NONRESIDENT
TRAINING
COURSE

January 1994

Gas Turbine Systems Supervisor

NAVEDTRA 14111

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

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

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: After completing this nonresident training course, you should be able to identify the programs, reports, and records required of supervisors of gas turbine systems personnel. You also should be able to describe the procedures needed to maintain and inspect gas turbine propulsion systems.

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

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

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

1994 Edition Prepared by
GSCM(SW) Robert Kuzirian

Published by
NAVAL EDUCATION AND TRAINING
PROFESSIONAL DEVELOPMENT
AND TECHNOLOGY CENTER

NAVSUP Logistics Tracking Number
0504-LP-026-7770

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:

http://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:

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

STUDENT FEEDBACK QUESTIONS

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

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N315
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

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 2 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 Supervisor*

NAVEDTRA: 14111 **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

PROGRAMS, REPORTS, AND RECORDS

As you advance in the GS rating, you undoubtedly will find that much more of your time is spent in the training and administration of subordinates. This is as it should be, for knowledge must be passed from senior to junior. The most knowledgeable persons must be in charge. As a GS supervisor, you should not allow yourself to constantly be dragged into a maintenance position. If you do, your effectiveness as a leader will suffer. Weak leadership usually results in disharmony and, consequently, a poorly run, ineffective division or work center. This chapter addresses some of your administrative responsibilities as a First Class or Chief Gas turbine Systems Technician.

Administering and training subordinates on programs, reports, and records are never-ending responsibilities. Every day, whether you realize it or not, you administer people and programs and train junior personnel. You cannot have too much of either. (Although you can have too much paper work in your training and administration programs making them unmanageable.) Much of your training and administration is of an informal nature. A good leader uses good skills routinely and instinctively. However, formal programs in some areas of training do require more than instinct. Specific directives issued by superiors must be followed to conform to specific standards. Administration and training, whether formal or informal, are important responsibilities. They need to be taken seriously by all senior Gas turbine Systems Technicians.

TAG-OUT PROGRAM

An effective tag-out program is necessary because of the complexity of modem ships. Tag-out is also necessary to avoid the cost, delay, and hazards to personnel that could result from the improper operation of equipment. The purpose of the equipment tag-out program is to provide a procedure that prevents improper operation of components, equipment, systems, or a portion of a system isolated or in an abnormal condition. This procedure also should be used when other safety devices, such as blank flanges, are installed for testing, maintenance, or casualty isolation.

The use of **DANGER** or **CAUTION** tags is not a substitute for other safety measures, such as locking valves, pulling fuses, or racking-out circuit breakers. Tags attached to valves, switches, or other components should indicate restrictions on operation of systems or equipment, or restrictions necessary to avoid damage to safety devices. Never use danger or caution tags for identification purposes!

All procedures in the program are mandatory standardized tag-out procedures used by all ships and repair activities. The program also provides a procedure for use when an instrument is unreliable or not in a normal operating condition. It is similar to the tag-out procedure except that labels instead of tags are used to indicate instrument status. The tag-out program must be enforced during normal operations as well as during construction, testing, repair, or maintenance. Strict enforcement of tag-out procedures is required by both you and any repair activity that may be working on your equipment.

REVIEW AND MONITOR PROGRAM PROCEDURES

As stated in the previous paragraphs, strict adherence to tag-out program procedures is paramount. A brief description of the tag-out program was provided in the *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* volume 1. You should already know the program procedures as they pertain to the role of the maintenance person. Now as you move toward a more supervisory role, you will be required to have a much larger depth of knowledge. The one-sided program perception is in the past. You must now understand the program's inner workings to maintain a safe environment. A more detailed description of the required tag-out program procedures is provided in *Standard Organization and Regulations of the U. S. Navy,* OPNAVINST 3120.32 series.

REVIEW AND MONITOR PROGRAM EFFECTIVENESS

There are a couple of ways to review and monitor the tag-out program's effectiveness. The first of which is pretty obvious. Were there any personnel injuries or damaged equipment because of violations to the tag-out program? This first method sounds good, but it is not always accurate. The second method (required) really does not take that much time if performed consistently. Use of the second method also will ensure that personnel injuries and equipment damage do not occur. What method are we referring to? It is the audit portion of the program.

As a maintenance person you probably were not concerned with the audit portion of the program. That is, unless there was a discrepancy found on an equipment tag-out that you were responsible for. But now as a GS supervisor your responsibilities have changed. You will probably be in charge of a work center, and as you continue to progress you will probably qualify as an EOOW/EDO. Eventually you will be required to know all aspects of the program. Now take a look at how tag-out audits should be conducted.

All tag-out logs (records) must be kept in the space(s) designated by your ship's instruction. Normally, these records for the engineering department will be kept in the central control station (CCS). Supervisory watch standers (EOOWs/EDOs) must review these records as part of the watch-relieving process.

Checks and audits of all tag-outs must be conducted every two weeks. However, these requirements may be superseded by your type commander (TYCOM) or even your own ship's instruction. Remember, just as with PMS, <u>audit frequency can only be increased, not decreased.</u>

1. All outstanding tags listed on the Tag-out Record Sheet must be checked as correctly installed by visual comparison of the information on the tag, the record sheet, and the item on which the tag is posted. when a valve or switch position is prescribed, a visual check that the item is in its proper position is made unless an operation such as removal of a cover, cap, or closure is required. No operation of a valve or switch is authorized as part of a routine tag-out audit. In addition, a spot check of installed tags should be conducted to ensure that tags so checked are effective (that is, covered by an active Tag-out Record Sheet). Report all discrepancies in the check of actual position at once to the EOOW/EDO before proceeding any further with the tag audit. The date, time, discrepancies (including corrective actions), and signature of the person conducting the check is logged on each Tag-out Record Sheet under the last tag listed.
2. When the actual position of a DANGER-tagged valve is in question, the EOOW/EDO, with the specific permission of the responsible department head, if available, may authorize two people to independently check the position of the specific valve(s).

NOTE

Checking the position of a valve is done only by attempting to turn the valve handwheel/operator a small amount in the SHUT direction.

This is an approved exception to the prohibition on operation of DANGER-tagged equipment. This valve position check must be performed using the applicable approved procedures for valve lineup checks.

3. All outstanding Tag-out Record Sheets are audited against the Index/Audit Record section. As part of the audit, each Tag-out Record Sheet is checked as previously specified. The date, discrepancies noted, and signature of the person conducting the audit are logged by a line entry in the Index/Audit Record section of the tag-out log.
4. Checking the installation of instrument labels and auditing the logs must be conducted in the same manner as a tag-out audit.

To ensure that tag-out/label procedures are enforced properly, the cognizant department head (engineer officer) frequently checks the tag-out log, notes errors, and brings them to the attention of those responsible. The completed Tag-out Record Sheets and Instrument Logs are removed by the department head (engineer officer) after the review.

Remember, a violation of any tag compromises the entire tag-out system and could in itself have <u>serious consequences.</u>

All loose tags that have been removed must be destroyed.

ENVIRONMENTAL POLLUTION CONTROL PROGRAM

As the Navy and our country progress into the 21st century, a much needed and stronger emphasis has to be placed on environmental pollution control. For us to preserve our environment and our remaining resources, we must all be conscientious participants. The Navy is committed to operating its ships and shore facilities in a manner that is compatible with the environment. It is your responsibility as a supervisor to provide leadership and personal commitment to ensure that your personnel develop and exhibit an environmental protection ethic. Since this program contains such a vast amount of information and guidelines, we will not be able to cover more than a small part of the information. For a more comprehensive look at this program, read OPNAVINST. 5090.1.

MONITOR PROGRAM OPERATIONS

Monitoring the environmental pollution control program's operations is very important. This process can be very time consuming if proper training of all personnel is not done. As previously stated, this is not a one person program. It will take everybody's efforts to make it work.

Due to the large impact of any noncompliance, there are outside activities such as the Environmental Protection Agency (EPA) to monitor your program operations. Remember, most environmental statutes impose criminal liability for willful or knowing violations. In some cases, **individual service members** may be charged with criminal liability if their actions, or inactions, meet the requirements for imposing liability.

In the remaining segments of this section we will discuss some training tips and drill scenarios you may wish to use to better acquaint yourself and your personnel with this program.

TRAINING AND DRILL EVALUATION

This section provides some useful lesson plans, training tips, drill scenarios, and evaluation grading forms for hazardous material spills. Figure 1-1 is a sample lesson plan you can use to instruct personnel on response procedures for hazardous materials spills.

SAMPLE RESPONSE DRILL LESSON PLAN

LESSON TOPIC: HAZARDOUS MATERIAL SPILL RESPONSE/DRILL

AVERAGE TIME: 60 minutes (add 18 minutes for the videotape)

REFERENCES:

1. OPNAVINST 5100.19B, chapter B3, appendix B3-A
2. DOT Emergency Response Guidebook (if available)
3. OPNAVINST 5090.1A, chapter 17, Pollution Abatement Afloat

TRAINING AIDS:

1. Handout #1 Hazardous Material Spill Response Procedures (fig. 1-13, found at the end of this chapter from OPNAVINST 5100.19B, appendix B3-A)
2. Videotape "Shipboard Hazardous Material Spill Response and Cleanup," 803492-DN
3. Repair-locker materials and protective clothing from chemical handling areas or Hazardous Material Spill Response Kit, AEL 2-550024007
4. Damage control training team (DCTT) spill scenarios

OBJECTIVES:

The student should understand the special response procedures necessary to handle hazardous materials spills. The student should be able to demonstrate, or observe, response personnel donning protective equipment and cleaning up a simulated hazardous material spill.

Figure 1-1.—Sample lesson plan.

TARGET AUDIENCE:

All fire parties, damage control personnel, fire marshals, gas free engineers, gas free petty officers, rescue and assistance details, and command duty officers

REQUIREMENT:

Initial and annual training, with drill, according to OPNAVINST 5100.19B.

INTRODUCTION:

There are significant hazards associated with handling hazardous materials under a controlled situation, even more during a spill or emergency situation. A hazardous material spill can be a threat to the safety of the ship, the environment, and personnel. Users can usually handle small spills, less than 5 gallons of low toxicity material. Material safety data sheets (MSDSs) provide spill cleanup information. Larger spills of highly toxic, flammable, or explosive material can cause extensive damage to the ship and personnel injuries. As with any threat to the ship, damage control teams are tasked with responding and handling the emergency.

I. BACKGROUND

A. The Navy has established the Hazardous Material (HM) Program to provide the precautions and procedures to safely handle these materials.

B. Steps must be taken to prevent hazardous material spills from occurring.

1. The HM coordinator, along with the DCA, pinpoint those places aboard ship that are potential spill areas.
2. Potential spill areas include storerooms, stores-handling elevators and conveyers, crane-handling areas, in-use storage areas, sumps and tanks, and certain evolutions, such as UNREP/RAS, when spills may occur.
3. Periodic checking of these areas, especially after heavy weather, may alert you to a spill.
4. Environmental contamination of navigable waterways must be prevented!

C. Spillage, or accidental release of hazardous materials, must be handled with the proper protective clothing and with the correct procedures to avoid personnel injuries and damage to the ship.

1. Damage control personnel, CDOs, fire marshals, gas free personnel, and the DCA must be trained in spill response.
2. An annual spill response drill must be conducted.
3. Each member of the damage control team must be aware of the potential hazards of hazardous material spills. They must handle each spill as a special case. The DCA, CDO, or fire marshal will evaluate the spill and instruct team members in cleanup procedures.
4. Spills of oil, OTTO fuel, PCBs, radioactive material, mercury, CHT, and hydraulic fluid are handled by separate instructions. Specialized spill kits are available for each of these items, and trained spill teams generally respond to these types of spills.
5. Damage control personnel may be called upon to respond to spills of paint, thinner, dry-cleaning fluid, lube oil, acid, boiler water and feedwater chemicals, or laundry products.

Figure 1-1.—Sample lesson plan—Continued.

SHOW VIDEOTAPE "Shipboard Spill Response and Cleanup," IF AVAILABLE.

II. PHASES OF SPILL RESPONSE

A. DISTRIBUTE HANDOUT #1 Hazardous Material Spill Response Procedures (Handout #1, fig. 1-13, is found at the end of this chapter.)

As you can see on your handout, there are nine phases of spill response. They are similar to every damage control response, such as fire, flooding, or toxic gas. These phases do not always occur in order, and some may occur simultaneously.

B. Each of the nine spill response phases will be discussed in detail in this lesson plan and the handout. The phase names and the order of presentation are as follows:

- Discovery and notification
- Initiation of action
- Evalution
- Containment and damage control
- Dispersion of gases and vapors
- Cleanup and decontamination
- Disposal of contaminated materials
- Certification for safe re-entry
- Follow-up reports

1. SPILL DISCOVERY AND RESPONSE NOTIFICATION

a. Spills are discovered during zone inspections, by detection devices such as alarms, during routine operations, or safety surveys.

b. Early detection is critical! Leaking boxes, the sound of broken glass, seepage around barrel rims, unusual odors, or missing caps can be indicators of a spill.

c. Anyone can discover a spill. Everyone should be trained to notify their supervisor if they discover a spill.

– NEVER touch the spilled material.

– Evacuate the area and keep passersby from entering the spill site.

– If the situation is a severe hazard, or if you cannot reach your supervisor, contact damage control central (DCC) or the quarterdeck.

d. The person reporting the spill should report the same type of information you would report in case of fire or flooding:

- Time of spill discovery
- Location of the spill, by compartment name and compartment number
- Type of material spilled, if known
- Behavior of the material (Is it heading for a deck drain? Is it giving off thick red gas? Is it still spilling out of its container?)
- Source of the spill (such as a 55-gallon drum, 5-gallon can, tank, or pipe)

Figure 1-1.—Sample lesson plan—Continued.

- Any personnel injuries or witnesses?
- How much material is spilled, how many gallons, how many square feet on the deck?

e. DCC needs as much information as possible to decide who to send to the scene. For example, a 5 gallon can of paint thinner was dropped down a ladder near a storeroom. The can burst open when it hit the deck. The vestibule has no ventilation and the flammable vapors are building. In response to this spill, the DCA may want to send the entire fire party with charged fire hoses to the scene. The DCA needs specific information to make proper decisions.

2. INITIATION OF ACTION

a. The most important initial actions are to evacuate personnel, secure power to the affected area (if material is flammable), and call away a medical emergency for any injured personnel.

b. Block off the area until help arrives.

c. The DCA, CDO, fire marshal, repair locker leader, scene leader, or other authority will stabilize the situation before thinking about the cleanup. Stabilization may include securing deck drains, securing ventilation, setting spill boundaries, and staging backup personnel.

d. Once the situation is stable, injured personnel have been removed and cared for, and there is no immediate threat of fire or explosion, then the authorities can consider their next step.

3. EVALUATION

a. The medical department representative and the HM coordinator must have an MSDS for every hazardous material held on board. Each CDO, DCA, fire marshal, and key player must know where to find these MSDSs and how to use them.

b. These MSDSs provide specific spill and hazard information for the spilled item. The MSDS will tell if the item is corrosive, gives off toxic fumes, or reacts with nearby substances. In trying to decide how to handle and cleanup the spill, the MSDS information is critical.

c. Part of an evaluation may take place during the initiation of the action phase. The remainder may take place during the next phase of containment and damage control.

4. CONTAINMENT AND DAMAGE CONTROL

a. During this phase, the CDO, DCA, fire marshal, or scene leader decides if a Red Devil blower is needed for ventilation, and if any further damage control actions, beyond the initial action, is needed.

b. The decisions are made, based on the MSDS, what type of protective equipment is needed, and who will dress-out to approach the spill.

c. Barriers of sand, absorbent, blankets, or paper toweling maybe placed around the spill to prevent spreading.

d. The gas free engineering petty officer maybe required to determine explosive levels and levels of toxic gas.

Figure 1-1.—Sample lesson plan—Continued.

5. DISPERSION OF GASES AND VAPORS

a. Ventilation from the surrounding area, a Red Devil blower, ram fan air mover, or local exhaust system may be used to reduce explosive levels, or to disperse or dilute air contaminants.

b. Take care when exhausting vapors and gases to the weather decks to prevent re-introducing them into the ship.

c. The gas free engineering petty officer uses meters and Draeger tubes to check for ventilation.

6. CLEANUP AND DECONTAMINATION

a. Once the initial phases are complete, the team can take its time cleaning up the spill and decontaminating the area. Remember that cleanup personnel must be appointed and supervised as they don the required protective clothing. Protective clothing is provided in each ship's spill cleanup kit, kept in or near a repair locker.

Note to the instructor: If your ship has the spill cleanup kit available, breakout the kit and show all the components to the students. Explain the use of each item.

b. During cleanup and decontamination, one person supervises the cleanup while the others assist. The DCA, CDO, fire marshal, or scene leader will decide what protective clothing and respiratory protection is required and instruct the team members in the cleanup.

7. DISPOSAL OF CONTAMINATED MATERIALS

a. All the spilled material, absorbent, disposable clothing contaminated with the spilled material, and items which cannot be decontaminated are considered used hazardous material. These items must be double-bagged in plastic or placed in an empty drum or barrel and sealed. The material must be labeled with a hazardous chemical label. The material must then be turned over to the supply department for disposal.

b. You must decontaminate reusable items, such as rubber boots, dustpans, brooms, and mops before reuse. Place them in a doubled, plastic, labeled bag until you can accomplish the decontamination. The safety officer or the HM coordinator will help decide how to safely decontaminate reusable spill equipment.

8. CERTIFICATION FOR SAFE REENTRY

Once the decontamination is completed, the CDO, DCA, or fire marshal inspects the area to be sure the cleanup is complete. If toxic gases or vapors were involved the area also may need to be cleared by the gas free engineer.

9. FOLLOW-UP REPORTS

a. The spill response should be logged in the DCC log (Engineering Log) and the ship's deck log.

b. The CDO may want a written report to present to the CO or XO. Give a copy of this memo to the HM coordinator.

c. If there was local press interest, or if the spill caused fatalities or excessive damage, an OPREP-3 is probably required. Spills, such as oil, mercury, and PCBs have their own reporting requirements.

Figure 1-1.—Sample lesson plan—Continued.

(1) OPNAVINST 5090.1A provides hazardous materials spill response and reporting procedures for spills over the side, in Navy, non-Navy, and foreign ports. Report formats are provided.

(2) Any environmentally significant spill requires an OPREP-3 report.

d. Mishap reports to the Naval Safety Center are only required if the hazardous material exposure required medical treatment, resulted in five lost workdays, or caused a death.

III. HAZARDOUS MATERIAL SPILL DRILLS

Hazardous material spill drills must be conducted at least annually. These drills are in addition to the already required mercury spill drills, OTTO fuel spill drills, and others required by separate directives. The drill should be realistic and related to the ship class. The DCTT should develop spill drill scenarios involving the entire fire party.

SUMMARY:

Hazardous material spills may become damage control situations that threaten the ship and personnel. Damage control parties must be aware that, although similar to other damage control situations, spills may require special handling and precautions because of the chemical involved. Damage control personnel must be trained and drilled to understand hazardous material spill response procedures.

FOR MORE INFORMATION CONSULT OPNAVINST 5100.19B, APPENDIX B3-A.

SPILL RESPONSE SCENARIOS ARE PROVIDED. SELECT ONE FOR A HAZARDOUS MATERIAL FREQUENTLY USED ON BOARD (MSDS AVAILABLE) OR DEVELOP YOUR OWN DRILL.

Figure 1-1.—Sample lesson plan—Continued.

HAZARDOUS MATERIAL SPILL RESPONSE DRILL SCENARIOS

The following sample hazardous material spill response drill scenarios (fig. 1-2) have been collected from several ships. The DCTT should review and discuss these scenarios for applicability to your ship. Each drill should involve as many actions as possible. Walk through the scenario first to train personnel before conducting a complete drill. Each duty section and all CDOs and fire marshals should observe or participate in a hazardous material spill drill. If available, use your ship's spill response kit.

Other scenarios could include a crane delivering a pallet load of paint breaking over the helo deck and spilling; several 5-gallon cans of ammonia floor wax stripper breaking free during heavy weather and spilling in a berthing area; or a 50-pound container of powdered citric acid falling in the engine room and breaking open, spilling the powder into the bilges and over two levels of deck grating. Be creative, but realistic.

Gasoline Spill

Figure 1-3 is a sample of a training drill scenario and evaluation sample for a gasoline spill drill. This scenario, like all others, should be tailored to meet the needs of your ship. The purpose of this sample is to provide you, the supervisor, a practical way to initiate the drill and to monitor and evaluate your response team's abilities. Keep in mind, the maximum credit points are arbitrary. You should assign point values based on the importance of each task being performed.

SCENARIO #l

An Engineman is removing a 12-volt battery from the motor whale boat. The boat is on the davit, and the Engineman must carry the battery down the side ladder. As he lifts the battery over to the side of the boat, his glove slips, and the battery falls about 10 feet to the deck below. The battery caps fly off and about 2 quarts of battery acid spill on the deck The acid is flowing toward the deck edge and scupper over the side. A nearby Boatswain's Mate tries to set the battery up to stop the spill and suffers acid burns on his hands.

This spill will involve:

—A medical emergency for acid bums

—Stopping the spill from spreading

—Using baking soda to neutralize the acid around the battery, and using personnel protective equipment to pick it up and bag it

—Spreading baking soda and scrubbing the spill area

—A fire party to charge hoses and dilute the acid while washing it over the side

—Personal protective equipment that would include rubber boots, rubber gloves, a rubber apron, and goggles (a respirator may not be required)

The used hazardous material would include the broken battery and any contaminated containment materials. The acid spill should be neutralized before washing it over the side. The alternative is to neutralize with baking soda and absorbing it up with towels, absorbent, or other material. All this would be bagged as used hazardous material.

SCENARIO #2

An SK3 went down to the flammable liquid storeroom to break out a 5-gallon can of paint thinner (flash point less than 100 degrees). As he carries this can up the ladder, the handle breaks off the can, and it falls down to the bottom of the ladder. As the can hits, the cap pops off and the contents spill. The vestibule is small and there is no ventilation in the ladder well. The SK3 tries to go down after the can, and while trying to right the can, replace the cap, and cleanup the spill, falls unconscious in the thinner. A sailor in a space above smells the strong vapors and phones DCC to get the fire marshal to investigate. The sailor and the fire marshal find the unconscious SK3 and see the spilled paint thinner in the vestibule.

This spill will involve:

—Explosive vapors and the need to secure sources of ignition.

—A medical emergency with the SK3 overcome by the vapors and skin contact with the chemical. A rescue would require respiratory protection but not an OBA due to flammable vapors.

—Ventilating the area with a Red Devil blower.

—Calling away the fire party in case of explosion and fire.

—Gas-freeing the area.

—Dressing out two people in goggles, organic vapor respirators, rubber boots, rubber gloves, and disposable coveralls.

—Cleaning up the spill using absorbent, double plastic bagging, and marking the material as used hazardous material.

—Decontamination of the area with soapy water.

Figure 1-2.—Response drill scenarios.

GASOLINE SPILL DRILL

OBJECTIVE: To train damage control personnel in spill cleanup procedures and equipment use.

APPLICABILITY: All

SUPPORT SERVICES REQUIRED: None

ACCEPTABLE EQUIVALENCY As approved by ISIC

REQUIREMENTS: None

SCENARIO I: Ship in port. MOGAS piping failure leads to 500-gallon spill in the pump room.

SCENARIO II: Ship undervay. Misalignment of valve causes 25-gallon spill through vent into pump room.

PROCEDURES:

1. INITIAL PROCEDURES:

   a. Spill stopped and reported to DCC

   b. Ship to General Quarters

   c. Spill reported via OPREP-3, Navy Blue or Unit SITREP, and Oil Spill Report, OPNAVINST. 5090.1

2. DAMAGE ASSESSMENT:

   a. Isolate area electrically and otherwise.

   b. Break out free-fighting equipment and prepare to combat fire and explosion.

   c. Determine gasoline vapor concentration in the air as related to the lower explosive limit. Select protective equipment and clothing based on this finding.

3. REPAIR TASKS:

   a. Breakout spill cleanup equipment and stage materials in the local area.

   b. Dress out personnel in appropriate protective equipment provided in the spill cleanup kit. In concentrations above the LEL, self-contained breathing apparatus (SCBA) should be used, if available, vice OBAs.

   c. Contain spill using diking materials or other equipment.

   d. Stage equipment and materials to maximize efficiency separating contaminated materials for final disposal.

   e. Commence cleanup operations using absorbent pads and other equipment.

   f. Collect contaminated materials for reuse or segregate for disposal.

   g. Continue cleaning until no visible sign of liquid is present and vapor concentration levels are below 10 percent of the LEL.

   h. Containerize contaminated materials in preparation for transportation and disposal. Sealed containers of gasoline contaminated materials may be explosive and highly flammable. The materials should be removed from the ship by the quickest available means including jettisoning overboard.

   i. Restore unused materials.

   j. Decontaminate personnel and equipment..

   k. Package residual contaminated material for disposal.

   1. Stow equipment and unused materials in spill kit and return kit to storage.

   m. Make follow-up reports via appropriate message.

SAFETY: Ensure the safety of all personnel and equipment.

Figure 1-3.—Spill drill for gasoline.

MARKING FACTORS

1. Preparation. Evaluate adequacy of preparation including but not limited to the following:

	MAXIMUM CREDIT	SCORE
a. Spill cleanup kit available	5	____
b. Spill contingency plan available	5	____
c. Spill cleanup team briefing adequate	5	____
2. Damage Control Organization:		
a. Spillage reported efficiently	5	____
b. Immediate response adequate	20	____
c. Message notification adequate	5	____
d. Spill cleanup personnel level of knowledge in:		____
(1) Use of equipment	10	____
(2) Use of materials	10	____
e. Speed and efficiency of the cleanup operation	20	____
f. Safety of personnel throughout all aspects of the operation	15	____

MAXIMUM SCORE 100

TOTAL SCORE ____

Figure 1-3.—Spill drill for gasoline—Continued.

Oil Spill

Figure 1-4 is a training scenario and evaluation sample for an oil spill drill. Remember, this is only a sample and should be tailored to suit the needs of your ship.

Freon Spill

Figure 1-5 shows a sample of a freon spill drill. The purpose of this sample is not to limit you, but to encourage you to create your own viable scenarios.

PREPARE REPORTS

For all practical purposes, you probably will not be responsible for the actual reports that will be sent to your command's higher reporting authority. But keep in mind, you probably will be tasked with providing your superiors with the preliminary data. For you to be effective in this task, you should be familiar with the reporting procedures outlined in OPNAVINST. 5090.1 series.

ENGINEERING OPERATIONAL CASUALTY CONTROL (EOCC) MANUALS

The casualty control portion of the EOSS contains information relevant to the recognition of casualty symptoms and their probable causes and effects. This is also a source for information on actions to be taken to prevent a casualty. The EOCC manuals specify procedures for controlling single- and multiple-source casualties.

Casualty prevention must be the concern of everyone on board. Proper training of all personnel must provide adequate knowledge and experience in effective casualty prevention. The EOCC manuals have efficient, technically correct casualty control and prevention procedures. These procedures relate to all phases of an engineering plant. The EOCC documents possible casualties that may be caused by human error, material failure, or battle damage. The EOCC manuals describe proven methods for the control of a casualty. They also provide information for prevention of further

OIL SPILL DRILL (OVERBOARD)

OBJECTIVE: To train damage control personnel in spill cleanup procedures and equipment use.

APPLICABILITY: All

SUPPORT SERVICES REQUIRED: In port: Port Services punts and oil boom
Not in port: None

ACCEPTABLE EQUIVALENCY: As approved by ISIC

REQUIREMENTS: OPNAVINST 5100.19B requires one drill of this type per year.

SCENARIO I: Ship moored at pier inadvertently releases 1,000 gallons of fuel.

SCENARIO II: Ship at anchor inadvertently releases 1,000 gallons of fuel.

PROCEDURES:

1. INITIAL PROCEDURES:

a. Continued spillage stopped

b. Ship reports spill via OPREP-3, Navy Blue or Unit SITREP, and Oil Spill Report, OPNAVINST. 5090.1

c. Review the ship's spill contingency plan

d. Brief spill cleanup team

2. DAMAGE ASSESSMENT:

a. Determine environmental significance of spill

b. Determine volume of spill:

(1) Within ship's capability, clean, designate personnel, break out spill cleanup kit, and launch small boats as necessary

(2) Beyond ship's capability, take immediate action to control spill and request assistance by message from the designated naval on scene coordinator (NOSC)

3. REPAIR TASKS:

a. Breakout spill cleanup equipment and stage materials in small boats

b. Dress out personnel in appropriate protective equipment provided in the spill cleanup kit

c. Launch small boats

d. Contain spill using booms or other equipment

e. Stage equipment and materials in the small boats to maximize efficiency

f. Separate contaminated materials for disposal

g. Commence cleanup operations using absorbent pads, skimmers, and other equipment

h. Collect contaminated materials for reuse or segregate for disposal

i. Continue cleaning until no sheen is apparent on the surface of the water

j. Seal contaminated materials in preparation for transportation and disposal

k. Restore unused materials

1. Retrieve small boats

Figure 1-4.—Spill drill for oil.

m. Decontaminate personnel and equipment

n. Package residual contaminated materials for disposal

o. Stow equipment and unused materials in spill kit and return kit to storage

p. Make follow-up reports to NOSC via appropriate message formats in OPNAVINST 5090.1

SAFETY: Ensure the safety of all personnel and equipment.

MARKING FACTORS

1. Preparation. Evaluate adequacy of preparation including but not limited to the following:

	MAXIMUM CREDIT	SCORE
a. Spill cleanup kit available	5	____
b. Spill contingency plan available	5	____
c. Spill cleanup team briefing adequate	5	____
2. Damage Control organization:		
a. Spillage reported efficiently	5	____
b. Immediate response adequate	20	____
c. Message notification adequate	5	____
d. Spill cleanup personnel level of knowledge in:		
(1) Use of equipment	10	____
(2) Use of materials	10	____
e. Speed and efficiency of the cleanup operation	20	____
f. Safety of personnel throughout all aspects of the operation	15	____

MAXIMUM SCORE 100
T0TAL SCORE ___

Figure 1-4.—Spill drill for oil—Continued.

damage to components, the system, or the engineering plant.

The EOCC manuals are available to personnel in their own machinery space so that they can be used as a means of self-indoctrination. These manuals also can be used to improve casualty control procedure techniques for all watch standers. The manuals contain documentation to assist engineering personnel in developing and maintaining maximum proficiency in controlling casualties to the ship's propulsion plant.

Proficiency in EOCC procedures is maintained through a well-administered training program. Primary training concentrates on the control of single-source casualties. These are casualties that may be attributed to the failure or malfunction of a single component or the failure of piping at a specific point in a system. Advanced training concentrates on the control of multiple casualties or on conducting a battle problem. An effective, well-administered EOCC training program must contain, as a minimum, the following elements:

FREON SPILL DRILL

OBJECTIVE: To train damage control personnel in spill cleanup procedures and equipment use.

APPLICABILITY: ALL

SUPPORT SERVICES REQUIRED: None

ACCEPTABLE EQUIVALENCY As approved by ISIC

REQUIREMENTS: None

SCENARIO I: Ship is in port. Piping failure leads to complete venting of refrigerant from reefer deck into an AC machinery room. The body of one individual is visible from the access hatch/door.

SCENARIO II: Ship is underway. Misalignment of valve causes venting of refrigerant into AC machinery room. The body of one individual is visible from the access hatch/door.

PROCEDURES:

1. INITIAL PROCEDURES:

   a. Spill stopped and reported to DCC

   b. Ship reports spill via OPREP-3, Navy Blue or Unit SITREP, and Oil Spill Report, OPNAVINST. 5090.1

2. DAMAGE ASSESSMENT:

   a. Isolate area

   b. Breakout equipment to retrieve injured personnel

   c. Determine freon vapor concentration in the air

   d. Select protective equipment and clothing based on findings

3. REPAIR TASKS:

   a. Breakout spill cleanup equipment and stage materials in the local area

   b. Dress out personnel in appropriate protective equipment provided in the spill cleanup kit

   c. Remove injured personnel and provide first aid

   d. Contain liquid spill using Wing materials or other equipment

   e. Stage equipment and materials to maximize efficiency

   f. Separate contaminated materials for disposal

   g. Commence cleanup operations using absorbent pads and other equipment

   h. Collect contaminated materials for reuse or segregate for disposal

   i. Continue cleaning until no visible sign of liquid is present and vapor concentration level is below 10 percent of the LEL

   j. Containerize contaminated materials in preparation for transportation and disposal

   k. Restore unused materials

   1. Decontaminate personnel and equipment

   m. Package residual contaminated materials for disposal

Figure 1-5.—Spill drill for freon.

n. Stow equipment and unused materials in spill kit and return kit to storage

o. Make follow-up reports to NOSC via appropriate message formats in OPNAVINST 5090.1

SAFETY: Ensure the safety of all personnel and equipment.

MARKING FACTORS

1. Preparation. Evaluate adequacy of preparation including but not limited to the following:

	MAXIMUM CREDIT	SCORE
a. Spill cleanup kit available	5	______
b. Spill contingency plan available	5	______
c. Spill cleanup team briefing adequate	5	______
2. Damage Control Organization:		
a. Spillage reported efficiently	5	______
b. Immediate response adequate	20	______
c. Message notification adequate	5	______
d. Spill cleanup personnel level of knowledge in:		
(1) Use of equipment	10	______
(2) Use of materials	10	______
e. Speed and efficiency of the cleanup operation	20	______
f. Safety of personnel throughout all aspects of the operation	15	______

MAXIMUM SCORE 100

TOTAL SCORE ___

Figure 1-5.—Spill drill for freon—Continued.

- Recognition of the symptoms
- Probable causes
- Probable effects
- Preventive actions that may be taken to reduce, elimimte, or control casualties

An EOSS package is not intended to be forgotten once it is developed and installed. It offers many advantages to the ship's operational readiness capabilities and provides detailed, step-by-step sequencing of events for all phases of the engineering plant operation. Because it is work-studied and system-oriented, the EOSS provides the basic information for the optimum use of equipment and systems. It does this by specifying correct procedures tailored for a specific plant configuration.

The EOSS is not intended to eliminate the need for skilled plant operators. No program or system can achieve such a goal. The EOSS is a tool for better use of manpower and available skills. Although the EOSS is an excellent tool for shipboard training of personnel, it is primarily a working system for scheduling, controlling, and directing plant operations and casualty control procedures.

EOCC VERIFICATION CHECKS

Since EOCC procedures are a part of the EOSS, EOCC verification checks should be performed whenever the EOSS is verified. The purpose of verification checks is to validate required changes to EOCC procedures due to authorized SHIPALTs, changes in operating philosophy, or changes in parameters.

Cold Plant

During a ship's scheduled PMA/SRA/ROH, Naval Warfare Center Ships System Engineering Station (NAVWARCENSSES) Philadelphia will schedule an EOSS verification check (cold plant) approximately 4 weeks prior to the end of the ship's availability. This will ensure that all system modifications/installations affecting EOSS are completed before the check in order to permit an accurate update.

At the end of the verification check a copy of the affected EOSS documentation must be annotated and given to the ship for review and use when approved by the commanding officer. The annotated documents will be used until the final laminated EOSS is received (usually within 12 weeks).

Hot Plant

The hot plant checks are conducted just as the name describes. This means the plant is fully operational, and the checks are normally performed as a training evolution in the form of casualty control drills. These checks are usually used to fine tune watch-stander efficiency and identify procedural deficiencies.

USING THE FEEDBACK SYSTEM

Since the EOCC procedures makeup only part of the overall EOSS, we will discuss the use of the EOSS feedback system. The EOSS feedback system is the means by which you may make changes in your EOSS. Any naval activity may originate these requests. The information in this section will cover the proper preparation of feedback reports and other aspects of the feedback system.

You must submit feedbacks to accomplish the following:

1. Obtain replacement documents, holders, covers, and twisties.
2. Recommend approval of revisions for:
   a. Procedural changes to correct document errors.
   b. Configuration changes for authorized equipment or piping installations.

Feedback reports should NOT be submitted just because the EOSS conflicts with other technical guidance. The EOSS always supersedes other guidance! An EOSS feedback should be submitted only when the EOSS is suspected to be in error. Feedback on other documentation such as technical manuals should be submitted via its respective system.

Urgent Feedbacks

An urgent EOSS feedback report describes a technical discrepancy that could cause damage to equipment or injury to personnel. This category was established to provide rapid resolution of EOSS technical discrepancies related to genuine operational needs.

PREPARATION.— Submit urgent feedbacks by priority message to NAVWARCENSSES Philadelphia. Information addresses must include COMNAVSEA-SYSCOM Washington, DC, and your TYCOM. They must contain the following information:

1. An urgent EOSS feedback number consisting of the year and feedbacks sequential position based upon earlier urgent feedbacks you've submitted that year. For example, 93-2; the 93 represents the year and the 2 shows this as the second urgent feedback in 1993.
2. The code number of the EOSS procedure(s) involved (for example, BLF/O21/0585).
3. A detailed description of the problem.
4. The recommended solution citing appropriate justification and any reference documentation.

NOTE

Review each urgent feedback to be certain the feedbacks a valid urgent submission as defined in the EOSS user's guide.

PROCESSING.— An urgent feedback report is processed in the following manner:

1. The commanding officer authorizes a preliminary pen and ink change to the EOSS pending official guidance from the NAVWARCENSSES.
2. NAVWARCENSSES will provide guidance by message. This is done in 1 to 10 working days depending upon the complexity of the issue. TYCOM monitors and provides assistance as necessary.

3. The commanding officer authorizes the final pen and ink change to EOSS according to message guidance.

4. NAVWARCENSSES forwards advance copies of the corrected document(s) to the ship within 15 working days of the guidance message.

5. NAVWARCENSSES forwards final laminated documents to the ship within 3 months of the guidance message.

Routine Feedbacks

A routine EOSS feedback is one of two categories, A or B. Category A feedbacks are used to request EOSS materials. Category B feedbacks describe technical discrepancies that are not urgent. Recommended revisions could be an addition or deletion, or a change in the sequence of steps, the parameters, or the diagrams.

PREPARATION.— Submit routine feedbacks using the Planned Maintenance System (PMS) form, OPNAV 4790/7B. Each revision requested requires a separate form. If the same change is requested for several documents, it may be explained once and then listed on the documents affected. Rearranging several steps in a document because of a single technical change counts as one revision. On the other hand, more than one technical recommendation in a single document requires more than one form. The printed information on the PMS form does not apply to EOSS. Maintain a separate EOSS feedback system. When using this form for EOSS the following instructions apply:

1. Fill in the ship's name in the **FROM** block.

2. In the **SERIAL #** block, fill in a EOSS feedback number consisting of the year and the feedback's sequential position. Routine feedbacks must have a different set of feedback numbers than urgent feedbacks. Category A and B routine feedbacks should share the same set of numbers.

3. In the **DATE** block, fill in the date the feedback is to be mailed.

4. In the **TO** block, mark the appropriate square for category A or B feedbacks. For category A feedbacks write NAVWARCENSSES Philadelphia in the space provided.

5. Mark the **SUBJECT** block as follows:

   a. In the SYSTEM block, fill in either EOP or EOCC as appropriate.

   b. In the SYSCOM MIP block, fill in the document code number (for example, TG/0471/0980 and HBWL/0099/0980).

   c. Leave the APL and SYSCOM MRC blocks blank.

6. Leave the **DESCRIPTION OF PROBLEM** block blank except when you are commenting on a procedure that has not been finalized for your use. In that case mark the OTHER block with the words, HOT CHECKS. Situations when this would apply include a package that has been hot checked but not approved and installed, a package that belongs to another ship of the class, or before one ship's development,

7. Fill in the **REMARKS** section as follows:

   a. For category A feedbacks be specific.

      (1) Documents; specify code number(s) of document(s) needed and the number of laminated (max 2) and unlaminated copies requested.

      (2) Holders; specify type (single and/or double) and number of each requested.

      (3) Covers; specify type (EOP and/or EOCC) and number of each requested.

      (4) Twisties; specify size (4-3/4", 5-3/4", or 8") and number-of each requested.

   b. For category B feedbacks, be as clear as possible. The more precise you are, the faster a response can be generated

      (1) Identify the location of the problem in the EOSS document.

      (2) Describe the problem and recommend a solution.

      (3) Reference your justification for the change where applicable. Provide a copy of the reference pages that support your recommendation

      (4) Use the unlaminated logroom copy, make a photocopy of the procedure, and mark it to reflect your recommendation Attach a duplicate of the unlaminated copy to the 4790/7B form. Do not use a yellow marker because it will not photocopy. Do not obscure the original

text or the reference, because this will cause a delay in answering your request.

8. In the signature blocks, indicate with an asterisk* the person who would serve as the best point of contact. Make sure the name is legible and include phone numbers when possible. The **3-M COORDINATOR** block must be signed by the EOSS coordinator. Note that the EOSS feedback system is separate from the PMS system. The distribution of the feedback copies is as follows:

   a. White, yellow, and pink copies to NAVWARCENSSES Philadelphia for category A feedbacks or to the TYCOM for category B feedbacks. If the TYCOM determines that the NAVWARCENSSES action is appropriate, they will forward the white and yellow copies to NAVWARCENSSES. The white copy will be returned with the requested material for category A feedbacks. No copies will be returned for category B feedbacks.

   b. The blue copy is retained by the EOSS coordinate.

   c. The green copy is retained by the originating work center.

PROCESSING.— Feedbacks are processed as quickly as possible. Generally, the more comprehensively prepared a feedback is, the easier it is to answer. Do all the homework you can before submitting a feedback.

1. Category A feedbacks are sent to NAVWARCENSSES. The items requested are forwarded within 21 working days of the request receipt.

2. Category B feedbacks are screened by the TYCOM and may be answered by them and returned to you. This could occur when your recommended change is not according to their policy or EOSS program policy. When your TYCOM forwards the feedback to NAVWARCENSSES, there are three possible responses.

   a. Concur—Advance copies of the revised document(s) will be forwarded.

   b. Do not concur—An explanation of the reason for nonconcurrence will be forwarded within 21 working days of receipt.

   c. Other—Advance and final copies will be forwarded as with concur items. An explanation of the partial concurrence will accompany the advance copies.

3. Annotations for routine feedbacks are limited to documenting authorized configuration changes. Routine procedural/parameter pen and ink changes are not authorized.

Make Local Changes to Manuals

Local changes to EOSS are **NOT AUTHORIZED** except as described in section 4 of chapter 1 of the EOSS User's Guide. Only NAVWARCENSSES can approve and issue changes to the NAVSEA-installed EOSS.

PREPARE FULL POWER AND ECONOMY TRIAL REPORTS

As a GS supervisor, full power and economy trials will be a very important part of your responsibilities. Through proper leadership and training these trials can be proof of your management skills. They are proof of your ability to maintain your propulsion equipment at peak levels of performance.

Although FXP-4 mobility (MOB) exercises delineate general requirements for conducting engineering trials, inconsistencies have developed among different naval commands in levying different requirements for full power and economy trials for nonnuclear surface ships. Full power and economy trial requirements are based partially on calculations and partially on design requirements. It is not economically feasible to conduct full-scale trials to document every possible condition. Therefore, to avoid confusion, the reporting system for trial results is found in OPNAVINST 9094.1, *Full Power and Economy Trial Requirements for Non-nuclear Surface Ship Classes.*

In this section we will briefly discuss the performance of these trials and the processing of data needed to complete the required reports.

FULL POWER TRIALS

A full power trial must be conducted annually for a minimum duration of one hour and at a minimum depth of water as prescribed in NSTM, chapter 094. All full power trials shall be conducted with a minimum 75 percent liquid load at the commencement of the trial. During the trials, fleet and type commanders must ensure machinery alignments are according to heat balance diagrams, propulsion operating guides, and applicable technical documentation.

Compile Information

The information compiled during the full power trial must be entered on standard forms used for all gas turbine-powered ships. All the following forms except the one shown in figure 1-9 are available through normal supply channels according to NAVSUP P-2002. Figure 1-6 is the trial transmittal letter (cover sheet), OPNAV form 9094/1A, NSN 0107-LF-090-9405. Figure 1-7 is sheet 1 of 2 of the trial data form, OPNAV form 9094/1D, NSN 0107-LF-090-9440. Figure 1-8 is sheet 2 of 2 of the trial data form, OPNAV form 9094/1D, NSN 0107-LF-090-9445. View A shows plant condition data for 1A GTE, while view B shows data for 1B GTE. The form shown in figure 1-9 is not available in the supply system, but it is the standard format used to report the actual propulsion plant condition to the chief observer before a full power or even an economy trial commences.

Disseminate Information

For you to properly disseminate the information, you must be familiar with all operating characteristics of your plant. In other words, you need to go back to the basics and use all the guidelines provided in the EOSS and applicable technical manuals. If the readings are improperly disseminated, it could mean the difference between a satisfactory or unsatisfactory trial.

ECONOMY TRIALS

Economy trials in most cases will be scheduled on the same day as the full power trials. They are usually scheduled in this manner because of the ship's competitive exercise schedule and the availability of observers. Just because these trials are usually conducted together does not mean their accomplishment periodicity is the same. Economy trial periodicity is established by your fleet and type commanders. Fleet and type commanders also must be sure machinery alignments during economy trials conform to propulsion operating guides and NAVSEA, SL101-AA-GYD-010, Energy Conservation.

All the economy trial report forms are the same as those used for the full power trials. Refer again to figures 1-6 through 1-8. The forms are the same, but the information entered in the equipment operating sections of these forms may differ. However, if both trials are accomplished on the same day, the information provided on the form shown in figure 1-9 will be the same.

DRAFT REPORTS

Reports of all satisfactory and unsatisfactory engineering trials must be provided to Commander, Naval Sea Systems Command (SEA56X1). The report of an unsatisfactory trial is particularly important. It provides information on design or material problems that preclude a successful trial.

MARINE GAS TURBINE EQUIPMENT LOGBOOKS

The Navy deploys gas turbine equipment in propulsion and ship-services systems in its surface fleet. Selection of gas turbine equipment for these systems reflects a commitment to increase ship availability through reduction in system downtime. Gas turbine equipment combines acceptable reliability and onboard maintenance features with ease of removal and replacement. System downtime and lower shipboard manning levels have been realized through properly directed maintenance and logistic support, and reliability and maintainability improvement efforts.

Service records, as described in this section, are used to retain significant historical operating and maintenance data of gas turbine equipment transferred between shipboard installations and repair or rework facilities. Service records provide a consolidated source of background information available to personnel conducting and analyzing maintenance activity.

All gas turbine records are designed according to the 3-M Maintenance Data System (MDS) organizational (ship) maintenance data collection or reporting requirements. They are particularly important because of the interface in marine gas turbine equipment support between shipboard organizational maintenance and shore-based depot maintenance.

The use of service records and logbooks is similar to the approach applied successfully in NAVAIR for many years in the aircraft jet engine community.

05 MARCH 1993

From: Chief Observer, GSCM (SW) J. Frost, USN, 111-11-1111
To: Commander, Destroyer Squadron Zero Zero
Via: 1. CO, USS Turbine (FFG-99)
2.
3.

Subj: USS Turbine (FFG-99) Trial Report: Forwarding of

Encl: (1) DATA SHEET
(2) CO, USS Turbine (FFG-99) Letter to Chief Observer

1. A(n) Full Power Trial (MOB-E-001-SF) Trial is reported herewith.

2. The ship complied with current directives as follows:

Split plant was utilized (if applicable) NA ☐ YES ☐ NO

Prescribed material condition was maintained ☒ YES ☐ NO

NOTE: Material condition Zebra set on fire and drainage systems.

Usual services were maintained during the trial, as follows:

☐ BOILER ☒ EVAPORATORS ☒ LIGHTING ☒ OTHER *(Specify)* Hotel Services, Port Stbd Fin Stablizers

Liquid loading equaled 79.2 %

Submarines Only: Status of fuel ballast tanks: Tank numbers (full) NA ; Tank numbers (empty) NA

Limiting speeds, temperatures, pressures(xxx/were not) exceeded.

3. Violations of safety precautions or of good engineering practices were noted, as follows:

None Noted

4. Information concerning fuel and power is as follows:

FUEL		POWER	INBOARD SHAFTS	OUTBOARD SHAFTS
USED	2377	REQUIRED ENGINE SPEED, PROPELLER RPM AND/OR PITCH TOTAL KW PROPULSION GENERATIONS OR BATTERY RATE (REQUIRED).	178 RPM 23.5 FT	NA
ALLOWED	2560	ENGINE SPEED, PROPELLER RPM, AND/OR PITCH TOTAL KW PROPULSION GENERATORS OR BATTERY RATE (MADE)	179.8 RPM 23.5 FT	NA
PERFORMANCE RATIO	1.00			

5. Trial requirements (were/XXXX) met (if not met, specify reason)

6. A mark of 100 % is recommended for this exercise.

(Signature)

COPY TO:
COMSAVSEASYSCOM (Sea 56X1) *(Complete)*
Washington DC
SWOSCOLCOM Newport RI *(Complete)*

ENGINEERING TRIAL REPORT
TRANSMITTAL LETTER
OPNAV 9094/1A(5-79) S/N 0107-LF-090-9405

REPORT CONTROL SYMBOL 9094.1

Figure 1-6.—Engineering trial report transmittal letter.

REPORT CONTROL SYMBOL OPNAV 9094/1

ENGINEERING TRIAL REPORT
TRIAL DATA (GAS TURBINE DRIVEN SHIPS)
OPNAV FORM 9094/1D (5/79) S/N 0107-LF-090-9440

SHEET 1 OF 2

PAGE NO. 1 OF 3 PAGES

SHIP (NAME-TYPE-NUMBER)	DATE OF TRIAL
U.S.S. Turbine (FFG-99)	05 MARCH 93

A. TYPE OF TRIAL

- [ ] FLEET TRAINING
- [X] FULL POWER
- [ ] PREOVERHAUL
- [ ] ECONOMY
- [ ] POST REPAIR
- [ ] OTHER (SPECIFY) ____________

B. GENERAL

1. DRAFT	FORWARD (FEET-INCHES)	AFT (FEET-INCHES)	MEAN (FEET-INCHES)	DISPLACEMENT (TONS)
	15' 7"	16' 0"	15' 9 1/2"	4000

2. BOTTOM FOULING DATA	DAYS OUT OF DOCK TIME SINCE HULL WAS CLEANED AND COATED OR, WHERE COMPARABLE; WATERBORNE CLEANING HAS BEEN ACCOMPLISHED	DAYS UNDERWAY SINCE LAST HULL CLEANING	DAYS NOT UNDERWAY SINCE LAST HULL CLEANING	TYPE OF BOTTOM PAINT
	179	116	61	F-132 ANTI-FOUL

3. PROPELLERS	NUMBER	DIAMETER (FT-IN)	DESIGN PITCH (FT-IN)	NO. OF BLADES	TYPE	CONDITION (NICKS, CURLED EDGES FOULING, ETC.)
1	1	16' 5"	23.5	5	NICKED ALUMINUM BRONZE	NONE

PARAMETER/TIME	FIRST HOUR	SECOND HOUR	THIRD HOUR	FOURTH HOUR	FIFTH HOUR	SIXTH HOUR	AVERAGE
4. WEATHER AND SEA CONDITIONS — GENERAL — BAROMETRIC (INCHES HG) PRESSURE	29.89						29.89
AIR TEMPERATURE (DRY BULB) (DEG F)	69.3						69.3
AIR TEMPERATURE (WET BULB) (DEG F)	64.8						64.8
RELATIVE HUMIDITY (PERCENT)	69						69
SEAWATER INJECTION TEMP (DEG F)	71.3						71.3
WIND — TRUE FORCE (KNOTS)	13.2						13.2
WIND — RELATIVE DIRECTION (DEG)	28						28
SEA — STATE (BEAUFORT NO.)	1						1
SEA — RELATIVE DIRECTION (DEG)	132.8						132.8
C. PLANT CONDITIONS (GENERAL							
5. POWERING PARAMETERS — SHIP SPEED (KNOTS)	30						30
REQUIRED SHAFT RPM — STARBOARD	178						178
REQUIRED SHAFT RPM — PORT	—						—
ACTUAL SHAFT RPM — STARBOARD	179.8						179.8
ACTUAL SHAFT RPM — PORT	—						—
METERED SHAFT TORQUE (LB-FT) — STARBOARD	1176000						1176000
METERED SHAFT TORQUE (LB-FT) — PORT	—						—
SHAFT (HP)1 — STARBOARD	40259						40259
SHAFT (HP)1 — PORT	—						—
6. PROPELLER PITCH ACTUAL (FT-IN) — STARBOARD	23.5						23.5
6. PROPELLER PITCH ACTUAL (FT-IN) — PORT	—						—
7. BLEED AIR FLOW USAGE — PRAIRIE (ON-OFF) OR CFM (IF AVAILABLE)	OFF						OFF
MASKER (ON-OFF) OR CFM (IF AVAILABLE)	OFF						OFF
ANTI-ICING (ON-OFF) OR CFM (IF AVAILABLE)	OFF						OFF
OTHER (ON-OFF) OR CFM (SPECIFY) ______	—						—
8. TOTAL FUEL CONSUMED — GALLONS	2377						2377
TYPE FUEL / LHV	F-76						F-76
9. SHIPS' SERVICE GENERATORS — DIESEL — NUMBER IN USE	#1						#1
RATING (KW)	1000						1000
BLEED AIR FLOW ON-OFF OR CFM (IF AVAILABLE)	—						—
HOT TEST BEARING — TEMP (DEG F)	179.7						179.7
HOT TEST BEARING — LOCATION	FWD						FWD
TOTAL AVERAGE LOAD (KW) (KW)	567.5						567.5
FUEL CONSUMED (GALLONS)	71						71
DIESEL — NUMBER IN USE	#4						#4
RATING (KW)	1000						1000
HOT TEST BEARING — TEMP (DEG F)	170.1						170.1
HOT TEST BEARING — LOCATION	AFT						AFT
TOTAL AVERAGE LOAD (KW) (KW)	560						560
FUEL CONSUMED (GALLONS)	59						59
10. INTERVAL READINGS WERE TAKEN DURING HOUR	EVERY 15 MIN						EVERY 15 MIN

1 SHIP - $\frac{\text{TORQUE X AF M}}{5252}$

ENTER DATA IF PARAMETER IS MONITORED BY INSTALLED INSTRUMENTATION
ENTER NA IF NOT

Figure 1-7.—Engineering trial report data, sheet 1 of 2.

REPORT CONTROL SYMBOL OPNAV 9094/1

ENGINEERING TRIAL REPORT
TRIAL DATA (GAS TURBINE DRIVEN SHIPS)
OPNAV FORM 9094/1D (5/79) S/N 0107-LF-090-5440

PAGE NO. 2 OF 3 PAGES

SHIP (NAME-TYPE-NUMBER): U.S.S. Turbine (FFG-99)
DATE OF TRIAL: 05 MARCH 93

ENGINE ROOM NUMBER: MAIN ENGINE ROOM
MAIN ENGINE OR MAIN PROPULSION UNIT NUMBER: 1A GTE

D. PLANT CONDITIONING (DETAILED)

	PARAMETER/TIME	FIRST HOUR	SECOND HOUR	THIRD HOUR	FOURTH HOUR	FIFTH HOUR	SIXTH HOUR	AVERAGE
1. GAS GENERATOR	SPEED (RPM)	8800						8800
	COMPRESSOR INLET TEMPERATURE (DEG F)	69.3						69.3
	COMPRESSOR INLET TOTAL PRESSURE (PSIA)	14.3						14.3
	COMPRESSOR DISCHARGE PRESSURE (PSIG)	193.3						193.3
	VIBRATION LEVEL MEASURED BY GAS GENERATOR PICKUP (MILS)	2.0						2.0
	VIBRATION LEVEL MEASURED BY POWER TURBINE PICKUP (MILS)	0.5						0.5
	BLEED AIR FLOW ON-OFF OR CFM (IF AVAILABLE)	OFF						OFF
2. POWER TURBINE	SPEED (RPM)	3550						3550
	TORQUE (LB-FT)	30250						30250
	POWER (HP)	20175						20175
	TURBINE INLET TEMPERATURE (DEG F)	1377.1						1377.1
	TURBINE INLET PRESSURE (PSIA)	49.1						49.1
	VIBRATION LEVEL MEASURED BY POWER TURBINE PICKUP (MILS)	1.0						1.0
	VIBRATION LEVEL MEASURED BY GAS GENERATOR PICKUP (MILS)	0.8						0.8
	EXHAUST GAS TEMPERATURE* (DEG F)	875						875
	EXHAUST GAS PRESSURE* (IN H_2O) (PSIG)	—						—
3. GT FUEL OIL	MANIFOLD PRESSURE (PSIG)	632.3						632.3
	INLET TEMPERATURE (DEG F)	94.4						94.4
4. LUBE OIL	GT SUPPLY PRESSURE (PSIG)	51.5						51.5
	COOLER OUTLET TEMPERATURE (DEG F)	168.6						168.6
	HOTTEST BEARING — LOCATION	B						B
	HOTTEST BEARING — TEMPERATURE (DEG F)	198.3						198.3
5. ENGINE COOLING OUTLET TEMPERATURE (DEG F)		207.4						207.4
6. FUEL CONSUMED* (GALLONS)		2247						2247
7. INTERVAL READINGS WERE TAKEN DURING HOUR		EVERY 15 MIN						EVERY 15 MIN

* ENTER DATA IF PARAMETER IS MONITORED BY INSTALLED INSTRUMENTATION
ENTER NA IF NOT

* NOTE: FUEL CONSUMED FOR BLOCK 6 IS TOTAL FOR BOTH GTE'S USE CONSUMED

VIEW A

REPORT CONTROL SYMBOL OPNAV 9094/1

ENGINEERING TRIAL REPORT
TRIAL DATA (GAS TURBINE DRIVEN SHIPS)
OPNAV FORM 9094/1D (5/79) S/N 0107-LF-090-5440

PAGE NO. 3 OF 3 PAGES

SHIP (NAME-TYPE-NUMBER): U.S.S. Turbine (FFG-99)
DATE OF TRIAL: 05 MARCH 93

ENGINE ROOM NUMBER: MAIN ENGINE ROOM
MAIN ENGINE OR MAIN PROPULSION UNIT NUMBER: 1B GTE

D. PLANT CONDITIONING (DETAILED)

	PARAMETER/TIME	FIRST HOUR	SECOND HOUR	THIRD HOUR	FOURTH HOUR	FIFTH HOUR	SIXTH HOUR	AVERAGE
1. GAS GENERATOR	SPEED (RPM)	8700						8700
	COMPRESSOR INLET TEMPERATURE (DEG F)	66.0						66.0
	COMPRESSOR INLET TOTAL PRESSURE (PSIA)	14.3						14.3
	COMPRESSOR DISCHARGE PRESSURE (PSIG)	194.6						194.6
	VIBRATION LEVEL MEASURED BY GAS GENERATOR PICKUP (MILS)	0.5						0.5
	VIBRATION LEVEL MEASURED BY POWER TURBINE PICKUP (MILS)	1.0						1.0
	BLEED AIR FLOW ON-OFF OR CFM (IF AVAILABLE)	OFF						OFF
2. POWER TURBINE	SPEED (RPM)	3500						3500
	TORQUE (LB-FT)	30625						30625
	POWER (HP)	20325						20325
	TURBINE INLET TEMPERATURE (DEG F)	1397.5						1397.5
	TURBINE INLET PRESSURE (PSIA)	50.3						50.3
	VIBRATION LEVEL MEASURED BY POWER TURBINE PICKUP (MILS)	0.6						0.6
	VIBRATION LEVEL MEASURED BY GAS GENERATOR PICKUP (MILS)	0.5						0.5
	EXHAUST GAS TEMPERATURE* (DEG F)	878						878
	EXHAUST GAS PRESSURE* (IN H_2O) (PSIG)	—						—
3. GT FUEL OIL	MANIFOLD PRESSURE (PSIG)	650.3						650.3
	INLET TEMPERATURE (DEG F)	93.9						93.9
4. LUBE OIL	GT SUPPLY PRESSURE (PSIG)	53.1						53.1
	COOLER OUTLET TEMPERATURE (DEG F)	176.5						176.5
	HOTTEST BEARING — LOCATION	B						B
	HOTTEST BEARING — TEMPERATURE (DEG F)	198.3						198.3
5. ENGINE COOLING OUTLET TEMPERATURE (DEG F)		191.5						191.5
6. FUEL CONSUMED* (GALLONS)		2247						2247
7. INTERVAL READINGS WERE TAKEN DURING HOUR		EVERY 15 MIN						EVERY 15 MIN

* ENTER DATA IF PARAMETER IS MONITORED BY INSTALLED INSTRUMENTATION
ENTER NA IF NOT

* NOTE: FUEL CONSUMED FOR BLOCK 6 IS TOTAL FOR BOTH GTE'S USE CONSUMED

VIEW B

Figure 1-8.—Engineering trial report data, sheet 2 of 2.

DEPARTMENT OF THE NAVY

IN REPLY REFER TO:
9094
CO
05 MAR 1993

From: Commanding Officer, USS Turbine (FFG - 99)
To: Chief Observer, GSCM (SW) J. Frost, USN, 111-11-111
Subj: CONDUCT OF FULL POWER TRIAL

Ref: (a) OPNAVINST 9094.1A
(b) NAVSEA S9086-04-STM-00/CH-094 R1 Trials
(c) FXP-4

1. Per references (a) and (b) through (c), a Full Power Trial MOB-E-001-SF will be conducted on 5 March 93.

2. The following amplifying data is submitted:

a. Date of last undocking: 1 October 92.

b. Date of last underway hull cleaning: 4 September 92.

c. List of safety devices and set dates:

(1) Emergency Shutdown of STM'S from PCC:

GTM	TIME	DATE
1A	1 second	11 FEB 93
1B	1 second	11 FEB 93

(2) Power Turbine Overspeed Trips:

GTM	DESIGN	ACTUAL	DATE
1A	3960 ± 40	3954	16 FEB 93
1B	3960 ± 40	3938	16 FEB 93

(3) GTM Speed Limiting:

GTM	DESIGN	ACTUAL	DATE
1A	3762 ±90	3704	16 FEB 93
1B	3762 ±90	3720	16 FEB 93

(4) GTM Lube Oil Pressure Low Alarm:

GTM	DESIGN	ACTUAL	DATE
1A	15 ± 1 PSIG	15 PSIG	02 FEB 93
1B	15 ± 1 PSIG	15 PSIG	02 FEB 93

VIEW A

Subj: CONDUCT OF FULL POWER TRIAL

(5) MRG Lube Oil Pressure Low Alarm:

DESIGN	ACTUAL	DATE
9 ± 1 PSIG	9 PSIG	24 FEB 93

(6) SSDG Overspeed Trip:

SSDG	DESIGN	ACTUAL	DATE
1	2070 ± 30 RPM	2060	09 SEP 92
2	2070 ± 30 RPM	2060	09 SEP 92
3	2070 ± 30 RPM	2075	09 SEP 92
4	2070 ± 30 RPM	2075	09 SEP 92

(7) SSDG Oil Pressure Alarm:

SSDG	DESIGN	ACTUAL	DATE
1	48 ± 1 PSIG	48 PSIG	18 JAN 93
2	48 ± 1 PSIG	48 PSIG	18 JAN 93
3	48 ± 1 PSIG	48 PSIG	21 JAN 93
4	48 ± 1 PSIG	48 PSIG	21 JAN 93

(8) SSDG Lube Oil Pressure Low Shutdown:

SSDG	DESIGN	ACTUAL	DATE
1	42 ± 1 PSIG	42 PSIG	18 JAN 93
2	42 ± 1 PSIG	43 PSIG	18 JAN 93
3	42 ± 1 PSIG	42 PSIG	21 JAN 93
4	42 ± 1 PSIG	43 PSIG	21 JAN 93

(9) Remote Shutdown Valves:

VALVE	SERVICE	DATE
PFS 10A	Fuel Supply Cutout 1A GTM	15 JAN 93
PFS 10B	Fuel Supply Cutout 1A GTM	15 JAN 93
PFS 1A	Fuel Service Tank 5-204-1F	15 JAN 93
PFS 1B	Fuel Service Tank 5-204-2F	15 JAN 93

d. All machinery safety devices were tested satisfactorily as per current PMS requirements cycle.

e. Following unsafe or unsatisfactory conditions exist in the propulsion and auxiliary plant: NONE

f. Following equipment is listed as OOC: 1 A/C.

W. T. DOOR

VIEW B

Figure 1-9.—Propulsion plant condition report

The Navy's policy is, all activities having custody of marine gas turbine equipment, that is, single-shaft engine assemblies or modular engine assemblies (major sections of the engine that are replaceable), associated components, accessories, and ancillary equipment, must maintain service records in a proper and up-to-date status.

REVIEW MGTE LOG BOOKS (MGTEL)

A periodic review of the MGTEL should be done and as a GS supervisor you may be tasked with this job. In the *Gas Turbine Systems Technician (Mechanical) 2* and *Gas Turbine Systems Technician (Electrical) 2* training manuals you were told the MGTEL is a hardcover book that houses all the marine gas turbine equipment service records (MGTESRs). You were also given a basic description of each record sheet and the type of information found on each sheet that makes up the various sections of the MGTEL.

In addition to the information provided in the rate training manuals and *NSTM,* chapter 234, you can use this sample checklist to follow when you conduct a review of your logbooks. The numbers listed at the end of each statement or question are reference paragraphs from *NSTM,* chapter 234.

1. Are receipts of engines signed for? 234-8.40
2. Are operating times logged monthly (minimum)? 234-8.44
3. Are operating times up to date? 234-8.44
4. Is there a special inspection page? 234-8.51
5. Is there a conditional inspection page? 234-8.51
6. Are required inspections entered (as per bulletins, casualties, pre-delivery, and such)? 234-8.50/51
7. Is there a gas turbine change (GTC) page? 234-8.55
8. Is there a GTC revision/amendment page? 234-8.60
9. Is there a gas turbine bulletin (GTB) page? 234-8.55
10. Is there a GTB revision/amendment page? 234-8.62
11. Are GTCs in numerical sequence? 234-8.62
12. Are GTBs in numerical sequence? 234-8.62
13. Do GTCs contain action categories? 234-8.57
14. Do GTCs contain status codes? 234-8.62
15. Do GTCs contain a brief description? 234-8.62
16. Do GTBs contain action categories? 234-8.57
17. Do GTBs contain status codes? 234-8.62
18. Do GTBs contain brief descriptions? 234-8.62
19. Is there a complete list of technical directives issued? IAW latest zero index.
20. Does the revisions issued column reflect the revisions/amendments issued? 234-8.60
21. Are NINC or NIS entries in pencil? 234-8.62.3.b
22. Are INC entries in ink or typed? 234-8.30
23. Does the selected component record (SCR) card/supplemental record indicate INC or NINC for directives issued? 234-8.61
24. Does the SCR page reflect current inventory? 234-8.66
25. Is the removal/replacement data correct on the SCR cards? 234-8.66
26. Is the total equipment count consistent with operating log entries? 234-8.67
27. Are "hours" or "start" entries followed by "H" or "S"? Fig. 234-8.28K
28. Is there a JCN on the SCR card for replaced components? 234-8.75
29. Is pertinent information for which no other place has been provided recorded on the miscellaneous history page? 234-8.64

UPDATE MGTE SERVICE AND OPERATING RECORDS

Updating MGTE service and operating records is normally performed by the log custodian. The log custodian is usually the main propulsion assistant (MPA). Even though the MPA is the log custodian, you may still be tasked to make updates to the logs. In any case, if you follow the guide provided in the next section you will know what entries are required and the proper way to make the update.

WHB OPERATING AND TREATMENT RECORDS

Even though the WHBs installed on your ship are considered auxiliary equipment, they play a very important role in the ship's ability to remain self-sufficient. That's why close scrutiny of their operating and treatment records is so important. The importance of maintaining accurate WHB operating records, boiler water and feedwater chemistry logs and records must not be underestimated. The engineer officer and assistants use the data in these records to measure the performance, stability, efficiency, and state of material readiness of the engineering plant. Remember, the decision-making process involved in effective WHB operations and the water chemistry program aboard your ship is supported by the information contained in these records. To be an effective engineer and supervisor, you should be familiar with the purpose, content, and general procedures to properly review and train your personnel to maintain each of these records.

UPDATE WHB OPERATING RECORDS

WHB operating records information is derived and compiled from several different logs and inspection reports. Basic boiler information is recorded in the engineering log as events occur. These events normally include start-ups, shutdowns, and blowdowns. However, the primary log where the majority of information is compiled is the WHB Boiler Water Chemistry Worksheet/Log. This log is updated as events occur and is closed out on a daily basis. Basically, all maintenance performed on the boiler and its operating systems, chemical treatments, and operating hours are entered in either the Remarks section or the Boiler Data section on the backside of the WHB Boiler Water Chemistry Worksheet/Log.

The last source of boiler status information that we will discuss is the Boiler Inspection and Repair Management Information System (BIRMIS) report. This system's purpose is to enhance the value of auxiliary boiler inspections. The BIRMIS report contains useful information concerning the health of your WHB. This report is filled out by the boiler inspector at the completion of any standard or emergent boiler inspection. As a supervisor you must understand the information provided in this report so you can effectively plan (schedule) and correct the listed discrepancies. In figure 1-10 of this next section, there is a sample of a BIRMIS report. This sample report should help you identify and understand the information provided.

As you can see, the BIRMIS report is broken down into three distinct sections. This sample report is representative of the inspection of the No. 3 WHB. The first section is the cover sheet and some standard information that you provide to the inspector. The second section is for inspector comments. In this sample, the inspector chose to provide a list of references that would be used as guidelines to perform the inspection. The third section contains (from left to right) the item (component) inspected, the number of discrepancies noted (entry condition), the recommended repair, and the deficiency status code. For clarification and standardization, the BIRMIS system uses set codes to identify each boiler component and subcomponents being inspected. As in the sample form, the **C** represents the boiler tubes (primary), and the **Cl** and **Cll** represent specific sections of the tubes. And finally, the entry condition is the sequential listing of each discrepancy found for that component.

UPDATE WHB WATER TREATMENT RECORDS

As a GS supervisor you must become more familiar with updating and reviewing WHB water treatment records. Depending on your assignment within the engineering department and if your ship has boilers, you will be tasked either daily or intermittently with updating and reviewing these records. In the remainder of this section you will find two basic check sheets (figs. 1-11 and 1-12) that you can use to properly review the WHB water treatment records. These check sheets are not mandatory, but the information is very helpful. This information was taken directly from an *NSTM* and the numbers listed at the end of each question should be a help to you.

SUMMARY

In this chapter we have discussed various programs, reports, and records needed by GS supervisors. The titles of the different sections of this chapter may sound like many of those presented in some engineering administration publications. Even though the topics are in other publications, the information in this chapter is specific togas turbine-powered ships. Throughout this chapter you have been referred to the EOSS, applicable technical manuals, or the PMS for specific information. You must use these references to guide you through the procedures. Use of the EOSS, technical manuals, and the PMS will help you make the proper decisions to best handle the duties of a GS supervisor.

STANDARD FORMAT, ALL RESULTS BOILER INSPECTION AND REPAIR RUN DATE 12 MAR 93
STARTING ITEM: C ENDING ITEM: W9 MANAGEMENT INFORMATION SYSTEM PAGE 1

BOILER INSPECTION REPORT

HULL	SHIP	BOILER	DATE	TYPE	MFG	INSPECTOR(S)	INSPECTOR UIC
DD-999	USS G. TURBINE	AUX3	24-NOV-92	ROUTINE	C2	DOE, JOHN BTC	00001
						FROST, JACK BTC	00002

OVERHAUL ACTIVITY: SSSD

STEAMING HOURS	DATE INFORMATION	
TOTAL HOURS ON BOILER: 13667.7	DATE OF LAST AVAILABILITY:	FEB 91
HOURS SINCE LAST OVERHAUL: 2420.4	DATE OF LAST OVERHAUL:	FEB 91
HOURS SINCE FIRESIDE/GASSIDE CLEANING: 0	DATE OF LAST TUBE NDE (BUIU, UT, ETC.):	UNK
HOURS SINCE WATERSIDE CLEANING CHEMICAL CLEANING (ACID): 0 MECHANICAL CLEANING:	DATE OF LAST 150% HYDROSTATIC STRENGTH TEST:	01OCT92
HOURS OF DRY FIRING: 38.5	DATE OF LAST 5-YR VISUAL INSPECTION:	UNK
	DATE OF LAST SOOT BLOWER NDE:	UNK
	DATE OF LAST BOTTOM/SURFACE: BLOW PIPING NDE:	UNK

DEFICIENCY STATUS CODES

NC - NOT COMPLETE

C - COMPLETE

D - DEFERRED

W - WAIVERED

PI - PREVIOUSLY INSPECTED (NOT COMPLETED)

NA - NOT APPLICABLE

Figure 1-10.—Sample BIRMIS report.

STANDARD FORMAT, ALL RESULTS BOILER INSPECTION AND REPAIR RUN DATE 12 MAR 93

STARTING ITEM: C ENDING ITEM: W9 MANAGEMENT INFORMATION SYSTEM PAGE 2

BOILER INSPECTION REPORT

HULL	SHIP	BOILER	DATE	TYPE	MFG	INSPECTOR(S)	INSPECTOR UIC
DD-999	USS G. TURBINE	AUX3	24-NOV-92	ROUTINE	C2	DOE, JOHN BTC	00001
						FROST, JACK BTC	00002

INSPECTOR'S COMMENTS

REFERENCES:

A. Boiler Inspection Manual, S9221-D2-MMA-010, formerly NAVSEA 0951-LP-021-6010

B. Boiler Overhaul and Repair Manual, 9221-C1-GTP-010/020, formerly NAVSEA 0951-LP-031-8010

C. "Boiler Water/Feedwater Test and Treatment," *NSTM* S9086-GX-STM-020, chapter 220

D. "Boilers," *NSTM*, S9086-GY-STM-010, chapter 221

E. Boiler Technician Manual, NAVSEA 0951-LP-031-0010

Figure 1-10.—Sample BIRMIS report—Continued.

BOILER INSPECTION AND REPAIR
MANAGEMENT INFORMATION SYSTEM
BOILER INSPECTION REPORT

RUN DATE 12 MAR 93
PAGE 3

HULL	SHIP	BOILER	DATE	TYPE	MFG	INSPECTOR(S)	INSPECTOR UIC
DD-999	USS G. TURBINE	AUX3	24-NOV-92	ROUTINE	CS	DOE, JOHN BTC	00001
						FROST, JACK BTC	00002

LINE ITEM DESCRIPTION	ENTRY CONDITION	REPAIR	STATUS
C TUBES	01	COMMENT: WATERSIDES NOT OPEN FOR INSPECTION, NOTED FOR INSPECTION.	NA
C1 TUBES	01	COMMENT: NO. 1 COIL HAS WELD REPAIR AT START OF FINNED SURFACES FROM THE OUTLET HEADER. NOTED FOR INSPECTION.	NA
C11 WATERSIDES	01	COMMENT: ACID CLEANED DURING OVERHAUL. NOTED FOR INSPECTION.	NA

Figure 1-10.—Sample BIRMIS report—Continued.

BOILER WATER CHEMISTRY WORKSHEET/LOG

1. Is a boiler water log maintained on a daily basis when the WHB is operating? 220-30.72

2. Are the boiler water chemistry worksheet/logs properly maintained? 220-30.72
   a. Are freshly filled and treated boilers properly handled? 220-30.36
   b. Are the required sampling frequencies being accomplished on a steaming WHB? 220-30.39
      (1) Within 30 minutes after online?
      (2) As often as required to maintain limits, but at least every 8 steaming hours?
      (3) Within 1 hour before commencing a blowdown?
      (4) 30-60 minutes after a blowdown?
      (5) 30-60 minutes after batch chemical treatment?
      (6) Within 90 minutes prior to securing?
   c. Are the WHBs under proper and authorized lay-ups and checked hourly when on a steam blanket? 220-30.56
      (1) Steam blanket lay-up (up to 30 days)
      (2) Dry lay-up (indefinite)
   d. Do the WHBs receive required blowdowns? 220-30.53
      (1) Every 24 hours when the sample contains sediment (bottom blow)
      (2) Every 168 steam hours (bottom blow)
      (3) Boiler will be secured over 2 hours (bottom blow)
      (4) Is the percentage of blowdown properly computed? 220-30.54
   e. Are the quarterly standards tests recorded on the monthly boiler data log every month? 220-27.9
   f. Are the results of the test of chemicals against standards recorded on the No. 1 WHB chemistry/log? 220-30.85
   g. Are all actions concerning the WHB indicated on the boiler water chemistry worksheet/log? 220-30.78
   h. Are all out-of-limit test results circled by the fuel and oil king? 220-27.3.1
   i. Are all out-of-limit test results that are circled by the fuel and oil king initialed by the engineer officer? 220-27.3.5

3. Does the engineering officer of the watch (EOOW) comply with all program requirements? 220-27.3.3

4. Does the LCPO review and initial the boiler water chemistry worksheet/log daily? 220-27.3

5. Does the MPA review and initial the boiler/water chemistry worksheet/log daily? 220-27.3.4

6. Does the engineer officer review and sign the boiler water chemistry worksheet/log? 220-27.3.5

Figure 1-11.—Boiler water chemistry check sheets.

FEEDWATER CHEMISTRY WORKSHEET/LOG

1. Is the feedwater log maintained on a daily basis when the system is in operation? 220-27.11

a. Are chemical tests and salinity cell comparison tests conducted daily when the system is in operation? 220-30.18

(1) If the chemical test result is lower than the salinity cell reading by more than 0.02 epm, is the water checked for hardness? 220-26.18

(2) If the hardness is equal to or less than 0.02 epm, is the water being used and is the salinity indicator checked for a malfunction? 220-30.18

(3) Are the necessary remarks annotated in the Remarks section when an unsatisfactory comparison is recorded? 220-27.16

(4) If a salinity indicator is malfunctioning, is the water monitored every 4 hours by a sample and chemical test until the salinity indicator is repaired? 220-30.19

b. Are the required tests (hardness, conductivity and silica) being conducted on shore source feedwater? 220-30.26

c. Are the feedwater tanks tested daily for chloride and hardness? Table 220-67

d. Are all actions concerning the feedwater system indicated on the feedwater chemistry worksheet/log? 220-27.11

e. Are all out-of-limit test results circled by the fuel and oil king? 220-27.3.1

f. Are all out-of-limit test results that are circled by the fuel and oil king initialed by the EOOW? 220-27.3.3

2. Does the LCPO review and initial the feedwater chemistry worksheet/log daily? 220-27.18

3. Does the MPA review and initial the feedwater chemistry worksheet/log daily? 220-27.18

4. Does the engineer officer review and sign the feedwater chemistry worksheet/log daily? 220-27.17

5. If a deaerated feed tank is installed, does the feedwater chemistry worksheet/log indicate a daily test for oxygen? Table 220-67

Figure 1-12.—Feedwater chemistry check sheets.

HANDOUT #1

HAZARDOUS MATERIAL SPILL RESPONSE PROCEDURES

Introduction: Because of the extremely hazardous nature of many materials used aboard ships, only trained personnel are to respond to a hazardous material (HM) spill. Personnel must be trained by division officers or supervisory personnel to clean up small spills of HM. Only appropriate material safety data sheets (MSDSs) and the hazardous material user's guide (HMUG), OPNAV P-45-110-91 June 91, are to be used to conduct training.

For descriptive purposes, the spill response procedures have been divided into nine phases:

1. Discovery and notification
2. Initiation of action
3. Evaluation
4. Containment and damage control
5. Dispersion of gases and vapors
6. Cleanup and decontamination
7. Disposal of contaminated materials
8. Certification for safe re-entry
9. Follow-up reports

Each response phase is **NOT** a separate response action entirely independent of all other phases. Several phases may occur simultaneously and may involve common elements in their operation. For example, containment and damage control may also involve cleanup and disposal techniques.

RESPONSE PHASES

1. Spill Discovery and Notification

a. Spills or potential spills of hazardous substances may be discovered by regularly scheduled inspections of storerooms and workshops, by detection devices such as fire alarms and oxygen deficiency detectors, or during routine operations. All discoveries of spills or situations that may lead to a spill must be reported **immediately** to supervisory personnel and the OOD/CDO. Crew members are **NOT** to remain in the area to investigate a spill. Whenever possible, however, the discoverer/initial response team should report:

- Time of spill discovery
- Location of spill
- Identification of spilled material
- Behavior of material (reactions observed)
- Source of spill (for example, tank or container)
- Personnel in vicinity of spill (list by name and department)
- Volume of spill
- Anticipated movement of spill (for example, leakage to lower deck passage from midships toward galley)
- Labeling or placarding information (copy data from spilled container only after exposure to spill is eliminated)

b. The commanding officer shall report all overboard spills of hazardous substances as required by OPNAVINST 5090.1A, "Navy Environmental and Natural Resources Program Manual."

Figure 1-13.—Handout #l for sample lesson plan.

2. Initiation of Action

Coordination and direction of spill response efforts at the scene of an HM spill are done by the ship's OOD, CDO, fire marshal, damage control party leader, or senior person at the scene. The coordinator of the response efforts will initiate the following actions:

a. Evacuate all personnel from areas that may be exposed to the spilled material. Especially evacuate those areas affected by vapors.

b. Block off the affected area.

c. Arrange first-aid for injured personnel.

CAUTION

Do NOT enter the contaminated area until the necessary protective clothing and equipment have been determined.

d. Establish a command post and communications network.

e. Prevent spills from entering other compartments by any means that does not involve personnel exposure to the spill, such as closing drains, ventilation ducts, doors, and hatches.

f. Disperse gases or vapors to the weather deck through the use of blow-out (forced exhaust) ventilation or by natural ventilation such as opening doors or hatches. If the atmosphere is suspected to be flammable or explosive, use only explosion-proof fans for blow-out ventilation.

g. Eliminate any fire or explosion hazards such as electrical equipment, incompatible materials, or open flames.

3. Evaluation

Proper evaluation of a spill can prevent fires, explosions, personal injury, or permit steps to lessen their impact. This evaluation consists of the following three steps:

a. Obtain as much information as possible from container labels and MSDS before commencing further response actions. Look for the type and concentration of the spilled material. Also look for hazardous characteristics of the spilled material. Notice and report the following information:

- Flash point
- Toxicity
- Corrosivveness
- Potentially incompatible substances
- Effects resulting from exposure (fainting, dizziness, skin or eye irritation, nausea)
- First-aid measures for exposure

b. Determine dangerous conditions or potential consequences of the spill, including:

- Fire or explosion
- Presence of oxygen-deficient atmosphere in the compartment
- Presence of toxic or explosive gases
- Possibility of dangerous vapors being drawn into the ship's ventilation system

Figure 1-13.—Handout #l for sample lesson plan—Continued.

- Other HM in the compartment that would play a role in a fire or explosion or is incompatible with the spilled material

c. Determine from the MSDS the appropriate spill response equipment and protective clothing necessary for safe and effective response

4. Containment and Damage Control

Actions taken during this phase are directed toward controlling the immediate spread of the spill and minimizing the impact to the ship and crew. Depending on the type of spill, some or all of the following procedures may be used:

a. Fight fire (if any), being careful to use fire-fighting methods compatible with the material involved.

b. Shut off or otherwise stop the spill at its source, whenever feasible, by:

(1) Replacing leaking containers

(2) Plugging leaks in tanks

(3) Emptying the tank of the remaining contents

(4) Encapsulating a leaking container into a larger, liquidtight container

c. Predict spill movement and take further action to prevent the spill from possibly entering other compartments by closing scuppers, drains, ventilation ducts, doors, or hatches.

d. Contain liquid material using barriers, such as sand, upholstery, sorbents, or other equipment suitable to dam the flow.

5. Dispersion of Gases and Vapors

If a flammable gas or vapor is released as a result of the spill, the gas/vapor must be dispersed or diluted as soon as possible. The gas/vapor must not be allowed to enter other compartments. In some cases, the explosive atmosphere can be contained and diluted to lower its concentration below the lower explosive limit (LEL). Have the gas free engineer check the spill area for LEL and toxicity. The atmosphere can then be dispersed by one of the following methods:

—Normal exhaust ventilation (explosion-proof only)

—Blow-out ventilation (powerful exhaust ventilation provided in some HM storerooms explosion-proof only)

—Doors and hatches open to the weather decks

—Portable fans (explosion-proof only)

6. Cleanup and Decontamination

During this response phase, personnel, as directed by the person in charge, will employ the spill cleanup methods recommended on the MSDS. All surfaces are to be thoroughly cleaned of the spilled material. After the spill cleanup, thoroughly ventilate the compartment. Thoroughly decontaminate reusable protective clothing and otherwise maintain it before returning it to its proper storage location.

7. Disposal of Contaminated Materials

All non-reusable cleanup materials are to be placed in impermeable containers, stored, and disposed of as hazardous waste according to Appendix B3-C of OPNAVINST 5100.19B. These materials include unrecoverable protective clothing, sorbents, rags, brooms, and containers.

8. Certification for Safe Re-Entry

The spaces affected by the spill must be certified safe by the OOD/CDO before normal shipboard operations are resumed in that space. The OOD/CDO must ascertain the following before allowing re-entry:

a. All surfaces, such as decks, counters, bulkheads, and overheads have been thoroughly cleaned of the spilled material.

Figure 1-13.—Handout #1 for sample lesson plan—Continued.

b. All compartments have been adequately ventilated as determined from analysis by the gas free engineer.

c. All contaminated cleanup materials, including protective clothing, have been packaged, marked, and handled as hazardous material.

9. Follow-Up Reports

The OOD/CDO must submit to the HM coordinator a spill report for all onboard spills. A copy of this report must be filed by the safety officer and must contain the following information:

—Date the spill occurred

—Location of the spill

—Identity of spilled material

—Cause(s) of spill

—Damage or injuries resulting from the spill

—Response and cleanup measures taken

—Any problems encountered

—Method of disposing of contaminated material

—Action taken to prevent the repeat of a similar spill

Figure 1-13.—Handout #l for sample lesson plan—Conthmed.

CHAPTER 2

GAS TURBINE MAINTENANCE

This chapter will cover object damage, borescope inspection, troubleshooting, and maintenance of the LM2500 and the Allison 501-K series of GTEs. The majority of this chapter deals with the LM2500 GTE damage evaluation. The last part of this chapter is on proper preservation and corrosion control methods for maintaining all GTEs in peak operating status.

OBJECT DAMAGE

There are two basic types of object damage GS supervisors see. One of the most damaging gas turbine casualties, and one of the easiest to prevent, is foreign object damage (FOD). In this section we will discuss the hazards of FOD and some of the ways to prevent it. The other type of object damage that can cause failure of a GTE is domestic object damage (DOD).

HAZARDS

The effects of object damage and the hazards involved vary greatly with the size and location of the object ingested. Small dents and abrasions may cause little or no damage. However, if a large enough object is ingested by the engine, severe internal damage will result. Large, soft items (such as paper) can clog the FOD screen, causing a loss of power and elevated turbine inlet temperatures. The other type of damage that was mentioned is DOD. DOD occurs when an internal object from the engine breaks loose and causes impact damage to the engine.

PREVENTION

To prevent FOD to engines while working in and around intake and plenum areas, you and your personnel must observe the following safety precautions:

—When performing maintenance inside the intake areas, always-follow all written guidelines found in the EOP. Remember to remove all loose objects from your person. You must also account for all tools and equipment used in the intake. After completing your work, inspect the intake for cleanliness, and reinventory the tools and equipment before securing the accesses.

—Periodically inspect all intakes for cleanliness, the state of preservation, and the condition of the FOD screens. Correct any abnormal conditions. The frequency of inspection will depend on the operating conditions, PMS requirements, and engineering department instructions. Remember, the PMS only provides minimum standards. PMS can always be exceeded if you or your superiors deem it necessary.

—When inspecting the intakes, be sure that the areas around the blow-in doors are kept clear of loose gear and debris that could be ingested if the blow-in doors are activated.

To prevent DOD damage, you and your personnel need to follow a strict regiment of cleaning and inspections (internal and external). This attention to detail, as described in the next two paragraphs, is absolutely necessary to avoid DOD damage.

—Make sure the engine is properly cleaned inside and out. Always following the standards in the PMS and the manufacturer's technical manual. Cleanliness is an important factor in the fight against corrosion. Corrosion control (discussed later in this chapter) also can reduce the chances of component failures that can lead to DOD.

—Perform frequent external and internal GTE inspections to reduce the possibilities of DOD occurrences. GTE external inspections are very important. Locating loose, missing, or broken external components (VSV retaining nuts) during these inspections is a significant factor in preventing damage.

—Using borescope inspections aids in determining the extent and prevention of DOD. The most frequent damage is identified as potential component failures (blade stress cracks).

BORESCOPE INSPECTIONS

Borescope inspection requirements and procedures are found on the maintenance requirement card (MRC). These cards contain all the basic information necessary to conduct an inspection. Included on the MRCs are the serviceability limits and a list of conditions that require an inspection. Borescope inspections are usually performed semiannually or when the engine has been operated beyond the allowable limits listed on the MRC.

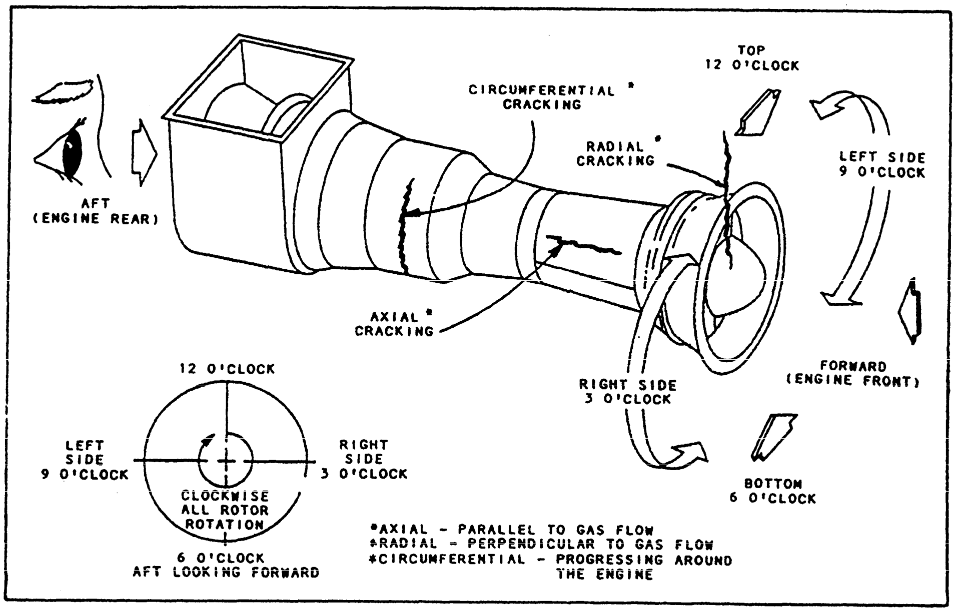


Figure 2-1.—Geometric orientation of the LM2500 GTE

The following section discusses the borescope procedures used to inspect the LM2500 GTE. The inspection procedures and the knowledge gained from damage evaluation may also be applied to the borescope inspection of the Allison 501-K17 GTE.

GENERAL INSPECTION PROCEDURES

It is a good engineering practice to review the machinery history of an engine before you conduct an inspection Various component improvement programs will eventuallyy effect all engines in service. A rebuilt or modified engine may contain improved parts that differ from the original. An example of this is the first-stage compressor midspan damper that may have its original coating, an improved coating, or a carboloy shoe welded on at the midspan damper interface. If you review the machinery history, you will discover the status of those parts that have been changed or modified.

Assuming that the engine history is normal and FOD is not suspected, you should be aware of the following factors when conducting a borescope inspection:

- Know your equipment.
- Locate all inspection areas and ports.

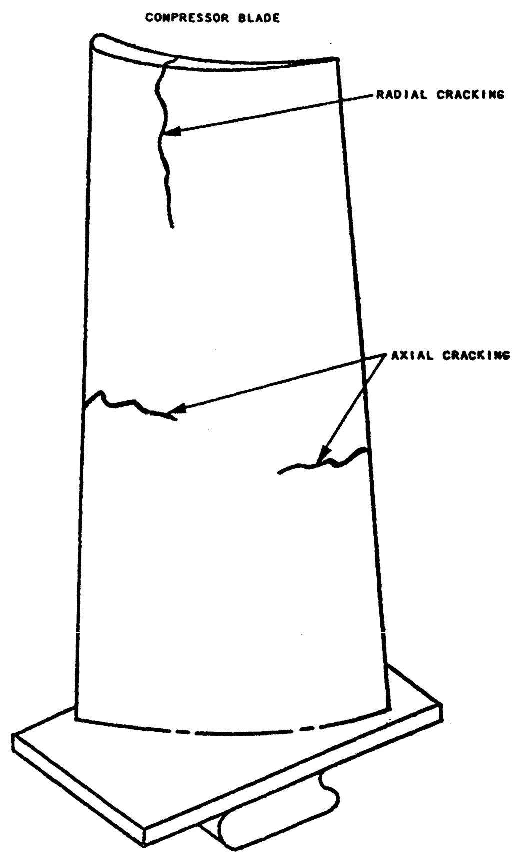


Figure 2-2.—Example of radial and axial cracking.

- Establish internal reference points.
- Scan the inspection area thoroughly and in an orderly manner.
- Note any inconsistencies.
- Evaluate the inconsistencies.
- Report your conclusions.

GEOMETRIC ORIENTATION OF THE ENGINE

To communicate information about an engine inspection, you must establish a geometric frame of reference for the engine assembly. A language for describing the physical damage is also necessary. An example of this information is provided in figure 2-1, geometric orientation of the LM2500 GTE. Figure 2-2 shows an example of radial and axial cracking on a compressor blade; figure 2-3 shows an example of circumferential and axial cracking in the combustion section. Table 2-1, a foldout at the end of this chapter, provides a list of condition codes and definitions of terms that you need to know when inspecting the LM2500 GTE.

When the probe is in the inspection hole, it is not unusual for you to lose your sense of direction. On the Wolf borescope, the large plastic disk just beneath the eyepiece has an index mark that shows the direction the probe object window is facing. You can feel and see this mark. Another reference you can use to detect the direction the object window is facing is

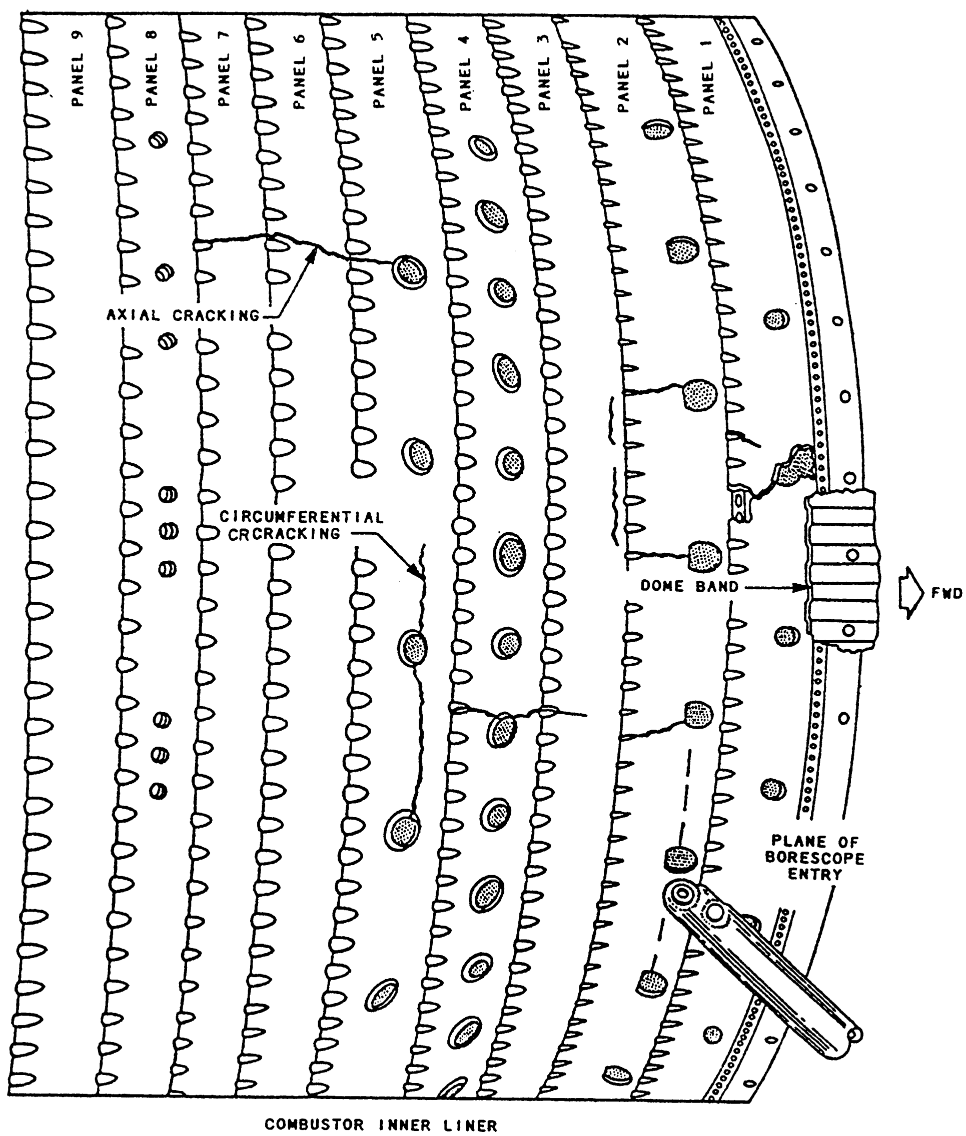


Figure 2-3.—Examp1es of circumferential and axial cracking.

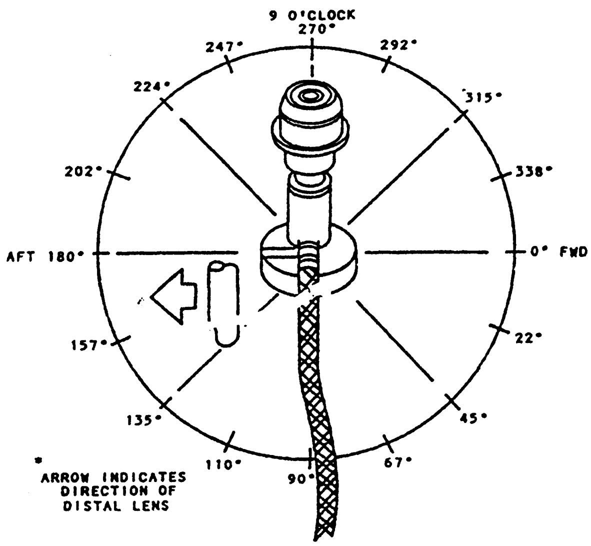


Figure 2-4.—Light cable azimuth for borescope probes.

the light cable attachment. On the Wolf and Eder probes, the viewing window is 90 degrees clockwise from the light cable, as shown in figure 2-4. In the future, borescoping equipment may have changes incorporated that significantly improve the inspection equipment. Newer models may incorporate a swiveling light cable that allows the cable to hang down regardless of the viewing direction. You must read the manufacturer's instruction manual before you can successfully use the equipment. Figure 2-5 is an example of how the engine and borescope geometry work together. It shows you how the borescope appears when looking forward and aft from the right side of the engine or from the left side of the engine.

BORESCOPE PORTS

Table 2-2 is a description of the ports and the areas that you can see from each borescope port. Figure 2-6 shows you the component materials and the temperatures at which the various components normally operate. The locations

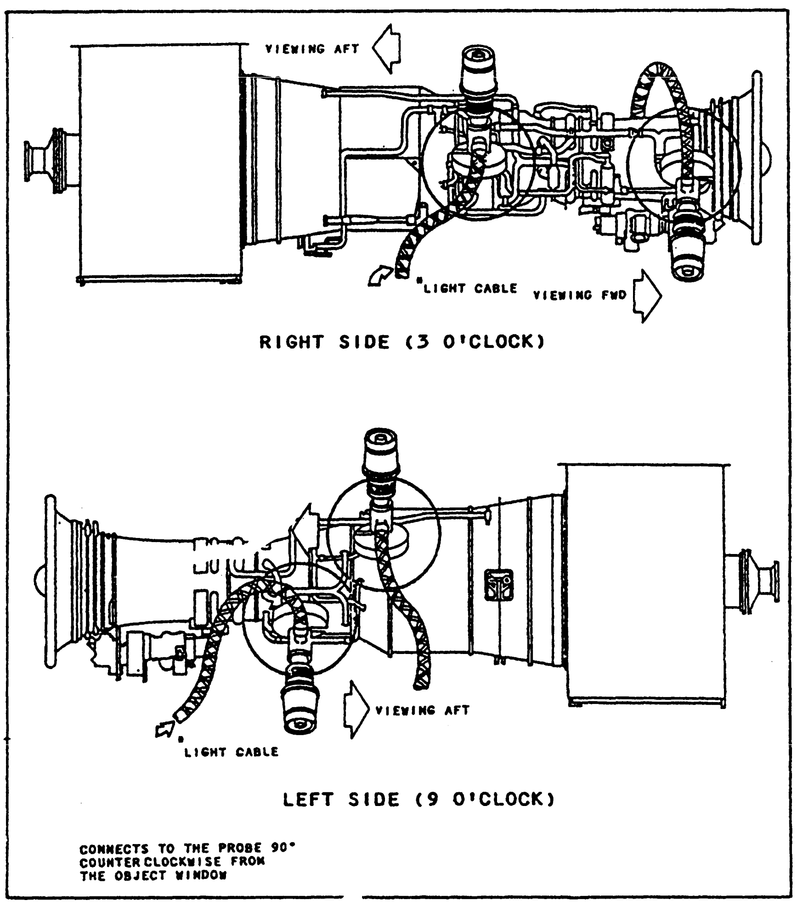


Figure 2-5.—Geometric orientation of the borescope.

Table 2-2.—Area Visible From Borescope Inspection Ports

PORT IDENTIFICATION	PART/AREA ACCESSIBLE FOR INSPECTION
29	Two Inlet Guide Vane Airfoils
28	Stages 1 and 2 Compressor Rotor Blades and two Stage 1 Stator Vane Airfoils
27	Stages 2 and 3 Compressor Rotor Blades and two Stage 2 Stator Vane Airfoils
26	Stages 3 and 4 Compressor Rotor Blades and two Stage 3 Stator Vane Airfoils
25	Stages 4 and 5 Compressor Rotor Blades and two Stage 4 Stator Vane Airfoils
24	Stages 5 and 6 Compressor Rotor Blades and two Stage 5 Stator Vane Airfoils
23	Stages 6 and 7 Compressor Rotor Blades and two Stage 6 Stator Vane Airfoils
22	Stages 7 and 8 Compressor Rotor Blades and two Stage 7 Stator Vane Airfoils
21	(Blocked)
20	Stages 9 and 10 Compressor Rotor Blades and two Stage 9 Stator Vane Airfoils
19	Stages 10 and 11 Compressor Rotor Blades and two Stage 10 Stator Vane Airfoils
18	Stages 11 and 12 Compressor Rotor Blades and two Stage 11 Stator Vane Airfoils
17	Stages 12 and 13 Compressor Rotor Blades and two Stage 12 Stator Vane Airfoils
16	Stages 13 and 14 Compressor Rotor Blades and two Stage 13 Stator Vane Airfoils
15	Stages 14 and 15 Compressor Rotor Blades and two Stage 14 Stator Vane Airfoils
14	Stages 15 and 16 Compressor Rotor Blades and two Stage 15 Stator Vane Airfoils
13	Combustor, Fuel Nozzles, and Stage 1 HP Turbine Nozzle
12	Stage 1 HP Turbine Rotor Blades and two Stage 1 HP Turbine Nozzle Airfoils
11	Stages 1 and 2 HP Turbine Rotor Blades and two Stage 2 HP Turbine Nozzle Airfoils
10	Stage 2 HP Turbine Rotor Blades, Stage 1 LP Turbine Blades and Vanes, Turbine Mid-Frame Liner, and $T_{5.4}$ Thermocouple Probes

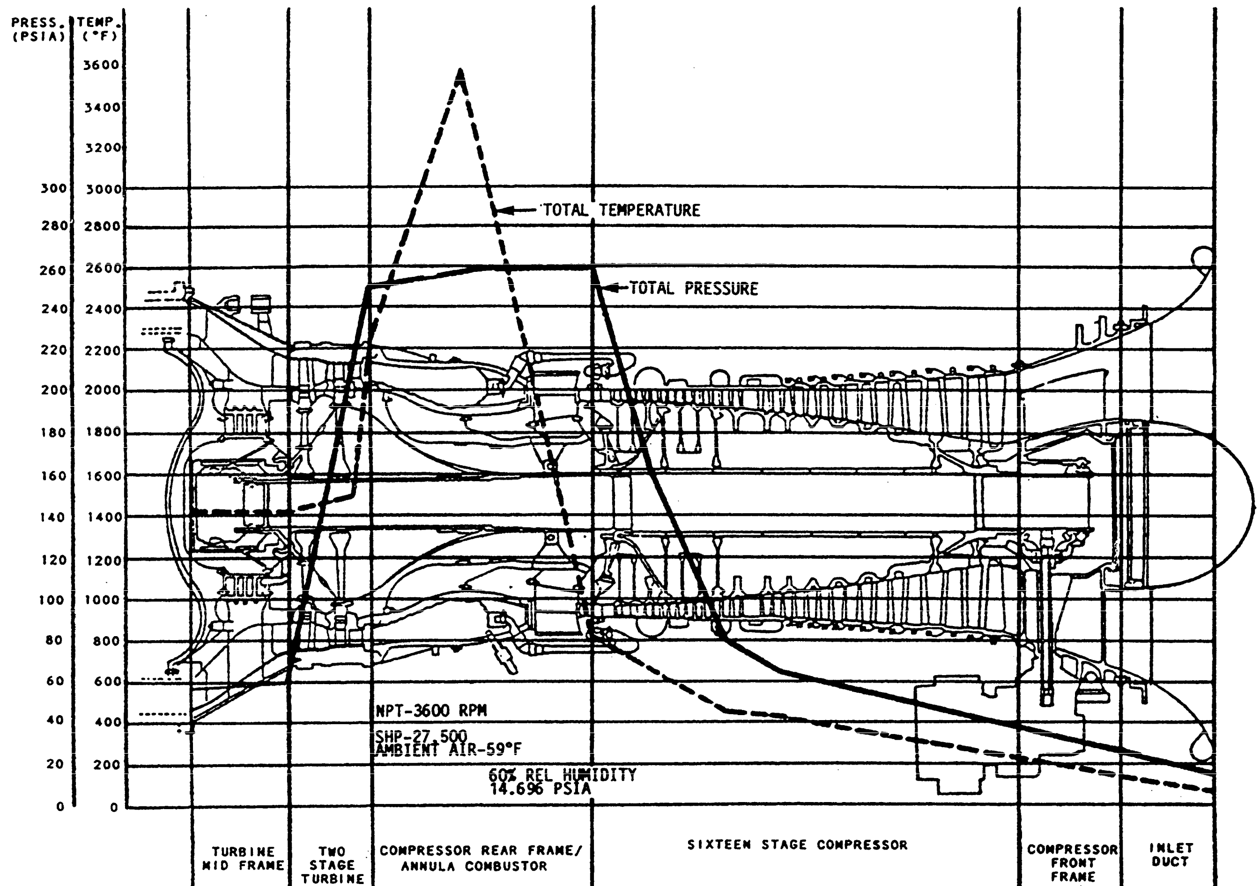
of the borescope inspection ports are shown in figure 2-7.

Compressor

Fifteen borescope inspection ports are in the compressor near the 3 o'clock split line. A port is located at every compressor stator stage. These vane ports start at the IGVs and work aft in the same direction as the airflow (except for stage 8, which is internally blocked). Stator stages 9 and 13 borescope ports require you to remove piping interferences.

Combustor and HP Turbine

Aft of the right-hand side compressor ports are six circumferentially positioned ports, just forward of the midflange of the compressor rear frame. From these ports you can inspect the combustor, the stage 1 HP turbine nozzle assembly, and a few fuel nozzles. Near the aft flange of the compressor rear frame on the right-hand side of the engine are two HP turbine stator ports that you can use for viewing the air-cooled turbine blades. The $P_{t5.4}$ pressure probe harness adjacent to the after flange of the turbine midframe is located aft of the



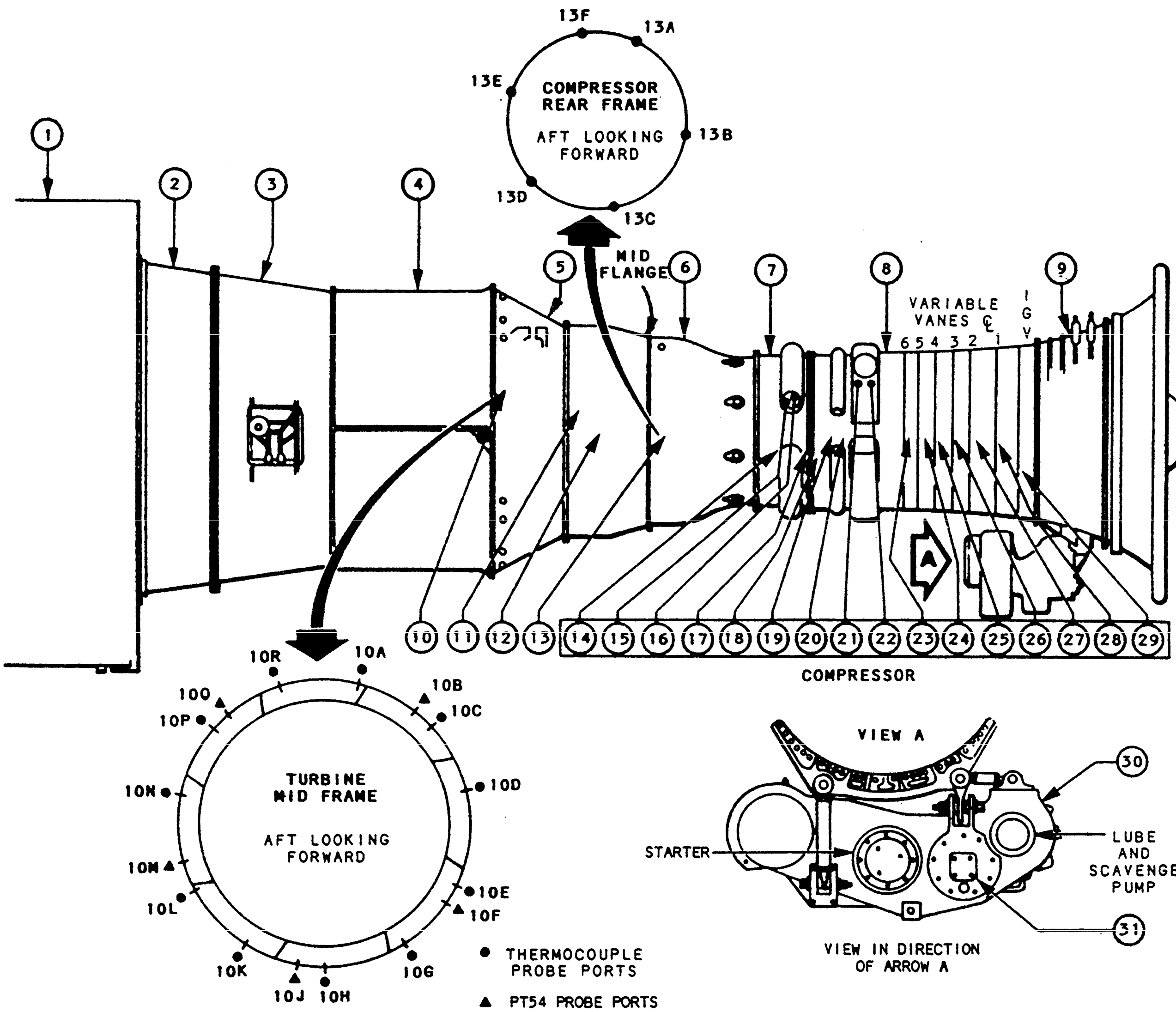
	TURBINE MID FRAME	TWO STAGE TURBINE	COMPRESSOR REAR FRAME/ ANNULA COMBUSTOR	SIXTEEN STAGE COMPRESSOR		COMPRESSOR FRONT FRAME	INLET DUCT
FRAMES	INCONEL 718					STEEL 17-4	ALUMINUM
CASINGS				INCONEL 718	TITANIUM		
ROTORS		INCONEL 718		INCONEL 718	TITANIUM		
BLADES		RENE 80		A286	TITANIUM		
COMBUSTOR			HASTELLOY X				

Figure 2-6.—Turbine materials and operating conditions.

stage land 2 turbine ports. Five pressure probes are located circumferentially around the turbine midframe at the inlet to the LP turbine. All five probes extend radially into the gas path and can be removed to inspect the LP turbine inlet and the HP turbine exhaust.

INDEXING AND ROTATING THE ENGINE

You can rotate the engine by using a socket wrench with an 18-inch long 3/4-inch drive extension. You attach the 3/4-inch drive extension after you remove the cover plate on the aft face, right-hand side of the accessory gearbox, next to the lube and scavenge pump (fig. 2-8). When you are inspecting through the forward-most borescope ports, there is not enough space for both you and the person turning the engine to work This requires you to do the turning yourself or to have the turner rotate the engine from the other location on the accessory gearbox. You can find the alternate drive pad for manual engine turning on the forward face, left-hand side of the accessory gearbox, also shown in figure 2-8.



1. Exhaust Duct
2. Outer Cone
3. Turbine Rear Frame
4. Turbine Case
5. Turbine Mid Frame
6. Compressor Rear Frame
7. Rear Compressor Casing
8. Front Compressor Casing
9. Compressor Front Frame
10. Turbine Mid Frame Ports
11. Compressor Rear Frame Port
12. Compressor Rear Frame Port
13. Compressor Rear Frame Port
14. Stage 15 port
15. Stage 14 port
16. Stage 13 port
17. Stage 12 port
18. Stage 11 port
19. Stage 10 port
20. Stage 9 port
21. Stage 8 port
22. Stage 7 port
23. Stage 6 port
24. Stage 5 port
25. Stage 4 port
26. Stage 3 port
27. Stage 2 port
28. Stage 1 port
29. Stage 0 port
30. Transfer Gearbox
31. Drive Pad Cover Plate

Figure 2-7.—Borescope inspection ports.

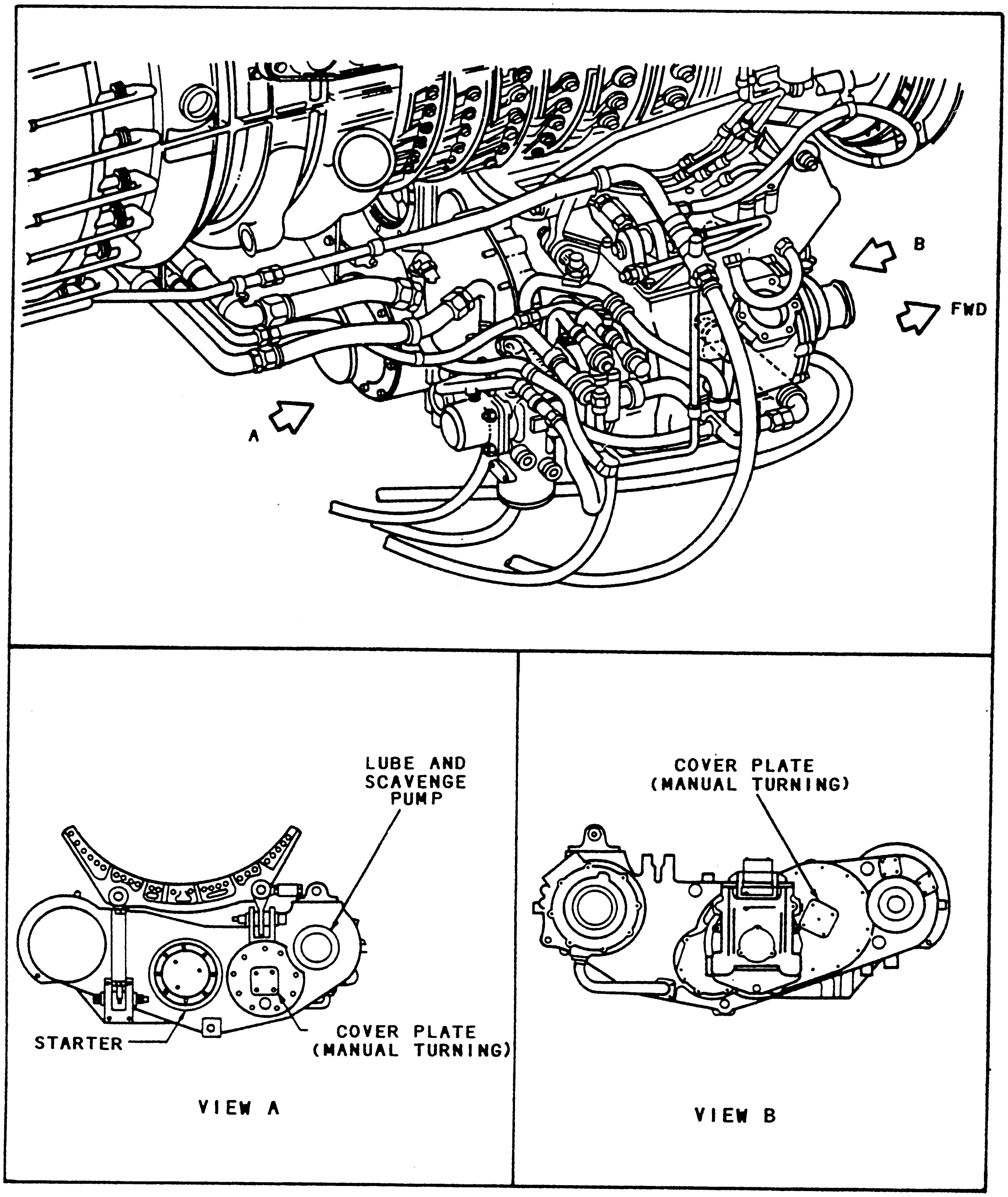


Figure 2-8.—Engine turning locations for borescope inspections.

Detailed procedures are provided for indexing and rotating the engine on the MRC. Figures 2-9 and 2-10 show the accessory drive gear ratios and the locking lugs used for indexing the compressor rotor. Zero reference for the compressor and HP turbine stages is established by use of the locking lug blades. Establishing the zero reference ensures a complete inspection for each stage. It also provides you an immediate circumferential reference point for distress reporting for each stage. You should not concentrate on counting the blades. Instead, concentrate on the specific condition of each airfoil as it passes. The forward and aft drive pads have different drive ratios to the main rotor shaft. You may find it advantageous to use a torque multiplier to slow down and maintain better control over the main rotor speed. Depending on the manual drive setup, you will be able

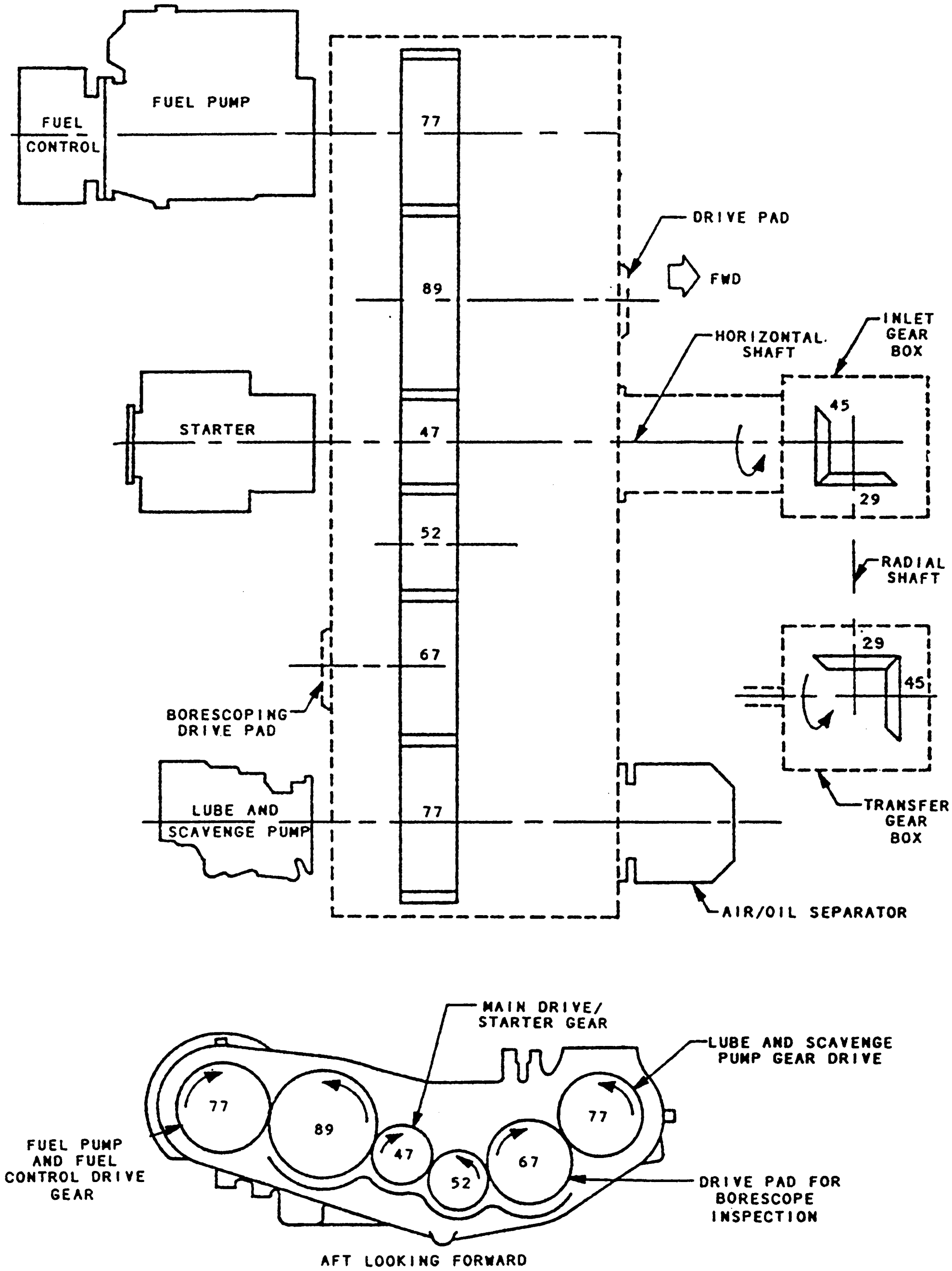


Figure 2-9.—Accessory drive gear ratios.

to establish how many full arcs of the ratchet wrench are required to move the main rotor one full revolution. For example, when you are using the forward pad, a 344-degree revolution of the input drive equals 360 degrees on the main rotor.

SERVICE LIMITS

This section discusses the types of damage that you might find when conducting a routine inspection. This material will be limited to a discussion of the major engine areas. The parts nomenclature that is used in this section is found in figure 2-11, a foldout at the end of this chapter.

Compressor Section

You should inspect the compressor section for nicks and dents, cracks, spacer rubs, casing rubs, blade tip rubs, bent edges, missing pieces, and trailing edge erosion. Inspect the first-stage compressor midspan damper for leading edge dents and other types of

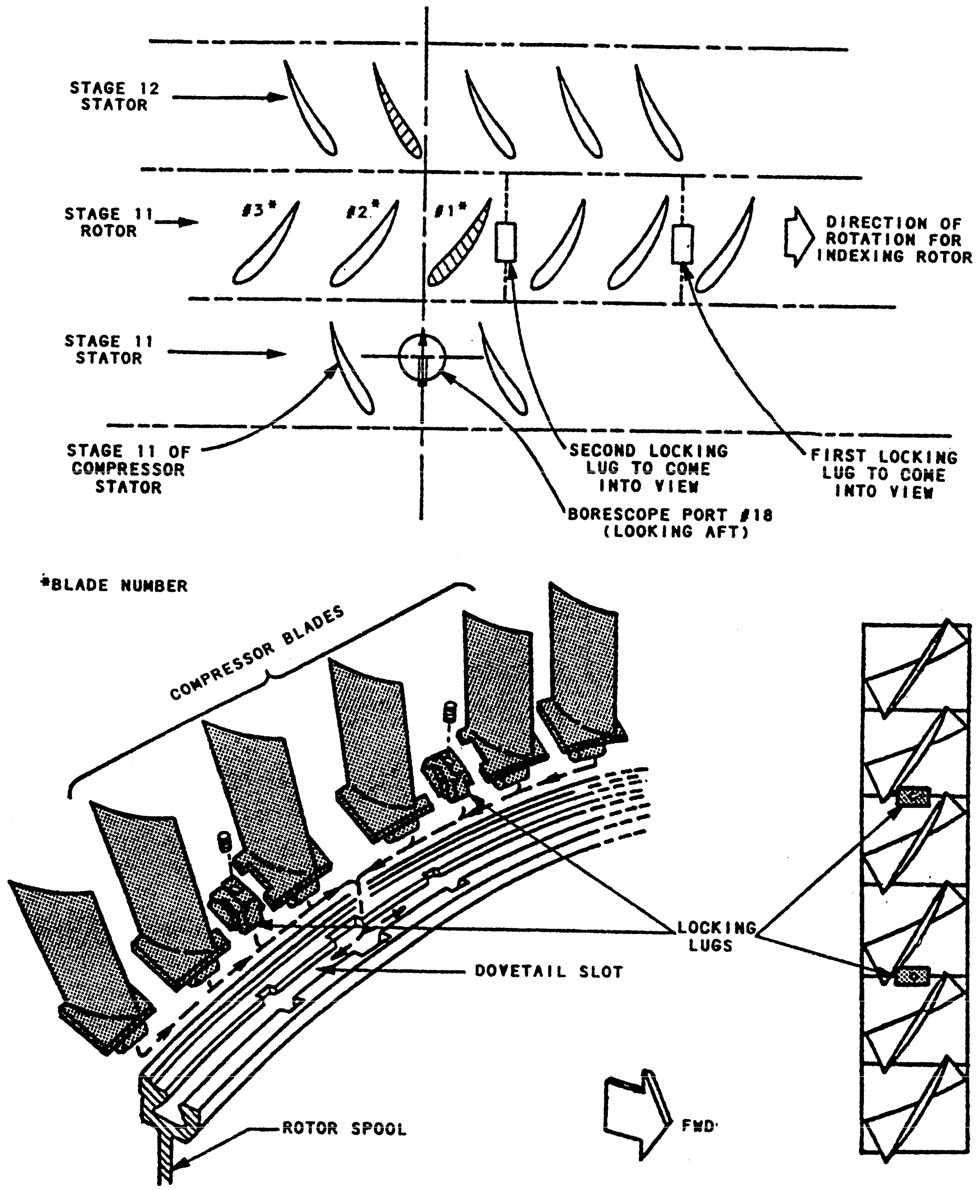


Figure 2-10.—Zero indexing the compressor rotor.

damage. Beginning with the third stage, if a slight tilting of the blade or raising of the blade platform is observed, suspect blade root failure. This condition requires suspended engine operation until the condition has been evaluated

COMPRESSOR DAMAGE.— In tie following paragraphs, redescribe some of the damage you may find during an engine inspection. You can find the condition codes used to describe engine damage in foldout table 2-1.

Airfoil and Tip Cracks.— Cracks in the compressor hardware are difficult to detect because they are tight and shallow in depth. You can miss these subtle defects because of deteriorated borescope optics or if you rotate the rotor too fast. You should record all crack information relative to the stage, area, magnitude, direction, and adjacent blade condition.

Cracked Dovetail.— A cracked dovetail of a blade may lead to blade loss. The location of the blade will determine the extent of engine damage. Before the actual catastrophic failure of the blade, the separated crack in the dovetail will be evident by a leaning blade platform. You can find this fault by using the borescope to inspect each blade platform. The leaning blade platform will be higher than the adjacent nonleaning blades. A "leaner" is a blade that has a crack on the aft side of the dovetail and is leaning in the forward direction (fig. 2-12). If a leaner is detected, it must be verified and the engine should be removed from service.

Airfoil and Tip Tears.—The most critical area of a torn blade is the area around the end of the tear and its location on the airfoil. You should inspect this area for cracks that lead from the tear and are susceptible to propagation. This condition could lead to the loss of the airfoil section that would create downstream impact damage. You should record all information such as stage, blade locations, area of the blade in which the defect was found, and the condition of the rest of the airfoil and adjacent airfoils. Section A of figure 2-11 shows the nomenclature of a blade.

Leading and Trailing Edge Damage.— Random impact damage can be caused throughout the compressor rotor stages by FOD and DOD. The leading and trailing edge of an airfoil is the area of the compressor blade extending from the edge into the airfoil. You must assess both sides or faces of the airfoil when determining the extent of a given defect. If you observe a defect, estimate the percentage of damaged chord length. Observe the defect and the condition of the airfoil area around the defect. If the observed damage is assessed to be "object damage," the most difficult determination is the differentiation between cracks, scratches, and marks made by the passing objects. Cracks are usually tight in the airfoils, but the apex of the damage usually allows viewing into the airfoil thickness. This provides a direct inspection of the area around the crack You may have to use all the probes at varying light levels to determine the extent of the damage.

Tip Curl.— Compressor rotor blade tip curl is a random and infrequent observation. tip curl is usually the result of blade rub on the compressor case. Tip curl also can be the result of objects being thrown to the outer circumferential area of the flow path and then being impacted by the rotating blade tip (either leading or

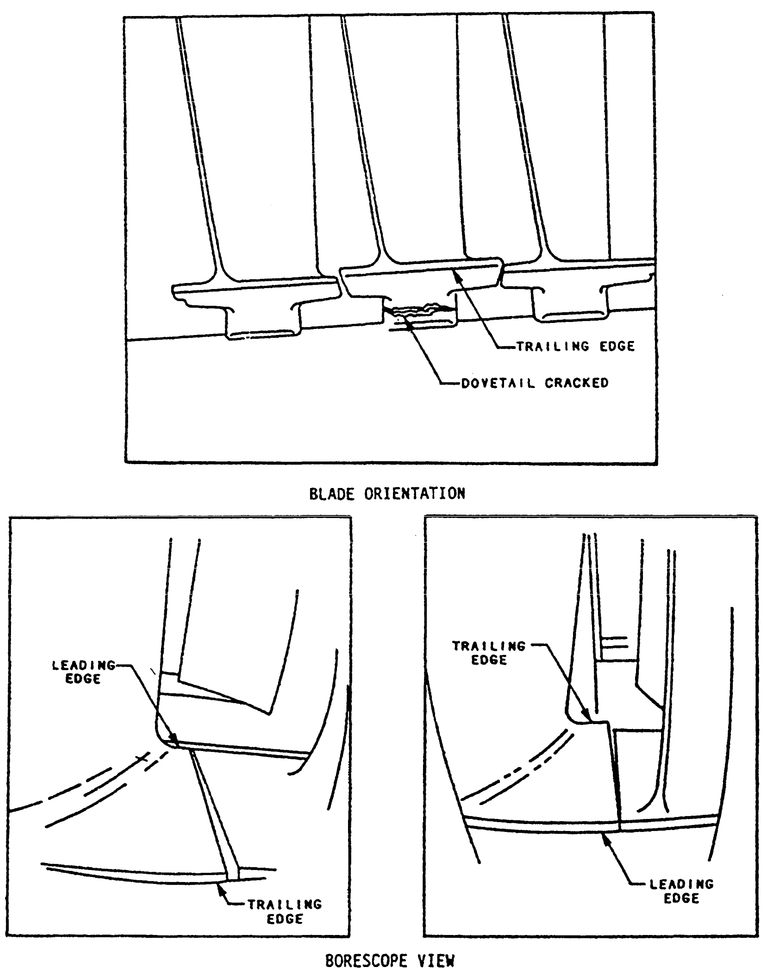


Figure 2-12.—Compressor blade leaners.

trailing edge). These curled tips are usually smooth in the bend area of the airfoil distortion. However, you should inspect the area at the change in normal airfoil for tears or cracks. When you report tip curl, estimate the percent of the chord length, the number of blades with curl, and the condition of the adjacent airfoil area. Record any evidence of impact and inspect for the origin of the impact. Always look at the adjacent blades for evidence of tip clang.

Missing Metal.— Missing metal from compressor rotor blade airfoils is a result of the progression of cracked or tom airfoils that release part of the airfoil into the flow path. Crack propagation in the root fillet area can result in the separation of the entire blade. Severe FOD or DOD may result in several random rotor and stator airfoils with missing metal. The inspection report should include the stage, the number of blades with missing metal, the amount, and the location on the airfoil. Estimate the percent of chord, the span of the airfoil that is missing metal, and the condition of the remaining airfoil.

Airfoil Surface Defects.— Surface defects are the result of object damage or adjacent blade interference (tip clang). Impacts in the center section of the airfoil are not common. Tip clang damage is the result of a blade leading edge tip contacting the adjacent blade tip at approximately one-third of the chord length forward of the trailing edge on the low-pressure (convex) side of the blade (fig. 2-13). This is the result of compressor stall and is observed in stages 3 through 6. You should report any observed defect on the airfoil surfaces in the inspection record. Your report should contain

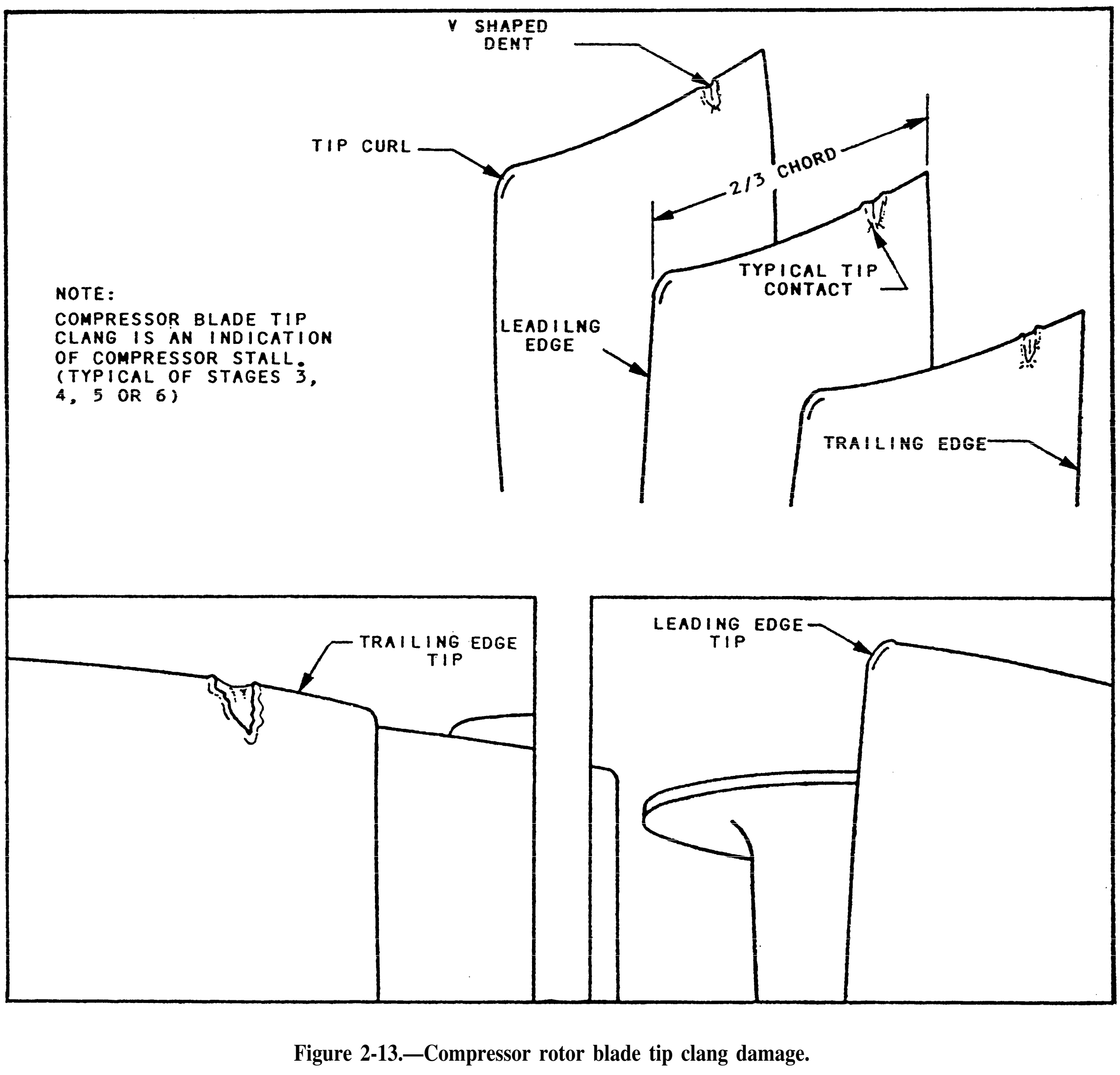


Figure 2-13.—Compressor rotor blade tip clang damage.

information relative to the stage, location on the blade (estimate the percent of chord and span), and the condition of the surrounding airfoil. You do not have to record the appearance of the defect (sharpness and contour). Compressor stall is one of the worst things that can happen to an engine. tip clang damage is difficult to spot and gives the appearance of minor damage. The V-shaped notch on the top of a blade caused by tip clang is only an indicator; it in itself is not the damage. The damage is at the blade root and normally cannot be seen. If a blade has been overstressed, it must be replaced.

Platform Distortion.— Compressor blade platform fretting or shingling (fig. 2-14) can be observed on some after stage blades. These distortions are the overlapping of one blade platform mating edge with the adjacent platform edge. When shingling is found, the platforms will be distorted and bowed (fig. 2-15). When the platforms are shingled, only the locking lug blades will exhibit this defect. Monitor this condition to see if a platform crack develops. Also look for missing pieces around the locking lugs. You must report and record any cracks in the platform. Be sure you have included the following information:

- The stage
- The number of blades

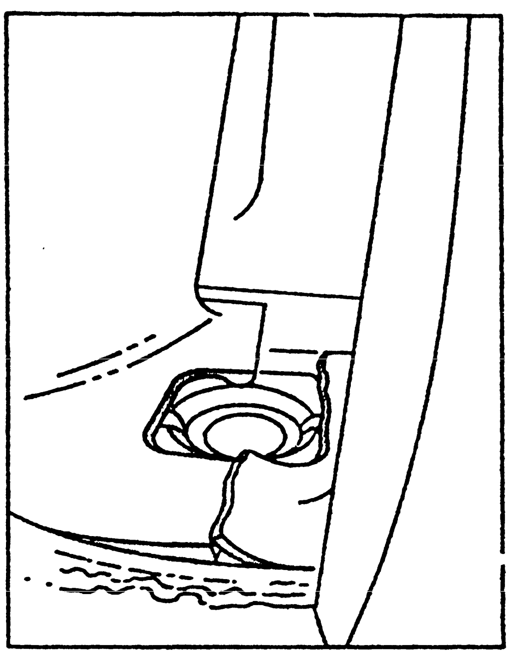


Figure 2-14.—Platform fretting or shingling.

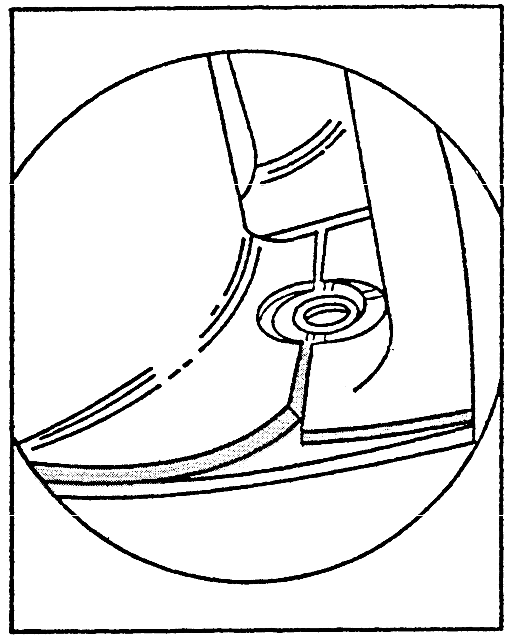


Figure 2-15.—Platform bowing.

- The spacing of the blade numbers separating the shingled blade platforms
- The platform gap observation (estimate gap as percent of circumferential span of the platform)
- The condition of the shingled edge (bent, fretted, or stepped as per table 2-1)

Midspan Shroud Wear.— Some stage 1 compressor blades show wear at the mating surfaces of the midspan damper shrouds. (See figs. 2-16 and 2-17.) Wearing of the tungsten-carbide wear coat causes the mating face contour to change from a straight line to a stepped line. This occurs at the after edge of the clockwise blade midspan (trailing edge) and the forward edge of the counterclockwise blade midspan shroud (leading edge). In the step area, some metal maybe turned or protruding from the midspan shroud mating line (mushrooming). This protrusion is indicative of wear-through. A missing pad on one face would initiate an accelerated failure of the mating surfaces.

BLADE DEPOSITS.— Compressor blades and stator vanes exhibit varying degrees of cleanliness. Variables such as air-inlet configuration, ambient atmospheric conditions, and air contaminants (chemicals, salt, dirt, water, and so forth) all tend to affect the surface condition of the compressor rotor and stator blades.

Aluminum Deposits.— Two areas in the compressor assembly are coated with aluminum, the

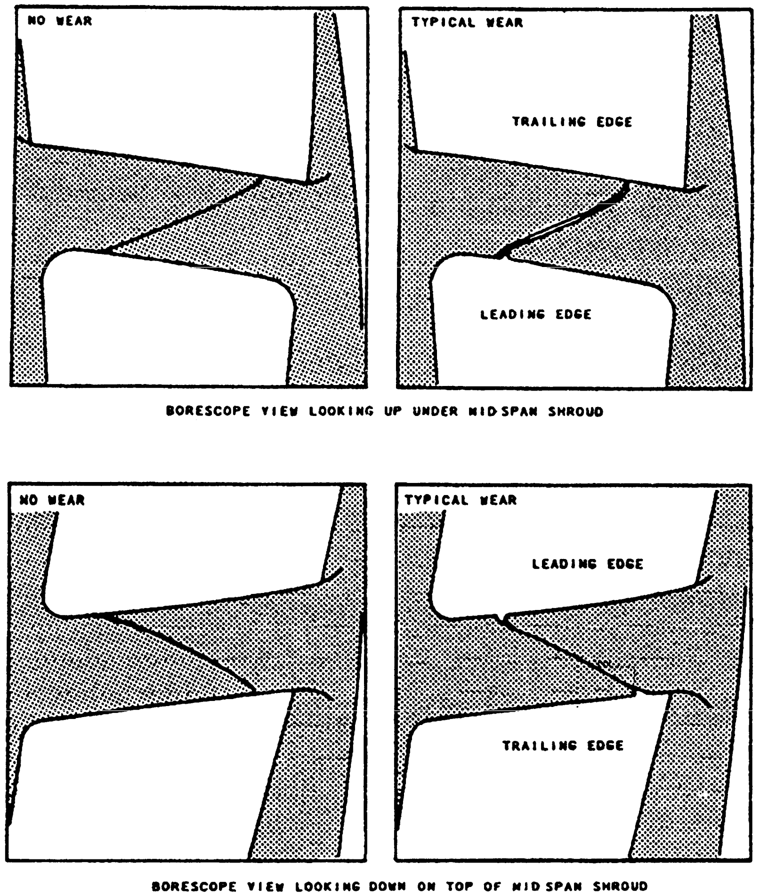
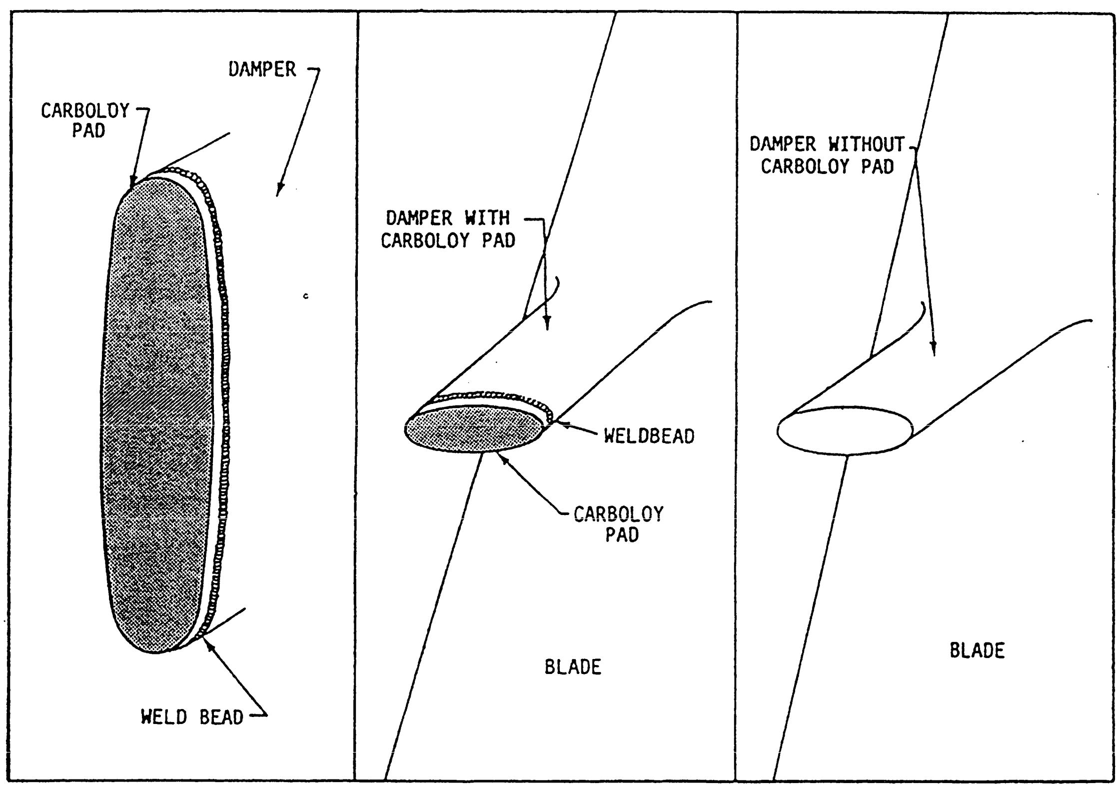


Figure 2-16.—Compressor blade midspan shroud wear.



l?igure 2-17.—Compressor blade midspan damper carboloy pad.

shrouding over the blade tips and the rotor drum area under the stator vanes. tip rubs of either the blades or the vanes will rub off the aluminum coating. As time is accrued on the compressor assembly, the after stages of the rotor release or flake the aluminum coating. This deterioration is a normal progression. Flaking occurs because of the differences in thermal expansion of dissimilar metals and the differences in the size and configuration of the various parts. The released aluminum flakes enter the airstream, impact the rotor blades or vanes, and splatter the airfoils. Aluminum splatter observed forward of stage 11 can be caused by object damage or aluminum flakes that are rubbed out of the compressor case coating. This condition requires a thorough inspection of the forward compressor stages.

Leading Edge Buildup.— Aluminum buildup on the leading edges of blades is usually observed in stages 11 through 16. The buildup changes the contour of the airfoil and can alter the stall margin. You should report the presence of leading edge buildup in the inspection report. This type of buildup may occur on low-time compressors. The compressor blades tend to "self clean" or lose this leading edge buildup as the assembly accrues time.

Airfoil Powdering.— Compressor rotor blades may have aluminum particles visible on the airfoils in varying degrees (from stage to stage). This powder is indicative of a possible compressor stall or a hard blade tip rub.

Combustion Section

Inspect the combustor for eroded or burned areas, cracks, nicks, dents, hot streaks, flatness of liners caused by hot spots, blocked air passages, and carbon buildup. If damage is found in the combustion section, it usually consists of a burn-through in the dome area adjacent to a fuel nozzle. The problem can usually be traced to a loss of film-cooling air caused by upstream debris or to a faulty fuel nozzle. Cracking is not normally a problem, but you should photograph and report any suspected or confirmed cracks. Carbon deposits around the fuel nozzles occur on all engines and are not considered serious. These deposits build up only on the venturi and swirl cup rather than on the shroud or discharge orifice. They do not usually interfere with the fuel spray pattern. If you find cracking, evaluate it to ensure that no pieces will detach and cause any secondary damage to the HP turbine. For reference to parts nomenclature used in the following section, refer to figure 2-11, sections B and C.

COMBUSTION SECTION DAMAGE.— In the following paragraphs, we describe some of the damage that you might find during a borescope inspection of the combustion section. Because the dark surfaces in the combustion section absorb light, you will need a 1,000-watt light source for a proper inspection.

Discoloration. — Normal aging of the combustor components will show a wide range of color changes. This is not a cause for concern. As operating time is accrued on the combustor assembly, an axial streaking pattern running aft of every other circumferential fuel nozzle will occur. On low-time assemblies, the coloration is random and has little or no information to aid you during the inspection. As operating time increases on the assembly, you will observe significant deterioration at the edges of the streaking patterns. Cracking will begin in the forward inner liner panels and will propagate aft. The axial cracks tend to follow the light streaks. Panel overhang cracking and liberation usually occur at the edge of the streaks.

Riveted Joints.— The dome band and the inner and outer liner assemblies are joined by rivets as shown in figure 2-18. The presence and condition of the rivet heads and rivet holes are easily assessed because of their position in relationship to the borescope ports. Record any missing rivets and torn or cracked hole edges.

Dome Assembly.— Distortion of the trumpets and/or swirl cups is random and occurs on high-time assemblies. Record the distortion (in percent) of the edge and/or span of the trumpet and the percent of circumference versus diameter of the swirlers.

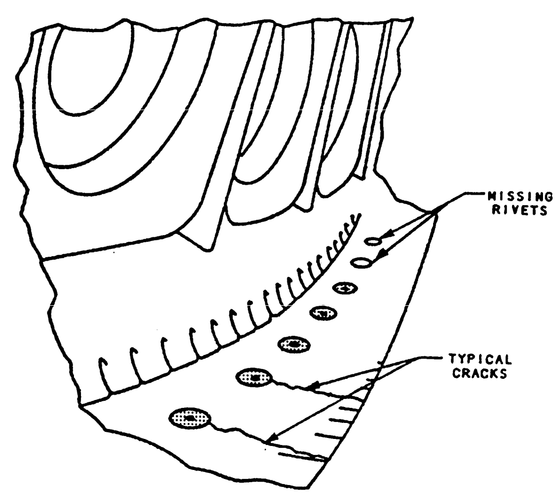


Figure 2-18.—Combustion liner dome rivet joint.

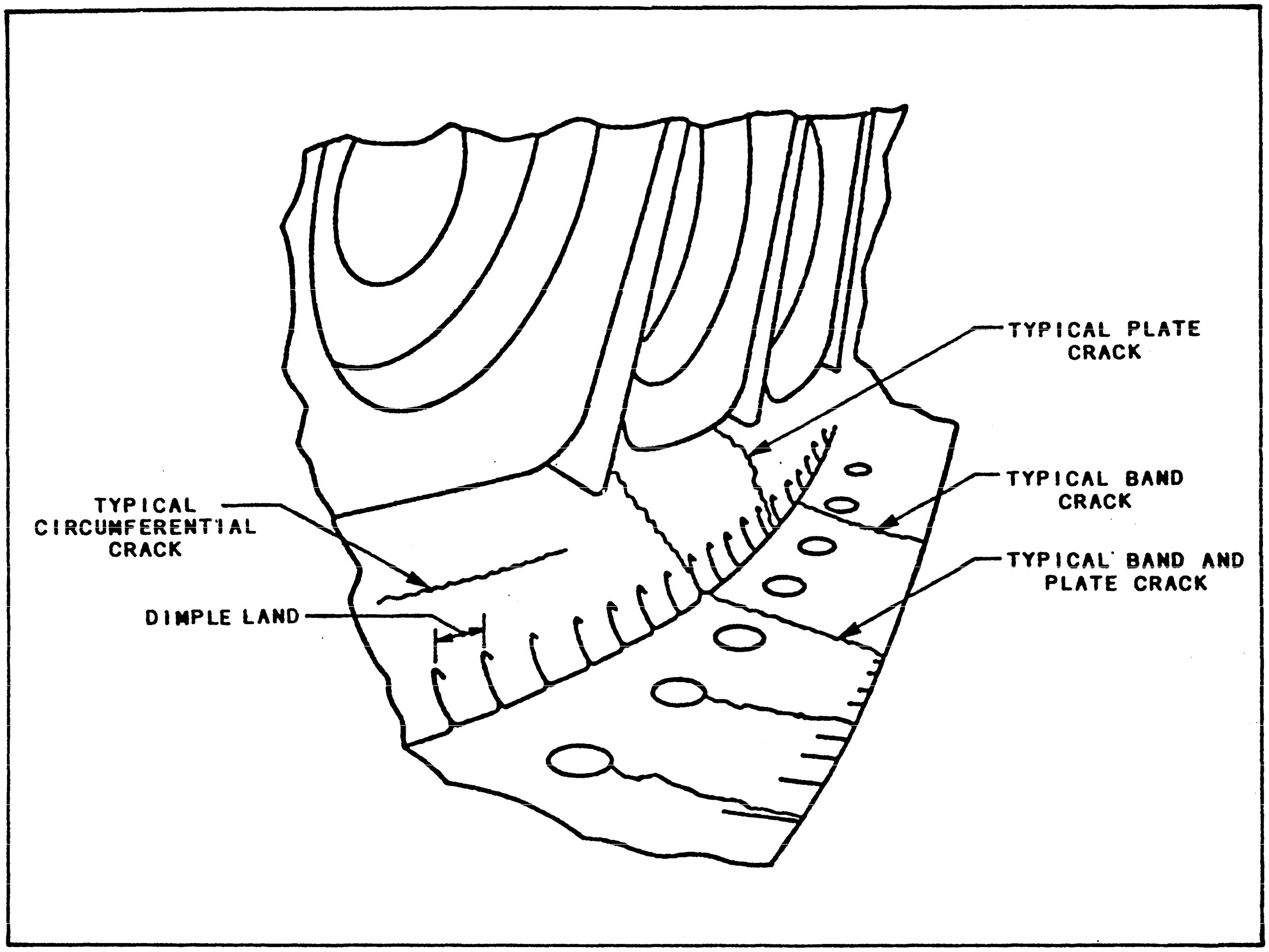


Figure 2-19.—Combustion liner dome band and plate cracks.

Cracking (fig. 2-19) in the dome band area occurs at relatively low operating time. Record the number of cracks and their relationship to one another. Indicate if these cracks are parallel, T-shaped, circumferential or angled to connect and separate part of the band, and so forth.

All the missing metal areas or burn-throughs (fig. 2-20) must be recorded. For the dome bands, estimate the magnitude by the number or partial/circumferential span of the dimples and axially by percent of span of the band overhang to the trumpet. Record the trumpet areas of burn-away and burn-through of the dome plate around the swirl cups. Burn-through in the combustor dome will reduce cooling flow to the HP turbine vanes. Monitor the HP turbine vane condition as burn-through progresses.

Igniter Tubes and Ferrules.— Inspect the two igniter locations (fig. 2-21) for the condition of the weld at the cutaway of the trumpet and the dome band. The ferrules are visible from these ports. Record the condition for evidence of cracking, loss of ferrule metal, or both. Cracking from the igniter tube aft to the panel overhang is common.

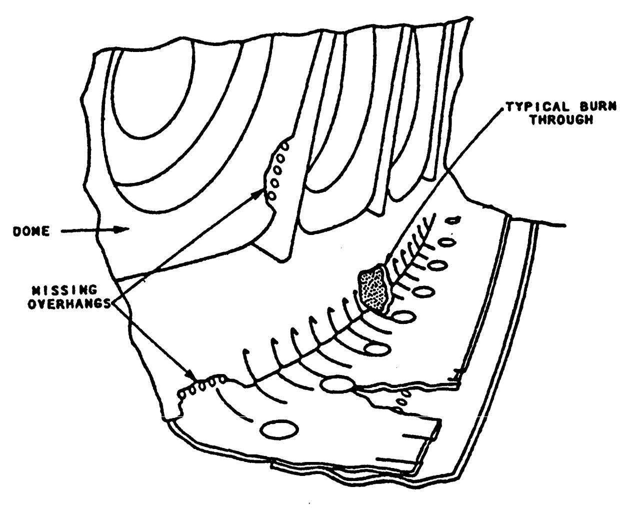


Figure 2-20.—Combustion liner dome bums and missing metal.

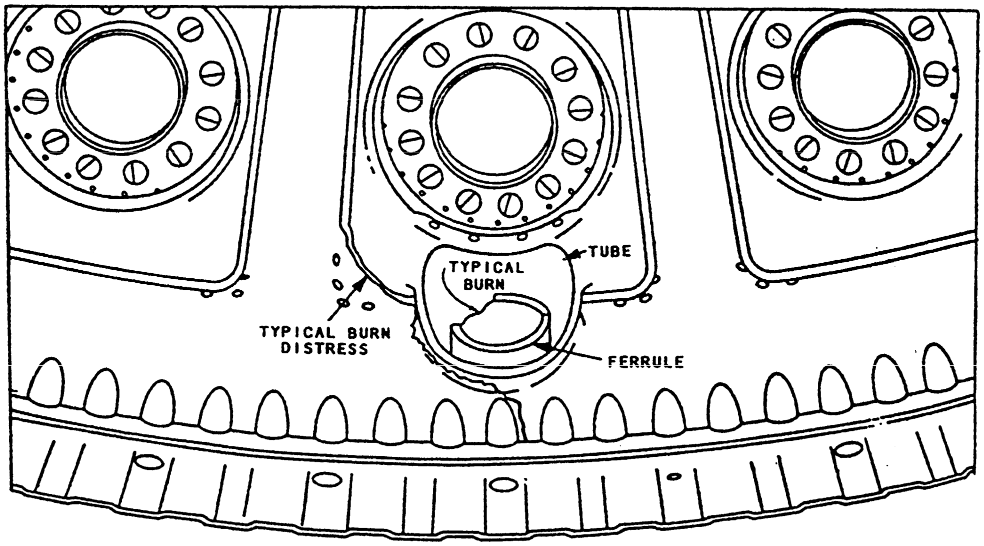


Figure 2-21.—Combustion liner dome igniter tube.

INNER AND OUTER LINER ASSEMBLIES.— You can inspect all areas of the inner and outer liner assemblies aft of the fuel nozzles by rotating and tilting the probe, and by varying the immersion depth. Some of the damage that you may find is described in the following paragraphs.

Circumferential Cracks.— Figure 2-22 shows an example of circumferential cracking on a high-time combustion liner. This type of cracking occurs over the area of the inner liner stiffening bands. The bands are circumferential stiffeners and are not visible when viewed through the borescope inside the combustor assembly. Before actual cracking, the thermal working of the liner shows stress lines. These lines will be visible in all panels. Take care to inspect for the presence of cracks, not merely lines. A crack will be open and the separation will show an edge. The distortion occurs so that the inner liner lifts up into the flow path and the outer liner bends down into the flow path. These irregularities are usually obvious when the liners are

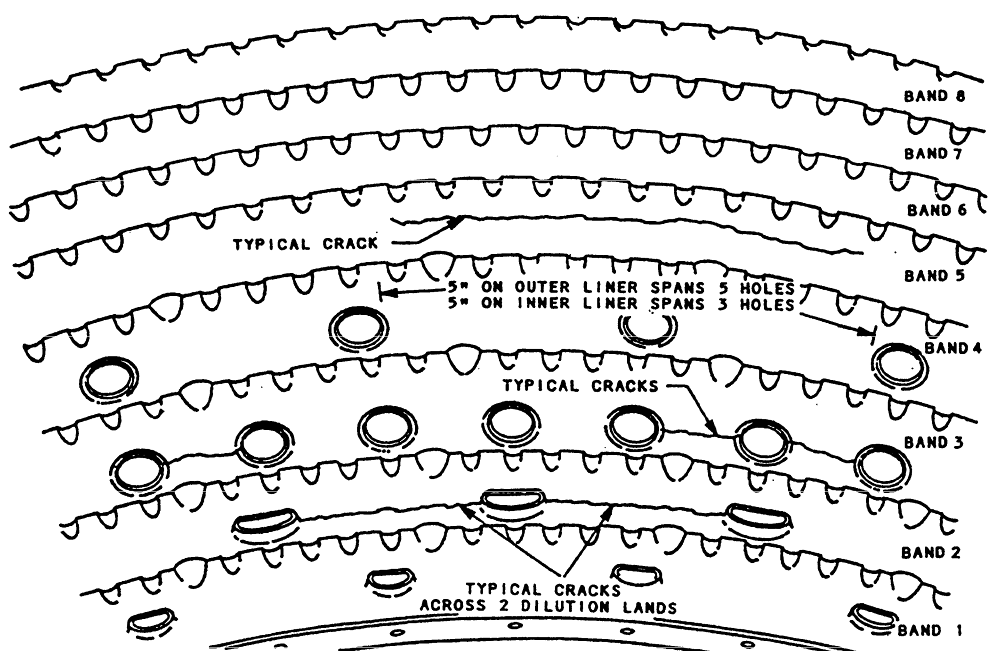


Figure 2-22.—Inner/outer liner circumferential cracks.

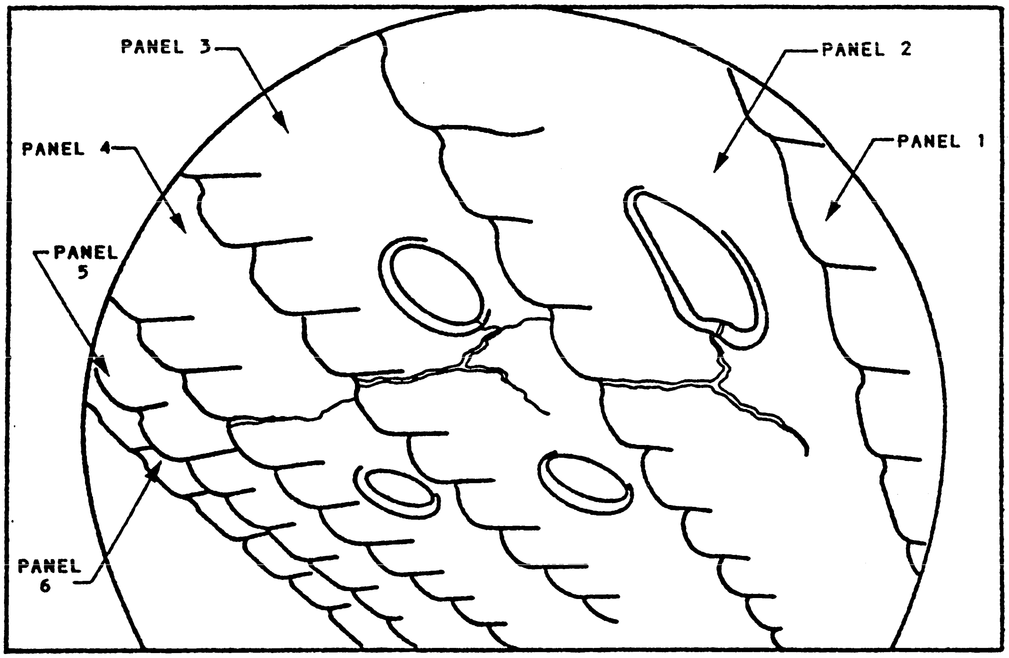


Figure 2-23.—Combustor inner liner cracks.

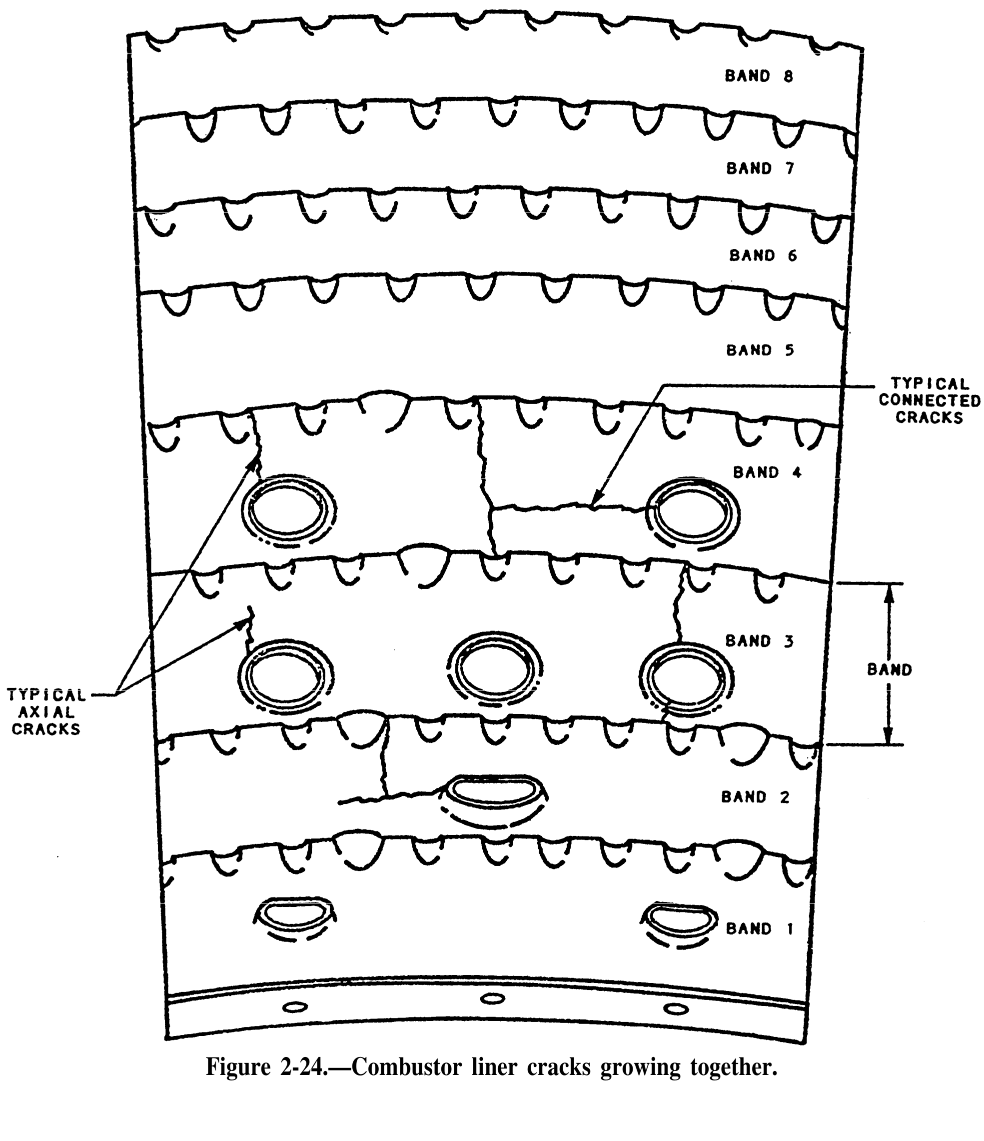


Figure 2-24.—Combustor liner cracks growing together.

viewed through wide angle probe No. 2. When circumferential cracking is observed, record the band number and the span of the cracking relative to the number of cooling/dilution holes. Use the diameter of the cooling holes as a comparative measurement gauge.

Axial Cracks.— Axial cracking usually starts at band No. 3 on the inner liners and propagates aft and forward. As operating time is accrued, these axial panel cracks grow into three-legged cracks as seen in figure 2-23. The edges of these cracks will separate and the corners will lift into the flow path. Inspect the areas aft and forward of these cracks, recording the axially separated cracks that show a tendency to grow together.

DOD is the primary cause of damage to the HP nozzle and turbine rotor elements. It is caused by pieces from the combustor liners cracking out of the panel overhangs and impacting with the rotating turbine elements. The most serious problem is the separation of a large section of liner that could cause significant damage. This usually occurs as a result of axial and circumferential cracks growing together as shown in figure 2-24. It is important to record the damage to adjacent areas of about 5 inches to either side of the damaged area. These areas can grow together and liberate large pieces of material. These circumferentially spaced, cracked areas are usually separated at every other fuel nozzle spacing along with axial color streaking.

Missing Metal and Burn-Through.— Inspect for the loss of metal at the panel overhang and the area between dimples (fig. 2-25). Bum-through of the liners is not common. What is common are the bluish-black slag areas that show roughness and appear to be oxidized. Inspect these areas carefully for T cracks because they will propagate and open up.

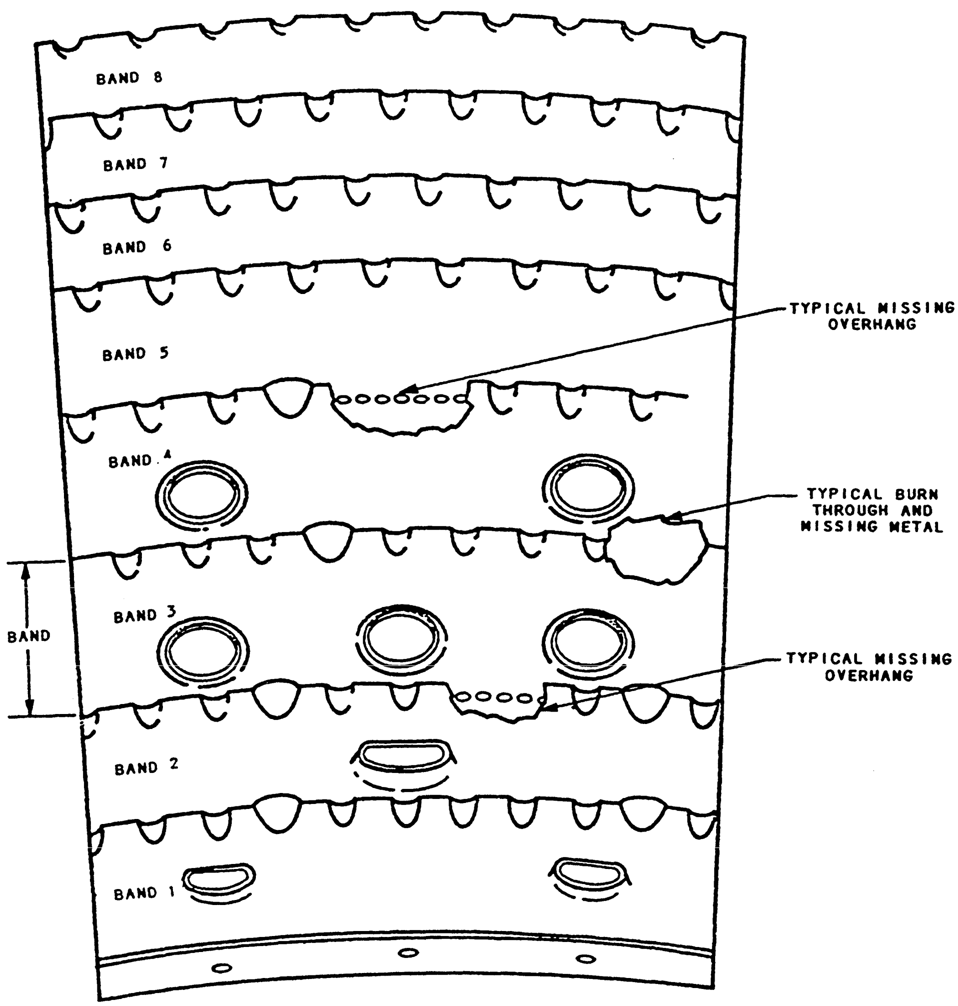


Figure 2-25.—Inner/outer liner burns and missing metal.

Distortion. — Distortion or bowing of the liner assemblies is extremely difficult to assess when viewed through the borescope. If an axial streak (gutter) is observed to be out of contour, estimate the relative distortion in terms of dimples spanned or in relation to the diameter of the dilution holes. If the distortion is present at the No. 1 band, estimate the contour change at the dome band relative to the panel.

HP Turbine

Inspect the HP turbine for eroded or burned areas, cracks or tears, nicks or dents, and missing blades. Knifing (erosion resulting in sharp edges) can occur on first-stage blades. The severity will vary according to the cleanliness of the turbine inlet air. Check for pitting on the leading edge near the root of the second-stage blading.

Cracking of the first-stage nozzle guide vanes is not very common, but photograph and report any suspected cracks. First-stage vane surfaces at the juncture of the inner and outer platforms have a tendency to corrode or erode. It would not be unusual for you to find several small penetrations in a vane platform during its service life. Most of these penetrations remain small and are not usually severe enough to warrant engine replacement. Record any such penetrations and regularly inspect them for any changes in size or quantity.

Vane HP (concave) surfaces will show gradual erosion with time, and the trailing edge slots will become elongated. When this degradation reaches maximum service limits, as noted on the PMS card or in the manufacturer's technical manual, the engine must be replaced.

HP turbine second-stage blades have a service life that is dependent upon operating conditions. Cracks are the major inspection criteria listed. You should document and report any confirmed cracks. The most common form of degradation is deposit buildup and erosion; this is not usually as severe as on the first-stage blades. The most serious form of damage that you may find in this area is pitting in the root area, which you must document and report. For reference to the parts nomenclature used in this section, refer to figure 2-11, sections D and E.

HP TURBINE NOZZLE DAMAGE.— The first-stage turbine nozzle vanes are inspected simultaneously with the combustor and fuel nozzles. The following paragraphs describe the common damage you may find during the borescope inspections.

Discoloration.— Normal aging of the HP turbine nozzle stage 1 vanes will result in coloration changes as operating time is accrued. There is no limit relative to discoloration of HP turbine nozzle vanes.

Oxidation and/or burning of the vane areas is accompanied by dark areas silhouetting the initial distress. Cracks are shrouded in dark patches adjacent to the defect. Usually the distress starts as a crack, followed by oxidation of the shroud adjacent to the crack Impact damage usually shows as a dark spot on the leading edge.

Leading Edge Damage.— This type of damage can be found between the forward gill holes on the concave and convex side of the leading edge.

- Axial cracks form around the leading edge. Estimate the percent of span of the leading edge or span relative to the nose cooling hole rows to determine the crack length.
- Burns and spalling on the leading edge should not be construed as coloration only, but must have actual metal oxidized (surface metal loss), but no holes through the leading edge. Estimate the area boundaries by the nose cooling holes spanned both radially (up and down the leading edge) and axially (around or across the leading edge). Record the number of vanes affected.
- Blocked cooling air passages on the leading edge is another type of damage. If multiple hole blockage is observed, record the separation of the open cooling holes and the number of adjacent plugged holes.

Airfoil Concave Surface.— Radial cracks run spanwise in the vane airfoil surface (up and down the vane). Record the relative chord position of the cracks. Record the relation of axial cracking versus radial cracking, such as axial and radial cracks that intersect or join at the second row of gill holes. The intent of the service limits are to preclude the liberation (break-out) of pressure facepieces.

Other Airfoil Area Defects.— The following paragraphs describe other airfoil area defects that you may find during the inspections.

- Burns and cracks on concave and convex sides (charred). Record the area and length, estimate the length relative to the leading edge area (gill hole to gill hole and spanwise by span of cooling or gill holes). Estimate the surface damage relative to separation of gill hole rows and radially by gill or cooling holes.

- Craze cracking. These cracks are superficial surface cracks, caused by high temperature. They are random lines that are very thin in appearance with tight lines (no depth or width to the cracks). There is no limit against this condition.

- Nicks, scores, scratches, or dents. These defects are allowed by the service limit and may "be present on any area of the nozzle vanes.

- Cracks in the airfoil fillet at the platform. There is no limit restricting these cracks, except at the leading edge area.

- Metal splatter. Aluminum and combustor liner metal, when liberated by the compressor or combustor, frequently splatter the surface areas of the stage 1 HP turbine nozzle vanes. There is no limit for these deposits; however, abnormal amounts of this splatter is reason to inspect the compressor.

Platforms.— Cracking in the HP turbine nozzle stage 1 platforms is difficult to see from the combustor borescope ports. When this area is viewed through port No. 12, extreme magnification is afforded even with probe No. 2. This is due to the closeness of the surface to the distal end of the probe. Record the origin and end of the cracking and assess the magnitude using trailing edge slots and gill hole rows for radial and axial dimensions.

Nicks, scores, scratches, and dents on platform surfaces are again masked from the combustor ports, except for the forward areas. Viewed via port No. 12, the area is magnified. Record the magnitude of the defect using the geometry of the trailing edge, gill hole rows, and gill hole separation for comparative dimensions.

You must record burns on vane platform areas and use probe No. 1 to assess the conditions. If a burn-through occurs, the inner and outer surface edge of the platform should be seen. This difficult assessment can be done with the aid of a fiberscope. Any incomplete or doubtful evaluation should be the subject of a followup check after a specified amount of operating time.

HP TURBINE BLADE DAMAGE.— When inspecting the HP turbine blades, you should use probe No. 2 with the 150-watt light source. The following paragraphs describe some of the damage you may find.

Cracks in the Leading Edge.— The leading edge of the stage 1 turbine rotor blades is the area forward of the gill holes. Cracks in the leading edge can be caused by DOD impact (combustion liner pieces) or thermal stress. An indication on the leading edge open enough to show depth is defined as a crack. Some conditions may mislead you in the determination of the presence of cracks. Dirt and debris buildup inlayers on the leading edge, as shown in figure 2-26, are not cracks. When this buildup begins to flake off, the edge of the area where the flake came off causes visible lines. These lines are irregular and appear to be cracks. The other common point of cofusion on leading edge cracks is on the convex side of the leading edge tip area. This area is subject to "scratching" by the small pieces of combustor metal that pass through the HP turbine.

Cracks in the Trailing Edge.— The trailing edge is the flat surface with cooling holes that forms the after edge of the blade airfoil. Trailing edge cracks are difficult to see, but if a crack is suspected, use probe No. 1 for increased magnification. Record the location relative to a cooling hole and the magnitude of the crack. Record any plugged trailing edge cooling holes.

Cracks in Concave and Convex Surfaces.— The airfoil surfaces are the areas aft of the gill holes back to the trailing edge. The tip area is further restricted to that area above the tip cap. When you evaluate the airfoil serviceability, do not consider the tip as a part of that area. Cracks in the airfoil surfaces are very tight, but can readily be seen with probe No. 2. Airfoil surface cracks are irregular in edge appearance and are not usually confined with streaks, which are usually straight in appearance. Record the area by the percent of span or gill hole spacing equivalent for location and magnitude of the cracking. For axial position, use an estimate of percent chord and the position relative to the tip cooling film cooling holes.

Cooling Hole Blockage.— The HP turbine rotor stage 1 blades are film cooled by air that flows out of the cooling holes. Report plugged holes relative to the number of blades affected and the position and number of plugged holes. Ensure the correct callout of the holes (such as the nose cooling, convex gill, tip film cooling holes, and so forth.)

Distortion.— Heavy impact damage to the leading edge of the blade usually results in distortion. When the impact is severe enough, cracking and/or tearing of the leading edge, adjacent to the impact area, occurs.

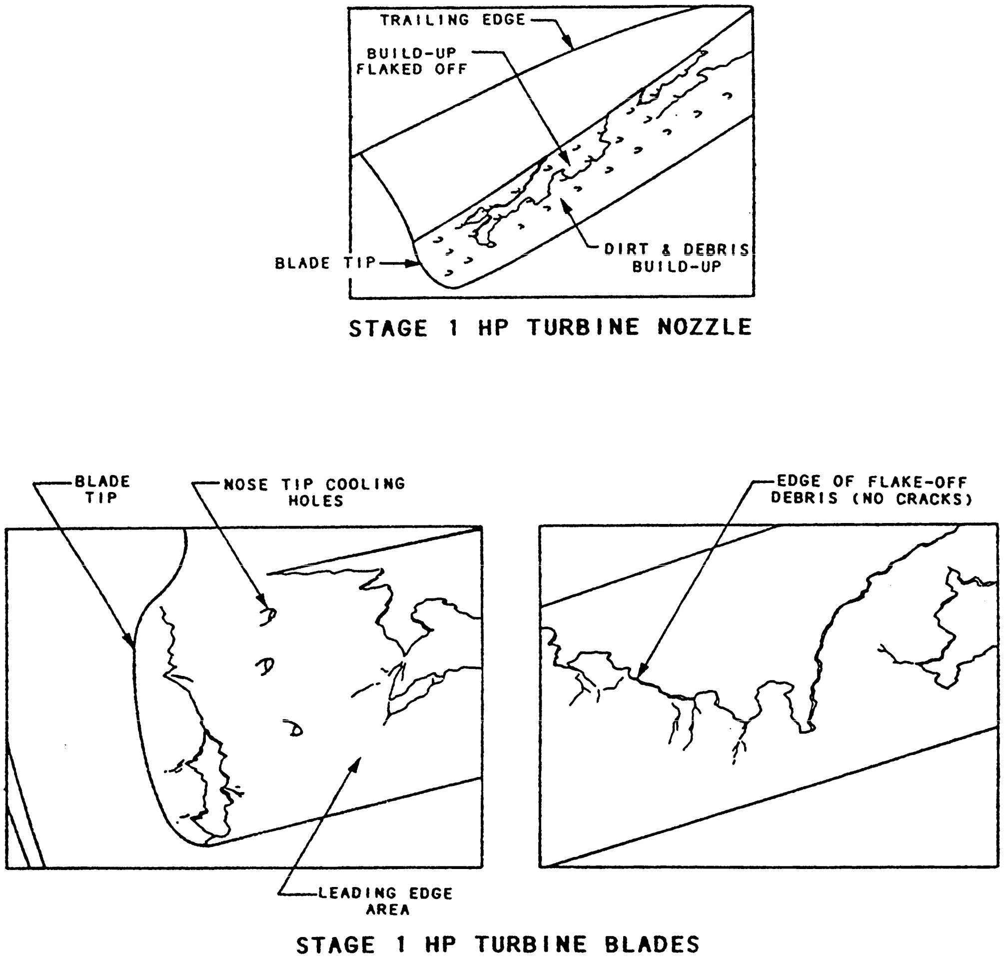


Figure 2-26.—HP turbine blade flaking and buildup.

Record the magnitude and span location relative to the number of gill holes spanned. Estimate the out of contour as percent of the leading edge frontal area width or relative to the lateral spanning of the leading edge cooling hole rows.

Blade Tip Nibbling.— The HP turbine rotor stage 1 blade tip nibbling is associated with hot running engines. Momentary overtemperature operation (such as experienced during compressor stalls) has exhibited this type of deterioration. This area of the blade is above the tip cap and located about two-thirds of the chord aft from the leading edge. Figure 2-27 shows a typical "nibbled tip" as a result of a severe stall.

Blade Leading Edge Impact Damage.— Figures 2-28 and 2-29 show an impacted and distorted leading edge of a stage 1 HP turbine rotor blade. (Note the cracking condition leading from the impact area into the airfoil surface.) The critical part of this type of damage is the axial or chord wire cracking. If this cracking progresses from the impacted damaged area into the convex or concave airfoil surface, the damage can be severe.

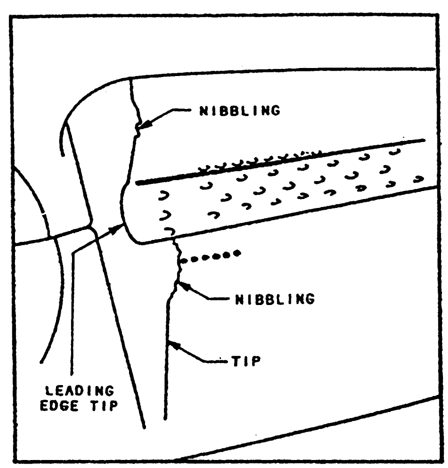


Figure 2-27.—HP turbine blade tip nibbling.

HP Turbine Blade Coating Failure.— The HP turbine protective coating is the key factor in the service

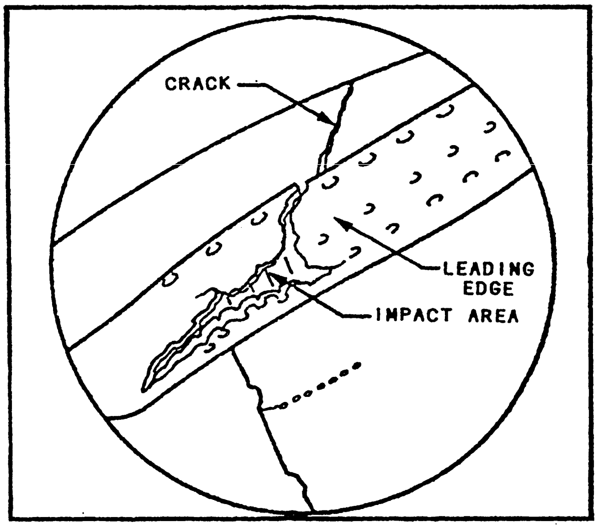


Figure 2-28.—HP turbine blade impact damage.

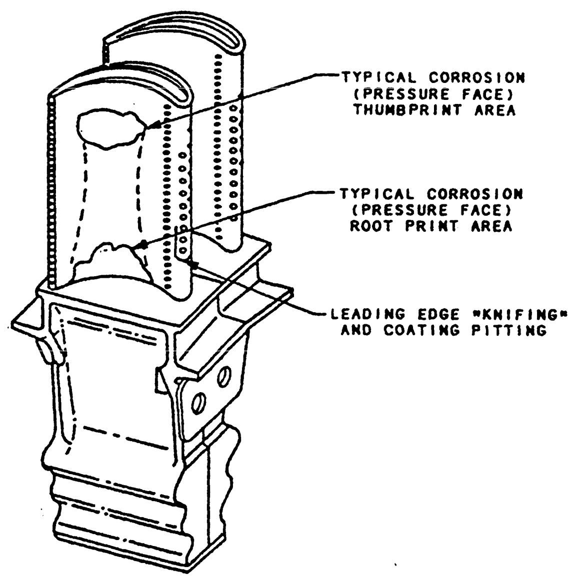


Figure 2-30.—HP turbine rotor stage 1 blade—areas of severe corrosion after extensive operating time.

life of an LM2500 GTE. The combined effect of film cooling and protective coating will extend the service life. Coatings are thinly and uniformly applied by a vacuum film deposition process. Coatings do not usually cause problems by chipping, peeling, or flaking. The normal failure mode is usually by pitting, rub off, or nicks and scratches. Occasionally a bubble will occur in the surface coating during the coating process. If a bubble occurs, it will be tested at the coating facility to ensure that it cannot be rubbed off the surface. These bubble imperfections pose no problem to the engine. If the bubble area of the coating fails, you should monitor that area to determine any further deterioration. Development and testing of new coatings that are highly resistant to corrosion and erosion are in progress. The present blade coating for single shank HP turbines is designated BC23. However, twin shank HP turbine blading presently have blade coating BC21. As they become serviceable by an area Naval Aviation Depot (NADEP) these blades will be replaced with blades coated with BC23. Use of these newer blade coatings can significantly extend blade service life.

HP TURBINE BLADE FAILURE MODES.— Failures that you may observe during a borescope inspection include the following types:

- Corrosion of the coating. This appears as pitting of the coating primarily in the 80-percent span midchord region of the concave airfoil (thumbprint) side and the 20-percent span midchord region (root print) (fig. 2-30). This corrosion/erosion has not been found on blades coated with BC23.

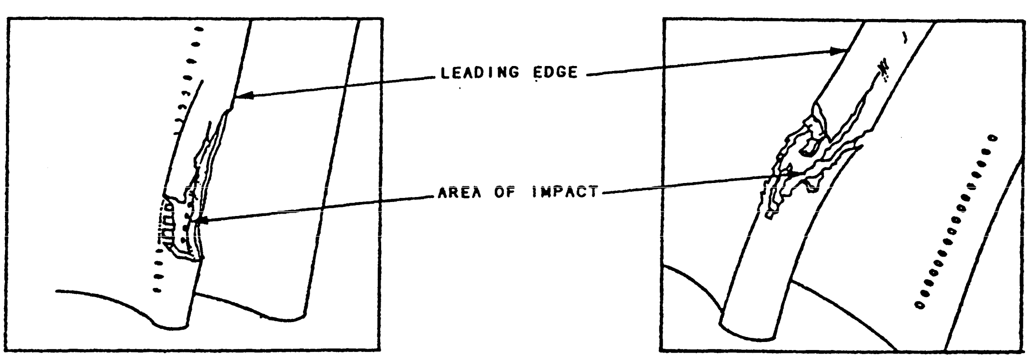


Figure 2-29.—HP turbine leading edge impact damage.

- Cracks in all areas of the blade, including radial cracks in the tips. Cracks generally start at the cooling holes.
- FOD/DOD, including nicks and dents.
- Aluminum spattering that appears as metallic deposits on the blade. This results from compressor tip rubs.
- HP turbine blade tip rubs. This results in coating removal and tip damage.

TURBINE MIDFRAME DAMAGE.— The following paragraphs describe damage that you may find when inspecting the turbine midframe.

Discoloration. — On low-time liners, the coloration is random and sometimes appears as a wavy surface. The coloration is random both axially and circumferentially. On high-time liners you may observe some axial carbon streaking. There are no service limits on discoloration

Liner Cracking.— Initial deterioration of the turbine midframe liners occurs at the forward inner liner flange in the form of axial cracking. It is difficult to determine the magnitude or length of a crack in this area. The area is immediately aft of the HP turbine stage 2 blade platforms. Small tight cracks will probably not be noticed. Of primary interest is that there are no cracks with visible turned up edges. If cracking is observed in the forward inner liner flange, you can use a fiberscope for a closer look to establish the extent of the crack and the adjacent area condition. Cracking can also occur around the leading edge weld beads on the strut fairings at both the inner and outer liner areas.

Liner Distortion.— Turbine midframe distortion most commonly occurs in the 10 to 12 o'clock area of the outer liner forward flange. The only relative gauge available for comparative assessment (roundness/contour) is the HP turbine stage 2 blade tip arc and the stage 2 shroud contour. A fiberscope is recommended for the final assessment of any suggested distortion of the liner. You will need a guide tube to position the fiberscope.

Power Turbine

The most common problem in the power turbine section is usually a loss of the hard coat on the tip shroud. Notch wear and subsequent blade bending are direct results of tip shroud hard coat loss. Notch wear and blade bending will ultimately lead to fatigue failure of the airfoil. The actual loss of the hard coat cannot be confirmed through the borescope. It can be confirmed by removal of the upper case and actual physical inspection of the tip shrouds. You can seethe symptoms through the borescope by looking at the notch with probe No. 1. Uneven notch wear may indicate loss of the hard coat. You should carefully inspect for any transverse cracks in the blade airfoil around the 10 percent span. <u>Any cracking is cause for replacement of the power turbine.</u>

The power turbine first-stage blades also have a history of deposit buildup that leads to rotor unbalance and excessive vibration. For reference to parts nomenclature used in this section, refer to figure 2-11, sections F and G. Power turbine damage that you may find is described in the following paragraphs.

CRACKS IN BLADES.— Inspect the total airfoil, platform, and tip shrouds for evidence of cracks. If you suspect a specific area, use the high-magnification probe. You will see a limited amount of the stage 1 blading when viewing aft from the turbine midframe liner inspection ports. You can see more detail with a fiberscope or by viewing forward from the turbine exhaust duct. Cracks will show depth and under magnification will show edge material definition. Be sure to distinguish cracks from false indications such as smears and carbon streaks.

NICKS AND DENTS.— Record these defects in relation to the percent span and percent chord for magnitude and location on the blade. Record also the condition of the blade material adjacent (at the extremities of the defect) to the observed defect. Record any cracking or sharpness of nicks or dents. Investigate smooth impact deformities to determine the origin of damage.

WEAR.— Inspect LP turbine rotor blade tip shroud interlocks or circumferential mating surface for wear at stage 1. Wear is observable and will appear as shown in figure 2-31.

DIRT, COLORATION, PITTING, AND CORROSION.— High-time LP turbine rotor assemblies may show airfoil surface irregularities that could be dirt accumulation, carbon buildup, surface pitting from particles in the gas stream, or corrosion of the blade material. Dirt and coloration are of little concern; however pitting and corrosion may be significant.

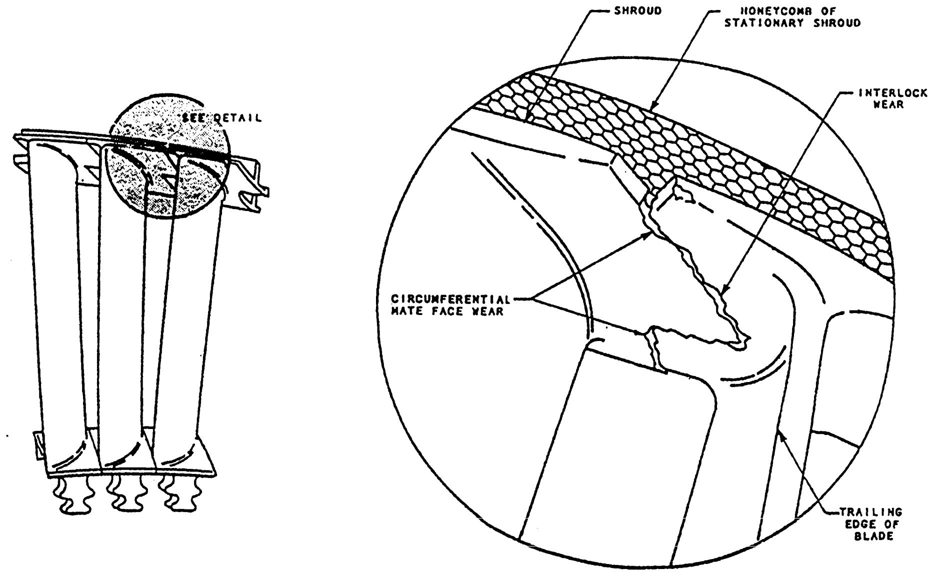


Figure 2-31.—Power turbine shroud wear.

Evaluating Physical Size

You determine physical size in several ways. By using dimensional data in the manufacturer's technical manual, you can estimate size by making a comparison to a known dimension in the field of view. Another way you can evaluate size, particularly in regard to cracks, is to use a lockwire of a known diameter. The lockwire is inserted into the field of view and placed next to the crack for size comparison. When using this method, you should be sure that the lockwire cannot fall inside the engine. Using an absolute reference for size, such as the lockwire or a known dimension, is more reliable than estimating the size through a borescope.

Color Evaluations

During inspections, you can observe deposits or various forms of deterioration. Table 2-3 is an engine color chart that lists the color of common deposits and

Table 2-3.—Engine Condition Color Chart

COLOR	LOCATION	INDICATION
Blue, blue-green	High-pressure turbine	Sulfidation, corrosion
Shiny black	High-pressure turbine	Fuel residue, wet
Dull black	High-pressure turbine	Fuel residue, dry, coking
White	High-pressure turbine	Water-wash detergent
White	High-pressure turbine	Sea salts
Brick red	High-pressure turbine	Iron oxide (rust)
Tan	High-pressure turbine	Silica (sand)
Black	Compressor	Grease (dirty)
Metallic white	Compressor	Aluminum oxide
Grey (light or dark)	Power turbine	Deposit buildup
Grey (dark)	High-pressure turbine	Oxidation of coatings

conditions. This information will aid you in interpreting what you see by evaluating the color of the area or component. Color photographs taken through the borescope are an effective method to record the results of an inspection.

It is difficult to make accurate color interpretation. Table 2-3 is only an aid. The only color indication that might give immediate cause for concern is aluminum oxide splatter in the hot section of the engine. Other colorations are normal and do not limit the service life of the engine.

WATER WASHING

Water washing an engine as a prerequisite to borescope inspections is the best way to achieve an accurate evaluation of an engine's condition. Dirt and soft carbon deposits may obscure small cracks and pitting that could be missed if the engine were dirty. For more information on borescoping procedures, you should consult the technical manual for *Internal Inspection and Evaluation of Marine Gas Turbine Engines (Model* LM2500), NAVSEA S9234-D1-GTP-010.

REPORTING INSPECTION RESULTS

Unless a discrepancy is found, you do not have to enter routine borescope inspections in the Marine Gas Turbine Engine Service Record (MGTESR). However, if the inspection was conducted as a troubleshooting procedure due to an engine malfunction or was ordered by a higher authority, you must log the inspection and note the findings. You must evaluate and report all major damage or exceeded service limits to NAVSEA. If the damage or wear is extensive, the engine must be replaced. Further information on the MGTESR is provided in chapter 1 of this TRAMAN and *Naval Ships' Technical Manual (NSTM),* chapter 234, "Marine Gas Turbines."

TROUBLESHOOTING

As a GS supervisor, you will find that successful troubleshooting is a rewarding experience. Proper use of the manufacturer's technical manual will enhance your professional abilities and result in getting the job done right the first time. This section discusses the use of the troubleshooting sections of the LM2500 GTE technical manual.

TROUBLESHOOTING TECHNIQUES

Troubleshooting is a systematic analysis of symptoms that indicate an equipment malfunction. These symptoms usually appear as deviations from the normal parameters. You must be able to recognize normal operating conditions to recognize abnormal operation. If you have a thorough knowledge of equipment systems and use logical reasoning, you will be able to solve most troubleshooting problems with little difficulty. The basic methods used during mechanical and electrical/electronic troubleshooting are as follows:

- Be sure you know the normal operating conditions (be able to recognize a problem).
- Find out everything about the nature of the malfunction. Write down all the symptoms and see if they follow an identifiable pattern.
- Check the obvious:

—Blown fuses

—Tripped circuit breakers

—Faulty alarms

—Loose connectors and cannon plugs

—Switches in the wrong position

—Burned-out lamps

—Physical damages

—Last PMS or maintenance procedure performed

—System alignment

LM2500 TROUBLE ISOLATION

The trouble isolation section (volume 2) of the LM2500 technical manual contains three chapters with troubleshooting information that will aid you in isolating faults and malfunctions in the LM2500 GTE and its ancillary equipment. The manual presents troubleshooting procedures in fault logic diagrams, fictional dependency diagrams (FDDs), and signal flow diagrams.

Fault Logic Diagrams

These diagrams are based on a fault indication observed during troubleshooting. The diagrams comprise a branching series of questions pertaining to fault isolation. Each question pertains to further observation or measurement, and results in a yes or no answer. In this way, the possible functional area of the fault is progressively narrowed. Tolerance values are presented in those instances where a definitive yes or no is not obtained. This progression and elimination will allow you to isolate the functional area of the equipment containing the fault. After lessening the possible causes, the diagram then refers you to the portion of the manual needed to complete the fault isolation and repair. Each diagram includes, or makes reference to, the information necessary to establish the test or operating conditions required for starting the fault isolation procedure. The following three types of blocks are used in fault logic diagrams.

- Shaded blocks (right and bottom border lines shaded) contain questions that may be answered from observation, without changing the test setup and without special equipment
- Single-line blocks contain questions requiring measurement by special setup of external test equipment
- Double-line blocks (conclusion blocks) list the fictional area within an equipment unit that is the probable source of the malfunction and reference a procedure or another diagram for further isolation or correction of a fault

Functional Dependency Diagrams

The FDDs are used to support troubleshooting of the gas turbine electronic power control system. An FDD is a block diagram that illustrates the fictional dependency of one test point (or circuit) upon another.

Signal Flow Diagram

The signal flow diagram depicts the circuitry for each of the main functions of the circuit that you are troubleshooting. The notes preceding the signal flow diagram contain instructions for establishing operating conditions and connecting test equipment that is required for measuring the circuit parameters. For more information on troubleshooting the LM2500, refer to *Propulsion Gas Turbine Module LM2500,* volume 2, part 1, NAVSEA S9234-AD-MMO-030/LM2500.

ECSS TROUBLESHOOTING PROCEDURES

This section will provide you with some simple, but helpful, information when isolating a fault in engineering control and surveillance system (ECSS) equipment. Remember, many of the tips previously mentioned are still applicable for electrical/electronics troubleshooting. To successfully troubleshoot any piece of ECSS equipment, you should keep the following five steps in mind:

1. Energize the equipment to full operation using the appropriate EOP steps and equipment lineups.
2. Identify the faulting functional area.
3. Locate the test and signal flow diagram relating to the faulting component.
4. Using the correct troubleshooting diagram, isolate the malfunction to the faulting replaceable or adjustable subassembly.
5. When a fault has been found to be in a specific replaceable subassembly, refer to the appropriate technical manual chapters for connective maintenance instructions.

When using the signal flow diagrams for troubleshooting, you should begin at the malfunctioning component and work back to the original signal source. By starting at the source of the problem, you should be able to identify and correct the problem in an efficient and timely manner.

TROUBLESHOOTING DIAGRAMS

The types of troubleshooting diagrams and charts used are the

- signal flow diagrams (description is given in previous section),
- power distribution diagrams,
- logic flow charts,
- timing diagrams,
- interconnecting diagrams,
- troubleshooting functional dependency diagrams, and
- the circuit card locator and function information plates.

Power Distribution Diagrams

Power distribution diagrams show the distribution of the primary ac power, secondary ac power, and the dc power from the input to the various components.

Logic Flow Charts

Logic flow charts have the event sequences as determined by the logic circuits. The charts are, in effect, pictures of the logic equations. They maybe used along with the logic equations found in chapter 3 of the S9234-series technical manuals.

Timing Diagrams

Timing diagrams are for all significant timing relationships. The diagrams show the exact timing relationships and the origin of all significant timing signals.

Interconnecting Diagrams

Interconnecting diagrams show the internal cabling between the consoles and the electronic enclosures. These diagrams identify the cabling and components by reference designations.

Troubleshooting Functional Dependency Diagrams

Troubleshooting fictional dependency diagrams (TFDDs) show the fictional dependency of one circuit upon another. The TFDDs are setup in pyramid fashion. The vertical chains of boxes show contributing branches of the signal development. They also show the fictional dependency through successive levels. The box at the top represents the function output of the equipment and reflects the results of all of the boxes below it.

Circuit Card Locator and Function Information Plates

Circuit card locator and function information plates (troubleshooting matrices) present the maintenance information you need to isolate a specific circuit card location. The matrix for troubleshooting is on the inside of the door of each electronic cabinet assembly (ECA).

The matrix relates the ship functions to the supporting circuit card within the ECA. The ship function column lists the ship function controlled or monitored. The qualifier column identifies the specific function listed in the function column. The type column identifies the function as a control, status, or alarm function. The card location column contains the card locations within the ECA. An *X* in the card location column indicates that the circuit card is in that location in the ECA card rack. The listings in the ship function column relate to the identities of the discrete panel readouts rather than the fictional groupings. The troubleshooting matrix can be used in conjunction with the demand display directories.

TROUBLESHOOTING EQUIPMENT

The tools and test equipment needed to properly adjust, align, calibrate, and troubleshoot the ECSS equipment are listed in volume 1, chapter 6, of all the S9234-series technical manuals. This is a list of all test gear, tools, and consumables needed. However, it does not necessarily mean that all of them have to be used on each piece of equipment. Equivalent tools and test gear with superior measuring capabilities may be substituted for the items shown by a double asterisk (**) before the name.

THE ALLISON 501-K17 GTE

Maintenance and troubleshooting procedures for the Allison 501-K17 GTE are similar to the procedures used for the LM2500 engine. In all cases, you must use the proper EOSS, PMS, and technical manuals when conducting any maintenance or troubleshooting.

Volume 2 of the *Model 104/Model 139 Gas Turbine Generator Set* technical manual is divided into two parts. Part 1 contains all the necessary information, procedures, and diagrams for locating a malfunction. Part 2 contains the corrective maintenance procedures for adjustment and alignment, repair, and removal/ replacement of components.

When entering and working within the engine enclosure, follow the proper EOSS procedures and all standard safety precautions at all times.

COMPONENT CHANGEOUT

Gas turbine-powered ships are outfitted with all the equipment necessary to remove and replace engine components. As a senior petty officer, you will be supervising component changeouts. As with any job, you must plan and organize before starting the project. Since most GTE problems occur while the ship is underway, corrective maintenance must be performed immediately. If you insist upon strictly following step-by-step procedures as set forth in the technical manual, you will save time by preventing errors. Do **not** rely upon your memory for component changeouts.

PREPARATIONS

Before changing components on a GTE, be sure that the replacement parts and tools needed to do the job are available. Inspect all measuring devices (such as torque wrenches, meters, and micrometers) to ensure they are in calibration. Also be sure that you and your team have read the proper technical manual procedures.

One method that helps ensure proper use of the technical manual procedures is to provide team members with a copy of the procedures. Have them check off each step as it is completed

ESTIMATED TIME OF REPAIR

When making an estimated time of repair (ETR), you must be as accurate as possible. Your ETR could ultimately affect the operational schedule of the ship. Take into account all the factors that may affect an ETR, such as capabilities of your personnel, availability of materials, test procedures, preparations, and time for unexpected delays.

REPLACEMENT

As a supervisor, your primary concern is for the safety of your personnel and equipment. As a responsible petty officer, you set the example. Short cuts that go around safety precautions do not save time. You can prevent accidents and save time by explicitly following safety precautions and actively using safety programs such as tag-out and electrical safety.

During component changeout, keep track of tools going into and out of the GTE enclosure. Be sure your personnel use care when removing lockwires, cannon plugs, and so forth. Tag and bag all bolts, nuts, washers, and interferences that are removed for reinstallation. Capping fluid lines will prevent contamination of open systems. Use care when replacing GTE components. Most problems that arise after component replacement are easily avoided. Just remember to work carefully and always follow the procedures listed in the technical manuals.

COMPLETION OF REPAIRS

After GTE repairs are complete, ensure that the proper entries are made in the MGTESR. and Engineering Log. If the replaced component is from selected equipment, make sure you follow procedures outlined in NSTM, chapter 234, "Marine Gas Turbine Equipment Log Books and Service Records," section 8.

When preparing turn-in components for shipment, plug or cap all openings. Do not take the components apart to look inside. You may damage the component and distort the findings of the testing facilities. The repair activity must make a determination of cause of failure. Other activities collect and use information on failed components to create design improvements.

LM2500 ENGINE CHANGEOUT

At some point in your career, you may have the opportunity to supervise an engine changeout. This section discusses this topic from a supervisory standpoint. For more information on procedures for engine changeout and post changeout adjustments, you should consult the *Propulsion Gas Turbine Module LM2500,* volume 2, part 3; the Gas *Turbine Generator Set,* volume 2; and the *Team Leader Guide for FFG-7 Class Ships* or the *Team Leader Guide for DD-963 Class Ships,* as applicable.

PREPARATION

Planning a full-scale evolution such as a GTE changeout takes effort, coordination, and drive. Careful planning is an essential ingredient to your effective supervision of a GTE changeout. You can reduce delays and confusion by anticipating the needs of escorts and clearances for intermediate maintenance activities (IMAs), civilians, and other personnel involved.

An organizational meeting of all personnel, including those involved with ancillary tasks (crane operators, hook tenders, riggers, and so forth), is necessary to plan the evolution. At the meeting you should inform each individual of his or her responsibility to the overall team effort. Explain how each job affects the effort and completion schedule. You should distribute monitoring guides and inventory lists to the parties concerned with an explanation of how and when to use them. During the meeting, you should clarify the time frame established for each task completion. Having given personnel clear directions, you can expect them to perform the procedures on schedule. They should not be surprised when you arrive for a checkpoint verification. The most important topic to emphasize is safety. It is your responsibility as team leader to ensure that all safety precautions are strictly followed.

Assign a safety observer to your changeout team. His/her sole responsibility is to ensure the safety of personnel working inside the GTE module and uptakes. The safety observer should ensure ancillary personnel and technicians are qualified for tasks assigned and all safety equipment is on station before starting changeout.

COORDINATION

You can reduce or eliminate wasted of time by properly coordinating several tasks throughout the changeout. Simple things such as the proper placement of the special support equipment (SSE) containers can eliminate extra walking and moving of components. The SSE containers should be placed within the reach of the crane to avoid unnecessary movement of equipment into the lift area. Crane service must be controlled and used exclusively for the changeout. The engine containers should be brought to the site as soon as possible so they can be opened and ready for installation when scheduled.

Team members must coordinate amongst themselves for certain functions, such as the removal and installation of components and the constant passing of fixtures down and into the module. Communication between team members during the changeout process is very important. One way you can enhance both teamwork and communications is by the use of portable radio equipment.

POST CHANGEOUT REQUIREMENTS

With the completion of an engine changeout, you must return the SSE and container to the cognizant repair (support) facility. The damaged engine is packaged in a container and is then shipped to the appropriate NADEP for repairs. The paper work involved in the changeout is lengthy, but necessary for proper documentation. careful preparation of SSE containers and engine containers will ensure they will reach their final destination with no shipping damage.

Returning Containers

Returning the replaced gas generator, power turbine," and containers requires that the major components plus the $T_{5.4}$ and $P_{t5.4}$ harnesses and the speed sensors of that engine be packed within the containers. The completed log book is also returned with the container. After everything is secured within the containers and the desiccant bags have been dried out/changed, the cover is bolted down and pressurized with nitrogen for shipment. The ship's supply department is responsible for shipping the engine containers to the designated NADEP.

When the SSE containers have been completely inventoried, restacked, and secured, the supply system is responsible for returning the empty containers to their place of origin. The 05X32 office of NAVSEA is notified of the condition of the containers by the team leader via the chain of command.

Reports

Reports from the team leader require the completion of the record log book for each component and the proper closeout of that log before stowage in the engine containers. All entries should be complete up to the time of changeout, checked for correctness, and signed off by the engineer officer. The SSE containers that were inventoried on arrival are to be inventoried again at completion for reissue to the next user. The engineer officer and main propulsion assistant are required by squadron directives to notify the proper people of any irregularities at the completion of the changeout. If lessons were learned because of the changeout, notify the people concerned. Any unique or suspect occurrences could be very valuable sources of information.

LESSONS LEARNED

The following section describes some lessons learned during engine changeouts.

Pierside Changeouts

Since the first changeout on the SPRUANCE class ships, problem areas and past discrepancies during pierside changeouts have been numerous. Problems such as location of the equipment and containers at pierside can delay the job. When equipment or containers are placed out of the crane's reach, the delay is costly and frustrating.

Some changeouts have been hampered by crane service that was not totally dedicated to the job of engine changeout. Many hours were lost awaiting the crane. Crane services are needed full time throughout the changeout. All concerned personnel should realize that to complete the changeout on time, the crane and operator's services are required the full 36 hours. Engine lifting is not all that is required of the crane. Every component of the rail system plus all the lift fixtures require crane services. The crane will be in constant use, especially when the personnel basket is used. Personnel are also required to check the engine's guide rollers in the permanently mounted guide tracks for freedom of movement.

At times, inclement weather has caused difficulties. This is especially true in an unprotected harbor where the water roughness or groundswells have had an effect on the movement of the ship at the pier. Therefore, to facilitate the changeout, the ship must be pierside and should be inboard of any other ship(s) present. Sometimes, floating cranes have been used, but the evolution was still hampered by the elements.

Tenderside Changeouts

Tenderside changeouts have problems of a different nature. The tender is a stationary platform. The ship must be moved and positioned around the tender to help the crane service. The SSE containers, when stored on the tender and within reach of the crane, were on the 03 or 04 level. This made travel to and from the containers very difficult.

Horizontal Rail Systems

The horizontal rail systems also have had problems. Some of these problems are attributed to a lack of inspection before use.

— To ensure safe and proper handling of the engine and/or components by the crane operator, have the ship ballasted to remove any listing.

—Dry trunnion bearings on rail stanchions are difficult to turn. This is especially true if the adjustment ring holes have been elongated. Therefore, a grease lubricant (MLG-G-10924 or equivalent) should be used to lubricate the adjustment ring.

—The horizontal rail flanges, when not properly lined up, will make the gas generator separation hazardous. Misaligned rail flanges may cause the gas generator position to shift and possibly damage the C-sump air seals. On mating up gas generator to power turbine, the No. 6 bearing cage can be damaged when the front-frame lift fixture roller crosses the forward flange in the rail. This makes the gas generator shift weight.

—The adjustable rollers on the lift fixtures are susceptible to corrosion. Corrosion may cause the roller to jam into one position. If not properly lubricated before use, the adjustable rollers on the lift fixtures are capable of freezing up. This makes it impossible to center the engine.

—When not properly serviced and filled with cylinder oil, the hydraulic support mechanism for the compressor front frame will not permit the jack to be extended far enough to support the front frame for removal of the support pins.

—Ensure all feeder rail sections are installed and aligned before checking the travel of the system with a hand-held roller.

—If a bearing failure necessitates an engine changeout, a complete flushing of the lube oil system is required.

Tag and Bagging Practices

There is evidence that tagging and bagging practices on engine changeouts have not been followed to the letter. This costs time during reassembly. Proper identification is a valuable asset when the new engine is reassembled in place. Lost and broken bolts, in some cases, do not exist as onboard spares. Therefore, you need to exercise care in disassembling and handling. Once bags have been filled and identified, place them in a secure place until they are required for the reassembly.

Replacement Engines

Replacement engines, when received, may not be complete with all the fittings and adapters necessary for connection. In some cases, a replaced engine was in the container and heading for the supply depot before this discovery was made. This caused additional time to be wasted reopening the container and resealing it after the parts or items were removed. Time has also been lost when the replacement engine's turbine midframe flange was improperly clocked and another engine had to be brought to the changeout site.

Silencers

Mark the location of the silencer hold-down brackets before removal. Proper marking makes it much easier to reinstall the brackets and silencers.

Quality Assurance

Review QA requirements of *Combined Forces Afloat Quality Assurance Manual,* COMNAVSUR-FLANTINST 5090.1A and COMNAVSURFPACINST 4855.22, for level A repairs.

GTG ENGINE CHANGEOUT

GTG engine changeout procedures are described in detail in the technical manuals, *Model 104 Gas Turbine Generator Set,* volume 2, and *Model 139 Gas Turbine*

Generator Set, volume 2. These procedures provide detailed engine and interference removal instructions. These instructions should be strictly followed due to the vast differences in removal procedures between a propulsion GTE and an SSGTG.

You must use the same planning skills and engineering practices in a GTG engine changeout as you use in an LM2500 GTE changeout. The same strict application of safety precautions and following of technical manual procedures apply to every GTG engine changeout.

COOPERATION

Ship's readiness is the common purpose in the changeout evolution. All personnel involved should share a common commitment in achieving that purpose. A willingness by each individual to submerge his or her personal interest in favor of getting the job done is a necessary prerequisite to cooperation. You may have to adjust working hours and watch-standing duties to meet changeout schedule requirements. Personnel may be assigned to duties they do not want to perform. Emphasize each individual's importance, willingness, and contribution to the evolution. Engine changeout is an opportunist y to display your professional abilities as a leader and technician

MAINTENANCE TIPS

As a GS supervisor you will be responsible for the proper completion of most maintenance procedures. This section will cover some maintenance tips that can help you to understand the critical relationship between maintenance performance and the proper operation of the LM2500. Remember, the contents of this section are **FOR TRAINING PURPOSES ONLY** and should in no way replace the use of the PMS or the manufacturer's maintenance procedures.

PLA RIGGING

If the PLA is replaced for whatever cause, the PLA rig check (mechanical and electrical) must be accomplished. If the main fuel control (MFC) rig pin does not fit properly (too loose, too tight, or can't be fully inserted), re-rig the PLA. Always comply with the PLA electrical rig check after you are assured that the throttle command voltages are properly set (idle and full throttle).

Mechanical

The key to a successful mechanical rigging is a proper alignment. Remember, although the PLA actuator arm is mechanically linked to the MFC lever arm, the PLA is electrically driven. The slightest mechanical restriction (binding) may cause incorrect PLA movement during engine operation. PLA movement is most sensitive to a restriction when in either engine speed or torque, and/or shaft torque limiting condition. If a possible restriction is suspected, advance and retard the PLA electrically and check for any hesitation or jerking during travel. If hesitation exists, there may be a mechanical restriction.

Electrical

The normal process for this rigging will be checking dc voltages at idle and full throttle positions. However, the moment the throttle is moved out of idle, indicated torque will go to midrange and oscillate. For example, on the DD-963/DDG-993 class ships, if mid-torque oscillations are accompanied by an overtorque indication and a PLA failure indication, then another problem exists.

Why? When the PLA is at idle, there is a $PT_{5.4}$ bias that assures $PT_{5.4}$ is greater than PT_2 for engine start purposes. During PLA electrical rigging, the bias drops out when the throttle is advanced.

If $PT_{5.4}$ is several tenths of a pound less than PT_2, the torque computer goes berserk. But, PLA rigging may be continued by pressing the BATTLE OVERRIDE button.

However, suppose you have just been informed that the $PT_{5.4}$ transducer requires calibration When the torque goes berserk as described, immediately dial up $PT_{5.4}$ and PT_2 on the respective DDIs. $PT_{5.4}$ will be lower than PT_2, thus requiring the activation of BATTLE OVERRIDE to continue. This lower reading tells you the $PT_{5.4}$ transducer requires calibration.

VSV FEEDBACK CABLE RIGGING

Why is it accomplished? Why is it important?

VSV feedback cable rigging is necessary because we are "timing" a pilot valve inside the MFC so the correct vane angle is obtained for a given CIT/gas generator speed day. Actually, we are assuring that the pilot valve is timed to close off high pressure fuel flow to both the ROD END and the HEAD END pressure ports inside the MFC. These pressure ports direct the fuel flow to the vane actuators via tubing.

This timing is accomplished by pumping the vanes to the full open position and maintaining 100 to 200 psig on the system. At the same time, be sure you check to see if the bottom of the rig plates are parallel with each other. NEVER relax the pressure on the system while performing the rig plate check. If the pressure is relaxed, the feedback lever may drift and the rig will be incorrect.

When the system is full open, and 100 psig is applied, try to move the bolt back and forth on the forward end of the cable at the bellcrank. If the bolt cannot be moved, it most likely indicates a binding at the front section of the cable assembly. Of course, this "assumes" that the bolt is of the correct diameter and is normally free to move. If the bolt cannot be moved back and forth, reverse the pump selector handle to the RE (rod end) position. You then need to apply a few strokes to move the vanes slightly towards the closed position. If the bolt becomes free to move, the forward section of the cable assembly is definitely binding. Binding is easily connected by loosening the jamnut on the forward rod end bearing and rotating the rod end bearing a half turn at a time. This adjustment shortens the distance (right-hand rotation) and usually solves the problem. Reinstall and recheck the rigging. If the rigging is still slightly off, use the trimmer bracket adjustment to make the correction.

The bottom line

What are you really trying to accomplish? Look at it this way. The system is pumped full open, and the piston inside each actuator is physically bottomed out. This in turn fixes the position of the bellcrank bolt hole when a minimum of 100 psig is maintained. If you manually hold the feedback lever arm in order to match the bottom of the rig plates, the plates become parallel to each other. The two fixed ends now have a fixed distance between them. By adjusting the length of the cable assembly, you will maintain a proper fit between the two fixed points.

You have now successfully accomplished a VSV feedback cable rigging. You were able to do so by a combination of adjusting the fore and aft rod end bearings within the limitations and following the published trimmer bracket instructions.

VSV SCHEDULING

VSV scheduling is verified by using the variable vane protractor (1C5714). You must check the protractor for accuracy before every use on the engine. The check will detect any inaccuracies due to damage, wear, and so forth. Use the protractor setmaster (9441M67G01) to accomplish this test. The protractor is installed on the master vane located at the 9 o'clock split line, aft looking forward.

CAUTION

Do not check the vane angle if idle speed is less than 4,900 rpm, or greater than 5,000 rpm. Before adjusting the idle rpm screw on the MFC, assure PLA mechanical and electrical rigging is connect.

Once the protractor's accuracy has been verified, you are now ready to install the protractor on the engine. Install the protractor locator on the engine and ensure it mounts correctly (it will only goon one way correctly).

If installed incorrectly, the shaft cannot be threaded on the vane stud. If the locator is wiggled around so that the shaft can be threaded on the vane stud, it will be cocked, but the protractor can still be installed over the locator. However, the vane angle is now 4° too far open.

If the protractor is left in this position, the angle will be 4° more open when checked at idle rpm than when compared to the table. This means a perfectly serviceable engine could be rejected because it failed the angle check. When installed correctly, the locator is flush to the lever and, at the same time, the shaft can be threaded on the vane stud without wiggling it around.

GAS TURBINE PRESERVATION AND CORROSION CONTROL

Modern gas turbines and their support equipment are dependent upon the structural soundness of the metals from which they are fabricated. The greatest threat to the structural integrity of this equipment is metal corrosion. With the higher demands being made on these metals, both in strength and in closer tolerances, this equipment would rapidly deteriorate and become inoperative without regular attention to corrosion control.

Corrosion endangers the gas turbine and its support equipment by reducing the strength and changing the structural characteristics of the materials used in their construction. All such materials are designed to carry certain loads and withstand given stresses and temperatures, as well as to provide an extra margin of strength for safety. Corrosion can weaken the structure, thereby reducing or eliminating this safety factor. Replacement or repair operations are costly, time consuming, and restrict the usage of the equipment. Corrosion in electronic and electrical components can cause serious malfunctions. These malfunctions reduce the effectiveness and reliability of the engineering plant and can often completely destroy these components.

A thorough comprehension of the dangers of corrosion and the ability to recognize and cope with the various types of corrosion should be included in the objectives of any maintenance training program. As a work center supervisor, you may find that corrosion prevention and control frequently turn out to be an all-hands evolution. To some extent you can avoid this situation through frequent inspections, effective use of available manpower, and proper training of your subordinates.

CORROSION

The problem of gas turbine engines and support equipment protection is threefold: (1) prevention of corrosion of the metal parts; (2) control of deterioration of nonmetallic materials; and (3) elimination of physical damage during replacement, repair, and maintenance. Of the three basic problems, corrosion of metals is the most difficult to control.

Metal corrosion is the deterioration of a metal. When the metal is combined with oxygen, it forms metallic oxides. This combining is a chemical process that is essentially the reverse of the process of smelting metal from ore. Very few metals occur in nature in the pure state. For the most part, they occur as metallic oxides. The refining process involves the extraction of relatively pure metal from its ore and the addition of other elements (both metallic and nonmetallic) to form alloys.

After refining, regardless of whether or not they are alloyed, base metals possess a potential or tendency to return to their natural state. However, this potential is not enough in itself to initiate and promote this reversion. There must also exist a corrosive environment in which the significant element is oxygen. It is the process of oxidation that causes metals to corrode.

It is a well-known fact that the tendency to corrode varies widely between various metals. For example, magnesium alloys are very difficult to protect and have a very low corrosion resistance. Copper alloys have relatively good corrosion resistance and are very easy to protect.

Corrosion may take place over the entire surface of a metal by having a chemical reaction with the surrounding environment. Or corrosion may be electrochemical in nature between two different metallic materials or two points on the surface of the same alloy that differ in chemical activity. The presence of some type of moisture is usually essential for corrosion to exist.

CAUSES

Prevention and control of corrosion begins with an understanding of the causes and nature of this phenomenon. As stated earlier, corrosion is caused by an electrochemical or a direct chemical reaction of a metal with other elements. In the direct chemical attack, the reaction is similar to that which occurs when acid is applied to bare metal. Corrosion in its most familiar form is a reaction between metal and water and is electrochemical in nature.

In an electrochemical attack, metals of different electrical potential are involved and they need not be in direct contact. When one metal contains positively charged ions and the other metal contains negatively charged ions and an electrical conductor is bridged between them, current will flow as in the discharge of a dry-cell battery. In this type of reaction, the conductor bridge may be any foreign material such as water, dirt, grease, or any debris that is capable of acting as an electrolyte. The presence of salt in any of the foregoing media tends to accelerate the current flow and hence speed the rate of corrosive attack.

Once the electrolyte has completed the circuit (fig. 2-32), the electron flow is established within the metal in the direction of the negatively charged area (cathode). The positively charged area (anode) is eventually destroyed. All preventive measures taken with respect to corrosion prevention and control are designed primarily to avoid the establishment of an electrical circuit. Or secondly, to remove electron flow as soon as possible after its establishment before serious damage can result.

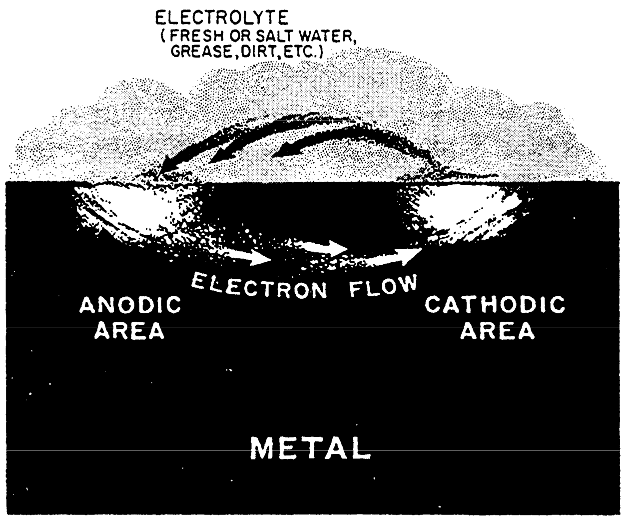


Figure 2-32.—Simplified corrosion cell.

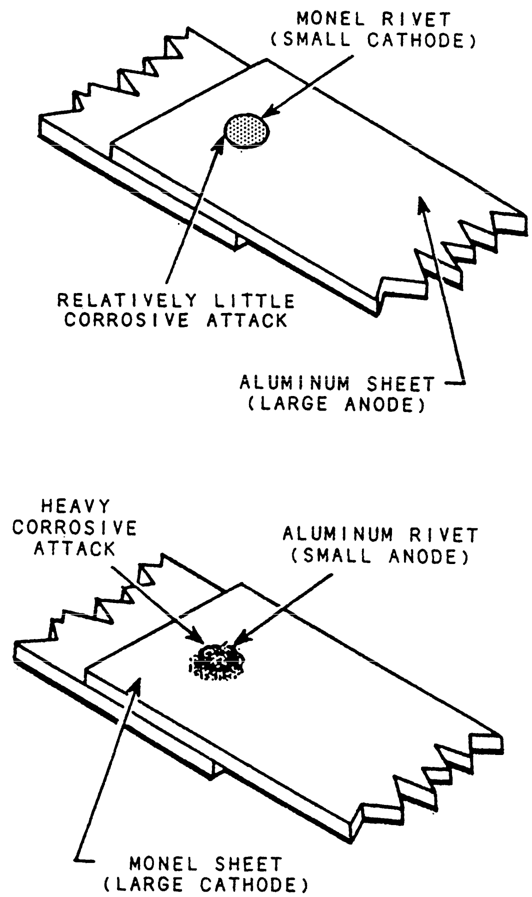
Electrochemical attack is evidenced in several forms depending on the metal involved, its size and shape, its specific function, the atmospheric conditions, and the type of corrosion-producing agent (electrolyte) present. A great deal is known about the many forms of metal deterioration that result from electrochemical attack. But despite extensive research and experimentation, there is still much to be learned about other more complex and subtle forms of metal deterioration. Descriptions are provided later in this chapter for the more common forms of corrosion.

Since there are so many contributing factors to the process of corrosion, selection of materials by the manufacturer must be made with weight versus strength as a primary consideration and corrosion properties as a secondary consideration. However, close attention during design and production is given to heat treating and annealing procedures, protective coatings, choice and application of moisture barrier materials, dissimilar metal contacts and accesses. Every logical precaution is taken by the manufacturers to inhibit the onset and spread of corrosive attacks.

There are many factors that affect the type, speed, cause, and seriousness of metal corrosion. Some of these factors can be controlled; others cannot. Preventive maintenance such as inspection, cleaning, painting, and preservation are within the control of maintenance personnel. Preventive maintenance offers the most positive means of corrosion deterrence.

The electrochemical reaction that causes metal to corrode is a much more serious factor under wet, humid conditions. The salt in seawater and in the air is the greatest single cause of corrosion. Hot environments speed the corrosion process because the electrochemical reaction develops faster in a warm solution. Warm moist air is usually sufficient to start corrosion if the metal surfaces are unprotected.

Another corrosion factor is the relationship between dissimilar metals. When two dissimilar metals come in contact, if the more active metal is smaller than the less active one, corrosive attack will be severe and extensive. Insulation between such contact will inhibit this process. If the area of the less active metal is small compared to the other metal, corrosive attack will be relatively slight (fig. 2-33).



A. Compressor Blade Nomenclature
B. Liner Band Numbering
C. Combustor Assembly Nomenclature
D. HP Turbine Nozzle Nomenclature
E. HP Turbine Rotor Blade Nomenclature
F. Power Turbine Nozzle Nomenclature
G. Power Turbine Rotor Blade

Figure 2-33.—Effects of area relationships in dissimilar metal contacts.

CHARACTERISTICS

The appearance of corrosion will vary with the metal involved. The following discussion includes brief descriptions of typical corrosion product characteristics. These descriptions are only for the most common materials used in gas turbine propulsion and support equipment.

Iron and Steel

Possibly the best known and most easily recognized of all forms of metal corrosion is the familiar reddish-colored iron rust. When iron and its alloys corrode, dark iron oxide coatings usually form first. These coatings, such as heat scale on steel sheet stock and the magnetite layer that forms on the inside of boiler tubes, protect iron surfaces rather efficiently. However, if sufficient oxygen and moisture are present, the iron oxide is soon converted to hydrated ferric oxide, which is conventional red rust. Hydrated ferric oxide, red rust, does not protect surfaces. It destroys surfaces.

Aluminum

Aluminum and its alloys exhibit a wide range of corrosive attacks, varying from general etching of surfaces to penetrating attacks along the internal grain boundaries of the metal. The corrosion products of aluminum are seen as white-gray powdery deposits.

Copper and Copper Alloys

Copper and its alloys are generally corrosion resistant, although the products of corrosive attack on copper are commonly known. Sometimes copper or copper alloy surfaces will tarnish to a gray-green color, while the surface will remain relatively smooth. This discoloration is the result of the formation of a fine-grained, airtight copper oxide crust, called a patina.

Patina offers good protection for the underlying metal in ordinary situations. However, exposure of copper alloys to moisture or salt spray will cause the formation of blue or green salts called verdigris. The presence of verdigris indicates active corrosion.

Cadmium and Zinc

Cadmium is used as a coating to protect the area to which it is applied and to provide a compatible surface when the part is in contact with other metals. The cadmium plate supplies sacrificial protection to the underlying metal because of its great activity. During the time it is protecting the base metal, the cadmium is intentionally being consumed. Zinc coatings are used for the same purpose, although to a lesser extent. Attack is evident by white-to-brown-to-black mottling of the surfaces. These indications do NOT indicate deterioration of the base metal. Until the characteristic colors peculiar to corrosion of the base metal appear, the coating is still performing its protective function.

Nickel and Chromium Alloys

Nickel and chromium alloys are also used as protective agents. They are used as electroplated coatings and as alloying constituents with iron in stainless steels and with other metals such as copper. Nickel and chromium plate provide protection by the formation of an actual physical noncorrosive barrier over the steel. Electroplated coatings, particularly chromium on steel, are somewhat porous. Eventually, corrosion starts at these pores unless a supplementary coating is applied and maintained.

TYPES OF CORROSION

As stated previously, corrosion may occur in several forms, depending upon the metal involved, its size and shape, its specific function, the atmospheric conditions, and the corrosion-producing agents present. Those corrosion types described in this section are the most common forms found on gas turbine engines and machinery structures.

Direct Surface Attack

The surface effect produced by reaction of the metal surface to oxygen in the air is a uniform etching of the metal. The rusting of steel, tarnishing of copper alloys, and the general dulling of aluminum surfaces are common examples of direct surface attacks. If such corrosion is allowed to continue unabated, the surface becomes rough, and in the case of aluminum, frosty in appearance. Direct surface attack is sometimes referred to as uniform etch corrosion.

Galvanic Corrosion

Galvanic corrosion is the term applied to the accelerated corrosion of metal caused by dissimilar metals being in contact in a corrosive medium.

Dissimilar metal corrosion is usually a result of faulty design or improper maintenance practices which result in dissimilar metals coming in contact with each other. This is usually seen as a buildup of corrosion at the joint between the metals. For example, when aluminum pieces are attached with steel bolts and moisture or contamination are present, galvanic corrosion occurs around the fasteners.

Pitting

The most common effect of corrosion on aluminum alloys is pitting. It is caused primarily by variations in the grain structure between adjacent areas on the metal surfaces that are in contact with a corrosive environment. Pitting is first noticeable as a white or gray powdery deposit, similar to dust, that blotches the surface. When the superficial deposit is cleaned away, tiny pits or holes can be seen in the surface. These pits may appear either as relatively shallow indentations or as deeper cavities of small diameters. Pitting may occur in any metal, but it is particularly characteristic of aluminum and aluminum alloys.

Intergranular Corrosion

Intergranular corrosion is an attack on the grain boundaries of some alloys under specific renditions. During heat treatment, these alloys are heated to a temperature that dissolves the alloying elements. As the metal cools, these elements combine to form other compounds. If the cooling rate is slow, they form predominantly at the grain boundaries. These compounds differ electrochemically from the metal adjacent to the grain boundaries. These altered compounds can be either anodic or cathodic to the adjoining areas, depending on their composition. The presence of an electrolyte will result in an attack on the anodic area. This attack will generally be quite rapid and can exist without visible evidence.

As the corrosion advances, it reveals itself by lifting up the surface grain of the metal by the force of expanding corrosion products occurring at the grain boundaries just below the surface. This advanced attack is referred to as EXFOLIATION. Recognition and necessary corrective action to immediately correct such serious instances of corrosion are vital. This type of attack can seriously weaken structural members before the volume of corrosion products accumulate on the surface and the damage becomes apparent.

Fretting

Fretting is a limited but highly damaging type of corrosion caused by a slight vibration, friction, or slippage between two contacting surfaces that are under stress and heavily loaded. Fretting is usually associated with machined parts such as the contact area of bearing surfaces, two mating surfaces, and bolted assemblies. At least one of the surfaces must be metal.

In fretting, the slipping movement at the interface of the contacting surface destroys the continuity of the protective films that may be present on the surfaces. This action removes fine particles of the basic metal. The particles oxidize and form abrasive materials that further accumulate and agitate within a confined area to produce deep pits. Such pits are usually located where they can increase the fatigue potential of the metal.

Fretting is evidenced at an early stage by surface discoloration and by the presence of corrosion products in any lubrication. Lubricating and securing the parts so that they are rigid are the most effective measures for the prevention of this type of corrosion.

Stress

Stress, evidenced by cracking, is caused by the simultaneous effects of tensile stress and corrosion. Stress may be internal or applied.

Internal stresses are produced by nonuniform deformation during cold working conditions, by unequal cooling from high temperatures during heat treatment, and by internal-structural rearrangement involving volume changes. Stresses set up when a piece is deformed. Examples of internal stresses include those induced by press-and-shrink fits and those in rivets and bolts.

Concealed stress is a more dangerous condition than design stress. Concealed stress corrosion is difficult to recognize before it has overcome the design safety factor. The magnitude of the stress varies from point-to-point within the metal. Stresses in the neighborhood of the yield strength are generally necessary to promote stress corrosion cracking, but failures may occur at lower stresses.

Fatigue

Fatigue is a special type of stress corrosion. It is caused by the combined effects of corrosion and stresses applied in cycles. An example of cyclic stress fatigue is the alternating loads to which the connecting rod of a double-acting piston in an air compressor is subjected. During the extension (up) stroke a compression load is applied, and during the retraction (down) stroke a tensile or stretching load is applied. Fatigue damage is greater than the combined damage of corrosion and stresses. Fracture of a metal part due to fatigue corrosion generally occurs at a stress far below the fatigue limit in a laboratory environment, even though the amount of corrosion is very small. For this reason, protection of all parts subject to alternating stress is particularly important wherever practical, even in environments that are only mildly corrosive.

PREVENTION AND CONTROL

Much has been done over the years to improve the corrosion resistance of newer Navy warships. Improvements include the selection and combination of materials of construction, chemical surface treatments, insulation of dissimilar metals, and protective paint finishes. All these improvements are aimed at reducing maintenance as well as improving reliability. Despite refinements in design and construction, corrosion control is a problem that requires a continuous maintenance program.

With this idea in mind, the NAVSEASYSCOM has developed some excellent ship class corrosion control manuals for you to use as reference tools aboard ship. There are two manuals a GS supervisor should read. They are the *Corrosion Control and Prevention Manual* for DD-963 class ships, NAVSEA S9630-AB-MAN-010, and the *Standard Corrosion Control Manual,* NAVSEA S9630-AE-MAN-010.

Cleaning

As a leading petty officer or work center supervisor, one of your most important aids in the prevention and control of corrosion is an adequate cleaning program. The term *clean* means to do the best job possible using the time, materials, and personnel available. A daily wipedown of all machinery is better than no cleaning at all. The importance of frequent cleaning cannot be overemphasized. Any cleaning procedures, however, should be in the mildest form possible to produce the desired results. For example, spraying water around multipin connectors can cause electrical shorts or grounds, with a possible loss of control functions or equipment damage.

In general, gas turbine engines and enclosures should be cleaned as often as necessary to keep surfaces free of salt, dirt, oil, and other corrosive deposits. A thorough inspection and cleaning of gas turbine intakes and enclosures should always be done in conformance with PMS requirements. These cleanings and inspections should be done before getting underway, after an extended stay in port, and after returning to port from an extended time at sea.

Since marine gas turbines are more subject to internal corrosion than engines used in other types of applications, internal cleaning is of particular importance. This is accomplished by means of water washing. A mixture of B & B 3100 water-wash compound and distilled water is injected into the engine air inlet while it is being motored and then rinsed with distilled water in the same manner. It is then operated for about 5 minutes to remove all liquid. For more detailed information on this procedure, consult the applicable PMS card.

Characteristics of Metals

As a GS supervisor, you should have a thorough knowledge of the characteristics of the various metals used throughout the engineering plant, as well as the engines themselves.

To some extent, all metals are subject to corrosion To keep corrosion to a minimum, corrosion-resistant metals are used to the fullest extent possible consistent with weight, strength, and cost considerations. On exposed surfaces, the major preventive for providing relative freedom from corrosion is a coating of protective surface film. This film can be in the form of an electroplate, paint, or chemicaI treatment, whichever is most practical.

Most of the metals used in the engineering plants require special preventive measures to guard against corrosion. In the case of aluminum alloys, the metal is usually anodized or chemically treated and painted. Steel and other metals such as brass or bronze (with the exception of stainless steels) use cadmium or zinc plating, protective paint, or both. In all cases, the protective finish must be maintained to keep active corrosion to an absolute minimum.

PRESERVATION AND DEPRESERVATION OF GAS TURBINE ENGINES

The main purpose of engine preservation is to prevent corrosion of the various types of materials that make up the engine and its accessories. Preservation also ensures against gumming, sticking, and corrosion of the internal passages.

Engine preservation and depreservation is vital because the corrosion of engine structures can and does have a great effect on the operational and structural integrity of the unit. Therefore, it is important that you know about methods of preservation, materials used, and depreservation procedures.

PRESERVATION AND PACKAGING FOR STORAGE

If you know that an engine is to be shipped or stored, you must make plans to preserved it prior to removal from the ship. Engines to be taken out of operation for periods of up to 1 month require only that the unit be protected from the elements. Units that will be stored or out of service for more than a month must be preserved for storage.

Packaging for storage should comply with current instructions for engine shipment furnished by the manufacturers. If specific manufacturer's instructions are not available, then the engine should be placed in a hermetically sealed metal container with a humidity control and an external humidity indicator.

All major engine parts, no matter how badly worn or damaged, must be returned with the engine whether it is to be overhauled or salvaged. Remember, the entire assembly (engine and accessories) must be protected from damage during shipment. When preparing the engine for shipment, you must be sure that all fuel lines, receptacles, oil lines, intakes, exhausts, and any other openings in the engine or its components are capped or covered before the engine is removed.

For further information, packaging requirements are given in MIL-E-17341, MIL-E-17555, and MIL-E-17289.

DEPRESERVATION

An engine that has been in storage, or inoperable for an extended period of time, must be depreserved before it can be placed in service. Before connecting the engine to the external portion of the fuel and oil system (supply tank, coolers, falters, and so forth), the external tubing and equipment must be thoroughly flushed and purged. After installation, fill the oil sump (Allison) or LOSCA (LM2500) with clean lubricating oil to the proper operating level.

CAUTION

To prevent accidental firing, ensure that the engine ignition circuit is disconnected when priming the fuel control and the fuel system.

Before initial operation, the engine fuel system must be flushed and purged. To accomplish this, the engine is motored until all bubbles are out of the fuel stream and only fuel comes through. While motoring, observe the engine oil pressure. If no pressure is indicated, the cause must be determined and corrected before the engine can be started. In all cases, the manufacturers' technical manual must be consulted for specific instructions on the depreservation and start-up of each particular engine.

SUMMARY

In this chapter we have discussed object damage, borescope inspection, and troubleshooting related to GTEs. We also discussed corrosion, its causes, effects, and some of the methods available to us to combat and minimize it. Since a TRAMAN is not designed to deal with all aspects of anyone subject, you should study the various publications on the prevention and control of corrosion mentioned in this chapter. of particular interest are the *Propulsion Gas Turbine Manual LM2500,* volume 2, part 2, S9234-AD-MMO-040 LM2500; the *NSTM,* chapter 234, "Marine Gas Turbines," S9086-HC-STM-000; and *Corrosion Control and Prevention Manual for DD-963 Class Ships,* NAVSEA S9630-AB-MAN-010. Throughout this chapter and again in the summary you have often been referred to the applicable technical manuals or the PMS for specific information. You must use these references to guide you through the procedures. Proper use of the technical manuals and the PMS will ensure that you make a complete inspection and/or properly isolate a problem.

Table 2-1a.—LM2500 Condition Codes

CONDITION OF PART	CODE	DEFINITION	RELATED TERMS
ACCEPTABLE	01	Satisfactory for further use.	OK, Checked OK
BATTERED	02	Damaged by repeated blows or impacts.	
BENT	03	Sharp deviation from original line or plane, usually caused by lateral force. Example: Creased or folded sheet metal.	Creased, Folded, Kinked
BINDING	04	Restricted movement such as tightening or sticking condition, resulting from high or low temperature, foreign object jammed in mechanism, etc.	Sticking, Tight
BOWED	05	Curved or gradual deviation from original line or plane usually caused by lateral force and/or heat.	
BROKEN	06	Separated by force into two or more pieces. (Complete destruction of cohesion.)	Fractured
BULGED	07	Localized outward or inward swelling, usually caused by excessive local heating and/or differential pressure.	Ballooned, Swelling
BURNED	08	Destructive oxidation, usually caused by higher temperature than the parent material can withstand.	
BURRED	09	A rough edge or a sharp projection on the edge of the surface of the parent material.	
CARBONED	10	Accumulation of carbon deposits.	Carbon Covered, Carbon Tracked, Coked
CHAFING	11	A rubbed action between parts having limited relative motion (as in vibration).	Abrasion, Fretting
CHECKED	12	Surface cracks, usually caused by heat.	
CHIPPED	13	A breaking away of the edge, corner, or surface of the parent material, usually caused by heavy impact (not flaking).	
CORRODED	14	Gradual destruction of the parent material by chemical action. Often evidenced by oxide buildup on the surface of the parent material.	Rusted, Oxidation
CRACKED	15	Visible partial separation of material which may progress to a complete break.	
CURLED	16	A condition where the tip(s) of compressor blades or turbine blades have been curled over due to rubbing against the engine casings.	
DENTED	17	A surface indentation with rounded bottom, usually caused by impact of a foreign object. Parent material is displaced, seldom separated.	Peened
DEPOSITS	18	A buildup of material on a part either from foreign material or from another part not in direct contact.	

PAGE 1

Table 2-1b.—LM2500 Condition Codes (Cont'd)

CONDITION OF PART	CODE	DEFINITION	RELATED TERMS
DISTORTED	19	Extensive deformation of the original contour of a part, usually due to impact of a foreign object, structural stresses, excessive localized heating, or any combination of these.	Buckled, Deformed, Depressed, Twisted, Warped
ERODED	20	Carry away of material by flow of fluids or gases, accelerated by applied pressure.	
FLAKE	21	A thin chiplike or scalelike layer of metal.	
FRETTING	22	Wear in a rippled pattern, caused by friction.	Chafing, Abrasion
FROSTED	23	A dulled, roughened surface finish.	
FUSED	24	Joining together of two materials, usually caused by heat or friction.	
GALL	25	A defect caused by the movement of two surfaces in contact with each other. In most cases an accumulation of foreign material is deposited on the parent material.	See Pickup
GOUGED	26	Scooping out of material, usually caused by a foreign object.	Furrowed
GROOVED	27	Smooth, rounded furrow or furrows of wear, usually wider than scoring with rounded corners and smooth on the groove bottom. Example: A ball bearing wearing into a ring could cause a grooved condition.	
INDICATIONS	28	Cracks, inclusions, fractures, etc., not visible without fluorescent or magnetic penetrants.	
KNIFING	29	Erosion resulting in sharp edges.	
LOOSE	30	Separation of the part from another part to which it is normally affixed.	Separated, Disengaged
MELTED	31	Deformation from original configuration due to heat, friction, or pressure as with melted bearings or insulation.	
MISMATCHED	32	Improper association of two or more parts.	
MISPOSITIONED	33	Improper installation of a part, resulting in damage to the installed part or to associated parts.	Misaligned, Reversed
NICKED	34	A sharp surface indentation caused by impact of a foreign object. Parent material is displaced, seldom separated.	
OBSTRUCTED	35	Prevention of free flow of a fluid (air, oil, fuel, water) because of foreign material in the flow path or malfunction in the flow member.	Clogged, Contaminated, Plugged, Restricted
OVER-TEMPERATURE	36	Subjected to excessive temperature, usually evidenced by change in color and appearance of the part.	Heat Discolored

PAGE 2

Table 2-1c.—LM2500 Condition Codes (Cont'd)

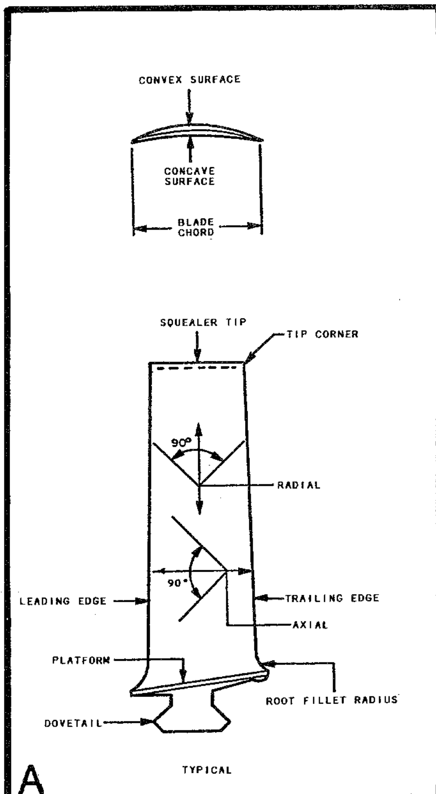
CONDITION OF PART	CODE	DEFINITION	RELATED TERMS
OXIDATION	37	A surface deterioration by the chemical reaction between oxygen in the air and the metal surface. Attack is manifested as red rust in iron and low-alloy steels when formed at ambient temperature. The oxides which form on super alloys are complex and can be green or black, depending on material composition and temperature at which it is formed.	
PART MISSING	38	The absence of a required part.	Loss
PEELED	39	A breaking away of surface finish such as coating, plating, etc.; peeling would be flaking or large pieces. A blistered condition usually precedes or accompanies flaking.	Blistered, Flaked
PICKUP	40	Transfer of one material into or upon the surface of another, caused by contact between moving parts or deposits of molten material on a cooler material.	Burr (usually tool-rub leaving high parent material), Gall, High Spot, Imbedment, Inclusion (usually Pileup), Protrusion (deposit on parent material), Metalization
PINCHED	41	Distortion of one or more surfaces of the parent material, caused by pressure.	Bound, Compressed, Flattened, Seized (see Seizure), Smashed (without separation into pieces), Squashed, Squeezed, Tight
PITTED	42	Small irregular shaped cavities in the surface of the parent material, usually caused by corrosion, chipping, or heavy electrical discharge.	
ROLLED-OVER	43	Lipping or rounding of metal edge.	Lipped, Turned Metal
RUBBED	44	To move with pressure or friction against another part, such as compressor rub.	
SCUFF	45	A surface roughened by wear.	Scape, Scratch
SEIZURE	46	A welding or binding of two surfaces which prevents further movement.	Bound Up, Frozen, Tight, (see Pinched), Tight (fit), Wedged, Welded (without external assistance)
SCORED	47	Deep scratch or scratches made on the part surface by sharp edges of foreign particles.	
SCRATCHED	48	Light, narrow, shallow mark or marks caused by movement of a sharp object or particle across a surface. Material is displaced, not removed.	

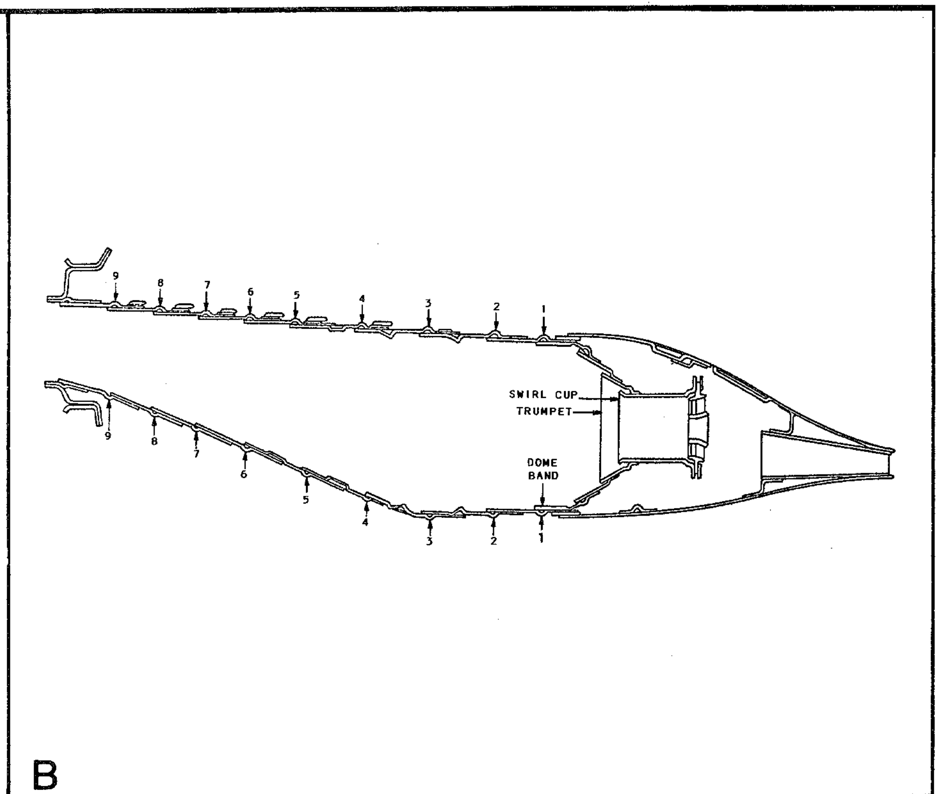
PAGE 3

Table 2-1d.—LM2500 Condition Codes (Cont'd)

CONDITION OF PART	CODE	DEFINITION	RELATED TERMS
SHEARED	49	Dividing a body by cutting action; i.e., division of a body so as to cause its parts to slide relative to each other in a direction parallel to their plane of contact.	
SHINGLING	50	The effect of two adjacent surfaces overlapping, usually caused by wear to one edge of the adjoining planes.	
SPALL	51	Broken or crushed material due to heat, mechanical, or structural causes. Chipping off of small fragments under the action of abrasion.	Chip
STALL	52	A disruption of normally smooth airflow through the gas turbine. The compressor blades stall in much the same manner as the wings of an aircraft. A high-speed stall is indicated by a rise of $T_{5.4}$ with corresponding reductions of N_1 and P_{s3}. A sub-idle stall is indicated by a rapid rise in $T_{5.4}$ and hangup of N_1. Personnel in the immediate area of the base enclosure may hear a chugging or a rumble during a stall. Stalls may occur during gas turbine acceleration, deceleration, or steady opertion. Stalls generally are the result of foreign object ingestion, an improperly rigged or malfunctioning compressor VSV feedback system, a malfunctioning CIT sensor, or main fuel control. The preceeding information is intentionally brief to provide a basis of understanding for the term *Stall*.	
SULFIDATION	53	A form of hot corrosion in heat-resistant alloys by the reaction at the metal surface of sodium chloride (sea air) and sulfur (from the fuel). Attack usually occurs over a broad front and can be identified as gray or black blisters (early stage) or surface delamination (advanced stages).	
TIP CLANG	54	The banging together of the leading edge of one blade and the trailing edge of the adjacent blade during stall. Tip clang results in tiraling edge fretting that can best be discovered on stages 3 through 6.	
TORN	55	Separation by pulling apart.	
VARNISH FILM	56	A hard surface film on metal, strawcolor to very dark brown, buildup by exposure to dry chemicals or fluids (commonly oil) while the part is heated above the breakdown point of the chemical or fluid.	Banded, Discolored, Oxidized, Stained
WARPED	57	Not true in plane or in line; out of true shape.	Distorted, Bent, Twisted, Buckled, Contorted
WORN EXCESSIVELY	58	Material of part consumed as a result of exposure to operation or usage.	

PAGE 4





LEGEND

A. COMPRESSOR BLADE NOMENCLATURE

B. LINER BAND NUMBERING

C. COMBUSTOR ASSEMBLY NOMENCLATURE

D. HP TURBINE NOZZLE NOMENCLATURE

E. HP TURBINE ROTOR BLADE NOMENCLATURE

F. POWER TURBINE NOZZLE NOMENCLATURE

G. POWER TURBINE ROTOR BLADE

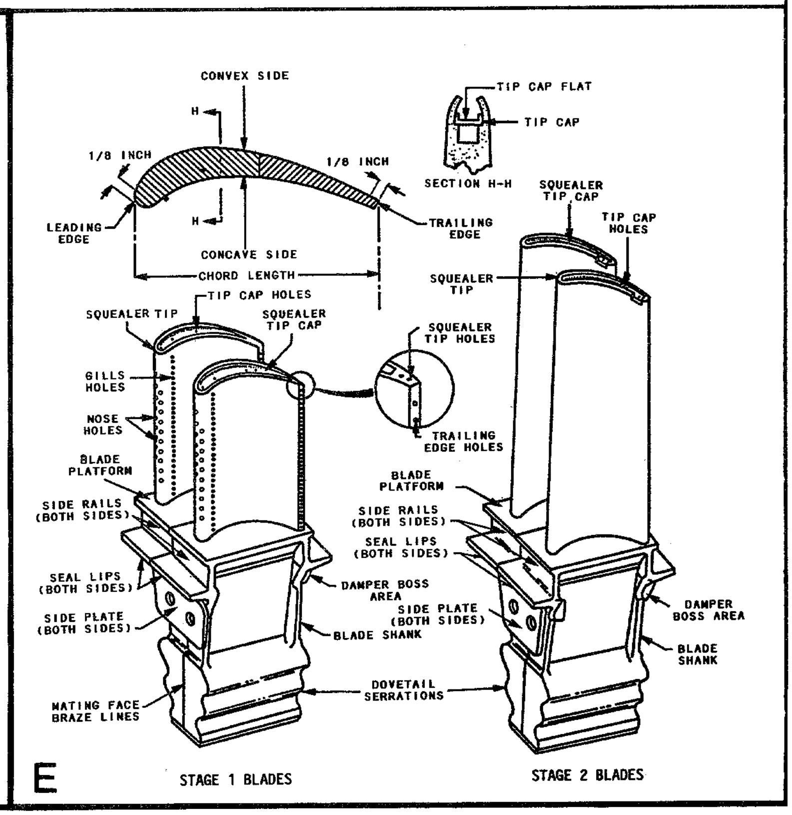
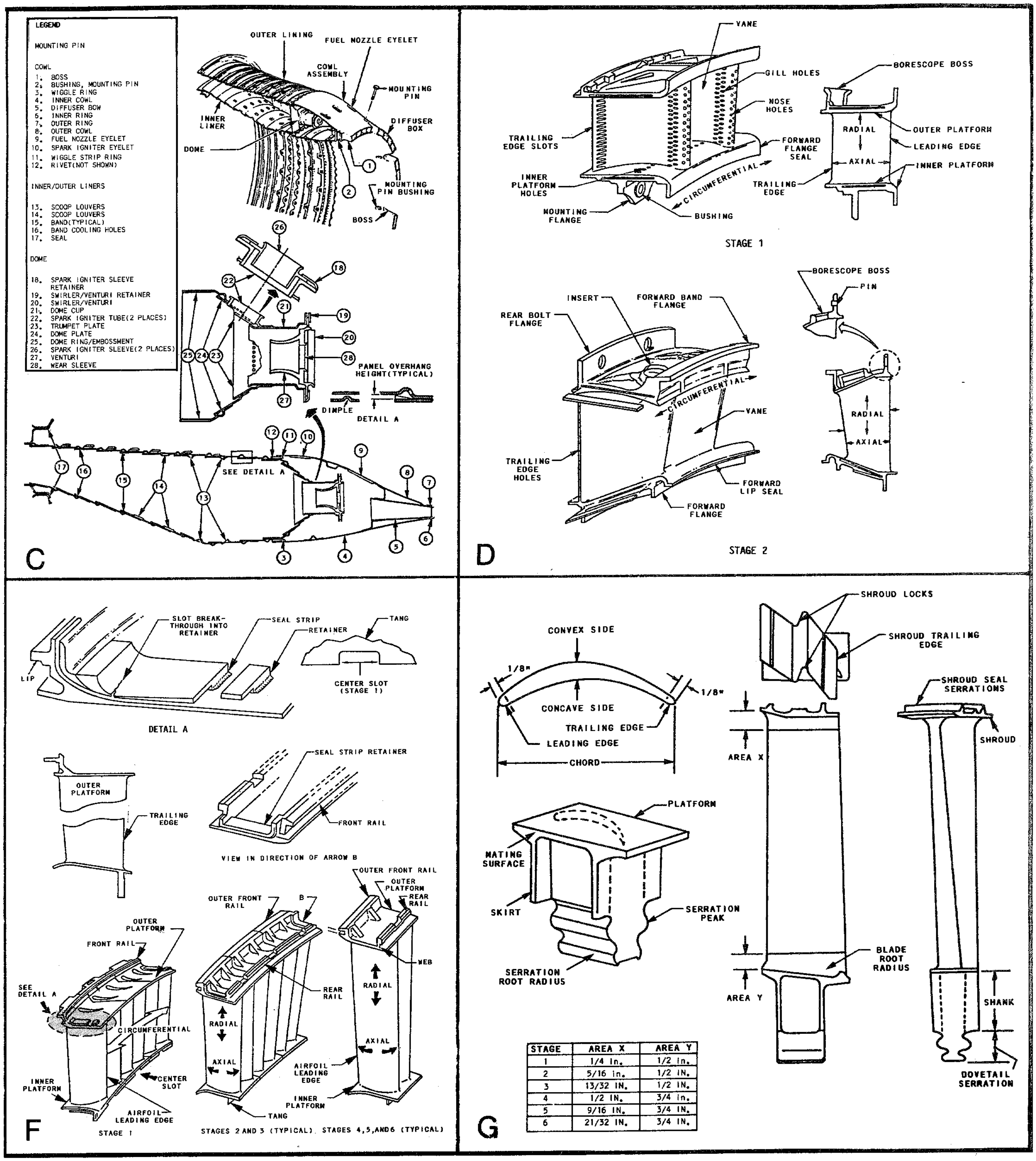


Figure 2-11a.—Engine inspection nomenclature.



STAGE	AREA X	AREA Y
1	1/4 in.	1/2 in.
2	5/16 in.	1/2 IN.
3	13/32 IN.	1/2 IN.
4	1/2 IN.	3/4 in.
5	9/16 IN.	3/4 IN.
6	21/32 IN.	3/4 IN.

Figure 2-11b.—Engine inspection nomenclature.

CHAPTER 3

POWER TRAIN AND PROPULSION SYSTEMS

As a GS supervisor, you will primarily supervise the operation and maintenance of the power train equipment and controllable pitch propeller systems. This chapter will focus on the maintenance and repair of the 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 well-rounded understanding of the drive train equipment and propulsion plant systems in gas turbine-powered ships. You should better understand terms of normal operations, some common malfunctions, and your role as the GS supervisor.

POWER TRAIN

In Gas *Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* volume 1, NAVEDTRA 10563, there is a fairly detailed description of the various power train arrangements used by gas turbine-powered ships. You may wish to review those chapters on such items as construction, principles of operation, nomenclature, and operating parameters. In this section, we will cover some of the power train system tests, inspections, adjustments, and repairs that you will be responsible for as a supervisor.

MAIN REDUCTION GEAR

The inspection procedures and problems that occur in main reduction gears (MRGs) are basically the same for any system. It will not be necessary to differentiate between classes of ships in this section, except where specific differences exist. Additional information on the inspection and adjustment of gear trains can be found in *Naval Ships' Technical Manual (NSTM),* chapter 9420, "Propulsion Reduction Gears, Couplings, and Associated Components," NAVSEA 0901-LP-420-0002, or in the manufacturer's technical manual for your specific installation.

Inspection and Repair

Before reading descriptions and details on MRG inspections, you need to be familiar with the terminology used throughout this section. The majority of the following gear nomenclature also applies to helical gears. Figure 3-1 may be of help on some of these definitions.

RATIO. The number of gear teeth divided by the number of teeth in the pinion.

LINE OF ACTION. The locus of the points of contact as the profiles go through mesh. This line passes through the pitch point and is tangent to the base circle.

HELIX ANGLE (fig. 3-l). The angle formed by a tooth and a plane passing through the axis of the gear.

PRESSURE ANGLE (fig. 3-1). The angle between the line of action and the line tangent to the pitch circles.

TRANSVERSE DIAMETRAL PITCH. The ratio of the number of teeth to the number of inches of the pitch diameter.

NORMAL DIAMETRAL PITCH. The transverse diametral pitch divided by the cosine of the helix angle.

CHORDAL TOOTH THICKNESS (normal) (fig. 3-1). The thickness of the tooth measured on the chord of the pitch diameter in the normal plane.

CIRCULAR PITCH (axial) (fig. 3-l). The length of the arc on the pitch circle between similar points of adjacent teeth in the plane of rotation.

CIRCULAR PITCH (normal) (fig. 3-l). The length of the arc on the pitch circle between similar points of adjacent teeth in the normal plane.

OUTSIDE DIAMETER (fig. 3-l). The diameter measured over the tops of the teeth.

PITCH DIAMETER (fig. 3-l). The diameter of the pitch circle.

BASE DIAMETER (fig. 3-l). The circle from which a line is unwound to generate the involute curve.

ROOT DIAMETER (fig. 3-1). The diameter of the root circle.

ADDENDUM (fig. 3-1). The distance from the pitch circle to the top of the tooth.

DEDENDUM (fig. 3-1). The distance between the pitch circle and the bottom of the tooth space.

WORKING DEPTH (fig. 3-1). The depth to which the teeth of a gear enter into their mating space.

CLEARANCE (root) (fig. 3-1). The distance between the top of a tooth and the bottom of its mating space.

WHOLE DEPTH. The total depth of the tooth space and also the sum of the addendum and dedendum.

INTERFERENCE. Contact between mating gears at some point other than along the line of action.

FILLET (fig. 3-l). The concave radius that joins the tooth profile and the bottom of the tooth space.

Tests and inspections according to the PMS are minimum requirements only. When defects are suspected, or operating conditions indicate, inspections should be made at more frequent intervals.

When opening gear cases for inspection, use extreme care. Even under normal conditions, when the covers are lifted the possibility of getting foreign particles inside the gear case is high. The engineer officer should evaluate all ongoing work in the engine room, especially in the areas over the gears. Besides evaluating the work, the engineer officer must schedule all necessary MRG inspections.

You must be sure that gear sumps are cleaned after all work to the MRG has been completed. Thoroughly inspect the gear sump and remove any foreign material. Absolute cleanliness is required before filling the gear sump with clean oil.

Oil should be renovated before returning it to the sump. If new oil is used, you must be careful to remove any water or foreign particles. Cloth bags placed in the lube oil (LO) strainer baskets after major repairs is another required precaution. The bags stop foreign particles from passing through the gear train and bearings. Once the proper temperatures and pressures have been reached in the LO system, inspect the MRG for leaks and all sight-flow indicators for proper flow.

The following paragraphs discuss some of the inspections, tests, and problems that may occur to MRGs.

BACKLASH.— Backlash is the play between the surfaces of the teeth in mesh measured at the pitch circle. The backlash will increase with wear, and can increase considerably without causing trouble. On some gears that are recut, the backlash does not affect operation or

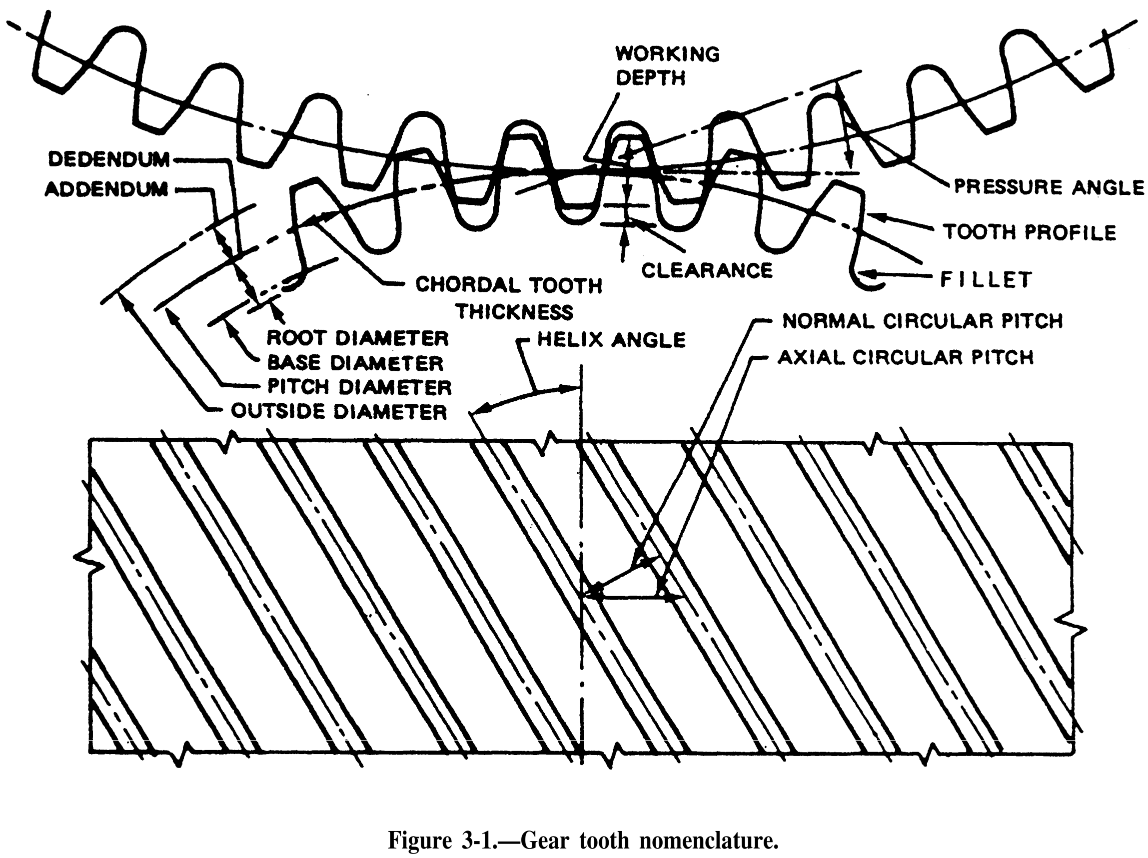


Figure 3-1.—Gear tooth nomenclature.

cause noise during ahead operation. However, a small increase in noise during astern and low-power operation may be apparent. Lack of backlash may cause noise, overloading, overheating, or failure of the gears and bearings.

DAMAGE BY FOREIGN PARTICLES.— In cases where both the pinion and gear teeth have been indented by foreign material, both should be relieved of all raised metal around the indentation. If a tooth has been dented or a foreign particle has been caught in the mesh, it will track on the mating teeth when the MRG is operated. You can hear a damaged tooth when the MRG is spin-tested. The frequency of the noise in hertz (cycles per second) will indicate which rotating element in the gear train has the damaged tooth. In double-reduction, locked-train MRGs, the damaged tooth may be on one of the four second-reduction pinions and/or one of the four first-reduction gears. The frequency will help you eliminate one of the four sets. If the damage is small, you must examine all four rotating elements until the damaged tooth is found.

FINDING DAMAGED TEETH.— Sufficient damage may be done so that just a careful visual inspection can locate the damage. If the damage is small, it may be faster to find the damaged tooth by painting the pinion teeth with a thin coat of metal-marking compound, such as prussian blue. After rotating the gears with the turning gear motor, the high spots will be shining through the coating of prussian blue.

REPAIR OF DAMAGED TEETH.— When very small foreign particles get in the gear train, they can scratch the teeth. Large particles can bend, dent, or crack the teeth. One bent or dented tooth will track on all teeth-in mesh with it. These bent and/or dented teeth can be repaired by stoning, filing, or scraping. The abraded portions of the teeth should be dressed enough to prevent the cutting of the meshing teeth. Dressing includes such actions as removal of a wire edge that is large enough to break off and pass through the mesh, and/or removal of high spots. Gear teeth should not be touched with hand tools except in an emergency! Even during an emergency, only steel scrapers or a fine file should be used, and every precaution must be taken to remove all filings or abrasive material. You should NEVER attempt to remove deep pitting or galling.

TOOTH ROOT CLEARANCE.— The designed root clearance of gears operating on their designed centers can be found in the manufacturer's technical manual drawings. You can determine the actual clearance with the insertion of a long feeler gauge, a wedge, or by the use of leads. The actual clearance should be within a few thousandths of an inch of the designed clearance and should be about the same at each end of the gear. If the root clearance is materially different at the two ends, the pinion and gear shafts may not be parallel. A difference of a few thousandths of an inch can be accounted for by errors in observation and by slight errors in machining. The amount of clearance may change a limited amount one way or another. This change is acceptable provided there is sufficient backlash so the teeth are not meshed so closely as to cause tooth interference.

GEAR TOOTH CONTACT.— Gears in mesh that are rotating in parallel and have uniform tooth contact will operate satisfactorily. Active pitting, tooth breakage, and uneven tooth contact indicate that some corrective action is required.

Satisfactory tooth contact is defined as at least 80 percent of the axial length of the working face of each tooth is in contact, distributed over nearly 100 percent of the face width. You can determine gear tooth contact using one of the following two methods:

1. Static check—Apply a thin coating of prussian blue to the pinion teeth and roll the gears with the turning gear. The compound will transfer to the gear teeth.

NOTE

Some gears are cut with a very slight taper of the teeth (helix angle deviation) to offset the effects of torsion. In such gears, full contact across the face will not be obtained by static testing.

2. Operation-Use blue or red DYKEM or copper sulphate to determine tooth contact under operating conditions. Use DYKEM for dock trials, as it will show marking with light loads. Copper sulphate shows marking after much longer and higher power operating conditions than that required for DYKEM.

TOOTH WEAR AND FAILURE.— Wear is defined as the removal of metal from the gear teeth. Normal wear is the removal of metal at a rate that does not impair the satisfactory operation of the gear. If proper tooth contact is obtained when the gears are installed, little trouble should be encountered in respect to wear. Excessive wear cannot take place without metallic contact. Proper clearances, inspections for removal of high spots, and/or adequate supplies of lubricating oil can prevent excessive wear. If the lubricating oil supply should fail and the teeth become scored, the gears must be overhauled at the first opportunity.

Pitting, particularly along the pitch line, may occur in the first few months of service. This pitting (often referred to as connective pitting) usually stops after a short time, and no further trouble is experienced. Corrective pitting requires only one precaution. You must be sure that no flakes of metal are allowed to remain in the LO system. Remember, very minor pitting does not affect operation. Pitting in new gears is due to very slight high areas. These high areas are removed by the pitting. This condition is corrective and will stop. However, pitting that continues can result in progressive deterioration of the gear (fig. 3-2).

Scoring is characterized by transfer of metal from one sliding surface to another. Scoring in gear teeth is caused by contact of the tooth tips due to insufficient tip relief or lack of lubrication.

Dirt tracks are caused by foreign particles passing through the mesh. The gear teeth are marked in the same location on each meshing tooth. Prominent high spots caused by foreign particles require removal. Removal of foreign particles avoids problems such as load concentration, pitting, or tooth breakage.

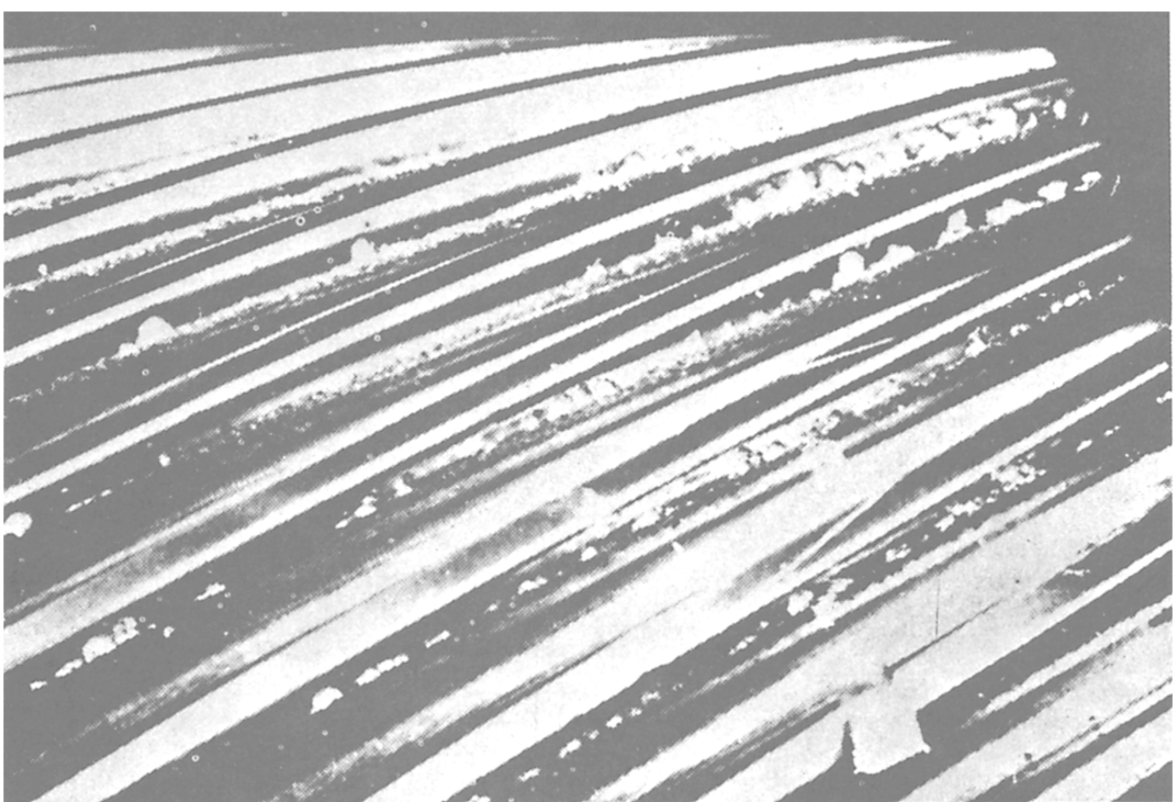
Wire edge caused by plastic flow of metal results in a “fin” at the outside diameter of the tooth. If the fin is heavy, it must be removed. If not removed, it may break off and pass through the mesh.

Cracked teeth are normally caused by fatigue, but may be caused by shock. Cracked teeth like those shown in figure 3-3 will break if operation of the MRG is continued. The cracks are clearly shown by indicating dyes used for inspection.

Tooth fatigue breakage is caused by repetitive cycling at a load greater than the fatigue strength of the material. Tooth fatigue is progressive. A short crack appears first, and then propagates. Characteristic “oyster shell” lines can usually be seen. Figure 3-4 shows a typical broken tooth.

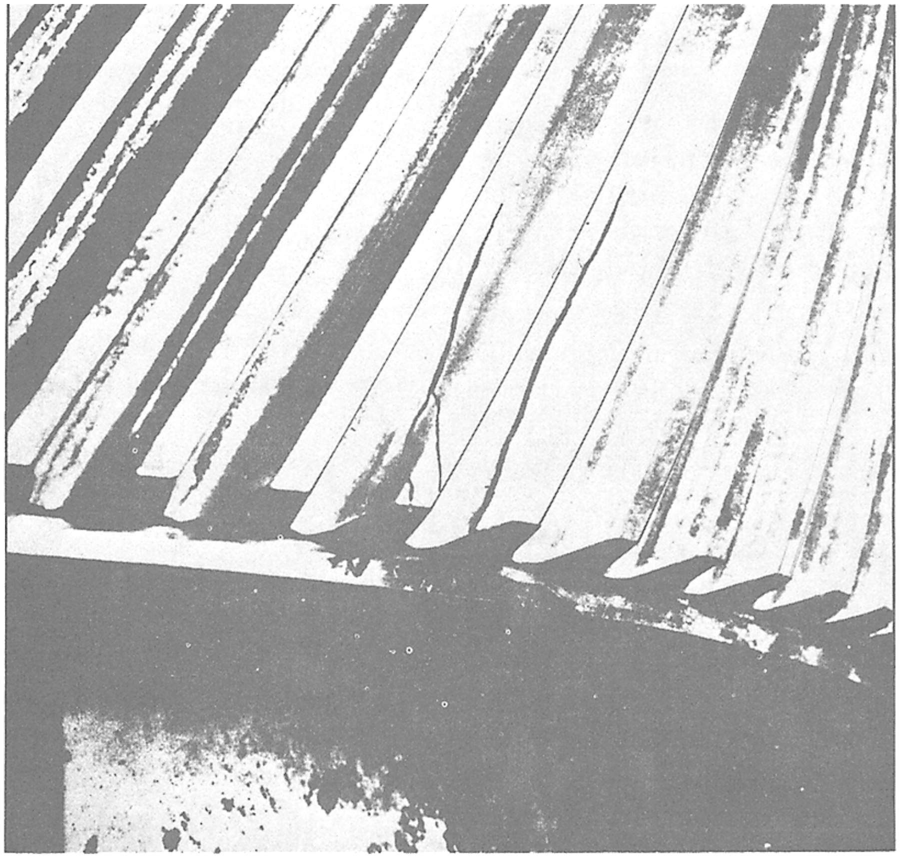
Alignment

The gear train is in alignment when the gear and the pinion are parallel. That is, the axis of the two shafts are in the same plane and equal distance from each other at



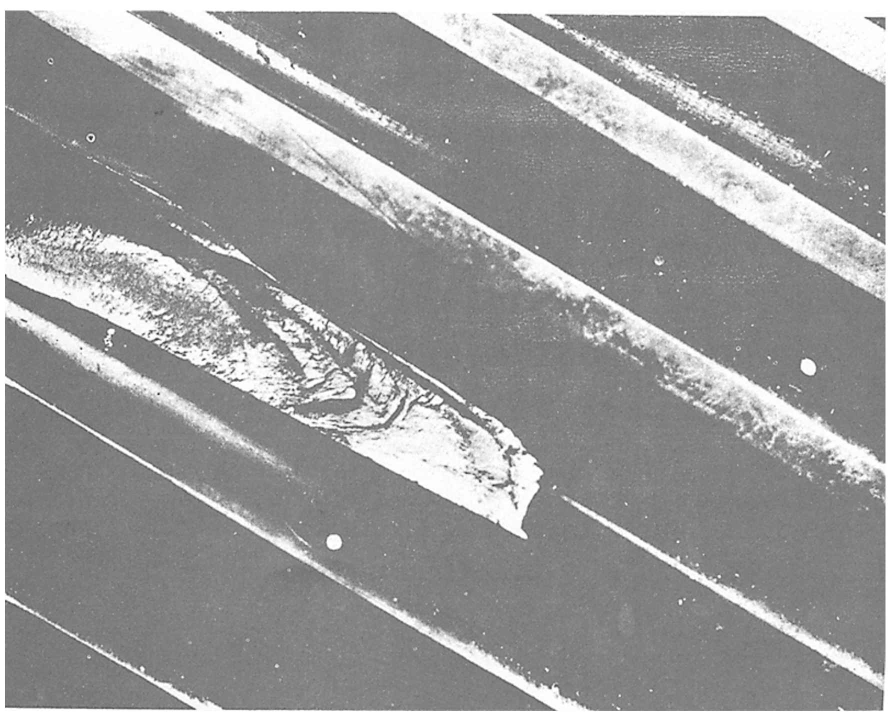
270.7

Figure 3-2.—Progressive destructive pitting.



270.8

Figure 3-3.—Cracked teeth



270.9

Figure 3-4.—Broken tooth.

all points. In service, the best indication of good alignment is good tooth contact.

The technical manual furnished with each gear installation describes the procedures for determining the proper depth of mesh and parallelism of gear and pinion shafts. The length of tooth contact across the face of the gear teeth is the key to satisfactory alignment of reduction gears.

Poor alignment between the line shaft and the MRG may be detected at the reduction gear. Uneven loading of the low-speed gear train and noisy operation in certain speed ranges are two common results of poor line shaft to MRG alignment.

The most favorable alignment position of the main engine to the reduction gear is when they are concentric at full power at the proper operating temperature. The flexible high-speed coupling is designed to handle the transient condition of slight misalignments as the machinery comes up to temperature. The two most common forms of misalignment between the prime mover and the driven shafts are angular and parallel offset, as shown in figure 3-5.

The object of the alignment is to locate the turbine so the axis of the spindle will be concentric with and parallel to the axis of the reduction gear input pinion shaft. Attaining alignment is complicated by the fact that the turbine, reduction gear, and foundations all expand as they are heated during operation to the hot running conition. Another factor is when operating pinion shafts move higher in their bearings under the influence of the hydrodynamic oil film and tooth pressure. These changes in position have been predetermined by the manufacturer, and you can find the offset readings in the appropriate technical manual for the installation.

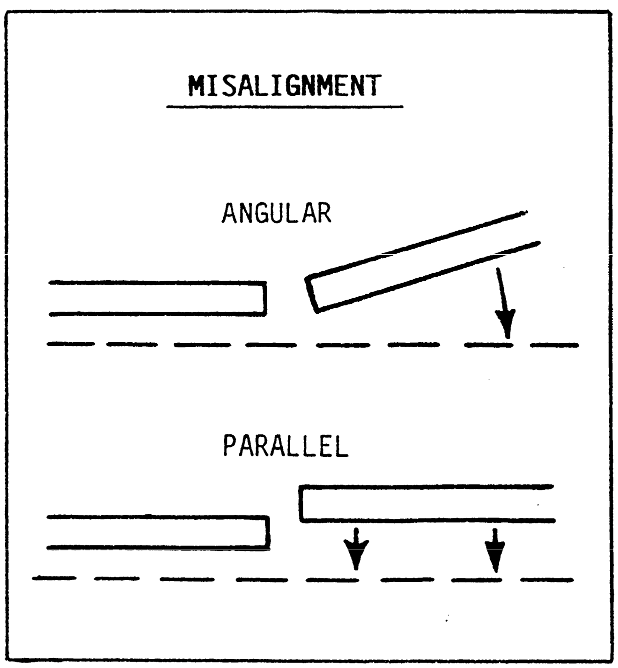


Figure 3-5.—Angular and parallel misalignment.

MAIN THRUST BEARING CLEARANCE MEASUREMENTS

As you have already learned in *Gas Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* volume 1, NAVEDTRA 10563, propeller thrust is transferred from each propulsion shaft to the hull through a Kingsbury main thrust bearing (fig. 3-6). The Kingsbury thrust bearing uses the wedge-shaped oil film lubrication principle. This principle is based on an oil film between two sliding surfaces tends to assume a tapered depth with the thicker film at the entering side. In a Kingsbury assembly, eight bearing shoes are installed on each side of the thrust collar. Therefore, eight separate wedge-shaped oil films are installed on each thrust face. Since the bearing shoes are free to tilt slightly, the oil automatically assumes the taper required by shaft speed, loading, and oil viscosity.

The main thrust bearing assembly consists of the bearing housing, two thrust rings, and a thrust collar. The housing, thrust rings, and thrust collar facings are all split horizontally. Each thrust ring is made up of 8 steel thrust shoes with tin babbitt facings, 16 leveling plates, and a retainer ring. The thrust collar has a two-piece removable steel thrust face attached to each side. Each thrust shoe contains a hardened shoe support with a spherical face. The support bears on the upper leveling plate and the spherical face allow the thrust shoe to pivot or tilt slightly in all directions. This arrangement allows the bearing to operate on the free-wedge film lubrication principle. One thrust shoe on each side is fitted with a resistance temperature element (RTE).

Due to the spring isolation system, main thrust bearing clearance measurements are no longer taken with a depth micrometer. All measurements are now taken with a dial indicator that measures the deflection of the propulsion shaft at the main flange. There are two methods (static and dynamic) used to create shaft deflection. The method used depends on the ship class. The static method must be used on CG-66 and above and all DDG-51 class ships. The dynamic method is

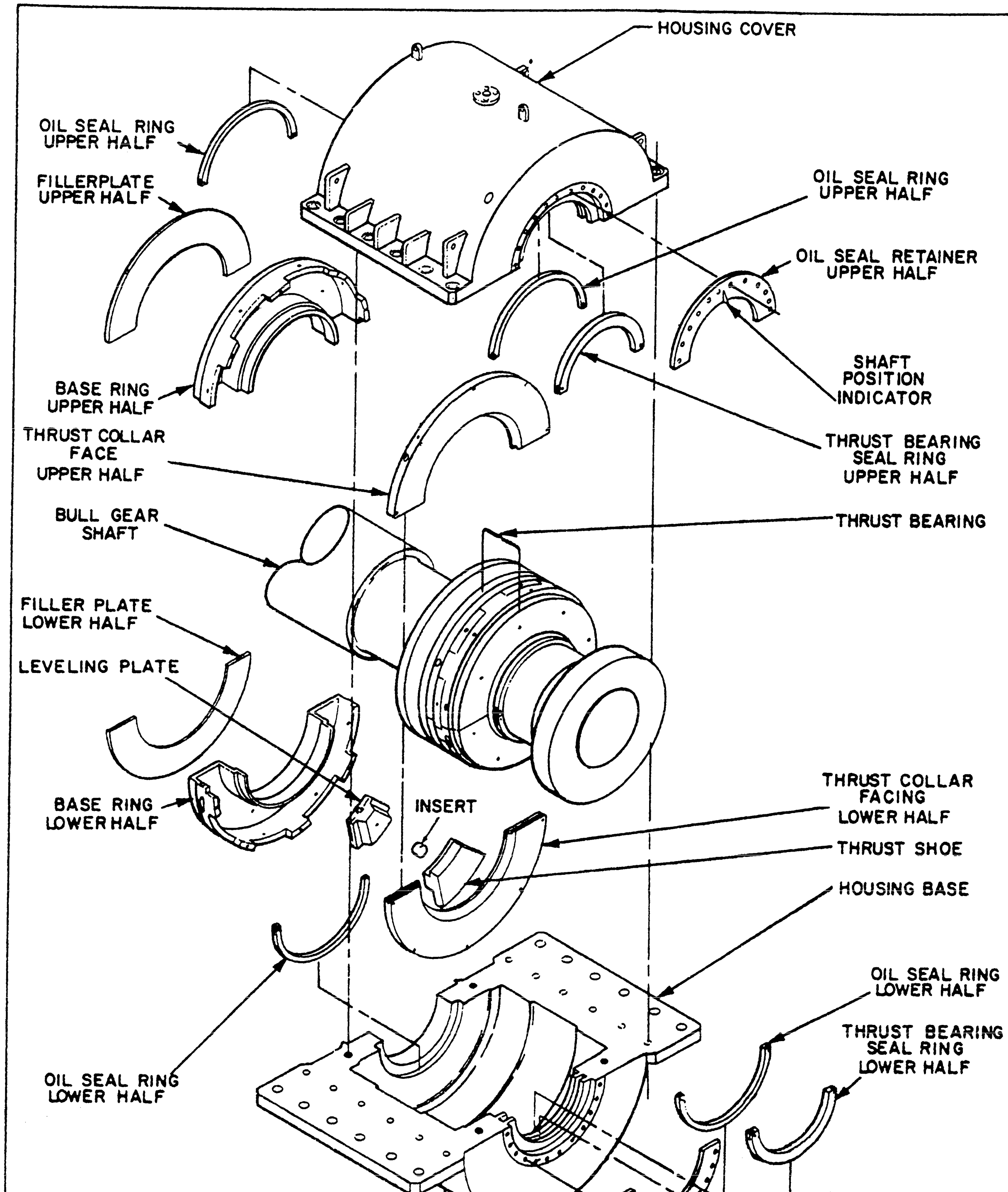


Figure 3-6.—Thrust bearing and housing.

used for all other gas turbine-powered ships. Take a brief look at these two methods to measure main thrust bearing clearances.

Static Method

In the static method, a dial indicator is mounted on top of the aft end of the thrust housing with the zero pointer against the forward face of the first shaft flange aft of the thrust bearing. While the controllable and reversible pitch (CRP) system is operating, the propeller pitch is advanced to 100 percent ahead with the local controls at the oil distribution (OD) box. The electric CRP pump is then secured, and the hub servo bottomed-out by use of the emergency pitch hand pump. The reduction gear is then rocked with the turning gear motor by use of the ratchet wrench to turn the motor. This movement assures that the shaft is bottomed-out on the ahead thrust collar.

If the clearance is within normal limits, and no abnormal conditions exist, log the readings and put the system back in service. If the clearance is not within normal limits, or a noticeable increase or decrease is measured, inspect the thrust bearing. Check for any abnormal rendition (scored or wiped shoes) and take corrective action as necessary.

NOTE

Approximately six to eight turns of the wrench in either direction will remove the backlash; turn an additional two to four turns. Repeat once or twice in each direction with 2500 to 3000 psi on the emergency hand pump.

Dynamic Method

Like the static method, the dynamic method requires a dial indicator and instrument placement to measure the shaft deflection. Dynamic measurements are done while the propulsion shaft is in operation. Communications must be established from the area of the thrust bearing to the station with throttle control. The ship must be operated in the ahead direction at a 1/3 bell for 10 minutes. Allow the shaft to coast to a stop and then position the dial indicator against the shaft flange. After the indicator is in place, operate the ship in the astern direction at a 1/3 bell for 5 minutes. After allowing the ship to coast to a stop, record your deflection reading. This procedure is repeated two more times (three times total). You must use the average of these three readings to obtain the main thrust bearing clearance. Designed thrust bearing clearance is 0.030" to 0.045", with a maximum of 0.080".

For specific detailed information on these procedures, consult the applicable PMS maintenance requirement card (MRC) or manufacturer's technical manual for the speed decreaser gear installed on your ship.

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 current clutch assemblies used on gas turbine-powered ships. The first and most widely used clutch assembly is the synchro self-shifting (SSS) type. This type of clutch assembly is installed on all CG-47, DDG-51, and FFG-7 class ships. The other type is a pneumatically operated, forced-synchronization type of clutch assembly. The forced-synchronization clutch assembly is installed on DD-963 and DDG-993 class ships.

Along with the two types of clutch assemblies, there are two types of power turbine (PT) brake assemblies installed on gas turbine-powered ships. 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 maintenance related to both types of clutch assemblies and all the brake assemblies. Because of the complexity, the elaborate control system, and the large number of labor hours required for maintenance, the Navy is gradually phasing out the forced-synchronization type of clutch. Because of this phase-out, we will focus our discussion 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. It is not the function, but the method of clutch engagement that 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 availability 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 permissive 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 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

Like the forced-synchronization clutch, the SSS clutch 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. 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 CG-47 and DD-963 class ships have a similar PT brake assembly. The PT brake assembly is an internally housed friction clutch design that is mounted to, but operates independently of, the SSS clutch assembly. There is one main difference between the CG-47 class ships brake and the one installed on the DD-963 class ships. The CG-47 brake 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 used 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 FFG-7 class ships. The shaft brake assembly is also a single-disc caliper brake assembly, such as the PT brake assembly we just described Consisting of two complete units, a shaft brake assembly is mounted on each starboard first reduction quill shaft. Once all permissive are met, the single purpose of this brake is to stop MRG rotation.

MAINTENANCE OF EQUIPMENT AND COMPONENTS

The maintenance of the clutch and brake assemblies and associated equipment and components is normally done 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 good operational record is the main reason the Navy is phasing out the forced-synchronization type of clutch in favor of the SSS clutch.

In the following paragraphs, we will discuss some general maintenance and repair practices associated with clutch and brake assemblies. You, the GS supervisor, must be familiar with these practices so you can properly supervise maintenance and repairs.

Cleaning

The cleaning of the clutch and brake assemblies is done primarily when the MRG is cleaned Cleaning the clutch assembly is limited to external cleaning. Pay attention to the areas around the inspection and access cover plates and the clutch position indicating ports.

The cleaning of externally mounted brake assemblies requires 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 that you keep dust accumulation to a minimum. Once 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 are performed according to the PMS. 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, you must check the externally mounted PT and shaft brake assemblies on a regular basis according to the PMS. These inspections 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 SSS clutches are reliable, problems that require troubleshooting are usually minimal. Like all other gear-driven assemblies, SSS clutches have a tendency to wear and produce noise with age. Normal failures are usually limited to faulty position indicator switches and failures related to the PT brake assemblies. We will not dwell on the clutch assemblies, but move on to some of the problems related to the installed brake assemblies and the ways in which you, the GS supervisor, can better identify them.

The basic operation of both the PT and shaft brakes is the same as the disc brake system installed in most automobiles. All brake systems 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 disc until the disc stops. Next are some common malfunctions that may occur in this system and ways that you can isolate the cause.

Failure to Engage

There are several problems that can cause a brake to fail to engage. You must understand the operating principles associated with the system. First, check to see if there is sufficient air or oil pressure for operation. It is 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, you should try the manual control. If the manual control works, you should consider an electrical fault as the problem source. If the manual control does not work, you should continue troubleshooting. If the pressure regulator is not working, 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 possibility 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 a slowing down or a stop. If the PT has stopped, your indicator light may be out or the indicator switch may be bad. If the PT does not stop, you may need help locating where the command signal is lost.

Failure to Release

When a brake fails to release, the three most common causes are a command problem, a bad position indicator switch, or a bad indicator light. If none of these are the cause, 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 adjustments or alignment checks 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 maybe 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.

LINE SHAFT (SPRING) BEARINGS

The line shaft (spring) bearings are self-aligning, oil-lubricated journal bearings. Each bearing is a self-contained assembly with its own oil reservoir that contains 2190 TEP oil.

An oil disc (ring) clamped to the shaft is used in each bearing to deliver oil to the upper bearing and journal surfaces. As the disc rotates, it picks up oil from the bearing reservoir and carries it to the oil scraper on the upper shell. The scraper removes oil from the disc and directs it to the upper bearing lining. A clear sight cover on the bearing housing allows visual confirmation of the oil disc operation. Figure 3-7 shows a typical disc-oiled line shaft bearing.

All bearing pedestals have an oil level rod and an oil reservoir thermometer for checking oil level and temperature. A resistance temperature detector (RTD) is installed in the lower bearing shell of each oil-lubricated bearing. The RTDs provide for remote readouts of each bearing's temperature on the digital demand displays.

Clearances are taken with a depth micrometer through a port in the upper bearing housing, which contains the anti-rotation pin. The original installation readings are stamped into the flat surface adjacent to this port. You must take readings according to PMS requirements or when an abnormal condition exists.

For information on maximum wear limits and repair procedures, you should consult the appropriate manufacturer's technical manual and *NSTM,* chapter 244, "Shafting, Bearings, and Seals."

STRUT AND STERN TUBE BEARINGS

Each propeller shaft extending aft of the stern tube is supported by two struts, each containing a seawater-cooled bearing. Figure 3-8 shows a typical strut bearing.

Stern tube bearings are in constant contact with the seawater surrounding the stern tubes. The clean seawater that passes through the stem tube seals from the ship's seawater service system or firemain system (in emergencies) also flows through the stern tube bearings. Stern tube bearings are identical to forward strut bearings. However, aft strut bearings are roughly 5 inches larger in diameter and twice as long as stem tube bearings. Remember that stem tube bearings are not remotely monitored.

PROPULSION SYSTEMS

The ship's propulsion thrust is provided by hydraulically actuated propellers. In the Gas *Turbine Systems Technician (Electrical) 3/Gas Turbine Systems Technician (Mechanical) 3,* volume 1, NAVEDTRA 10563, you were provided with a complete description of propulsion systems and how they operate. As a gas turbine supervisor you need to be knowledgeable and experienced with a variety of gas turbine propulsion

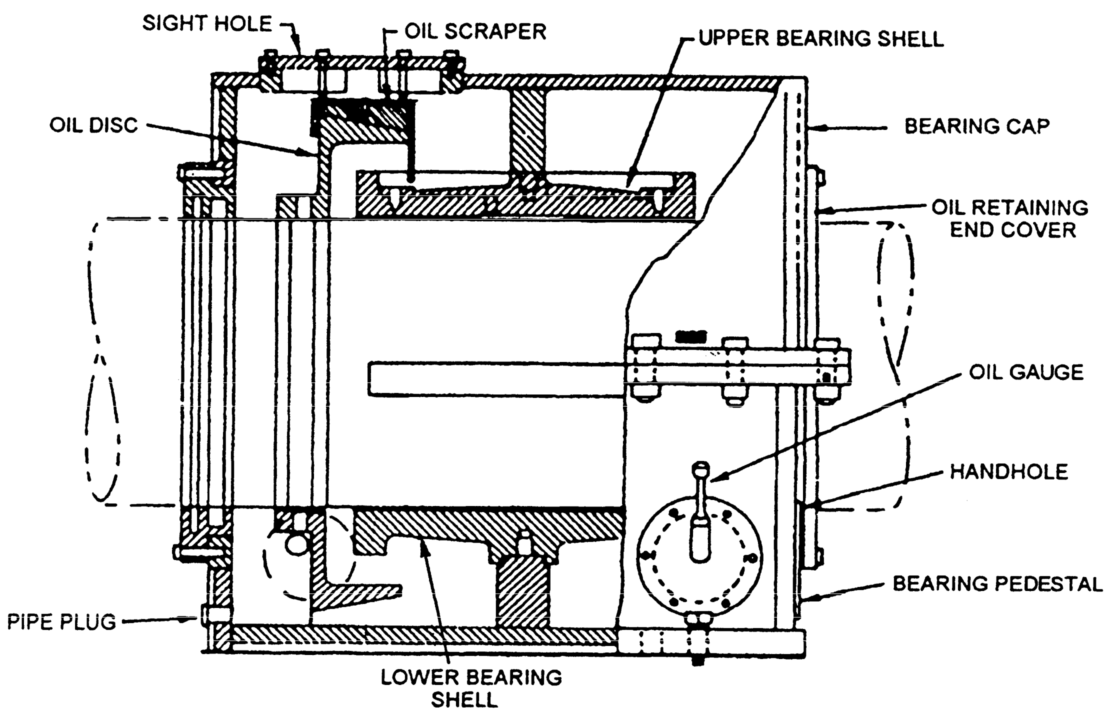


Figure 3-7.—Disc-oiled line shaft bearing,

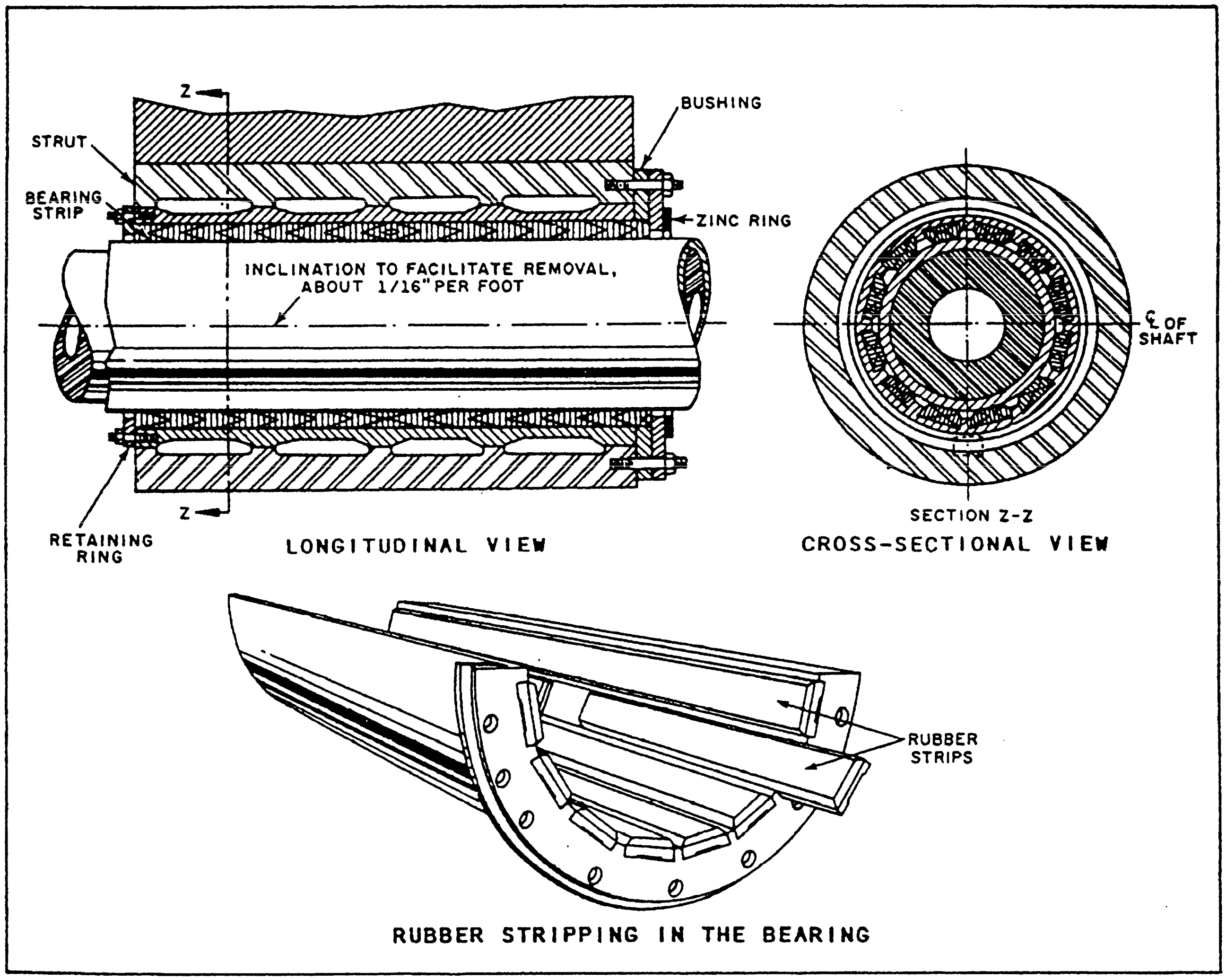


Figure 3—8.—Details of a typical underwater strut bearing.

system operations. This proficiency combined with leadership skills will assist you daily in your supervisory role.

CRP/CPP SYSTEMS OPERATIONS

In this section, we will briefly cover routine and emergency operations of the CRP/CPP systems. Since the various ship systems are functionally the same, we will not indicate ship type except when necessary. However, if you need to review the basic design and operational characteristics of these systems, consult *GSE3/GSM3,* volumes 1 and 2.

Routine Operation

Propeller pitch changes can be made through the full range of travel in one continuous movement. The pitch change can be made in automatic, remote manual, or local manual operating mode. The maximum rate of pitch change, 30 seconds from full ahead to full astern, is determined by the response of the hydraulic system. Pitch change rate is NOT determined by the speed of movement of the control lever.

The CRP/CPP systems were designed to maximize the ability of the ship's propulsion GTE to accelerate and decelerate rapidly and to enhance 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. The following sections will explain some of these changes and the contributions they make to system performance.

As a GS supervisor, 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. Look at some of the components that have changed in the OD box and the pitch indicating system.

OIL DISTRIBUTION BOX.— On DD-51 class ships, the configuration of the OD box has undergone several changes. 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 3-9. This change makes it easier for the operator to make the connections during testing or in case of an emergency.

PITCH INDICATING SYSTEM.— A significant change was made to the pitch indicating system. There are now two types of pitch indicating systems installed on DDG-51 class ships. One system is temperature compensated while the other is electronic. Because these two systems operate independently, DDG-51 class ships have both a normal and alternate means of measuring propeller pitch.

Temperature-Compensated Pitch Indicator System.— On DDG-51 class ships, the temperature-compensated pitch scale platform is rigidly

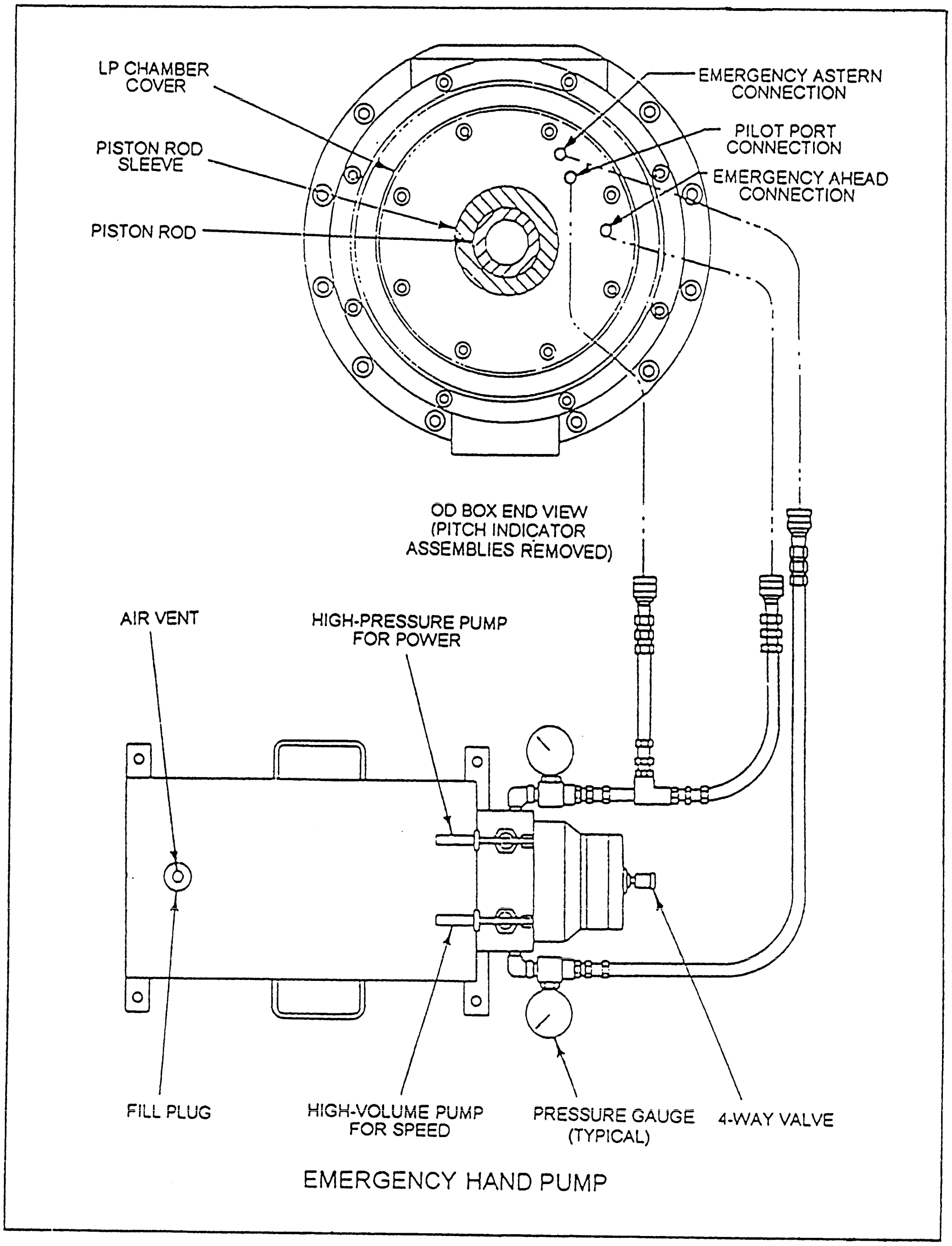


Figure 3-9.—Emergency pitch arrangement.

connected to the OD box. The scale platform holds the feedback potentiometer and local pitch indicator, as shown in views A and B of figure 3-10. This indicator is defined as temperature compensated because the indicator arm is connected to the prairie air tube. Look at 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, a primary means to sense and indicate propeller pitch, and a means 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

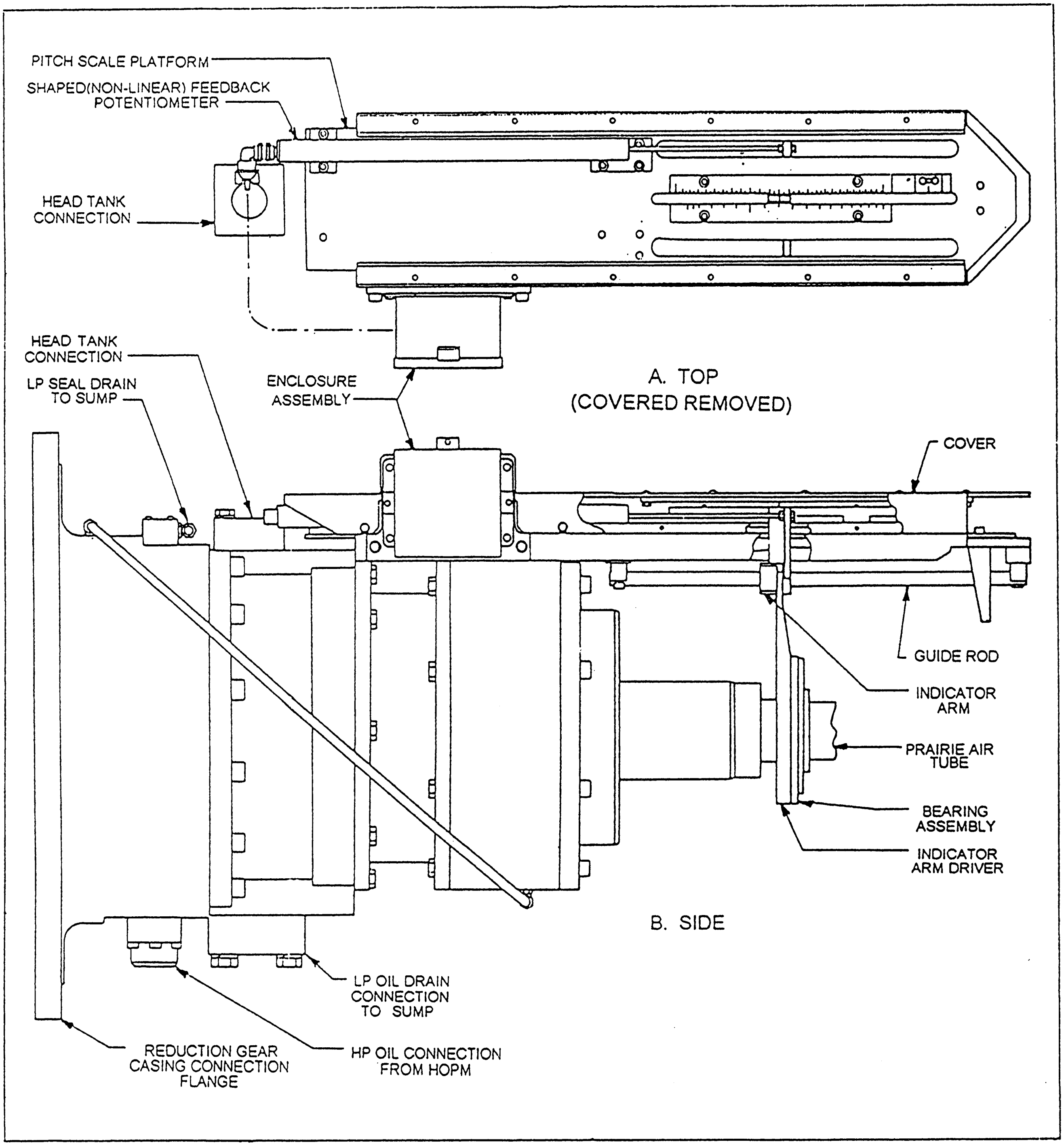


Figure 3-10.—Pitch scale platform showing temperature-compensated pitch indicating system.

cover plate on the propeller hub. This arrangement is shown in view A of figure 3-11. 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 3-11. 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 propeller pitch 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 propeller pitch 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 and astern pitch. The rotary transformer contains both the

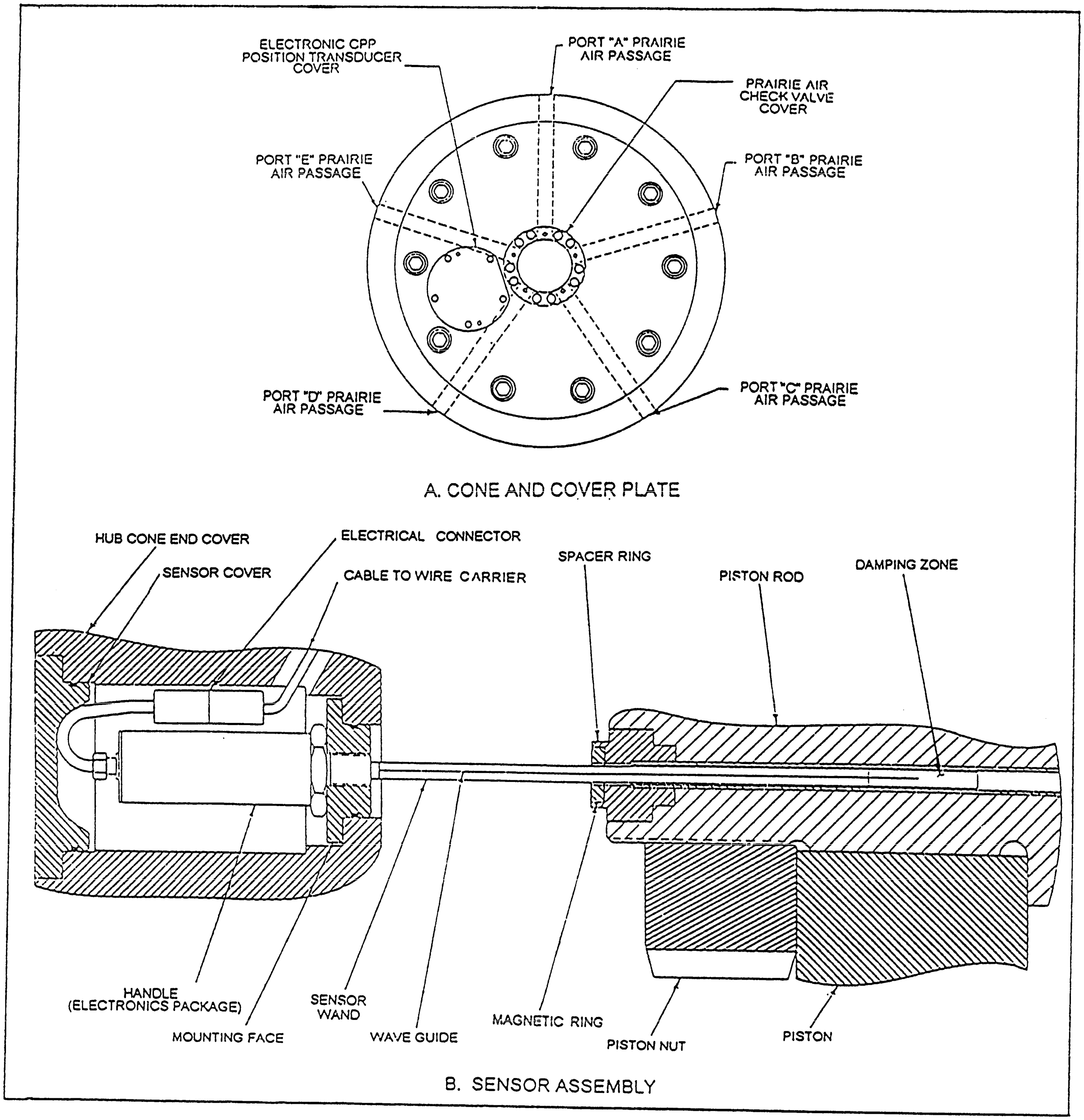


Figure 3-11.—Hub-mounted electronic pitch position transducer.

transducer excitation and output coils. The rotating electronics cylinder rectifies the rotary transformer excitation to 24 V dc for powering the hub-mounted transducer and receives the transducer output. The rotating electronics cylinder is attached to the prairie air tube extension at the end of the OD box. The cylinder electronically 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 DDG-51 CPP system technical manual.

Emergency Operation

If the electronic pitch control system becomes inoperative, you must instruct your personnel to shift to manual control at the OD box. Manual operation is accomplished by shifting the two changeover valve levers on the manifold block assembly from AUTO to MANUAL. The propeller will remain at the pitch set initiated at the time of the change. You can change the pitch by operating the control valve lever and observing the local pitch indicator.

Once the problem with the electronic controls has been corrected, shift back to automatic operation. Before initiating the change from MANUAL to AUTO, be sure the pitch command signal from the controlling remote station matches the actual pitch setting at the time the mode change (manual to auto) is initiated. Shift the two changeover levers simultaneously to the AUTO position. If the command signal and actual pitch settings do not match, the pitch will automatically change to the commanded pitch upon completion of the mode change.

If the local manual mode is inoperative, shift the changeover valves to the OFF position, secure the hydraulic oil power module (HOPM), and set emergency pitch according to engineering operational sequence system (EOSS) procedures.

NOTE

When operating in the emergency ahead mode, the OD box temperature must be monitored continuously. You may have to apply cooling water to the OD box housing to maintain the temperature below 160°F. Remember, the most effective and preferred method to maintain OD box temperatures is the use of prairie air.

CRP/CPP SYSTEM INSPECTIONS

The following is a list of routine checks and services that should be made to the CRP/CPP system while underway:

1. Hourly
   a. Check the OD box temperature, 160°F maximum (150°F DDG-51 class).
   b. Check the hydraulic system oil pressures; ensure all comply with EOSS.
   c. Check the prairie air rotoseal for leaks.
   d. Check the ΔP for the online strainers and falters.
2. Each watch
   a. Check the hydraulic oil level in the sump and head tank.
   b. Inspect the hydraulic system for leaks and vibration.
3. Before entering port or any restricted maneuvering situation
   a. Verify the control system response by decreasing pitch slightly and noting response.
   b. Verify the pump (attached or electric) operation depending on ship class.
4. When the system is secured
   a. Check the oil level in the head tank. If the head tank oil level is low, replenish oil as necessary by operating the system until the oil level returns to normal.
   b. Inspect the oil for water contamination periodically.

CRP/CPP TROUBLESHOOTING AND MAINTENANCE

Even though the CRP/CPP systems installed on a gas turbine-powered ship use the same types of pumps and fluids as the MRG LO system, they are much more sophisticated. Paying close attention to system operating pressures is your most important step in successfully troubleshooting any problem 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. The two most common casualties that you can identify just by noting variations in the system pressure are 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 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 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 fails to provide command or feedback data, the CPP system can be shifted to the alternate system. When 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. The following are 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:

- Pitch fails to respond to a desired integrated throttle control (ITC) change.
- Pitch changes (fluctuations) occur without a pitch change command.
- Hub servo pressure increases steadily without a change in system demands.

AUXILIARY RELIEF VALVE.— A faulty auxiliary relief valve also will 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. 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 the reducing valve fails in the closed position, the flow of control oil will be cut off to the auxiliary servo piston, and pitch will fail to respond. Like the auxiliary relief valve, this loss of pressure will have to be viewed at the HOPM during the 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 to a problem. The alarm will sound when casualties occur either to the main relief valve or to a sequencing valve. The alarm may or may not sound, however, when a major leak occurs. Look at the three main causes of hydraulic oil pressure loss and the resulting alarms.

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 after 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 the system control would fade. On the other hand, if the sequencing valve fails 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 when you detect a loss of pitch control or a loss of hydraulic oil pressure. Now, we will discuss some of the most common maintenance procedures you as a supervisor will expect your personnel to perform.

Cleaning and Lubrication

Cleaning is a continuous task. As a GS supervisor, you are already aware that good housekeeping practices must be maintained and passed on to your subordinates. The responsibilities for cleaning and lubricating the components of the CRP/CPP systems are very similar to those 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. When cleaning the valves of the CRP/CPP systems, be sure to pay close attention to detail. Attention to detail is important because most of the valves and piping of the CRP/CPP systems are located in the bilge area. Valves in the bilge area are constantly exposed to corrosive elements.

Other components that require cleaning and lubrication are the two CRP/CPP pump couplings. These pump couplings are not cleaned and lubricated as frequently as the valves, but their cleaning and lubricating are still very important responsibilities.

Alignments and Adjustments

You will routinely supervise alignments and adjustments to couplings and other system components. Your personnel usually perform these tasks after general maintenance (cleaning and lubrication). 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.

The CRP/CPP system is one of the few systems that you as a supervisor will be required to train your personnel to closely monitor locally. Local monitoring is necessary because of the lack of remote monitoring capabilities. You will also be required to train your personnel to make the necessary mechanical and electrical adjustments. Your personnel will periodically perform these procedures through your ship's PMS. Remember, first you must monitor the operation of the CRP/CPP system as a whole, and then isolate individual components (one at a time) to ensure they are functioning properly. The following paragraphs contain some of the components you maybe required to adjust and the functions they are designed to perform.

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.

Besides adjusting the components at the OD box, both mechanical and electronic pitch position alignment checks must be accomplished periodically. These checks will not only require your expertise to train your personnel, but also require your presence while they are being accomplished.

MECHANICAL ALIGNMENT.— The mechanical alignment procedure is basically the same for all the ship classes. This procedure is performed according to the PMS and is used to detect valve rod separation (unscrewing) or elongation. Remember, two people will be required to perform this check One must be positioned at the OD box and the other at the HOPM, and they must be able to communicate with each other (sound-powered phones or walkie-talkies). This test is normally fairly easy to accomplish if no problems are encountered. By problems we mean the pitch scale and the pitch position pointer being off by more than 1/16 of an inch. If this difference cannot be explained by thermal growth or contraction of the valve rod assembly, it will be necessary to verify that all connections in the valve rod assembly are tight. If the position of the pointer and pitch scale is subject to question at anytime, you must verify actual position of blade 1A to the hub body marks. If the ship is not in dry dock, you must use a diver to observe and confirm hub body marks. You must have confirmation of the hub body marks at design ahead and full ahead when pitch is ordered at normal operating temperatures.

NOTE

In most cases, an equipment malfunction is not the cause of the pointer and scale discrepancy. Usually, it is an operator error. To avoid this problem, make sure your personnel strictly follow the MRC and always take all measurements at the same system oil temperature.

On the other hand, if the pitch pointer and the scale difference is less than a 1/16 of an inch or the greater than reading is related to thermal growth or contraction, then the scale can be moved to match the pointer's position. The only drawback to adjusting the scale to match the pointer is that an electronic alignment (calibration) must be performed

ELECTRONIC ALIGNMENT.— The electronic alignment procedures differ depending on the ship class. But, one thing will always be the same. To accomplish any of these procedures, the ship must be in dry dock or you will require the assistance of a diver. All adjustments made to align the mechanical (actual) pitch and electronic display indications must be verified with the actual blade position on the propeller hub. There is one electronic alignment procedure (electronic pitch indicating [EPI] system calibration) on the DDG-51 class that can only be accomplished when the ship is in dry dock.

REMOVAL AND REPLACEMENT OF COMPONENTS

The CRP/CPP 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 filters 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.

SUMMARY

In this chapter, we have discussed many of the factors that affect GTE performance, power train operation and maintenance, and propulsion systems. As you prepare for advancement, you must continue to learn and increase both your leadership skills and technical expertise. You must be prepared to train and supervise your subordinates. Read the various reference materials cited in this chapter to increase your understanding of the information that was presented.

APPENDIX I

REFERENCES USED TO DEVELOP THE TRAMAN

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. Therefore, you need to be sure you are studying the latest revision.

Chapter 1

Emergency Response Guidebook, DOT P 5800.5, Washington, D. C., 1990 Edition.

Engineering Operational Sequencing System (EOSS) User's Guide, NAVSSES EOSS Form, Naval Ships Systems Engineering Station, Philadelphia, Pa., May 1989.

Engineering Trial Report, Transmittal Letter, OPNAV Form 9094/1A, SN 0107-LF-090-9405, Chief of Naval Operations, Washington, D.C., May 1979.

Engineering Trial Report, Trial Data (Gas Turbine Driven Ships), OPNAV Form 9094/lD, Sheet 1 of 2, SN 0107-LF-090-9440, Chief of Naval Operations, Washington, D. C., May 1979.

Engineering Trial Report, Trial Data (Gas Turbine Driven Ships), OPNAV Form 9094/1D, Sheet 2 of 2, SN 0107-LF-090-9445, Chief of Naval Operations, Washington, D. C., May 1979.

Full Power and Economy Trial Requirements For Non-Nuclear Surface Ship Classes, OPNAVINST 9094.1A, Enclosure (l), Chief of Naval Operations, Washington, D.C., November 1988.

Naval Sea Systems Technical Manual, SL101-AA-GYD-010, "Energy Conservation (Fuel Economy) Shipboard Application," Naval Sea Systems Command, Washington, D. C., 19 April 1988.

Naval Sea Systems Technical Manual, S9221-C1-STM-010, "Main Boiler Repair and Overhaul Manual," Naval Ships Systems Engineering Station, Philadelphia, Pa., 25 February 1991.

Naval Sea Systems Technical Manual, S9221-D2-MMA-010, "Steam Generating Plant Inspections (Non-nuclear)," Naval Sea Systems Command, Washington, D. C., 01 October 1990.

Naval Sea Systems Technical Manual, S9517-AS-OMI-010, "Waste Heat Auxiliary Boilers; Installation, Operation, Maintenance, and Repair," Naval Sea Systems Command, Washington, D.C., 15 July 1992.

Naval Ships' Technical Manual (NSTM) , NAVSEA S9086-C4-STM-000, Chapter 094, 'Trials," Naval Sea Systems Command, Washington, D.C., 01 March 1978.

Naval Ships' Technical Manual (NSTM), NAVSEA S9086-GX-STM-020, Chapter 220, Volume 2, "Boiler Water/Feedwater Test and Treatment," Naval Sea Systems Command, Washington, D.C., 15 November 1992.

Naval Ships' Technical Manual (NSTM), NAVSEA S9086-GY-STM-010, Chapter 221, "Boilers," Naval Sea Systems Command, Washington, D.C., 15 September 1992.

Navy Environmental and Natural Resources Program Manual, OPNAVINST 5090.1A, Chapter 17 (Pollution Abatement Afloat), Chief of Naval Operations, Washington, D.C., 02 October 1990.

Navy Occupational Safety and Health (NAVOSH) Program Manual For Forces Afloat, OPNAVINST 5100.19B, Chapter B3, Appendix B3-A, Chief of Naval Operations, Washington, D.C., April 1989.

Standard Organization and Regulations of the U.S. Navy, OPNAVINST 3120.3213, Chapters 5 and 6, Chief of Naval Operations, Washington, D.C., 26 September 1986.

Chapter 2

Corrosion Control Manual for DD-963 Class Ships, NAVSEA S9630-AB-MAN-010, Naval Sea Systems Command, Washington, D.C., January 1985.

Internal Inspection and Evaluation of Marine Gas Turbine Engines (Model LM2500), NAVSEA S9234-Dl-GTP-010/LM2500, Naval Sea Systems Command, Washington, D.C., April 1985.

Model 104 Gas Turbine Generator Set, Volume 2, Part 1, S9234-BC-MMO-020/Mod. 104 GTGS, Naval Sea Systems Command, Washington, D.C., December 1982.

Model 104 Gas Turbine Generator Set, Volume 2, Part 1, S9234-B3-MMO-020/Mod. 139 GTGS, Naval Sea Systems Command, Washington, D.C., December 1982.

Naval Ships' Technical Manual (NSTM), NAVSEA S9086-HC-STM-000, Chapter 234, "Marine Gas Turbines," Naval Sea Systems Command, Washington, D.C., August 1988.

Naval Ships' Technical Manual (NSTM), NAVSEA S9086-VD-STM-003, Chapter 631, "Preservation of Ships in Service (Surface Preparation and Painting)," Naval Sea Systems Command, Washington, D.C., December 1987.

Naval Ships' Technical Manual (NSTM), NAVSEA S9086-VG-STM-010, Chapter 634, "Deck Coverings," Naval Sea Systems Command, Washington, D.C., April 1991.

Navy Occupational Safety and Health (NAVOSH) Program Manual For Forces Afloat, OPNAVINST 5100.19B, Chapter 6, Chief of Naval Operations, Washington, D.C., April 1989.

Propulsion Gas Turbine Module LM2500, Volume 2, Part 1, Revision 1, NAVSEA S9234-AD-MMO-030/LM2500, Naval Sea Systems Command, Washington, D.C., September 1991.

Propulsion Gas Turbine Module LM2500, Volume 2, Part 2, Revision 1, NAVSEA S9234-AD-MMO-040/LM2500, Naval Sea Systems Command, Washington, D.C., September 1991.

Propulsion Gas Turbine Module LM2500, Volume 2, Part 3, Revision 1, NAVSEA S9234-AD-MMO-050/LM2500, Naval Sea Systems Command, Washington, D.C., September 1991.

Chapter 3

Naval Ships' Technical Manual (NSTM), NAVSEA S9243-A7-MMA-010/77842, "Stern Tube Seal," Naval Sea Systems Command, Washington, D.C., 14 April 1989.

Naval Ships' Technical Manual (NSTM), NAVSEA S9244-AT-MMA-010, "Propulsion Line Bearing, Oil Disc Lubricated," Naval Sea Systems Command, Washington, D.C., 14 April 1989.

Naval Ships' Technical Manual (NSTM), NAVSEA S9086-HN-STM-010, Chapter 244, "Propulsion Bearings and Seals," Naval Sea Systems Command, Washington, D.C., 31 July 1991.

Naval Ships' Technical Manual (NSTM), NAVSEA 0901-LP-420-002, Chapter 9420, "Propulsion Reduction Gears, Couplings, and Associated Components," Naval Sea Systems Command, Washington, D.C., 15 August 1985.

Naval Ships' Technical Manual (NSTM), NAVSEA 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-47 Class Ships," Volume 1, S9234-BL-GTP-010/FFG-47 PPM, Naval Sea Systems Command, Washington, D.C., 15 January 1992.

INDEX

Assignment Questions

<u>Information</u>: The text pages that you are to study are provided at the beginning of the assignment questions.

ASSIGNMENT 1

Textbook Assignment. "Programs, Reports, and Records," "Gas Turbine Maintenance," and "Power Train and Propulsion Systems," chapters 1, 2, and 3.

Learning Objective: Identify the procedures needed to properly maintain, monitor, and evaluate the programs, reports, and records required of gas turbine systems supervisors.

1-1. The tag-out program must be enforced during which of the following conditions?

1. New construction
2. Normal operations
3. Maintenance
4. All of the above

1-2. A detailed description of the tag-out program procedures can be found in which of the following OPNAV instructions?

1. 3120.32
2. 5090.1
3. 5100.1
4. 9094.1

1-3. At a minimum, how often must tag-out audits be conducted?

1. Every week
2. Every 2 weeks
3. Every month
4. Every quarter

1-4. If the position of a danger-tagged valve is in question during a tag-out verification, what action, if any, should you take?

1. Attempt to operate the valve a small amount in the open direction
2. Attempt to operate the valve a small amount in the closed direction
3. Attempt to operate the valves on either side of the valve in question and monitor for pressure changes
4. None

1-5. As part of a tag-out audit, which of the following entries is NOT required to be written in the INDEX/AUDIT RECORD section of the tag-out log?

1. Date of the audit
2. Discrepancies noted
3. Number of tags checked
4. Signature of the person conducting the audit

1-6. A comprehensive look at the Navy's environmental pollution control program can be found in which of the following OPNAV instructions?

1. 3120.32
2. 5100.19
3. 5090.1
4. 9094.1

1-7. Which of the following individuals is authorized to inspect a space and to certify it safe for re-entry after a hazardous material spill where no toxic gases or vapors are present?

1. CDO
2. DCA
3. Fire marshal
4. Each of the above

1-8. A hazardous material spill that is considered detrimental to the environment requires which of the following reports?

1. OPREP-1
2. OPREP-2
3, OPREP-3
4. OPREP-4

1-9. Primary casualty control training concentrates on the control of what type of casualties?

1. Personnel
2. Battle inflicted
3. Single source
4. Multiple source

1-10. The EOSS serves all EXCEPT which of the following purposes?

1. To train unskilled operators
2. To eliminate the need for skilled operators
3. To schedule plant operations
4. To control plant operations

1-11. During a scheduled ROH, an EOSS verification check will be scheduled approximately how many weeks prior to the end of the availability?

1. 6
2 8
3. 3
4. 4

1-12. The rough copies of the EOSS will be used for approximately how many weeks before the new laminated copies are received?

1. 6
2. 8
3. 10
4. 12

1-13. An EOSS feedback report should be submitted for all of the following reasons EXCEPT which one?

1. To report an EOSS conflict with another technical reference
2. To order new book holders
3. To correct document errors
4. To order new twisties

1-14. A final pen and ink change to the EOSS resulting from an urgent feedback is authorized by what individual?

1. The type commander
2. The group commander
3. The commanding officer
4. The engineer officer

1-15. A routine EOSS feedback report is submitted on which of the following OPNAV forms?

1. 4790/4B
2. 4790/7B
3. 9094/1A
4. 9094/1D

1-16. The 3-M COORDINATOR block on an EOSS feedback report must be signed by what individual?

1. The MPA
2. The chief engineer
3. The 3-M coordinator
4. The EOSS coordinator

1-17. All full-power trials will be conducted with what minimum liquid load?

1. 65%
2. 75%
3. 85%
4. 95%

1-18. A full-power trial must be conducted at what minimum periodicity?

1. Every quarter
2. Every 6 months
3. Every year
4. Every 18 months

1-19. The OPNAV form 9094/1A is used to provide what type of information?

1. An overall grade for the exercise
2. A detailed listing of plant conditions
3. A general listing of plant conditions
4. A listing of all safety devices and their set points

1-20. In the MGTEL which of the following entries is/are authorized to be written in pencil?

1. NINC only
2. NIS only
3. NINC and NIS
4. INC

1-21. The acronym BIRMIS refers to which of the following descriptions?

1. Boiler information and replacement management inspection system
2. Boiler inspection and replacement management information system
3. Boiler inspection and repair management information system
4. Boiler information and repair management inspection system

1-22. A steaming WHB must be sampled within what maximum number of minutes prior to securing?

1. 90 minutes
2. 60 minutes
3. 45 minutes
4. 30 minutes

1-23. A WHB placed in a dry lay-up can remain in that status for what maximum amount of time?

1. 10 days
2. 30 days
3. 60 days
4. Indefinite

1-24. If a salinity indicator is malfunctioning, the water it monitors must be tested at what minimum periodicity?

1. Every 2 hours
2. Every 4 hours
3. Every 8 hours
4. Every 12 hours

1-25. If a deaerated feed tank is installed, a dissolved oxygen test must be performed at what minimum periodicity?

1. Every 24 hours
2. Every 12 hours
3. Every 8 hours
4. Every 4 hours

Learning Objective: Describe the maintenance procedures needed to help maintain an MGTE in peak operating condition.

1-26. Domestic object damage is defined as damage originating from which of the following sources?

1. The inlet plenum
2. The uptake spaces
3. The base enclosure
4. The inside of the engine

1-27. If the FOD screen is clogged by soft items, which of the following conditions may result?

1. An increase in power
2. Low duct pressure
3. High duct pressure
4. Elevated turbine inlet temperatures

1-28. When working in and around intake areas, you should take all EXCEPT which of the following safety precautions?

1. Ensure the blow-in doors are clean
2. Inspect the intakes for cleanliness
3. Account for all tools and equipment
4. Remove all loose objects from your person

1-29. You can find the inspection requirements and procedures for borescope inspections in which of the following sources?

1. The MGTESR
2. The MRC
3. The propulsion plant manual
4. The engineering log

1-30. When conducting a borescope inspection, you must be aware of all EXCEPT which of the following factors?

1. The internal reference points
2. The inspection areas and ports
3. The engineer officer's experience
4. The limitations of your equipment

1-31. It is a good engineering practice for you to review the machinery history of an engine before a borescope inspection for all EXCEPT which of the following reasons?

1. To know past inconsistencies
2. To know the components that are damaged
3. To know the parts that have been modified
4. To know the parts that have been changed

1-32. What total number of borescope inspection ports are located in the LM2500 compressor?

1. 5
2. 10
3. 15
4. 20

1-33. After removing the $P_{t5.4}$ pressure probes, what area(s) can you inspect?

1. The LP turbine nozzle assembly
2. The HP turbine nozzle assembly
3. The LP turbine exhaust, HP turbine inlet
4. The LP turbine inlet, HP turbine exhaust

1-34. To manually rotate the engine, you should use which of the following tools?

1. 18-inch long 3/4-inch drive extension
2. 18-inch long 3/4-inch drive socket wrench
3. 18-inch long 1/2-inch drive extension
4. 18-inch long 1/2-inch drive socket wrench

1-35. Zero reference for the LM2500 compressor is established by the use of which of the following engine components?

1. Vane shrouds
2. Vane blades
3. Locking lug blades
4. Carboloy blade pads

1-36. To maintain better control over the rotor speed when jacking the engine, you should use which of the following tools?

1. A torque multiplexer
2. A torque multiplier
3. An electric drive motor
4. An air drive motor

1-37. A fifth stage blade platform that is tilted or raised may indicate which of the following failures?

1. Midspan damper
2. Carboloy pad
3. Blade root
4. Tip clang

1-38. If you find a "leaner" during a borescope inspection, you should take which of the following actions?

1. Remove the engine from service
2. Replace the failed part
3. Operate the engine at low power
4. Make temporary repairs

1-39. Tip curl is usually caused by which of the following malfunctions?

1. Blade rub
2. Vane rub
3. Misalignment
4. Object damage

1-40. Tip clang can usually be attributed to which of the following operating conditions?

1. Overloading
2. Compressor stall
3. Continuous low-power operation
4. Continuous high-power operation

1-41. When tip clang takes place on a GTE, the major damage occurs to what area of the blade?

1. The midspan
2. The chord
3. The root
4. The tip

1-42. When you are inspecting the combustion section of a GTE, what wattage light source should you use?

1. 1,000
2. 750
3. 500
4. 250

1-43. The dimples of a dome band that has low operating time will usually have what kind of damage?

1. Burn through
2. Burn away
3. Bowing
4. Cracks

1-44. Distortion of the liner assemblies is evident when you observe which of the following conditions?

1. The inner liner bends down, and the outer liner lifts up
2. The inner liner lifts up, and the outer liner bends down
3. Stress line streaks
4. Burn through

1-45. What malfunction is the primary cause of DOD to the HP turbine?

1. Broken combustion liner pieces
2. Loss of film cooling air
3. Blade cracking
4. Vane flaking

1-46. Fault logic diagrams use all of the following block types to aid in troubleshooting EXCEPT which one?

1. Single-line
2. Double-line
3. Highlighted
4. Shaded

1-47. A functional dependency diagram is used for troubleshooting what particular GTE system?

1. The fuel control system
2. The VSV actuator control system
3. The electronic power control system
4. The fire extinguishing control system

1-48. As a supervisor, what is your primary concern during a GTE component replacement?

1. Meeting deadlines
2. The safety of personnel
3. Proper replacement parts
4. The availability of tools

1-49. To plan an engine changeout, who should be present at the organizational meeting?

1. Department heads only
2. Security personnel only
3. Supervisors only
4. All involved personnel

1-50. During a changeout, where should the special support equipment (SSE) containers be placed?

1. Within reach of the crane
2. Out of the normally traveled area
3. In the main engine room (MER)
4. On the main deck of the tender

1-51. When should the replacement engine containers be brought to the site?

1. After the old engine has been removed
2. After supply has inventoried the containers
3. As the new engine is needed
4. As soon as possible

1-52. The completed MGTE log book should be shipped to the repair activity in what manner?

1. Returned with the technical representative
2. Returned with the container
3. Sent by registered mail
4. Sent by normal mail

1-53. When returning containers, you should use what inert gas to pressurize the shipment container?

1. Argon
2. Halon
3. Nitrogen
4. Helium

1-54. During the engine changeout, when should crane services be used for other purposes?

1. After placement of the SSE vans
2. Just prior to engine removal
3. During meal hours
4. After completion of the changeout

1-55. Improperly aligned horizontal rail flanges may result in damage to which of the following components?

1. Compressor blading
2. Flexible coupling
3. C-sump air seal
4. Aerodynamic coupling

1-56. Dry trunnion bearings should be lubricated with which of the following lubricants?

1. 2190 VSI
2. 23699
3. WD-40
4. MLG-G-10924

1-57. What form of damage is the greatest threat to gas turbine and support equipment?

1. DOD
2. FOD
3. Corrosion
4. Overheating

1-58. When dissimilar metals come in contact with a conductor, which of the following types of metal deterioration takes place?

1. Rust erosion
2. Etching erosion
3. Chemical corrosion
4. Electrochemical corrosion

1-59. A reddish-colored oxide usually forms on which of the following metals?

1. Steel
2. Aluminum
3. Chromium
4. Magnesium

1-60. A white-gray powdery deposit can usually be found on which of the following metals?

1. Steel
2. Aluminum
3. Magnesium
4. Magnetite

1-61. Active corrosion on copper alloys is indicated by which of the following conditions?

1. A verdigris formation
2. A white-gray powder formation
3. A gray-green patina formation
4. A copper-oxide crust formation

1-62. Cadmium and zinc coatings provide which of the following types of protection for the base metal?

1. Sealant
2. Chemical
3. Electrical
4. Sacrificial

Learning Objective: Identify the procedures for inspecting and maintaining propulsion systems and power train equipment.

1-63. Before opening a main reduction gear (MRG) cover, you should take all EXCEPT which of the following precautions?

1. Drain the LO sump
2. Post a security watch
3. Clean the areas around the covers
4. Obtain the chief engineer's permission

1-64. Backlash is best described by which of the following statements?

1. Clearance of the gears that do not mesh
2. Clearance of the gears operating in parallel
3. Play between the surfaces of the teeth in mesh
4. Radial play between the pinion teeth and bearings

1-65. When pinion and gear teeth have been slightly indented by foreign material, what action should you take?

1. Closely monitor the damage to see if it spreads
2. Remove both gears for a complete overhaul
3. Remove the raised metal on the damaged teeth
4. Remove the raised metal on both gears

1-66. When performing a static check to determine tooth contact, you should use which of the following compounds to coat the gear teeth?

1. An indelible marker
2. Copper sulfate
3. Persian blue
4. Prussian blue

1-67. Corrective pitting along the pitch line may occur during which of the following periods of service?

1. During full-power operation
2. During prolonged operation
3. During the first few months of operation
4. During excessive operation at low power

1-68. When determining offset alignment readings, manufacturers take into account all EXCEPT which of the following factors?

1. Speed of the installation
2. Thermal expansion of the MRG
3. The hydrodynamic oil film effect
4. Thermal expansion of the foundation

1-69. The line shaft (spring) bearing (LSB) used on gas turbine ships is what type of bearing?

1. Prealigned, self-lubricated bearing
2. Nonaligned, pressure lubricated bearing
3. Self-aligning, oil-lubricated roller bearing
4. Self-aligning, oil-lubricated journal bearing

1-70. On the LSB, where are the original installation clearance readings located?

1. On the lower bearing housing
2. On the upper bearing housing
3. On the base support
4. On the side cover

1-71. How are the stern tube and strut tube bearings cooled?

1. By heat-dissipating fins
2. By air from the masker air system
3. By fresh water
4. By seawater

1-72. 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

1-73. The electronic pitch position transducer is located in what area?

1. Inside the CRP electronics enclosure
2. On the right side of the OD box
3. On the front end of the OD box
4. Inside the propeller hub

1-74. A steady increase in hub servopressure, 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

1-75. During the mechanical pitch alignment check, the OD box pitch position plate can be moved (adjusted) a maximum of what distance as long as the distance change can be explained?

1. 1/32 inch
2. 1/16 inch
3. 1/8 inch
4. 1/4 inch