). It uses an input voltage of 16 to 30 V dc and will produce an output voltage of at least 2,400 V at the igniter assemblies. Its duty cycle is 2 minutes on, 3 minutes off, 2 minutes on, 23 minutes off.

Ignition Leads and Igniter Assemblies.– The ignition leads will operate in ambient air temperatures of –30° to 500°F (–34° to 260°C). Both the ignition leads and the igniter assemblies are designed to operate in a marine environment.

ENGINE GAS TEMPERATURE SYSTEM.– The EGT system works with the electronic control system to sense turbine speeds and provide monitoring information. First, the gas temperature is sensed by a chromel-alumel parallel thermocouple averaging arrangement. Then, it is biased by the air inlet temperature sensing device assembly and finally applied to the electronic control system for automatic monitoring purposes.

SPEED SENSING SYSTEM.– The gas producer (N_1) and power turbine (N_2) speeds are sensed by their magnetic pickups located nearby. The N_1 speed magnetic pickup is located on the rear face of the accessory gearbox module. The N_2 speed magnetic pickup is located inside the inlet housing. The pickup signals, fed to the electronic control system, provide visual speed readout signals along with engine control and governing functions.

FUEL SYSTEM.– The major function of the engine fuel system is to provide fuel to the atomizing combustor chamber assembly at a specific, regulated flow rate to ensure optimum engine performance at all stages of operation. The basic components of the fuel system are the fuel valve assembly (consisting of the fuel valve, limiter, and actuator), connecting hoses, main fuel and redundant valves, oil cooler assembly, high-pressure fuel filter, fuel flow divider, fuel return solenoid valve, fuel manifolds, and 28 fuel injection nozzles.

Filtered fuel flows from the fuel valve assembly. It then flows through the fuel solenoid valve, oil cooler assembly, and redundant fuel solenoid valve. Next, it flows into the fuel flow divider that provides primary and secondary fuel flow to the fuel injection nozzles, which deliver the fuel into the atomizing combustor chamber assembly.

A pressure-actuated combustion chamber drain valve assembly is mounted on the bottom perimeter of the atomizing combustor housing assembly. In the event of a shutdown, an aborted start, or engine flameout, this assembly automatically drains residual fuel from the combustion area. The fuel return solenoid valve automatically reduces fuel flow to reduce the EGT during the start sequence only if EGT rises to the warning offset set point.

NOTE: This can also be done manually during the start sequence or at any time during engine operation. The operator positions the START/STOP switch to the START position and holds it there.

The high-pressure fuel filter assembly consists of a throwaway 10-micron filter element and ahead and case assembly. The fuel filter has a rated flow of 12 gallons per minute.

The head assembly incorporates a stainless-steel bypass relief valve that opens at 45 to 55 psid and a differential pressure indicator that actuates a red pop-up button at 30 to 40 psid to indicate the filter is clogged. The pop-up indicator has a thermal lockout feature for temperatures from 20° to 50°F (–7° to 10°C) to prevent false indications in extremely cold conditions. If the pop-up indicator actuates, you must flush the filter case. You must also replace the filter when you reset the pop-up button.

LUBRICATION SYSTEM.– The TF40B lubrication system consists of the sump module, an accessory gearbox module driven lube and scavenge pump, an engine-mounted oil cooler assembly, the necessary piping, and a lube filter assembly. The lube and scavenge pump draws oil from the sump module and delivers it to the oil cooler assembly. The oil then flows from the oil cooler assembly into the oil inlet port where it surrounds the lube filter assembly, which contains a 7-micron element. The oil flows through the filter, up through the core, and out of the oil outlet port to the oil distribution block. From here, the oil flows into the accessory gearbox module and inlet housing module to lubricate the forward internal bearings and gears. If the 7-micron filter becomes clogged, the oil is bypassed. Located in the head assembly is a differential oil pressure switch, which actuates at 13 to 19 psid, and a bypass valve, which opens at 21 to 29 psid if the filter becomes clogged and can no longer function. The differential oil pressure switch will actuate just before bypass to illuminate an oil filter warning light on the instrument panel. This switch is mechanically locked until oil temperature reaches 115° to 155°F (46° to 68°C) to provide for warmup in cold weather conditions.

External piping in the lubrication system also supplies filtered oil to the power output shaft assembly and to the compressor and power turbine bearings. A scavenge oil pump mounted on the accessory gearbox is integral to the lube and scavenge pump. The scavenge oil pump provides positive drainage of the No. 4 and No. 5 bearing scavenge oil through external oil hose assemblies and the lube monitor assembly to the top of the inlet housing module. An external oil hose assembly provides gravity drainage of the No. 2 bearing scavenge oil from the combustor and power turbine assembly to the sump module. The scavenge oil drains internally by gravity from all the other components through the accessory gearbox module, inlet housing module, and compressor housing to the sump module. Electronic chip indicators in the No. 4 and No. 5 bearing oil scavenge lines and in the sump module initiate warnings in case of metallic chip accumulation in the lubricating oil.

ELECTRONIC CONTROL SYSTEM.– The TF40B electronic control system provides for automatic start and power control and monitoring of engine operations. It also sequences automatic shutdown of the engine.

The electronic control system consists of a modular control box assembly, instrument and control panel, the associated wiring and cabling, and sensing and

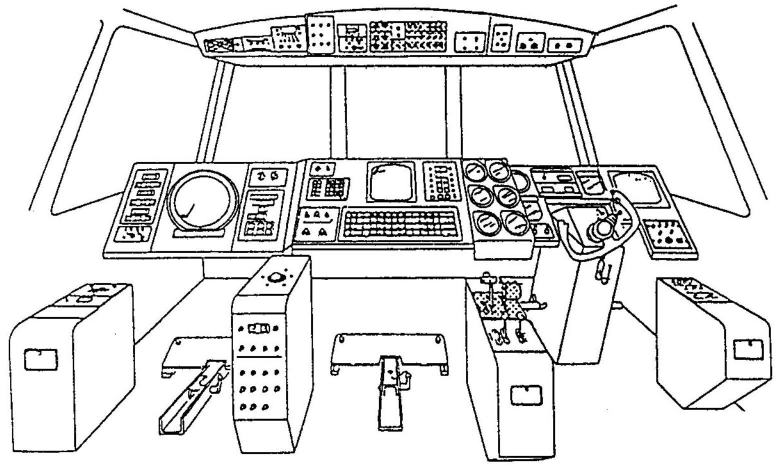


Figure 6-4.-LCAC operator station command module.

indicating devices for engine pressure, temperature, and speed. Visual indications of engine sequencing, EGT, speed, and lubrication conditions are provided on the command station instrument and control panel and on the modular control box assembly modules.

The modular control box assembly is a solid-state modular unit encased in a splashproof enclosure. This assembly contains the system power supply, temperature monitor, GP speed monitor, PT speed monitor, engine sequence, malfunction monitor, fuel control, isolation analog, and utility panel modules.

During the start cycle, a maximum current drain of approximately 10 amperes at 24 V dc is required. This current requirement is reduced to approximately 6 amperes after the start sequence is completed.

AIR SYSTEM.– We will discuss the TF40B air system in terms of its major sections and general functions.

Air Starter System.– The starter is mounted on a pad on the accessory gearbox module in the power output section. Air enters the inlet housing module through ports on each side of the inlet housing assembly. The inlet air is then powered by 37 to 46 psi through the air start valve and directed to the compressor rotor assembly where it is compressed. The compressed air then flows through the air diffuser assembly and into the combustion chamber. After the engine has started, a control switch terminates starter operation. For a more detailed discussion of these components, refer to the specific technical manual for this system.

Air Bleed System.– The air bleed system consists of an air bleed valve assembly that is located on the air bleed manifold housing. The air bleed manifold housing is located on the combustor housing assembly. The air bleed valve is spring loaded. It is modulated by P_4 air from the combustor. The function of the air bleed system is to provide a margin for compressor surge. This function protects the engine while it is accelerating to maximum power. The air is vented overboard through ports in a screened flange in the assembly.

LCAC CONTROL SYSTEMS

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. AVCO 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 6-4 shows the physical arrangement of a typical LCAC

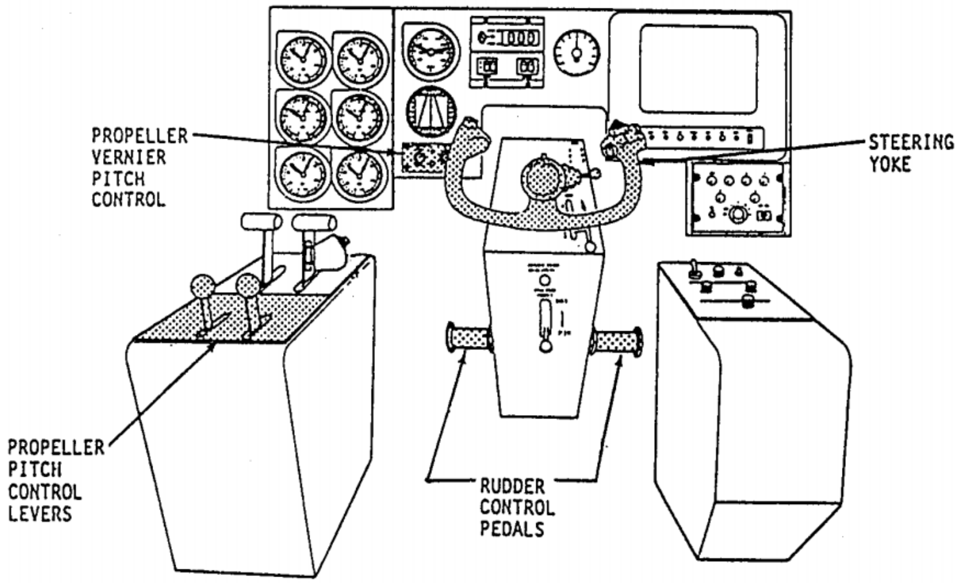


Figure 6-5.-Steering control station.

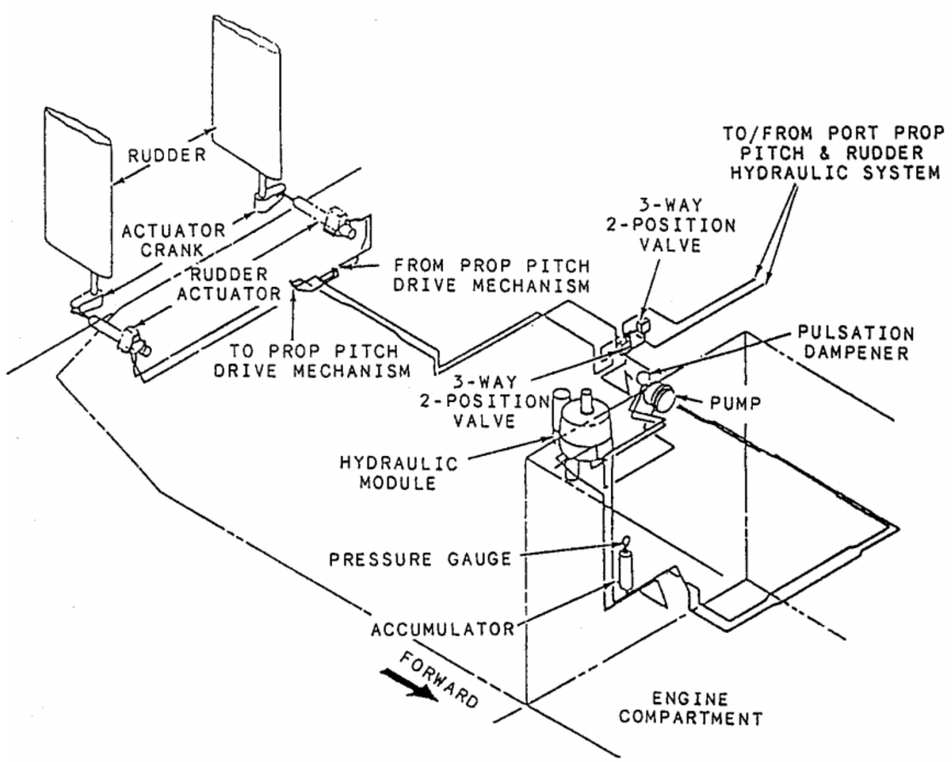


Figure 6-6.-Physical arrangement of the rudder control system.

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 these control systems, we will discuss the electrical system that provides the electrical power for these units.

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

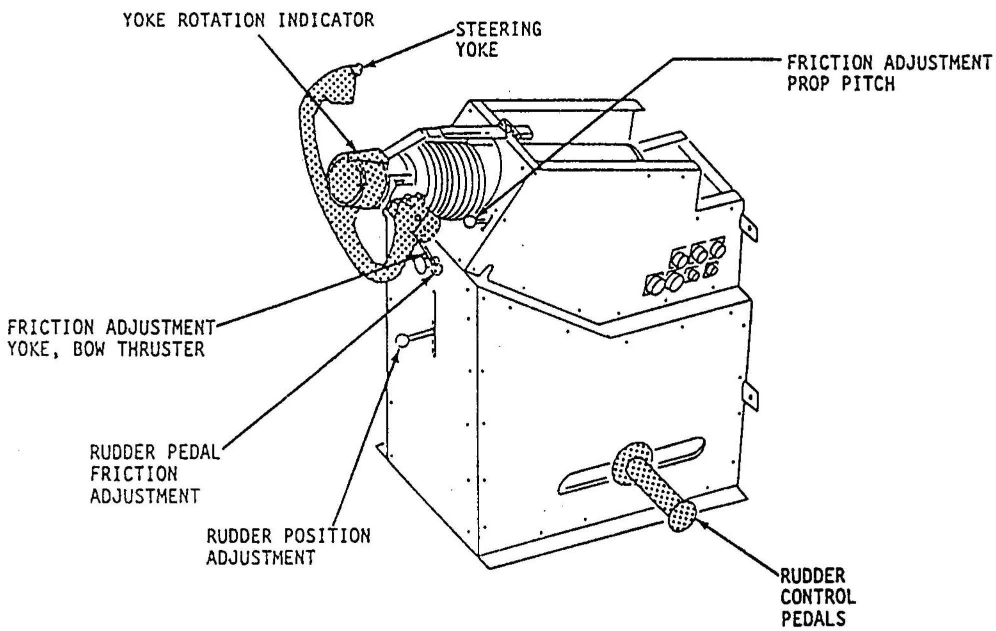


Figure 6-7.-Rudder pedals.

thruster control system and the associated operational controls, as shown in the shaded areas of figure 6-5. 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 6-6 shows the basic configuration of the rudder control system. (Study and compare figs. 6-1 and 6-6.) Study figure 6-6 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 6-5 shows the location of the rudder control pedals at the steering control station. Figure 6-7 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. 6-5 and 6-7.) 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

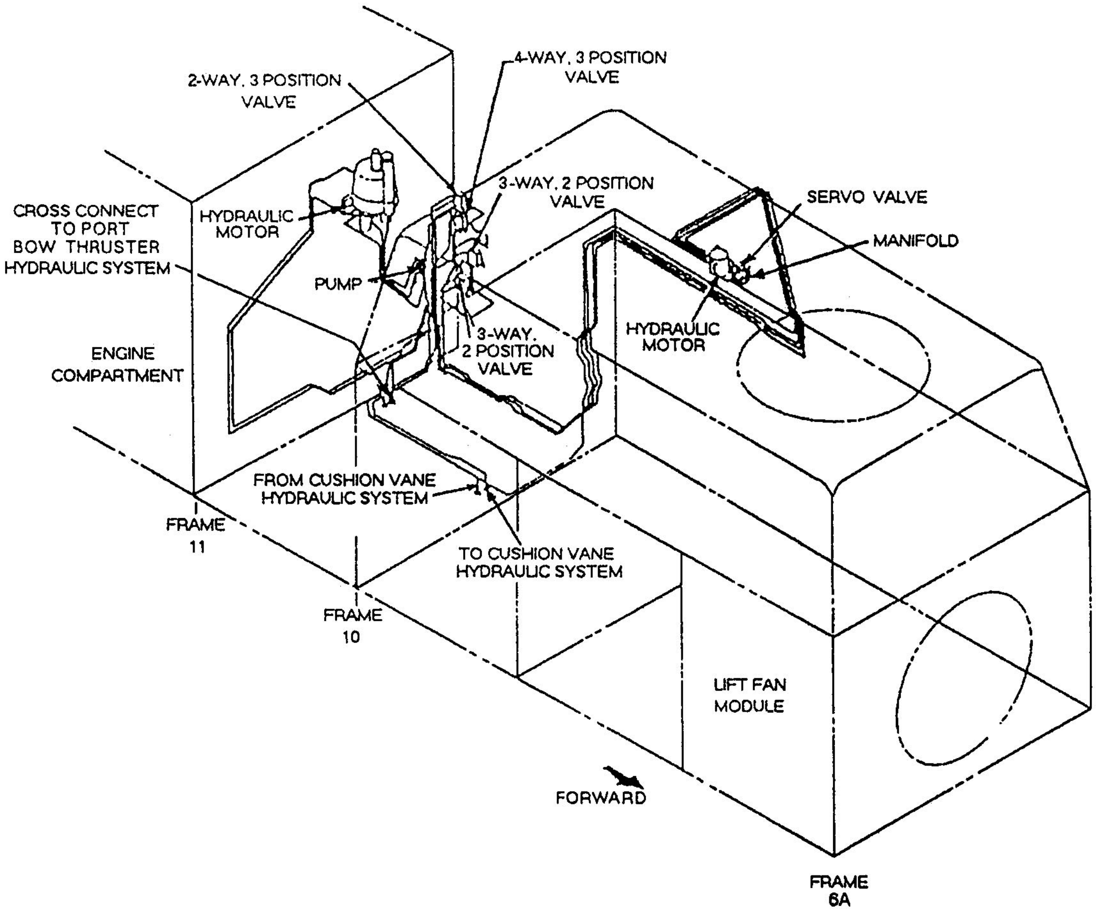


Figure 6-8.-Physical arrangement of the LCAC bow thruster control system.

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 servomotor, and feedback potentiometer. The CSEP sends an electrical drive signal to the electric drive servomotor 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 arc mounted vertically across the trailing edge of each propeller shroud. The rudder blades are broad, flat, aerodynamic, movable devices that measure 10.4 feet 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 channel 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

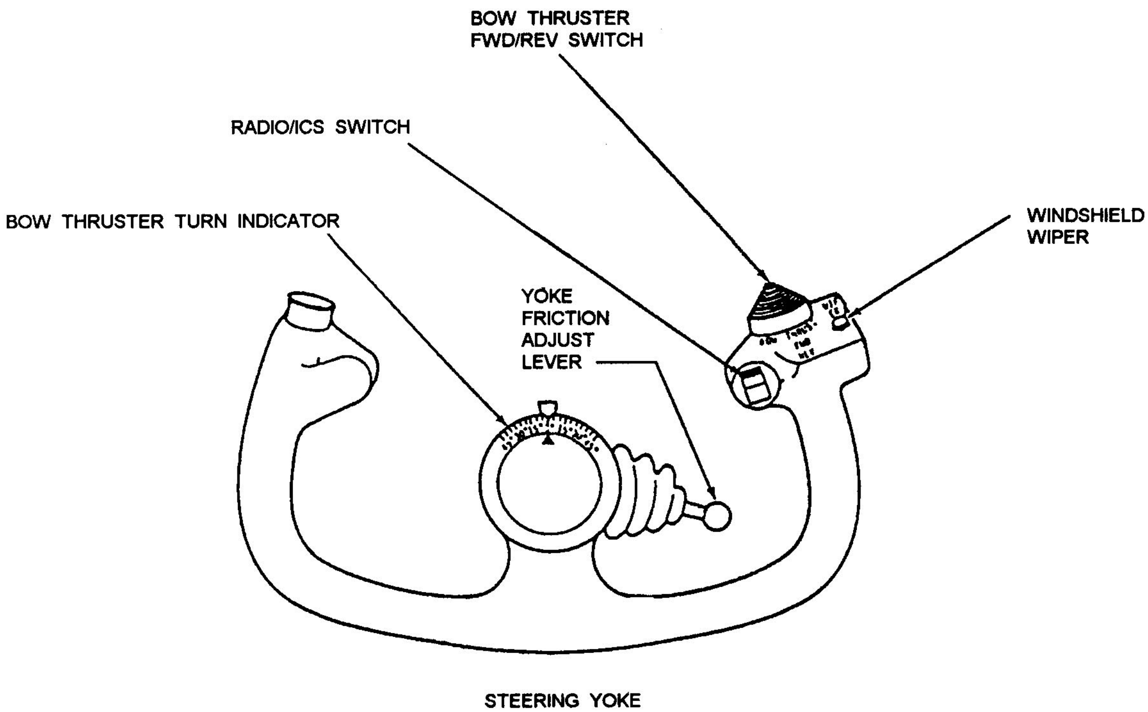


Figure 6-9.-Steering yoke and controls.

and assembly port and one The bow thruster control system consists of two bow thrusters (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 6-8. 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 craft 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 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 6-5. The components and controls of the steering yoke are shown in greater detail in figure 6-9. 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. 6-9) 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.

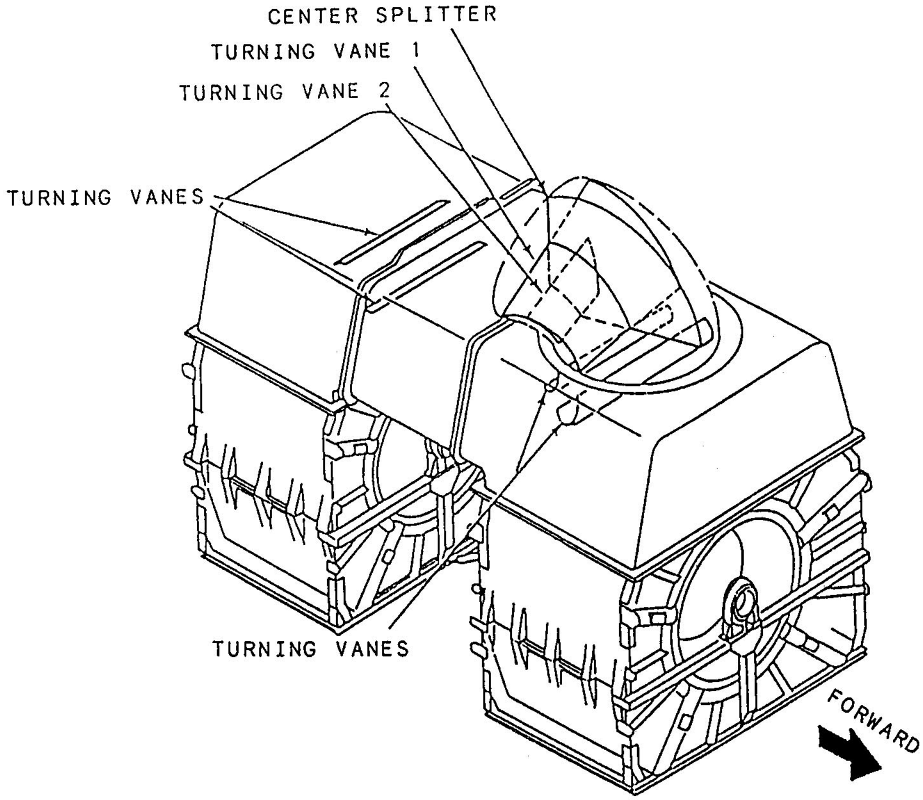


Figure 6-10.-Bow thruster turning vanes.

BOW THRUSTER TURNING VANES.– The purpose of the turning vanes is to direct airflow toward and out of the bow thrusters. Figure 6-10 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 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 6-5 shows the physical location of the propeller pitch controls in the operator station. Let's talk shout some of these controls and how they work.

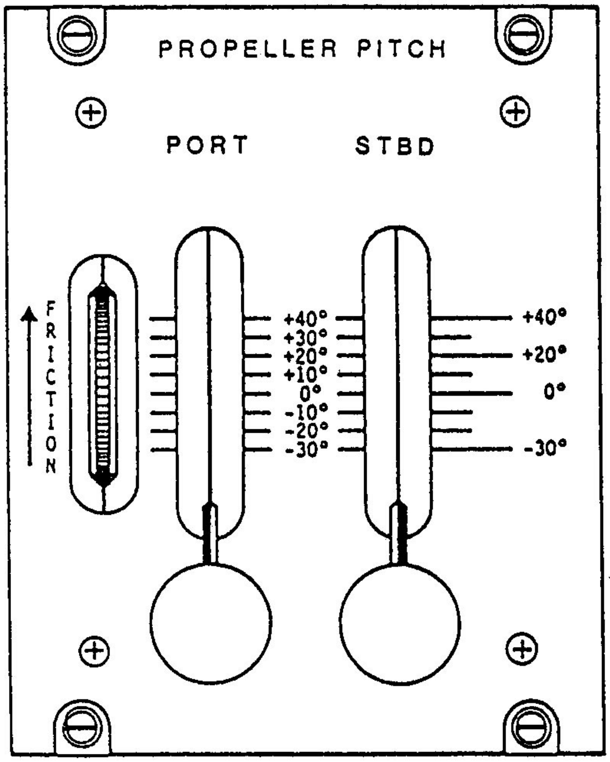


Figure 6-11.-Propeller pitch control levers.

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 6-11 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°.

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.

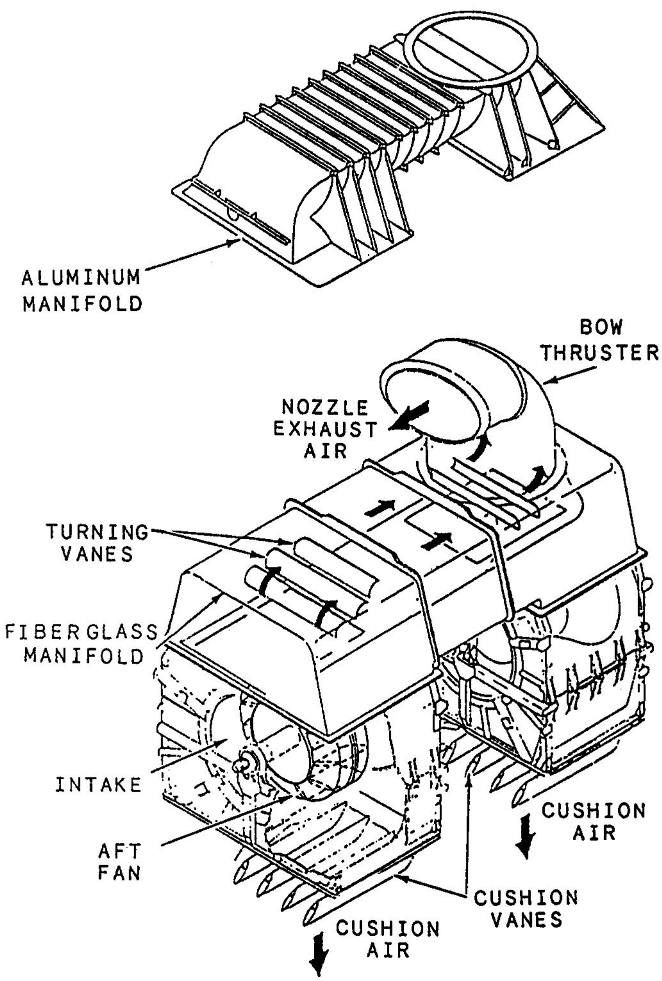


Figure 6-12.—Lift fans and cushion vanes assembly.

The structure of the lift fans and associated vane cushion assembly is shown in figure 6-12. 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 are driven by the TF40B gas turbine engines through right-angle gearboxes, as illustrated in figure 6-13. 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. 6-14.) 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 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

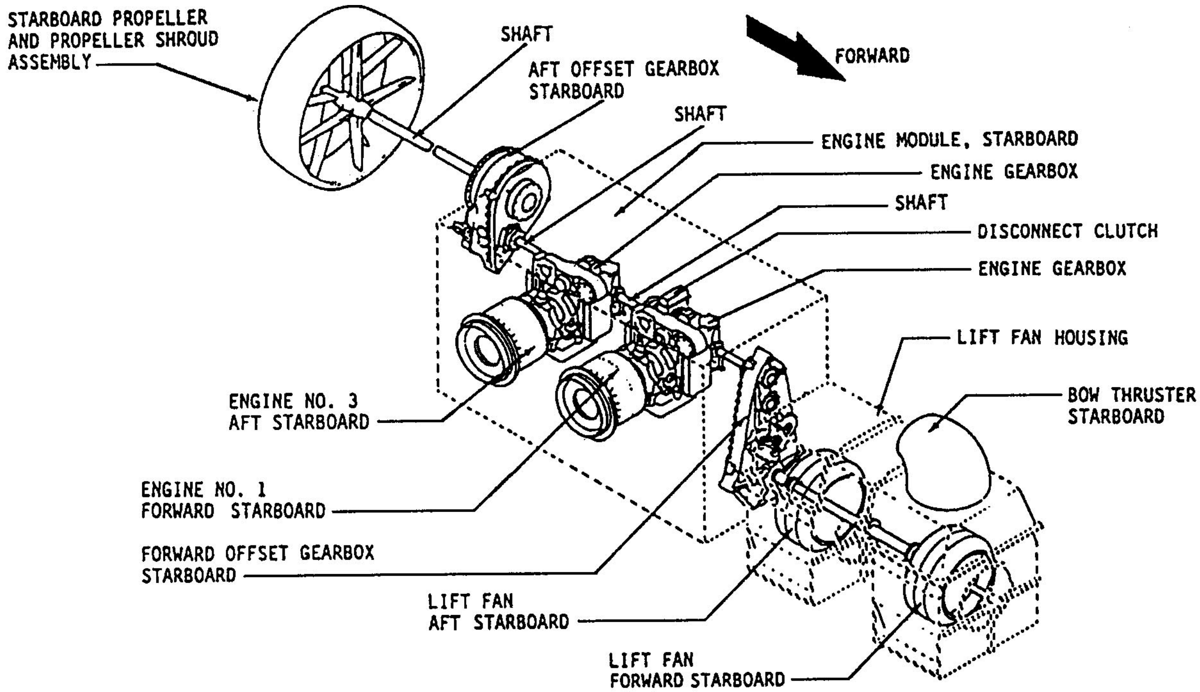
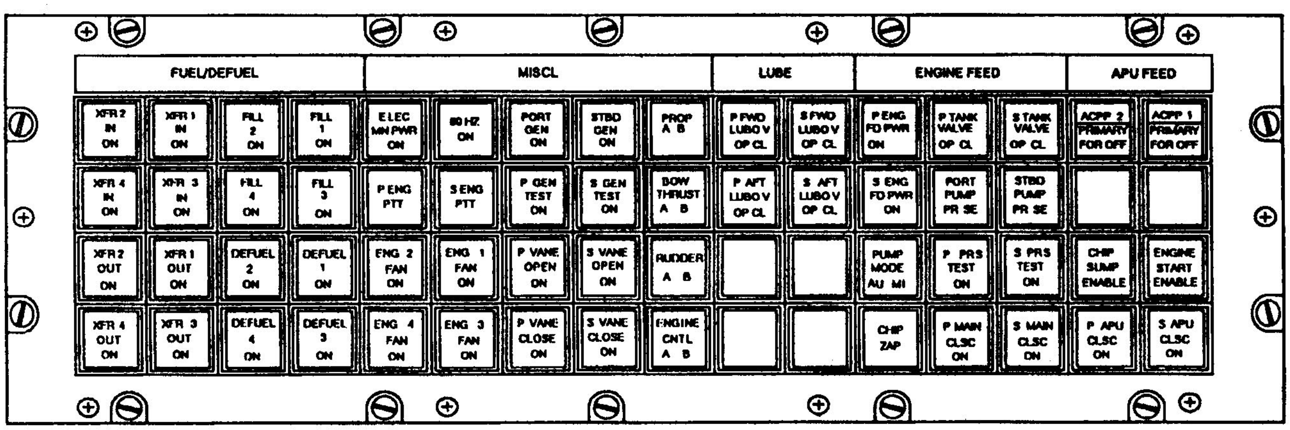
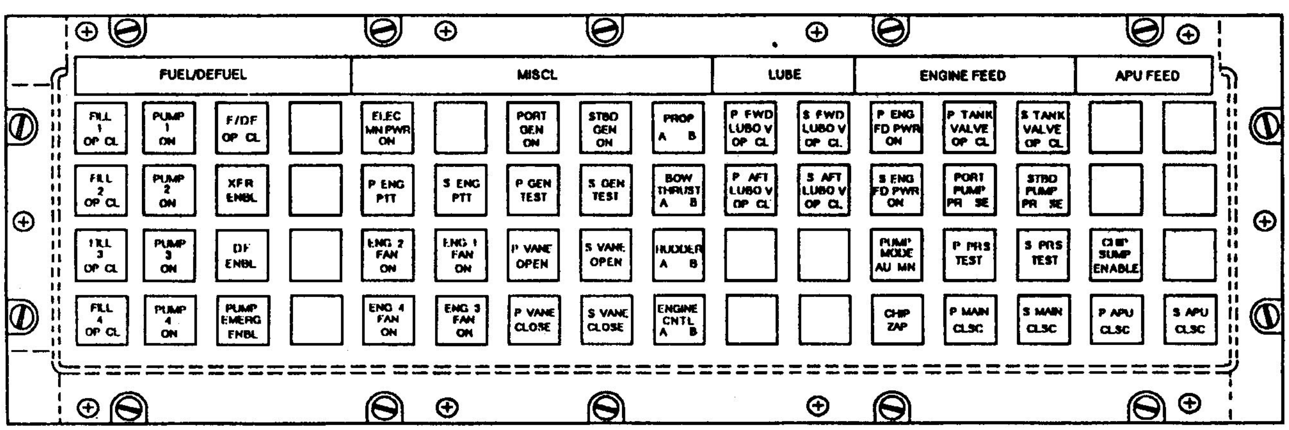


Figure 6-13.-TF40B propulsion and drive system arrangement.



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 6-14.-Command and control (C&C) keyboard.

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.

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. N1
2. N2
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 dc 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 Turbine Engines

As stated earlier, the four direct-drive, high-speed TF40B gas turbine engines are located in pairs on the port and starboard sides of the craft. The two-engine assembly for each side of the craft consists of a 2-stage, free-power turbine and a combination axial/centrifugal compressor driven by a two-step, axial-flow turbine. (Compare figs. 6-1 and 6-13.) 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 pwer 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. his 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 functional 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 6-14, 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 functional 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 6-14 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.

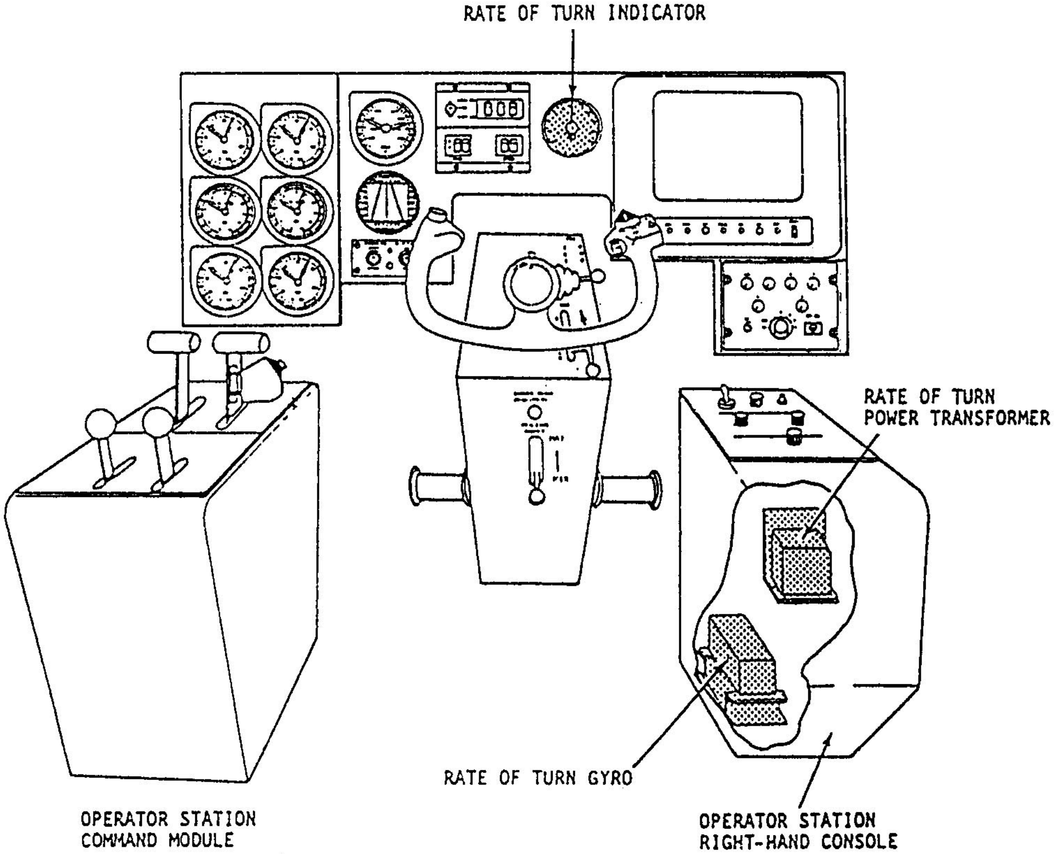


Figure 6-15.-Rate of turn gyro system.

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 CHIPZAP 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 6-15. 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 directional 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 6-16.

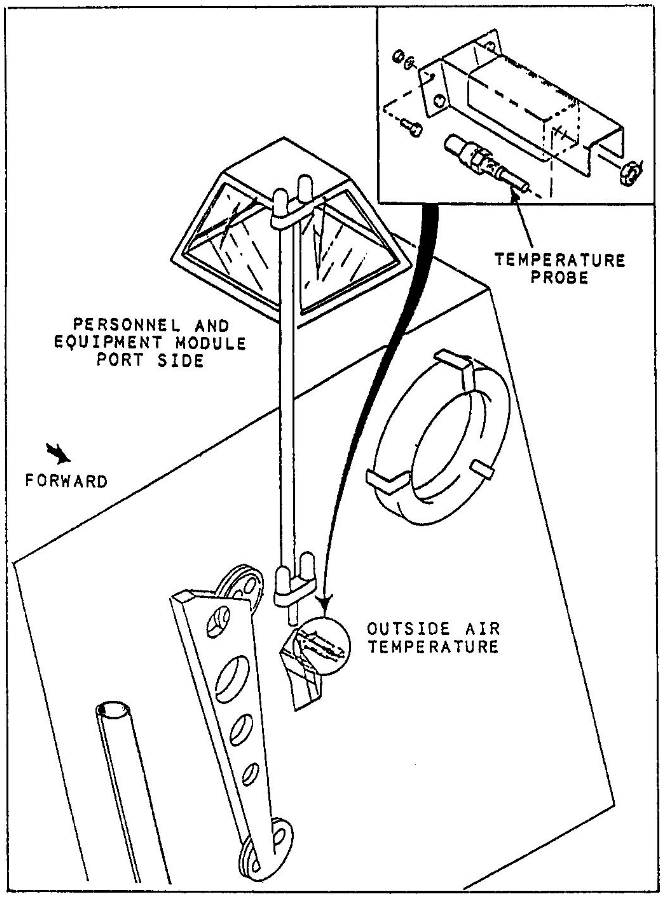


Figure 6-16.—Outside air temperature probe installation.

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 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. 6-17.) 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.

LCAC ELECTRICAL SYSTEM

In this chapter, we will give you an overview of the LCAC's electrical system. In chapter 7, we will discuss the electric plant in greater detail.

The electrical power generation for the LCAC provides alternating and direct current requirements for power and lighting loads on the craft. The APU system, generator set, and its associated auxiliary control equipment are responsible for the generation of 120/208-V ac, 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 from 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

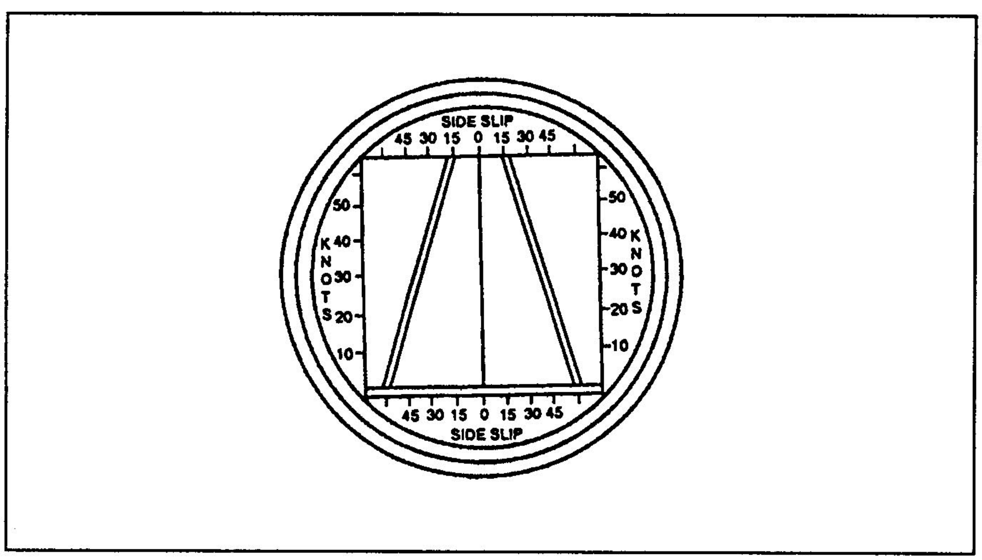


Figure 6-17.—Operator station sideslip indicator.

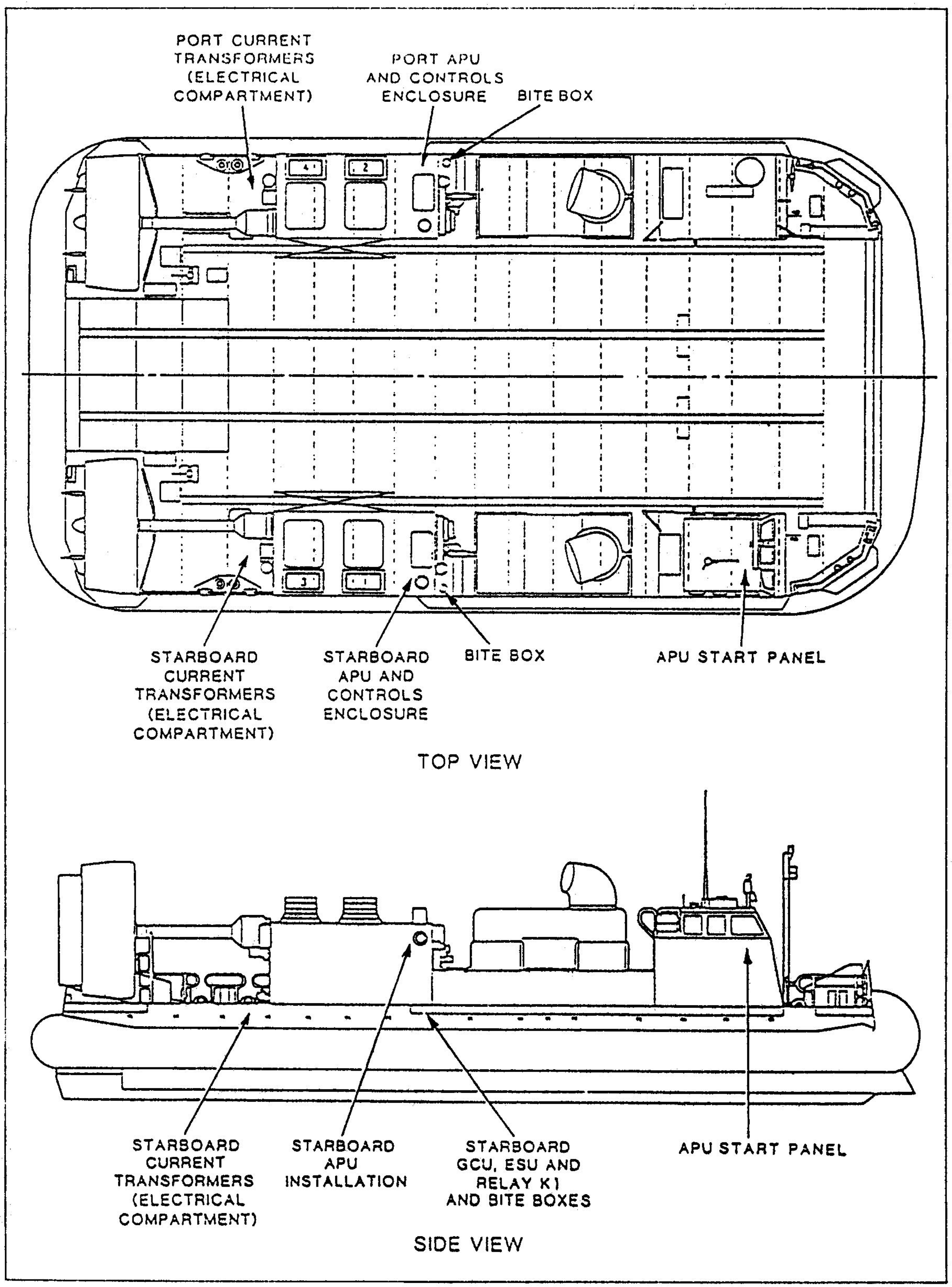


Figure 6-18.—Auxiliary power unit (APU) locations.

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 6-18, 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 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 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 aft 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.

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 filter, a filter 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, a start-fuel nozzle, a 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 over-frequency 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 from 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 on line 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 normal] y 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.

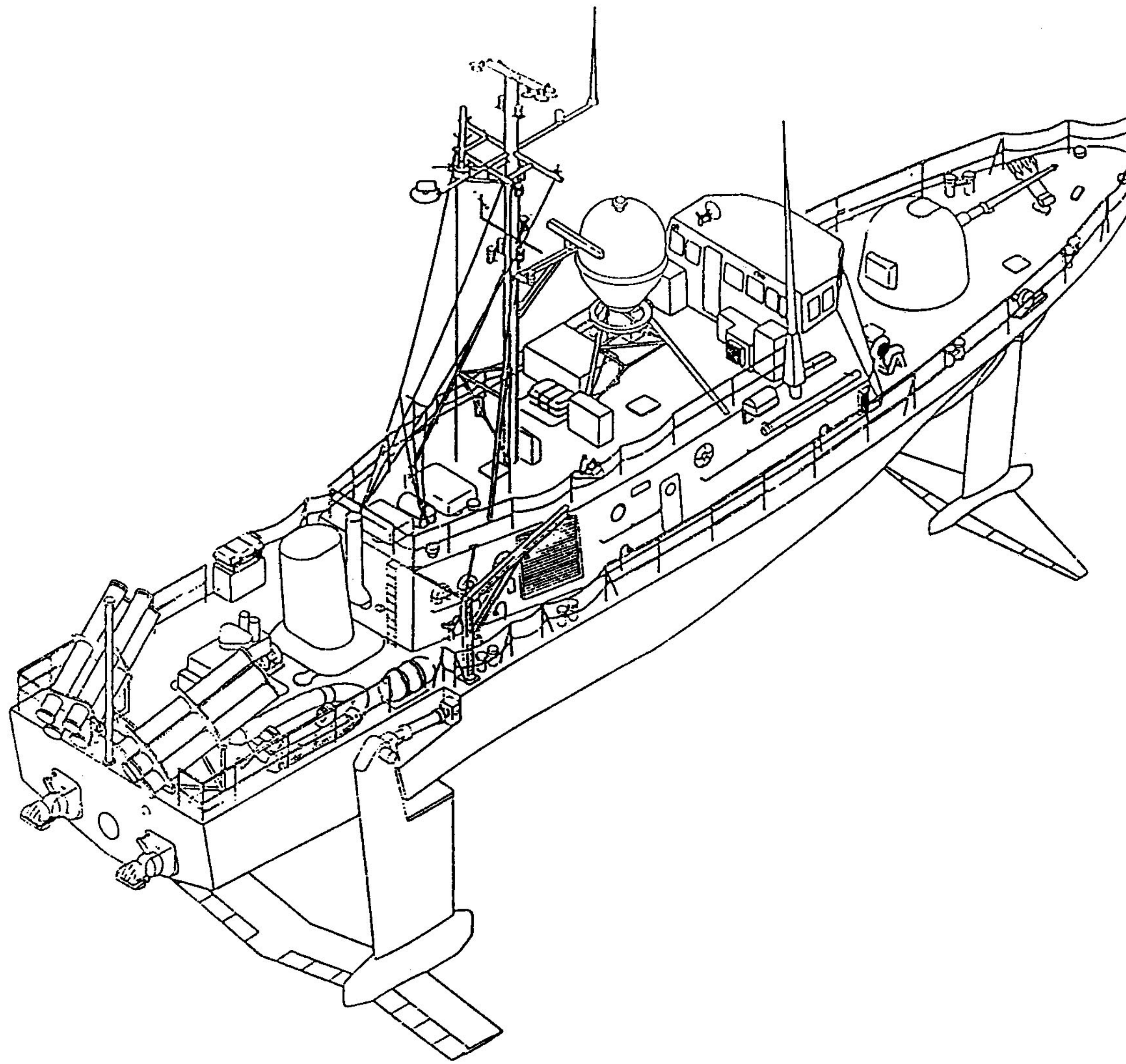


Figure 6-19.–Patrol combatant missile (hydrofoil) (PHM).

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 connect, 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 6-19. 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 a 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)
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 foil borne system and (2) the

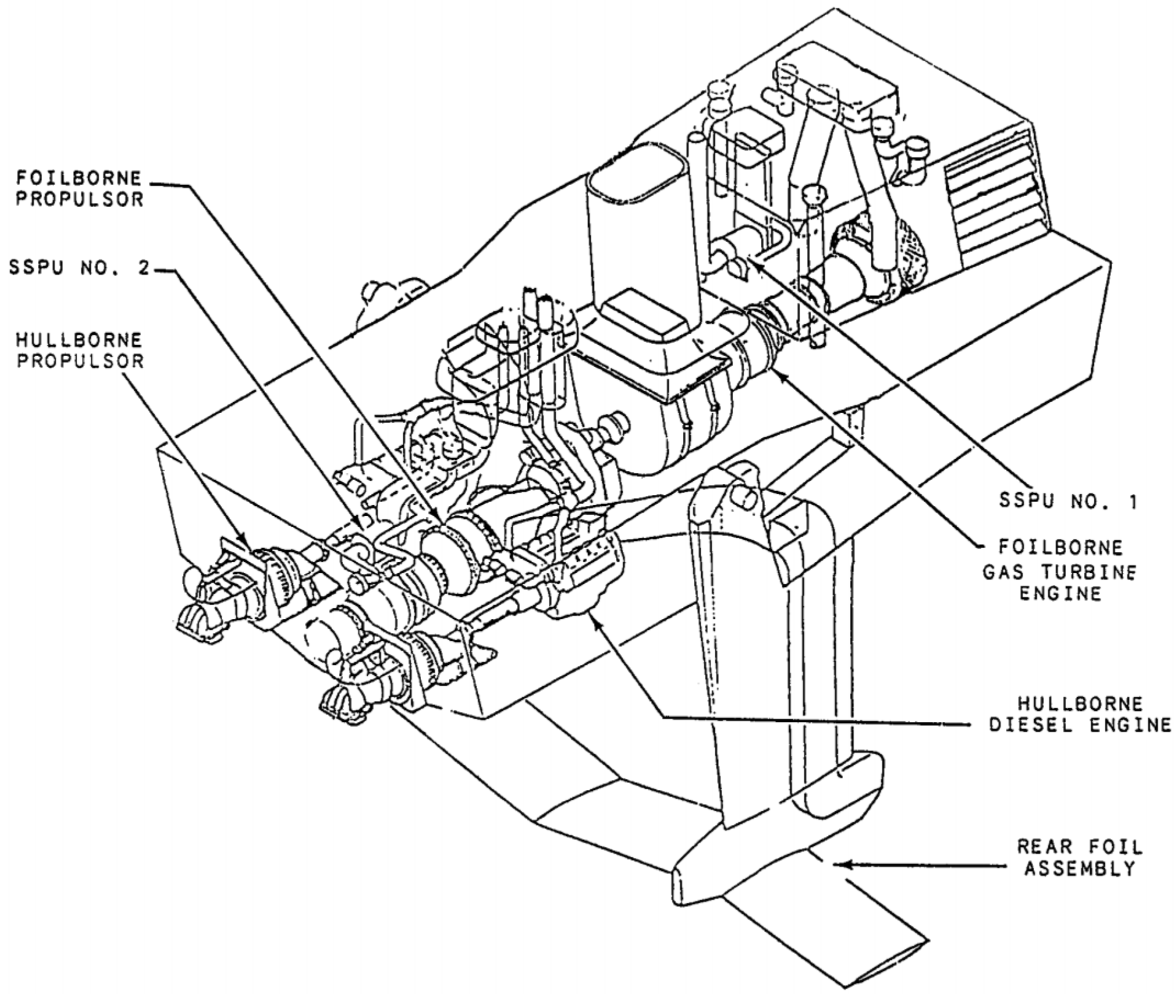


Figure 6-20.—Main machinery arrangement for foilborne and hullborne propulsion systems.

hullborne system. As its name implies, the foilborne propulsion system propels the ship in the foilborne mock 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 6-20.

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. 6-20.) 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.

FOILBORNE PROPULSION SYSTEM

The foil borne propulsion system provides the PHM with speed and stability. The basic components of the foilborne propulsion system are shown in figure 6-21. The foilborne power plant supplies the thrust required for takeoff and foilborne operations. Foilborne propulsion is created by a 2-stage water jet pump powered by a gas turbine engine. The propulsion thrust

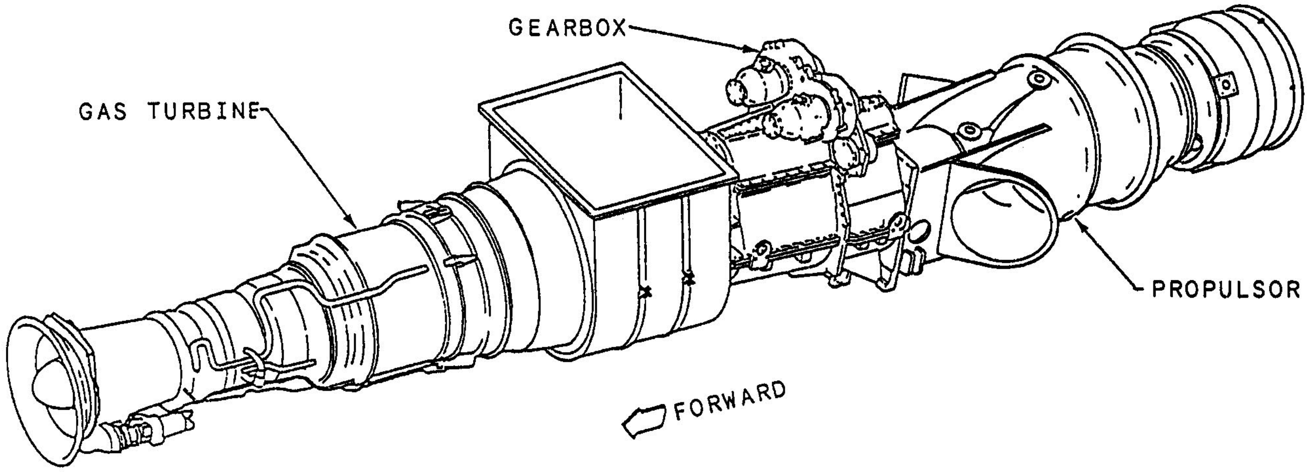


Figure 6-21.-Foilborne propulsion system.

occurs as seawater is pumped through the water jets and expelled through a nozzle at the stem. 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-shaft 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 furnish 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 filters, 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 normal] y 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 2-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. 6-20 and 6-21.) The first 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.

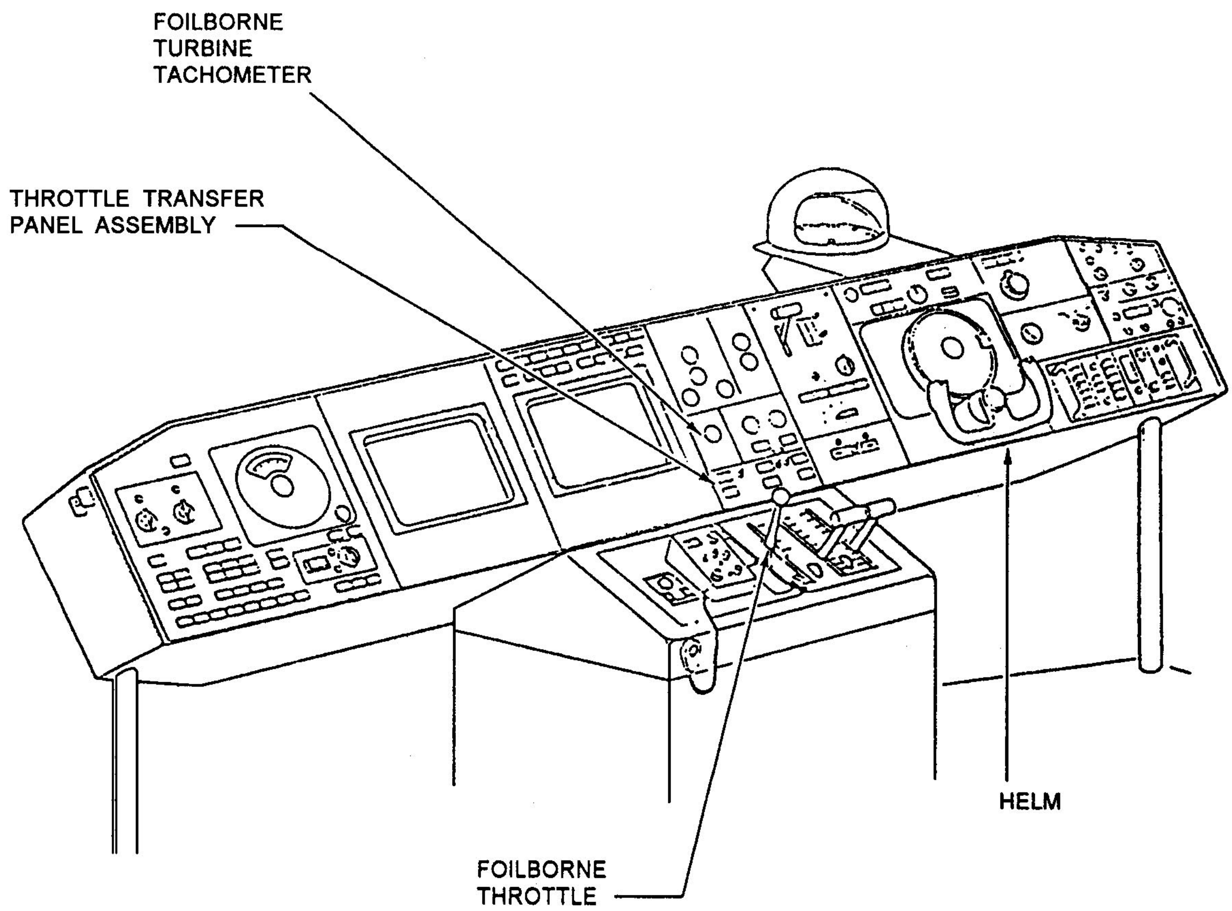


Figure 6-22.-FBCS controls at the pilothouse control console,

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 6-22, 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.

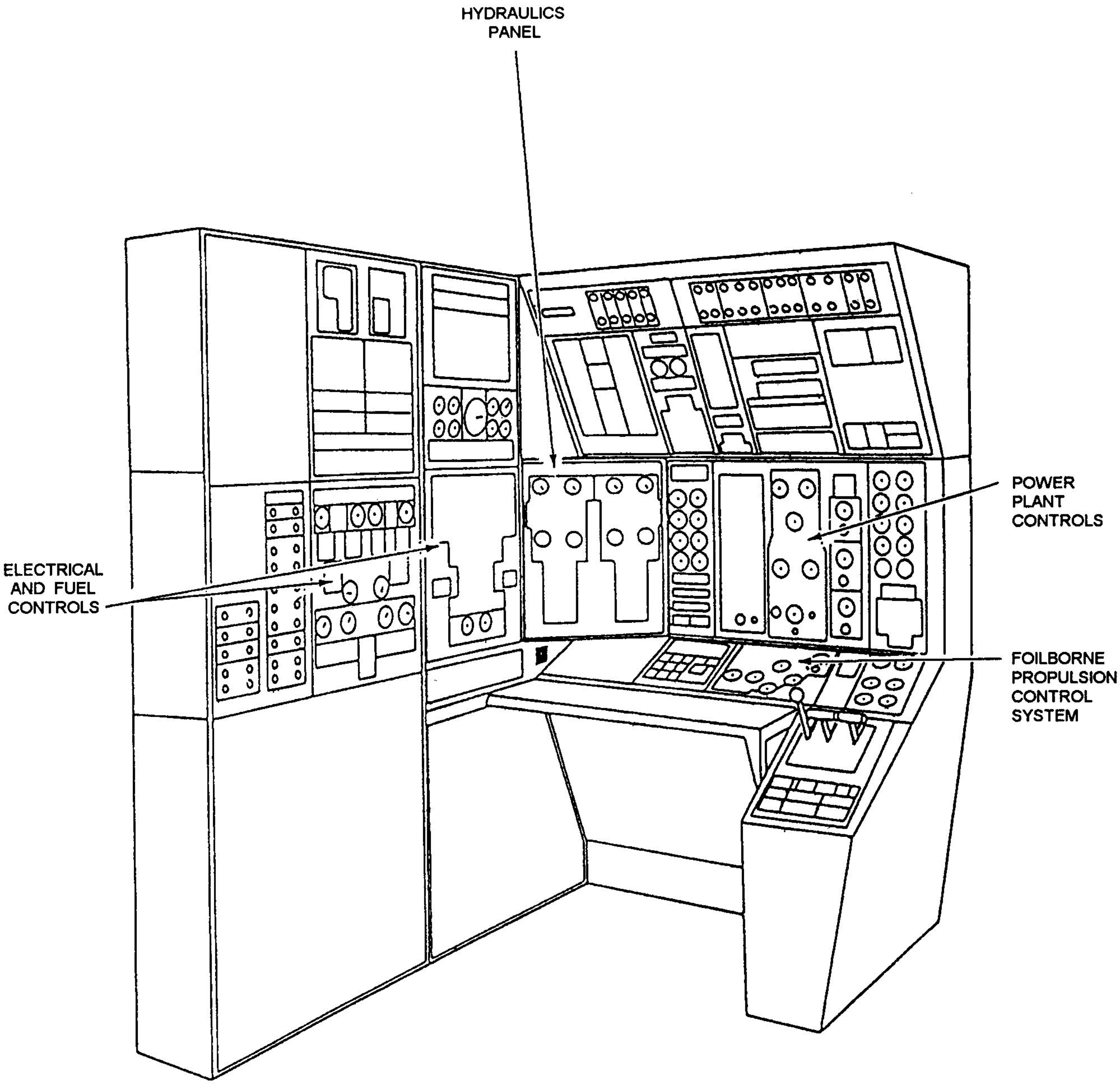


Figure 6-23.-Engineer operating station (EOS) showing panel arrangement.

The EOS control panel arrangement is shown in on the fuel, electrical, hydraulic, seawater, freshwater, figure 6-23. 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 control panel is shown in figure 6-24. 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 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.

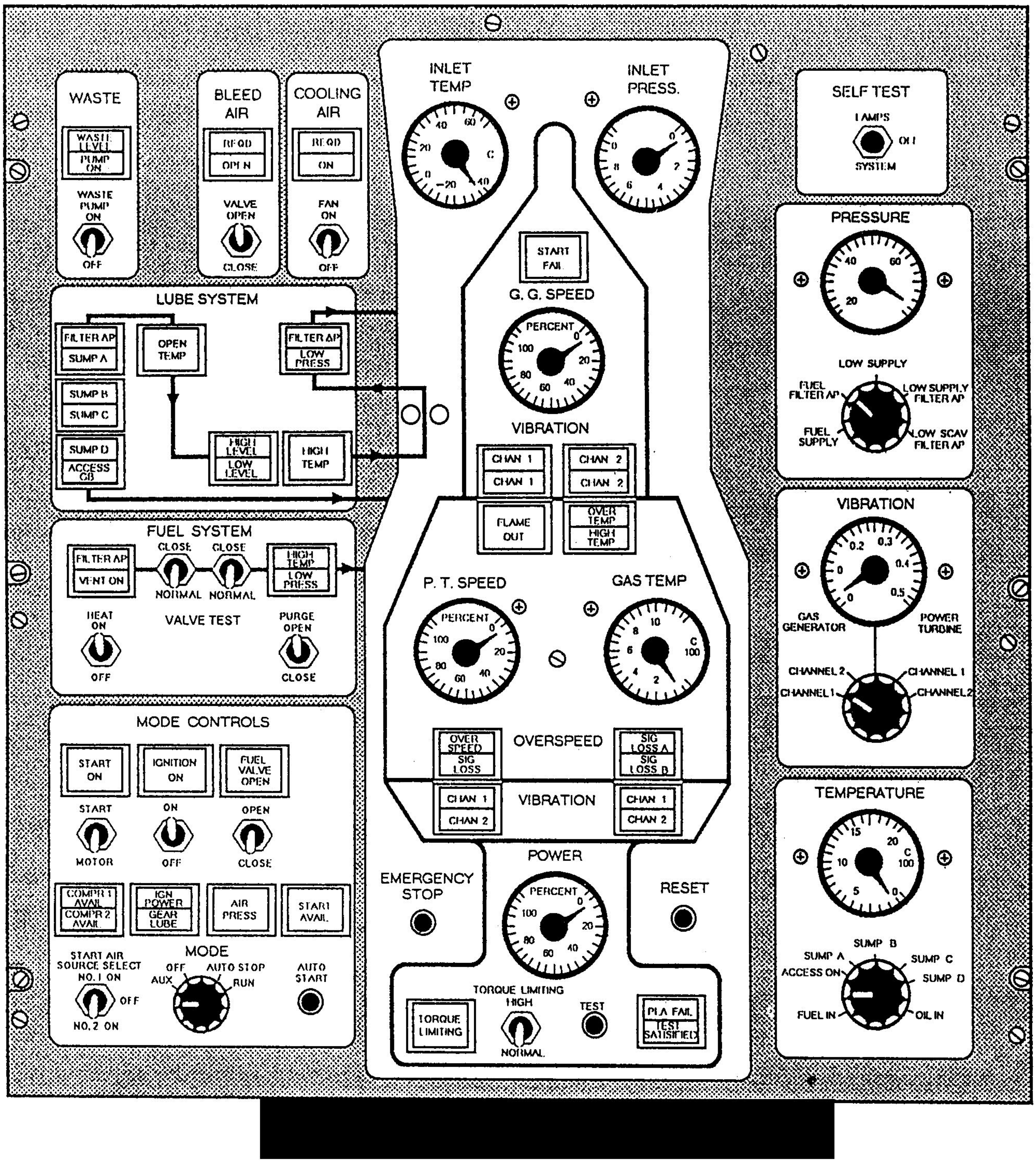


Figure 6-24.—Foilborne engine control system (FECS) panel at the EOS.

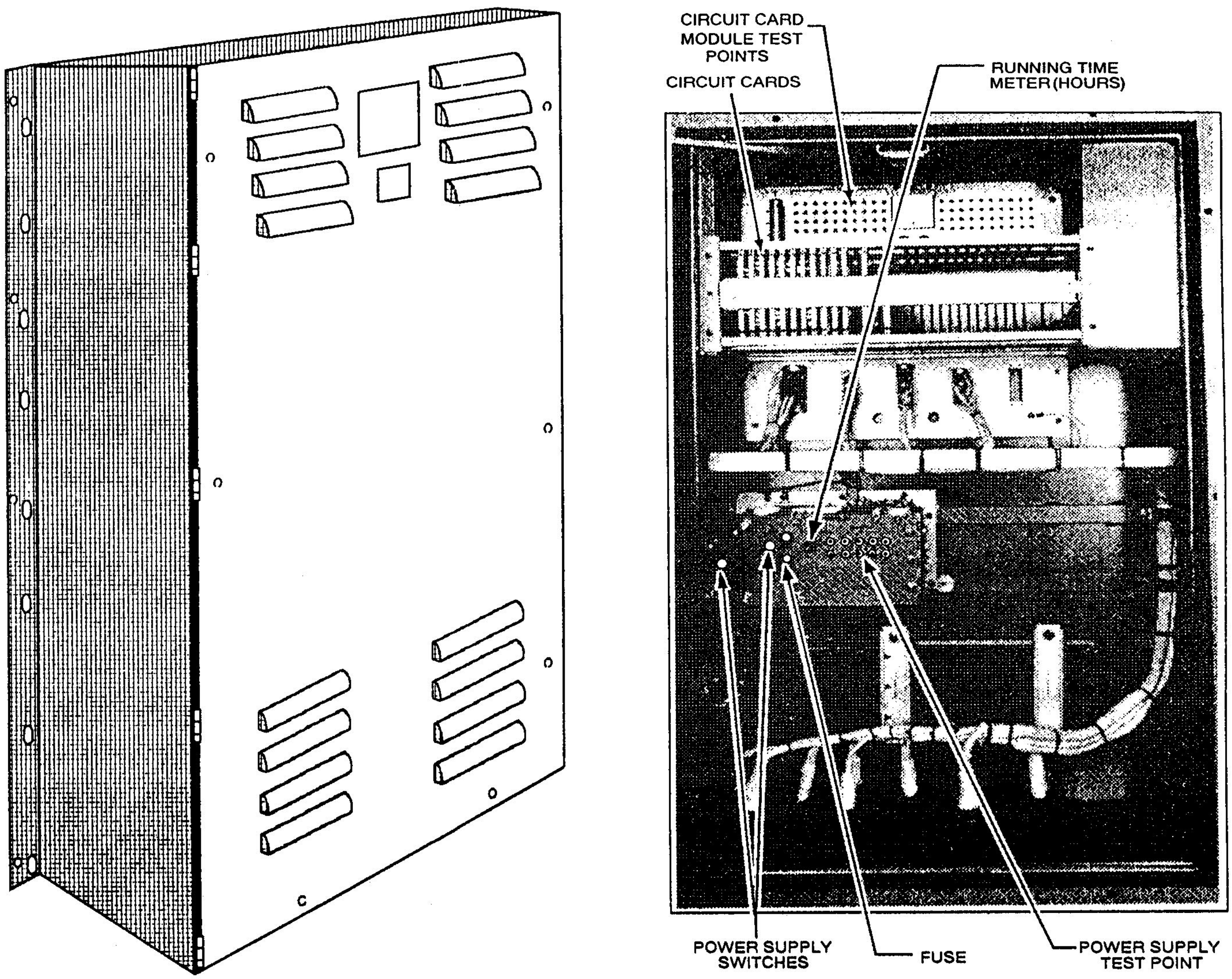


Figure 6-25.-Bulkhead-mount & electronics enclosure (BMEE).

Bulkhead-Mounted Electronics Enclosure

The BMEE is located in the EOS. The exterior and interior views of this unit are shown if figure 6-25. The BMEE contains the following gas turbine electronics that interface with the propulsion control system:

1. Power lever angle (PLA) actuator electronics
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 y 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 6-26, 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 primary to backup power when a loss of primary power occurs.

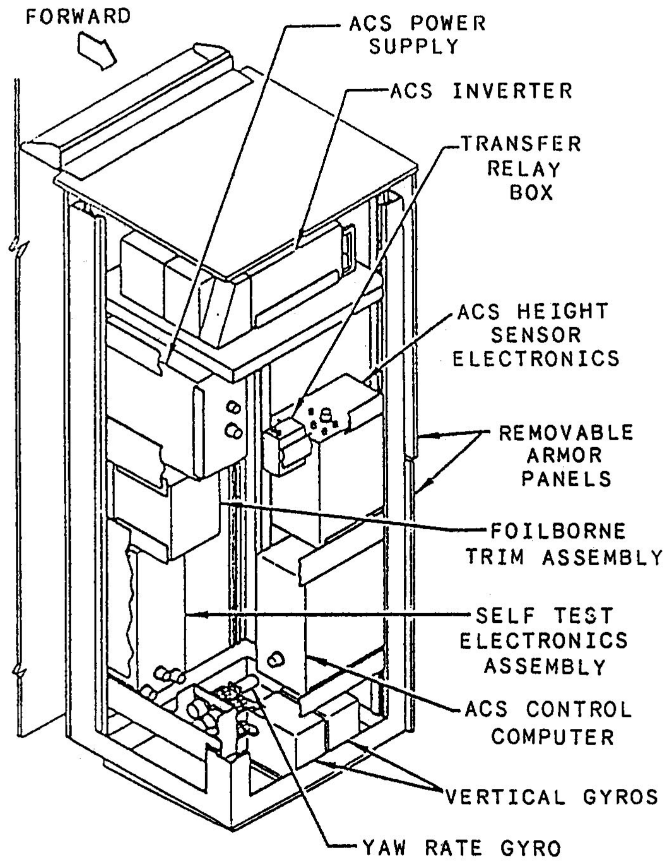


Figure 6-26.-Ship control electronics installation showing ACS.

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

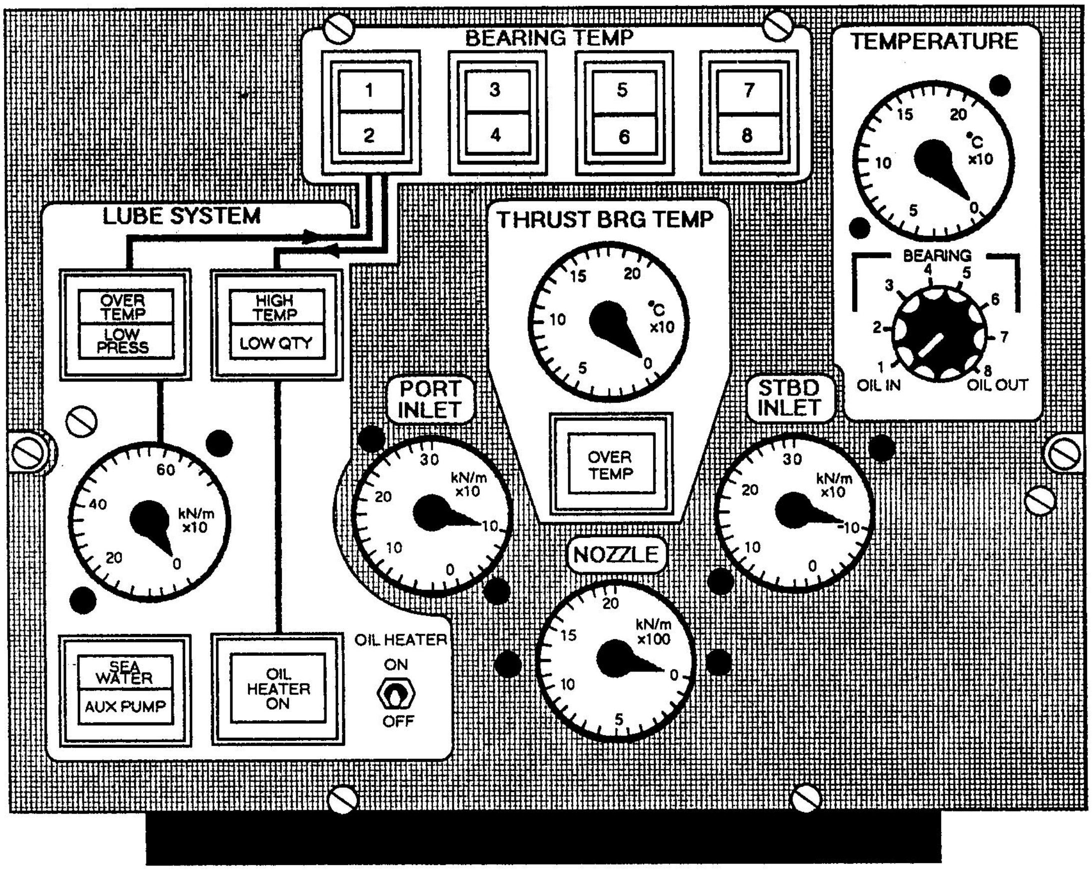


Figure 6-27.-Foilborne propulsor control system (FITS) panel.

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 6-24 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 6-27. 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.

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, foil borne 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 microfuses for that specific power in the ACS power supply will be blown. his 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.

HULLBORNE PROPULSION 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.

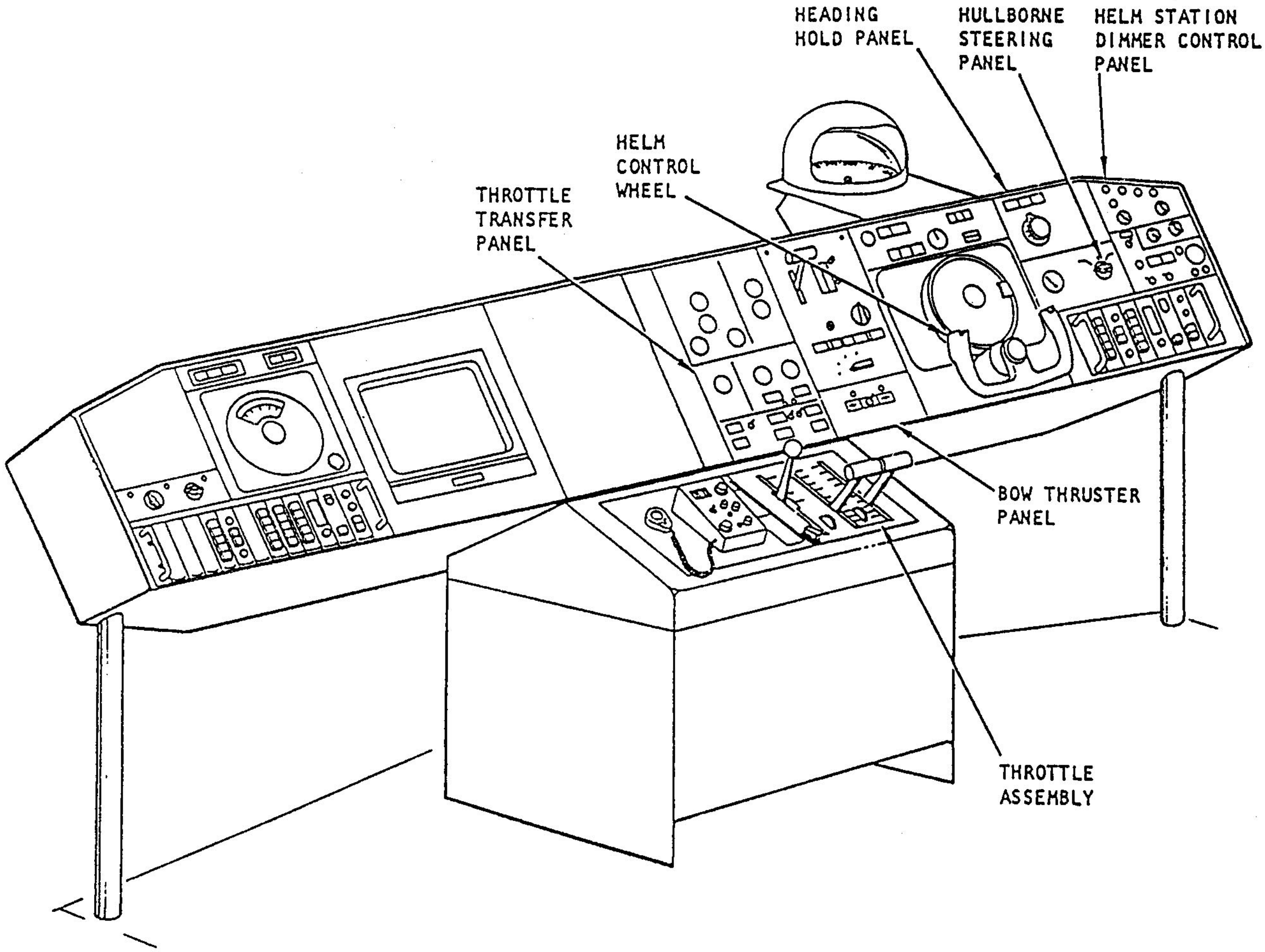


Figure 6-28.-HBCS controls at the pilothouse control console.

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 stern. 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.

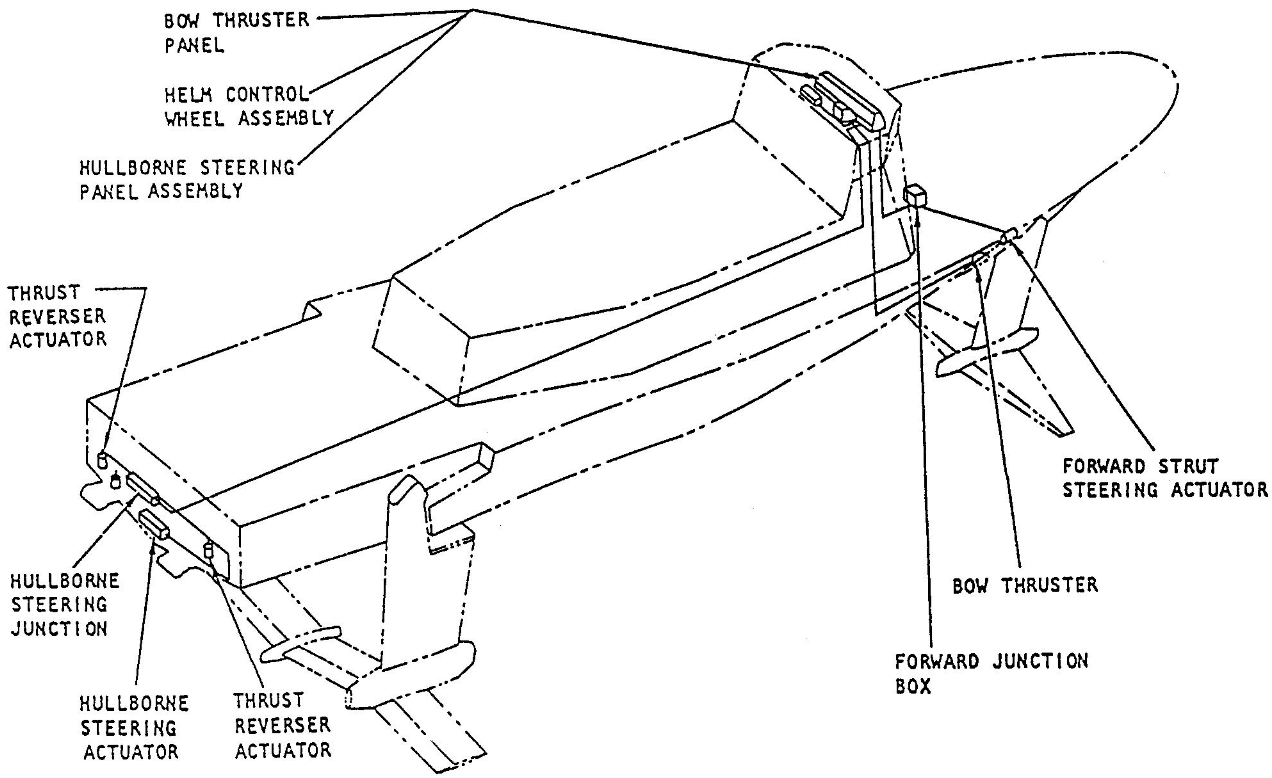


Figure 6-29.-Hullborne steering system equipment.

Now that you have read about the main components of the hull borne 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 (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 6-28 and 6-29. 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 6-29.

Primary steering control is provided by a hydraulic actuator that vectors the hull borne 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.

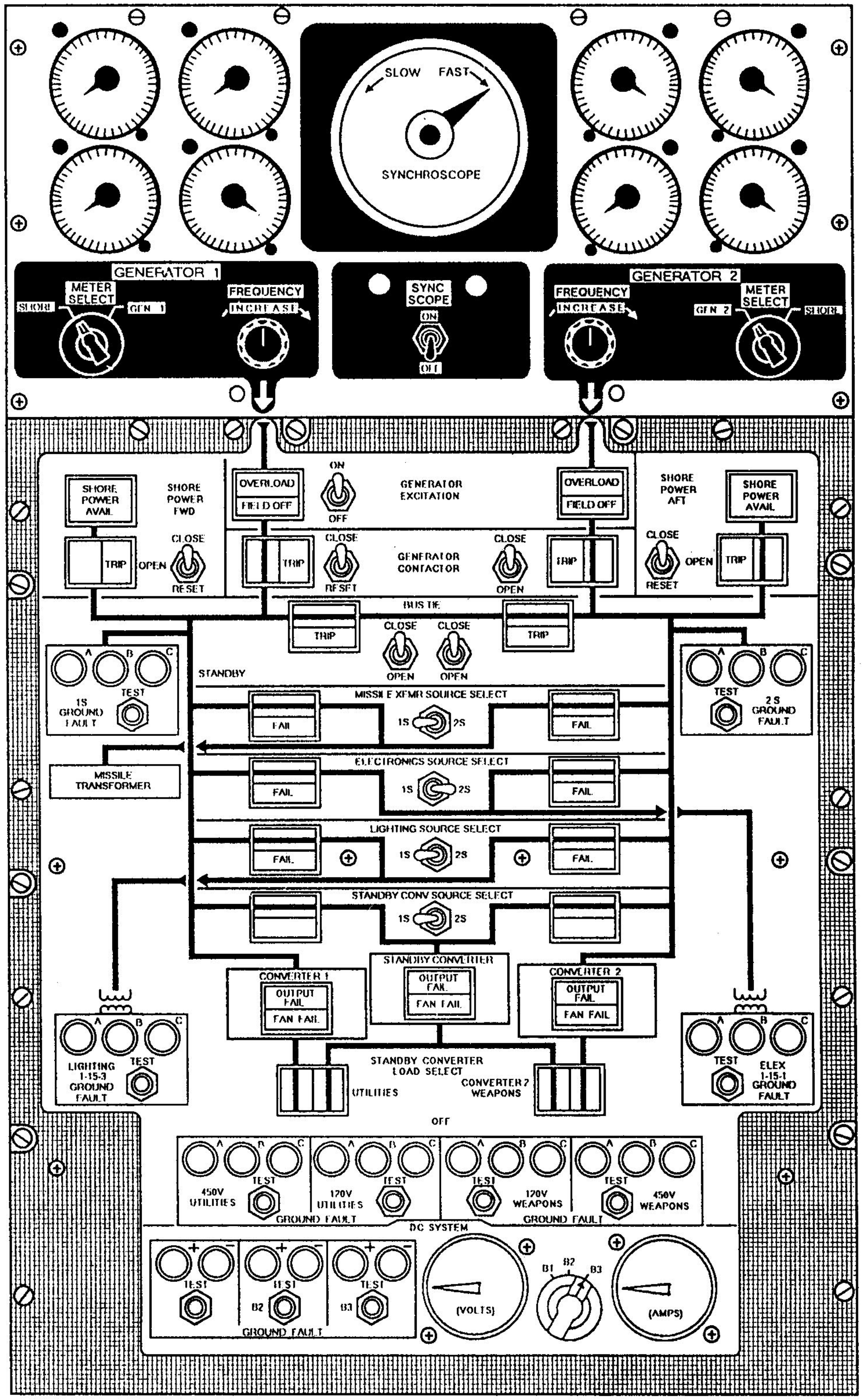


Figure 6-30.—Electrical system indicator and control panel.

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 6-30, 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 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.

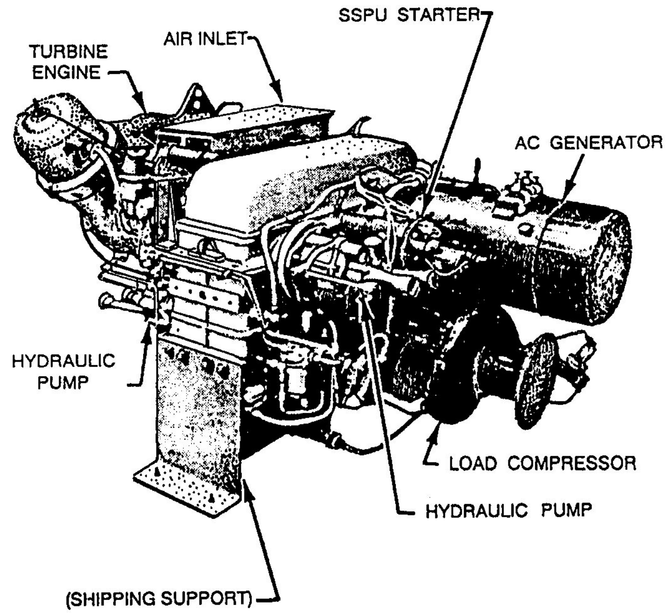


Figure 6-31.—Ship's service power unit (SSPU).

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 6-31. 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

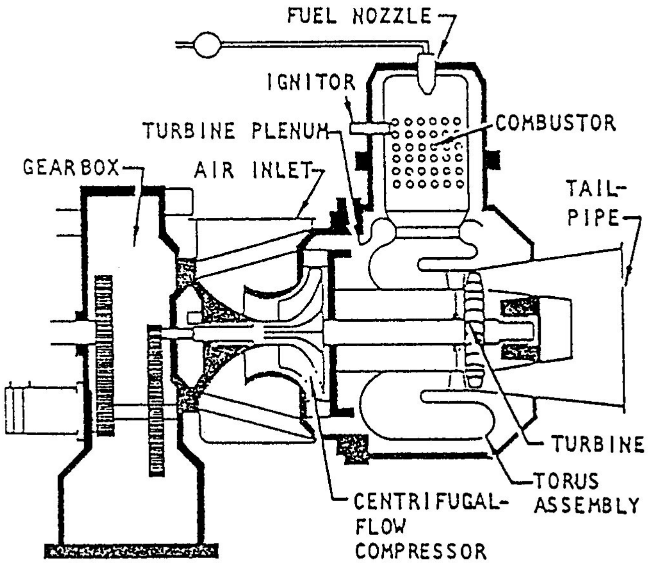


Figure 6-32.—Cutaway view showing main components of an SSPU turbine engine.

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 SSPUs 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.

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 6-32 is a cutaway vie w 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 fuel/air 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.

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 filter 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 7.8 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.

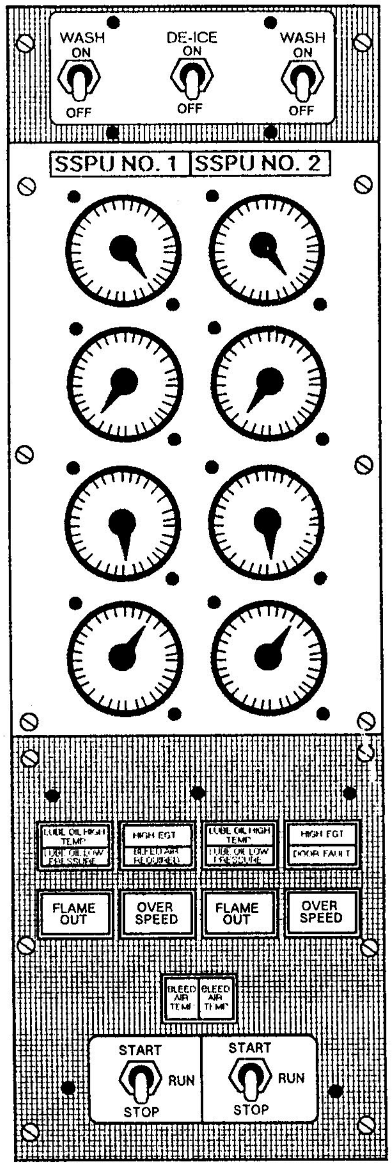


Figure 6-33.—SSPU control panel.

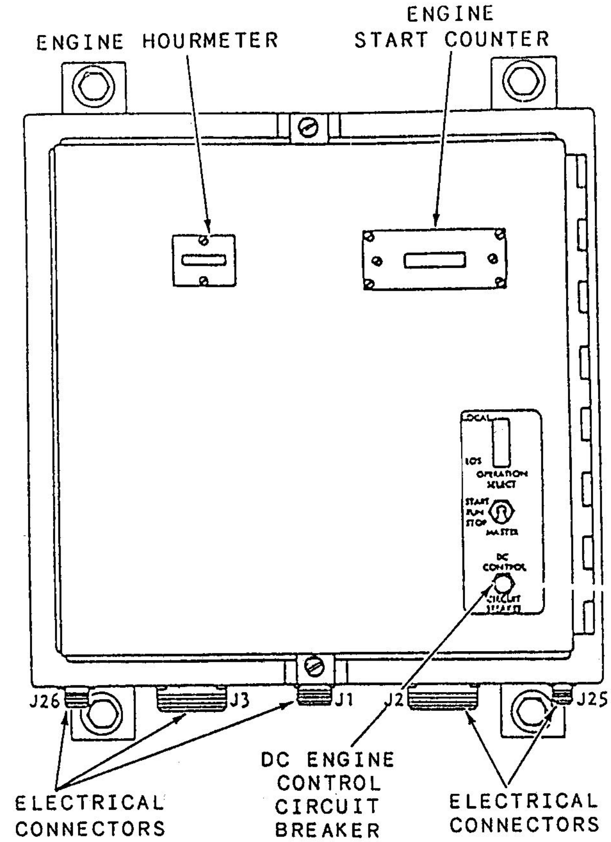


Figure 6-34.—SSPU local control (emergency) panel.

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 6-33. 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 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 6-34. 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 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

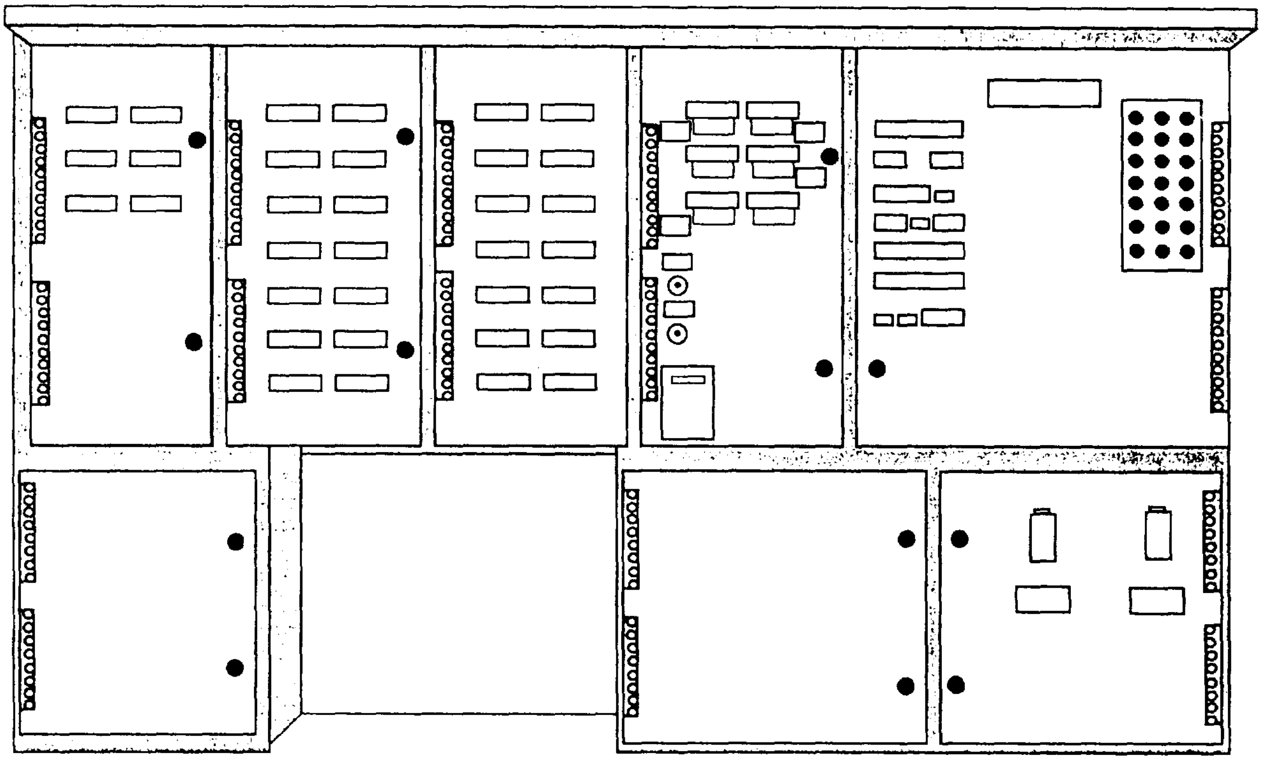


Figure 6-35.—Main deck switchboard.

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 coding. 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 (ICU 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 6-35. 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 6-35 the enclosure for this switchboard is equipped with hinged doors and 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 6-36. 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 6-36, 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.

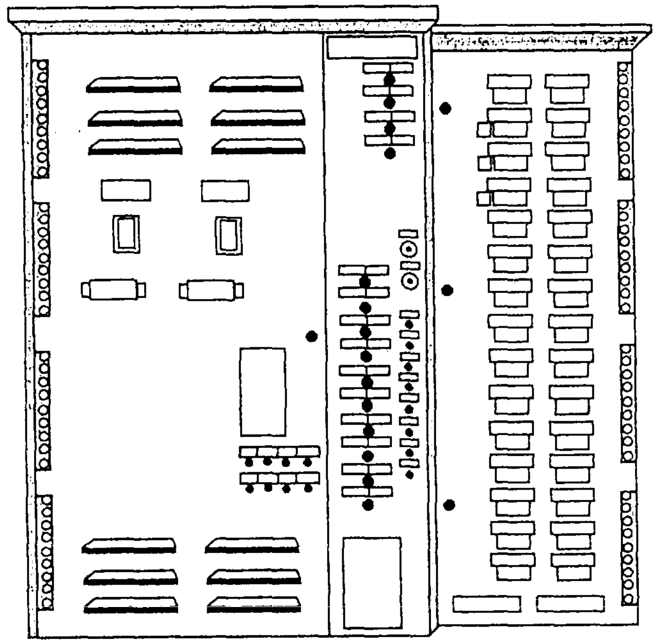


Figure 6-36.—Platform deck switchboard.

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 a shore 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. 6-37.)

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.

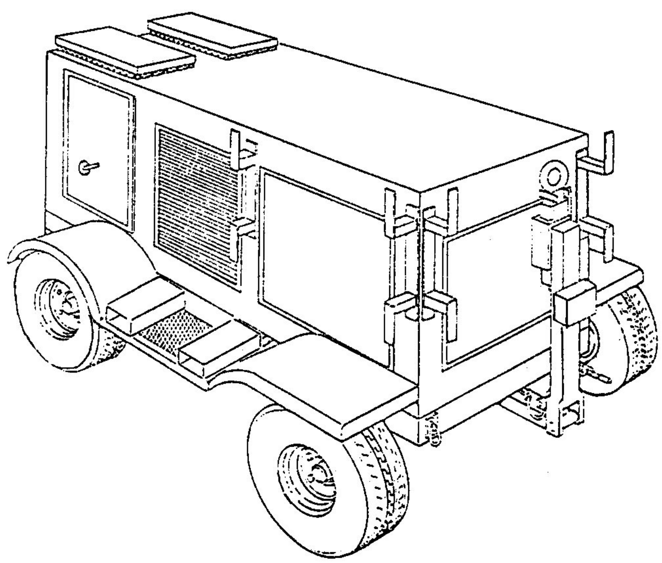


Figure 6-37.—Mobile electric power plant.

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.

TROUBLESHOOTING PROCEDURES

In troubleshooting the PHM's 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 ac-powered pumps
2. Two dc-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 stern.

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 GSM, 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.

CHAPTER 7

ELECTRIC PLANT

As a GSM2, you will need to be familiar with not only the basic construction and function of the electric plant on board your ship but also the basic troubleshooting techniques and repair procedures. Several different electric plants exist on gas turbine-powered ships. Some are diesel powered, like those installed on FFG-class ships. The majority, however, are gas turbine powered, with the Allison 501-K17 GTE being the most widely used.

After reading the information in this chapter, you should be able to answer basic questions in regard to the basic design, operations, and maintenance and repair responsibilities for the power-generating prime movers and generators installed on gas turbine-powered ships.

PRIME MOVERS

As the most widely used prime mover, the Allison 501-K17 GTE is installed on the CG-47, DD-963, and DDG-993 class ships. The Allison 501-K34, a modified version of the K17, is installed on the latest addition to the fleet, the DDG-51 class ships.

The Garrett ME 831-800A GTE is installed on the PHM-class ships. The LCAC-class ships use the Sunstrand TX32T-40-7 GTE. On FFG-chss ships, the electric power is supplied by the Detroit Diesel 16V149.

Throughout this chapter, we will focus on areas that you, the GSM, should understand to be able to carry out your basic responsibilities to maintain these prime movers in an operational state of readiness. The information provided in this TRAMAN and in *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine* Systems Technician (Mechanical) 3 should help you identify the equipment, systems, and components these plants have in common and recognize their individual differences. In each case, we will discuss your role as a GSM in the cleaning and maintenance requirements, tests and inspections, troubleshooting and repair techniques, and removal and replacement of selected components. Let's start with the electric plant for the most commonly used GTE, the Allison 501-K17, and its modified version, the Allison 501-K34.

ALLISON 501-K17 AND 501-K34

To be proficient as a GSM2, you will need a well-rounded knowledge of the operations and routine maintenance requirements for both the Allison 501-K17 and 501-K34. This chapter will discuss some basic engine operations and frequently performed maintenance and repair requirements. For a better understanding of the information presented in this section, we recommend you review the construction, design, and operations information on the Allison 501-K17 provided in chapter 3 of *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* Volume 2, NAVEDTRA 10564.

GTGS DESIGN AND OPERATION

On the CG- and DDG-51 class ships, ship's service electric power is provided by three 2,500-kW GTGSs. On the DD- and DDG-993 class ships, except for USS *Paul E Foster,* ship's service electric power is provided by three 2,000-kW GTGSs. USS *Paul F. Foster* has a fourth GTGS, model 170, which is a modified version of model 104. For detailed information on this GTGS, refer to the current edition of NAVSEA technical manual, *Description, Operation and Installation, Model 104 Gas Turbine Generator Set,* S9234-BC-MMO-010.

For the CG-, DDG-51, DD-, and DDG-993 class ships, under normal operating conditions, any two generators can supply the entire ship's demand. The third GTGS can be set up in auto standby, allowing it to come on the line automatically in case either of the two on-line GTGSS should fail.

Location

On the CG-, DD-, and DDG-993 class ships, the No. 1 GTGS and the No. 2 GTGS are located in the No. 1 and No. 2 engine rooms, respectively, on the second platform level. They are located opposite the main engines. The No. 3 GTGS is located in the No. 3 generator room at the first platform level.

On the DDG-51 class ships, the No. 1 GTGS is located in auxiliary machinery room (AMR) No. 1. The

No. 2 GTGS is located in main engine room (MER) No. 2. The No. 3 GTGS is located in the generator room.

In each ship class, the engine arrangements and relative locations of the GTGSs separate each GTGS by at least three watertight bulkheads. his placement of the GTGSs reduces the chance of total loss of electric power resulting from battle damage.

Monitoring and Control

In each ship class, the GTGSs can be started and monitored either locally at the local operating panel (LOCOP) mounted on the generator end of the unit or remotely from the SWBD or the EPCC in the CCS. The LOCOP contains the electronic controls that sequence and monitor the operation of the GTE. Control of the generator voltage, frequency, and circuit breaker is available at either the EPCC or the switchboard.

Construction

Each GTGS is a module consisting of a GTE, a reduction gear assembly, and a generator. These main components are mounted on a common base with the associated engine controls and monitoring devices. The GTE and the reduction gear assembly are housed in an acoustical enclosure.

On the CG-, DD-, and DDG-993 class ships, each generator has a remotely mounted generator control unit. The lube oil cooler for each gas turbine/reduction gear system is mounted under the module base.

On the DDG-51 class ships, the configurations for the generator control unit and the turbine lube oil cooler are somewhat different from those on the other ship classes. We will point out these configuration differences later in this chapter.

In all ship classes, each GTGS has its own seawater cooling system, lube oil system, and start air system. Each GTGS module receives cooling and emergency cooling water from the seawater service system, fuel from the engine room's fuel oil (FO) service system, and gas turbine cleaning and rinsing solution from the water wash system. It also receives starting air from the bleed (low-pressure) air system and high-pressure air systems and signal air from the ship's service air system (SSAS).

On the DD- and DDG-class ships, the GTGS module is cooled by air supplied from the intake system through a single electric fan. On the CG-47 class ships, cooling air is supplied from two fans.

On the CG-, DD-, and DDG-993 class ships, the GTGS module receives carbon dioxide ($C0_2$) from the fire-extinguishing system. On the DDG-51 class ships, the GTGS module receives Halon from its fire-extinguishing system.

ALLISON 501-K34 VERSUS THE ALLISON 501-K17

If you have not recently reviewed chapter 3 of the *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* Volume 2, NAVEDTRA 10564, you should at least make certain you understand the basic design and operational features of the Allison 501-K17. In this section, we will discuss some basic design differences between the Allison 501-K17 and the newer K34 model found on the DDG-51 class ships. After studying the information in this section, you should have a better understanding of the design changes in the newer engine and how these changes make the KI7 and the K34 different.

In discussing the differences between the two engines, we will describe the basic changes to the equipment in terms of design and location. We will only briefly mention the changes to equipment operating set points or parameters, as these changes are minimal. In fact, we will mention them only to give you a basis for comparison. Remember, all equipment set points and parameters are listed in your ship's EOSS and in the applicable technical manuals.

Engine Foundation and Enclosure

Let's first look at the changes made to the engine foundation and its enclosure because most of the configuration changes from the Allison 501-K17 to the K34 model are in these areas.

In the Allison 501-K34, the foundation and enclosure for the engine are larger to provide more space for the internal and external equipment additions and modifications. Actually, the size of the original equipment on the older engine did not change. The engine foundation for the K34, however, had to be made longer to accommodate both the additional equipment and the relocation of the LOCOP.

Study figure 7-1. Notice that the K34 has several new equipment items. Notice also that the location of some of the equipment on the K34 is different from that on the K17. Notice on the K34 how several new pieces of equipment are located on the generator end of the foundation. Refer to figure 7-1 as we describe the design and location of some of these new items. Remember, the

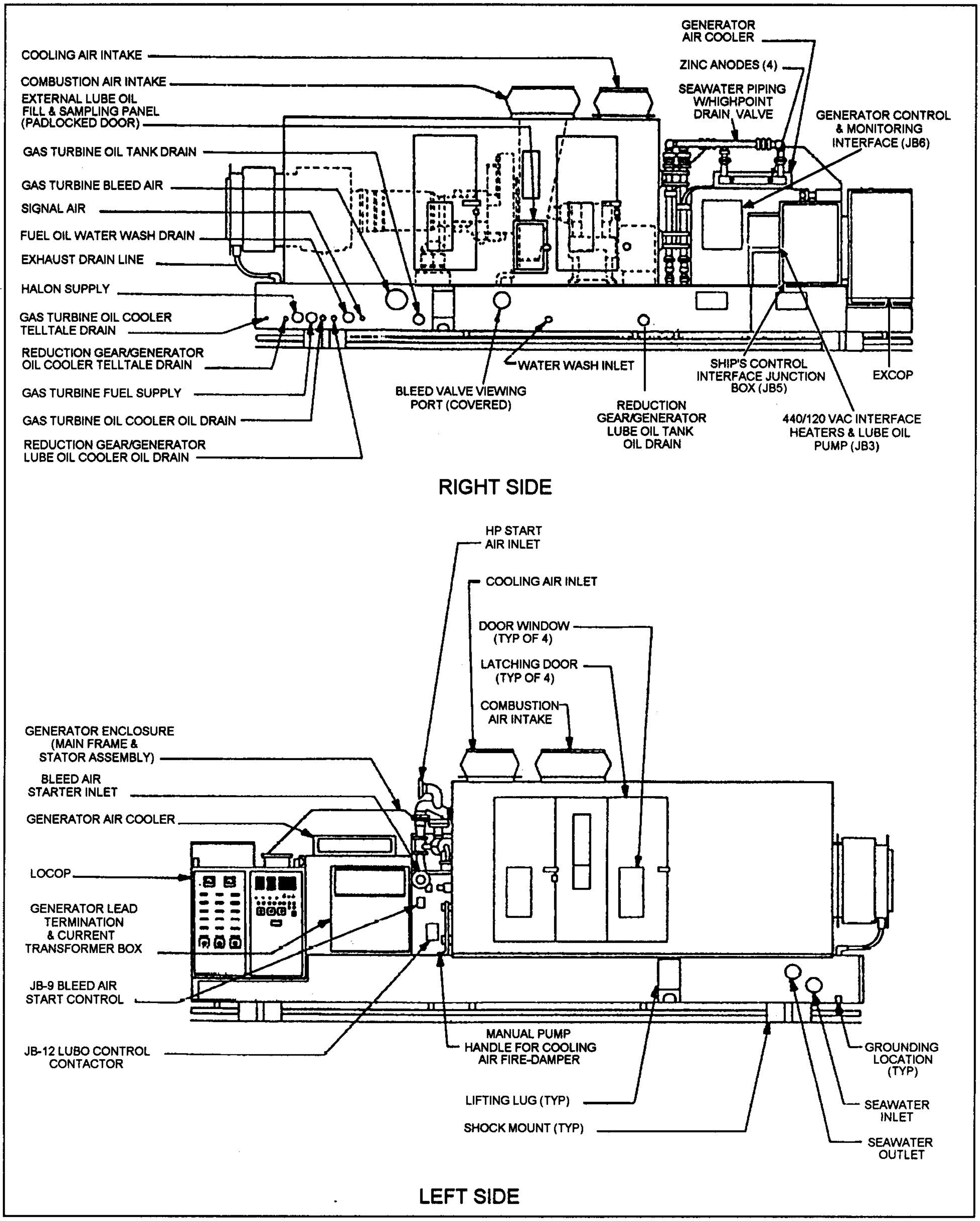


Figure 7-1.—Side views of the Allison 501-K34 gas turbine generator.

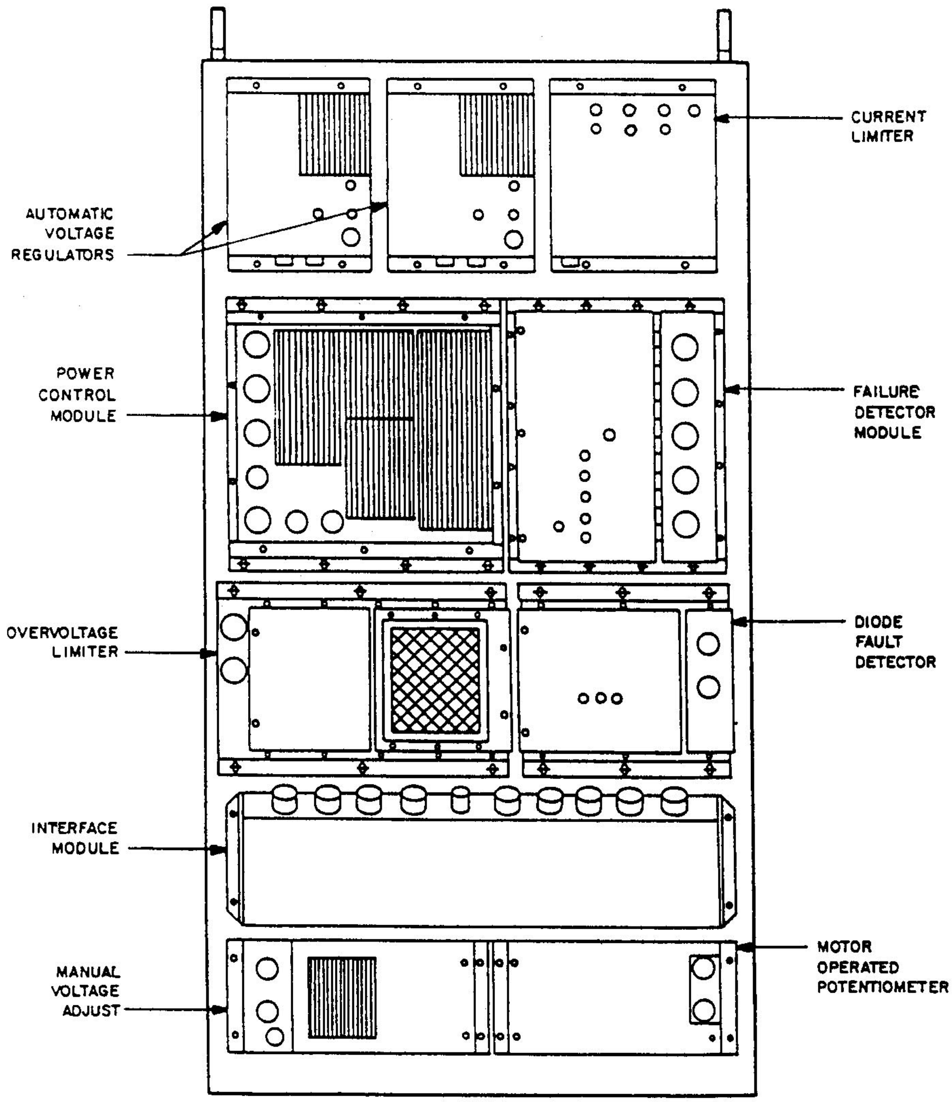


Figure 7-2.—Excitation control panel (internal view).

Allison 501-K34 is found specifically on the DDG-51 class ships.

Excitation Control Panel (EXCOP)

On the DDG-51 class ships, the EXCOP on the Allison 501-K34 replaces the governor control unit (GCU) on the Allison 501-K17 model found on the CG-, DD-, and DDG-993 class ships.

The DDG-51's EXCOP is a stainless-steel housing located on the module base. It receives speed, voltage, and current sensing signals from the SSGTG output. It also receives ac power from the PMA. It uses these outputs in combination with performance control signals to regulate the following major components:

- Automatic voltage regulator (AVR)
- Power control module (PCM)
- Overvoltage limiter (OVL)
- Interface module (IFM)
- Manual voltage adjust (MVA)
- Motor-operated potentiometer (MOP)
- Diode fault detector (DFD)
- Failure detector module (FDM)
- Current limiter (CL)

Figure 7-2 is an illustration of the EXCOP showing the relative location of these components, which we will briefly describe in the following paragraphs. Please refer to figure 7-2 as you read the following sections.

AUTOMATIC VOLTAGE REGULATOR ASSEMBLIES.– There are two AVR assemblies in the

EXCOP. Each AVR provides generator field excitation through the other major components. The AVR selection is made at the switchboard, with only one AVR active at a time. Unless it is disabled, the inactive AVR becomes an automatic backup.

A PMA output is required for field excitation. A dc bridge rectifier contains silicon controlled rectifiers (SCRs) that convert the PMA ac voltage output to dc voltage. The SCR circuits are influenced by system adjustments and controls.

NOTE

On the switchboard operating panels, each AVR switch is labeled voltage regulator (VR).

POWER CONTROL MODULE.– The PCM routes PMA power to the DFD, OVL, and primary AVR modules. The PCM also converts the PMA power into 28 volts dc for use by the EXCOP electronic circuits.

OVERVOLTAGE LIMITER.– The OVL limits the field excitation if the output voltage should exceed the 552-volt trip point value or the instantaneous trip setting of 590 volts. An OVL trip is set to hold the voltage at 518 volts (a setting that can be adjusted), to start the cooling fan, and to illuminate the LIMITING IN CONTROL indicator on the LOCOP. The OVL can be reset by either of the following two methods:

1. Placing the switchboard VOLT REG SELECT switch in the OFF position. This will shut down the exciter and turn the fan off. (This switch is labeled EXCITATION SELECTOR SWITCH (ESS) in the SSGTG technical manual.)

2. Securing the SSGTG by normal means. This will cause a reset to occur as the voltage drops to half the 450-volt ac rated value.

INTERFACE MODULE.– The IFM connects the EXCOP to the ship's cables and the SSGTG auxiliaries. The IFM also routes the control signals within the EXCOP and controls the signals to the LOCOP and exciter armature.

MANUAL VOLTAGE ADJUST.– The MVA controls the generator output voltage by using a variable ratio transformer to change the exciter field dc power level in the MANUAL mode. When the switchboard AUTO/OFF/MANUAL switch is in MANUAL, the MVA will move the motor-operated variable ratio transformer on demand from either the EPCC or the switchboard LOWER/RAISE control.

MOTOR-OPERATED POTENTIOMETER.– With the VOLTAGE RAISE/LOWER switch in the AUTO mode, the MOP will adjust the AVR operating level by establishing a reference voltage for automatic voltage regulation operation.

DIODE FAULT DETECTOR.– The DFD protects the exciter armature from high current damage resulting from open, shorted, or leaking (unwanted current) rotating diodes. The three LED-type DIODE STATUS indicators on the module labeled DETECTOR STATUS/OPEN/SHORTED can be seen through chassis openings.

FAILURE DETECTOR MODULE.- The FDM has two principal functional areas: (1) AVR switching and (2) signaling the LOCOP of failures.

CURRENT LIMITER.– The CL monitors the current phase transformers. Transformer signal values representing more than 3.2 times the rated current (12.9 kA) will override the other AVR signal inputs, reducing the field excitation and, in turn, reducing the generator voltage and current. The CL has three adjusting rheostats, one for each phase, that are used to set the maximum current output. The rheostats are mounted on the EXCOP cover.

There are three junction boxes in the K34's CL. They are installed in the area where you would normally find the LOCOP on the CG-, DD-, or DDG-993 class ships.

Local Operating Panel (LOCOP)

The LOCOP controls and monitors the SSGTG operation. Control and monitoring functions include starting control, events sequencing, indicating parameters, and stopping the SSGTG.

On the Allison 501-K34, the LOCOP is located on the base assembly front edge. (See fig. 7-1.) The LOCOP has two front doors with attached control and

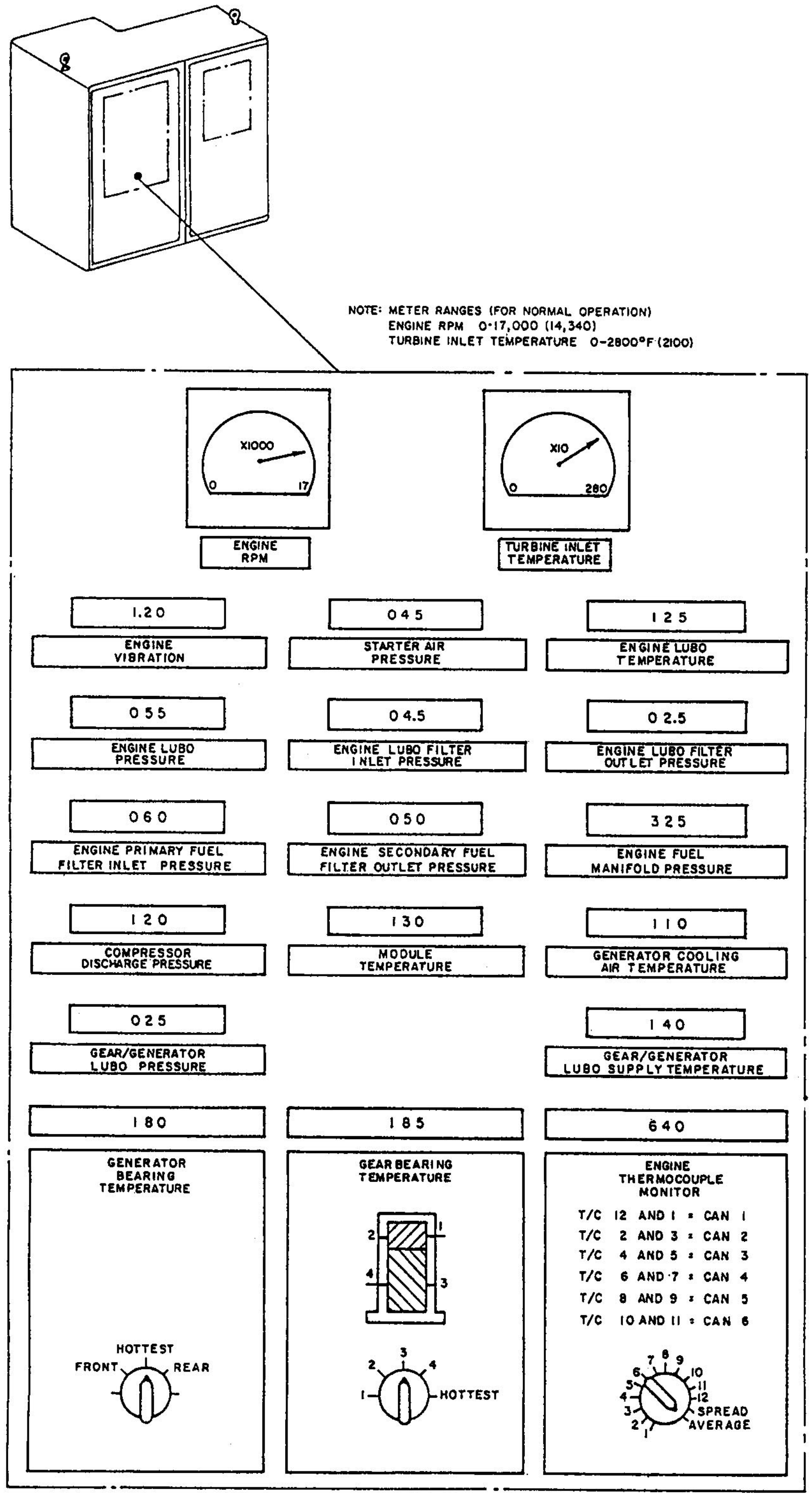


Figure 7-3.–LOCOP meters.

status features. (The LOCOP meters are shown in fig. 7-3. The annunciator and controls are shown in fig. 7-4.) The two doors provide access to the internal components. A removable rear panel provides access to SSGTG junction box 7.

The LOCOP contains the following internal components:

1. The 301 electronic sequencer

2. Electronic governor

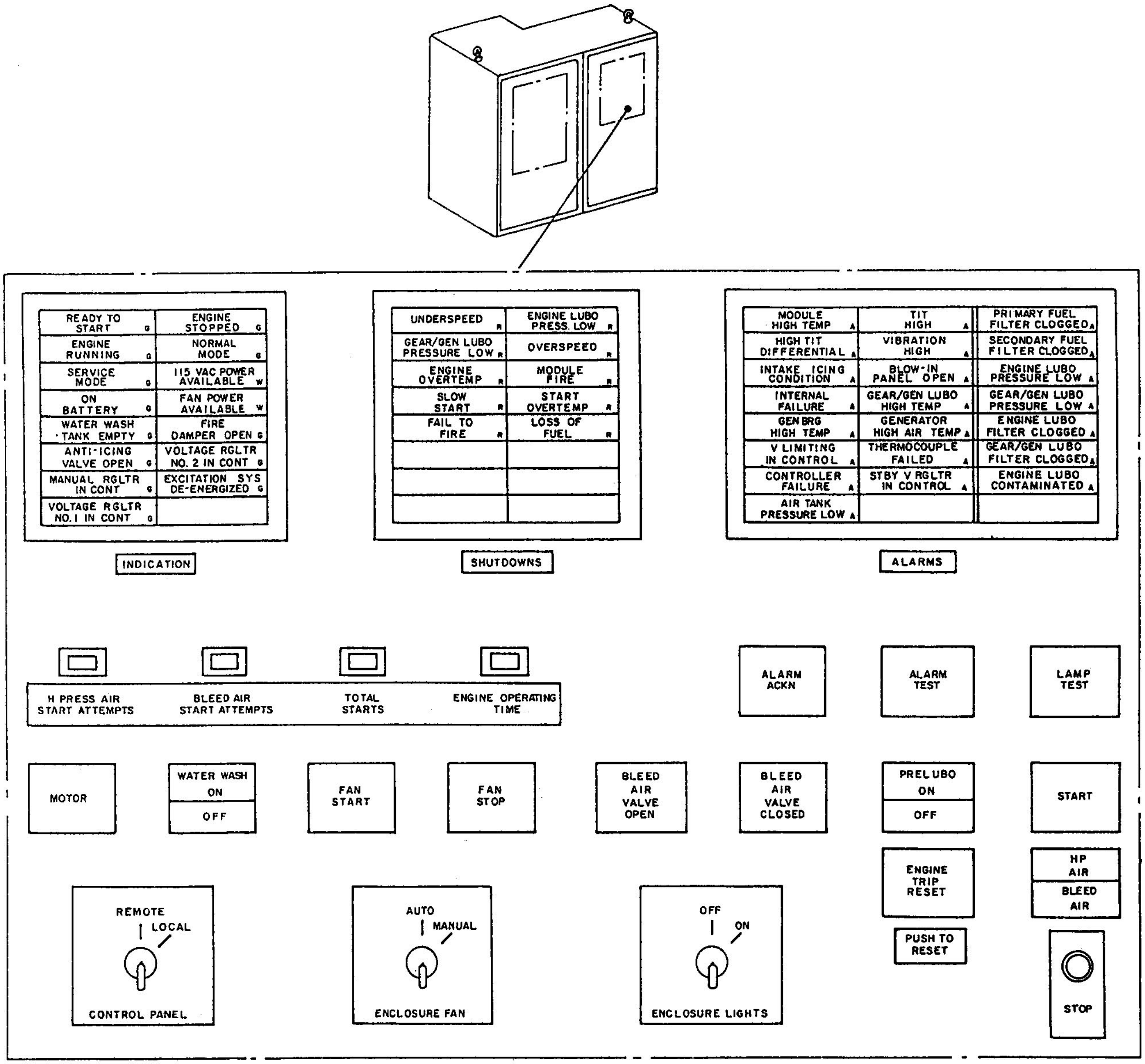


Figure 7-4.–LOCOP annunciator and controls.

3. Speed/temperature box
4. Vibration monitor
5. Relay boxes
6. Optoisolators
7. Electromagnetic interference (EMI) filters
8. Isolated signal converters (ISCs)
9. Transient load sensor

In the following paragraphs, we will briefly describe each of these components. For a more detailed description, consult the appropriate technical manuals.

301 ELECTRONIC SEQUENCER.– The 301 electronic sequencer is a commercial gas turbine microprocessor-based control that has been modified for military use. It stops, starts, and monitors the SSGTG. It also decides upon actions, activates alarms, and initiates shutdowns during its SSGTG control. The sequencer receives discrete and analog signal information, manipulates this information, and produces discrete and analog outputs during its control process.

The sequencer is installed in an enclosure that has upper and lower sections. The upper section contains the input/output modules and the central processor unit. The lower section contains two power supplies and a power auxiliary module. Another module, located on the top of the enclosure, contains power supplies for external system functions. For its internal and external connections, the 301 sequencer uses a motherboard.

ELECTRONIC GOVERNOR.– The electronic governor is located in the LOCOP and is powered by an external dc supply. The function of the electronic governor is to regulate fuel flow to the engine during (1) light-off, (2) temperature control, (3) acceleration, and (4) power generation. To produce output control signals for these operations, the governor uses the following input signals:

1. Generator current
2. Generator voltage
3. Engine speed
4. Compressor inlet temperature (CIT)
5. Calculated turbine inlet temperature (CTIT)

The governor uses these inputs to provide several output control functions. First, the generator current and voltage use provides the load sharing and parallel operation control signals. The engine speed signal provides a fuel schedule during start-up and any frequency matching requirements commanded from the EPCC. The CIT is used to correct the speed and turbine inlet temperature (TIT) reference circuits. The CTIT is used to maintain safe operating temperatures during start and rated speed.

The governor control output signal causes the governor actuator mechanical linkage to position the fuel metering valve. The valve's position is then fed back to the control to tighten the servo loop and improve the responses to speed demands.

For testing, a suitcase-type electronic governor test set is used. The test set is equipped with hookup cables for power, an interface, and a 28-volt dc power supply 10 power the governor during test only.

SPEED/TEMPERATURE BOX.– The speed/temperature box monitors the SSGTG for speed and correct operating temperatures. This box is an electronic digital control that provides data for starting, normal running, and emergency shutdown. Inputs to the speed/temperature box include the following:

1. SSGTG speed
2. Turbine outlet temperature (TOT)
3. CIT

Turbine speed comes from a magnetic pickup positioned at the power takeoff (PTO) shaft. The TOT is taken from 12 engine-mounted thermocouples whose outputs are averaged together. The CIT sensor at the compressor inlet provides the ambient temperature and the CIT signal. The box computes the CTIT for the governor to control engine temperature.

VIBRATION MONITOR.– The vibration monitor determines the vibration value during all SSGTG operations from start-up to shutdown. The vibration levels are presented on the LOCOP panel. When vibration design levels are exceeded, an alarm is initiated on the annunciator panel.

RELAY BOXES.– The relay boxes furnish the discrete output relay contacts for the electronic sequencer and governor circuits. These contacts provide isolation for the governor's sensitive circuits, thereby protecting them from any electrical noise developed on the wiring to the devices using the outputs.

OPTOISOLATORS.– The optoisolators provide isolation for the input data wiring to the sequencer and the governor. Optoisolators use alighting device to keep electrical noise on the current path from being transmitted to the sequencer or governs. The lighting device breaks the current paths of the wiring and associated electronic device with alight beam that stops any electrical noise on the current path from being transmitted to the sequencer or governs.

ELECTROMAGNETIC INTERFERENCE FILTERS.– The EMI filters are also used on the LOCOP input and output electrical lines. These filters are tuned devices that shunt current in a certain frequency range to ground or the current supply return. This action prevents these bothersome currents from interfering with the desired signals and distorting their value or utility.

ISOLATED SIGNAL CONVERTERS.– The ISCs provide very stable and accurate current or voltage signal outputs. The ISCs receive inputs that have inherent instability characteristics. They develop these signals into very stable and accurate current or voltage output signals. The inputs are data from the speed/temperature box and represent TIT and engine speed. As a GSM, you may also hear ISCs referred to as 4-20 milliampere conversion modules.

TRANSIENT LOAD SENSOR.– The function of the transient load sensor is to monitor varying loads and prevent engine stalls. The transient load sensor uses a 0- to 2-volt ac signal from burden resistors placed across the current transformers. This signal represents the kilowatt load on the generator's individual phase windings. At 1,000 kW, the circuit is armed for high transient loads. With a 500-kW step increase, however, the sensor will transmit a signal to close the turbine's 14-th stage bleed air valve. This action of the sensor will prevent engine stalls resulting from such load variations.

The transient load sensor also monitors the generator's main circuit breaker and its shutdown relays. Consequently, other SSGTGs on the bus will receive a bleed valve closure signal if a shutdown should occur.

Hand Pump Assembly

Study figure 7-1 and focus your attention on the space between the generator and the enclosure. On the Allison 501-K34, a new piece of equipment, a hand pump-operated actuator mounted on the module's exterior wall, has been added. The pump is used to close the fire damper if ship's service air or power is not available.

Because of this new item, a change was made to the K34's start air piping. The change on the K34 provides a single manifold where the high-pressure and low-pressure start air enter the starter inlet. In the older Allison model, the high-pressure and low-pressure start air were individually piped to the starter.

Now that we have discussed the important design differences in the Allison 501-K17 and K34 models, let's take a look at the prime mover used on the PHM-class ships, the Garrett ME 831-800A.

GARRETT ME 831-800A

Manufactured by the Garrett Corporation, the ME 831-800A ship's service power unit (SSPU) is the electrical and hydraulic power source on the PHM-class ships. On these hydrofoils, the SSPU provides the electrical power to (1) activate the compressed air system that starts the foil borne engine, (2) drive the ac generator, (3) support the speed and load control circuitry and equipment, and (4) operate the two hydraulic pumps.

In chapter 6, we gave you an overview of this SSPU. Now, let's take a slightly closer look at some of its systems and components.

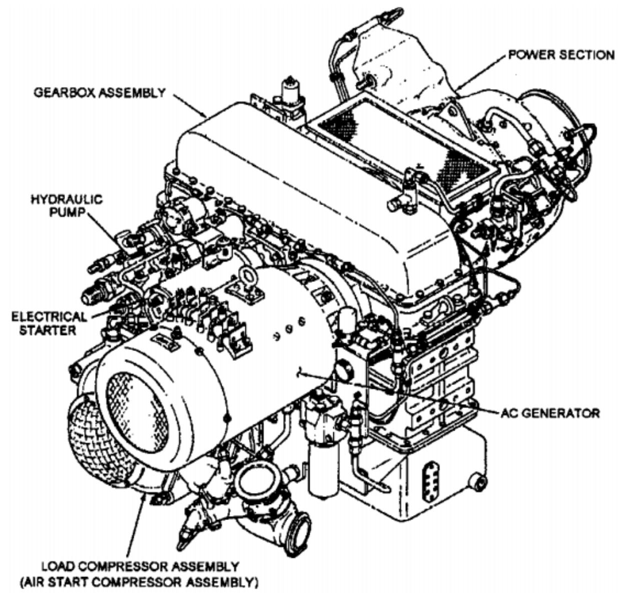


Figure 7-5.–Garrett ship's service power unit (SSPU).

CONSTRUCTION AND DESIGN

The electric plant of the Garrett ME 031-800A SSPU includes the following five systems:

1. Electrical system
2. Lubrication system
3. Fuel system
4. Water wash system
5. Bleed air (de-icing) system

Before we look at each of these systems and how they work, let's first describe the SSPU in terms of its two major sections: (1) the power section and (2) the gearbox assembly section. Figure 7-5 shows an orthographic view of the SSPU. Refer to figure 7-5 as we describe the construction and design features of both sections.

The power section consists of the 2-stage centrifugal-flow compressor, the 3-stage axial-flow turbine, the inlet plenum, and the combustion system. The power turbine is mounted on the rear of the gearbox assembly.

The gearbox section consists of the reduction gear train contained in a split-housing assembly. Mounted on the reduction gear assembly are the ac generator, two hydraulic pumps, and a load compressor. A more detailed description of the gearbox and its operations will be provided later in this chapter.

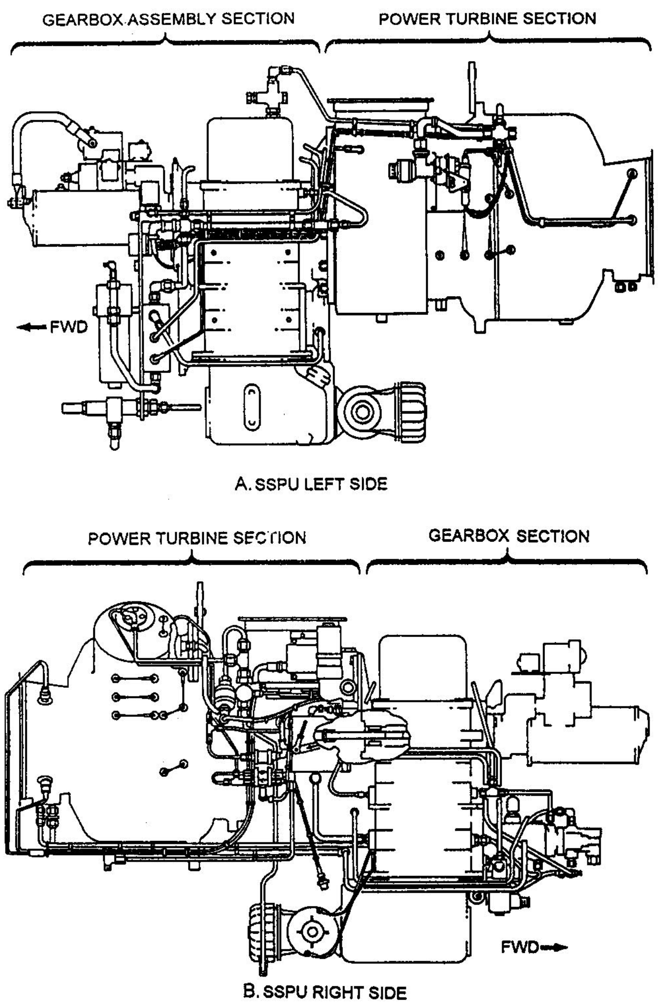


Figure 7-6.—SSPU left and right side views.

Figure 7-6 shows the design and construction of the SSPU as you would see it from the left side (view A) and right side (view B). The power section is coupled to the reduction gear train by a splined torsion shaft. The shaft transmits power from the SSPU to drive the driven components at a constant speed. This gear train arrangement allows the electrical starter to drive the power section and necessary equipment during the start cycle.

To understand the design and operation of the SSPU, let's take a closer look at the power section. Figure 7-7 is a diagram of airflow in the power section. As we describe the major components, we will include numbers in parentheses. Use these numbers to refer to the corresponding parts on the figure.

In the compressor and turbine assembly, the compressor impellers (5, 21) and turbine wheels (18, 19, 20) are locked together by curved couplings. A shaft assembly, consisting of a tie bolt through the center (22) with a nut on each end (15, 24), allows the assembly to work as a single rotating group. The rotating group is supported by journal bearings (3, 14) and seals (4, 13) on each end of the shaft assembly. A thrust washer (23) and the rotor (2) take up end thrust at the compressor end. Study how this assembly works as we trace the airflow.

Outside air is drawn into the compressor through the inlet plenum (1). Here it is compressed in two stages. The first-stage diffuser (6) guides the discharged air from the first-stage impeller (5) into the inlet of the second-stage impeller (21). The second-stage diffuser (7) then guides the compressed air into the turbine plenum (17), which provides outlets for de-icing bleed air and other external uses. From the turbine plenum, the compressed air flows into the combustion liner assembly (11) of the combustion chamber (9, 11). In the combustion chamber, the compressed air is mixed with fuel supplied by the fuel nozzles (10) and ignited by the igniter plug (8). The resulting hot gases flow to the first-, second-, and third-stage turbine wheel assemblies (18, 19, 20). The spent gases are expelled through the exhaust flange assembly or tailpipe (16).

Now that we have traced the airflow, let's look at the SSPU in terms of its different systems, starting with the electrical system.

ELECTRICAL SYSTEM

The SSPU electrical system automatically actuates various electrical circuits in proper sequence. These circuits control starting, acceleration and governed speed, fuel flow, and monitoring during SSPU operation. The major components of the electrical system, as identified in figure 7-8, include the following units:

- Electric starter
- Oil pressure switches
- Ignition unit
- Monopoles
- Speed switch
- Load and speed control
- Thermocouples
- Electronic temperature control (ETC)
- Governor actuator

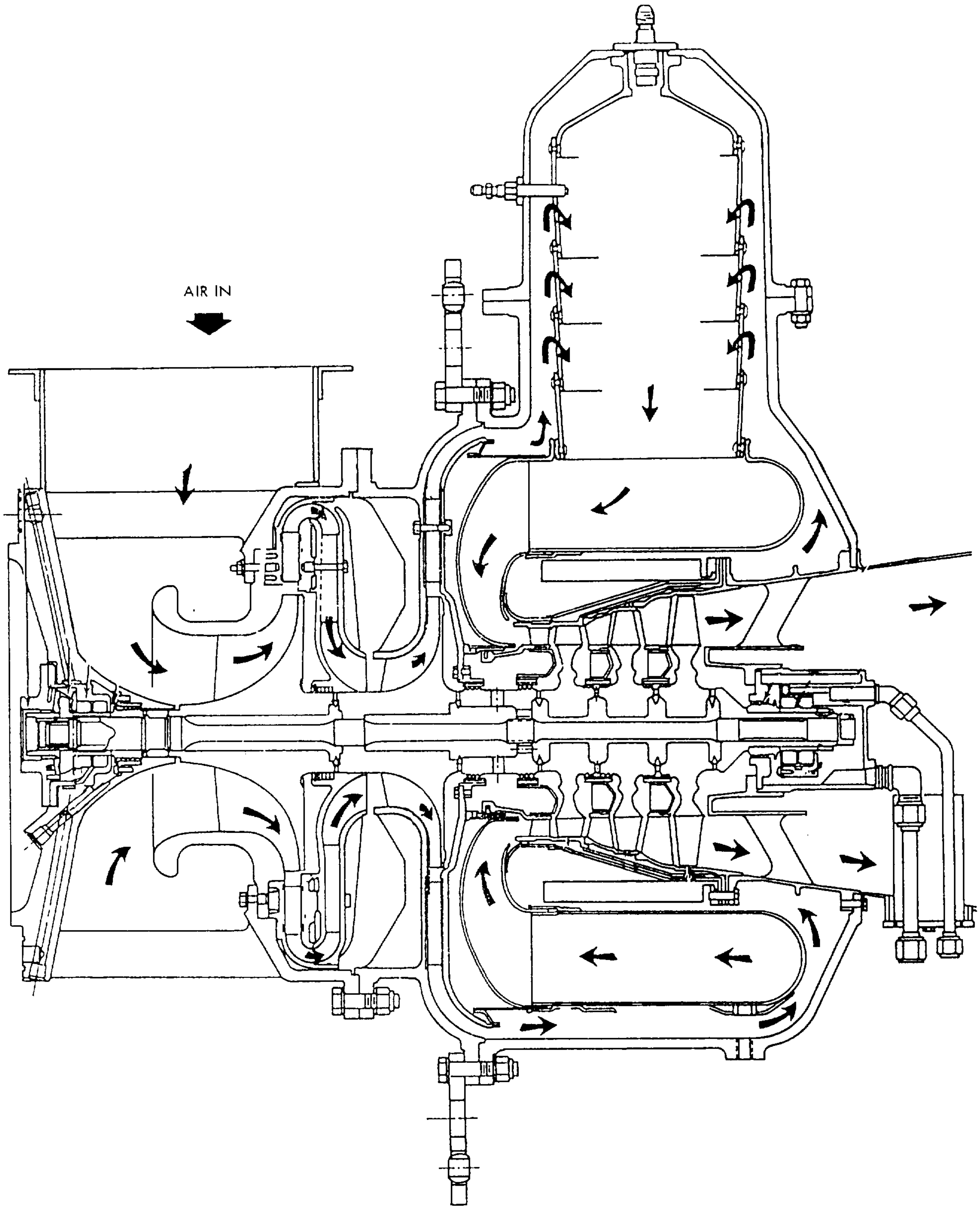


Figure 7-7.-Power section airflow schematic.

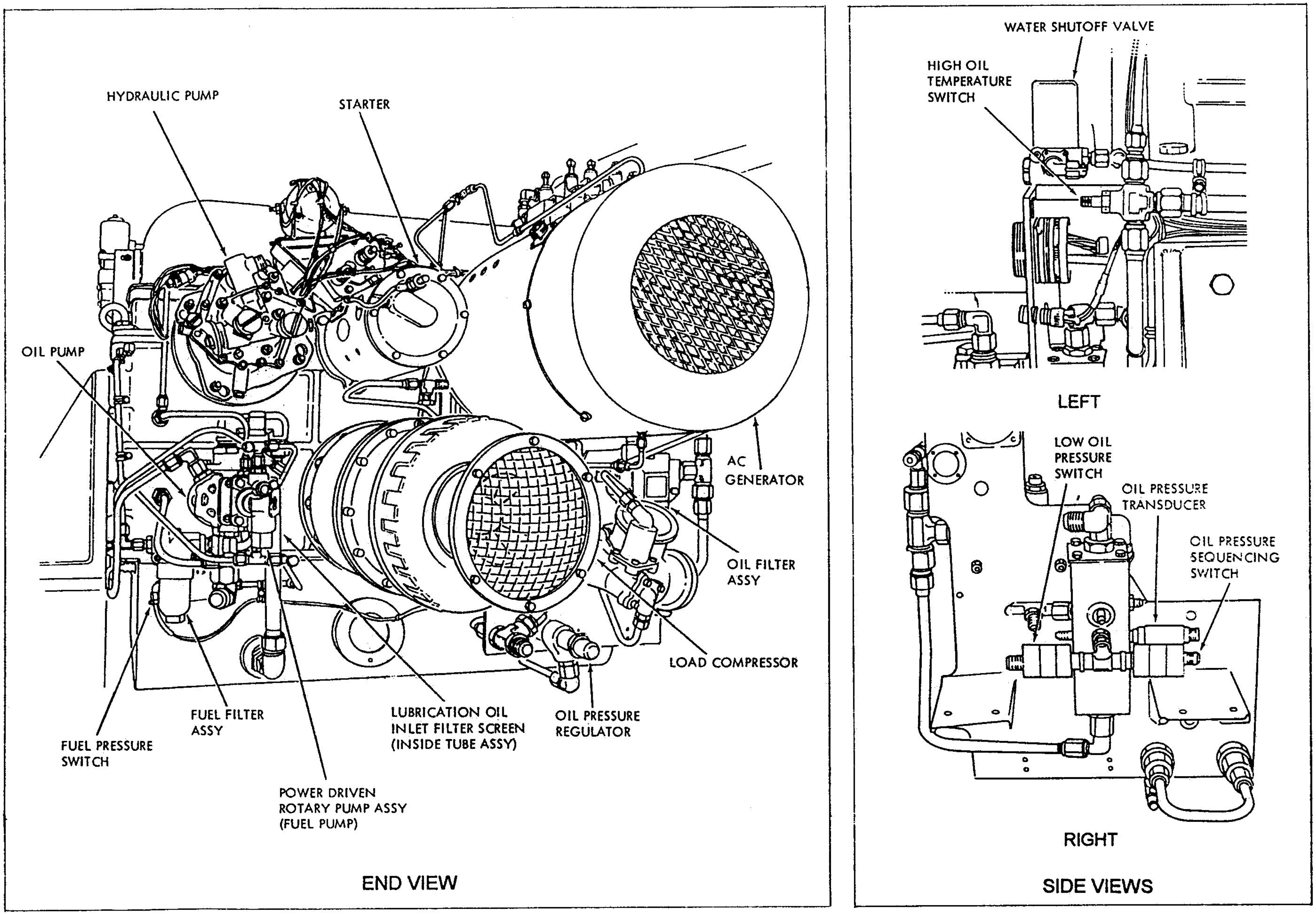


Figure 7-8.–Identification and location of the SSPU's major components.

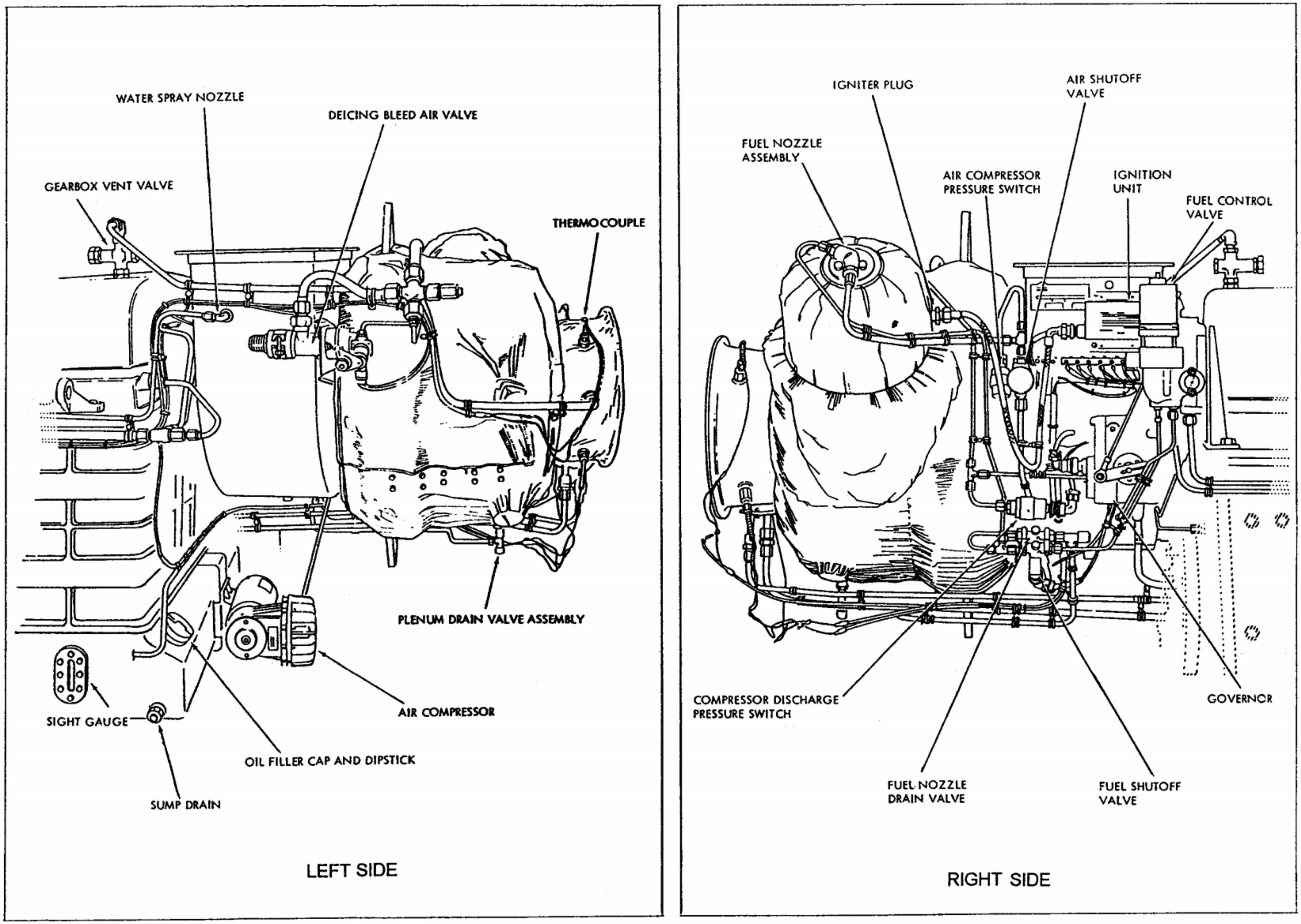


Figure 7-8.–Identification and location of the SSPU's major components–Continued.

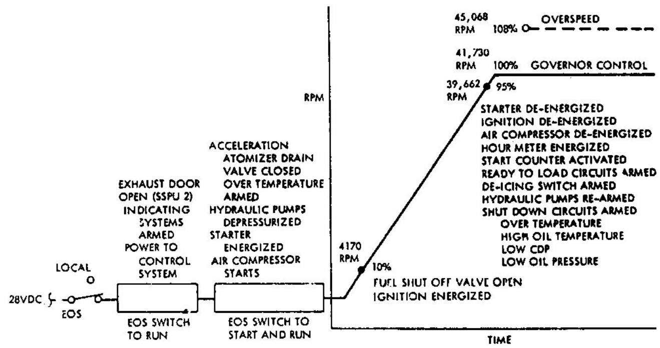


Figure 7-9.–SSPU circuit actuation sequence.

In the following paragraphs, we will discuss each of these units and their functions. Refer to figures 7-8 and 7-9 as you read about these components.

Electric Starter

The electric starter is mounted on the gearbox accessory pad. When energized, the starter engages the gearbox drive train, permitting the starter to drive the power section and necessary equipment.

A 24-volt dc battery set provides power to energize the starter. When 95 percent GTE speed is attained, the speed relay disengages the starter. When 95 percent of GTE speed cannot be obtained, a 60-second (overcrank) relay disengages the starter.

Oil Pressure Switches

Oil pressure switches include the oil pressure sequencing switch, low oil pressure switch, high oil temperature switch, fuel pressure switch, and compressor discharge switch. We will discuss each of these switches in terms of its relative location in the SSPU, function, and pattern of normal operation.

OIL PRESSURE SEQUENCING SWITCH.– The oil pressure sequencing switch is located near the oil pressure transducer. The function of the oil pressure sequencing switch is to monitor oil pressure during starts. If an oil pressure of 4 ± 1 psig is not obtained within 10 seconds, the oil pressure sequencing switch activates to disable the fuel and ignition logics. This ensures sufficient oil pressure to protect the engine from internal damage.

LOW OIL PRESSURE SWITCH.– The low oil pressure switch is located in the same area as the oil pressure sequencing switch. The function of the low oil pressure switch is to monitor oil pressure during normal operation. When oil pressure decreases to 55 ± 4 psig, the switch opens, causing the SSPU to shut down.

HIGH OIL TEMPERATURE SWITCH.– The function of the high oil temperature switch is to sense SSPU oil temperature during normal operation. When the oil temperature reaches 183 ± 3°F, the switch breaks circuit to the fuel shutoff valve. The fuel valve closes causing the SSPU to shut down.

FUEL PRESSURE SWITCH.– The fuel pressure switch monitors turbine fuel pressure during normal operation. When fuel pressure drops below 4 ± 1 psig, the fuel pressure switch opens. An alarm is activated, warning the operator that corrective action is necessary.

COMPRESSOR DISCHARGE PRESSURE SWITCH.– The compressor discharge pressure (CDP) switch senses pressure in the SSPU turbine plenum during normal operation. When pressure in the turbine plenum drops below 70 ± 5 psig, the CDP switch closes and the flame out relay is energized. When energized, the flame out relay breaks the circuit to the fuel shutoff valve. The fuel shutoff valve then closes, causing the SSPU to shut down.

Ignition Unit

The ignition unit is a high energy capacitor discharge unit that supplies the air-gap igniter plug with a high intensity voltage of short duration. The ignition unit is energized between 10 and 95 percent of engine speed.

The role of the igniter plug is to provide an air gap to create a spark while conducting the current flow supplied from the ignition unit. The spark ignites the fuel/air mixture used for combustion.

Monopoles

A simple diagram of a monopole assembly is shown in figure 7-10. A monopole consists of a soft iron core surrounded by a coil. It is attached to a small permanent magnet. The monopole assembly is enclosed in a metal encasement provided with a mount flange and an electrical connector.

Two monopoles are used for SSPU speed control. These monopoles, referred to as monopole (pickup) No. 1 and monopole (pickup) No. 2, are shown in figure 7-11. The soft iron core is mounted close to the main shaft nut. As the shaft rotates, the nut apex passes through the magnetic lines of flux from the permanent magnet, and voltage is generated.

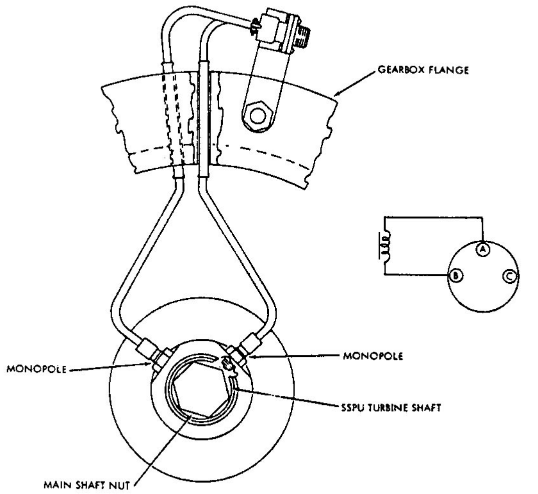


Figure 7-10.–SSPU showing monopole assembly.

The frequency and amperage of the generated voltage will vary proportionally with SSPU speed. As shown in figure 7-11, the output signal from one monopole (No. 1) is directed to the speed switch to actuate the 10, 95, and 108 percent speed switches and to provide signal conditioning to drive the tachometer indicator. The output signal from the other monopole (No. 2) is directed to the speed control. Its function is to maintain constant SSPU speed under varying load conditions.

Speed Switch

The speed switch, also shown in figure 7-11, receives an input signal from monopole No. 2. It produces a dc voltage output proportional to the monopole No. 2 input to close the 10, 95, and 108 percent switches. The 10, 95, and 108 percent switches energize the relays that control the SSPU start, acceleration, and overspeed functions.

The speed switch provides a signal for readout on the SSPU rpm indicator. If SSPU speed reaches 108 percent, the 108 percent switch closes. This action energizes the overspeed relay, which causes the fuel shutoff valve to close. This shutdown feature cannot be disabled by a battle override function.

Load and Speed Control

The function of the load and speed control unit is to provide constant SSPU speed. The load and speed control circuitry is housed in the local/emergency control panel. The ship's 24-volt dc battery set provides the power required for its operation.

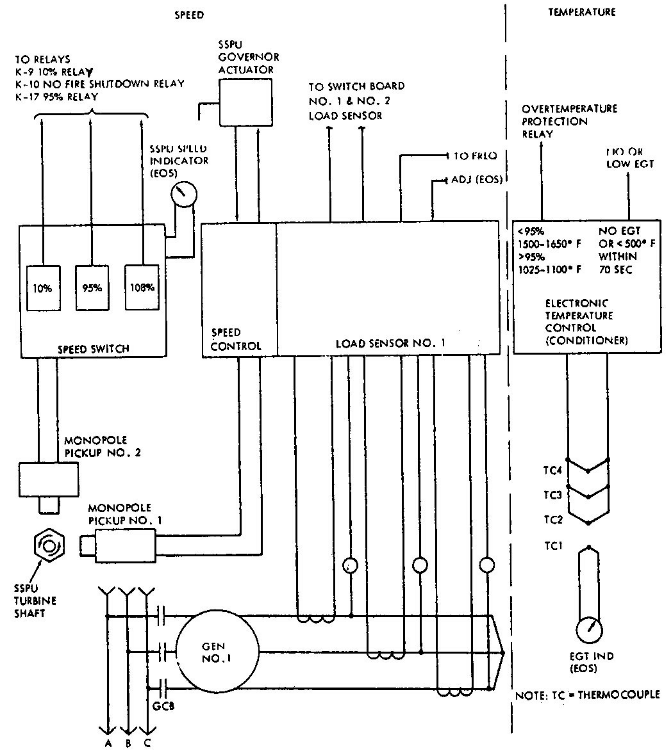


Figure 7-11.–SSPU speed control block schematic diagram.

The load and speed control unit provides constant SSPU speed for either single or parallel generator operations. The speed control receives inputs from monopole No. 1. The load control receives inputs from three current transformers and the line voltage. The output from the load and speed control unit to the governor and to the switchboards (load sensors) is not subject to change. This allows the unit to provide the desired speed and load relationship called for by the input signals to the control.

Thermocouples

The thermocouples are shown in figure 7-8. They consist of two dissimilar metals (alumel and chromel) joined together in a metal encasement.

Refer to figure 7-11. Four thermocouples, indicated as TC 1 through TC4, are installed into the SSPU exhaust duct gas stream. As a thermocouple is heated, a voltage is produced that is proportional to the heat to which the thermocouple is exposed. A 1-millivolt output from one thermocouple (TC1) is used by the exhaust gas temperature indicator (EGT IND). The other three thermocouples (TC2, TC3, and TC4) are paralleled for electronic temperature control.

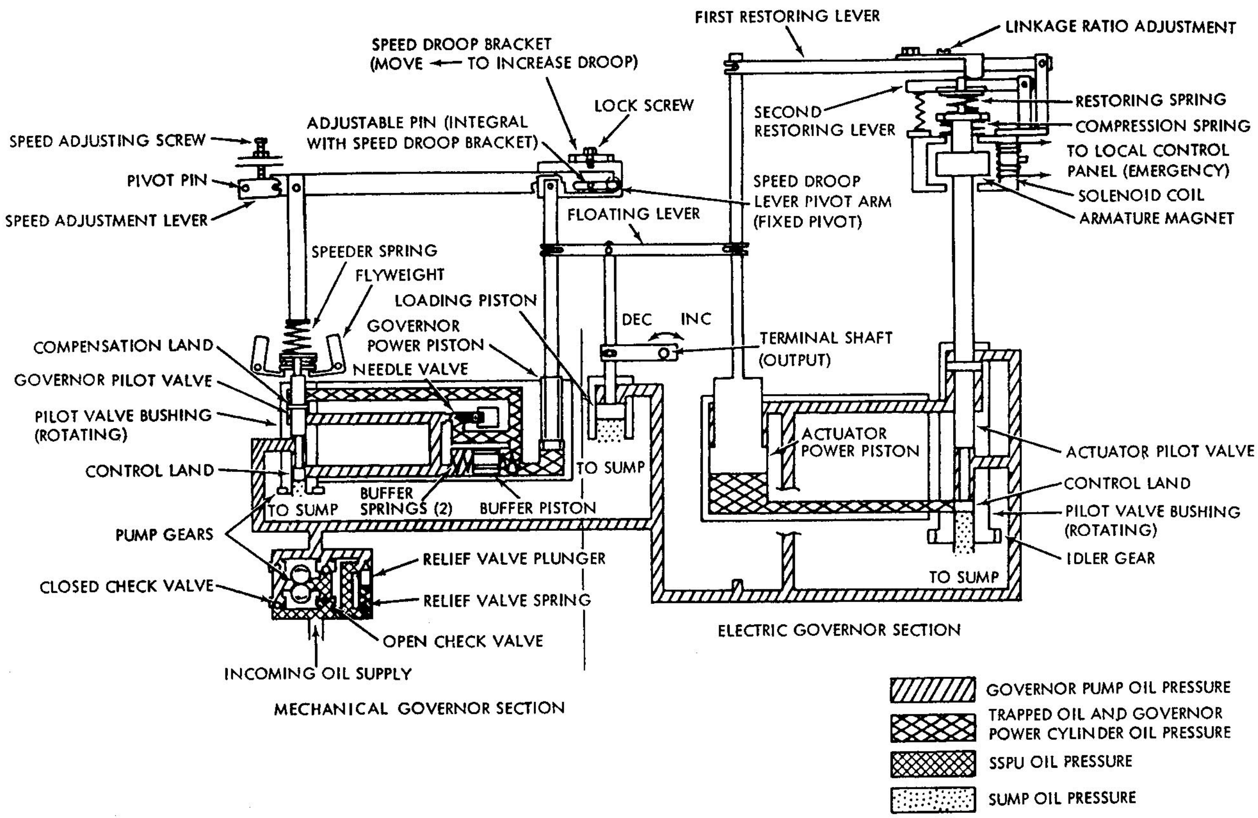


Figure 7-12.–Governor actuator assembly showing mechanical and electrical control sections.

Electronic Temperature Control

The ETC, also shown in figure 7-11, receives an electrical signal from the thermocouple unit and automatically controls the overtemperature protection circuit during SSPU acceleration and operation. When exhaust gas temperature reaches 1,575 ± 75°F during acceleration, the overtemperature protection relays are energized, causing the fuel shutoff valve to close. The normal run operation overtemperature shutdown limit is l,025°F to 1,100°F. The battle override function will disable this shutdown feature.

Governor Actuator

The various components of the governor actuator and their relative locations are shown in figure 7-12. The governor actuator is driven by the gearbox assembly. A mechanical linkage connects the governor to the fuel control valve.

The governor actuator consists of two controlling sections: (1) the mechanical (centrifugal) control section and (2) the electric control section. As you read the following paragraphs, try to visualize how the components in both sections work, along with the droop feature, to accommodate load and speed requirements. Notice also how the principles of operation we similar for both sections. Let's first look at the electric governor section.

ELECTRIC GOVERNOR SECTION.– The main components of the electric governor section include the governor terminal shaft, loading piston, actuator power piston, actuator pilot valve, restoring spring, solenoid coil, and armature magnet assemblies. Study the electric governor section in figure 7-12 (right side) and locate these components as you read the following paragraphs.

Governor Terminal Shaft.– In figure 7-12, the governor terminal shaft is located to the extreme left of the electric section (center of fig. 7-12). Its function is to position the fuel control valve for the desired fuel flow. During starting, the governor terminal shaft positions the fuel control valve for maximum fuel flow. During steady state (governed) speed, it positions the valve to decrease the rate of fuel flow.

Loading Piston.– In figure 7-12, the loading piston is located to the immediate left of the governor terminal shaft. The role of the loading piston is to rotate the governor terminal shaft. This rotation causes the governor terminal shaft, through linkage, to position the fuel control valve for the desired fuel flow. Oil from the SSPU lube oil system is supplied to the governor oil pump gears through check and relief valves. The resulting oil pressure forces the loading piston up. As the loading piston moves up, the governor terminal shaft, through linkage, positions the fuel control valve to decrease the rate of fuel flow. A decrease in oil pressure causes the loading piston to move downward, causing the governor terminal shaft to position the fuel control valve to increase the rate of fuel flow.

Actuator Power Piston, Pilot Valve, and Restoring Spring.– Along with the actuator pilot valve and the restoring spring, the actuator power piston plays an important role in the relationship between the SSPU speed and the speed control signal. (See fig. 7-12.)

When the SSPU speed increases, the speed control signal decreases. The restoring spring raises the actuator pilot valve, causing the oil under the actuator power piston to drain back to the SSPU oil sump. The resulting change in oil pressure causes the loading piston and the actuator power piston to move downward. As both pistons move downward, the terminal shaft rotates and positions the fuel control valve to decrease the fuel flow. While both pistons are moving down, the load on the restoring spring begins to increase. (The load is created by the force of the first restoring lever pushing down on the second restoring lever.) The actuator power piston continues to move downward until the restoring spring force offsets the speed control signal. When the actuator pilot valve is centered, movement of both the actuator power piston and the terminal shaft will stop. These events work in reverse when the SSPU speed decreases and the speed control signal increases.

Actuator Pilot Valve, Armature Magnet and Solenoid Coil.– Locate the actuator pilot valve, armature magnet, and solenoid coil in the electric governor section of figure 7-12. The main function of the actuator pilot valve is to control oil flow to the actuator power piston. An armature magnet is connected to the actuator pilot valve. This magnet is suspended in a field flux created by the solenoid coil. The solenoid coil receives electrical signals from the SSPU speed control unit.

During steady-state speed, the speed control signals will tend to center the actuator pilot valve. When the actuator pilot valve is centered, no oil will flow to the actuator power piston and movement of both the actuator power piston and the governor terminal shaft will stop.

MECHANICAL (CENTRIFUGAL) GOVERNOR SECTION.– The mechanical governor section is shown in the left side of figure 7-12. The main components in the mechanical governor section are the governor power piston, governor pilot valve, speeder spring, flyweights, buffer piston, compensation land, and needle valve assemblies. As we discuss each of these components and their functions, notice how the principles of operation are similar to those of the components in the electric governor section.

Governor Pilot Valve.– The role of the governor pilot valve is to control the oil flow to and from the governor power piston. The description in the following paragraph of how the governor pilot valve and governor power piston work should give you abetter idea of how the governor actuator unit, through linkage, controls the required fuel flow.

Governor Power Piston, Flyweights, Speeder Spring, and Buffer Piston.– Two opposing forces move the governor pilot valve: (1) the speeder spring force tends to push the valve down; (2) the centrifugal force of the rotating flyweights tends to force it up.

During steady-state speed, the governor pilot valve will tend to remain centered. No oil will flow, of course, when the pilot valve is centered. However, when the speeder spring setting is slightly higher than that of the actuator, the valve will not center and the resulting oil pressure will hold the power piston against its stop.

At steady-state speed, the actuator pilot valve is centered. When a load is applied, the SSPU speed and governor speed decrease. The speeder spring force is now greater than the force of the flyweights, so the pilot valve is now pushed down by the speeder spring. When pressure oil flows to the buffer piston, it moves towards the power piston. The oil displaced by the buffer piston forces the power piston up, the loading piston rises, and the terminal shaft rotates to increase fuel to meet the new load demand. When the fuel requirement is met, the terminal shaft and power piston movement stop. Then, the pilot valve centers and the SSPU speed increases to normal speed, thereby decreasing the force of the flyweights.

Compensation Land and Needle Valve Assemblies.– Centering of the pilot valve is aided by differential pressure created across the compensation land by the action of the needle valve. As the power piston moves upward, the needle valve orifice starts to displace the oil pressure created by the movement of the buffer piston, and soon equalizes the oil pressure above and below the compensation land. his oil displacement is proportional to the return of normal SSPU speed. Once the oil pressure is equalized, the buffer spring force recenters the buffer piston.

Now, picture the operation of all the mechanical section components in reverse. As the SSPU load decreases, the flyweights begin to move outward, causing the governor pilot valve to rise. The oil on the left side of the buffer piston drains to the oil sump, thereby causing both the loading piston and the power piston to move down. Once the fuel requirement is met, movement of both the loading piston and the power piston will stop, and the governor pilot valve will recenter.

Speed Droop Function.– The speed droop function divides and balances loads between the SSPUs. The speed droop function is automatic when both generators are operating in parallel and driving a common load.

The governor power piston, through linkages, creates the speed droop function. The linkage mechanism varies the speeder spring loads. The linkage assembly has an adjustable pin that is integral with the speed droop bracket. (See fig. 7-12.) Any movement of the power piston will cause a change in the position of the adjustable pin. The changed position of the adjustable pin, in turn, will determine the change in speeder spring force. No change occurs when the speed adjustment lever pivot pin and the adjustable pin are on the same center line. As the adjustable pin moves from the center line, however, the speeder spring force will change accordingly.

During electric governor control, the power piston will be in the maximum fuel flow position. This position will be maintained throughout all load conditions. Therefore, the speed droop function will be inoperative during electric governor control. During governor actuator control, the speed droop linkage will not alter the speeder spring force.

LUBRICATION SYSTEM

The lubrication system for the Garrett ME-831-800A is a full pressure, wet sump type. This system provides lubricating oil to the SSPU bearings, gear meshes, and shafts. It also provides lubrication to the ac generator and the load compressor.

The capacity of this oil system is 7.8 gallons. The lower part of the gearbox forms the oil sump, which is equipped with a filler cap and dipstick for servicing.

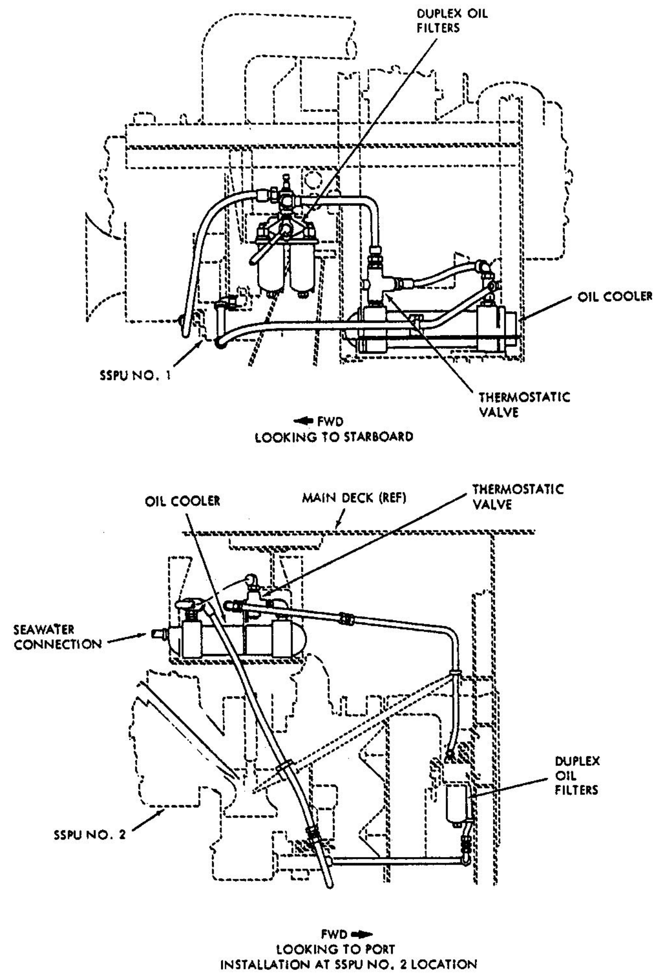


Figure 7-13.–Oil cooler, duplex oil filter, and thermostatic valve installation.

Cooling for the Garrett's lube oil is provided by a seawater type of oil cooler, such as the one shown in figure 7-13. The cooler is equipped with a thermostatic bypass valve.

The Garrett's lubrication system is composed of the following major units:

- Oil pump
- Oil filter assembly
- Oil inlet (filter) screen
- Oil manifold assembly
- Oil cooler
- Thermostatic valve
- Gearbox vent valve
- Duplex oil filter assembly
- Oil sample valve

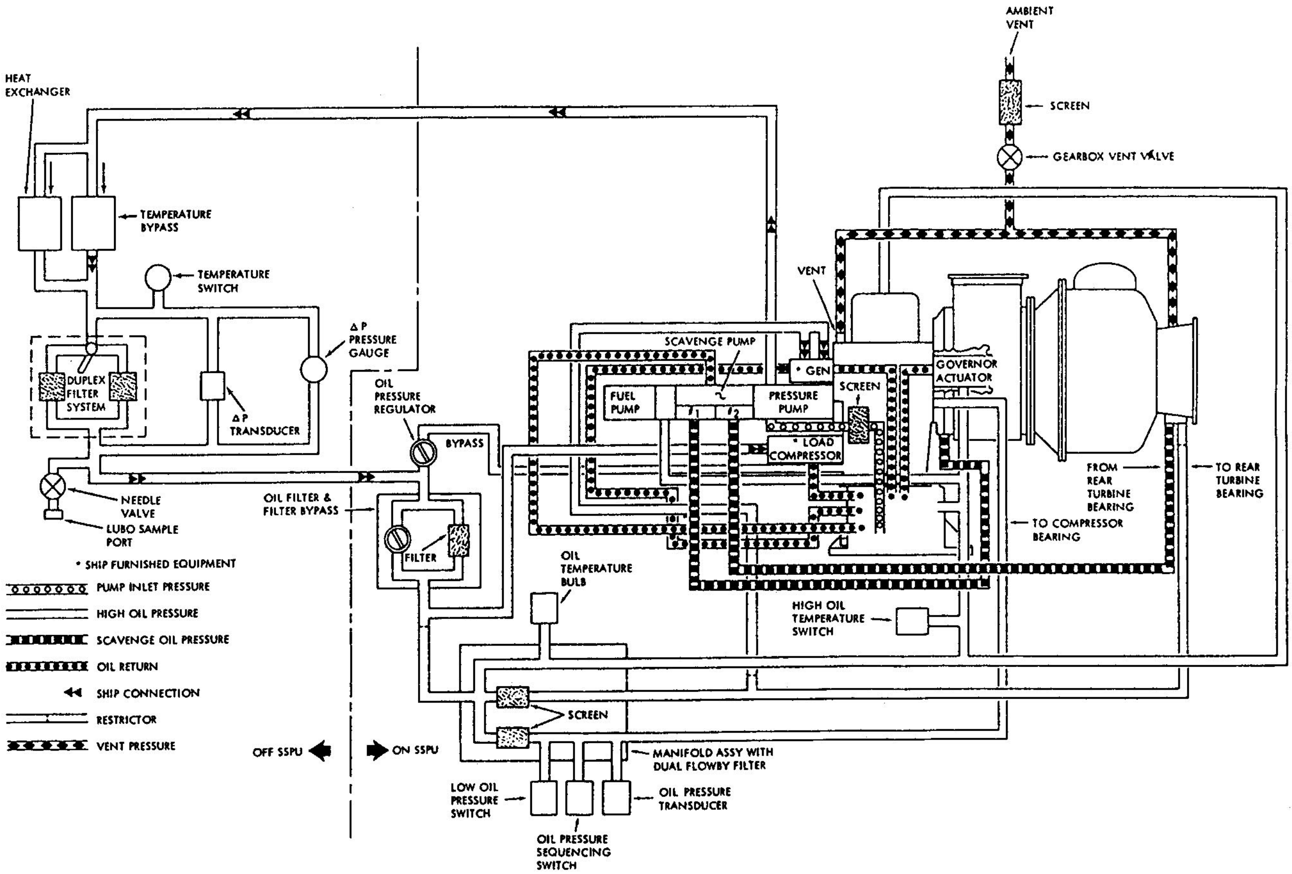


Figure 7-14.-Garrett lubrication system.

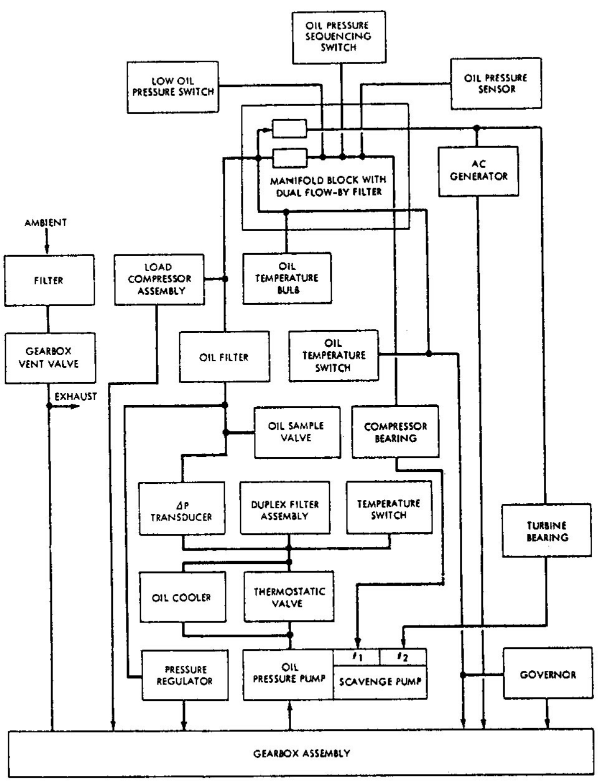


Figure 7-15.–Garrett lubrication system block diagram.

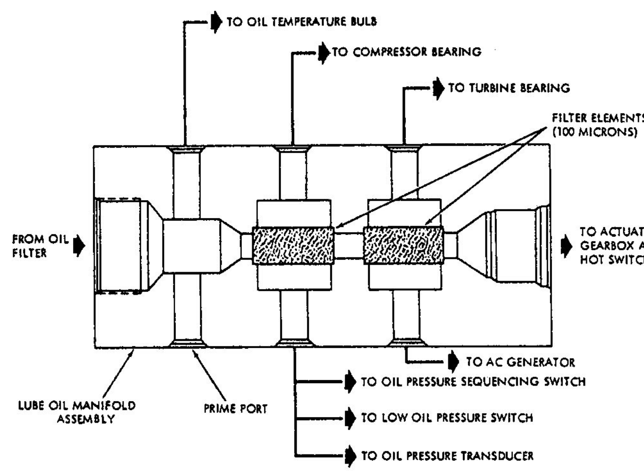


Figure 7-16.–Garret lube oil manifold assembly showing oil flow.

These components are shown in figures 7-14 through 7-17. Refer to these figures as we discuss the Garrett lube oil system's components and their functions.

Oil Flow

First, locate the oil pump and suction tube in figure 7-14. The oil pump uses the suction tube to pickup the oil. A screen in the suction tube filters the oil before it enters the pump. From the pump, the oil flows through

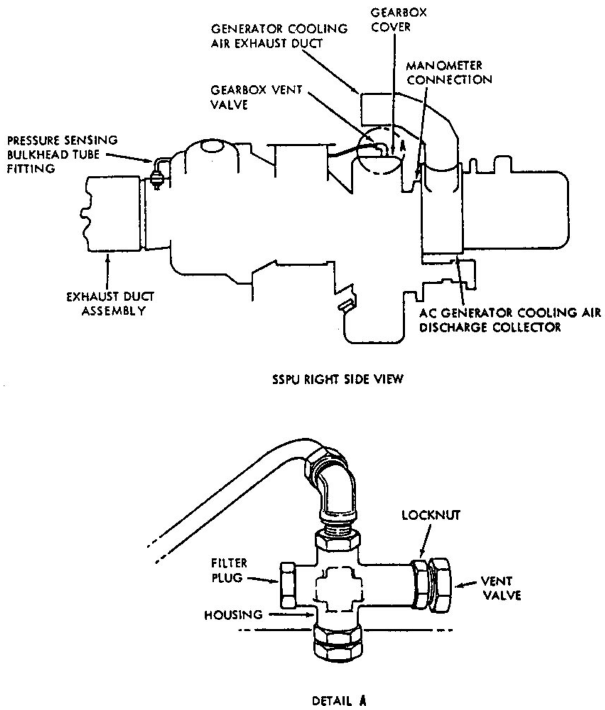


Figure 7-17.–Gearbox vent valve.

the cooler, the thermostatic bypass valve, and the duplex oil filter to the pressure regulator. During steady-state speed, the pressure regulator maintains the oil pressure at 95 ± 15 psig and the oil temperature at 160°F. From the oil pressure regulator, the oil flows to the oil filter assembly. At this point, relief oil is returned to the sump from the oil pressure regulator and the filtered oil flows to the oil manifold assembly. From the oil manifold assembly, the oil flows to the load compressor, turbine bearings, ac generator, governor, gearbox assembly, and fuel pump spline.

Now that you have traced the oil flow and read how these components work together, let's look more closely at the individual components, starting with the oil pump.

Oil Pump

The oil pump consists of an oil pressure pump and a dual-inlet scavenge pump. (See figs. 7-14 and 7-15.) Both pumps are driven by a common shaft.

OIL PRESSURE PUMP.– The oil pressure pump is a positive-displacement pump that supplies oil under pressure to all bearings, major gear meshes, and shafts. It also supplies oil under pressure to the ac generator, load compressor, governor, and fuel pump shaft. At governed speed, minimum flow from the pump is 20.8 gallons per minute.

DUAL- INLET SCAVENGE PUMP .– At governed speed, the positive-displacement, dual- inlet

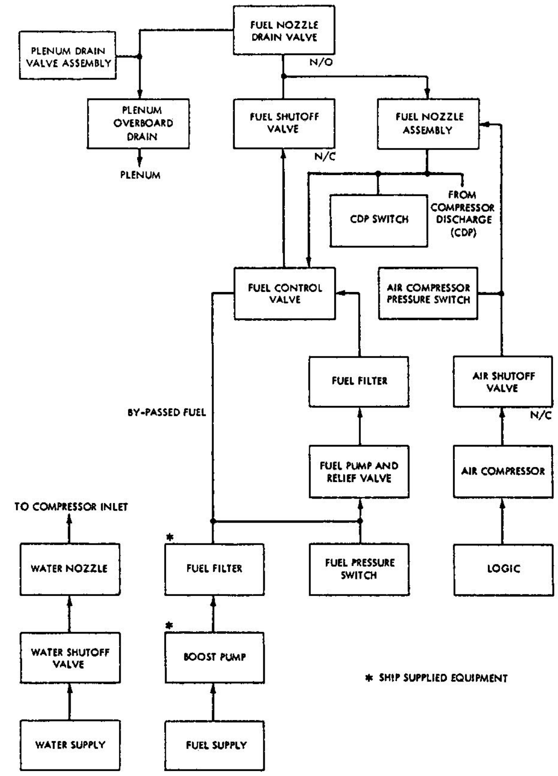


Figure 7-18.—Fuel, air, and water system block diagram.

scavenge pump has a minimum flow of 13 gallons per minute. The compressor and turbine bearings are scavenged separately by this pump.

Oil Filter Assembly

The function of the oil filter assembly is to remove foreign materials from the oil. The filter element is a high-pressure, 10-micron replacement type. This oil filter assembly also includes a bypass valve to bypass oil around the filter if the filter element should become blocked. The filter assembly also has an indicator to show you when the filter is contaminated. Before raising the indicator, however, you must make certain that the differential pressure in the unit is 50 psid.

Oil Inlet Filter Screen

As mentioned earlier, the oil inlet filter screen is a wire-mesh screen installed in the oil pump suction tube. This screen prevents foreign material from entering the pump and pressure regulator.

Lube Oil Manifold Assembly

As shown in the oil flow pattern illustrated in figure 7-16, the lube oil manifold assembly is installed downstream from the oil filter assembly. The manifold

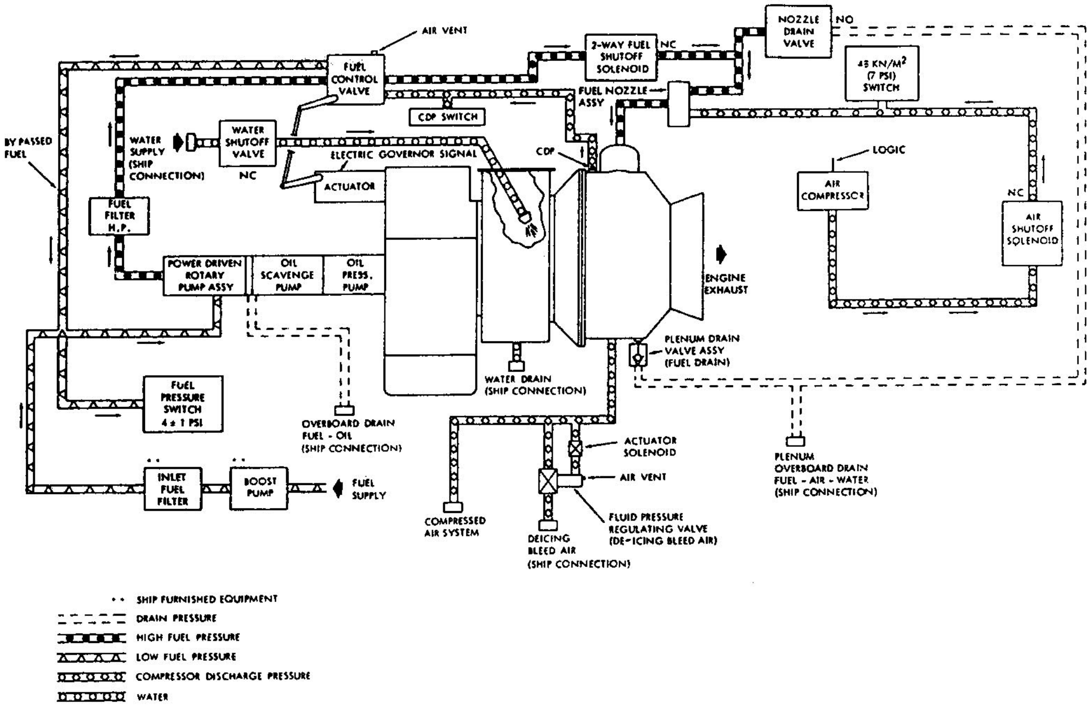


Figure 7-19.–Fuel, air, and water system schematic.

provides mounting for the oil temperature and oil pressure sensors.

The manifold assembly consists of a dual flow-by filter. Each filter is a self-cleaning, 100-micron, wire-mesh element.

Oil Pressure Regulator

Refer to the oil pressure regulator shown in figure 7-8 (end view). This oil pressure regulator is an adjustable valve type. The adjustable spring pressure forces the valve closed. When oil pressure exceeds spring pressure, the valve opens. At governed speed, the oil pressure regulator maintains the oil pressure at 95 ± 15 psig by relieving the excess oil back to the sump.

Oil Cooler

Locate the oil cooler in figure 7-13. The function of the oil cooler is to use seawater flow to maintain the desired lubricating oil temperature.

Thermostatic Valve

The thermostatic valve is mounted on the oil cooler, as shown in figure 7-13. This valve maintains the oil temperature at 160°F by permitting the oil to either bypass or flow through the oil cooler. When the oil temperature is above 170°F, the thermostatic valve will not open below 75 psig.

Gearbox Vent Valve

Proper SSPU lubrication depends on a balanced air pressure level within the system. The role of the gearbox vent valve is to help maintain this balanced air pressure level.

The gearbox vent valve is shown in figures 7-14 and 7-17. This removable valve is installed on the gearbox cover. It can be adjusted to maintain -2 to -4 inches of water within the system. A filter in the vent valve housing filters the vent air pressure. Gearbox venting is through the tailpipe connection.

Duplex Oil Filter Assembly

The duplex oil filter assembly is shown in figures 7-8 and 7-13. The duplex filter system receives oil from the output of the heat exchanger. The system is equipped with a diverter valve that directs the oil through the selected filter element. The system provides continuous flow and filtration through one unit while servicing the other. An oil sampling connection is also provided on the downstream side of the assembly. The needle valve in this connection allows for either static or operational sampling.

FUEL SYSTEM

The Garrett's fuel system automatically regulates fuel flow to maintain constant speed. Study the fuel system sections in figures 7-18 and 7-19 as we describe the fuel flow pattern.

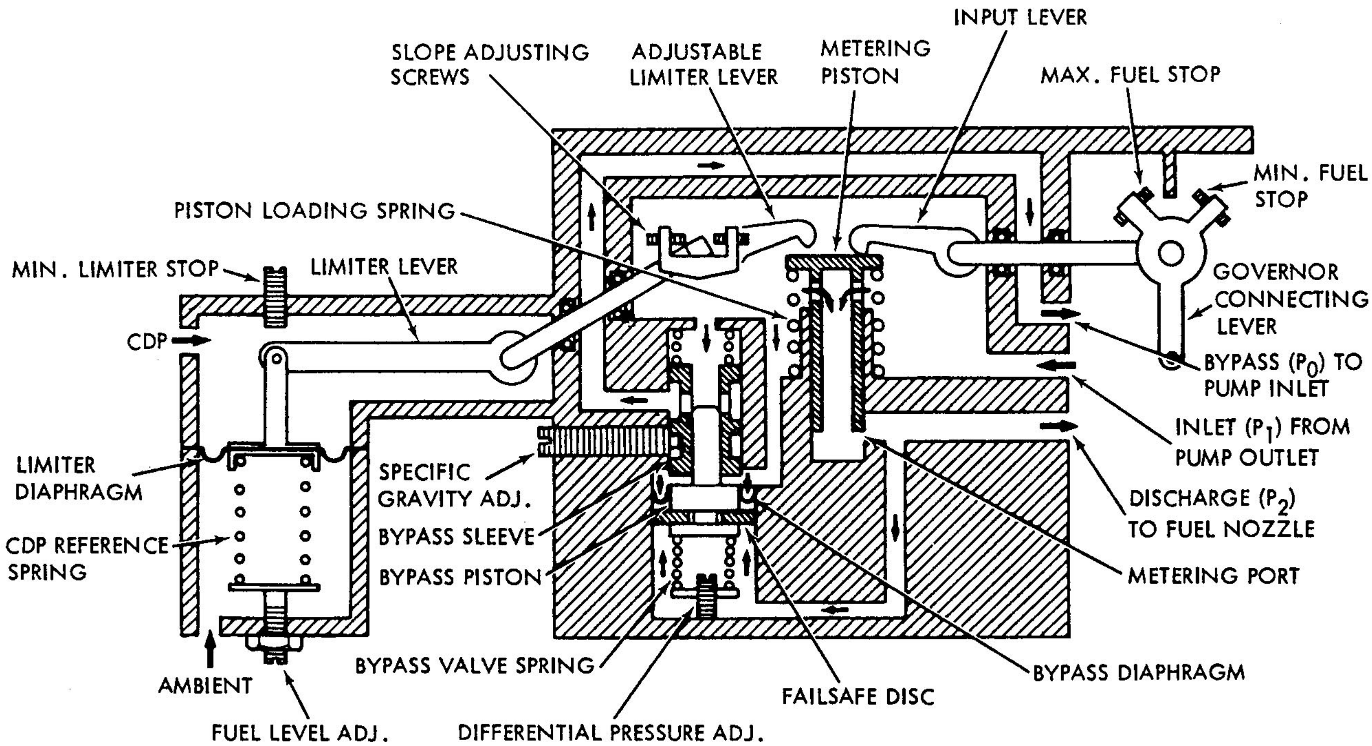


Figure 7-20.–Fuel control functional schematic diagram.

From the ship-mounted boost pump and inlet filter, the fuel flows to the fuel pump. From the fuel pump, the fuel under pressure flows to the filter assembly, then to the fuel control valve. The fuel control valve meters the fuel flow and directs it to the fuel nozzle assembly. The fuel is then sprayed into the combustion liner assembly.

The following major units make up the Garrett's fuel system:

- Fuel pump
- Fuel filter assembly
- Fuel control valve
- Fuel shutoff valve
- Fuel nozzle assembly
- Fuel nozzle drain valve
- Plenum drain valve assembly
- Air assist system (air compressor and the air shutoff valve)

Let's briefly look at each of these units.

Fuel Pump

The fuel pump is a positive-displacement pump that is mounted to the oil pump assembly and it is driven through a splined shaft. This shaft is lubricated prolong spline life. The pump output pressure controlled by a relief valve, which is set to lift to is at 500 ± 25 psig. During governed speed operation, excess fuel flow is bypassed back to the fuel pump inlet by the fuel control valve.

Fuel Filter Assembly

The fuel filter assembly removes contaminants from the fuel before the fuel enters the fuel control valve. The fuel filter assembly also protects downstream components in case of a fuel pump failure. The filter element is a 10-micron replaceable type.

Fuel Control Valve

The role of the fuel control valve is to meter fuel for combustion under all operating conditions. Metered fuel flow is directed from the fuel control valve to the fuel nozzle assembly, where it is then sprayed into the combustion liner assembly.

The fuel control valve meters fuel flow during starting, acceleration, steady-state speed, and all load change operations. During acceleration, fuel flow metering is a function of CDP and ambient pressure. During steady-state speed, fuel flow is controlled by the governor through a mechanical linkage.

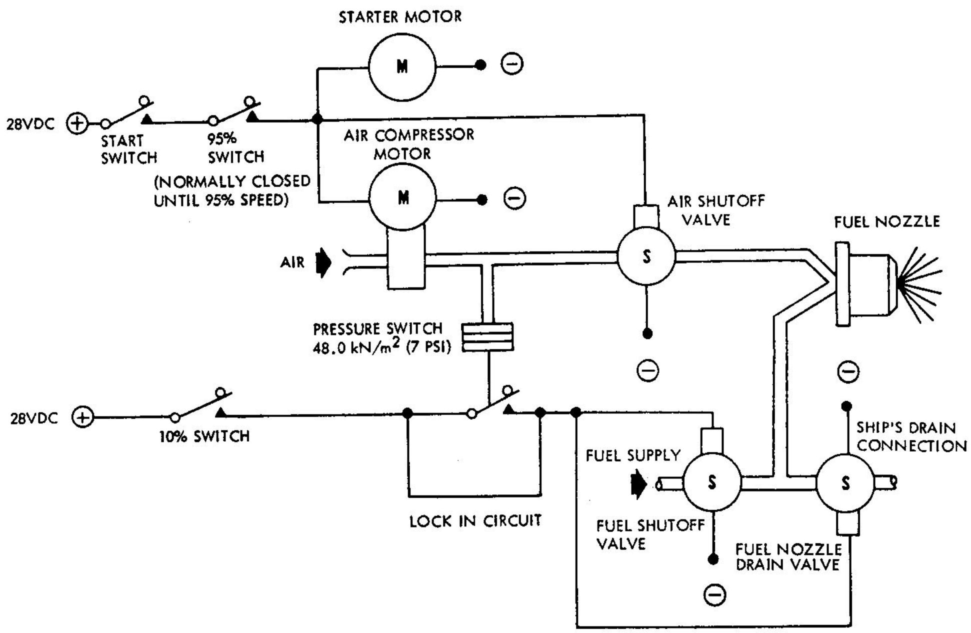


Figure 7-21.–Air assist system.

Figure 7-20 shows the fuel control components in their relative positions. During initial start, the metering piston is in the minimum fuel flow position for 15 seconds. The limiter lever tends to hold the piston in the start position by spring force. As the compressor discharge pressure increases with speed and begins to overcome the limiter spring force, the limiter lever moves the metering piston toward the fully open position. This action continues until governor speed is reached. At governed speed, the governor controls fuel flow (P_2) by the governor connecting lever.

Fuel (P_0) that is not required to maintain governed speed is bypassed to the fuel pump inlet. This function is provided by the bypass piston and valve spring. Fuel flow adjustments on fuel control valve are as follows:

- Fuel lever (start acceleration adjustment)
- Specific gravity
- Minimum limit stops (acceleration adjustment)
- Maximum and minimum fuel stops

Fuel Shutoff Valve

The fuel shutoff valve is a normally closed, two-way valve. When the valve is open, fuel is directed to the fuel nozzle assembly.

Fuel Nozzle Assembly

The fuel nozzle assembly, as shown in figure 7-8, is an air-assist, air-blast type. It is mounted on the combustion chamber cap.

Fuel Nozzle Drain Valve

The fuel nozzle drain valve, shown in figure 7-8, is normally open, allowing the fuel nozzle assembly and line to drain during shutdown. This valve is energized closed during start at 10 percent speed and remains closed until shutdown.

Plenum Drain Valve Assembly

The plenum drain valve assembly, also shown in figure 7-8, is a spring-loaded, open-type valve. It allows fuel, air, and water to drain from the turbine plenum. The compressor discharge pressure is used to close the valve during turbine operation.

Air Assist System

The air assist system is shown in figure 7-21. The main components of this system include an air compressor and an air shutoff valve. The 24-volt dc air compressor supplies compressed air to the fuel nozzle assembly to aid in fuel atomization. The unit is de-energized automatically at 95 percent turbine speed.

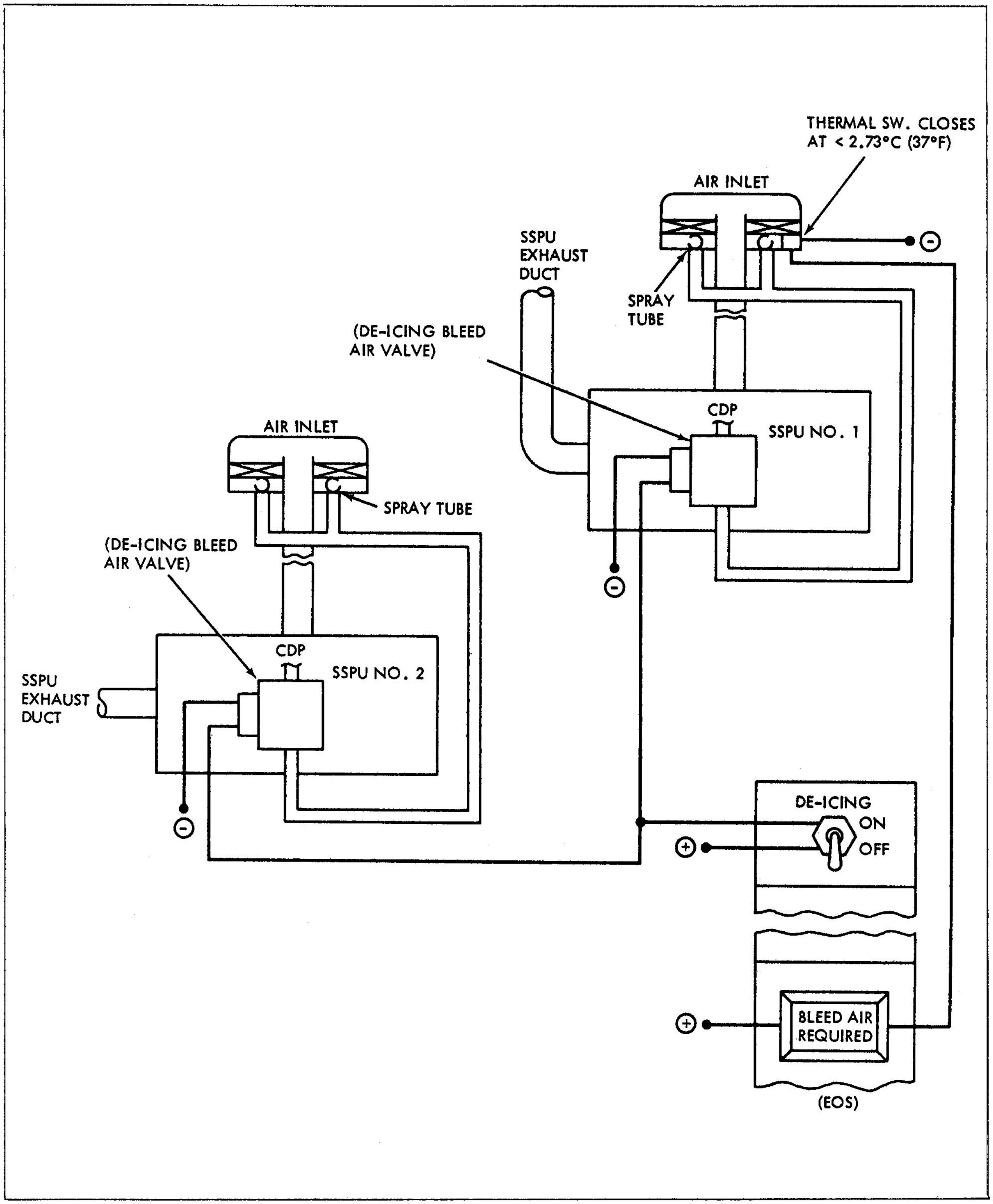


Figure 7-22.—Bleed air (de-icing) system.

The air shutoff valve is opened to direct air to the fuel nozzle assembly to assist in fuel atomization. The valve remains open until the 95 percent turbine speed switch de-energizes the air compressor, then the valve closes.

The air compressor switch closes when air compressor pressure is 7 psi. This allows the fuel shutoff valve to open and the fuel nozzle drain valve to close and lock in the circuit.

WATER WASH SYSTEM

The water wash system removes salt deposits from the compressor's internal parts. The system sprays wash water solution into the compressor turbine plenum. The used solution is then expelled from the exhaust. As shown in figure 7-8, a water shutoff valve is mounted on the SSPU. The wash water solution is supplied from a ship shore connection at a pressure of 30 psi. A ship-mounted water shutoff valve is located next to the SSPU. The wash switch, located in the EOS, controls the water shutoff valve.

The water spray nozzle is mounted in the turbine inlet plenum. It consists of an orifice and a whirl plate. This design generates a turbulence within a whirl chamber, causing water wash solution to spray into the compressor inlet. The flow rate through the nozzle is 3.5 gallons per minute at 30 psi inlet pressure.

To operate the wash system, place the wash switch in the ON position. This opens the water shutoff valve and deactivates the fuel and ignition systems. Then, position the START-RUN-STOP switch to the RUN position to energize the starter. At 20 percent turbine speed, the ship-mounted water shutoff valve should be manually opened to allow wash water to flow through the water spray nozzle. The starter automatically de-energizes after 60 seconds. When the starter de-energizes, the water wash switch is positioned to OFF. The manually operated water valve is also closed. For rinsing, this procedure is repeated using fresh water. Afler the rinse is completed, the SSPU should be operated for 5 minutes.

BLEED AIR (DE-ICING) SYSTEM

The bleed air system prevents icing in the air inlet ducts. The system works by directing compressor discharge pressure from the turbine plenum into the ship's air inlet demisters.

At the onset of an icing condition, the thermal switch closes at 37°F, completing the circuit to the BLEED AIR REQUIRED warning light located on the SSPU control module assembly. The warning light alerts the operator to the icing condition. The operator then places the DE-ICING switch located on the SSPU wash and de-icing module assembly in the ON position. This switch energizes the de-icing bleed air valve OPEN, directing compressor discharge pressure to the spray tubes in the air inlet demisters. (See fig. 7-22.) The hot compressor discharge pressure raises the inlet air temperature. When icing conditions no longer exist, the thermal switch opens and the BLEED AIR REQUIRED warning light extinguishes. The operator then positions the DE-ICING switch to OFF, closing the de-icing bleed air valve.

The de-icing bleed air valve is spring-loaded closed and electrically actuated open. When placed in the ON position, the DE-ICING switch on the EOS wash and de-icing module assembly sends a 24-volt dc signal to open the de-icing bleed air valve. When the valve opens, the compressor discharge pressure is directed to the ship's air inlet demisters to start the de-icing process in the air inlet ducts.

Now that you have read about the Garrett SSPU found on the PHM-class ships, let's look at the Sunstrand T-62T-40-7 auxiliary power unit (APU) found on the LCACs. In chapter 6, you were given an overview of this prime mover. In the following section, we will present additional information that you, the GSM, should be aware of concerning this important engine.

SUNSTRAND T-62 APU

The T-62T-40-7 APU used on the LCACs is manufactured by the Sunstrand Corporation. Mounted both port and starboard on the LCAC-class ships, the Sunstrand T-62 APU provides electrical power and bleed air for main engine starting. In chapter 6, we provided an overview of this APU. In this chapter, we will take a closer look at this important unit.

CONSTRUCTION AND DESIGN

The Sunstrand T-62T-40-7 APU system installed on the LCAC-class ships consists of two GTGSs, two GCUs, an electronic sequencing unit (ESU), a relay (K1), two current transformers, and two built-in test equipment (BITE) annunciator box assemblies.

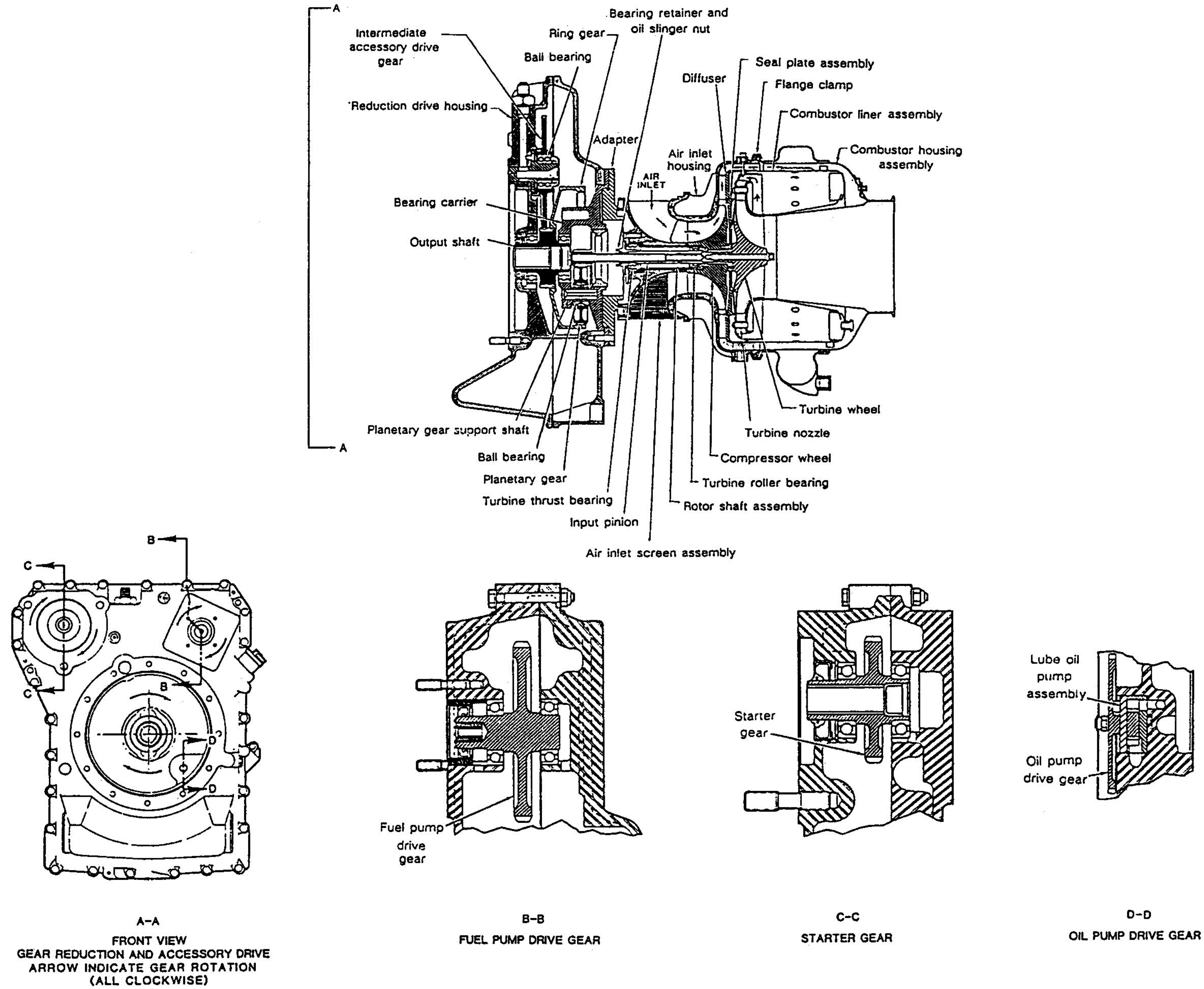


Figure 7-23.–Basic internal components of the Sunstrand APU.

Gas Turbine Generator Set

The basic internal components of the Sunstrand's GTGS are shown in figure 7-23. There are two GTGSs on the LCAC; one mounted port, the other mounted starboard. These sets are mounted in modules within plenum compartments.

COMPONENTS AND DESIGN.– Each GTGS consists of an ac generator, air inlet housing, combustor assembly, turbine assembly, and reduction gear drive assembly. Filtered air within the plenum compartments is used for turbine inlet combustion air and generator cooling.

Enclosure Assembly.– An enclosure assembly houses each GTE and provides mounting for the turbine, exhaust connections, ship's pipes and drain connections, and electrical connections. Access doors on the enclosure provide for access to the gas turbine components and enable inspection and maintenance.

Generator.– The generator is a 120/208-volt, 400-Hz, 60-kW ac generator. The GTE is a radial-flow, 150-horsepower, single-stage turbine, coupled gas turbine.

Control Components.– The control components for each GTGS are mounted in a controls enclosure located in a compartment below the GTGS. (This location is on both port and starboard sides.)

The control components consist of a GCU, an ESU, and a K1 relay. The gas turbine is controlled and monitored by the ESU. The ESU contains all the logic circuitry to start, control, monitor, and shutdown the gas turbine. The APU speed is monitored at the craft's alarm and monitoring system. The ESU provides the signals to this system.

The GCU controls the operation of the generator. It provides voltage regulation, controls output voltage, and protects the generator from overvoltage, undervoltage, underfrequency, overfrequency, and fault current. Relay K1 (port and starboard sides) is a generator protective device that opens and disconnects the generator when a fault is sensed by the ESU.

Current Transformer.– A current transformer, located on both port and starboard sides, provides feeder fault protection for the generator. It will sense a short between the generator and any of its line contacts. If a short exists, the current transformer will disconnect the generator.

BITE Annunciator Box Assemblies.- The BITE annunciator box assemblies are located in the port and starboard sides of the craft. The BITE box is an indicator unit that receives gas turbine status signals from the ESU. The BITE display identifies probable causes of GTE shutdown.

Gas Turbine Engine

The Sunstrand T-62T-40-7 engine is a radial-flow, 150-horsepower, single-stage compressor, single-stage turbine, coupled gas turbine unit. Figure 7-24 provides several views of this unit. The top and one side are shown in view A. The front and rear are shown in view B.

The Sunstrand T-62T-40-T consists of the following major units:

- Compressor
- Combustor
- Turbine
- Gear reduction drive

In the following paragraphs, we will briefly discuss the Sunstrand and its associated equipment, including the electrical control devices, accessories, and piping. Let's first start with the air inlet housing.

AIR INLET ASSEMBLY.– The air inlet housing is a contoured, cylindrical casting with forward and aft flanges. The forward flange is bolted to an adapter, which is bolted to the aft end of the reduction drive housing. The aft end of the air inlet housing is externally flanged to permit attachment of the combustor assembly. The air inlet housing thus serves as a rigid member between the reduction drive assembly and the combustor assembly. An air inlet screen assembly covers the intake portion of the housing.

ROTOR ASSEMBLY.– The rotor assembly consists of a rotor shaft, single-stage centrifugal compressor wheel, radial-inflow turbine wheel, bearing retainer and oil slinger nut, spacer, forward ball bearing, and aft roller bearing. The rotor shaft is mounted on bearings within a sleeve in the bore of the air inlet housing. The single forward ball bearing resists thrust and radial loads, while the aft roller bearing resists radial loads only. The forward ball bearing is held in position by a retainer plate and an oil slinger nut.

COMPRESSOR WHEEL ASSEMBLY.– The compressor wheel shoulders against a flange on the aft end of the rotor shaft. Three threaded compressor bolts are inserted through the flange into the compressor wheel. These bolts maintain the alignment of the

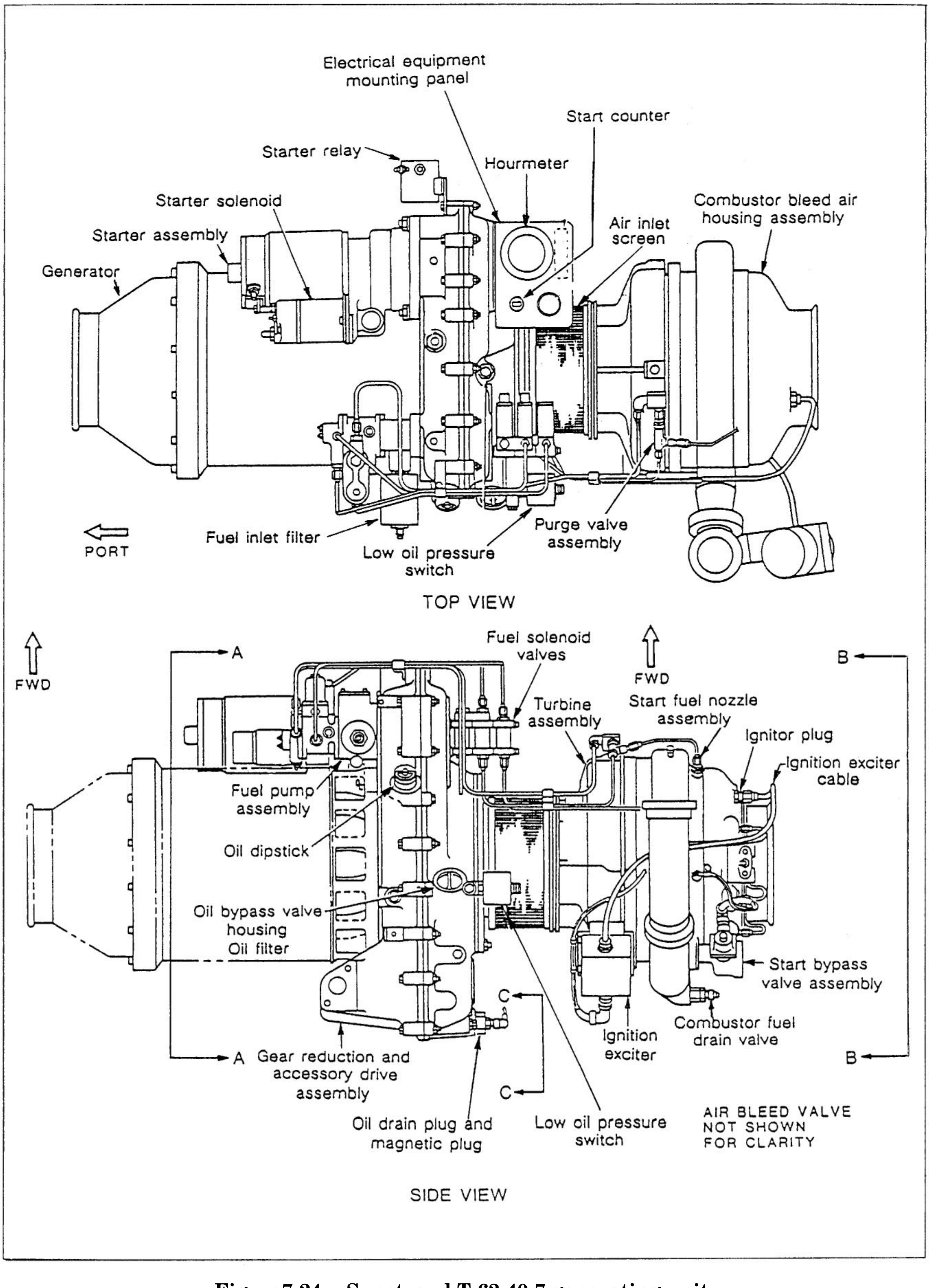
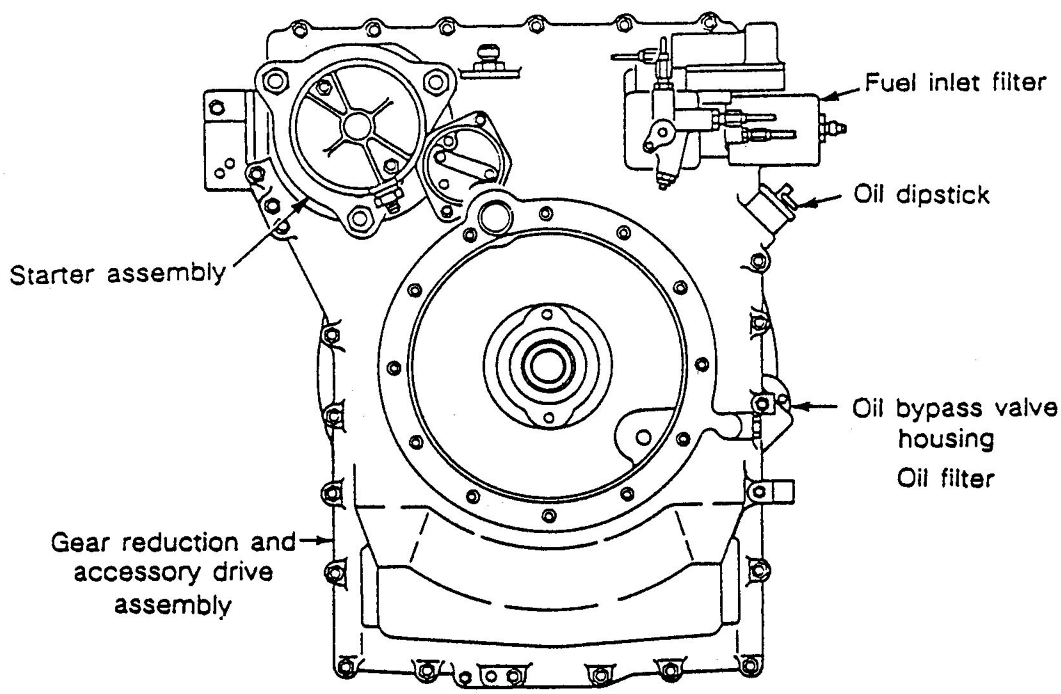
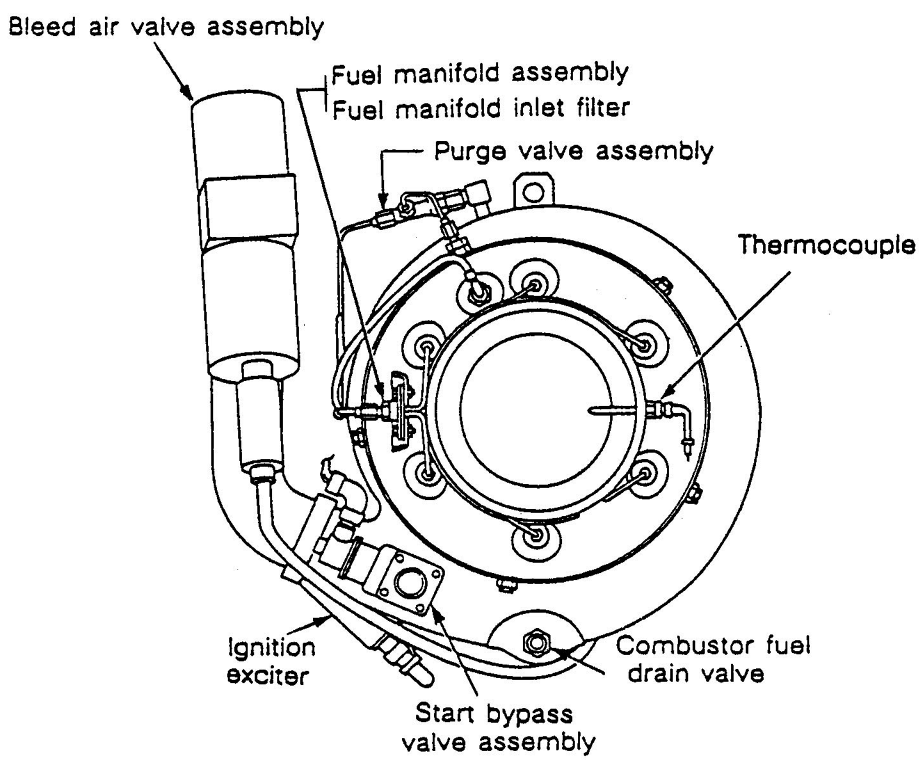


Figure7-24.—Sunstrand T-62-40-7 generating unit.



A–A
FRONT VIEW
(GENERATOR NOT SHOWN FOR CLARITY)



B–B
REAR VIEW

Figure 7-24.—Sunstrand T-62-40-7 generating unit—Continued.

compressor wheel and secure it to the rotor shaft flange. The turbine wheel is pressed onto the aft end of the rotor shaft and aligned by three dowels. A threaded bolt fastens the turbine wheel to an internally threaded plug in the aft end of the rotor shaft.

A circular, compressor-to-turbine air seal separates the compressor section from the turbine section. The seal is radially positioned on the nozzle assembly. The axial position of the seal on the rotor shaft is maintained by compressor pressure, which forces the seal against a shoulder on the turbine nozzle. The cantilevered arrangement of the rotor assembly in the air inlet housing places both the forward and aft bearings in areas of minimal temperature. Cooling and lubrication of the rotor shaft bearings are accomplished by a air-oil mist from the reduction gear and accessory drive housing, through the output pinion (within the rotor shaft), through the aft and forward bearings, and back into the gear reduction and accessory drive housing.

COMBUSTOR ASSEMBLY.– The combustor is an annular air atomizing-type. It encases the combustor liner assembly. The combustor liner is secured in the combustor housing by four locating bolts. An external flange at the forward end of the combustor housing mates with an external flange on the aft end of the turbine assembly. The combustor is secured to the assembly by a quick-release, V-type clamp (marmon) that fits over the flanges. The outer wall of the combustor liner fits snugly under the outer aft edge of the turbine nozzle assembly. The mating of the combustor housing inner wall with the aft end of the turbine nozzle assembly forms a circular exhaust duct for the flow of the exhaust gases as they leave the turbine portion of the rotor assembly and flow out of the APU. (See fig. 7-24.)

Airflow.– Intake air passes through the vanes of the diffuser, flows between the walls of the combustor housing and liner, and reverses direction to enter the burner section of the combustor. This flow of air cools the combustor housing and liner. Air is also directed between the inner walls of the combustor housing and liner; then it flows to the aft surface of the turbine nozzle assembly. Additional cooling of the turbine nozzle is accomplished by a flow of cooling air that is forced around the aft, internal edge of the diffuser, through equally spaced holes in the ring on the combustor inner liner assembly, and over the aft side of the forward plate of the nozzle assembly.

Fuel Delivery and Combustion Process.– An igniter plug, which is mounted in a boss at the aft, left side of the combustor housing, ignites the fuel-air mixture by the start fuel nozzle during a start. Fuel to the combustor is supplied through an external fuel manifold assembly. The outlet tips of the fuel manifold assembly are equally spaced around the combustor housing. The tips are swagged to form an orifice at their ends. The fuel manifold assembly provides six jets of fuel into the throats of six small venturis, which atomize the fuel at the aft end of the combustor liner. A combustor drain port in the lowest point of the combustor housing provides a drain for the fuel that might accumulate in the combustor during a false start or other malfunction.

Thermocouple.– A dual-element thermocouple is mounted in a boss at the aft, right side of the combustor housing. The function of the thermocouple is to sense exhaust temperatures. The two elements of the thermocouple are mounted on bosses at the aft, right side of the combustor housing. One element functions as an overtemperature detector. The other element functions in conjunction with the load control valve.

DIFFUSER AND TURBINE NOZZLE ASSEMBLY.- The diffuser is a circular casing consisting of 36 vanes on the outer periphery and 17 vanes on the forward face. The turbine nozzle is a brazed, matched assembly consisting of a forward circular plate and an aft circular plate. The diffuser is secured in the aft position of the air inlet housing by six threaded nozzle retaining pins. These pins pass through the diffuser and also secure the turbine nozzle assembly concentric with the rotor assembly. The turbine nozzle assembly seats against a mating of the diffuser at the fore and aft ends only (not radially).

GEAR REDUCTION AND ACCESSORY DRIVE ASSEMBLY.– The gear reduction 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.

Input Pinion Assembly.– The reduction drive input pinion drives three planetary gears that drive an internally splined ring gear. The ring gear is centrally splined to a short output shaft.

Output Shaft Assembly.– The external gear of the output shaft drives the oil pump drive gear. The internal splines of the output shaft provide for connecting the driven equipment to the engine. The aft end of the output shaft is supported by a ball bearing in the bearing carrier of the planetary gear system. The middle of the output shaft is supported by a ball bearing mounted in the forward, internal support web of the reduction drive housing.

Planetary Gear Shafts.– The forward and aft ends of the planetary gear shafts are supported by ball bearings. Within the bearing carrier housing, there is a circular bearing carrier. The circular bearing carrier is fitted and bolted in the aft face of the drive housing, which holds the six planetary gears' ball bearings in position inside the ring gear.

Intermediate Accessory Drive Assembly.– The intermediate accessory drive gear is mounted on the gear support shaft in the forward, upper end of the reduction drive housing. The gear shaft is supported by a double-row ball bearing.

The accessory drive is the upper portion of the reduction drive assembly. The output shaft transmits power through the intermediate gear to the fuel pump drive and starter gears, which convert the reduction output speed to 6,000 rpm. This is the speed required to drive the APU's accessories.

Fuel Pump and Starter Gears.– The fuel pump gear operates at 4,200 rpm. When the starter is 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 starting torque to the GTE.

These gears are mounted on shafts supported by ball bearings within the accessory drive portion of the reduction drive housing. The gears and bearings are lubricated by an air-oil mist from the reduction drive assembly. To prevent leakage of the air-oil mist, seals are mounted in the reduction drive housing at the ends of the output shaft, fuel pump drive, and starter gears. The fuel pump and engine acceleration control, which is mounted in tandem with the fuel pump, is mounted on the left forward pad of the reduction drive assembly. The starter assembly is mounted on the right forward pad.

SYSTEMS

In the next sections, we will look at the following operating systems of the Sunstrand T-62:

- Fuel system
- Lubricating oil system
- Air system
- Electrical system

In the following paragraphs, we will provide a brief description of each of these systems. For additional information, we recommend you consult the appropriate technical manuals.

Fuel System

The Sunstrand's fuel system, shown in figures 7-24 and 7-25, 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 Sunstrand's fuel system consists of the following main components:

- Inlet fuel filter
- Fuel pump
- Start, main, and maximum fuel solenoid valves
- Start fuel nozzle
- Purge valve
- Manifold assembly
- Acceleration control assembly

Let's take a brief look at each of these areas.

INLET FUEL FILTER.– The inlet fuel filter assembly is threaded into the fuel pump inlet port and contains a fitting for the connection of an external fuel supply line. The filter assembly contains a 25-micron, disposable element.

FUEL PUMP.– The fuel pump is a positive-displacement, gear-type pump. The pump is mounted on the left forward pad of the accessory drive portion of the reduction drive assembly. A 25-micron, cleanable filter element is installed in the pump housing. The fuel pump splined shaft fits into an eight-point square drive in the shaft portion of the accessory drive gear. The other end of the fuel pump driveshaft is spline-coupled to the drivehead assembly in the engine acceleration control. A drain port in the pump housing drains fuel that might leak past the pump drive seal or past the drop regulating valve pin. At 4,200 rpm, the pump is capable of delivering 400 pounds per hour of fuel against a discharge pressure of 400 psig.

START, MAIN, AND MAXIMUM FUELSOLENOID VALVES.– The start, main, and maximum fuel solenoid valves are hermetically sealed. They are installed on the fuel valve mounting bracket. They are operated by an electrical input of 14 to 28 volts dc. Stainless-steel tubing connects each valve with the engine acceleration control assembly. The fuel solenoid valves are controlled by the ESU.

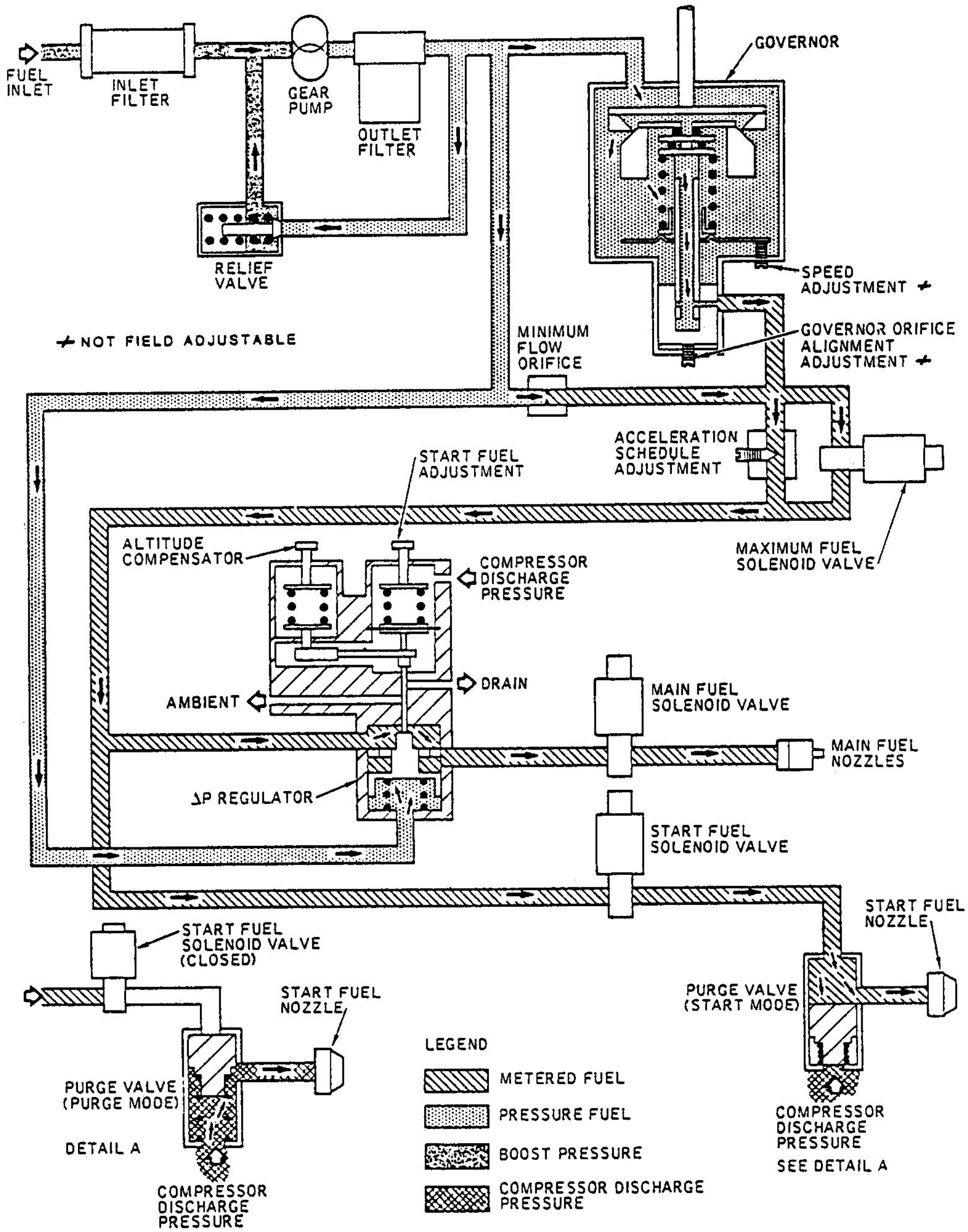


Figure 7-25.–Fuel system.

Start Fuel Solenoid Valve.– The start fuel solenoid valve is a normally closed valve. It is energized to the open position by the ESU to supply fuel to the start fuel nozzle. At 90 percent of rated engine speed, the valve is de-energized. In the de-energized position, the valve shuts off fuel flow to the start fuel nozzle.

Main Fuel Solenoid Valve.– The main fuel solenoid valve is a normally closed valve. It is energized open by the ESU. When open, this valve allows fuel to flow to the fuel manifold assembly. De-energizing this valve produces a normal shutdown of the APU.

Maximum Fuel Solenoid Valve.– The maximum fuel solenoid valve is also normally closed. It assists in fuel scheduling for the start acceleration control. At 90 percent of rated engine speed, plus 2 seconds, is energized. It bypasses the acceleration orifice and the valve allows maximum fuel flow for governing at rated engine speeds and loads.

START FUEL NOZZLE.– The start fuel nozzle is contained in a special fitting located on the left side of the combuster. Fuel to this nozzle is controlled by the start fuel solenoid valve. Fuel that is atomized by the nozzle is ignited by the igniter plug. The plug is located close to and directly in line with the start fuel nozzle.

PURGE VALVE ASSEMBLY.– A start fuel nozzle purge system is used to prevent the buildup of varnish resulting from fuel evaporation. The purge system consists of a purge valve assembly and rigid tubing connected to the start fuel nozzle. The purge valve assembly is threaded into a special fitting that is installed on the compressor discharge pressure port.

During an APU start, the start fuel solenoid valve opens and fuel pressure forces the piston in the purge valve to one side in the valve chamber. This allows fuel to flow through the start fuel nozzle. At approximately 65 percent of engine speed, the start fuel solenoid valve closes to cut off 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 directed to the combustor to be burned.

FUEL MANIFOLD ASSEMBLY.– The fuel manifold assembly consists of a brazed assembly of six stainless-steel lines, each terminated with a 0.016-inch orifice at the exit end. The main fuel transfer line is connected between the main fuel solenoid valve outlet and the distribution boss on the fuel manifold.

The fuel manifold filter assembly contains a wire-cloth element. The filter is internally installed in the housing at the inlet end of the fuel manifold assembly and held in place by a retaining ring. The filter provides a 10-micron, in-line filtration of the fuel before it enters the combuster.

ACCELERATION CONTROL ASSEMBLY.– The engine acceleration control assembly consists of three components secured together: (1) the governor, (2) the fuel control, and (3) the bellows cover assembly.

Governor.– The governor includes a pressure relief valve, a governor control spring, a flyweight assembly mounted in a drivehead assembly, and a matched ball bearing set, which supports the internally splined shaft end of the drivehead assembly. The flyweight assembly is located between the bearing and valve assembly and the governor drivehead assembly. It is pivot-mounted against the governor drivehead assembly and the bearing plate of the bearing and valve assembly.

The threaded ports in the governor provide attaching points for the fuel line to the main fuel solenoid valve and the relief valve. The governor also includes a ported differential pressure regulating valve, which maintains a differential pressure across the fuel metering valve ports proportional to compressor discharge pressure and controls fuel flow to the APU.

Fuel Control.– The fuel control, which is secured to the forward face of the governor, contains a minimum fuel flow orifice, an acceleration needle adjustment, a ported fuel metering valve assembly, a governor adjusting plunger, a governor tension lever, a bearing and valve assembly, and an outlet port. The aft end of the fuel metering valve extends into the fuel control housing. The spring retainer, which fits over the end of the fuel metering valve, is held in position around the metering valve by flanges on the spring retainer and the bearing and valve assembly. The piston of the bearing and the valve assembly fits into the center of the fuel metering valve assembly.

Bellows Cover Assembly.– The bellows cover assembly is secured to the top of the governor housing and consists of two interconnected sections. These sections are the diaphragm and bellows housing and a lever housing. The diaphragm is located between the pressure sensing portion of the bellows cover assembly and the lever housing which, through a mechanical connection, operates the differential pressure regulating valve in the governor housing. A diaphragm adjusting screw is installed in the pressure sensing portion of the bellows cover assembly.

FUEL DISTRIBUTION SYSTEM.– A single low-pressure fuel line is necessary to supply the engine's fuel system from an external source (5 to 40 psig with 200 pounds per hour minimum flow). The turbine engine's high-pressure fuel system has stainless-steel piping that connects the engine acceleration control assembly with the fuel solenoid valves, compressor pressure outlet port, purge valve, start fuel nozzle, and fuel manifold assembly. An additional stainless-steel line supplies compressor discharge pressure to the load control valve.

Lubricating Oil System

The lubricating oil system provides lubrication to the high-speed input pinion, reduction and accessory gears, shafts, and bearings. The Sunstrand's integral lubrication system consists of the following parts:

- Oil pump
- Oil filter and bypass relief valve
- Oil pressure relief valve (main)
- Oil pressure switch
- Oil temperature switch
- Oil distribution ring assembly

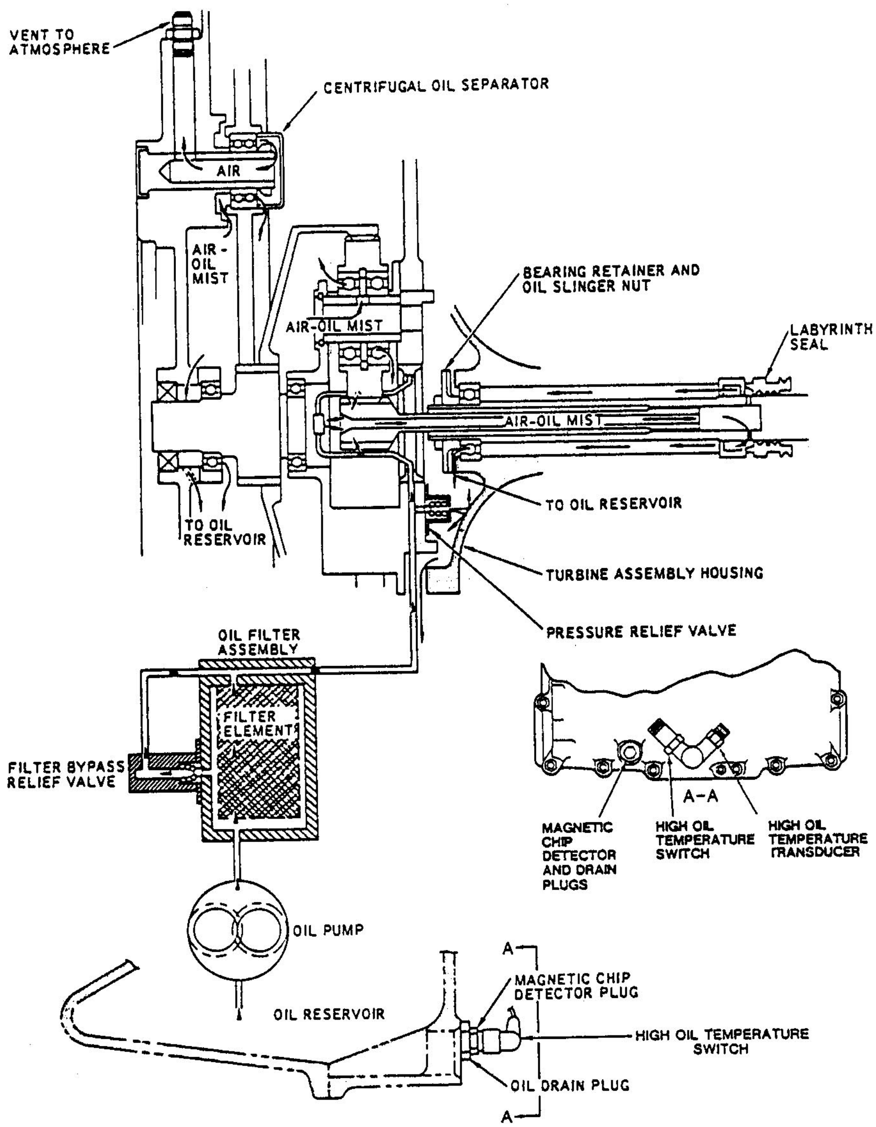


Figure 7-26.–Lubricating oil system.

- Oil sump

All these components, shown in figure 7-26, are contained within the gear reduction and accessory drive assembly. Let's take a brief look at each one.

OIL PUMP.– The oil pump consists of two internal gears pinned on shafts. The shafts are mounted inside a two-piece housing, which is secured in the reduction drive housing. The oil pump drive gear is pinned to the driven shaft and secured with a nut to the end of the pump drive shaft just outside the oil pump housing. The oil pump drive gear is driven by the pinion of the output and accessory gear shaft.

OIL FILTER AND BYPASS RELIEF VALVE ASSEMBLY.– The oil filter assembly consists of a filter housing in the reduction drive, a nominal 10-micron, disposable filter element, and a bypass relief valve housing that serves as a cap for the filter element. The cap (relief valve housing) incorporates a spring-loaded, ball-type, bypass relief valve. (See also fig. 7-24.)

OIL PRESSURE RELIEF VALVE.– The oil pressure relief valve consists of a spring and ball assembly mounted on the inside of the planetary gear carrier assembly. The spring and ball assembly is retained in the carrier by the relief valve housing attached to the carrier. The relief valve regulates the system oil pressure at 40 psig, while bypassing a portion of the oil back to the sump. The major portion of the oil continues to the oil jet ring, which is located in the planetary gear carrier assembly.

OIL PRESSURE SWITCH.– The oil pressure switch has a set of normally open contacts that will close when engine oil pressure rises to 6 ± 1.5 psig. After the

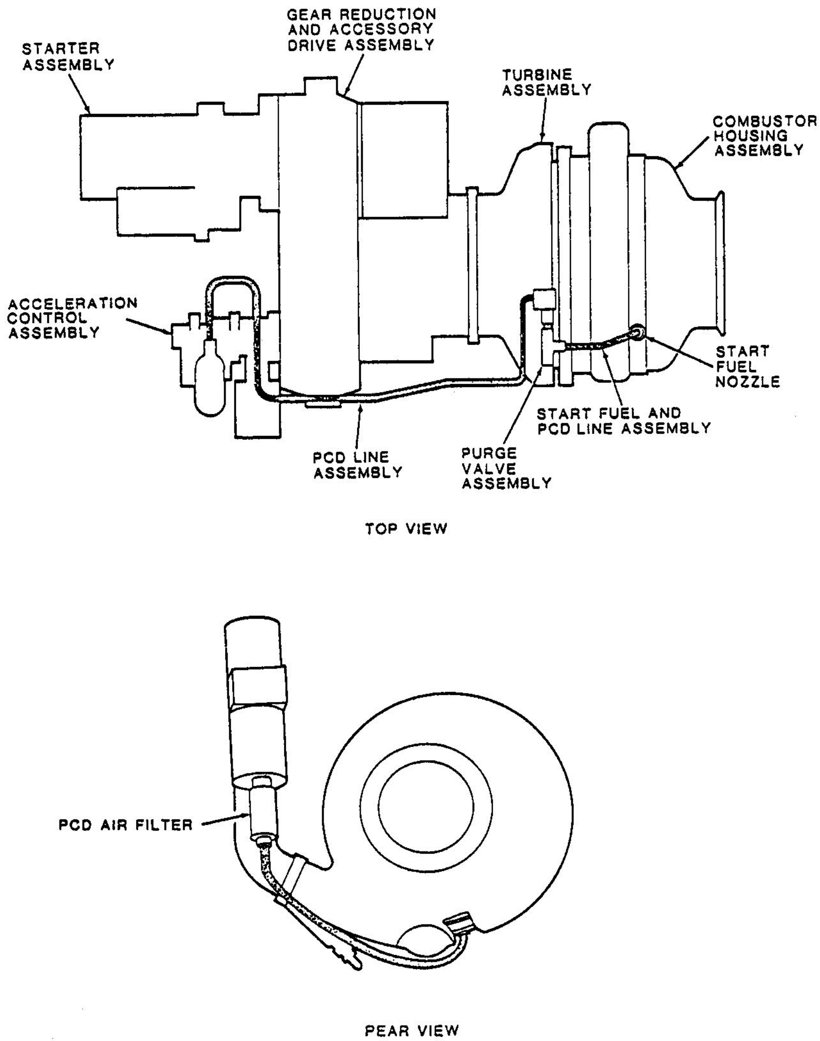


Figure 7-27.–Air pressure system.

APU is operating at or above 90 percent of rated engine speed, decreasing oil pressure below 6 ± 1.5 psig opens the contacts and, through the ESU, the APU will shut down because of low oil pressure.

OIL TEMPERATURE SWITCH.– The high oil temperature switch is installed in the reduction drive assembly. The switch is electrically connected to the ESU to enable the ESU to monitor the oil temperature and shut down the APU when the oil temperature reaches 275° ± 5°F.

OIL DISTRIBUTION RING ASSEMBLY.– The oil jet ring is located in the bearing carrier assembly for the planetary gear system. The jet ring encircles the high-speed input pinion that provides the three jets of oil that are directed at the mesh points of the input pinion and the planetary gears.

OIL SUMP.– The oil sump is integrally cast with the reduction gear housing. The oil sump has a full capacity of 5 U.S. quarts. This represents the oil requirement for (approximately) a 1-minute deaeration period to minimize oil foaming. An oil shield is cast integrally with the reduction drive housing between the gears of the reduction drive assembly and the oil sump. The shield prevents the lubricating oil in the sump from coming into contact with the moving gears. It also prevents foaming of the oil.

An expansion-type dipstick mounted in the reduction drive housing indicates the oil level in the sump. The dipstick is retained in place by an integral rubber seal, which expands against the dipstick receptacle when the dipstick folding ring is rotated clockwise. The dipstick is integral with the oil filler cap.

Air Pressure System

The air pressure system, shown in figure 7-27, controls the flow of fuel during the starting phase, as a function of engine speed. This is accomplished as the

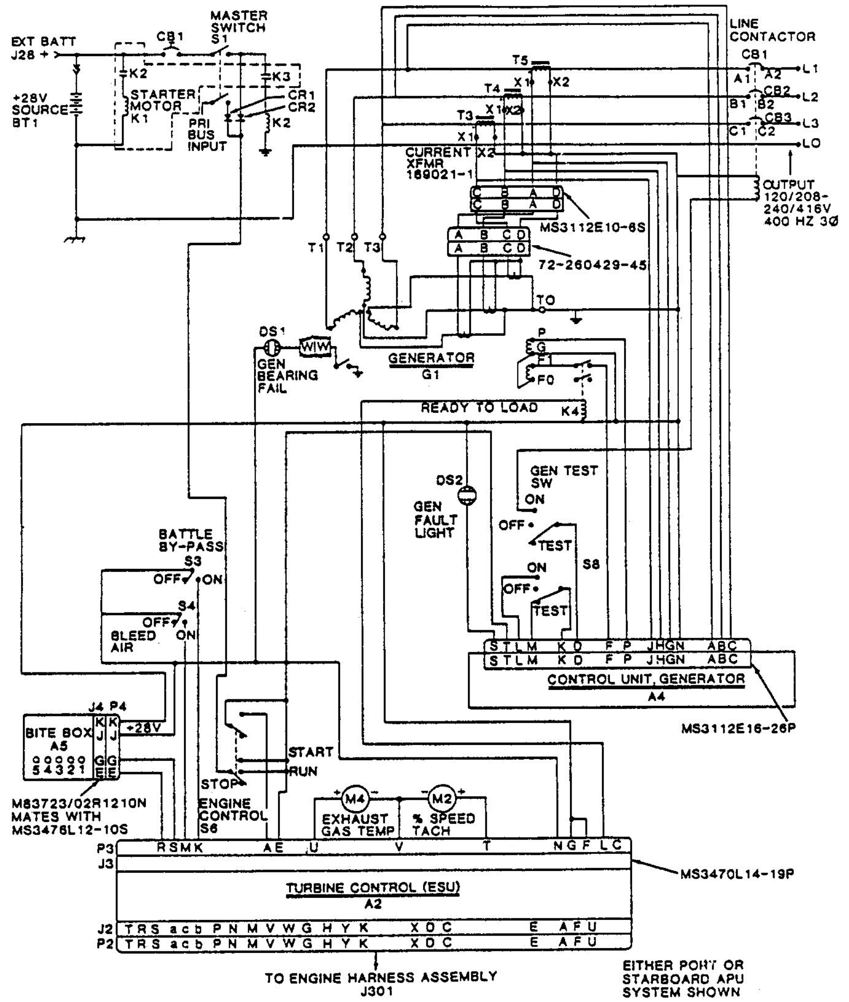


Figure 7-28.–Sunstrand electrical system.

fuel control assembly senses the compressor discharge pressure tapped from the air inlet housing.

START AIR OPERATION.– For starting, the air is drawn in by the compressor wheel. The compressed air is tapped from the compressor chamber through a special fitting located on top the aft center of the turbine assembly. From this point, the discharge air is transmitted to the engine acceleration control assembly. The acceleration control senses this pressure and reacts to meter the fuel to the main fuel nozzles on the fuel manifold during the starting operation.

PURGE VALVE ASSEMBLY.– The air from the special compressor pressure fitting is also routed to the purge valve assembly. (The purge valve is connected to the special compressor pressure fitting.) During the start cycle, fuel pressure to the start fuel nozzle is greater than the compressor pressure impinging on the purge valve; therefore, only start fuel can flow through the purge valve to the start fuel nozzle at this time. When fuel flow to the start fuel nozzle ceases, the purge valve opens to allow compressor discharge air pressure to flow through the purge valve to purge the start fuel nozzle of all residual fuel.

LOAD CONTROL VALVE ASSEMBLY.– Compressor discharge pressure is also tapped from an outlet port on the aft bottom of the turbine housing through tubing and a 20-micron, in-line, disposable filter. This air pressure is used for operation of the butterfly valve piston and the electropneumatic torque motor in the load control valve.

The operation of the bleed air system, which consists of the start bypass valve and bleed air valve, will be described under the electrical system.

Electrical System

Some of the components we have already described for the other systems are also part of the Sunstrand's electrical system. We will now indicate how these components function as an integral part of the Sunstrand

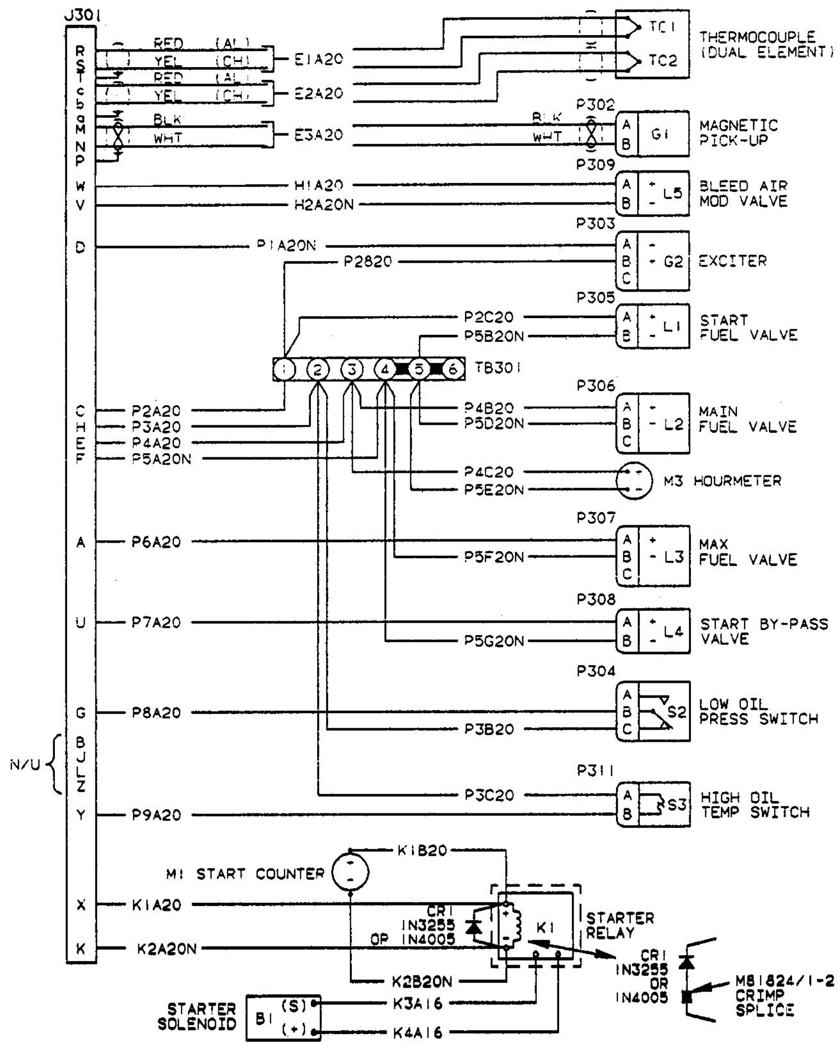


Figure 7-29.—Sunstrand electrical harness assembly.

APU. (Refer to fig. 7-24.) Our discussions will basically include the following engine-mounted components:

- Generator
- Starter assembly
- Start bypass valve
- Start counter
- Ignition exciter
- Ignition cable
- Igniter plug
- Thermocouples
- Magnetic pickup
- Time totalizing meter (hour meter)
- Electropneumatic air bleed valve
- Oil pressure switch
- Fuel solenoid valves

As we indicated, you have already read about some of these components. For example, the oil pressure switch and the fuel solenoid were described in the fuel and lubricating oil sections. You have already read about the generator and the start air operation. In the following paragraphs, we will confine our discussions to the other engine-mounted components of the Sunstrand's electrical system.

For the electrically operated components on the Sunstrand's GTE power unit to function properly, electric power at 12 to 30 V dc is required during the engine start sequence. Keep this requirement in mind and refer to figures 7-28 and 7-29 as you read about the following components.

STARTER ASSEMBLY.– The starter assembly is mounted on the forward, upper, right pad of the gear reduction and accessory drive assembly. It is a 24-volt dc disengaging-type starter, with an integral solenoid and contactor assembly that is totally enclosed. The enclosure protects this unit from exposure to dirt and foreign material. (See figs. 7-24 and 7-27.)

The solenoid, mounted on the motor field frame, operates the lever mechanism to shift the splined drive into mesh with the mating splint of the starter gear in the gear reduction and accessory drive assembly.

START BYPASS VALVE.– The start bypass valve is a spring-loaded, normally closed, solenoid valve. The valve is installed on the lower portion of the combustor air manifold. A minimum of 2 to 4 psig compressor air is sufficient to start to open the valve. (A minimum of 7 to 9 psig will fully open the valve.)

During the start cycle, the start bypass valve is open to prevent a surge condition. When the APU reaches 90 percent of rated engine speed, plus 2 seconds, the start bypass valve is energized to the closed position through output current from the ESU upon actuation of the bleed air valve.

START COUNTER.– The miniature start counter is installed on the fuel valve and the electrical equipment mounting bracket. This assembly is located on the upper left side of the reduction drive. The start counter records the total APU starts and operates on 12 to 30 volts dc.

IGNITION EXCITER.– The ignition exciter is bolted to the turbine assembly housing. This capacitor discharge-type exciter converts a dc input to a high-energy ac output. The high-energy ac output is supplied to the igniter plug for fuel ignition. The minimum igniter rate is four sparks per second at 12 volts dc input. (See fig. 7-24.)

IGNITION CABLE.– The ignition cable connects the ignition exciter to the igniter plug. The high-energy pulse from the exciter to the plug is supplied through the ignition cable. The cable is protected by a flexible metal shielding.

IGNITER PLUG.– The igniter plug is a 10-millimeter, surface-discharge type. It is threaded into a boss in the upper left aft section of the combustor. As we mentioned earlier, the igniter plug provides the spark necessary for initial ignition of the fuel during the starting phase of the APU. (See fig. 7-24.)

THERMOCOUPLE.– A dual-element, chromel/alumel thermocouple extends into the exhaust stream and senses engine exhaust temperature. The output signal of each element is transmitted to the ESU. Overtemperature from the thermocouple to the ESU will result in either an APU shutdown or operation of the bleed air valve to limit bleed air flow. (See fig. 7-24.)

MAGNETIC PICKUP.– The magnetic pickup is installed in the top center section of the reduction drive housing assembly. The magnetic pickup generates a voltage output as the ring gear passes through the magnetic field surrounding the pole piece at the sensing end of the pickup. The voltage output is then transmitted to the ESU. An overspeed/underspeed signal from the ESU will result in an APU shutdown. (See fig. 7-24.)

TIME TOTALIZING METER.– The time totalizing meter (hour meter) indicates the total accumulated hours of APU operation. This unit is installed in the fuel valve and the electrical equipment mounting bracket, located on the upper left side of the reduction drive. The time totalizing meter operates on 12 to 30 volts dc.

ELECTROPNEUMATIC AIR BLEED VALVE.– The electropneumatic servo actuated air bleed valve (load control valve) consists of a piston operated butterfly flapper and an electropneumatic torque motor. Operating air pressure for the butterfly piston is obtained from compressor discharge air pressure through a port in the valve body. (See fig. 7-24.) The air pressure (filtered) is controlled by the electropneumatic torque motor, which regulates the pneumatic pressure to the piston in the air bleed valve, thereby positioning the butterfly flapper. This operation is performed as a function of an electrical signal produced by the ESU. Thus, any changes in exhaust temperature will result in movement of the butterfly flapper to control the bleed air flow from the APU, maintaining exhaust gas temperatures within safe operating limits.

We have just discussed the major design and operating systems of the Sunstrand APU found on the LCAC-class ships. In the following sections let's shift our focus to the FFG-7 class ship and the Detroit Diesel 16V149, which furnishes its electric power.

DETROIT DIESEL 16V149

If assigned aboard an FFG-7 class ship, you, the GSM, will need to be familiar with the Detroit Diesel 16V 149. The FFG-7 class ship's electric power is supplied by four ac generators, shown in figure 7-30. Each of these generators is driven by a Detroit Diesel 16V149. These units are also capable of providing

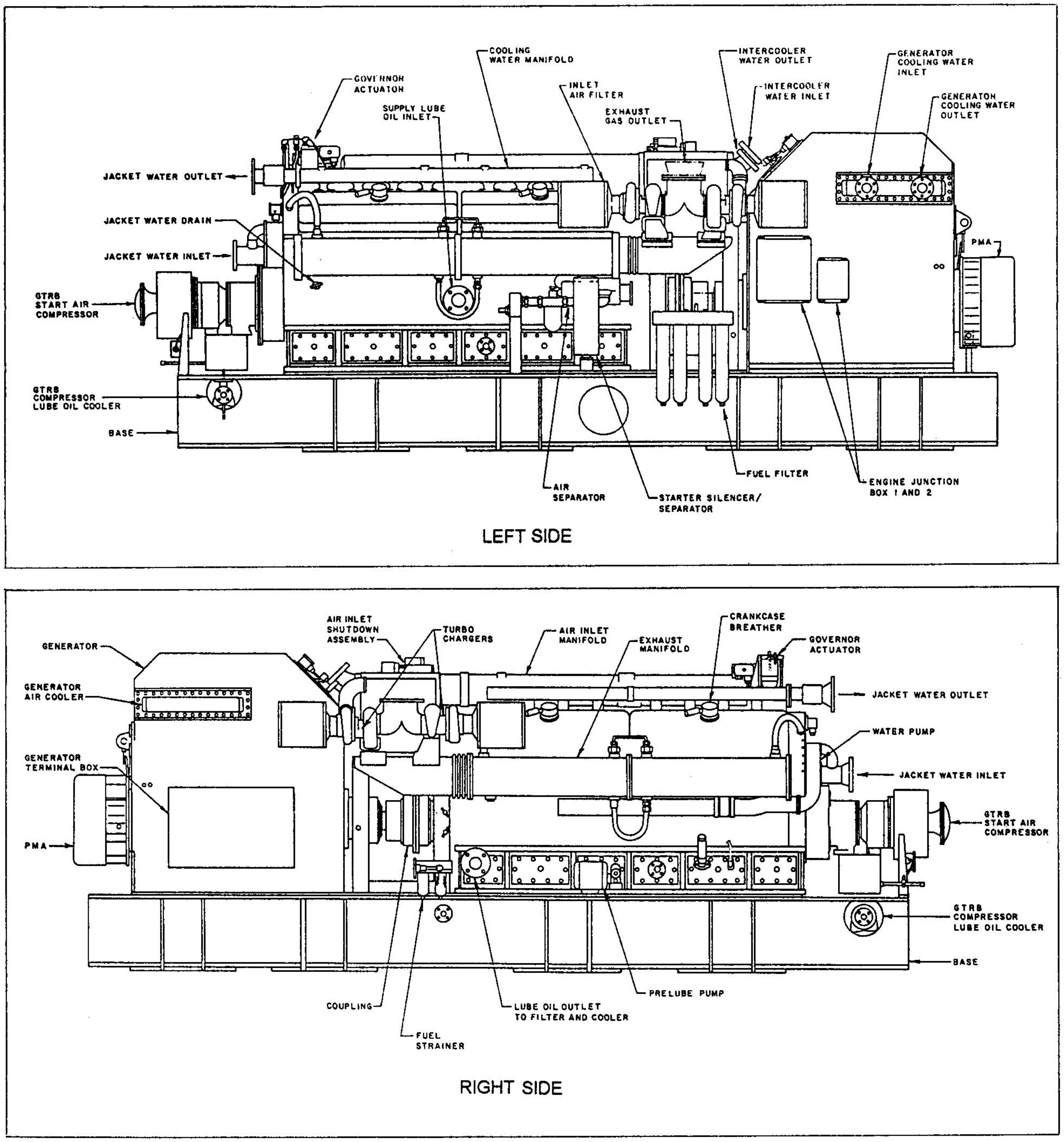


Figure 7-30.—Detroit Diesel 16V149 (SSDG on FFG-7 class ships) (left and right side view).

take-home power in the event of a casualty to the propulsion system. Two of the units are equipped with start air compressors, which we will describe later in this chapter.

DESIGN AND OPERATION

Each SSDG set is driven by a 1,600 horsepower, V-type, 16-cylinder, two-cycle, turbocharged, intercooled Detroit Diesel engine with right-hand rotation. The engine has a total displacement of 2,389 cubic inches and a compression ratio of 16:1. Normal operating speed is 1,800 rpm.

The engine has individual cylinder heads, crosshead-type pistons, unit fuel injection, and a full scavenging air system. Figure 7-30 shows the design and location of the key components of the Detroit Diesel 16V149.

SYSTEMS

Refer to figure 7-30 as we talk about the following five major systems of the Detroit Diesel 16V149:

- Fuel system
- Lubricating oil system
- Jacket water cooling system
- Starting air system
- Air intake and exhaust system

We will take just a brief look at each of these systems. For a more in-depth view, we recommend you consult the appropriate technical manuals.

Fuel System

The diesel's fuel system consists of the following components:

- Fuel strainer (primary)
- Fuel pump
- Fuel filter (secondary)
- Fuel block and check valves
- Fuel manifolds
- Fuel injectors

The components that are external to the engine include the fuel service tank, fuel return cooler, and connecting lines.

OPERATION.– During operation, the fuel is drawn from the service tank through the (primary) strainer by the engine-mounted fuel pump. The pump passes the fuel to the secondary filter to the junction block. At the junction block, the fuel is routed to the fuel inlet manifolds for each cylinder bank. The injectors receive fuel from the inlet manifold through individual pipes. A small portion of the fuel supplied to the injector is pumped into the cylinder through the spray tip at high pressure. Surplus fuel passes through the injector, serving to lubricate and cool the working parts. It then returns from the outlet side of the injector, through the fuel outlet pipes, to the return manifold. The return fuel the passes through the fuel junction block, to the cooler, and returns to the engine fuel inlet.

CONTROL AND MONITORING COMPONENTS.– The control and monitoring components in the auxiliary fuel service system consist of the solenoid-operated tank suction valves and the quick-closing shut-off valves located in the supply line from each tank.

Solenoid-Operated Tank Suction Valves.–The solenoid valves can be opened and closed locally or from the EPCC. They are provided with a manual override in case of coil failure or loss of power.

Quick-Closing Shut-Off Valves.– The quick-closing shut-off valves are operated from the space entry access trunks.

Resistance Temperature Deteetor and Thermometer Assemblies.– A resistance temperature detector (RTD) and a thermometer are located in the discharge line from the fuel cooler. The RTD provides a signal to the EPCC for a demand display readout, and actuates audible and visual alarms when fuel temperature exceeds 115°F. The thermometer is provided for local monitoring.

Pressure Transducers.– Two pressure transducers on each engine provide a demand display readout and a continuous display of the engine fuel pump discharge pressure. The pressure transducers also provide low fuel pressure audible and visual alarms at the EPCC downstream of the fuel filter. The alarm is set at 35 psig.

Pressure Switches.– Three pressure switches in the fuel system area part of the automatic control circuit. A tank level instrument in each fuel tank provides continuous tank level, demand display readout, and high- and low-level alarms at the EPCC.

STRAINER ASSEMBLY.– The fuel strainer is a metal-edge disk-type simplex unit with dual strainer elements. The strainer consists of a strainer element surrounded by a sump to collect foreign material removed from the fuel stream. The element consists of a series (stack) of thin edge-type disks separated slightly by spacer disks. The strainer element is arranged on a spindle and clamped together by long screws or studs. A handle attached to the spindle is used to rotate the strainer element against the cleaner or scraper blade.

The fuel that enters the strainer is forced between the casing and the disk assembly and then passes through the disks to the center of the element. The fuel then passes up through the element and out through the strainer outlet.

FUEL PUMP ASSEMBLY.– The fuel pump is a positive-displacement gear-type pump. It is used to transfer fuel from the service tank to the fuel injectors. The pump circulates an excess fuel supply through the injectors. The excess fuel purges air from the system and cools the injectors. The used fuel is returned to the engine fuel inlet through the cooler.

The fuel pump is mounted on an adapter attached to the flywheel housing and is driven off the end of the blower drive gear by a coupling fork. The fuel pump is a right-hand rotation pump. The fuel pump pressure is regulated by a spring-loaded relief valve that is incorporated into the pump casing. The relief valve is set to lift at 100 psig in the event of high pump discharge pressure. The excess fuel recirculates from the pump discharge to the suction side of the pump.

FILTER ASSEMBLY.– The fuel filter assembly consists of four housing units in a duplex arrangement. A selector handle is used to shift from the active elements to the standby units. Each filter unit consists of a shell, a cover, and five replaceable filtering elements. The filter elements slide over a filter guide. The fuel enters the shell and passes inward through the filter element, where it enters the filter guide and passes to the filter outlet. Check valves are installed in the filter outlet connections to prevent fuel backflow to the standby unit. The filter elements should be replaced when the differential pressure exceeds 15 psid.

FUEL BLOCK AND CHECK VALVE SYSTEM.– The fuel junction block distributes fuel from the filter to the fuel manifolds through flexible lines. A valve, located in the inlet piping before the fuel junction block, prevents fuel stoppage through the injector, which could cause cylinder head damage. A check valve, installed in the fuel junction block on the outlet (spill) side, prevents fuel from draining from a high mounted fuel tank back into the injectors when the engine is not running. An orifice (0.136 inch and 0.1695 inch) drilled in the fuel pressure relief valve plug maintains pressure in the fuel system.

FUEL MANIFOLDS.– The fuel manifolds are attached to the top of the cylinder block on each bank of the engine. Fuel connectors, installed in the bottom of the manifold, supply fuel to the injector and return excess fuel from the injector back to the return passage in the manifold. The manifolds are installed with the supply passages on the outboard side on each injector bank. Surplus fuel is returned to the fuel strainer inlet through the return fuel cooler.

UNIT INJECTOR ASSEMBLIES.– Combustion required for satisfactory engine operation depends on the injection of a small quantity of accurately metered and finely atomized fuel into the cylinder at the correct time. Unit injectors combine the high pressure pump necessary for proper injection and the injection nozzle in one unit. The injectors create the high fuel pressure required for efficient injection. They both meter and inject the correct amount of fuel required by the engine load, and atomize the fuel for mixing with the air in the combustion chamber.

The injector fits snugly in the injector tube installed in the cylinder head. The tip projects slightly below the bottom of the cylinder head. Jacket water circulates around the lower part of the injector tube to keep it cool.

Each injector has two connections, one to supply fuel and the other to carry away bypassed fuel (spill). The injector is actuated by the injector rocker, which works directly off the camshaft. The amount of fuel injected is regulated by the control rack which is operated by a lever secured to the rack control tube. The control tube is positioned by linkages from the governor actuator.

COOLER.– The return fuel cooler is of the shell and tube design. The cooler is a single-pass heat exchanger. The heads are bolted to the shell assembly. Baffles are used along the length of the tube bundle to support the tubes and to direct the flow of fuel. Seawater is used as the coding medium.

Now that we have looked at the Detroit Diesel's fuel system, let's examine its lubricating oil system.

Lubricating Oil System

This efficient lubricating oil system provides lubrication for both the diesel engine and the generator from a common system. The Detroit Diesel's lubricating oil system consists of the following main components:

- Oil sump
- Oil pump and relief valves
- Oil filter
- Oil cooler
- Regulating valves
- Monitoring system

Let's look briefly at each of these components. For an in-depth view, again, we recommend you consult the appropriate technical manuals.

MAIN OIL SUMP.– The main oil sump is a reinforced fabricated steel plate assembly that supports the engine on its base assembly. The main oil sump is equipped with a series of handholes along the sides for access to the rod bearings, oil pump, and pressure regulating valves. Mounted on the handhole covers are the lube oil discharge fitting, the lube oil fill and drain fittings, and the ribbon-type dipstick.

OIL PUMP.– The oil pump is mounted on the two rear main bearing caps and is driven by the rear crankshaft gear. The oil pump assembly consists of a main section and a scavenging pump section mounted in tandem. The scavenging oil pump is not used.

The main oil pump takes a suction from the sump through the inlet screen and suction pipe and discharges into the oil discharge line. When the pump discharge pressure exceeds 100 psig, the spring-loaded relief valves mounted on the oil discharge fitting lift to direct the excess oil back to the sump. The oil discharge pipe leads out of the sump through the rear hand hole cover on the right side and connects to the ship's lube oil piping system through a flexible connection.

LUBE OIL FILTER AND COOLER ASSEMBLIES.– The lube oil filter and cooler are mounted off the engine. Ship's piping routes the lube oil from the engine oil outlet to the lube oil filter, where particulate matter is filtered out.

Filter Assembly.– The lube oil filter is a four-element, full-flow assembly. It is equipped with a bypass relief valve at each filter element. If one of the filter elements should become clogged, the bypass valve for that element will open when the differential pressure reaches 20 psid. The bypass valve will then maintain the oil flow with only a slight reduction of filtration. Lube oil is piped from the filter to the shell side of the oil cooler.

Oil Cooler.– The lube oil cooler is similar in design to the fuel return cooler. It is a single-pass, shell and tube design heat exchanger. This oil cooler uses jacket water as the cooling medium. After passing through the oil cooler, the lube oil returns to the engine through a flexible connector and the final lube oil strainer, which is mounted on the left-hand side.

REGULATING VALVES.– The main oil gallery extends the full length of the cylinder block and connects with the main bearings, camshaft bearing, and gear trains through drilled passages. Stable oil pressure is maintained under various conditions by two spring-loaded pressure regulating valves. These valves are located at the ends of two of the four vertical oil galleries. These pressure regulating valves are similar in construction to the pressure relief valves mounted at the main oil pump. When the oil pressure at a regulating valve exceeds 50 psig, the valve lifts and discharges the excess oil back to the engine oil sump.

OIL DISTRIBUTION SYSTEM.– Oil from the main oil gallery flows through drilled passages to each main bearing and through drilled passages in the crankshaft to each adjacent journal bearing. A groove in the upper half of the rod bearing directs oil to the piston pin through a drilled passage in the connecting rod. A portion of the oil is used to lubricate the piston pin; the other part is sprayed on the underside of the piston dome for cooling.

Oil from the main oil gallery is also picked up by diagonal holes in the camshaft and directed through an axial passage to the couplings and drive shafts located at the rear of the camshaft. The valve and injector operating mechanism is lubricated from both the camshaft bearing caps and the grooves in the camshaft bearings. The camshaft lobes and the rocker arm rollers are lubricated by spray jets machined in the bearing caps. Excess oil from the rocker arms lubricates the valve stems.

The gear train is lubricated by oil from passages drilled in the cam hubs and the idler gear retaining bolts, and from splash from the main oil sump. A certain amount of oil also spills into the gear train compartment from the blower drive bearing and the idler gear bearings. The idler gear bearings are pressure lubricated from the main oil gallery.

The lube oil manifold is mounted between the engine and the block. It supplies oil to the turbochargers and generator bearings. Oil flows from the lube oil manifold to the turbochargers through an external tube and flexible hose connections.

MONITORING SYSTEM COMPONENTS.– The lube oil monitoring system consists of a pre-start lube oil pump, pressure gauges, transducers, temperature sensors, pressure shutdown and alarm switches, a low oil level switch, and an oil filter differential pressure transducer. Except for the pre-start lube oil pump, these lube control and monitoring system components are automatic without any operator control.

Pre-Start Lube Oil Pump.– The pre-start lube oil pump is provided to ensure the lube oil system is charged with oil while the engine is in a standby condition. This pump permits the system to be charged after maintenance or any extended idle periods. This unit consists of an electric motor directly connected to a pump. It has local start/stop controls and remote start controls and monitoring adjacent to the EPCC.

Resistance Temperature Detectors.– RTDs are provided at both the engine inlet (cooler outlet) and the pump discharge. The inlet RTD provides a signal to the EPCC to actuate an audible and visual alarm if the oil temperature exceeds 225°F. The signal also allows demand display or data logger printout. The pump discharge RTD provides a continuous display at the EPCC.

Pressure Transucers.– Pressure transducers are located at the engine inlet, the oil manifold, and the pump discharge. The manifold transducer provides continuous display and actuates an audible and visual alarm at the EPCC when the oil pressure drops to 48 psig. The discharge transducer gives a demand display only. The engine inlet transducer provides a gauge readout on the local control panel.

Level and Pressure Switches.– A level switch mounted in the oil sump provides an audible and visual alarm when the sump level drops 9.5 inches below the full mark.

Two pressure switches are provided on the system. One switch actuates an audible and visual alarm. The other switch automatically shuts the engine down when oil pressure drops below 42 psig.

Ventilation System.– The crankcase ventilation system removes harmful vapors from the crankcase, gear train, and valve compartments. The crankcase is vented through four breather assemblies. These assemblies are mounted on the rocker covers to an electrostatic vent fog precipitator. The breather assemblies are connected to the precipitator by four rubber hoses.

The precipitator is a two-stage device that removes oil fog and particulate matter from the airstream flowing from the breather vents. It is designed for continuous operation in a maximum ambient air temperature of 225°F and a maximum flow rate of 150 cubic feet per minute (cfm). It is most efficient in the 50 to 100 cfm range.

Now that you have taken a look at the components of the lube oil system, let's look at the Detroit Diesel's cooling system.

Jacket Water Cooling System

The jacket water cooling system uses fresh water, circulated by a centrifugal pump, to keep the engine cool. The jacket water system also cools the lube oil and gives up heat to the waste heat system.

COMPONENTS.– The Detroit Diesel's jacket water cooling system contains both engine-mounted and off-engine components. Let's take a look at these components and how they work together.

Engine-Mounted Components.– The engine-mounted components include the following units:

- Water pump and inlet adapter
- Water inlet and outlet manifolds
- Jacket water outlet

These components are mounted on or to the engine itself.

Off-Engine Components.– The off-engine components include the following units:

- A 30-gallon jacket water expansion tank
- A 5-gallon water treatment tank
- Cooler
- Waste heat exchanger
- Temperature regulating valve
- Lube oil cooler

These components are mounted off the engine and are located in the ship's piping system.

OPERATION.– The water pump is mounted on the engine front cover and is driven by the front crankshaft gear through two idler gears. It draws a suction from the off-engine system and pumps water into the cylinder block, around the cylinder liners, and through the cylinder heads, to the water outlet manifolds. The flow divides in the water outlet manifolds with approximately 60 gallons per minute, discharging to the exhaust manifolds at 30 gallons per minute per side.

A flow of approximately 400 gallons per minute discharges into the jacket water outlet. From the jacket water outlet, the water then returns to the off-engine system for cooling.

Monitoring, Control, and Regulating Components.– Two RTDs are provided in the jacket water outlet line. One RTD sends a signal to the EPCC for a continuous display and to actuate a high temperature audible and visual alarm. The alarm is set at 205°F. The second RTD supplies a signal to an indicator mounted on the LOP.

A differential pressure switch is located between the inlet and outlet of the engine. This switch sends an alarm signal to the EPCC, which will shut down the engine upon a loss of jacket water flow.

Water from the exhaust manifolds enters cored passages in the engine front cover and returns to the pump suction. After leaving the engine, the flow of jacket water is diverted between the jacket water cooler and the waste heat exchanger. (A three-way temperature regulating valve in the piping system is used to control the division of the flow.) The jacket water recombines after passing through one or both heat exchangers, flows through the lube oil cooler, and back to the water pump suction flange.

The three-way temperature regulating valve and auxiliaries form a control circuit that diverts the jacket water to the jacket water cooler or the waste heat exchanger, depending on the engine jacket water and the waste heat exchanger freshwater outlet temperatures. The temperature regulating valve assembly consists of a three-way diverting valve with a reverse-acting, air-operated diaphragm actuator and a valve positioner controlled by two temperature pilot controllers. The pilot controllers work together to direct all jacket water to the waste heat exchanger when the outlet temperature of the waste heat fresh water is $\leq$ 171°F and that of the jacket water is $\leq$ 191°F. When the waste heat temperature is between 171°F and 178.5°F and the jacket water is between 191°F and 199°F, both controllers will regulate to divide the flow between the jacket water cooler and the waste heat exchanger. If the waste heat temperature rises above 178.5°F or the jacket water temperature rises above 199°F, the affected pilot will close, shutting off control air pressure to the control valve and diverting the jacket water to the required area.

Now that you have seen how the jacket water cooling system works, let's look at the air systems.

Air Systems

The Detroit Diesel's air systems consist of the starting air system and the intake and exhaust air system.

STARTING AIR SYSTEM.– The starting air system supplies compressed air to the engine starter from the high-pressure air flasks. Each flask is charged at 3,000 psig from the ship's high-pressure air system. The system has sufficient capacity for 10 engine starts before recharging is necessary.

The high-pressure air is reduced to 150 psig through a reducing station. One start air reducing station with associated piping is installed at each SSDG. A pressure transducer and pressure switch are installed in the start air piping to the engine. The transducer provides a signal to the EPCC to actuate an audible and visual alarm whenever the air pressure drops to 100 psig. The pressure switch actuates an alarm at the local alarm panel outside the SSDG enclosure.

AIR INTAKE AND EXHAUST SYSTEM.– The air intake and exhaust system supplies air to the cylinders for combustion and scavenging. During operation, the air is drawn into the blower section of the turbocharger through an air filter, where it is compressed and the temperature is increased. It is then delivered to the intercooler where the air temperature is reduced. From the intercooler, the cooled dense charge of air is routed to the blower intake. The blower further compresses the air and sends it to the air box that surrounds the cylinder liners. The air is then forced into the cylinders for combustion.

After combustion takes place, the exhaust valves open and the hot gases are discharged to the exhaust manifold. The exhaust manifold and adapter direct the exhaust gases to the turbine section of the turbocharger. After providing the turbocharger with its driving medium, the hot exhaust gases are routed to a muffler located in the uptake space.

The turbocharger consists of a radial inward flow turbine wheel and shaft assembly and a centrifugal compressor wheel mounted on the opposite end of the turbine shaft. The turbine housing is a heat-resistant alloy casting that encloses the turbine wheel and provides flanged exhaust gas inlet and an axial exhaust gas outlet. The turbine housing is bolted to the center housing. The compressor housing has an axial air inlet and a discharge connection. It is connected to the inlet air cleaner and to the outlet piping with a clamp arrangement. The compressor housing is clamped to the compressor end of the center housing. The turbocharger is mounted on the exhaust manifold adapter with connectors.

The two intercoolcrs are mounted at the rear of the engine at the top. They are used to cool the compressed air from the turbochargers. They consist of an air inlet housing, a core, a cover plate, and a seawater inlet/outlet plate. Each intercooler is shared by two turbochargers with an air elbow and hose attached to the air inlet shutdown assembly with bolted flanges. The air is cooled by circulating seawater through the core of the intercoolers.

The air shutdown housing is mounted between the intercoolers and serves as a plenum chamber for the intake manifold. The air shutdown assembly is mounted in the shutdown housing. It consists of a spring-actuated damper (valve) pivoted over the air outlet to the intake manifold and a shutdown solenoid. The solenoid actuates a latch mechanism to release the valve plate when an emergency shutdown signal is received. The emergency shutdown solenoid can be actuated by a signal from the Halon interlock, the engine overspeed circuitry, or the remote EMERGENCY STOP push button at the EPCC. A manual trip cable is also provided at the machinery space access.

The two roots-type blowers are connected in tandem and mounted to the air box between the cylinder banks. The two three-lobed rotors rotate in opposite directions to provide supercharged air to the engine. The helical designed lobes are used because fewer lobes are needed to provide a greater airflow capacity in a smaller size without sacrificing the smoothness of flow.

You have now read about the basic construction, functions, and operations of the electric plants installed on gas turbine-powered ships. In the remainder of this chapter, you will read about some of the important safety requirements and practices you must observe whenever you are preparing to perform or supervise maintenance of these plants. You will also read about some of the more common routine maintenance procedures for these plants. As a GSM, you will need to be aware of these procedures and your responsibilities for performing them correctly.

ROUTINE MAINTENANCE AND REPAIRS

In this section, we will briefly discuss some of the common shipboard maintenance practices and repair procedures that you, the GSM, will be expected to perform on your ship's electric plant. First, we will take a look at some of the more common maintenance responsibilities you will encounter for your ship's GTE. Next, we will tell you about some maintenance responsibilities you will likely have concerning other areas of the electric plant. Because it is so important in today's Navy, we will also tell you about some important safety considerations you should keep in mind whenever you are working with or around GTEs or your ship's electric plant equipment.

GAS TURBINE ENGINES

As we mentioned earlier, the Allison 501-K17 is the most widely used GTE on board the Navy's gas turbine-powered ships for electric power generation. This is why we will use the Allison 501-K17 as a standard model as we discuss the general maintenance and repair requirements that are fairly common to most of the GTEs. Remember, even though we may use the Allison 501-K17 as our standard example, you should be aware that the maintenance requirements will be applicable to more than one type of prime mover. Wherever necessary, we will indicate the specific procedures that apply to a particular prime mover. To maintain your engine in peak performance, you will perform these routine procedures quite frequently.

NOTE

The contents of this section are provided for training purposes only and are not intended to replace the authorized maintenance and repair procedures for your ship. For the authorized maintenance practices and specifications for your ship, always consult the appropriate MRCs and technical publications.

Before continuing with this section, you should take time to refresh your memory concerning the safety precautions you should follow whenever you plan to perform maintenance on any GTE prime mover.

SAFETY PRECAUTIONS

Chapter 2 of this TRAMAN told you about some of the safety precautions you should use whenever you are handling fuels or other hazardous petroleum products. In the following paragraphs, we will focus on the safety precautions you should take whenever you are performing, supervising, or preparing to perform maintenance on any section of a GTE prime mover.

Remember, these precautions are general. You should always follow the authorized guidelines and specifications for your ship. In fact, the most important safety rule you can follow is to adhere conscientiously to all authorized safety practices, requirements, and procedures for your ship. As a responsible GSM, you must comply with the guidelines and regulations contained in the current edition of Navy Safety *Precautions for Forces Afloat,* OPNAVINST 5100.19B, and your ship's EOSS documents.

Let's first look at some of the safety precautions for maintenance performed inside the engine enclosure. Next, we will talk about safety precautions for maintenance performed within the turbine inlet plenum.

ENGINE ENCLOSURE

As you are already aware, the base enclosure assembly of a GTE consists of a shock-mounted base, an enclosure, a gas turbine mounting system, intake and exhaust systems, fire detection and extinguishing systems, a fuel enclosure heater, a lighting system, and a gas turbine water wash system.

The purpose of the engine enclosure is to provide a thermally and acoustically insulated structure for the gas turbine assembly as well as connections for electrical, fire extinguishing, and air and liquid services. Because the GTE operates inside this enclosure, its inner walls arc designed to withstand high temperatures. Because ventilation air is supplied to the enclosure, the temperature of its outer walls normally will not exceed 150°F.

Among the gas turbine ship classes we have discussed, the main design differences in the enclosure are in the access areas to the engine. The FFG-7 class ship has doors on either side of the enclosure. The DD-963, DDG-993, and CG47 class ships have only one door with a top hatch and an access ladder. On the DDG-51 class ships, GTM access is provided by a side door and a top hatch. Removable side panels are provided next to the door. On the LCAC-class ships, the enclosure is modular.

Regardless of the class of ship or the design of the engine enclosure, you must observe the following standard safety practices whenever you are preparing to perform or supervise maintenance within an engine enclosure:

1. Comply with all authorized safety regulations and requirements for your ship, including *Navy Safety Precautions for Forces Afloat, OPNAIVINST* 5100.19B, and the EOSS documents for your ship.

2. Tag the gas turbine/diesel generator OUT OF SERVICE.

3. Deactivate the fire-extinguishing system.

4. Allow the engine to cool. In the event of an emergent y shutdown of a turbine engine when it is <u>not</u> possible to cool down the engine according to the normal shutdown procedures, you must use an additional precaution.

CAUTION

To minimize time before personnel can safely enter the enclosure, you may want to cool the turbine by motoring. But do not motor for more than 2 minutes. Also, keep in mind that it may not be desirable or possible to motor a gas turbine engine, depending on the reason for the emergency shutdown.

5. Post a safety observer at the door.

6. Wear the required protective clothing.

7. Open the access doors and make sure they remain open during all maintenance procedures.

8. Make sure the power sources are secured because of the potentially hazardous voltages.

9. Make certain that tools, parts, materials, test equipment, and other objects are accounted for before personnel enter and after they exit the enclosure.

10. After the maintenance has been completed, make certain all personnel have exited and are clear of the enclosure before the access doors are closed.

As you are following the required safety procedures for your ship, use your common sense. Remember, many accidents are the result of inattentiveness.

TURBINE INLET PLENUM

In addition to the safety precautions we just discussed for maintenance within the engine enclosure, you must comply with the following special precautions whenever you prepare to perform or supervise maintenance within a turbine inlet plenum:

1. Before entering the enclosure, comply with all the precautions we described for maintenance within the engine enclosure.

2. Before entering the intake plenum or inlet air duct, remove all articles from your pockets. This means all personnel should remove all objects from clothing or pockets, including badges, identification tags, and hats.

3. Before leaving the intake plenum or inlet air duct area, inspect for foreign objects. Account for all tools, parts, materials, and personnel.

CAUTION

Objects left in the inlet area can cause GTE damage.

Whenever you are preparing to perform maintenance within any part of the engine, always follow the authorized procedures and keep your attention focused on the job at hand.

ROUTINE GTE MAINTENANCE

As a GSM, you will be direct] y involved in the maintenance and upkeep of your ship's prime mover. Most of the routine maintenance procedures you will be required to perform will fall in the general areas of cleaning (and lubricating), tests and inspections, borescoping, and removal and replacement of some of the components. Let's first take a general look at these areas. We will then discuss your general maintenance responsibilities in terms of specific systems and components.

CLEANING

One of the most frequent and critical maintenance procedures you will ever perform is cleaning. The quality of attention you give to your engine's cleanliness, both inside and out, can either enhance or downgrade its performance. Let's take a brief look at cleaning in terms of your responsibilities for both external and internal cleaning of the engine.

External Cleaning

External cleaning of the engine and its enclosure is not only a good engineering practice but also an important way to help you, the watch stander, identify leak locations and possible component failure. Improperly performed external cleaning can lead to potential hazards to both equipment and personnel.

Internal Cleaning

The requirements for internal cleaning are also extremely important. The lack of cleaning or improperly performed cleaning will result in poor engine performance and the reduction in the engine's serviceable life.

As a watch stander, you can readily identify poor engine performance by a noticeable increase in the TIT, hard starting, and poor engine response when electrical loads are added. The loss of the engine's serviceable life is normally caused by salt or sand erosion of the engine's casing and blades.

Water Washing

You can accomplish internal cleaning of your engine by the procedure referred to as water washing. The water washing procedures for all the GTEs we have discussed in this chapter are similar. For the specific water washing procedures for your particular GTE, refer to the appropriate PMS procedures or manufacturer's technical manuals for your ship. You will need this information to make decisions concerning several different factors, such as hours of operation, sea state, and so forth; the cleaning medium you should use, such as water or solvent solution; and the maintenance frequency.

All GTEs installed on gas turbine-powered ships have spray nozzles located on the engine's air inlet assembly (bellmouth) or in the air inlet plenum. These nozzles are aimed directly into the airstream of the compressor section.

Among the different GTEs, however, the design or method by which the wash liquid is delivered to the engine's intake, as well as the liquid itself, may be different. For example, let's look at the differences between the water wash system installed on the Allison and the one installed on the Garrett.

ALLISON AND GARRETT.– Even though the water wash systems in both the Allison and Garrett are permanently piped, the wash solution is pressurized differently. In the Allison, the ship's low-pressure air system provides the required pressure. In the Garrett, a booster pump supplies the wash solution at the required pressure.

SUNSTRAND.– The Sunstrand water wash system also uses a booster pump, but only to deliver distilled water. When the Sunstrand requires a detergent cleaning, the detergent (PD-680 type II) must be delivered to the compressor inlet through a handheld spray nozzle.

WATER WASH OPERATION.– In all cases, the GTE is motored as the water or wash solution enters the engine's inlet. There, the wash solution or water breaks up oil, dirt, and salt deposits. The used solution or water is then carried downstream to the exhaust plenum. After the wash is complete, the GTE is usually started and run for approximately 5 minutes to dry out the engine.

TESTS AND INSPECTIONS

Many tests and inspections that are routinely accomplished are covered by the PMS or manufacturer's technical manuals. As part of your responsibilities for troubleshcmting and inspecting the GTE, you must also be knowledgeable of borescoping. We will discuss borescoping later in this chapter.

In the following paragraphs, we will confine our discussion to the tests and inspections you will be required to perform for specific components and various parts of your GTE. After we look at the individual components, we will take a look at the GTE and your responsibilities for borescoping.

Compressor

The compressor contains several pieces of equipment that will require maintenance much more frequently than the compressor itself. Most of the internal maintenance for a compressor will be accomplished at a naval air depot (NADEP) or shore intermediate maintenance activity (SIMA).

Unless you are assigned to a SIMA, the only maintenance procedure that you, the GSM, will likely perform on the compressor is cleaning. In the following paragraphs, let's take a look at your responsibilities for cleaning and maintaining the various components associated with the compressor.

BLEED AIR VALVES.– On the Allison GTE, the fifth- and tenth-stage bleed air valves are used to prevent compressor stalls during engine start up. Your maintenance of these valves will be basically limited to cleaning the screens and visually inspecting the wire-braid hoses for proper operation during starts, fire stops, and water washing.

START AIR BYPASS VALVE.– Much like the Allison's fifth- and tenth-stage bleed air valves, the Sunstrand uses the start air bypass valve to prevent compressor surge (stall) during starting. Your maintenance for the Sunstrand's valve will be similar to that for the Allison's fifth- and tenth-stage bleed air valves. In both cases, your responsibilities will be limited to visual inspections and checking for proper operation during starts.

Two other valves that work hand-in-hand with the fifth- and tenth-stage bleed air valves are the three-way bleed air control valve and the speed sensitive valve.

THREE-WAY BLEED AIR CONTROL VALVE.– The three-way control valve is used to port fourteenth-stage bleed air to the fifth- and tenth-stage bleed air valves. The air holds these valves closed at engine speeds above 12,780 rpm. The three-way control valve also ports ship's service air to hold these valves closed during an enclosure fire stop sequence. Your maintenance of the three-way bleed air control valve will consist of tests and inspections through routine PMS and in conjunction with safety checks.

SPEED SENSITIVE VALVE ASSEMBLY.– The speed sensitive valve is the controller (brain) for the bleed air system. It is attached to and driven by the accessory gearbox. When engine speed is below 12,780 rpm, the valve activates to vent the bleed air received from the diffuser (fourteenth-stage air) to the atmosphere, thereby allowing the engine's internal air pressure to push open the bleed air valves. When engine speed exceeds 12,780 rpm, the air is ported through a filter to the bleed air valves to hold them closed.

Your main responsibility for this system is to keep the filter located between the speed sensitive valve and the bleed air valves clean. The filter is a cleanable mesh type that is consistently exposed to salt, dirt, and moisture. If this filter is not kept clean, the system may end up with sufficient air pressure to hold the fifth-stage bleed air valves closed but not enough to hold the tenth-stage valves closed. If the filter becomes completely blocked, both sets of valves will remain open, creating excess air pressure in the engine enclosure and increasing the chances of a compressor stall.

CUSTOMER BLEED AIR VALVE.– Although it is installed in the Allison, Garrett, and Sunstrand systems, the customer bleed air valve serves a different function on each GTE.

Allison.– The Allison's bleed air valve is installed in the enclosure on the base. It provides bleed air to the entire bleed air system. This air is used for SSGTG and GTM starting, prairie air, masker air, and anti-icing air. While the valve is supplying bleed air, it works automatically to regulate TIT to keep it below the high TIT alarm set point.

There are two solenoids (A and B) installed on the Allison's customer bleed air valve to control the valve's position. These solenoids are adjustable and receive the TIT signal inputs from a relay driver card in the LOCOP. The A solenoid controls the high temperature (valve closing) operation. The B solenoid controls the low temperature (valve opening) operation. Other than removal and replacement, the only maintenance you, the GSM, may have to perform will be the solenoid adjustments, and you will most likely be assisted by a GSE in this task.

Garrett.– The Garrett's bleed air (de-icing) valve is installed on the side of the engine. The Garrett's bleed air valve serves only one function: it supplies hot bleed air to the turbine air inlet plenum for de-icing. Valve removal and replacement is the only maintenance that you will usually have to perform.

Sunstrand.– The Sunstrand's bleed air (load control) valve operates in a reamer similar to the bleed air valve installed on the Allison. The Sunstrand's bleed air valve provides bleed air for main engine starting and anti-icing air. The bleed air is directed to the propeller shrouds, not the engine intakes. The Sunstrand's bleed air valve also has automatic controls to maintain the exhaust gas temperature (EGT) within safe operating limits while it is in use. The removal and replacement of this valve is the only maintenance that you will usually perform.

Combustor

The combustor section has a large number of serviceable components. Most of these components are designed to be serviceable due to their location on the engine and the extreme conditions to which they are subjected during operation. All of the combustor-related components we will discuss in this section are fairly easy to maintain and can provide a long service life if properly cared for.

COMBUSTION CHAMBER.– Unlike the other components, when a combustion chamber is damaged, it must be replaced. This procedure is usually accomplished by a SIMA because your ship will likely lack the required special tools and experienced personnel.

COMBUSTION LINER.– On the Allison, Garrett, and Sunstrand GTEs, you will use a slightly different procedure to determine the condition of the combustion liner.

Allison.– On the Allison GTE, you will use a borescope inspection to determine the condition of the liner. The Allison has individual liners or cans. This design will allow you to replace only the cans that are damaged, not the whole combustion section.

Garrett.– The Garrett has a single combustion chamber. If it is damaged, the Garrett's combustion chamber will require complete replacement. The replacement procedure is not difficult and can be performed at the shipboard maintenance level.

Sunstrand.– On the Sunstrand GTE, you can use the 500-hour hot-section teardown inspection to check the condition of the liner. Like the Garrett, the Sunstrand has a single combustion chamber that will require complete replacement if it is damaged. Also like the Garrett, the replacement procedure for the Sunstrand is quite simple and can be performed at the shipboard maintenance level.

COMBUSTOR DRAIN VALVES.– The combustor drain valves are installed on the Allison and Sunstrand GTEs. For the Allison and the Sunstrand, the tests, inspections, and maintenance of these valves will involve specific procedures. These procedures are covered in the PMS and the applicable manufacturer's technical manual.

Sunstrand.– Every 500 hours of operation, the Sunstrand's drain valves must be removed for testing, inspection, and cleaning.

Allison.– The Allison's drain valves, however, are usual] y tested in place. You must consult the appropriate documentation for each of these GTEs.

For either the Allison, Garrett, or Sunstrand, no matter what procedure you use or engine you maintain, it is extremely important for you to be thorough. If you find a faulty valve in either one of these GTEs, you should repair or replace it immediately. Allowing a faulty valve to remain in operation can cause serious damage to the engine either through hot starts or a post-shutdown fire.

IGNITION SYSTEM.– Your maintenance responsibilities for your GTE's ignition system will be fairly common, especially concerning the igniters and exciters.

Igniters.– The igniters on your GTE are cleanable. The frequency with which you should clean your igniters will be based on the hours of engine operation. Although the cleaning procedure is easy to accomplish, you must take extra care to make certain the ignition system is completely de-energized.

WARNING

The voltages produced by the ignition exciter unit can be lethal.

CAUTION

You should also take special care when you are handling the PD 680 type-II solvent you will normally use to clean the igniters. The safety precautions you should use for handling this solvent are contained on the PMS card, in the manufacturer's technical manual, and in chapter 2 of this TRAMAN.

The igniters used on the Garrett and Allison GTEs are similar in design. They both have a fixed flange. Unlike the igniters installed on the LM2500 GTE, you will not have to take a depth measurement on the Allison and Garrett igniters before you install them.

Exciters.– As a rule, the Allison and Garrett ignition exciter units will not require much maintenance.

Cables.– You must, however, make certain the cables are inspected at the appropriate intervals. On the Allison, you must inspect the cables during every GTGI. On the Garrett, you must inspect the cables after each shutdown and before each start-up.

FUEL NOZZLES.– The maintenance frequency for the fuel nozzles is also determined by hours of engine operation. Dirty fuel nozzles will not only rob the engine of its power, the resulting poor spray pattern can damage the combustion liners in the form of hot spots. To maintain your GTE at peak operating efficiency, you must keep the fuel nozzles clean.

FUEL MANIFOLD DRAIN VALVES.– On the Allison GTE and the Garrett GTE, your responsibilities for maintaining the fuel manifold valves will be different.

Allison.– The fuel manifold drain valves on the Allison GTE must be checked for proper mechanical and electrical operation approximately every quarter. As a GSM, you will be testing the mechanical functions of the Allison's valves to make certain they open and the residual fuel can drain. The GSEs will be checking the electrical signal sent to the valve. Both mechanical and electrical checks will also be accomplished periodically during safety checks.

Garrett.– Even though a manifold drain valve is installed on the Garrett GTE, there are no specific maintenance requirements for which you, the GSM, will be responsible.

FUEL SHUTOFF VALVE.– The fuel shutoff valve performs the same function on all of the GTEs we have discussed. This valve is the fuel's last stop before it reaches the fuel nozzles.

The only engine that has a required maintenance procedure on this valve is the Allison. This check is usually performed in conjunction with safety checks.

There are really only two types of failures that will normally occur with the Allison's fuel shutoff valve. The first failure is when the valve fails to open and the engine does not start. This problem is fairly simple to solve. The first thing you should check is the fuel manifold pressure gauge. Do this while attempting a start. If fuel pressure does not register on the gauge, you should have a GSE check the electrical signal to the valve. If a GSE verifies that the valve is receiving the proper electrical signal, then you must replace the valve. The second type of failure is when the valve fails to close or it leaks by. Valve leak by is not a rare occurrence on the Allison GTE. This problem will usually manifest itself in a spectacular fashion–either by a post shutdown fire or an exhaust boot fire. The only remedy to this problem is to replace the valve.

Turbine

The turbine section of your GTE will have very few shipboard serviceable components. As with most of the major engine components, the repairs will normally be accomplished by a SIMA.

Most of the shipboard maintenance on the turbine section will be electrical. The GSEs will service the thermocouples and the vibration pickup. You, the GSM, will service the rear scavenge oil pump and the air/oil vent system. Your maintenance of the rear scavenge oil pump will be limited to the removal and replacement of the pump and the inspection of the pump cover oil seal.

Accessory Gearbox

In each of the GTEs we have discussed, a generator set will have an accessory gearbox. On the Garrett and Sunstrand, however, the gearboxes serve a double role. They not only provide drive and mounting capabilities for the accessories, they also serve as the reduction gear and the turbine's oil reservoir.

The number of tests and inspections and the type of maintenance performed on any of the gearbox assemblies will vary somewhat, depending on the type of unit. Most of the service requirements will pertain to the gearbox accessories rather than the gearbox itself.

Most of the components attached to the accessory gearbox can be serviced, repaired, or replaced by the ship's personnel. The gearbox itself, on the other hand, is normally not serviced by the ship. These units are normally replaced when damage is suspected. The activity that will perform the removal and replacement procedures will depend upon the circumstances, special tool availability, and experience of the activity's personnel. In most cases an IMA or support activity will be called upon to perform the job.

BORESCOPING

Some very basic information on borescoping was provided to you in the *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* Volume 1, NAVEDTRA 10563. In this section, however, we will go into more detail to familiarize you more thoroughly with borescoping equipment and procedures.

BoreScope Kit

In most cases, your ship should have its initial equipment load out consisting of one set of borescope equipment. Your ship's borescope set or kit will be provided by either Wolfe or Eder, as these are the only two manufacturers that currently supply the Navy with this type of equipment.

As for your borescoping responsibilities, it will not matter which company manufactured your particular unit. The basic borescoping operation will always be the same. In the following paragraphs, we will tell you about how you should make the proper probe selection, inspect for damage, and determine the extent of any damage you discover. We will also tell you about specific guidelines you should follow when you are documenting the results of your inspection.

Remember, the borescoping kit for your ship was originally assembled for the LM2500. Fortunately, many factors were taken into consideration so that the borescoping kit would contain a combination of components that would suit the overall inspection requirements of the engine. Because of this foresight, the borescoping kit that was originally designed for the LM2500 remains very versatile and can also be used for many other types of GTEs. As a GSM, your main responsibility will be to use this equipment in the most effective way.

Selection of Equipment

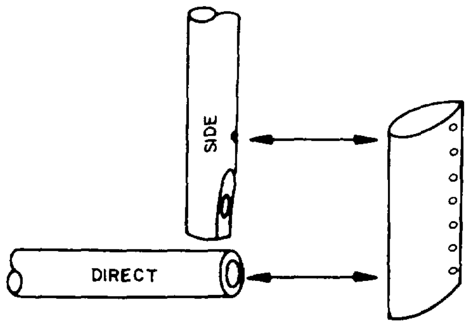
Now, let's look at figure 7-31 and talk about some of the major factors that will influence your selection of borescoping components.

PROBES.– Your borescope kit will contain three probes. Each probe has a unique configuration with special capabilities. The parameters that are varied among each of the three probes to achieve each probe's special capabilities are the viewing angle, field of vision, and magnifying factor. Let's consider the characteristics of each of the three probes.

Probe No. 1.– Probe No. 1 has a 90-degree direction of vision, a narrow field of view, and a high magnification factor. Its most important advantage is its high magnification factor. Its main disadvantage is its narrow field of view, making it difficult to usc for searching for an object. Its short depth of field will also require constant refocusing. You will most likely use probe No, 1 last. After using probe No. 2, and even probe No. 3, you will then use probe No. 1 to view a discrepancy close up.

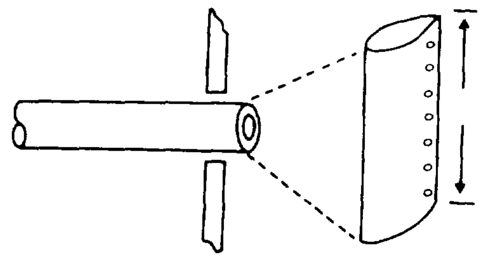
Probe No. 2.– Use probe No. 2 (red) for all initial inspections. Probe No. 2 is for looking down. In fact, its view of 100° from the axis of the probe is designed specifically for looking down. Probe No. 2 also has a wide angle view, making it very useful for searching. Its wide angle view, good depth of field, and an angle of view (100°) that is closest to the horizontal plane (90°) all serve to minimize distortion. In fact, you can perform an almost complete borescope inspection by using just probe No. 2.

Probe No. 3.– Use probe No. 3 only after you have used probe No. 2 for your initial inspection. In fact, you will use probe No. 3 only for retrospect viewing. Because its angle of view is 70° from the axis of the probe, probe No. 3 is used only for looking up. In spite of its wide view, probe No. 3 tends to be tricky to use. For example, when using probe No. 3 to lookup at (to obtain a retrospect view of) the compressor or turbine blade tips. you can accidentally bring the probe into the path of the rotating blades, causing damage to the probe and possibly the engine. Use probe No. 3 with extreme caution.



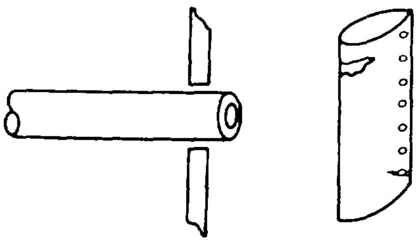
OBJECTIVE DISTANCE

THIS FACTOR HELPS DETERMINE THE ILLUMINATION SOURCE REQUIRE, THE REQUIRED OBJECTIVE FOCAL DISTANCE FOR MAXIMUM SHARPNESS, RESOLVING POWER AND MAGNIFICATION.



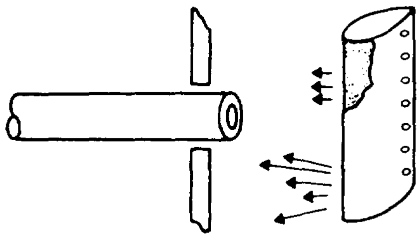
SIZE OF OBJECT

WHEN COMBINED WITH DISTANCE, THIS FACTOR DETERMINES WHAT LENS ANGLE OR FIELD OF VIEW (FOV) IS REQUIRED IN ORDER TO OBSERVE THE ENTIRE SURFACE, PARTICULAR WITH SIDE VIEWING RIGID BORESCOPES.



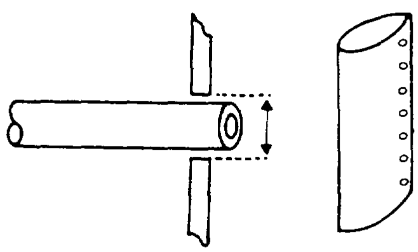
SIZE OF DEFECT

THE SIZE OF ANY DEFECTS CONSIDERED SIGNIFICANT OR CRITICAL (SUCH AS HAIRLINE CRACKS) DETERMINES THE MAGNIFICATION AND RESOLUTION REQUIRED.



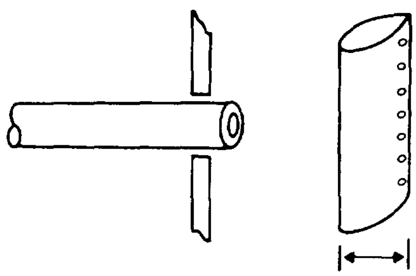
REFLECTIVITY

LIGHT-ABSORBENT OR DARK SURFACES SUCH AS THOSE COATED WITH CARBON DEPOSITS REQUIRE HIGHER LEVELS OF ILLUMINATION.



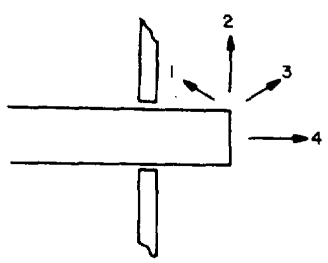
ENTRY PORT SIZE

THIS SETS THE MAXIMUM DIAMETER OF THE INSTRUMENT WHICH CAN BE INSERTED INTO THE INSPECTION AREA.



DEPTH OF OBJECT

IF PORTIONS OF THE OBJECT ARE AT DIFFERENT PLANES, THEN THE SCOPE MUST HAVE SUFFICIENT FOCUS ADJUSTMENT OR DEPTH OF FIELD TO VISUALIZE THESE DIFFERENT PLANES SHARPLY.



1.RETROSPECTIVE 2.SIDE 3.FORE-OBLIQUE 4.DIRECT

LOCATION IN RELATION TO ENTRY PORT

THIS DETERMINES THE REQUIRED DIRECTION OF VIEW OF THE SCOPE, ESPECIALLY WITH THE RIGID BORESCOPES. THIS ALSO DETERMINES THE LENGTH OF PROBE REQUIRED.

Figure 7-31.-Factors influencing borescope component selection.

ORDER OF USE.– As a general rule, use the borescope probes in the following order:

1. First, use probe No. 2 for all initial inspections.

2. Then, use probe No. 3 to obtain a retrospect view in areas where you cannot obtain a retrospect view in any other way or if there is danger of damaging probe No. 2.

3. Finally, when you have discovered a discrepancy or discontinuity by using probe No. 2 and then probe No. 3, use probe No. 1 to investigate that area more closely.

Now, let's look at some other important factors in your responsibilities for borescoping.

Borescope Inspection

The configuration of the engine's components and the location of the borescope holes will determine how you must use the borescoping equipment to accomplish the desired inspections. Referring to the physical description of the engine in the manufacturer's technical manual, you should be able to determine which equipment you will need to use to complete the inspection.

Now, let's quickly review the most important steps you must remember while doing a borescope inspection. First, review the MRC for inspection procedures, inventory of tools and equipment, safety precautions, preinspection procedures, and the procedure for engine rotation.

BORESCOPING PROCEDURE.– Next, use the following important steps and guidelines:

1. Know your equipment. By knowing your equipment, you will also know how to find what you are looking for. Before beginning your inspection, review your engine's construction information. This will refresh your memory as to the internal construction of your engine, the location and numbering of its borescope ports, and the convention for directional orientation.

2. Locate all inspection areas. The MRC will guide you to all the areas you should inspect. The inspections log book and the back of the MRC will tell you if a condition was noted during the last inspection and should be surveyed again.

3. Establish internal reference points. Photographs and drawings will allow you to choose a familiar feature or compment as a point of reference. This will allow you to confirm that you understand what you are looking at.

4. Scan the inspection area thoroughly and in an orderly manner. Your goal is to do a thorough job in a timely manner. There are a limited number of hours during which you can effectively borescope before fatigue and boredom will threaten to render the results of your inspection questionable.

5. Note all inconsistencies. The purpose of scanning is to provide an overview of all parts. An inconsistency passing through your view should automatically alert you to perform a more thorough analysis of the affected area.

6. Evaluate all inconsistencies. Use authorized techniques and guidelines to determine the type and magnitude of all defects.

7. Report your conclusions. A definitive repent is the only way you have to recall a previous condition. Just as you must use the conclusions drawn by former inspectors, you must thoroughly report and document your own conclusions of existing conditions. Your report must include an identification of the component and the surface involved. You should also describe the type and magnitude of the defect.

8. Determine the serviceability of your engine. You can determine the serviceability of your engine based on the data you have collected from the borescope inspection and the serviceability limits established by the MRC.

PHYSICAL SIZE EVALUATION PROCEDURES.– Once you find a discrepancy, you must evaluate its physical size. You can use several different ways to make a physical size evaluation.

Dimensional Data Charts.– Using the dimensional data charts that are usually located in the manufacturer's technical manual, you can estimate the physical size of a discrepancy by comparing the discrepancy area to a known dimension in the field of view.

Lockwire.– Another way to evaluate size, particularly in regard to cracks, is to use a lockwire of a known diameter. Insert the lockwire into the field of view and place it next to the crack for size comparison. When using this method, take care to make certain the lockwire does not fall inside the engine. Using an absolute reference for size, such as the lockwire of a known dimension, is more reliable than estimating by the appearance of size through the borescope.

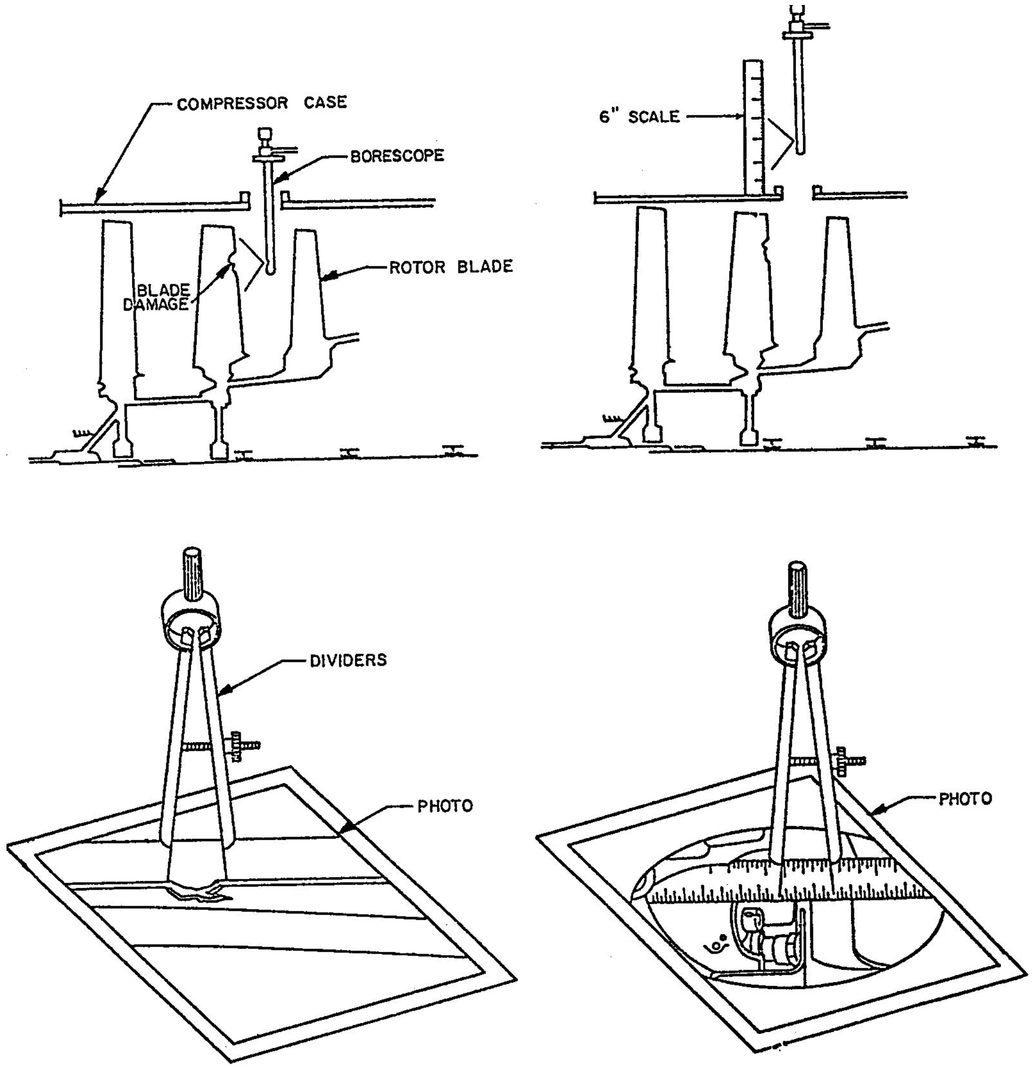


Figure 7-32.—Damage measurement techniques.

Polaroid Camera Equipment.– It is relatively easy to make a comparative measurement if Polaroid equipment is available, such as the photograph shown in figure 7-32. For the Polaroid method of estimating damage, use the following steps:

1. Position the rotor to obtain the best view of the defect, usual] y normal (at a right angle) to the defect and centered in the field of view.

2. Obtain a Polaroid photo of the defect.

3. Using a full-scale cross section of the engine for reference, locate a scale (machinist 6-inch rule) in the relative axial and circumferential position outside the compressor case. Withdraw the borescope probe with the camera attached. Hold the borescope aligned with the center line of the borescope port and obtain a photo of the measurement scale. (Holding the borescope aligned with the center line of the borescope port means using the same position, axial, angle of look, and circumferential orientation by which you obtained the defect photo.)

4. By comparative measurement, apply the magnified scale increments from the photo of the scale to the photo of the actual defect. These two photos should be at the same relative magnification.

Comparative Assessment.– If photographic equipment is not available, the comparative assessment becomes more difficult. You can still make a comparative assessment successfully by using the following procedure:

1. Position the rotor at the optimum rotation angle to view the defect.

2. Use a sample blade (if available) and mark a similar or depiction of the blade defect. Place your sample blade in the relative position of the installed defective blade on the outside of the engine.

3. Withdraw the borescope retaining the axial circumferential orientation, look at the angle relationship, and visually assess the comparison of the actual to the marked defect (from the installed blade to the external sample).

4. Correct the depiction until you are satisfied that the two images compare.

5. Measure the marked defect.

Regardless of the method you use to determine the size of the damaged area, you must always document your conclusions.

DOCUMENTATION.– At the completion of any borescoping procedure or inspection, you must always document your observations so that an accurate evaluation of engine condition can be made. Remember, the decision to continue engine operation or to remove the engine from service will be made according to documented engine conditions.

In performing your routine maintenance, inspection, and repair responsibilities, you may frequently discover component deterioration that will be within the acceptable limits. This is why it is so important that you keep an accurate record of the degree of deterioration. You should consult the applicable equipment and component records before you begin an inspection. After your inspection, you should carefully document the extent or degree of deterioration and damage to each affected area. When subsequent inspections must be performed, other inspectors must be able to use your documentation in the same way you were able to use the existing documentation before beginning your own inspections. Before any inspection, the records and documentation concerning the condition of each component should be consulted before the inspection is started so areas of concern can be emphasized and not overlooked. This will allow a subsequent inspection to determine how rapidly the component is failing. With experience and good documentation, it is often possible to make estimates of the remaining life of a component.

We have now discussed your maintenance responsibilities for the GTE. In the following sections, we will take a look at some of your responsibilities for other areas of the electrical generating plant.

GENERATORS AND REDUCTION GEARS

As a GSM2, you will need to become more and more familiar with the total electrical plant. Remember, just because you are a GSM, you are not exempt from learning about the operations of the generators. In this section, we will give you a brief explanation of the operations of the generators and their accessories. The primary goal of this section, however, will be to tell you about your responsibilities concerning maintenance, troubleshooting deficiencies, and repair of these generators, their support systems, and reduction gears.

NORMAL OPERATIONS OF DIFFERENT MODELS

The primary function of all generators installed on any gas turbine-powered ship is to provide stable 60-or 400-Hz electrical power for distribution throughout the ship. As we have explained throughout this chapter, gas turbine ships use a variety of prime movers to rotate these generators.

At the time this book was written, there were six different models of generators used on gas turbine-powered ships. Of theses six models, four provide stable 60Hz, 450-volt ac power to their respective ships. In the following paragraphs, let’s take a closer look at these four models.

CG-, DD-, DDG-51, DDG-993, and FFG-Class Ships

All of the four generator models that produce the same 60-Hz, 450-volt ac power arc installed on the CG-, DD-, DDG-51, DDG-993, and FFG-class ships. Among the four generator models installed on these ships, the main difference is in their kW outputs.

KILOWATT OUTPUTS.– On the FFG-class ships, the generators have a 1,000 kW output. On the DD- and DDG-993 class ships, the generators are rated at 2,000 kW. On the CG- and DDG-51 class ships, the generators are rated at 2,500 kW.

ACCESSORIES.– Among these four generator models, another difference you will find is in the accessories that are installed to support these units.

REDUCTION GEAR ASSEMBLIES.– Although all of these generators receive the transmission of power (rotation) from their prime movers through some form of reduction gear, the reduction gear assembly will be different, depending on the class of ship. On the DD-class ships, for example, the generators need only 1,800 rpm to produce the required frequency, voltage, and power output. Remember, 1,800 rpm is significantly lower than the turbine’s speed of 13,821 rpm.

LCAC-Class Ships

The fifth model of ac generator, found only on the LCAC-class ships, supplies 400-Hz, 120-to 208-volt ac power. You have already read about the LCAC electrical power system in chapter 6 and earlier sections of this chapter.

PHM-Class Ships

The sixth model generator is installed only on the PHMs and supplies the PHM-class ships with 400-Hz, 450-volt ac power. You have already read about the PHM's electrical power distribution system in chapter 6 and in earlier sections of this chapter.

GENERAL MAINTENANCE AND REPAIR PROCEDURES

For the CG-, DD-, DDG-993, and DDG-51 class ships, probably 90 percent of all generator maintenance will be performed at the shipboard level. As a GSM, you will be responsible for most of this maintenance. Only a small portion of the overall maintenance will be performed by the GSEs. In fact, the primary concern of the GSEs will be to maintain the internal cleanliness of the external switches and their wiring connections. On the other hand, as a GSM, you will be concerned with maintaining all of the generator's support components and systems, including the lube oil and cooling systems.

Because of the small number of design and operational differences among the models of the generators installed on the CG-, DD-, DDG-993, and DDG-51 class ships, the maintenance and upkeep of these generators and their associated systems will be the primary focus of our discussion. We will occasionally mention the LCAC, PHM, and FFG electrical systems. For detailed information concerning these ships, we recommend you consult the appropriate technical manuals.

Lubricating Oil System

All of the generators installed on the CG-, DD-, DDG-993, and DDG-51 class ships use 2190 TEP oil for bearing lubrication. Except for those installed on the DDG-51 class ships, all of these generators have their own independent oil sump. On the DDG-51 class ships, the generators share the lubricating oil that also supplies the reduction gear. On the FFG-class ships, however, the generators use 9250 (diesel) oil. On the PHM-class ships, the SSPUs use 23699 oil for lubrication. On the LCAC-class ships, the APUs have sealed bearings, which do not require external lubrication.

Even though the lubricating oil systems installed on gas turbine-powered ships use a variety of oils, they all have the same primary goals and basic system design. The goal of all these systems is to provide cooling and lubrication to the generator bearings. Regardless of the class of ship, the basic design of the lubricating oil system is the same. The system draws oil from a sump through a positive-displacement pump, where it is pumped through an oil cooler (seawater cooled) and then through a filter assembly. Lubricating oil is then distributed to the generator bearings, and then (in most cases) gravity drained back to the sump.

DESIGN DIFFERENCES.– Except for those on the DDG-51 class ships, the majority of the generator oil systems installed on gas turbine-powered ships are of this design. On the DDG-51 class ships, however, three differences make the lubricating oil system unique from all of the other Allison generator sets. These differences are shown in figure 7-33. In the DDG-51 class ships, the first difference is that the generator shares the reduction gear oil system. The second difference is the installation of a generator scavenge pump. The last difference is the installation of a jet pump eductor.

Look closely at figure 7-33 and follow along as we describe the function of the jet pump eductor. Since the generator no longer has its own sump, gravity draining of the generator bearing housing is not very efficient, a condition that could cause flooding of the bearing housing. That is why a lube oil scavenging system was installed. The pump, however, only operates when the generator is operating; therefore, the scavenging system only solves half of the problem. The other half of the problem was what to do with the excess oil during prelube operations. That is why the eductor was installed. Look again at figure 7-33. Notice that the prelube oil is used twice. Not only does it provide sufficient pre-start lubrication for the reduction gear and generator, it also powers the eductor that scavenges oil from the generator oil return lines.

Now that we have briefly discussed the basic system operations and some of the system design differences, let's move on and discuss some of the common maintenance and repair procedures you will probably be required to perform.

TESTS AND INSPECTIONS.– All generator tests and inspections, if not performed during the normal watch routine, will be covered in the PMS.

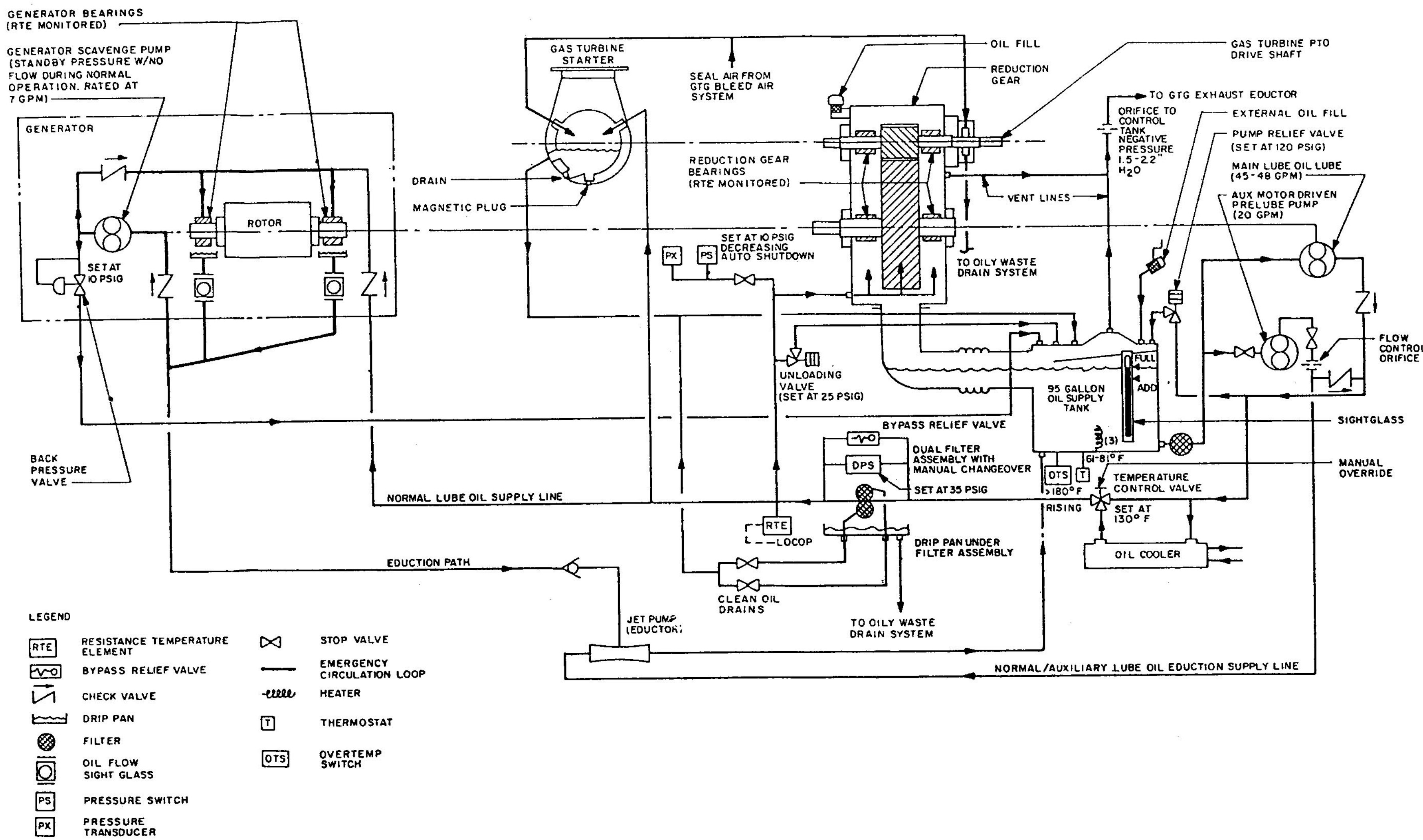


Figure 7-33.–Reduction gear/generator lube oil system (DDG-51).

Electrical Tests.– Most of the tests will be electrical. As a GSM, you will be primarily concerned with assisting the GSEs. Even then, most of the tests will be minor and easily accomplished. Primarily, these tests will consist of voltage and resistance readings on the generator, lube oil pressure and air temperature switch testing, and testing of the associated alarms.

Generator Load Testing.– The last test we will discuss is generator load testing. Load testing is normally required and accomplished after major repairs have been made to the generator. This procedure is usually accomplished by a repair activity because of the special equipment (salt box) required and the magnitude of the job.

Inspections.– Inspections, on the other hand, are primarily accomplished as part of the watch routine as well as during maintenance. As a watch stander, you will continually inspect the generator for oil leaks and overall operating efficiency. Depending on the location of the leak, an oil leak can be extremely detrimental to the operation of any generator. For this reason, you will normally inspect the oil system for leakage inside as well as outside the generator. You will perform this inspection by looking through an inspection window (where provided) on the end of the generator.

If an oil system develops a leak on the inside of the generator, several problems can result. The first and probably the most serious problem is a fire. Other problems include the abnormal or rapid wearing of the generator brushes (if installed) and the lowering of the generator's overall insulation resistance. Ultimately, these other problems can also cause a fire if they are left unattended.

TROUBLESHOOTING.– Trouble shooting a problem in any of the generator oil systems is fairly cut and dry. There are really only four problems that you will probably encounter. In the following paragraphs, we will describe these problems and some of their probable causes. We will discuss these problems in pairs because of the similarities in their symptoms and probable causes. Remember, this information is intended to make your job a little easier; it is not meant to replace your use of the approved maintenance publications.

Low or No Oil Flow.– A condition of low or no oil flow must be verified locally, unless accompanied by a low-pressure alarm. Always inspect the system for leaks first. Afterwards, use the following steps:

1. Verify the oil pressure. If the oil pressure is low, this condition should be accompanied by an alarm. If the oil pressure is sufficient, then a blockage in the system maybe the cause of the problem. In this case, because the system's oil pressure is measured after the filter, you can eliminate the filter as the problem.

2. Check the sump level. If the level is low, inspect for leakage or an improperly positioned drain valve and then add oil if the loss can be explained. If the oil level is satisfactory, you must trace the system and identify the faulty component. Some of the likely causes of the problem could include;

   a. A faulty pump. Check for a faulty relief valve or sheared drive.

   b. A faulty bypass valve (DD- and DDG-993 class ships).

   c. A blocked cooler (DDG-51 class ships).

High Oil or Bearing Temperature.– In many cases, a high oil or bearing temperature can accompany or cause the other problem to occur. For example, if the oil temperature becomes too high, the bearing temperatures will also increase. Also, if a bearing becomes overheated, the excess heat will be transferred to the oil. If either one of these problems should occur, take the following steps:

1. Verify the oil pressure and flow. Low oil pressure or low oil flow can cause the generator bearings to overheat. If either of these symptoms is the probable cause, refer to the preceding section on low or no oil flow.

2. Inspect the oil for contamination. If the oil is contaminated with water, it will lose its lubricating and cooling capabilities. The primary cause of water contamination is cooler leakage. Also, the oil sumps cannot be purified. Sometimes, in high humidity areas, condensation forms and cannot be removed. The condensation thereby contaminates the oil.

3. Verify the seawater pressure and flow through the cooler. Normally, if flow and pressure are both low, then the seawater strainer is likely clogged. It will be easy to identify if the strainer is clogged. Remember, all the generator set coolers are connected in series. You will probably receive a high turbine oil temperature alarm before you get a high generator bearing temperature alarm. If a generator bearing high temperature alarm is your only indication and a loss of cooling water is the cause, then either the valves are misaligned or the cooler is clogged.

REMOVAL AND REPLACEMENT OF COMPONENTS.– Except for the generator itself, all of the support components can be removed and replaced by ship's personnel. Even generator bearing and seal replacement (sometimes with outside assistance) can be performed by ship's personnel. But, because system reliability is high, your maintenance may be limited to the removal and replacement of oil filters for quite some time.

Cooling System

Like the oil system, the proper operation of the cooling system is vital to the overall performance of the generator. However, similar to the oil system, a generator/air/seawater cooling system is used on all of the generator sets except the APU found on the LCAC-class ships and the SSPU found on the PHM-class ships.

The generator's cooling system plays a multiple role. On the larger GTGSs, the cooling system will supply cooling water through three coolers. For example, the normal cooling water flow path on a DD-963 with proper valve alignment is from (1) generator cooling water pump, (2) a strainer, (3) the generator air cooler, (4) the generator oil cooler, and then to (5) the reduction gear and engine oil cooler before it is discharged overboard.

TESTS AND INSPECTIONS.– As the GSM, you will be responsible for all tests and inspections for the cooling water system. There are very few electrical components installed in this system. In fact, the primary electrical component is the pressure switch. This switch on a DD-963 class ship, for example, controls the flow of emergency cooling water if the normal pressure is lost. For the most part, the only tests you will need to perform will be operational checks on the cooling water pump and the emergency cooling water system.

Inspections will normally be performed as part of the watch routine. For the cooling water system, even though water is not flammable, a leak, depending on its location, can be extremely damaging. For example, just like in the oil system, a leak inside the generator can damage components and even cause a fire. The PMS will also require the cleaning and inspection of all of the generator's coolers.

TROUBLESHOOTING.– The troubleshooting procedures you should perform were described in the section on high oil or bearing temperatures. Also, remember always to use an approved technical reference.

REMOVAL AND REPLACEMENT OF COMPONENTS.– If required, all of the components in the cooling system can be removed and replaced by ship's personnel. Except for the relief valve, the cooling water pump will probably be removed, replaced, or rebuilt more than any other system component. The primary reason for pump disassemble y or removal will be because of a faulty mechanical seal.

Reduction Gear Assembly

All of the GTGSs that we have discussed throughout this chapter use some type of a reduction gear assembly. These assemblies are used to reduce the high speeds of the turbine to a workable speed used to turn the generator. For example, the generator on a DD-963 class ship requires only 1,800 rpm to produce its rated output. This means the 13,821 rpm speed of the turbine must be reduced by an approximate ratio of 7.67 to 1.

The proper operation and care of these reduction gears will play a vital role in the overall performance of the generating plant. Without the reduction gear, the generator would be inoperable.

In this section we will discuss how to maintain, troubleshoot, and repair this very vital piece of equipment and its support components. However, we will only discuss the most prominent type of reduction gear. These units are installed on the CG-, DD-, and DDG-993 class ships.

TESTS AND INSPECTIONS.– Testing is normally limited to the reduction gear's lubricating oil and some alarm circuits. On the other hand, inspections are constantly performed. Inspections vary in complexity from the normal routine or visual inspections performed while the unit is operating to the complicated task of opening the gear casing to inspect gear teeth wear and high-speed pinion axial thrust. Remember, even though this reduction gear is part of the generator, an internal inspection must be treated in the same manner as if you were inspecting the main reduction gear.

There are some other inspections that you will probably be required to perform. These inspections are performed on the reduction gear support components, such as the turbine starter, power take off (PTO) shaft, and reduction gear to generator drive shaft.

Turbine Starter.– The turbine starter is probably the one support component you will inspect the most frequently. You will normally check the turbine starter for oil leaks, diffuser vane wear, and drive gear clearances. The drive gear clearance inspection is very important because you must check for proper starter drive engagement to the reduction gear drive assembly.

PTO Shaft.– The PTO shaft inspection is part of an overall maintenance check in which you will measure the turbine-to-reduction gear alignment. There are two other components that are associated with the PTO shaft that you will be responsible to inspect-the midbearing oil spray nozzle and the turbine speed pick up.

Midbearing Oil Spray Nozzle.– You should periodically remove and inspect the oil spray nozzle to ensure the nozzle holes are clear of debris and that the nozzle has been providing a proper oil supply to the midbearing.

Turbine Speed Pick Up.– The last component in the PTO shaft you should check is the turbine speed pick up. You should normally clean and inspect this component to make certain the measuring surface is clean and undamaged.

Reduction Gear to Generator Shaft.– The last inspection we will discuss is the reduction gear to generator shaft. This inspection is not difficult or involved. Your main concerns will be inspecting for any loose flange bolts or foreign objects rubbing against the shaft. You should also make sure the shaft is free of dents or dings that could affect the shaft's balance.

ALIGNMENTS AND ADJUSTMENTS.– As we talked about in the previous section, the proper alignment of reduction gear components is very crucial. Since we have already discussed the components that require aligning, let's talk about the adjustments needed to make these alignments correct.

Starter.– The proper engagement of the starter is necessary for the smooth transmission of power from the starter to the reduction gear. Considering the price of a starter and the fact that you have never done this procedure before, you will probably be pretty nervous on your first try.

Essentially, the adjustment is made by the addition or removal of shims on the backside of the reduction gear drive gear. This adjustment is made to ensure a predetermined distance between the two gears is maintained before engagement. This distance is based on the maximum amount of travel of the starter drive gear. The space between the two gears is not very hard to calculate if you use the following steps:

1. With the starter removed, measure the distance from the starter mounting flange to the face of the gear and record this amount. (We will refer to this distance as measurement A.)

2. Measure the distance from the reduction gear mounting flange to the face of the driven gear (measurement B) and record this amount. (We will refer to this distance as measurement B.)

3. You already have the measurement for the predetermined amount of the starter shaft travel, which we will refer to as measurement C. Now that you have measurements A, B, and C, you will need to calculate whether the addition or removal of shims is necessary. In most cases, due to wear of gear teeth, the addition of shims will be necessary.

4. Add measurements A and C together and record the total (measurement D). Now subtract measurement B from measurement D and record this amount. (You will usually subtract because of wear.)

5. The last amount you must determine is the distance that needs to be compensated for with shims. Select the shims and install and repeat the measurement procedure until the proper clearances are achieved.

The procedure we have just described is an overview and is not intended to replace the procedures found in the PMS or another approved technical procedure.

PTO Shaft.– To achieve proper PTO shaft alignment (turbine to reduction gear), you must make an adjustment by changing the turbine's position on its mounts. Usually the addition of shims to the turbine's pedestal mount is necessary to bring the engine back to the proper alignment height. Since this procedure can be very involved, we recommend you consult the appropriate technical references.

Generator Drive Shaft.– This procedure is very difficult to perform. Although you may be asked to assist, the work will be accomplished by a repair facility and sometimes under the close supervision of a NAVSEA representative. The key things that make this job so difficult are the following conditions:

1. The equipment is very heavy, and experienced rigging is required.
2. Changes in ambient air temperature will adversely affect accurate measuring capabilities.

TROUBLESHOOTING AND REPAIRS.– Troubleshooting a problem on the generator's reduction gear or its support components can sometimes be difficult. The hardest problem for you to isolate will be an unusual noise. Since the majority of the components are metal, they will readily transmit noise. The noise will be amplified and will sound as though it is everywhere. For this reason, it is extremely important for you, the GSM, to make yourself very familiar with every little noise that pertains to the unit's operation. Simply stated, you should be able to recognize what is normal so you will be able to identify a problem if one should occur.

Starter.– There are some problems with the starter that you, the GSM, should be able to diagnose and repair. The following list contains a description of these problems and their probable solutions:

1. The starter fails to engage. When this occurs, you should first check to see if the starter is turning. Next, verify the condition of the drive and driven gears. Remember, if they are worn excessively they will not engage. Also check for proper clearances between the gear faces. The last item to check is the starter drive shaft movement. Is it actually moving out for engagement? Most of these problems can be repaired at the shipboard level. The exception is if the starter drive fails to move out. In this case, the whole starter must be removed and replaced.

2. The starter fails to disengage. This condition will normally occur when the starter drive binds up in the extended position or the gear-to-gear clearance is too small.

PTO Shaft.– A problem in the PTO shaft will probably be one of the easiest to solve. For example, if the midbearing seizes, the shaft assembly is designed to shear at the taper coupling. This design prevents damage to the turbine. After all, a PTO shaft is much cheaper to replace than a turbine. The following list includes a description of symptoms that will appear if the taper coupling shears:

1. While attempting a start, the starter engages and the reduction gear is rotating, but the turbine is not.

2. While operating, the generator voltages drop rapidly and the turbine and reduction gear oil pressure diminishes because the reduction gear is not turning (CG-, DD-, and DDG-993 class ships). If you are on a DDG-51 class ship, then the generator and reduction gear oil pressures would be affected,

Generator Drive Shaft.– You will probably never encounter a problem in which you can pinpoint this shaft as the failed part. There are only two ways that could cause this shaft to fail: (1) if the shaft has been dropped in shipping, installation, or removal, and (2) a catastrophic failure due to a manufacturer's defect.

REMOVAL AND REPLACEMENT OF COMPONENTS.– All of the components we have discussed, except the complete reduction gear assembly and the generator drive shaft, can be removed and replaced at the shipboard maintenance level.

The starter, as you know, is removed all the time for periodic inspections and maintenance. Therefore, if the starter fails, replacing it is not considered to be a major evolution.

On the other hand, the PTO shaft does not fail that often and you may never see the time when it will have to be replaced. The procedure for replacing the PTO shaft requires the engine to be removed from its mounts and moved back. Once the engine is moved back far enough to be uncoupled, it must then be angled inside the enclosure to allow enough access for shaft removal. You will likely be required use an IMA for assistance in this procedure.

As already discussed, the removal and replacement of the generator drive shaft cannot be accomplished at the shipboard maintenance level.

SUMMARY

You have just read about some of the components, systems, and maintenance requirements associated with the electric plants installed on the different gas turbine-powered ships. You also read about the operations, maintenance requirements, and troubleshooting techniques for prime movers, such as the Allison 501-K17 and K34 models, the Garrett found on the PHM-class ships, the Sunstrand found on the LCAC-class ships, and the Detroit Diesel you will encounter on the FFG-class ships. After reading the information in this chapter, you should be able to recognize the similarities among these important units and their operating, design, and functional differences. Most importantly, you, as a GSM who may be assigned to any of these gas turbine ships, should be able to identify your responsibilities for the maintenance, repair, and operational readiness of these important units.

APPENDIX I

GLOSSARY

ALARM ACKNOWLEDGE.– Apush button 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 continuous y 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 separated 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 CCS 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, GCU, 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 ship 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-poweredships.

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 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).– Located in 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).– 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 conducts. It is measured in amperes.

DAMAGE CONTROL CONSOLE (DCC).– This console is located in CCS and provides monitoring for hazardous conditions (tire, 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 ship.

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 of 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 frequency for any varying load. 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 voltage 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.

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 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 which 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 (EOP).– 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'S OPERATING STATION (EOS).– This station, located on the PHM, contains machinery controls, fire detection and extinguishing panel, 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 (EOP) and casualty control procedures (EOCC) for the propulsion plant.

ENGINE ORDER TELEGRAPH (EOT).– A non-voice 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 information 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 more pure 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; dint, 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 ELECTROMC 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 CCS and is the central station for monitoring and control of the fuel fill and transfer system.

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 which 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 ship.

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 tell 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.– This 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 (.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 (2). The unit of resistance. One ohm is the value of resistance through which a potential difference of one volt will maintain a current of one 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 which 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 (e.g., single-phase, three-phase, etc.).

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 alpha-numeric 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 which 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 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 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 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 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 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 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's 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 draw 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 which, 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).– Provide a means of controlling and monitoring ship's speed, heading, plant propulsion status, and shaft performance. Most of the SCE is 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 a part 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 (e.g., 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 (e.g., diodes, transistors, etc.).

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 it 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 which 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 waste heat boiler 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

ABT–automatic bus transfer

at–alternating current

ACC–auxiliary control console

A/C–air conditioning

ACS–automatic control system

A/D–analog-to-digital

AMR–auxiliary machinery room

AMS–alarm and monitor system

APD–automatic paralleling device

APL–allowance parts list

APU–auxiliary power unit

B

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&C–command and control

CB–circuit breaker

CCS–central control station

CNO–Chief of Naval Operations

COSAL–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

D

dc–direct current

DCC–damage control console

DCU–data converter unit

DDI–demand display indicator

DMS–data multiplex system

DSP–disodium phosphate

DTG–date-time group

E

ECM–engine control module

ECSS–egineering 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 causalty control

EOOW/LU–engineering officer of the watch/logging unit

EOOW–engineering officer of the watch

EOP–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

F

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

G

GCU–generator control unit

GS–gas turbine systems technician

GSE–gas turbine systems technician (electrical)

GT–gas turbine

GTB–gas turbine bulletin

GTC–gas turbine change

GTE–gas turbine engine

GTGS–gas turbine generator set

H

HBCS–hullborne control system

hp–horsepower

HSVL–high speed velocity log

Hz–hertz

I

IC–interior communication electrician

IIEC–interim integrated electronic control

IMA–intermediate maintenance activity

in.lb–inch pound

in.H_2O–inches of water

I/O-input/output

ITC-integrated throttle control

K

kW–kilowatt

L

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

M

mA–milliampere

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

N

NAVSEACEN–naval sea support center

NRTC–nonresident training course

NSTM–naval ships' technical manual

O

OD–oil distribution

OOD–officer of the deck

P

PACC–propulsion and auxiliary control console

PAMCE–propulsion and auxiliary machinery control equipment

PAMISE–propulsion and auxiliary machinery information system

PCBæprinted 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

Q

QA–quality assurance

QAO–quality assurance officer

R

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

SAC–start air compressors

SCC–ship control console

SCE–ship control equipment

S/CE–signal conditioning enclosure

SCR–silicon controlled rectifier

SCS–supervisory control system

SCU–shaft control unit

SEM–standard electronic module

SIMA–shore intermediate maintenance activity

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

T

TCPI–temperature compensated pitch indicator

TD–technical directive

TIT–turbine inlet temperature

TLI–tank level indicator

TOPS–turbine overload protection system

TRAMAN–training manual

TSP–trisodium phosphate

TYCOM–type commander

U

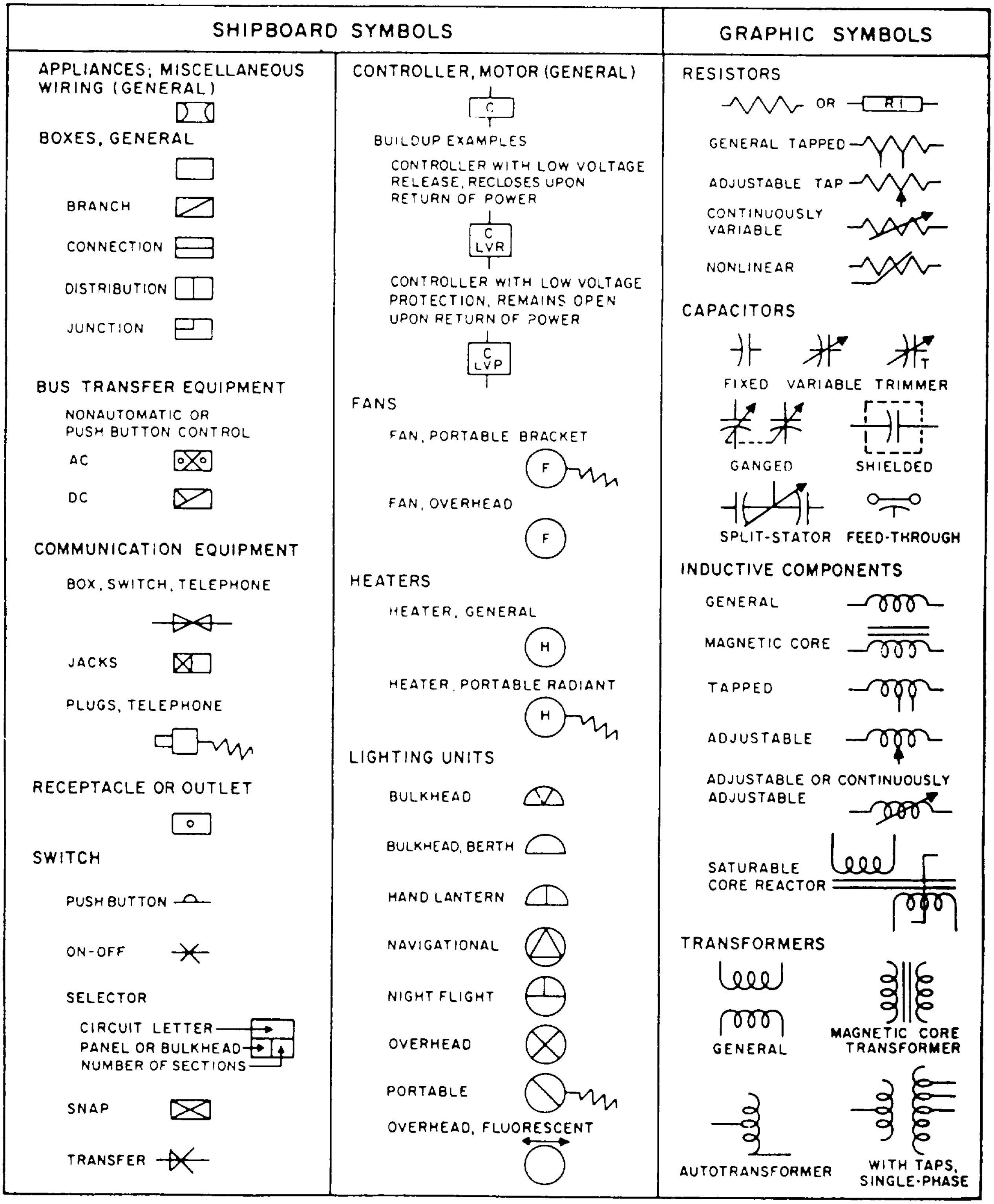
UPS–uninterrupted power supply

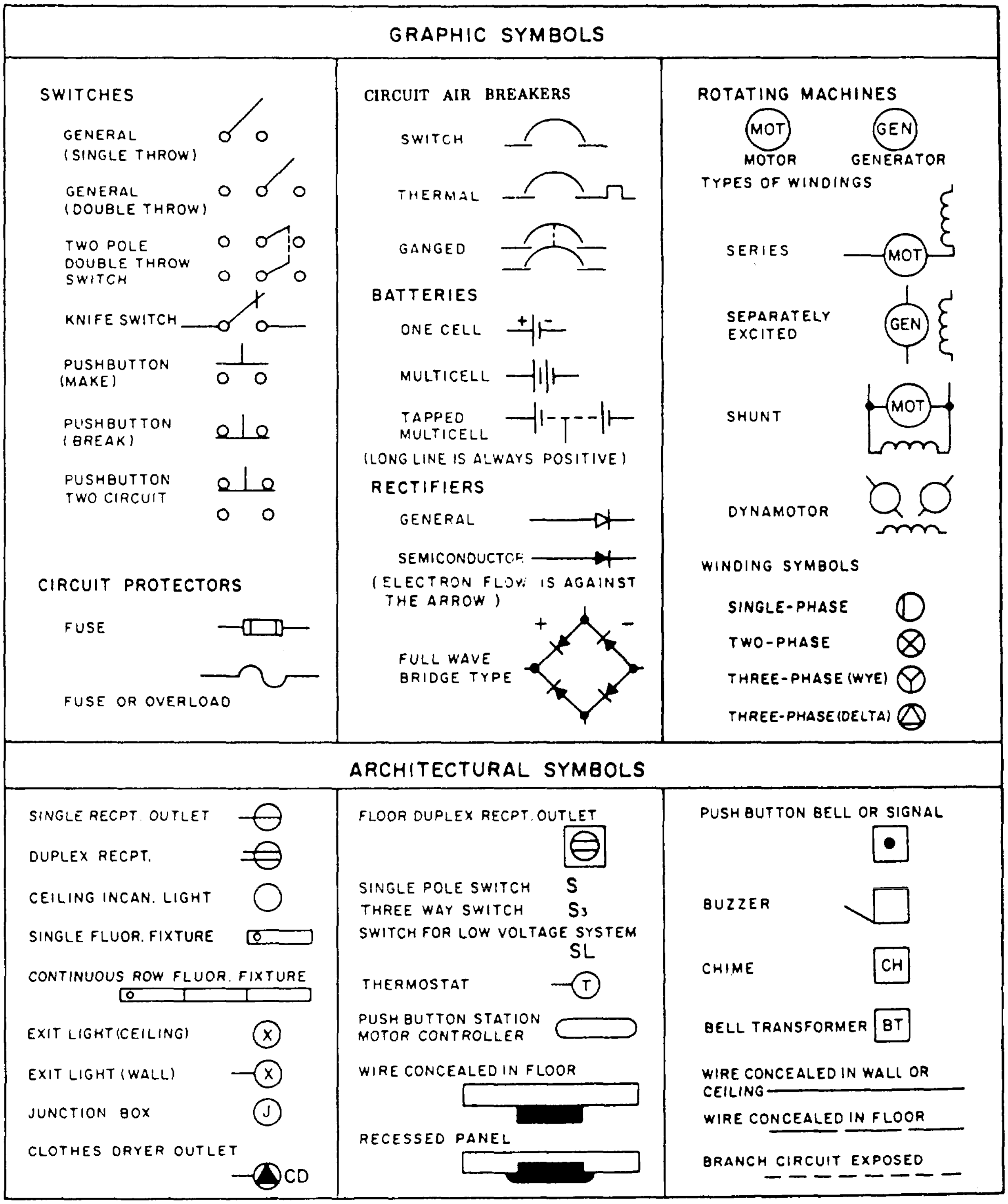
W

WHB–waste heat boiler

APPENDIX III

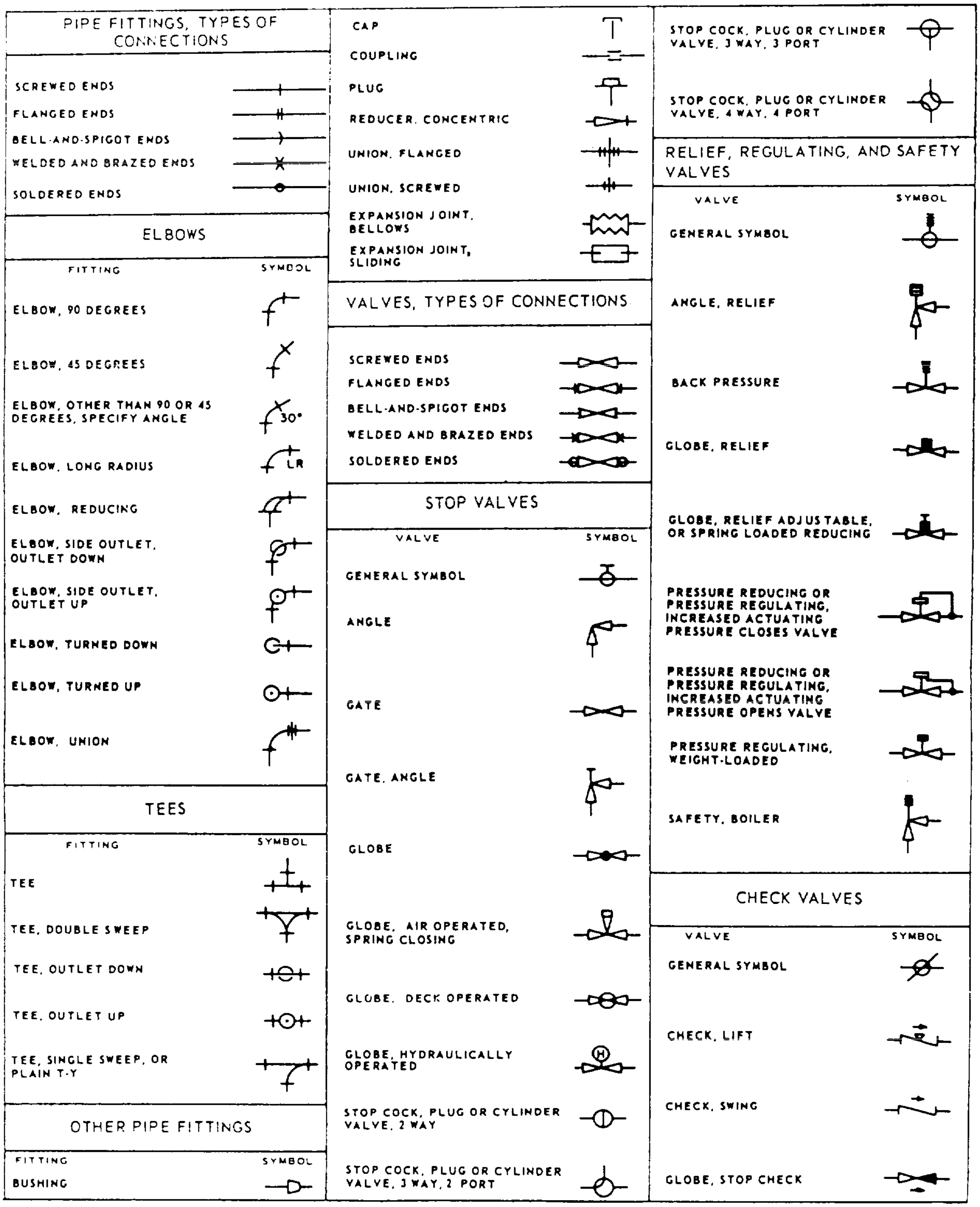
ELECTRICAL SYMBOLS


SHIPBOARD 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
GRAPHIC SYMBOLS
RESISTORS
OR
R1
GENERAL TAPPED
ADJUSTABLE TAP
CONTINUOUSLY VARIABLE
NONLINEAR
CAPACITORS
T
FIXED
VARIABLE
TRIMMER
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
MOT
SEPARATELY EXCITED
GEN
SHUNT
MOT
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)
X
EXIT LIGHT (WALL)
X
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

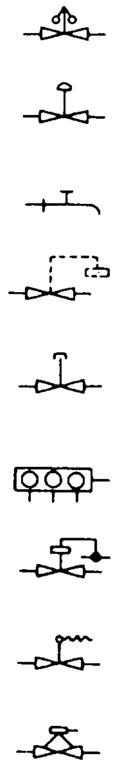
APPENDIX IV

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

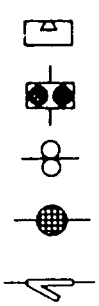
OTHER VALVES

VALVE	SYMBOL
AUTOMATIC, OPERATED BY GOVERNOR	
DIAPHRAGM	
FAUCET	
FLOAT OPERATED	
LOCK AND SHIELD	
MANIFOLD	
PUMP GOVERNOR	
SOLENOID CONTROL	
THERMOSTATICALLY CONTROLLED	



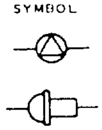
STRAINERS

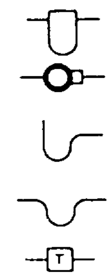
TYPE	SYMBOL
BOX STRAINER	
DUPLEX OIL FILTER	
DUPLEX STRAINER	
STRAINER	
Y STRAINER	



TRAPS

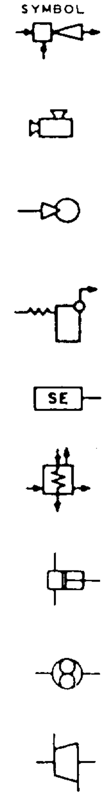
TYPE	SYMBOL
AIR ELIMINATOR	
BOILER RETURN TRAP	
BUCKET TRAP	
FLOAT TRAP	
P TRAP	
RUNNING TRAP	
TRAP	T





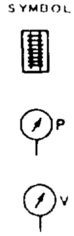
POWER AND HEATING PLANT EQUIPMENT

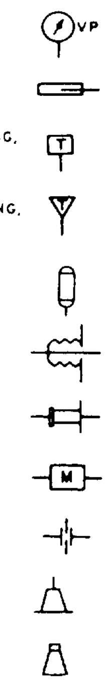
UNIT	SYMBOL
AIR EJECTOR	
BLOWER	
BLOWER, SOOT	
BOILER, STEAM GENERATOR (WITH ECONOMIZER)	
ENGINE, STEAM	SE
EVAPORATOR, SINGLE EFFECT	
PUMP, RECIPROCATING	
PUMP, ROTARY AND SCREW	
TURBINE, STEAM	



GAGES, THERMOMETERS, AND MISCELLANEOUS

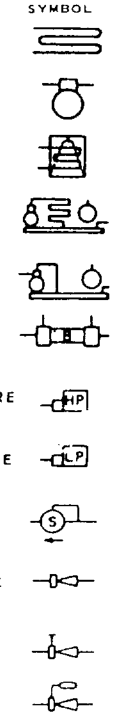
TYPE	SYMBOL
LIQUID LEVEL	
PRESSURE	P
VACUUM	V
VACUUM-PRESSURE	VP
THERMOMETER	
THERMOMETER, DISTANT READING, BARE BULB TYPE	T
THERMOMETER, DISTANT READING, SEPARATE SOCKET TYPE	
AIR CHAMBER	
BULKHEAD JOINT, EXPANSION	
BULKHEAD JOINT, FIXED	
METER, DISPLACEMENT TYPE (OTHER THAN ELECTRICAL)	M
ORIFICE	
SEA 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

METRIC SYSTEM

Table AV-1.-Decimal System Prefixes

THESE PREFIXES MAY BE APPLIED TO ALL SI UNITS

Multiples and Submultiples	Prefixes	Symbols
1 000 000 000 000 = 10^{12}	tera (tĕr′ȧ)	T
1 000 000 000 = 10^{9}	giga (ǰi′gȧ)	G
1 000 000 = 10^{6}	mega (mĕg′ȧ)	M*
1 000 = 10^{3}	kilo (kĭl′ō)	k*
100 = 10^{2}	hecto (hĕk′tō)	h
10 = 10	deka (dĕk′ȧ)	da
0.1 = 10^{-1}	deci (dĕs′ĭ)	d
0.01 = 10^{-2}	centi (sĕn′tĭ)	c*
0.001 = 10^{-3}	milli (mĭl′ĭ)	m*
0.000 001 = 10^{-6}	micro (mī′krō)	μ*
0.000 000 001 = 10^{-9}	nano (năn′ō)	n
0.000 000 000 001 = 10^{-12}	pico (pē′kō)	p
0.000 000 000 000 001 = 10^{-15}	femto (fĕm′tō)	f
0.000 000 000 000 000 001 = 10^{-18}	atto (ăt′tō)	a

*Most commonly used

293.80

Table AV-2.-Metric Conversions

Multiply	By	To Obtain
Acres	40.47	Ares
Acres	4,047	Centares
Acres	10	Square Chains
Acres	43,560	Square Feet
Acres	4,840	Square Yards
Ares	0.02471	Acres
Ares	100	Centares
Ares	1,076	Square Feet
Ares	119.6	Square Yards
Barrels (U.S., dry)	3.281	Bushels
Barrels (U.S., liquid)	4.21	Cubic Feet
Barrels (U.S., liquid)	31.5	Gallons
Board Feet (1′ × 1′ × 1′)	144	Cubic Inches
Cable Lengths (U.S.)	120	Fathoms
Cable Lengths (U.S.)	720	Feet
Cable Lengths (U.S.)	240	Yards
Centares	10.76	Square Feet
Centares	1.196	Square Yards
Centimeters	0.3937	Inches
Cubic Centimeters	0.06102	Cubic Inches
Chains	66	Feet
Chains	100	Links
Chains	4	Rods
Cubic Feet	1,728	Cubic Inches
Cubic Feet	0.02832	Cubic Meters
Cubic Feet	0.03704	Cubic Yards
Cubic Feet	6.229	Gallons (British)
Cubic Feet	7.481	Gallons (U.S.)
Cubic Feet	28.316	Liters

Table AV-2.-Metric Conversions-Continued

Multiply	By	To Obtain
Cubic Inches	16.39	Cubic Centimeters
Cubic Inches	0.0005787	Cubic Feet
Cubic Inches	0.003606	Gallons (British)
Cubic Inches	0.004329	Gallons (U.S.)
Cubic Inches	0.01639	Liters
Cubic Meters	35.31	Cubic Feet
Cubic Meters	1.308	Cubic Yards
Cubic Yards	27	Cubic Feet
Cubic Yards	0.7646	Cubic Meters
Cubic Yards	764.6	Liters
Degrees (C.) 17.8	1.8	Degrees (F.)
Degrees (F.) –32	0.5556	Degrees (C.)
Degrees	0.01745	Radians
Fathoms	0.00833	Cable Lengths (U.S.)
Fathoms	6	Feet
Fathoms	1.8288	Meters
Feet	30.48	Centimeters
Feet	0.1667	Fathoms
Feet	0.3048	Meters
Feet per Minute	0.01136	Mile per Hour
Feet per Second	0.5921	Knots
Feet per Second	18.288	Meter per Minute
Feet per Second	0.6818	Miles per Hour
Furlongs	10	Chains
Furlongs	660	Feet
Furlongs	40	Rods
Furlongs	220	Yards
Gallons (British)	4,546.1	Cubic Centimeters
Gallons (British)	0.1605	Cubic Feet

Table AV-2.-Metric Conversion-Continued

Multiply	By	To Obtain
Gallons (British)	277.274	Cubic Inches
Gallons (British)	1.2009	Gallons (U.S.)
Gallons (British)	4.546	Liters
Gallons (British)	4	Quarts (British)
Gallons (U.S.)	0.03175	Barrels (Liquid U.S.)
Gallons (U.S.)	3,785.4	Cubic Centimeters
Gallons (U.S.)	0.13368	Cubic Feet
Gallons (U.S.)	231	Cubic Inches
Gallons (U.S.)	0.8327	Gallons (British)
Gallons (U.S.)	3.785	Liters
Gallons (U.S.)	4	Quarts (U.S.)
Grams	15.43	Grains
Grams	0.001	Kilograms
Grams	1,000	Milligrams
Grams	0.03527	Ounces (Avoirdupois)
Hands	10.16	Centimeters
Hands	4	Inches
Hectares	2.471	Acres
Hectares	100	Ares
Hectoliters	0.1	Cubic Meters
Hectoliters	26.417	Gallons (U.S.)
Hectoliters	100	Liters
Hogsheads	2	Barrels (Liquid, U.S.)
Hogsheads (U.S.)	63	Gallons, (U.S.)
Hundredweights	0.508	Quintals (Metric)
Inches	72	Points
Inches	6	Picas
Inches	6	Ems
Inches	12	Ens

Table AV-2.-Metric Conversions-Continued

Multiply	By	To Obtain
Inches	2.54	Centimeters
Inches	0.0833	Feet
Inches	1,000	Mils
Inches	0.0277	Yards
Inches of Mercury	0.49131	Pounds per Square Inch
Kilograms	1,000	Grams
Kilograms	2.2046	Pounds (Avoirdupois)
Kiloliters	1	Cubic Meters
Kiloliters	1.308	Cubic Yards
Kiloliters	264.18	Gallons (U.S.)
Kiloliters	1,000	Liters
Kilometers	4.557	Cable Lengths
Kilometers	3,280.8	Feet
Kilometers	39,370	Inches
Kilometers	1,000	Meters
Kilometers	0.5396	Miles, Nautical
Kilometers	0.62137	Miles, Statute
Kilometers	1,093.6	Yards
Knots	1.1516	Statute Mile per Hour
Knots	1.688	Feet per Second
Leagues, Nautical	25.33	Cable Lengths
Leagues, Nautical	5.5597	Kilometers
Leagues, Nautical	3	Miles, Nautical
Leagues, Statute	4.8280	Kilometers
Leagues, Statute	3	Miles, Statute
Links	7.92	Inches
Liters	1,000	Cubic Centimeters
Liters	61.025	Cubic Inches
Liters	0.21998	Gallons (British)

Table AV-2.-Metric Conversions-Continued

Multiply	By	To Obtain
Liters	0.26418	Gallons (U.S.)
Liters	0.8799	Quarts (British)
Liters	0.908	Quarts (U.S., dry)
Liters	1.0567	Quarts (Liquid, U.S.)
Meters	100	Centimeters
Meters	0.001	Kilometers
Meters	1.0936	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1,000	Millimeters
Meters	1.0936	Yards
Meters per Minute	0.0547	Feet per Second
Meters per Second	2.237	Miler per Hour
Microns	0.001	Millimeters
Miles, Nautical	8.44	Cable Lengths
Miles, Nautical	6,076.1	Feet
Miles, Nautical	72,963	Inches
Miles, Nautical	1.8532	Kilometers
Miles, Nautical	1,853.2	Meters
Miles, Nautical	1.1508	Miles, Statute
Miles, Nautical	1	Minutes of Latitude
Miles, Nautical	2,026.8	Yards
Miles per Hour (Statute)	88	Feet per Minute
Miles per Hour (Statute)	1.467	Feet per Second
Miles per Hour	0.8684	Knots
Miles, Statute	7.33	Cable Lengths
Miles, Statute	5,280	Feet
Miles, Statute	8	Furlongs

Table AV-2.-Meric Conversions-Continued

Multiply	By	To Obtain
Miles, Statute	63,360	Inches
Miles, Statute	1.6093	Kilometers
Miles, Statute	1,609.3	Meters
Miles, Statute	0.8689	Miles, Nautical
Miles, Statute	1,760	Yards
Millier (See Tons - Metric)		
Milliradians	206.265	Seconds of Arc
Mils	0.001	Inches
Myriameters	10	Kilometers
Ounces (Avoirdupois)	28.3495	Grams
Pint (Liquid, U.S.)	4	Gills (U.S.)
Pint (Liquid, Br.)	4	Gills (British)
Pint, (Liquid, Br.)	0.56825	Liters
Pint (Liquid, U.S.)	0.4732	Liters
Pounds (Avoirdupois)	7,000	Grains
Pounds (Avoirdupois)	453.59	Grams
Pounds (Avoirdupois)	0.4536	Kilograms
Pounds (Avoirdupois)	16	Ounces
Pounds (Avoirdupois)	1.2153	Pounds (Troy)
Pounds (Troy)	0.8229	Pounds (Avoirdupois)
Pounds per Square Inch	2.03537	Inches of Mercury
Quart (British)	1.1365	Liters
Quart (British)	2	Pints (British)
Quart (Liquid, U.S.)	0.9463	Liters
Quart (U.S.)	2	Pints (U.S.)
Quintals (Metric)	1.97	Hundredweights
Quintals (Metric)	100	Kilograms
Radians	57.30	Degrees

Table AV-2.-Metric Conversion-Continued

Multiply	By	To Obtain
Rods	16.3	Feet
Rods	25	Links
Square Centimeters	0.1550	Square Inches
Square Feet	0.0929	Centares
Square Feet	929	Square Centimeters
Square Feet	144	Square Inches
Square Feet	0.1111	Square Yards
Square Inches	6.452	Square Centimeters
Square Inches	0.006944	Square Feet
Square Kilometers	100	Hectares
Square Kilometers	0.3861	Square Miles (Statute)
Square Meters (See Centares)		
Square Miles, Statute	640	Acres
Square Miles, Statute	25,900	Ares
Square Miles, Statute	259	Hectares
Square Miles, Statute	2.59	Square Kilometers
Square Yards	0.8362	Centares
Square Yards	9	Square Feet
Square Yards	1,296	Square Inches
Tons (Long)	1.016	Metric Tons
Tons (Long)	2,240	Pounds (Avoirdupois)
Tons (Metric) (Millier)	1,000	Kilograms
Tons (Metric) (Millier)	2,204.6	Pounds (Avoirdupois)
Tons (Short)	0.9072	Metric Tons
Tons (Short)	2,000	Pounds (Avoirdupois)
Yards	91.44	Centimeters
Yards	0.9144	Meters

APPENDIX VI

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
Module 23	Magnetic Recording
Module 24	Introduction to Fiber Optics

APPENDIX VII

REFERENCES USED TO DEVELOP THE TRAMAN

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be insured. Therefore, you need to be sure that you are studying the latest revision.

Chapter 1

Blueprint Reading and Sketching, NAVEDTRA 10077-F1, Naval Education and Training Program Management Support Activity, Pensacola, Fla., July 1988.

Boiler Technician 1 & C, NAVEDTRA 10536-F, Naval Education and Training Program Management Support Activity, Pensacola, Fla., 1985.

Engineering Administration, NAVEDTRA 10858-F1, Naval Education and Training Program Management Support Activity, Pensacola, Fla., April 1988.

Engineman 1 & C, NAVEDTRA 10543-E1, Naval Education and Training Program Management Support Activity, Pensacola, Fla., April 1987.

Naval Ships' Technical Manual, S9086-CZ-STM-000, Chapter 090, "Inspections, Tests, Records, and Reports," Naval Sea Systems Command, Washington, D.C., 1 July 1988.

Naval Ships' Technics/ Manual, S9086-GX-STM-020, Chapter 220, "Boiler Water/Feedwater Test and Treatment," Volume 2, Naval Sea Systems Command, Washington, D.C., 15 December 1987.

Naval Ships' Technical Manual S9086-HB-STM-000, Chapter 233, "Diesel Engines," Naval Sea Systems Command, Washington, D.C., 15 June 1987.

Naval Ships' Technical Manual, S9086-HC-STM-000, Chapter 234, "Marine Gas Turbines," Naval Sea Systems Command, Washington, D.C., 15 August 1988.

Naval Ships' Technical Manual, S9086-H7-STM-010, Chapter 262, "Lubricating Oils, Greases, Hydraulic Fluids and Lubrication Systems," Naval Sea Systems Command, Washington, D.C., 15 September 1987.

Naval Ships' Technical Manual, S9086-RW-STM-010, Chapter 516, "Refrigeration Systems," Naval Sea Systems Command, Washington, D.C., 1 December 1986.

Naval Ships' Technical Manual, S9086-SN-STM-000, Chapter 541, "Petroleum Fuel Stowage, Use, and Testing," Naval Sea Systems Command, Washington, D.C., 1 September 1986.

Naval Ships' Technical Manual, S9086-SP-STM-010, Chapter 542, "Gasoline and JP-5 Fuel Systems," Naval Sea Systems Command, Washington, D.C., 28 September 1990.

Naval Snips' Technical Manual, S9086-SY-STM-010, Chapter 551, "Compressed Air Plants and Systems," Naval Sea Systems Command, Washington, D.C., 15 September 1989.

Naval Ships' Technical Manual, 0901-LP-420-0002, Chapter 9420, "Propulsion Reduction Gears, Couplings, and Associated Components," Naval Sea Systems Command, Washington, D.C., 15 August 1985.

Ship's Maintenance and Material Management (3-M) Manual, OPNAVINST 4790.4B, Office of the Chief of Naval Operations, Washington, D.C., 13 August 1987.

Standard Organization and Regulations of the U.S. Navy, OPNAVINST 3132.32B, Office of the Chief of Naval Operations, Washington, D.C., 26 September 1986.

Chapter 2

Engineering Administration, NAVEDTRA 10858-F1, Naval Education and Training Program Management Support Activity, Pensacola, Fla., April 1988.

Naval Ships' Technical Manual, S9086-GX-STM-020, Chapter 220, "Boiler Water/Feedwater Test and Treatment," Volume 2, Naval Sea Systems Command, Washington, D.C., 15 December 1987.

Naval Ships' Technical Manual, S9086-HB-STM-000, Chapter 233, "Diesel Engines," Naval Sea Systems Command, Washington, D.C., 15 June 1987.

Naval Ships' Technical Manual, S9086-HC-STM-000, Chapter 234, "Marine Gas Turbines," Naval Sea Systems Command, Washington, D.C., 15 August 1988.

Naval Ships' Technical Manual, S9086-H7-STM-010, Chapter 262, "Lubricating Oils, Greases, Hydraulic Fluids and Lubrication Systems," Naval Sea Systems Command, Washington, D.C., 15 September 1987.

Naval Ships' Technical Manual, S9086-KC-STM-010, Chapter 300 R2, "Electric Plant-General," Naval Sea Systems Command, Washington, D.C., 28 February 1991.

Naval Ships' Technical Manual, S9086-SN-STM-000, Chapter 541, "Petroleum Fuel Stowage, Use, and Testing," Naval Sea Systems Command, Washington, D.C., 1 September 1986.

Naval Ships' Technical Manual, S9086-SP-STM-010, Chapter 542, "Gasoline and JP-5 Fuel Systems," Naval Sea Systems Command, Washington, D.C., 28 September 1990.

Chapter 3

Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3, Volume 2, NAVEDTRA 10564, Naval Education and Training program Management Support Activity, Pensacola, Fla., September 1989.

Propulsion Plant Manual, "propulsion Plant System for CG-47 Class Ships," Volume 4, S9234-D8-GTP-040/CG-47 PPM, Naval Sea Systems Command, Washington, D.C., 15 December 1990.

Propulsion Plant Manual, "propulsion Plant System for DD-963 Class Ships," Volume 4, S9234-AL-GTP-040/DD-963 PPM, Naval Sea Systems Command, Washington, D.C., 1 March 1990.

Propulsion Plant Manual, "Propulsion Plant System for DDG-51 Class Ships," Volume 4, S9234-GA-GTP-040/DDG-51 PPM, Naval Sea Systems Command, Washington, D.C., 1 February 1991.

Propulsion Plant Manual, "propulsion Plant System for FFG-7 Class Ships," Volume 4, S9234-BL-GTP-040/FFG-7 PPM, Naval Sea Systems Command, Washington, D.C., 15 August 1984.

Chapter 4

Gas Turbine Systems Technician (Mechanical) 2 & 3, NAVEDTRA 10548-2, Naval Education and Training Program Management Support Activity, Pensacola, Fla., August 1988.

Naval Ships Technical Manual. S9086-GY-STM-010, Chapter 221, "Boilers," Naval Sea Systems Command, Washington, D.C., 15 September 1990.

Naval Ships' Technical Manual, S9086-RK-STM-010, Chapter 505, "Piping Systems," Naval Sea Systems Command, Washington, D.C., 15 April 1988.

Naval Ships' Technical Manual, S9086-SY-STM-010, Chapter 551, "Compressed Air Plants and Systems," Naval Sea Systems Command, Washington, D.C., 15 September 1989.

Naval Ships' Technical Manual, S9253-AD-MMM-010, "Maintenance For Valves, Traps, and Orifices (Non-Nuclear)," Volume 2, Naval Sea Systems Command, Washington, D.C., 15 April 1988.

Propulsion Plant Manual, "Propulsion Plant System for CG-47 Class Ships," Volume 1, S9234-D8-GTP-010/CG-47 PPM, Naval Sea Systems Command, Washington, D.C., 15 December 1990.

Propulsion Plant Manual, "Propulsion Plant System for CG-47 Class Ships," Volume 2, S9234-D8-GTP-020/CG-47 PPM, Naval Sea Systems Command, Washington, D.C., 15 December 1990.

Propulsion Plant Manual, "Propulsion Plant System for CG-47 Class Ships," Volume 3, S9234-D8-GTP-030/CG-47 PPM, Naval Sea Systems Command, Washington, D.C., 15 December 1990.

Propulsion Plant Manual, "Propulsion Plant System for DD-963 Class Ships," Volume 1, S9234-AL-GTP-010/DD-963 PPM, Naval Sea Systems Command, Washington, D.C., 1 April 1991.

Propulsion Plant Manual, "Propulsion Plant System for DD-963 Class Ships," Volume 2, S9234-AL-GTP-020/DD-963 PPM, Naval Sea Systems Command, Washington, D.C., 15 February 1991.

Propulsion Plant Manual, "Propulsion Plant System for DD-963 Class Ships," Volume 3, S9234-AL-GTP-030/DD-963 PPM, Naval Sea Systems Command, Washington, D.C., 1 March 1991.

Propulsion Plant Manual, "Propulsion Plant System for DD-963 Class Ships," Volume 4, S9234-AL-GTP-040/DD-963 PPM, Naval Sea Systems Command, Washington, D.C., 1 March 1990.

Propulsion Plant Manual, "Propulsion Plant System for DDG-51 Class Ships," Volume 1, S9234-GA-GTP-010/DD-51 PPM, Naval Sea Systems Command, Washington, D.C., 1 February 1991.

Propulsion Plant Manual, "Propulsion Plant System for DDG-51 Class Ships," Volume 2, S9234-GA-GTP-020/DD-51 PPM, Naval Sea Systems Command, Washington, D.C., 1 February 1991.

Propulsion Plant Manual, "Propulsion Plant System for FFG-7 Class Ships," Volume 1, S9234-BL-GTP-010/FFG-7 PPM, Naval Sea Systems Command, Washington, D.C., 15 January 1992.

Propulsion Plant Manual, "Propulsion Plant System for FFG-7 Class Ships," Volume 3, S9234-BL-GTP-030/FFG-7 PPM, Naval Sea Systems Command, Washington, D.C., 15 August 1984.

Propulsion Plant Manual, "Propulsion Plant System for FFG-7 Class Ships," Volume 4, S9234-BL-GTP-040/FFG-7 PPM, Naval Sea Systems Command, Washington, D.C., 1 March 1992.

Chapter 5

Electronic Installation and Maintenance Book, General, NAVSEA SE000-00-EIM-100, Naval Sea Systems Command, Washington, D.C., April 1983.

Gas Turbine Systems Technician (Mechanical) 2 & 3, NAVEDTRA 10548-2, Naval Education and Training Program Management Support Activity, Pensacola, Fla., August 1988.

Naval Ships' Technical Manual, S9243-A7-MMA-010/77842, "Stern Tube Seal," Naval Sea Systems Command, Washington, D.C., 14 April 1989.

Naval Ships' Technical Manual, S9244-AT-MMA-010, "Propulsion Line Shaft Bearing, Oil Disc Lubricated," Naval Sea Systems Command, Washington, D.C., 14 April 1989.

Naval Ships' Technical Manual, S9086-HN-STM-010, Chapter 244, "Propulsion Bearings and Seals," Naval Sea Systems Command, Washington, D.C., 31 July 1991.

Naval Ships' Technical Manual, S9086-KC-STM-010, Chapter 300 R2, "Electric Plant-General," Naval Sea Systems Command, Washington, D.C., 28 February 1991.

Naval Ships' Technical Manual, 0901-LP-420-0002, Chapter 9420, "Propulsion Reduction Gears, Couplings, and Associated Components," Naval Sea Systems Command, Washington, D.C., 15 August 1985.

Naval Ships' Technical Manual, 0901-LP-430-0012, Chapter 9430, "Shafting, Bearings, and Seals," Naval Sea Systems Command, Washington, D.C., 15 August 1985.

Propulsion Plant Manual, "Propulsion Plant System for CG-47 Class Ships," Volume 1, S9234-D8-GTP-010/CG-47 PPM, Naval Sea Systems Command, Washington, D.C., 15 December 1990.

Propulsion Plant Manual, "Propulsion Plant System for DDG-51 Class Ships," Volume 1, S9234-GA-GTP-010/DDG-51 PPM, Naval Sea Systems Command, Washington, D.C., 1 February 1991.

Propulsion Plant Manual, "Propulsion Plant System for FFG-7 Class Ships," Volume 1, S9234-BL-GTP-010/FFG-7 PPM, Naval Sea Systems Command, Washington, D.C., 15 January 1992.

Chapter 6

AC Generator, S6265-AB-MMO-010/977J031-2/3, Naval Sea Systems Command, Washington, D.C., 1 December 1989.

Electrician's Mate 3 & 2, NAVEDTRA 10546-F, Naval Education and Training Program Management Support Activity, Pensacola, Fla., July 1988.

Gas Turbine Generator Set, Model 831-800 Series, S9234-EL-MMO-010/MOD ME831-800, Naval Sea Systems Command, Washington, D.C., 15 March 1986.

Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3, Volume 1, NAVEDTRA 10563, Naval Education and Training program Management Support Activity, Pensacola, Fla., September 1989.

Gearbox Assembly, S9567-AD-MMO-010/ P/N 44267R1, Naval Sea Systems Command, Washington, D.C., 31 December 1991.

IC Electrician 3, NAVEDTRA 10559-A, Naval Education and Training Program Management Support Activity, Pensacola, Fla., May 1989.

Instrumentman 3 & 2, NAVEDTRA 10193-D, Naval Education and Training Program Management Support Activity, Pensacola, Fla., January 1986.

Landing Craft, Air Cushion (LCAC) Craft Control Systems, S9568-AK-MMA-010, Naval Sea Systems Command, Washington, D.C., 15 April 1991.

Mobile Electric Power Plant, SG320-AA-MMO-010/90911, Naval Sea Systems Command, Washington, D.C., 15 March 1985.

Propulsion Gas Turbine Module LM5200, Trouble Isolation, Volume 2, Part 1, S9234-AD-MMO-030/LM2500, Naval Sea Systems Command, Washington, D.C., 30 September 1991.

Propulsion Gas Turbine Module LM5200, Trouble Isolation, Volume 2, Part 3, S9234-AD-MMO-050/LM2500, Naval Sea Systems Command, Washington, D.C., 30 September 1991.

System Operation and On board Maintenance PHM-3 Series, S9PHM-AC-SHP-010/(U) PHM-3 CL, Naval Sea Systems Command, Washington, D.C., 1 May 1991.

System Operation and On board Maintenance PHM-3 Series, S9PHM-AC-SHP-020/(U) PHM-3 CL, Naval Sea Systems Command, Washington, D.C., 1 October 1990.

System Operation and On board Maintenance PHM-3 Series, S9PHM-AC-SHP-030/(U) PHM-3 CL, Naval Sea Systems Command, Washington, D.C., 1 November 1991.

System Operation and Onboard Maintenance PHM-3 Series, S9PHM-AC-SHP-040/(U) PHM-3 CL, Naval Sea Systems Command, Washington, D.C., 1 May 1991.

System Operation and On board Maintenance PHM-3 Series, S9PHM-AC-SHP-050/(U) PHM-3 CL, Naval Sea Systems Command, Washington, D.C., 1 November 1991.

Gas Turbine Generator Set, Model 831-800 Series, S9234-EL-MMO-010/MOD ME831-800, Naval Sea Systems Command, Washington, D.C., 15 March 1986.

Naval Ships' Technical Manual, S9234-D1-GTP-010, "Internal Inspection and Evaluation of Marine Gas Turbine Engines," Naval Sea Systems Command, Washington, D.C., 15 October 1982.

Naval Ships' Technical Manual, S9311-A3-MMA-010, "Operational and Maintenance Manual For Auxiliary Power Unit (APU) System/Installation," Naval Sea Systems Command, Washington, D.C., 15 July 1991.

Propulsion Plant Manual, "Propulsion Plant System for CG-47 Class Ships; Volume 2, S9234-D8-GTP-020/CG-47 PPM, Naval Sea Systems Command, Washington, D.C. 15 December 1990.

Propulsion Plant Manual, "Propulsion Plant System for DDG-51 Class Ships," Volume 2, S9234-GA-GTP-020/DD-51 PPM, Naval Sea Systems Command, Washington, D.C. 1 February 1991.

Propulsion Plant Manual, "propulsion Plant System for FFG-7 Class Ships," Volume 2, S9234-BL-GTP-020/FFG-7 PPM, Naval Sea Systems Command, Washington, D.C., 15 January 1992.

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Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

COMMANDING OFFICER
NETPDTC
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PENSACOLA, FL 32509-5237

10 Aug 1999

ERRATA #1

Specific Instructions for Errata for
Nonresident Training Course

GAS TURBINE SYSTEMS TECHNICIAN (MECHANICAL) 2

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

2-10 through 2-13
2-15 through 2-17
2-22 through 2-26
2-28
2-33 through 2-40
4-63 through 4-65
5-7 through 5-49

Make the following changes:

Question	Change
2-5	Change the question to read: "When testing F-76 fuels, you will use the CFD (previously called the AEL MK III) to perform how many of the required tests?"
2-48	Change "Na/COO/2000" to "Nalcool 2000"
Page 21	Top of page in "Textbook Assignment," delete "and PHM" so the title of chapter 6 reads "LCAC Propulsion Systems"
Page 28	Top of page in "Textbook Assignment," delete "and PHM" so the title of chapter 6 reads "LCAC Propulsion Systems"
5-59	Change all four responses to reflect the following: 1. 95 3. 65 2. 85 4. 55

ASSIGNMENT 1

Textbook Assignment: "Engineering Administration," chapter 1, pages 1-1 through 1-23, and "Oil Laboratory Procedures and Administration," chapter 2, pages 2-1 through 2-4.

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. PMS
2. PQS
3. 3-M
4. QA

1-2. The QA manual for the surface fleet describes what level of QA requirements?

1. Basic
2. Detailed
3. Minimum
4. Maximum

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 responsiblities?

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. 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

1-19. 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

1-20. 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

1-21. 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

1-22. A standard MGTESR binder consists of what total number of separate sections?

1. 5
2. 8
3. 10
4. 12

1-23. 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

1-24. 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

1-25. 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 the PMS

1-26. In what section of the MGTESR are engine lay-up procedures recorded?

1. MGTE Technical Directives
2. MGTE Record of Rework
3. MGTE Selected Component Record
4. MGTE Miscellaneous/History

1-27. 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

1-28. A supplemental service record sheet must be maintained for each disc or stage of the compressor rotor assembly.

1. True
2. False

1-29. At what interval does the CO receive a fuel and water report?

1. Monthly
2. Weekly
3. Daily
4. Hourly

1-30. 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

1-31. Disposal procedures for Navy records can be found in which of the following SECNAV instructions?

1. SECNAVINST A5212.5
2. SECNAVINST B5212.5
3. SECNAVINST P5212.5
4. SECNAVINST L5212.5

1-32. If they are no longer needed or required on board, all reports sent to or received from NAVSEA can be destroyed after what total amount of time?

1. 1 year
2. 2 years
3. 3 years
4. 6 months

1-33. What is the quickest form of written communication used in the Navy?

1. Correspondence
2. Message
3. Tickler
4. Letter

1-34. Reports should be kept on board for all of the following reasons EXCEPT which one?

1. They serve a specific purpose
2. They serve as duplicate publications for a back-up resource
3. They provide information not found in other available publications or manuals
4. They are required

1-35. The system used to file divisional correspondence should be made available only to the keeper of the file and the division officer.

1. True
2. False

1-36. Which of the following methods is NOT used to file messages?

1. Alphabetical arrangement
2. Date-time group
3. Order of precedence
4. Subject matter

1-37. Which of the following filing systems refers specifically to a desk-top method of maintaining important information?

1. Correspondence
2. Message
3. Tickler
4. Letter

1-38. Which of the following filing systems makes handling recurring reports easier?

1. Letter
2. Tickler
3. Message
4. Correspondence

1-39. What method or means should ships use to notify the NAVSEACEN or TYCOM of nonurgent matters pertaining to the PMS?

1. PMS feedback report
2. Correspondence
3. Naval message
4. OPNAV 4790/2L

1-40. The instructions for preparing and submitting a PMS feedback report (FBR) are 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

1-41. 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

1-42. The date and serial number for an FBR are assigned by which of the following personnel?

1. Divisional 3-M coordinator
2. Division officer
3. Department head
4. Ship's 3-M coordinator

1-43. Category A on an FBR is used for all the following reasons EXECPT which one?

1. To order new maintenance index pages
2. To order new maintenance requirement cards
3. To discuss matters of a nontechnical nature
4. To report procedural discrepancies

1-44. What type of FBR is required to be sent by naval message?

1. Priority
2. Special
3. Strategic
4. Urgent

1-45. The equipment identification section of an FBR requires all of the following information EXCEPT which one?

1. SYSCOM MIP control number
2. SYSCOM MRC control number
3. Description of problem
4. Allowance parts list

1-46. The number of entries allowed on a single EGL page is restricted to the total number of work items that can be completed within what maximum number of work days?

1. One
2. Two
3. Three
4. Four

1-47. A concave metal corner on an inside surface is best described by which of the following terms?

1. Casting
2. Fillet
3. slot
4. Slide

1-48. Rounds are used to prevent which of the following types of damage?

1. Chipping
2. Scoring
3. Denting
4. Warping

1-49. What type of drawing shows acceptable plus or minus variations in tolerance?

1. Longitudinal
2. Unilateral
3. Bilateral
4. Multi-faceted

1-50. Which of the following terms specifically refers to a slot or groove within a cylindrical tube?

1. Keyseat
2. Keyway
3. slot
4. Slide

1-51. The process of shaping hot metal either manually or by machine is described by which of the following terms?

1. Milling
2. Casting
3. Tempering
4. Forging

1-52. What type of drawing method is used when variations from the design size are permissible in one direction only?

1. Bilateral
2. Unilateral
3. Longitudinal
4. Multi-faceted

1-53. A drawing that provides a two-dimensional view (height and width) is which of the following types?

1. Oblique
2. Orthographic
3. Isometric
4. Detail

1-54. A drawing that projects the front and top of an object (height, width, and length) is which of the following types?

1. Oblique
2. Orthographic
3. Isometric
4. Detail

1-55. A set of three or more views of an object where all lines are shown in their true length describes which of the following drawings?

1. Oblique
2. Orthographic
3. Isometric
4. Detail

1-56. The flash point of a fuel is the highest temperature at which the fuel will give off sufficient vapor to form a flammable mixture.

1. True
2. False

1-57. What is the minimum flash point for naval distillates?

1. 135°F
2. 140°F
3. 145°F
4. 150°F

1-58. The general specifications for the building of ships require suitable insulation to be installed on any surface that might exceed what maximum temperature?

1. 200°F
2. 300°F
3. 400°F
4. 500°F

1-59. Because most chemicals are hazardous by nature, what information source should you review before using a chemical?

1. MSDS
2. MSOS
3. MSIG
4. MSIB

1-60. The testing of oils is normally limited to what two types of chemicals?

1. Isopropyl alcohol and dry-cleaning solvent
2. Dry-cleaning solvent and absolute methanol
3. Absolute methanol and hydrogen peroxide
4. Hydrogen peroxide and isopropyl alcohol

1-61. Absolute methanol is considered to be highly toxic if ingested.

1. True
2. False

1-62. When mixing water treatment chemicals such as DSP or TSP, you are cautioned against using hot water for what main reason?

1. The chemicals will tend to cake
2. The chemicals will generate heat that may exceed the safe dispensing temperature
3. The chemicals will tend to foam
4. The chemicals will become inactive

1-63. If alkalies come into contact with your eyes, you should flush your eyes for at least what period of time?

1. 5 minutes
2. 10 minutes
3. 15 minutes
4. 20 minutes

1-64. Which of the following hazardous compounds will likely be present in the water test chemicals you must use aboard ship?

1. Caustic soda
2. Nitric acid
3. Mercuric nitrate
4. All of the above

1-65. You can find authorized procedures for handling and disposing of hazardous wastes in which of the following OPNAV instructions?

1. OPNAVINST 5090.1A
2. OPNAVINST 51OO.23B
3. OPNAVINST 3540.1B
4. OPNAVINST 3540.12B

ASSIGNMENT 2

Textbook Assignment: "Oil Laboratory Procedures and Administration," chapter 2, pages 2-4 through 2-43.

2-1. All oily discharges within 12 nm of the U.S. coastline must not exceed what maximum ppm of effluent?

1. 5 ppm
2. 10 ppm
3. 15 ppm
4. 20 ppm

2-2. If your ship does not have a waste oil system dedicated to collecting waste synthetic oil, the synthetic oily waste must be stored in what minimum size of steel container?

1. 5 gal
2. 10 gal
3. 30 gal
4. 55 gal

2-3. All bottles containing mercury wastes can be turned over for disposal to all of the following persons or facilities EXCEPT which one?

1. Public works officer
2. Engineering officer
3. Public works center at a naval installation
4. Industrial facility

2-4. To perform a BS&W test, the centrifuge you use must be capable of holding (a) at least how many pear-shaped tubes (b) of what standard capacity (per tube)?

1. (a) Two; (b) 50 ml
2. (a) Two; (b) 100 ml
3. (a) Four; (b) 50 ml
4. (a) Four; (b) 100 ml

2-5. When testing F-76 fuels, you will use the AEL MK III contaminated fuel tester to perform how many of the required tests?

1. Five
2. Two
3. Three
4. Four

2-6. The flash point tester uses a propane flame to heat the fuel being tested.

1. True
2. False

2-7. As a minimum requirement, your ship should have FO sample valve connections at all of the following locations EXCEPT which one?

1. Each sounding tube connection
2. Each purifier clean-fuel discharge
3. Each coalescer fuel inlet
4. Each coalescer fuel outlet

2-8. Visual samples for F-76 fuel during a refueling evolution must be taken at what intervals?

1. Every 15 minutes
2. The beginning, middle, and end
3. Both 1 and 2 above
4. Every 40 minutes

2-9. When receiving F-76 fuel from a U.S. government supply source, your ship must perform which of the following tests to satisfy the minimum requirements for sampling and testing?

1. API gravity test
2. Flash point test
3. Visual samples only
4. Visual inspections and three BS&W tests

2-10. When performing a BS&W test on F-76 fuel, the fuel sample must not be below what minimum temperature?

1. 80°F
2. 70°F
3. 60°F
4. 50°F

2-11. Each time a FO sample is tested for BS&W, the sample must spin for what specified amount of time”?

1. 5 minutes
2. 10 minutes
3. 15 minutes
4. 20 minutes

2-12. You must centrifuge a BS&W fuel sample until you obtain the same reading for what total number of consecutive times?

1. Five
2. Two
3. Three
4. Four

2-13. To determine the total BS&W of a fuel sample, you must always add the readings of both tubes and then divide by 2.

1. True
2. False

2-14. The API gravity conversion charts for F-76 fuel can be found in what chapter of the Naval Ships’ Technical Manual?

1. Chapter 233
2. Chapter 234
3. Chapter 541
4. Chapter 542

2-15. When performing a flash point test, you should set the test flame to what specified height?

1. 3/16 in.
2. 5/16 in.
3. 3/32 in.
4. 5/32 in.

2-16. During a flash point test, the rate of temperature rise of the test fuel should NOT exceed what maximum amount?

1. ll°F
2. 10°F
3. 9°F
4. 8°F

2-17. During a flash point test, you should lower the test flame into the vapor space each time the fuel sample temperature rises what specified number of degrees?

1. 1°F
2. 2°F
3. 3°F
4. 4°F

2-18. After receipt of fuel, a water contamination test will be performed on noncompensated FO storage tanks after what specified number of hours has elapsed?

1. 12 hours
2. 24 hours
3. 36 hours
4. 48 hours

2-19. During a service tank replenishment, you must sample and inspect the purifier discharge at what specified intervals?

1. 5 minutes after the start of transfer and every 15 minutes thereafter
2. 5 minutes after the start of transfer and every 30 minutes thereafter
3. 15 minutes after the start of transfer and every 15 minutes thereafter
4. 15 minutes after the start of transfer and every 30 minutes thereafter

2-20. A properly working FO purifier can remove up to what maximum amount of contaminates in a single pass?

1. 50%
2. 60%
3. 70%
4. 80%

2-21. Once a FO service tank is placed on suction, you must sample and test the coalscer discharge (a) within what maximum number of minutes after the tank is placed on suction and (b) at what specified interval thereafter?

1. (a) 15 min; (b) every 2 hr
2. (a) 15 min; (b) every 4 hr
3. (a) 5 min; (b) every 2 hr
4. (a) 5 min; (b) every 4 hr

2-22. When performing a fuel contamination test on F-76, you must fill the AEL Mk III tester's plastic sample bottle with test fuel to what prescribed level?

1. 100 mL
2. 200 mL
3. 400 mL
4. 800 mL

2-23. Before pumping an F-76 test sample through the water detection pad, you should shake the sample vigorously for at least how many seconds?

1. 10 seconds
2. 20 seconds
3. 30 seconds
4. 60 seconds

2-24. To be suitable for use, F-44 fuels cannot exceed what maximum amount of solids contamination?

1. 2.00 mg/L
2. 2.64 mg/L
3. 5.00 ppm
4. 40.0 ppm

2-25. An FSII test requires what amount of fuel to be poured into the graduated cylinder?

1. 100 mL
2. 120 mL
3. 140 mL
4. 160 mL

2-26. During an FSII test, after adding water to the fuel, you must shake the sample to allow the icing inhibitor to leach into the water.

1. True
2. False

2-27. At a minimum, the LO on idle equipment should be sampled at what specified interval?

1. Daily
2. Weekly
3. Biweekly
4. Monthly

2-28. An F-76 free water test result of 5 ppm or less by chart equates to an actual limit of which of the following amounts?

1. 10 ppm or less
2. 20 ppm or less
3. 30 ppm or less
4. 40 ppm or less

2-29. What number of LO sampling methods are commonly used aboard ship?

1. One
2. Two
3. Three
4. Four

2-30. Normal LO sampling for the MRG must be performed for all of the following situations EXCEPT which one?

1. Daily on operating equipment
2. Weekly on idle equipment
3. During casualty control drills
4. 30 minutes after equipment start-up

2-31. A LO thief sampler is approximately how many inches longer than the sounding tape plumb bob?

1. 6 in.
2. 5 in.
3. 3 in.
4. 4 in.

2-32. Which of the following information is NOT required on a properly labeled LO sample?

1. Equipment name
2. Equipment sump level
3. Oil type
4. Date

2-33. To perform a visual inspection on a LO sample, you should invert the sample bottle (a) a minimum of how many times, and allow the fuel sample to settle (b) a minimum of how many seconds between inversions?

1. (a) Two; (b) 30 sec
2. (a) Two; (b) 60 sec
3. (a) Three; (b) 30 sec
4. (a) Three; (b) 60 sec

2-34. A LO sample you have taken from an LPAC fails a visual test. Which of the following actions should you take next?

1. Change the oil
2. Change the oil filter
3. Perform a BS&W test
4. Perform a transparency test

2-35. To perform a BS&W test on a LO sample, you should dilute the LO with what solution?

1. Water-saturated, dry-cleaning solvent
2. Isopropyl alcohol
3. Absolute methanol
4. Hydrogen peroxide

2-36. The results of a BS&W test on a LO sample show that sediment is less than 0.1% and combined BS&W is 0.3%. What is the actual status of the LO?

1. Satisfactory
2. Warning
3. Controlled
4. Condemned

2-37. To perform a mineral oil contamination test, you should use what specified amount of synthetic oil in your test sample?

1. 75 mL
2. 50 mL
3. 25 mL
4. 10 mL

2-38. A diesel LO acidity test must be performed on an idle diesel at what minimum periodicity?

1. Daily
2. Weekly
3. Biweekly
4. Monthly

2-39. When performing a diesel LO dilution test, you must make certain the temperature difference between the new LO and the used LO does not exceed what maximum amount?

1. l°F
2. 2°F
3. 3°F
4. 4°F

2-40. Diesel LO must be changed when fuel dilution reaches what maximum percentage?

1. 0.2%
2. 0.5%
3. 2.0%
4. 5.0%

2-41. A water bath is used to raise the temperature of a cloudy LO sample to what specified amount?

1. 100°F
2. 110°F
3. 120°F
4. 140°F

2-42. What is the primary contaminant of shipboard water?

1. Rust
2. Silica
3. Sediment
4. Chloride

2-43. Water that results when used steam is cooled is referred to by what term?

1. Reserve feedwater
2. Deaerated feedwater
3. Condensate
4. Distillate

2-44. When samples are taken from a steaming boiler, the time between samples should not exceed what maximum number of hours?

1. 24 hours
2. 12 hours
3. 8 hours
4. 4 hours

2-45. A waste heat boiler water sample must be taken for all of the following situations EXCEPT which one?

1. A minimum of every 8 hours when operating
2. Prior to every start-up
3. Prior to a blowdown
4. 30 minutes after start-up

2-46. If a chemical chloride test result is less than the salinity indicator reading by more than 0.02 epm, what action(s), if any, should you take next?

1. Perform a hardness test
2. Perform another chloride test
3. Secure and dump the boiler
4. None

2-47. As indicated by the conductivity indicator, the water draining from the air ejector drains must not exceed what specified conductivity amount?

1. 1 μ mho/cm
2. 5 μ mho/cm
3. 8 μ mho/cm
4. 10 μ mho/cm

2-48. Sodium nitrite used in Na/COO/2000 helps to form what type of protective layer on ferrous metal surfaces?

1. Alkaline
2. Borate
3. Oxide
4. Silicate

2-49. You can find authorized diesel jacket water test procedures in which of the following NSTM publications?

1. Chapter 220, Volume 2
2. Chapter 233
3. Chapter 234
4. Chapter 262

2-50. Whenever the waste heat system is used to operate a distilling plant, the waste heat water must be sampled and tested for nitrite levels at what minimum periodicity?

1. Every 8 hours
2. Every 12 hours
3. Every 24 hours
4. Every 48 hours

2-51. The addition of DSP to boiler water should result in what change, if any, to the (a) phosphates and (b) alkalinity?

1. (a) Increase; (b) slight increase
2. (a) No change; (b) increase
3. (a) Decrease; (b) no change
4. (a) Slight increase; (b) decrease

2-52. In the testing of boiler water, which of the following tests should be accomplished first?

1. Alkalinity and phosphate
2. Conductivity
3. Chloride
4. Either 2 or 3 above, depending on the availability of test equipment

2-53. A common mistake when performing a chloride test is to add reagents too quickly while titrating.

1. True
2. False

2-54. When the continuous chemical injection system is started, the pump stroke should be at what setting?

1. 40%
2. 50%
3. 60%
4. 70%

2-55. The continuous chemical injection tank must be refilled when the liquid level drops to what capacity range?

1. Between 1 and 5 gallons
2. Between 5 and 10 gallons
3. Between 10 and 20 gallons
4. Between 20 and 25 gallons

2-56. What is the maximum amount of TSP that can be injected into a boiler at one time?

1. 200 grams
2. 300 grams
3. 400 grams
4. 500 grams

2-57. Which of the following symptoms does NOT describe chemical hideout?

1. A large chemical decrease when the generator load decreases
2. A large chemical increase when the generator load decreases
3. A large chemical decrease when the generator load increases
4. A large chemical increase when the generator is secured

2-58. When chemical hideout has been confirmed, alkalinity and phosphates must be maintained above what minimum levels?

1. 25.0 epm alkalinity and 0.005 ppm phosphate
2. 2.50 epm alkalinity and 0.050 ppm phosphate
3. 0.25 epm alkalinity and 0.050 ppm phosphate
4. 0.025 epm alkalinity and 5.0 ppm phosphate

2-59. It boiler water samples contain sediment, the maximum time between blowdowns should not exceed how many hours?

1. 48 hours
2. 24 hours
3. 12 hours
4. 8 hours

2-60. To allow the water to circulate and the boiler to stabilize, you should wait a minimum of how many seconds between blowdown cycles?

1. 30 seconds
2. 45 seconds
3. 60 seconds
4. 90 seconds

2-61. With the feedwater system operating properly, the makeup feedwater rate should be less than what specified amount per day?

1. 500 gallons
2. 600 gallons
3. 900 gallons
4. 1,000 gallons

2-62. Dissolved oxygen contamination can be caused by all of the following mechanical failures EXCEPT which one ?

1. Low water level in the DFT
2. Improper operation of the DFT spray nozzles
3. Inadequate venting of the DFT
4. A malfunctioning steam control valve

2-63. Maintaining nitrite levels below 1,000 ppm is ideal for corrosion control in a diesel jacket water system.

1. True
2. False

2-64. Conversion charts supplied with each quantab bottle can only be used with the test strips from that bottle.

1. True
2. False

2-65. The nitrite concentration level in the waste heat system must not exceed what maximum amount?

1. 5 ppm
2. 10 ppm
3. 20 ppm
4. 25 ppm

ASSIGNMENT 3

Textbook Assignment: "Engineering Control System Operation," chapter 3, pages 3-1 through 3-30, and "Engineering Support and Auxiliary Equipment and Systems," chapter 4, pages 4-1 through 4-8.

3-1. Which of the following classes of gas turbine-powered ships uses 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

3-2. 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

3-3. 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

3-4. On the CG-47 class ships, what two major engineering control consoles are located in the CCS?

1. FSCC and PACC
2. FSCC and EPCC
3. EPCC and PCC
4. EPCC and PACC

3-5. On the DD-963 class ships, which of the following FO service system functions are available at the PACC?

1. FO transfer system control
2. FO service control and monitoring
3. GTE FO control and monitoring
4. Both 2 and 3 above

3-6. On the DDG-993 class ships, which of the following fuel service functions are available at the PACC and the PLCC simultaneously?

1. Monitoring
2. Control
3. Both 1 and 2 above
4. Defueling control

3-7. 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

3-8. 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 HP air
3. Ship's service air and HP air
4. Emergency air and HP air

3-9. 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

3-10. 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

3-11. What type of throttle and pitch control system is used on a CG-47 class ship?

1. Analog
2. Digital
3. Discrete
4. Binary

3-12. 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

3-13. 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

3-14. On the EPCC of a DD-963 class ship, the two modes of governor operation are normal and what other mode?

1. Isochronous
2. Droop
3. Continuous speed
4. Automatic

3-15. 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

3-16. 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 3-17 THROUGH 3-36 PERTAIN TO DDG-51 CLASS SHIPS.

3-17. 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

3-18. 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

3-19. 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

3-20. 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

3-21. 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

3-22. 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

3-23. What is the basic method of controlling a ship's speed?

1. Manual control mode
2. Lockout manual control mode
3. Normal programmed control mode
4. Automatic control mode

3-24. The programmed 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

3-25. 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

3-26. 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

3-27. Which of the following EPCC functions will be 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

3-28. The generator field excitation is regulated by which of the following components?

1. EXCOP
2. LOCOP
3. Switchboard
4. EPCC

3-29. 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

3-30. The EPCC automatically controls circuit breakers as a part of the standby generator start function.

1. True
2. False

3-31. 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

3-32. 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

3-33. 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

3-34. The bell log printer is a part of what MCS console?

1. EPCC
2. PACC
3. SCU
4. EOOW/LU

3-35. 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 O

3-36. 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 3-37 THROUGH 3-48 PERTAIN TO FFG-7 CLASS SHIPS.

3-37. Which of the following consoles is specifically used to control and monitor the auxiliary subsystems?

1. ACC
2. DCC
3. EPCC
4. PCC

3-38. The two modes of operation for the FO service pumps are manual and what other mode?

1. LEAD
2. AUTO SPEED ADVANCE
3. LEAD SPEED ADVANCE
4. AUTO LEAD

3-39. The gas turbine emergency supply valve fails to what position upon loss of electrical power?

1. Open
2. Closed
3. Diverted
4. Regulated

3-40. The LO coastdown pumps are driven by which of the following components?

1. Electric motor
2. Hydraulic actuator
3. Air motor
4. Piston actuator

3-41. 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

3-42. 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

3-43. A normal stop on a GTE can be initiated by the PCC operator in either the programmed control mode or the manual control mode.

1. True
2. False

3-44. The stator temperature meter on the EPCC is graduated in what type of degree measurement units?

1. Fahrenheit
2. Centimeters
3. Centigrade
4. Rankine

3-45. 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%

3-46. 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. 20%
2. 25%
3. 30%
4. 40%

3-47. The ACC interfaces with the data processor in which of the following consoles?

1. SCC
2. DCC
3. EPCC
4. PCC

3-48. 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

3-49. The helical-screw type of LPAC installed on a CG-47 has what CFM rating?

1. 50 cfm
2. 100 cfm
3. 150 cfm
4. 200 cfm

3-50. On ships with three LPACs, during normal operations the cutout pressure switches should be set at what prescribed pressures?

1. 150 psig, 145 psig, 140 psig
2. 145 psig, 140 psig, 135 psig
3. 140 psig, 135 psig, 130 psig
4. 125 psig, 120 psig, 115 psig

3-51. An LPAC fails to start. All of the following malfunctions could be the cause EXCEPT which one?

1. A previous automatic safety shutdown
2. A blown fuse
3. The air receiver pressure is above the falling pressure set point
4. The power switch is tripped

3-52. When a screw-type LPAC starts and runs in the wrong direction, it will automatically stop between 5 to 12 seconds.

1. True
2. False

3-53. Loose drive belts on a reciprocating-type LPAC will NOT cause an abnormal noise during operation.

1. True
2. False

3-54. Most automatic temperature control valves used for cooling fail to which of the following positions?

1. Closed
2. Open
3. Off

3-55. The steam diverting valve installed in a WHB system uses what device, if any, for manual operation?

1. A pneumatic override
2. A special wrench
3. A handwheel
4. None

3-56. The types and sizes of valves used in any system are determined by the needs of the system.

1. True
2. False

3-57. Valve operator mechanical linkages are used for which of the following purposes?

1. To reach valves installed in the overhead
2. To reach valves installed in the bilges
3. To reach valves installed in an adjoining space
4. All of the above

3-58. Extensive damage may occur to a solenoid-operated valve if it is not exercised periodically according to the standards in which of the following NSTM chapters?

1. Chapter 504
2. Chapter 505
3. Chapter 551
4. Chapter 555

3-59. To ensure proper operation, solenoid valves should be cycled at what minimum frequency?

1. Once a day
2. Once a week
3. Once every two weeks
4. Once a month

3-60. Most diaphragm control valve actuators require what minimum amount of air pressure to start valve stem movement?

1. 1 psi
2. 2 psi
3. 5 psi
4. 10 psi

3-61. The use of a hot plate provides the most efficient means to regulate temperature during calibration of a temperature control device.

1. True
2. False

3-62. What two basic types of LO pressure regulating valves are used on gas turbine-powered ships?

1. Pilot and bellows-operated
2. Pneumatic and self-contained
3. Solenoid-operated and needle-type
4. Manual and operator-controlled

3-63. Self-contained pressure regulating valves have which of the following modes of operation?

1. Manual only
2. Automatic only
3. Manual and automatic
4. Bypass

3-64. You are testing automatic operations of a self-contained pressure regulating valve. It should modulate and maintain the set pressure within what specified range?

1. 1 to 2 psi
2. 2 to 3 psi
3. 3 to 4 psi
4. 0 to 1 psi

ASSIGNMENT 4

Textbook Assignment: "Engineering Support and Auxiliary Equipment and Systems," chapter 4, pages 4-11 through 4-24; "Propulsion Plant Systems and Drive Train Equipment," chapter 5, pages 5-1 through 5-25; and "LCAC and PHM Propulsion Systems," chapter 6, pages 6-1 through 6-47.

4-1. The ship's service LP air system is divided into what total number of basic subsystems?

1. Six
2. Two
3. Three
4. Four

4-2. Which of the following LP air subsystems provides air to the sonar dome?

1. MER vital air system
2. Ship's vital air system
3. Electronic dry air system
4. MER nonvital air system

4-3. On a DDG-51 class ship, an HP/LP air reducing station is located in which of the following areas?

1. AMR1
2. MER1
3. MER 2
4. Both 2 and 3 above

4-4. The bleed air collection and distribution system supports what total number of subsystems?

1. One
2. Two
3. Three
4. Four

4-5. The bleed air collection and distribution system is regulated to what specified pressure?

1. 100 psi
2. 80 psi
3. 75 psi
4. 65 psi

4-6. What is the only gas turbine-class ship that does not have HP air starting capabilities for the propulsion GTEs?

1. DDG-51
2. DDG-993
3. GG-47
4. DD-963

4-7. The GTM start air system on DD-963 class ship mixes hot bleed air and cool masker air for which of the following reasons?

1. The increase in air temperature allows the propulsion turbine end GTE starters to consume a lower amount of air
2. The decrease in air temperature causes the propulsion turbine and GTE starters to use a greater amount of air
3. The increase in air temperature allows for HP start air capabilities
4. The decrease in air temperature allows for HP start air capabilities

4-8. The start air system on a CG-47 class ship has what three modes of operation?

1. Normal, motor, and automatic
2. Motor, automatic, and emergency
3. Normal, motor, and emergency
4. Normal, automatic, and emergency

4-9. For a GTM start, what must the valve position be for the following valves: (a) Masker XFR, (b) Masker CLR, (c) HI temp bleed, (d) motor air reg, and (e) mixing bypass?

1. (a) Start, (b) close, (c) open, (d) off, (e) close
2. (a) Start, (b) open, (c) close, (d) off, (e) close
3. (a) Start, (b) open, (c) open, (d) on, (e) close
4. (a) Start, (b) open, (c) open, (d) off, (e) close

4-10. In the GTM HP start air system, what ship class requires the use of orifices after the HP/LP air reducer?

1. FFG-7
2. DD-963
3. DD-993
4. CG-47

4-11. On a DDG-51 class ship, the HP air used for GTM staring is reduced to what final air pressure?

1. 40 psig
2. 45 psig
3. 75 psig
4. 80 psig

4-12. An FFG-7 GTM can receive starting air from what total number of sources?

1. Five
2. Two
3. Three
4. Four

4-13. Before the cross-bleed starting method on an FFG-7 class ship can be performed, the online GTM GG speed must be at least how many rpm?

1. 8,000 rpm
2. 7,500 rpm
3. 6,500 rpm
4. 6,000 rpm

4-14. In addition to routine tests and inspections as specified in the PMS, additional maintenance requirements for WMB safety valves can be found in which of the following NSTM chapters?

1. Chapter 220, V1
2. Chapter 221
3. Chapter 223
4. Chapter 233

4-15. The inability of a WMB system to maintain the proper steam drum pressure can be caused by all of the following conditions EXCEPT which one?

1. Faulty steam stop valve
2. Faulty diverting valve
3. Low boiler water
4. Airbound recirculating pump

4-16. The FFG-7 waste heat system contains what total number of heat exchangers?

1. Five
2. Two
3. Three
4. Four

4-17. The FFG-7 waste heat system uses what total number of supplementary electric heaters?

1. Five
2. Two
3. Three
4. Four

4-18. The FFG-7 waste heat electric heaters have (a) what kilowatt rating and maintain (b) what minimum system temperature?

1. (a) 200 kW; (b) 160°F
2. (a) 300 kW: (b) 170°F
3. (a) 350 kW; (b) 175°F
4. (a) 450 kW; (b) 185°F

4-19. What total number of relief valves are installed in the FFG-7 waste heat system?

1. Five
2. Two
3. Three
4. Four

4-20. All preventive maintenance actions or steps can be grouped into which of the following three basic categories?

1. Troubleshooting, routine maintenance, and repair
2. Testing, adjusting, and troubleshooting
3. Routine maintenance, testing. and adjusting
4. Adjusting, testing, and repair

4-21. Using authorized maintenance procedures and performing maintenance at specified intervals are included in what type of maintenance actions?

1. Casualty
2. Routine
3. Emergent
4. Deferred

4-22. Which of the following corrective maintenance actions is considered to be the weakest link in the corrective maintenance process?

1. Repair
2. Malfunction location
3. Testing
4. Symptom recognition

4-23. In the area of troubleshooting, the amount of equipment downtime is generally proportional to all of the following conditions EXCEPT which one?

1. Parts availability
2. System complexity
3. Poor methodology
4. Lack of system knowledge

4-24. The most important tool you can use in troubleshooting is to have a thorough knowledge of an equipment or system's normal operating condition.

1. True
2. False

4-25. While performing a FO pump logic test, you discover that pump timing is off. Which of the following actions should you take to correct this problem?

1. Adjust the timing circuit card
2. Replace the pressure transducer
3. Repair the pressure switch
4. Replace the timing circuit card

4-26. Most FO service system low pressure problems can be traced to which of the following sources?

1. Faulty instruments
2. Faulty unloader valves
3. Faulty pressure relief valves
4. Both 2 and 3 above

4-27. The MRG system LO pressure Is regulated to the proper pressure as sensed at which of the following locations?

1. The LO pump discharge
2. The LO unloader valve inlet
3. The MRG most remote bearing
4. The MRG inlet header

4-28. Requirements for the operation and care of the MRG LO strainer can be found in which of the following NSTM chapters?

1. Chapter 262
2. Chapter 244
3. Chapter 234
4. Chapter 233

4-29. On DD-963 class ships, the MRG LO strainers should be shifted and inspected once per watch for all of the following conditions EXCEPT which one?

1. For the first 48 hours following MRG repairs
2. During normal operations
3. When the propulsion plant is operating at more than 85% full power
4. For the first 24 hours after rough weather

4-30. The aligning of an attached LO pump on CG-47 ships requires which, if any, of the following components or tools?

1. A special set of feeler gauges
2. A special dial indicator
3. A special shaft assembly
4. None of the above

4-31. All twin-screw, gas turbine-powered ships have identical CRP/CPP systems.

1. True
2. False

QUESTIONS 4-32 THROUGH 4-35 PERTAIN TO CRP/CPP SYSTEMS INSTALLED ON THE DDG-51 CLASS SHIPS.

4-32. The electronic pitch position transducer is located in which of the following areas?

1. In the CRP electronics enclosure
2. On the right side of the OD box
3. On the front end of the OD box
4. In the propeller hub

4-33. The CRP/CPP stationary electronics cabinet sends an excitation signal of what value to the rotary transformer?

1. 4 kHz
2. 8 kHZ
3. 10 kHz
4. 12 kHz

4-34. The temperature-compensated pitch indicating system depends on the thermal stability of which of the following transmitting mediums to sense pitch position?

1. Seawater
2. Prairie air
3. Masker air
4. CRP oil

4-35. The CRP rotating electronics rectifies the rotary transformer excitation to which of the following power levels?

1. 12 V dc
2. -12 V dc
3. 24 V dc
4. -24 V dc

4-36. A steady increase in hub servo pressure, without a change in system demands, is a good indication that which of the following components is faulty?

1. Auxiliary relief valve
2. Sequencing valve (closed position)
3. Reducing valve
4. Electrohydraulic servo valve

4-37. Which of the following components supplies control oil to the OD box?

1. Reducing valve
2. Sequencing valve
3. Main servo piston
4. Auxiliary servo piston

4-38. When an MRG is opened for inspection or repair, the persons assigned to the security watch must be in what minimum paygrade or above?

1. E-3
2. E-4
3. E-5
4. E-6

4-39. Some MRG inspection requirements and troubleshooting guides can be found in which of the following NSTM chapters?

1. Chapter 9340
2. Chapter 9420
3. Chapter 9430
4. Chapter 9880

4-40. An indication of reduced oil flow in an MRG sight flow indicator can result from all of the following problems EXCEPT which one?

1. Air leakage around the base *or* glass of the sight flow indicator
2. A partially unseated sight flow indicator oil supply tube
3. A small hole in the sight flow indicator oil supply tube
4. Dirt accumulation in the bearing oil passage

4-41. Even if oil flow is missing from only one sight flow indicator, the condition must be treated as if a loss of LO has occurred to the entire MRG.

1. True
2. False

4-42. Which of the following symptoms can indicate a faulty pump angle drive assembly?

1. High failure rate of the attached pump flexible coupling
2. Difficulty in disengaging
3. Both 1 and 2 above
4. Failure of the electrical motor

4-43. An SSS clutch system requires which of the following inputs or conditions to make engagement possible?

1. LP air
2. HP air
3. Electronic signals
4. PT input shaft speed greater than that of the first reduction pinion

4-44. In the SSS clutch systems installed on Navy gas turbine ships, a total of how many different types of PT brake systems are used?

1. Six
2. Two
3. Three
4. Four

4-45. The shaft brake assembly installed on an FFG-7 class ship is what type?

1. Internally housed, friction pack assembly
2. Externally mounted, friction pack assembly
3. Internally housed, single-disc caliper assembly
4. Externally mounted, single-disc caliper assembly

4-46. Propulsion shaft bulkhead seals perform which of the following functions?

1. Maintain propulsion shaft axial alignment
2. Maintain propulsion shaft radial alignment
3. Both 1 and 2 above
4. Maintain watertight integrity between machinery spaces

4-47. A line shaft bearing sump should be drained and opened for all of the following reasons or conditions EXCEPT which one?

1. Bearing wear measurements , (depth readings) must be taken
2. The oil becomes contaminated and must be changed
3. A bearing temperature sensor needs to be replaced
4. Excessive leakage from bearing oil seals is observed

4-48. Propulsion shaft alignment will be affected under all of the following circumstances EXCEPT which one?

1. Placing the ship in drydock
2. The removal of the ship’s propeller or propellers
3. A faulty bulkhead seal
4. Damage to a line shaft bearing

4-49. A line shaft bearing contains what total number of sealing rings?

1. One
2. Two
3. Three
4. Four

4-50. Bulkhead sealing rings are made of such durable material that no lubrication will ever be required.

1. True
2. False

4-51. The LCAC is powered by which of the following types of GTEs?

1. LM2500
2. AVCO Lycoming TF40B
3. Allison 501-K34
4. Pratt Whitney 1500TB

4-52. 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

4-53. 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

4-54. 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

4-55. 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

4-56. The LCAC lift fan control system consists of which of the following components?

1. Two single-entry centrifugal fans only
2. Two double-entry centrifugal fans only
3. Four single-entry centrifugal fans
4. Four double-entry centrifugal fans

4-57. 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. (a) 70%; (b) 30%
3. (a) 30%; (b) 70%
4. (a) 40%; (b) 60%

4-58. In the engine control system on the LCAC, which of the following units is the power producer control unit?

1. N_1
2. N_2
3. N_3
4. N_4

4-59. The power turbine section of the TF40B GTE consists of what total number of stages?

1. Eight
2. Two
3. Six
4. Four

4-60. 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

4-61. 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

4-62. 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

4-63. 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

4-64. The PHM has what total number of complete but separate propulsion systems?

1. One
2. Two
3. Three
4. Four

4-65. 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

ASSIGNMENT 5

Textbook Assignment: "LCAC and PHM Propulsion Systems," chapter 6, pages 6-27 through 6-47, and "Electric Plant," chapter 7, pages 7-1 through 7-61.

5-1. On gas turbine-powered ships, what is the most widely used generator prime mover?

1. Sunstrand T-62T-40-7
2. Garrett ME 831-800A
3. Allison 501-K17
4. Allison 501-K34

5-2. On the DDG-51 class ships, the GTG foundation and enclosure were made larger for which of the following reasons?

1. The turbine is larger
2. The generator is larger
3. To provide more space for maintenance
4. To provide more space for internal and external equipment additions

5-3. The Allison 501-K34 GTE uses which of the following major components to replace the GCU used with the 501-K17 GTE?

1. PCM
2. EXCOP
3. IFM
4. FDM

5-4. On a 501-K34, PMA power is routed to various modules by what component?

1. DFD
2. OVL
3. AVR
4. PCM

5-5. To regulate GTE fuel flow on a 501-K34, the electronic governor uses all of the following input signals EXCEPT which one?

1. Calculated turbine inlet temperature
2. Compressor discharge pressure
3. Generator voltage
4. Generator current

5-6. The 501-K34 start air piping was modified to accommodate which of the following components?

1. The band pump
2. The turbine prelube pump
3. The EXCOP
4. The LOCOP

5-7. On a PHM operating at 100 percent power, the GTE delivers what maximum (a) horsepower to the gearbox assembly and at what approximate (b) input speed?

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

5-8. 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

5-9. What system of the PHM provides automatic starting and stopping of the GTE and gearbox auxiliary LO pump?

1. FECS
2. FPCS
3. HECS
4. HPCS

5-10. 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

5-11. 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

5-12. In the PHM, the GTE is directly coupled to the propulsor through the gearbox with no disengagement capabilities.

1. True
2. False

5-13. 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

5-14. What is the input power to the ACS power supply assembly of the PHH?

1. 115 V ac, 60 Hz
2. 115 V ac, 400 Hz
3. 450 V ac, 60 Hz
4. 450 V ac, 400 Hz

5-15. 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

5-16. Each hullborne power plant on a PHM consists of a diesel engine and which of the following components?

1. Propulsor assembly and water brake
2. Water jet pump and speed reduction gearbox
3. Water jet pump and water brake
4. Speed reduction gearbox and water brake

5-17. 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

5-18. The hullborne propulsion system of the PHM consists of a total of how many diesel engines?

1. One
2. Two
3. Three
4. Four

5-19. 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

5-20. On the PHM, basic control of the electrical generators is provided at what station?

1. EOS
2. CCS
3. EPCC
4. Pilothouse

5-21. 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

5-22. 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

5-23. During the start of an SSPU, at what percentage of engine speed does the ignition system automatically de-energize?

1. 10%
2. 50%
3. 95%
4. 100%

5-24. 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

5-25. 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

5-26. 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

5-27. In the PHM, what is the capacity of the oil sump for each SSPU?

1. 7.8 quarts
2. 7.4 quarts
3. 7.8 gallons
4. 7.4 gallons

5-28. What minimum percent of SSPU speed will cause an overspeed trip?

1. 105%
2. 108%
3. 110%
4. 115%

5-29. The SSPU load and speed control unit requires what specific level of power to operate?

1. 11O-V ac
2. 11O-V dc
3. 24-V ac
4. 24-V dc

5-30. During steady-state speed, the oil pressure regulator maintains what minimum SSPU oil pressure?

1. 60 psi
2. 70 psi
3. 80 pSi
4. 90 psi

5-31. In the PHM, the filter 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 dirt and dust
3. To filter the feedback signal from the SSPU
4. To filter the EM1 generated by the exhaust gas temperature meter transducers

5-32. Which of the following 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-kVA, 450-V ac, 60-Hz, single-phase

5-33. 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

5-34. 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

5-35. The generators on the PHM can be operated in all of the following modes EXCEPT which one?

1. Individual
2. Series
3. split-plant
4. Parallel

5-36. The shore power receptacles on the PHM are rated for the shore power electrical load of the ship plus what percent growth margin?

1. 10%
2. 20%
3. 30%
4. 40%

5-37. 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

5-38. Which of the following 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

5-39. 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

5-40. 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

5-41. 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

5-42. 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. An HP air compressor
4. LM2500 16th-stage bleed air

5-43. 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

5-44. 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

5-45. On the PHM, the seawater system consists of a total of how many pumps?

1. One
2. Two
3. Three
4. Four

5-46. 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

5-47. On the PHM, routine maintenance is categorized under what maintenance level?

1. Training
2. Organizational
3. Intermediate
4. Depot

5-48. What level of maintenance is conducted at sea by the PHM crew?

1. Training
2. Organizational
3. Intermediate
4. Depot

5-49. On the PHM, major modifications are categorized under what maintenance level?

1. Training
2. Organizational
3. Intermediate
4. Depot

5-50. 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

5-51. The APU controls enclosure is mounted in which of the following locations?

1. In the compartment below the GTGS
2. In the compartment aft of the GTGS
3. In the forward bulkhead inside the GTGS enclosure
4. In the aft bulkhead inside the GTGS enclosure

5-52. Which of the following best describes the ac generators on the LCAC?

1. 120/208-V ac, 60-Hz, 90-kW
2. 120/208-V ac, 400-Hz, 90-kW
3. 120/208-V ac, 60-Hz, 60-kW
4. 120/208-V ac, 400-Hz, 60-kW

5-53. Which of the following best describes the Sunstrand GTE?

1. Radial-flow, 150-horsepower, single-stage turbine
2. Radial-flow, 150-horsepower, multistage turbine
3. Axial-flow, 150-horsepower, single-stage turbine
4. Axial-flow, 150-horsepower, multistage turbine

5-54. The Sunstrand GTE compressor-to-turbine air seal axial position is maintained by which of the following methods?

1. Turbine pressure
2. Spring pressure
3. Compressor pressure
4. Nozzle pressure

5-55. The Sunstrand GTE combustor line is secured to the combustor housing by which of the following ways?

1. Clipped
2. Bolted
3. Pinned
4. Spot welded

5-56. What is the minimum speed required to drive APU accessories?

1. 4,000 rpm
2. 5,000 rpm
3. 6,000 rpm
4. 7,000 rpm

5-57. The APU fuel pump is mounted to the reduction drive assembly on what location?

1. Left forward mounting pad
2. Left aft mounting pad
3. Right forward mounting pad
4. Right aft mounting pad

5-58. Fuel is supplied to the Sunstrand GTE at a minimum flow capacity of how many pounds per hour?

1. 50
2. 100
3. 150
4. 200

5-59. The APU start fuel solenoid valve de-energizes at what percent of rated engine speed?

1. 75
2. 80
3. 90
4. 95

5-60. The APU purge valve uses what medium to clear the start fuel solenoid valve of residual fuel?

1. Load compressor air
2. Compressor discharge air
3. Ship’s service LP air
4. HP air

5-61. The APU start bypass valve Is energized closed by output current from which of the following components?

1. GCU
2. ESU
3. BITE
4. DTNA

5-62. The SSDG FO solenoid operated tank suction valves can be operated from how many different locations?

1. One
2. Two
3. Three
4. Four

5-63. The SSDG fuel filter elements should be replaced when differential pressure exceeds what specified amount?

1. 5 psid
2. 10 psid
3. 15 psid
4. 20 psid

5-64. The SSDG oil pump relief valve directs excess oil pump discharge pressure to the sump at what maximum pressure?

1. 70 psi
2. 80 psi
3. 90 psi
4. 100 psi

5-65. The SSDG vent fog precipitator has what maximum flow rate?

1. 200 cfm
2. 150 cfm
3. 125 cfm
4. 100 cfm

5-66. The SSDG start air system has sufficient air capacity for how many starts before recharging is necessary?

1. 15
2. 12
3. 10
4. 8

5-67. Of all GTE routine maintenance practices, which of the following will be performed more frequently than the others?

1. Lubricating
2. Aligning
3. Adjusting
4. Cleaning

5-68. When a Sunstrand GTE requires a detergent cleaning, if possible, how must the cleaning liquid be delivered?

1. Permanent spray nozzle
2. Handheld spray nozzle
3. Temporary spray nozzle ring attached to the bellmouth

5-69. A start air bypass valve is used to prevent compressor surging during starts on which of the following GTEs?

1. Allison
2. Garrett
3. Sunstrand
4. Lycoming

5-70. The Sunstrand bleed air (load control) valve supplies bleed air to the GTE air intake for anti-icing operations.

1. True
2. False

5-71. From the axis of the probe, a No. 2 borescope probe will provide what degree of viewing?

1. 100°
2. 90°
3. 80°
4. 70°

5-72. A No. 3 borescoping probe will primarily provide what type of view?

1. Downward
2. Upward
3. Side
4. Full

5-73. When preparing to perform a borescope inspection, what step or guideline should be first on your list?

1. Establish internal reference points
2. Locate all areas to be inspected
3. Familiarize yourself with the equipment
4. Determine engine serviceability

5-74. On a DDG-51, excess generator bearing oil is removed from the bearing housing during prelube operations by which of the following methods?

1. Gravity drained to the sump
2. Piped back to the suction side of the prelube pump
3. Piped to an oil scavenging pump
4. Drained as a function of a jet pump eductor