NONRESIDENT
TRAINING
COURSE

April 1992

Engineman 2

NAVEDTRA 14076

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

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

ERRATA #l   26 July 1999

Specific Instructions and Errata

ENGINEMAN 2

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

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

3. Assignment Booklet

Make the following changes:

4-44   ADD the word "rise" after 20°F

4-54   CHANGE "clean oil" to "cleaning fluid"

Delete the following questions, and leave the corresponding space blank on the answer sheet:

Question

4-4

4-63

PREFACE

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

COURSE OVERVIEW: In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following subjects: Administration and Training; Measuring and Repair Instruments; Internal Combustion Engines; Speed Control Devices; Refrigeration and Air Conditioning; Compressed Air Systems; Laundry, Mess Decks, Galley, and Scullery Equipment; Auxiliary Equipment; and Lathe and Machining Operations.

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

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

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

1992 Edition Prepared by
ENC Renato D. Dizon

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AND TECHNOLOGY CENTER

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Sailor’s Creed

“I am a United States Sailor.

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

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

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

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

CONTENTS

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

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

SELECTING YOUR ANSWERS

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

SUBMITTING YOUR ASSIGNMENTS

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

Grading on the Internet: Advantages to Internet grading are:

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

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

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 N314
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
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 6 points. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty,* BUPERSINST 1001.39, for more information about retirement points.)

Student Comments

Course Title: *Engineman 2*

NAVEDTRA: 14076 **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

ADMINISTRATION AND TRAINING

Everytime you advance in paygrade, you increase your responsibility for administration and training. This chapter deals briefly with some of your administrative responsibilities and then touches on certain aspects of your responsibility for training others.

ENGINEERING RECORDS AND LOGS

As an EN2, you will be primarily concerned with updating logs and similar records. Some of the logs and records are official, legal records. Others are used to ensure proper and timely upkeep of the ship's equipment. The information given in the following sections is intended to help you learn how to prepare and use the logs and records. The standard forms for the logs and records are prepared by the various systems commands and the CNO. The forms are for issue to forces afloat and are available as indicated in the *Unabridged Navy Index of Publications and Forms*, NPFC PUB 2002 D. These forms are revised as conditions warrant and personnel ordering them must be sure they order the most current forms. If you need similar forms for local use, ensure that an existing standard form will not serve the purpose before you request that a special form be prepared and printed.

LEGAL ENGINEERING RECORDS

The Engineering Log and the Engineer's Bell Book are the only legal records compiled by the engineering department. The Engineering Log is a midnight-to-midnight record of the ship's engineering department. The Engineer's Bell Book is a legal record of any order regarding change in the movement of the propellers.

Engineering Log

The Engineering Log is a complete daily record, by watches. It covers important events and data pertaining to the engineering department and the operation of the ship's propulsion plant. The log must show the following information:

1. The total engine miles steamed for the day

2. Draft and displacement upon getting underway and anchoring

3. The disposition of the engines, boilers, and principal auxiliaries and any changes in their disposition

4. Any injuries to engineering department personnel

5. Any casualties to engineering department machinery, equipment, or material

6. Other matters specified by competent authority

Depending on your training and watch position, you may have to either make entries in the Engineering Log or both make and verify such entries. Whatever the case, each entry must be made according to instructions given in (1) the Engineering Log form, NAVSHIPS 3120/2D; (2) the *Naval Ships' Technical* Manual (NSTM), chapter 090; and (3) directives issued by the type commander. Each entry must be a complete statement using standard phraseology. The type commander's directives may contain other specific requirements pertaining to the Remarks section of the Engineering Logs for ships of the type.

The *original* Engineering Log, prepared neatly and legibly in ink or pencil, is a legal record. Do NOT keep a rough log. Keep the Engineering Log current. Enter each event onto the Engineering Log as it happens. No erasures are permitted in the log. When a correction is necessary, draw a single line through the original entry so that the entry remains legible. The correct entry must be clear and legible. Corrections, additions, or changes are made only by the person required to sign the log for the watch This person then initials the margin of the page.

The engineering officr of the watch (EOOW) or the senior petty officer of the watch (SPOW) should prepare the remarks for the log and should sign the log before being relieved at the end of the watch or duty day. The engineer officer verifies the accuracy and completeness of all entries and signs the log daily. The log sheets must be submitted to the engineer officer in time to allow him or her to check and sign them before noon of the day following the date of the log sheet(s). The commanding officer approves the log and signs it on the last calendar day of each month and on the date he or she relinquishes command. Completed pages of the log, filed in a post-type binder, are numbered consecutively. They begin with the first day of each month and run through the last day of the month.

When the commanding officer (or engineer officer) directs a change or addition to the Engineering Log, the person directed must comply unless he or she believes the proposed change or addition to be incorrect. In that event, the commanding officer or engineer officer will personally enter his or her comments and sign the log. After the log has been signed by the the commanding officer, it may not be changed without his or her permission or direction.

Engineer's Bell Book

The Engineer's Bell Book, NAVSHIPS 3120/l, is a record of all bells, signals, and other orders received by the throttleman for movement of the ship's propellers. Entries are made in the Bell Book by the throttleman (or an assistant) as soon as an order is received. Entries are usually made by the assistant when the ship is entering or leaving port, or engaging in any maneuver that is likely to involve numerous or rapid speed changes. This procedure allows the throttleman to devote his or her undivided attention to answering the signals.

The Bell Book is maintained in the following manner:

1. A separate bell sheet is used for each shaft each day, except where more than one shaft is controlled by the same throttle station. In that case, the same bell sheet is used to record the orders for all shafts controlled by the station. All sheets for the same date are filed together as a single record.

2. The time of receipt of the order is recorded in column number 1.

3. The order received is recorded in column number 2. Minor speed changes (generally received via revolution indicator) are recorded by entering the number of rpm ordered. Major speed changes (normally received via engine order telegraph) are recorded using the following symbols:

a. 1/3-ahead 1/3 speed

b. 2/3-ahead 2/3 speed

C. I-ahead standard speed

d. II-ahead full speed

e. III-ahead flank speed

f. z-stop

g. B1/3-back 1/3 speed

h. B2/3-back 2/3 speed

i. BF-back full speed

j. BEM-back emergency speed

4. The number of revolutions corresponding to the major speed change ordered is entered in column 3. When the order received is recorded as rpm in column 2 (minor speed changes), no entry is made in column 3.

5. The shaft revolution counter reading (total revolutions) at the time of the speed changes is recorded in column 4. The shaft revolution counter reading-as taken hourly on the hour while underway-also is entered in column 4.

For ships and craft equipped with controllable reversible pitch propellers, the propeller pitch in feet and fractions of feet set in response to a signaled speed change, rather than the shaft revolution counter readings, is recorded in column 4. The entries for astern pitch are preceded by the letter *B.* Each hour, on the hour, entries are made of counter readings. This helps in calculating engine miles steamed during the time the propeller pitch remained constant at the last value set in response to a signaled order.

On ships with gas turbine propulsion plants, a bell logger provides an automatic printout each hour. This printout is also provided whenever propeller rpm or pitch is changed by more than 5 percent, when the engine order telegraph is changed, or when the controlling station is shifted. Provision must be made for manual logging of data in the event the bell logger is out of commission (OOC).

Before going off watch, the EOOW signs the Bell Book on the line following the last entry for his or her watch. The next officer of the watch continues the record immediately thereafter. In machinery spaces where an EOOW is not stationed, the bell sheet is signed by the watch supervisor.

NOTE: A common practice is also to have the throttleman sign the Bell Book before it is signed by the EOOW or his or her relief.

The Bell Book is maintained by bridge personnel in ships and craft equipped with controllable reversible pitch propellers and those in which the engines are directly controlled from the bridge. When control is shifted to the engine room, however, the Bell Book is maintained by the engine-room personnel. The last entry made in the Bell Book on the bridge shows the time that control is shifted. The first entry made in the Bell Book in the engine room shows the time that control is taken by the engine room. Similarly, the last entry made by engine-room personnel shows when control is shifted to the bridge. When the Bell Book is maintained by the bridge personnel, it is signed by the officer of the deck (OOD).

Alterations or erasures are not permitted in the Bell Book. An incorrect entry is corrected by drawing a single line through the entry and recording the correct entry on the following line. Deleted entries are initialed by the EOOW, the OOD, or the watch supervisor, as appropriate.

OPERATING RECORDS AND REPORTS

Engineering operating records are used to ensure regular inspection of operating machinery and to provide data for performance analysis. Operating records do not replace frequent inspections of operating machinery by supervisory personnel nor do they necessarily warn of impending casualties. Personnel who maintain operating records must be properly trained to correctly obtain, interpret, and record data, and to report any abnormal conditions.

The type commander's directives specify which engineering operating records must be maintained and prescribe the forms to be used when no standard record forms are available. The engineer officer may require additional operating records when he or she deems them necessary.

The operating records discussed in this chapter are generally retained on board for a period of 2 years, after which they may be destroyed according to current disposal regulations. Completed records must be stowed so they will be properly preserved and can be easily located.

Diesel Engine Operating Record

The Diesel Engine Operating Record-All Ships, NAVSEA 9231/2 (figs. 1-1 and 1-2), is a daily record maintained for each operating diesel engine. In ships with more than one main engine in the same engine room, a separate record sheet is maintained for each operating engine.

The watch supervisor enters the remarks and signs the record for his or her watch. The petty officer in charge of the engine room or the senior engineman checks the accuracy of the record and signs the record in the space provided on the back of the record. Any unusual conditions noted in the record are immediately reported to the engineer officer, and the record is sent to the engineer officer for approval.

Fuel and Water Accounts

The maintenance of daily diesel fuel, lubricating oil, and water accounts is vital to the efficient operation of the engineering department. Forms and procedures necessary to account for fresh water and fuel are generally prescribed by the type commanders.

The accounts tell the engineer officer the status of the ship's liquid load and form the basis of engineering reports submitted to higher authority.

Ship and unit commanders *must know the* exact amount of burnable fuel on hand. When you compute the amount of burnable fuel on board, consider only the fuel in the service and storage tanks. All the fuel below the fuel suction line is considered not burnable.

Fuel and Water Reports

The Fuel and Water Report, NAVSEA 9255/9 (rev. 2-80) (figs. 1-3 and 1-4), is a report submitted daily to the commanding officer. This report indicates the amount of fuel oil and water on hand as of midnight, the previous day. The Fuel and Water Report also includes the previous day's feed and potable water consumption figures and results of water tests. The original and one copy are submitted to the OOD in sufficient time for submission to the commanding officer or command duty officer with the 1200 reports. The copy is retained by the OOD.

Monthly Summary

The Monthly Summary of Fuel Inventory and Steaming Hours Report, CINCLANTFLT 3100-4, is a comprehensive monthly report of engineering data. These data are used to calculate the operating efficiency and general performance of the ship's engineering plant (see fig. 1-5). Requirements for this report are contained in fleet commander instructions. The engineer officer prepares the report, has the supply officer verify the fuel receipt figures, and forwards it to the commanding officer. The commanding officer approves the report and sends it directly to the fleet commander. One copy is retained on board in the files of the engineering department. An additional copy of the report may be provided to the type commander.

The Monthly Summary includes the ship's fuel receipts data, fuel consumption and steaming hours necessary to establish monthly financial obligations,

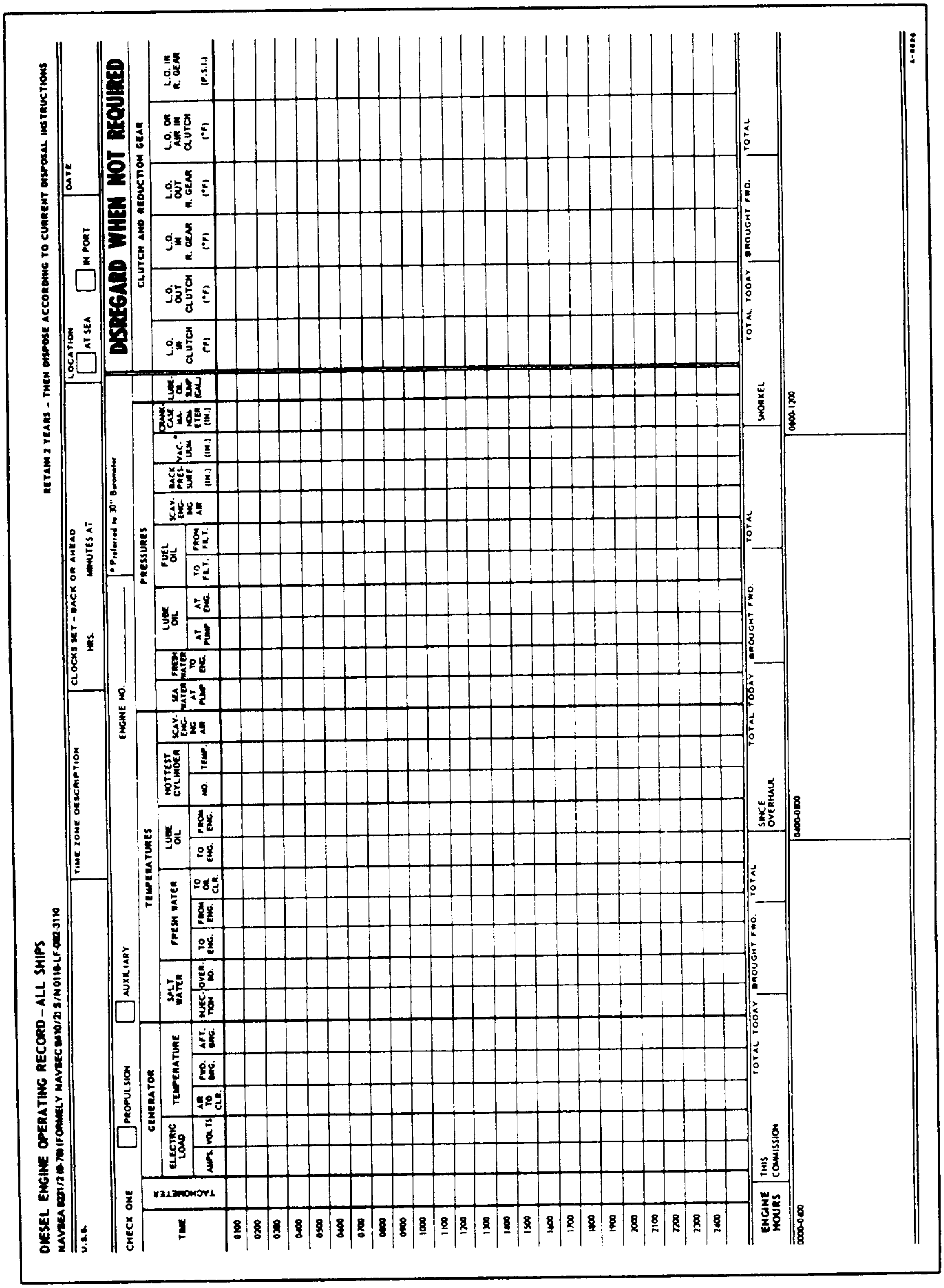


Figure 1-1.–Diesel Engine Operating Record–All Ships (front).

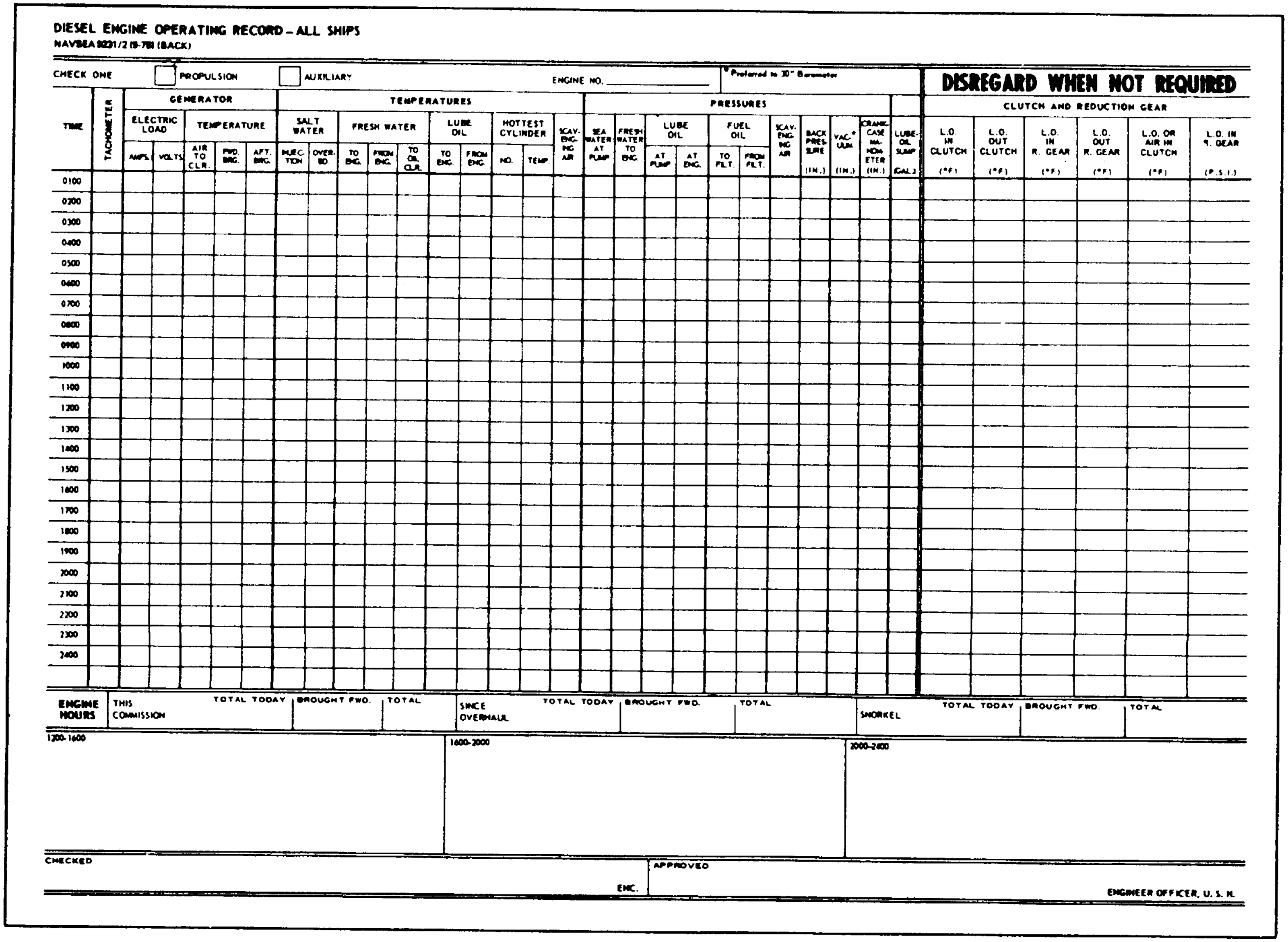


Figure 1-2.–Diesel Engine Operating Record–All Ships (back).

NAVSEA 9255/9 (1-79) (Front)
(Formerly NAVSEA 9510/1)

FUEL AND WATER REPORT

DATE ____________

TO: COMMANDING OFFICER, USS ______________________________

	FUEL (GALLONS)		LUBE OIL (GALLONS)	WATER (GALLONS)	
	BOILER FUEL	DIESEL FUEL	STORAGE TANKS	POTABLE	RESERVE FEED
ON HAND LAST REPORT					
RECEIVED (+)					
DISTILLED (+)					
EXPENDED (-)					
GAIN (+) LOSS (-) BY INVENTORY					
ON HAND THIS REPORT					
ON HAND %					

TRANSFERS/RECEIPTS (FUEL, LUBE OIL, OR WATER)

OIL
FROM ________ HRS TO ________ HRS AMOUNT (GAL) ________ SOURCE ______________________

WATER
FROM ________ HRS TO ________ HRS AMOUNT (GAL) ________ SOURCE ______________________

POTABLE WATER RECORD		
PERSONNEL ON BOARD	GALLONS USED PER PERSON	STANDARD

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

REMARKS:

Figure 1-3.—Fuel and Water Report (front).

and fuel requirements data for budget justification. This report includes all fuel data as of 2400 hours of the last day of the month. Fleet commander instructions contain detailed instructions for completing the forms, as well as the definitions of the terms used.

In addition to data on fuel inventory, the report contains space for fuel consumed underway, fuel consumed not underway, and fuel consumed by boats. Space is also provided for total steaming hours broken down as underway and not underway.

Most engineer officers prefer to compile the necessary data for this summary on a daily basis rather than wait until the end of the month and make computations from the various records. If you prepare

NAVSEA 9255/9 (1-79) (Back)

HOURS SINCE CLEANING				BOILER WATER CONDITIONS — RECORD THE BOILER WATER TEST RESULTS IN THE DESIGNATED SPACES. RESULTS NOT WITHIN LIMITS MUST BE CIRCLED IN RED AND EXPLAINED IN REMARKS ON THE FRONT OF THIS REPORT.									
				LAST SAMPLE				RANGE OF RESULTS					
BLR NO.	FIRE-SIDE	WATER-SIDE (MECH)	WATER-SIDE (CHEM)	pH	COND.	PHOS-PHATE	CHLOR-IDE	pH	COND.	PHOS-PHATE	CHLOR-IDE	LAYUP CODE	TOTAL STEAMING HOURS
								MAX					
								MIN					
								MAX					
								MIN					
								MAX					
								MIN					
								MAX					
								MIN					
								MAX					
								MIN					
								MAX					
								MIN					
								MAX					
								MIN					
								MAX					
								MIN					

DEAERATED FEEDWATER CONDITIONS

SYSTEM	DISSOLVED OXYGEN (PPB)				SALINITY INDICATOR (EPM CHLORIDE)				pH			
	1	2	3	4	1	2	3	4	1	2	3	4
RANGE OF RESULTS	MAX				MAX				MAX			
	MIN				MIN				MIN			

BOILER WATER LIMITS:

	TYPE A	TYPE B
pH	10.20 - 10.60	9.80 - 10.20
CONDUCTIVITY (μMHOS/CM)	600 MAX	400 MAX
PHOSPHATE (PPM)	50 - 120	25 - 60
CHLORIDE (EPM)	NOTE 1	NOTE 1

NOTE 1: SHOULD NOT NORMALLY EXCEED 1.00 EPM (CONTAMINATION NOT OCCURRING)

FEEDWATER LIMITS:

	ALL SHIPS
DISSOLVED OXYGEN (PPB)	15 PPB BY METER, 15 PPB BY CHEMICAL TEST
SALINITY (EPM CHLORIDE)	0.02
pH	8.60 - 9.00

BOILER LAYUP

DRY

DES	DESICCANT
HTD	HEATED AIR

WET

STM	150 PSI STEAM (SHIP)
STS	150 PSI STEAM (SHORE)
NIT	NITROGEN
DFT	HOT DFW FILL
HYD	HYDRAZINE

PREPARED BY: (OIL KING)	REVIEWED: (MPA)	REVIEWED: (ENGINEER OFFICER)

Figure 1-4.—Fuel and Water Report (back).

or assist in preparing this report, be very careful with your mathematical calculations and ensure that they are accurate. Doing so will help to avoid the necessity of resubmitting a corrected form later.

Daily Boat Fueling Record

The Daily Boat Fueling Record is a routine record of daily fueling, which is highly recommended for any ship that carries or maintains a number of boats. Use of this schedule will help prevent special fuelings at unusual hours and will keep the boats ready for

MONTHLY SUMMARY OF FUEL INVENTORY AND STEAMING HOURS REPORT

LANTFLT 3100/1 (Rev. 7/73) *0103-LF-631-0011*

CINCLANTFLT REPORT 3100-4

(No letter of transmittal required. Submit by 3rd of following month.)

FROM *(Name, type, hull no.)* USS		UIC	MONTH/YEAR
TO COMMANDER IN CHIEF U.S. ATLANTIC FLEET (CODE 042) NORFOLK, VA. 23511	MAIN PROPULSION FUEL TYPE *(Check one)* ☐ NSFO ☐ JP-5 ☐ DIESEL ☐ DISTILLATE	OPR CDR CODE (SEE REVERSE)	DAYS UNDERWAY

		NSFO (GALLONS)	DIESEL (GALLONS)	JP-5 (GALLONS)	DISTILLATE (GALLONS)
FUEL INVENTORY ON BOARD BEGINNING OF MONTH					
RECEIPTS DURING MONTH	(+)				
GAIN BY INVENTORY	(+)				
LOSS BY INVENTORY, STRIPPING, CONTAMINATION	(−)				
TOTAL MONTHLY DELIVERIES TO SHIP, HELO, ETC.	(−)				
FUEL CONSUMED UNDERWAY	(−)				
FUEL CONSUMED NOT UNDERWAY	(−)				
FUEL CONSUMED FOR BOATS, AUX, ETC.	(−)				
FUEL INVENTORY ON BOARD END OF MONTH	(Bal)				

	STEAMING UNDERWAY	STEAMING NOT UNDERWAY	NOT UNDERWAY COLD IRON	TOTAL HOURS FOR MONTH
HOURS				

FUEL RECEIPTS - DETAIL FROM ISSUING SHIP OR SHORE ACTIVITY				FUEL DELIVERIES - DETAIL AND DOCUMENT NUMBERS			
Date	From	Type	Gallons	Date	To	Type	Gallons

SUBMITTED	RECEIPTS/DELIVERIES VERIFIED	FORWARDED APPROVED
CHIEF ENGINEER	SUPPLY OFFICER	COMMANDING OFFICER

Figure 1-5.—Monthly Summary of Fuel Inventory and Steaming Hours Report, CINCLANTFLT Report 31004.

unexpected calls. The following list contains the recommended headings for this record:

— Boat number

— Fuel capacity in gallons

— Gallons on hand

— Approximate fuel consumption in gallons per hour

— Operating hours of fuel remaining

— Fueled or not fueled to capacity

Distilling Plant Operating Record

The Distilling Plant Operating Record is a daily record of the operation of the ship's evaporators and their auxiliaries. Entries are made for each hour of the watch while the distilling plants are in operation. Different ships have different types of distilling plants, but all of the daily distilling plant operating records require practically the same data.

The information required by this record consists of the following:

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

2. Scaling record for each evaporator unit, which includes the date of the last scaling, the hours operated, and the quantity of distilled water produced

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

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

You must make accurate entries in the Distilling Plant Operating Record! Accurate entries not only help predict troubles but, should abnormal operating conditions suddenly develop, aid in locating the sources of trouble.

For other recommended miscellaneous records, refer to *NSTM*, chapter 90.

DISPOSAL OF ENGINEERING RECORDS AND REPORTS

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

Both the Engineering Log and Engineer's Bell Book must be preserved as permanent records on board ship for a 3-year period unless they are requested by a naval court or board, or by the Navy Department. In such case, copies (preferably photostatic) of records that are sent from the ship are certified by the engineer officer as being true copies and are put in the ship's files.

At regular intervals, such as each quarter, records that are over 3 years old are destroyed. When a ship that is less than 3 years old is decommissioned, the current books are retained on board. If a ship is scrapped, the current books are forwarded to the nearest Naval Records Management Center.

All reports forwarded to, and received from, NAVSEA or another superior command may be destroyed when they are 2 years old, if they are no longer required.

Finally, to control the volume of paper work, reports should only be kept on board ship if they

1. are required,

2. serve a specific purpose, or

3. may provide repair personnel with information not found in publications or manuals.

MEASURE PROGRAM

All equipment requiring calibration or servicing should be maintained at maximum dependability. To meet this requirement, the Chief of Naval Material implemented the Metrology Automated System for Uniform Recall and Reporting (MEASURE).

The MEASURE system is a tool for your use. It is only as good as the information that you put into it. Therefore, it is important that alI the information be complete, legible, accurate, and consistent.

As an EN you will be required to read gauges to determine if the equipment is operating properly. The gauges must be calibrated periodically to assure their accuracy. The MEASURE program provides this calibration. In this section, we will discuss some of the major parts of the MEASURE system.

METER CARD

The METER card is a five-part color-coded form to which the equipment identification and receipt tag is attached. It is filled out by either the customer or the calibrating activity. You will have a METER card for every item for which you are responsible that requires calibration.

This card is used to record a calibration action, to add or delete items from inventory, to reschedule calibration, to transfer custody, or to record manhours for a completed calibration.

The white copy of a completed METER card is sent to the MEASURE Operational Control Center (MOCC), where the information is keypunched into a computer to update the MEASURE data base. The new information is then printed on another METER card and sent back to the customer activity to be used the next time another transaction is to be completed.

Accurate data, completeness, and legibility in filling out the meter card is essential. Remember a computer **CANNOT think!**

FORMAT 310

This report is sent to you every month and is an inventory of all your items, including overdue and delayed items. If you have any additions, deletions, or corrections to this format, submit them to the MOCC on either the METER card or on the Add-On-Inventory form.

FORMAT 350

This report is also sent to you monthly and is for information purposes. It is prepared in a customer/subcustodian sequence to readily identify all items held on subcustodian basis by other activities. This format is produced concurrently with format 310. Both formats 310 and 350 will have the last calibration dates of all items and the due dates of their calibrations.

FORMAT 802

Format 802 is a recall schedule. It is updated and distributed monthly. It tells you what equipment is due for calibration that month. It is sequenced by customer activity, by subcustodian, and by calibration laboratories.

EQUIPMENT AND INSTRUMENT TAG-OUT

Whenever you make repairs, you will be required to isolate and tag-out that equipment or section of the system. The tag-out program provides a procedure to be used when a component, piece of equipment, system, or portion of a system must be isolated because of some abnormal condition. The tag-out program also provides a procedure to be used when an instrument becomes unreliable or is not operating properly. The major difference between equipment tag-out and instrument tag-out is that tags are used for equipment tag-out and labels are used for instrument tag-out.

Tag-out procedures are described in *Standard Organization and Regulations of the U.S. Navy,* OPNAVINST 3120.32B. and represent the minimum requirements for tag-out. These procedures are mandatory and are standardized aboard ships and repair

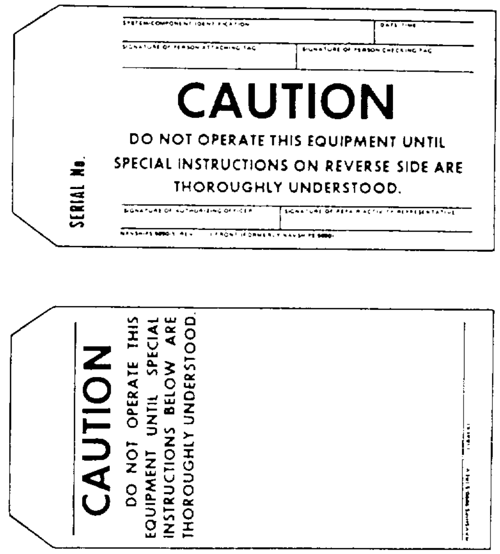


Figure 1-6.—CAUTION tag.

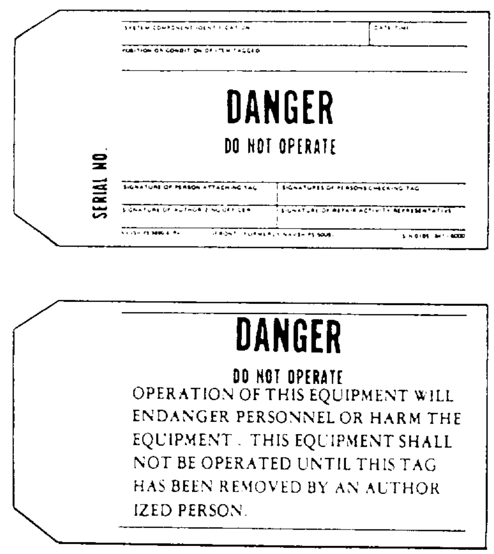


Figure 1-7.–DANGER tag.

activities. The following definitions are used in the tag-out bill:

1. Authorizing officer-This individual has the authority to sign tags and labels and to have tags and labels issued or cleared. The authorizing officer is always the officer responsible for supervising the tag-out log. The commanding officer designates authorizing officers by billet or watch station. The authorizing officer for engineering is normally the EOOW underway and the engineering duty officer (EDO) in port.

2. Department duty officer (DDO) (repair activities only)-This individual is designated as DDO on the approved watch bill or plan of the day.

3. Engineering officer of the watch (EOOW)–This individual may be either the EOOW or the EDO, depending on engineering plant conditions.

4. Officer of the deck (OOD)–This individual may be either the OOD or the ship's duty officer, depending on the ship's condition.

5. CAUTION tag (See fig. 1-6.)–This is a YELLOW tag used as a precautionary measure. It provides temporary special instructions or warns that unusual caution must be used to operate the equipment. These instructions must state exactly why the tag is installed. Use of phrases such as "DO NOT OPERATE WITHOUT EOOW PERMISSION" is not appropriate. Yellow tagged equipment or systems must not be operated without permission from the responsible supervisor. The CAUTION tag may not be used if personnel or equipment can be endangered while working under normal operating procedures. In such cases, a DANGER tag must be used.

6. DANGER tag (See fig. 1-7.)–This is a RED tag that prohibits the operation of equipment that could jeopardize the safety of personnel or endanger equipment, systems, or components. Equipment may not be operated or removed when tagged with DANGER tags.

7. OUT-OF-CALIBRATION labels (See fig. 1-8.)–These are ORANGE labels used to identify instruments that are out of calibration and do not give accurate readings. These labels warn that the instruments may be used for system operation, but only with extreme caution.

8. OUT-OF-COMMISSION labels (See fig. 1-9)–These are RED labels used to identify instruments that will not give accurate readings because they are either defective or isolated from the system. The instruments should not be used until they have been recertified for use.

9. Repair activity–This is any activity other than the ship's force that is involved in the construction, testing, repair, overhaul, refueling, or maintenance of the ship (intermediate or depot level maintenance activities).

10. Ship's force–These are personnel who are assigned to the ship and are responsible for the maintenance and operation of the ship's systems and equipment. Only qualified personnel are authorized to make a tag-out.

11. Tag-out log–This is the control document used to administer the entire tag-out procedure.

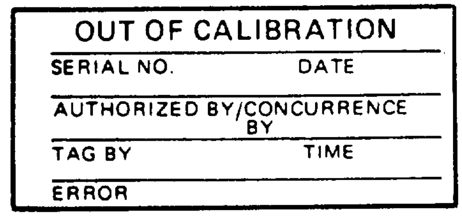


Figure 1-8.–Out-of-calibration label.

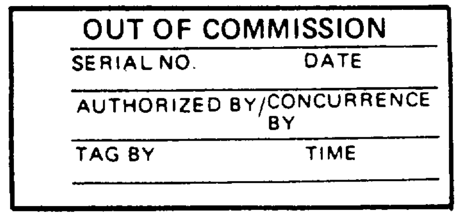


Figure 1-9.–Out-of-commision label.

TAG-OUT LOGS

The number of tag-out logs on a ship depends on the ship's size. For example, a minesweeper or nonnuclear-powered submarine may need only one tag-out log; a major surface combatant may need a separate log for each major department. Individual force commanders specify the number of logs needed and their location.

A tag-out log is a record of authorization for each tag-out action. It includes the following information:

1. A copy of OPNAVINST 3120.32B and any amplifying directives needed to administer the system.

2. The DANGER/CAUTION Tag-out Index and Record of Audit (Index/Audit Record). This is a sequential list of all tag-outs issued. It provides a ready reference of existing tag-outs, ensures that serial numbers are issued sequentially, and is useful in conducting audits of the log. A sample of this index is shown in figure 1-10. Index pages with all tag-outs listed as cleared may be removed by the department head.

3. DANGER/CAUTION Tag-out Record Sheet (figs. 1-11 and 1-12). All tags that have been used in the tag-out of a particular system are logged on one DANGER/CAUTION tag-out record sheet along with the reason for the tag-out. All effective sheets are kept in one section of the log.

4. Instrument Log (fig. 1-13). Labels used with OUT-OF-CALIBRATION and OUT-OF-COMMISSION instruments are logged in the instrument log.

5. Cleared DANGER/CAUTION Tag-out Record Sheets. Sheets that have been cleared and completed are

DANGER/CAUTION TAG-OUT INDEX AND RECORD OF AUDIT
(INDEX/AUDIT RECORD)

LOG SERIAL	DATE ISSUED	TYPE (DANGER/CAUTION)	DESCRIPTION (SYSTEM, COMPONENT, WORK PERMIT OR TEST DOCUMENT REFERENCE)	DATE CLEARED

Figure 1-10.—Danger/Caution Tag-out Index and Record of Audit.

DANGER/CAUTION TAG-OUT RECORD SHEET NAVSEA 9210/9 (REV 8-81) *(Cont'd on Reverse)*	DATE/TIME TAG-OUT ISSUED
SYSTEM OR COMPONENT	LOG SERIAL NO.

REASON FOR TAG-OUT

PERSONNEL/EQUIPMENT HAZARDS INVOLVED *(Mandatory for danger tags)*

AMPLIFYING INSTRUCTIONS *(Mandatory for caution tags)*

WORK NECESSARY TO CLEAR TAG(S) *(Including tests)*

INDEPENDENT TAG COVERAGE CHECKS MADE BY:	SIGNATURE OF PETTY OFFICER IN CHARGE OF WORK	SIGNATURE OF REPAIR ACTIVITY REP. *(When approp.)*
	SIGNATURE OF SECOND PERSON	SIGNATURE OF OFFICER AUTHORIZING TAG(S) *(Watch/Duty Officer)*

OPERATIONS/WORK ITEMS INCLUDED IN TAG-OUT

APPLICABLE DOCUMENTATION *(i.e., Job Order, Rip-Out O/P, etc.)* NUMBER & TITLE	ADDITIONAL TAG NUMBERS*	DATE/TIME* ADDED	PETTY OFFICER IN CHARGE* / SECOND PERSON *(Signature)*	AUTHORIZING OFFICER* / REPAIR ACTIVITY REP. *(When approp.)*	WORK COMPLETE: AUTH OFFICER / REPAIR ACTIVITY REP *(When approp.)*	DATE

☐ *Check box if continued on addi'l sheet.*

**For added work items only. Where not appl. fill in "N/A."*

S/N 0116-LF-092-1046

Figure 6 DANGER/CAUTION Tag-out Record Sheet

Figure 1-11.—Danger/Caution Tag-out Record Sheet (front).

DANGER/CAUTION TAG-OUT RECORD SHEET
NAVSEA 9210/9 (REV 8 81) (BACK)

TAG NO	LOCATION	POSITION/ CONDITION	POSTED BY (Initials)	POSTING CHECKED BY (Initials)	CLEARANCE AUTHORIZED (Signature)		DATE/ TIME REMOVED	RE MOVED BY (Initials)
					AUTHORING OFFICER	REPAIR ACTIVITY		

Tags removed & destroyed. System lineup check(s) completed when required. System or component returned to normal operating condition. *(Delete inapplicable portions)*	Date/Time	Condition Prescribed By
SIGNATURE OF WATCH OFFICER/DUTY OFFICER		☐ *Continued on add'l. sheet (Check box if applicable)*

Figure 1-12.—Danger/Caution Tag-out Record Sheet (back).

NAVSHIPS 9890/10 (REV. 7-67)
(Formerly NAVSHIPS 5011– N/S-0105-642-0100

INSTRUMENT LOG

LABEL CONDITION CODE AND NO.	DATE/TIME LABELED	INSTRUMENT NAME OR NUMBER	CONDITION AND/OR CORRECTION FACTOR	AUTHORIZED BY (SIGNATURE)	ATTACHED BY INITIALS	WORK NECESSARY TO CLEAR	DATE/TIME CLEARED	CLEARANCE AUTHORIZED BY (SIGNATURE)	LABEL REMOVED BY (INITIALS)

LABEL CONDITION CODE: OCC – OUT OF COMMISSION
CAL – OUT OF CALIBRATION

LINE OUT COMPLETE ENTRIES

Figure 1-13.—Instrument Log.

transferred to this section of the log until they are reviewed and removed by the department head.

TAG-OUT INFORMATION

A tag-out procedure is necessary because of the complexity of modem ships and the cost, delays, and hazards to personnel that can result from the improper operation of equipment. Learn and use the following guidelines:

1. Enforce the tag-out procedure at all times. You must do this during normal operations as well as during construction, testing, repair, or maintenance.

2. Do not use tags or labels as a substitute for other safety measures. Examples are chaining or locking valves, removing fuses, or racking out circuit breakers. However, you must attach tags to the fuse panel, the racked-out circuit breaker cabinet, or a locked valve to show a need for action. You do not need to use tags where a device will be locked during normal operations.

3. Use tags to show the presence of, and the requirement for, freeze seals, blank flanges, or similar safety devices. When equipment or components are placed out of commission, use the tag-out procedures to control the status of the affected equipment. Examples are disconnecting electrical leads, providing jumpers, or pulling fuses for testing or maintenance.

4. Never use tag-outs to identify valves, to mark leaks, or for any purpose not specified in the tag-out procedure.

5. Do not laminate tags or labels for reuse. The reuse of tags or labels is not allowed.

6. The absence of a tag or label may not be taken as permission for unauthorized operation of equipment.

7. Whenever a tag or label is issued, correct the situation requiring the tag or label so it can be removed as soon as possible.

8. The tag-out procedure is for use by the ship's personnel on the equipment and systems for which they are responsible. However, repair activity personnel should use the procedure to the maximum extent practicable with systems and equipment that are still under construction.

9. Standard Organization and Regulations of the U.S. Navy, OPNAV Instruction 3120.32B, is also required when work is being done by an intermediate level maintenance activity on equipment or systems that are the responsibility of the ship's force. Sometimes a ship is under construction or assigned to a repair activity not under the control of the type commander. When that happens, the ship's force and the repair activity may have to agree on the use of tags and labels. In this case, the tag-out system should be formal in nature and familiar to both the repair activity and the ship's force.

10. Any person who knows of a situation requiring tags or labels should request that they be issued and applied.

11. When using labels, you should list on the log any associated requirements specified for installation procedures, test procedures, work permits (ripouts or reentries), or system turnover agreements.

12. Make each decision on a case-by-case basis as to whether an OUT-OF-COMMISSION or an OUT-OF-CALIBRATION instrument label is to be used. In general, if the instrument error is small and consistent, you can use an OUT-OF-CALIBRATION label and the operator may continue to use the instrument. When you use an OUT-OF-CALIBRATION label, mark on the label the magnitude and units of the required correction. However, when you use an OUT-OF-COMMISSION label, the instrument should not be used.

13. Use enough tags to completely isolate a section of piping or circuit being worked on, or to prevent the operation of a system or component from all stations that could exercise control. Use system diagrams or circuit schematics to determine the adequacy of all tag-out actions.

14. Careful planning of tag-outs can significantly reduce the number of record sheets and tags. Planning can also reduce the effort required to perform audits, particularly during periods of overhaul or repair. For example, a system and the equipment serviced by the system can be isolated and tagged-out at its boundaries with other systems. Then several different actions can be performed within the boundaries. Also, only one tag-out record sheet with associated tags will be required for the work within the boundaries. When you initiate the tag-out, include all known work items in the Operations/Work Items Included in Tag-out section. If you add work items to a tag-out record sheet after initial issue, take the following action:

a. If no additional tags are required for the new work, have the authorizing officer and, if required, the repair activity representative make sure the work is consistent with the purpose of the tag-out. New work must be fully described in the Operations/Work Items Included in Tag-out section of the record sheet. The authorizing officer should make a thorough review to ensure the completeness and accuracy of the existing tag-out. This is the same procedure used to initiate a new tag-out record sheet for the added work The authorizing officer (and repair activity representative) should sign the appropriate blocks next to the added item.

b. Additional tags may be needed to provide enough isolation for work that is to be added. If so, you must follow the procedures described later in this chapter for adding tags to an existing record sheet.

PROCEDURES

Assume that a requirement for tags has been identified, and that the affected system will be out of commission as a result of the tag-out action. The authorizing officer must ask the commanding officer and the responsible department head for permission to begin the tag-out. The authorizing officer must also notify the responsible division officer of the requirement for tag-out. On ships having damage control central (DCC), the authorizing officer must notify DCC if the affected system or component will be out of commission. The authorizing officer should have approval from either the OOD or the EOOW if the tag-out will affect systems under their responsibility. After obtaining permission, the authorizing officer should direct the preparation of the tag-out record sheet and tags according to the following procedures. The procedures may be modified during overhaul periods at the discretion of the commanding officer.

1. PREPARING TAGS AND THE RECORD SHEET. DANGER and CAUTION tags and the associated tag-out record should be prepared as follows:

a. The person designated to prepare the tag-out is normally the ship's force petty officer in charge of the work This person fills out and signs the record sheet and prepares the tags.

b. A tag-out record sheet is prepared for a specific purpose. All tags used for that purpose are listed on an initial record sheet and additional sheets as necessary. The stated purpose may include several work items. Each record sheet is assigned a log serial number in sequence, from the index/audit record. Log serial numbers are also used to identify all tags associated with a given purpose. Each tag is given its own sequential number as it is entered in the record sheet. For example, tag 7-16 would be the sixteenth tag issued on a single record sheet with the log serial number seven. To differentiate among tag-out logs, a prefixed system, approved by the commanding officer, is used with the log serial numbers.

c. The tag-out record sheet includes references to other documents that apply. Some examples are work permits, work procedures, repair directives, reentry control forms, test forms, and rip-out forms. Certain information should be gotten either from reference documents or from the personnel requesting the work Some examples are the reasons for tag-out, the hazards involved, the amplifying instructions, and the work necessary to clear the tags. This information should be detailed enough to give watch standers a clear understanding of the purpose of, and necessity for, each tag-out action.

d. Use enough tags to completely isolate the system, piping, or circuit being worked on. Be sure you use tags to prevent the operation of a system or component from all the stations that could exercise control. Use system diagrams or circuit schematics to determine the number of tags needed. Indicate the location and position/condition of each tagged item by an easily identifiable means. Some examples are MS-l, STBD TG BKR, OPEN, SHUT, BLANK FLANGE INSTALLED.

e. After you have filled out the tags and the tag-out record sheet, have a second person make an independent check of the tag-out coverage and usage. That person should use appropriate circuit schematics and system diagrams. The second person verities the completeness of the tag-out action by signing the record sheet.

f. The authorizing officer then reviews the record sheet and tags for adequacy and accuracy. When satisfied, the officer signs the record sheet and the tags.

(1) If a tag-out is requested by a repair activity, the repair activity representative (shop supervisor or equivalent) must sign the tag-out record sheet. This shows that the repair activity is satisfied with the completeness of the tag-out. Verified tags alert all personnel that the repair activity must approve the removal of the tags.

(2) If the repair activity representative's concurrence is not required, this space on the record sheet need not be filled in.

(3) On ships with DCC, the authorizing officer annotates the tag-out record sheet in the upper right-hand corner with the words *DCC notified,* and then initials it. This ensures that DCC knows the extent of the tag-out and the status of the material condition of the unit.

(4) The authorizing officer then authorizes installation of the tags.

g. The person attaching the tag must make sure the item tagged is in the prescribed position or condition. If the item is not in the prescribed position or condition, he or she must get permission from the authorizing officer to change it to the prescribed condition or position. As each tag is attached and the position or condition is verified, the person attaching the tag must sign the tag and initial the record sheet.

NOTE: Only a qualified person from the ship's force may position equipment and affix tags and labels. The tags should be attached so they will be noticed by anyone who wants to operate the component. Tags must NOT be attached to breaker covers or valve caps that may be removed later.

h. After all tags have been attached, a second person must independently verify proper item positioning and tag attachment, sign each tag, and initial the record sheet. If repair activity concurrence is required, a repair activity representative must witness the verification, sign the tags, and initial the tag-out record sheet.

NOTE: Only qualified ship's force personnel may perform the second check of tag installation.

i. Sometimes additional tags are required because of added work on an existing tag-out record sheet. In that case, the person making the change must handle the DANGER and CAUTION tags and tag-out record sheet as follows:

(1) Ensure that the purpose of the existing record sheet remains unchanged by the new work and its associated tags.

(2) Fill out the tag-out record sheet to reflect the added work. Prepare whatever additional tags are required. Review the reason for the tag-out, the hazards involved, the amplifying instructions, and the work necessary to clear the tags. Do this on the existing tag-out record sheet to ensure that it reflects the old work and the new work being added to the record sheet. After completing the review of the record sheet, have the petty officer in charge of the work sign the first coverage check block next to the added work item.

(3) Number each tag added to the existing tag-out sequentially, beginning with the number after the last number in the original tag-out. Annotate the serial numbers of the new tags next to the associated new work item on the record sheet. Enter the updated number of effective tags at the top of the record sheet by crossing through the previous number and writing in the new number.

(4) After the new tags and the tag-out record sheet have been filled out and signed by the petty officer in charge of the work, have a second person make a review. The second person makes an independent check of the tag coverage and usage by referring to appropriate schematics and diagrams. This person should sign the record sheet in the block for the new work item to show satisfaction with the completeness of the tag-out actions. This includes both the additional and the previously issued tags.

(5) Request that the authorizing officer and, when required, the repair activity representative review the entire record sheet and the new tags for completeness and accuracy. They should then sign their respective blocks for the added work item. The authorizing officer will then issue the tags.

j. Do not allow work to start until all the DANGER tags required for the protection of personnel or equipment have been attached according to established procedures.

2. REMOVING DANGER AND CAUTION TAGS. Remove these tags immediately after the situation requiring the tag-out has been corrected. As each work item identified on the tag-out record sheet is completed, delete it from the tag-out record sheet. Completed work items listed in the Operations/Work Items Included in Tag-Out section of the record sheet must be signed off. This is done by the authorizing officer (and repair activity representative, when required) in the designated signature block. All DANGER tags must be properly cleared and removed before a system or portion of a system can be operationally tested and restored to service. To remove individual tags, the authorizing officer must ensure that the remaining tags provide adequate protection for work, testing, or operations that still remain to be performed. Tags may only be removed following the signed authorization of the authorizing officer. When a tag-out action was initiated by a repair activity, an authorized representative of that repair activity must concur that the job is complete. A shop supervisor or equivalent must sign the tag-out record sheet before the tags may be removed. As the tags are removed, the date/time of removal must be initialed. Ditto marks are not allowed. All tags must be returned immediately to the authorizing officer. This officer then requires a system lineup or a lineup check Tags that have been removed must be destroyed after they have been delivered to the authorizing officer. All tags associated with each specific tag-out action must be destroyed and the system or component returned to normal operating (shutdown) condition. The authorizing officer must then certify these actions by entering the date and time when the system lineup or lineup check was completed. In a case where a system or component restoration was performed according to a specific document, reference to that document is made in the Condition Prescribed By block Inapplicable portions of the statements on the record sheet are lined out and initialed when a valve lineup check is not required or when the system is not returned to a normal condition. The authorizing officer must also enter the date and time cleared on the appropriate line of the tag-out index/audit record. The completed record sheets must be removed from the effective section of the log and placed in the completed section, They will be reviewed and removed by a designated officer. On ships having a DCC, the authorizing officer must notify DCC that the tag-out has been cleared. To complete the process, the authorizing officer must annotate the completed tag-out record sheet in the lower right-hand corner on the reverse side with the words DCC *notified,* and then initial it.

a. When any component is tagged more than once, the DANGER tag takes precedence over all other tags. All DANGER tags must be removed and cleared before the equipment may be operationally tested or operated.

b. A missing or damaged tag is reissued by indicating on the tag-out record sheet, on the line corresponding to the damaged or missing tag, that the tag was missing or damaged and that a replacement was issued. The new tag is issued using the next number in the tag-out record sheet. The authorizing officer should sign the tag-out record sheet to authorize the clearing of damaged or missing tags and to authorize their replacement.

3. ISSUING AND REMOVING LABELS. Labels are issued and removed in a manner similar to that required for tags.

a. The authorizing officer authorizes the use of labels by signing the label and the instrument log. When labels are required for reactor plant systems and reactor plant support systems, the repair activity representative concurs by signing on the label and in the instrument log next to the signature of the authorizing officer.

b. Second check signatures are not required on the label or on the instrument log.

c. When a label like one of those shown in figures l-8 and l-9 is assigned, it must be affixed to the exterior surface of the affected instrument, so operators can easily determine the status of the instrument.

d. A different procedure is used for installed instruments not associated with propulsion plants on nuclear-powered ships and for portable test and radiac equipment. In these cases, the labels shown in figures l-8 and l-9 may be replaced by those affixed by a qualified instrument repair or calibration facility.

ENFORCEMENT

Tag-out logs are kept in the spaces designated. Supervisory watch standers must review the logs during watch relief. They must also check outstanding tags and labels and conduct an audit of the tag-out log as described in the following list. The authorizing officer must ensure that the checks and audits are performed at the required frequency and that the results are reported to the cognizant officer.

1. All outstanding tags listed on each tag-out record sheet must be checked to ensure they are installed correctly. This is done by comparing the information on the tag with the record sheet and the item on which each tag is posted. When a valve or switch position is prescribed, a visual check of the item is made unless a cover, cap, or closure must be removed. Checking the operation of a valve or switch is not authorized as part of a routine tag-out audit. A spot check of installed tags must be conducted to ensure the tags are effective; that is, that they are covered by an active tag-out record sheet. All discrepancies in actual position must be reported at once to the responsible watch/duty officer before the tag audit is continued. The date, time, type of discrepancies (including corrective action), and signature of the person conducting the check must be logged on each tag-out record sheet.

2. All outstanding tag-out record sheets must be audited against the index/audit record section. As part of the audit, each tag-out record sheet should be checked both for completeness and to ensure that the installed tags were checked. The date, discrepancies noted, and the signature of the person conducting the audit must be logged by a line entry in the index/audit record section of the tag-out log.

3. The installation of instrument labels and the auditing of logs must also be checked. A line entry made in the instrument log containing the date, the time, the discrepancies noted, and the signature confirms the check

4. Checks and audits of all tag-outs are usually performed every 2 weeks.

5. Results of audits are reported to the responsible department head.

The responsible department head should frequently check the tag-out log, note errors, and bring them to the attention of the persons responsible. This is to ensure that tag-out/label procedures are being enforced properly. Completed tag-out record sheets and instrument logs should be removed after the review.

A violation of any tag-out compromises the entire tag-out system and may have serious consequences. Therefore, strict adherence to the tag-out procedure, without exception, is required of all personnel.

1. Labels must be removed immediately when the affected instrument has been satisfactorily repaired, replaced, aligned, or calibrated.

2. Tags, which have been removed, must be destroyed.

Remember, always insist on proper tag-out. It helps to prevent accidents, both minor and major.

SHIP-TO-SHOP WORK

Many repair jobs are designated by the ship or approved by the repair activity as “ship-to-shop” jobs. In this type of job, the ship’s force does a large part of the repair work For example, the repair or renewal of a damaged pump shaft might well be written up as a ship-to-shop job. The ship’s force will disassemble the pump and remove the shaft. Then the shaft and any necessary blueprints or technical manuals are delivered to the designated shop of the repair activity. After the shaft has been repaired, or a new one has been made, it is picked up and brought back to the ship by the ship's force. The pump is reassembled, inspected, and tested by the ship's force to make sure it is operating satisfactorily.

An important thing to remember is that the repair facility is responsible for ensuring that its personnel repair or manufacture this this to the manufacturer's specifications, perform all tests required by quality assurance (QA), and fill out properly all the required forms. You, however, are responsible for witnessing any test required by QA, monitoring the status of the job at all times, and reassembling and test operating the pump properly. The end results will produce a reliable, operating piece of equipment.

EQUIPMENT TESTS

As an EN2, you will assist in scheduling and performing various tests on your equipment. The purpose of those tests is to determine how your equipment is performing and if there are any equipment malfunctions. The tests are performed at various times, such as (1) before the ship goes to the shipyard for overhaul, (2) after post deployment, (3) during a tender availability, or (4) as required by PMS. The tests are performed by the ship's force, IMA personnel, shipyard personnel, or an inspection team (such as a Board of Inspection and Survey [INSURV]). Detailed types of inspections are described in *COMNAVSURFLANT Maintenance Manual,* COMNAVSURFLANT INST. *9000.lC* or *COMNAVSURFPAC Ship and Craft Maintenance Manual*, Volumes 1 and 2, Planned Maintenance, COMNAVSURPAC INST. 4700.lB.

Two types of inspections and tests that can be used to "spot" impending trouble in an internal combustion engine are called trend and spectrographic analyses. We will now discuss and explain their importance and use in detecting problems in internal combustion engines.

ENGINE TREND ANALYSIS

Preventive maintenance receives a great deal of attention from everyone in the field of diesel engine operation, since letting an engine run as long as it will run and fixing it only after a breakdown occurs is not only foolish, but extremely costly. On the other hand, you would be just as foolish to constantly tear down an engine just to inspect it. You should know that vital parts of an engine last longer and operate better if they are not tampered with unnecessarily. Therefore, an attempt must be made to find a happy medium between these two forms of maintenance.

One way to determine the condition of an engine is by monitoring its operation. This is done by regularly obtaining certain engine operating data and by studying, analyzing, and comparing it with previous data. This information is then reduced to a form that all engineering personnel can interpret and decide whether the engine needs to be overhauled or just temporarily shut down for simple maintenance. For more detailed procedures, refer to NAVSEA S9233-C3-HBK-010/010, Diesel *Engine, Over 400 BHP, Trend Analysis Handbook*

SPECTROGRAPHIC ANALYSIS

Spectrographic analysis is a method of determining engine or equipment wear by analyzing engine oil and hydraulic oil samples for chemicals and particles not found in new oil or hydraulic fluid. This analysis is done in laboratories on samples provided by ships according to instructions given in their sampling kits.

Ships must maintain accurate records of operating hours since major overhauls, oil changes, and samplings to provide the testing facility with the information requested in the sampling kit. (COMNAVSURFLANT uses the services of the Charleston Naval Shipyard, and COMNAVSURFPAC uses intermediate maintenance activities (IMAs) for analyzing oil samples from machinery employing closed lube oil/hydraulic systems.) In addition, ships must maintain a record of conditions found and repairs made as a result of laboratory recommendations.

When the shipyard or IMA laboratory receives the oil sample, a physical test and a spectrometric analysis are performed. The physical test consists of the following actions:

1. All samples are tested for fuel dilution, and a report by percent volume is provided to all concerned.

Iron (Fe)	Nickel(Ni)	*Sodium (Na)
Lead (Pb)	Silver (Ag)	Phosphorous (P)
Copper (Cu)	Tin (Sn)	Zinc (Zn)
Chromium (Cr)	Silicon (Si)	Calcium (Ca)
Aluminum (Al)	Boron (B)	Barium (Ba)
*Only when evidence of water is present.		

2. All samples are tested for solids by being spun in a centrifuge. Solids will settle at the bottom of the sample.

3. Allowable "use limits" are tested and recorded.

When the physical test is completed, the shipyard/IMAs will make a spectrometric analysis of each used oil sample, then report to all concerned the concentrations of the following elements in parts per million (ppm).

Additional information on trend analysis and oil spectrometric analysis is contained in COMNAVSURFLANTINST 9000.1C or COMNAVSURFPACINST 4700.lB.

POTABLE WATER SYSTEMS

The potable water system supplies scuttlebutts, sinks, showers, sculleries, and galleys and provides makeup water for various freshwater cooling systems. This system is often called the freshwater system. The term *fresh water* is not correct because fresh water is not potable unless it is safe for human consumption.

Potable water may be contaminated during production, handling, storage, or distribution. Treatment with a halogen, such as chlorine or bromine, is the only approved method of disinfecting potable water. Submarines and servicecraft are not equipped to use the halogen treatment method. They are provided with emergency methods to treat fresh water. The ship's engineering and medical departments are responsible for the receipt, distribution, and quality testing of potable water. For more in-depth information concerning potable water systems, refer to *NSTM*, Chapter 533, "Potable Water Systems." Additional references related to potable water systems are shown in the following list.

Title and Publication Number

NSTM, Chapter 090, "Inspections, Tests, Records, and Reports"

NSTM, Chapter 220, "Boiler Water/Feedwater"

NSTM, Chapter 9580, "Distilling Plants Low Pressure Submerged Tube Steam Plants"

NSTM, Chapter 9480, "Piping Systems"

NSTM, Chapter 631, "Preservation of Ships In Service (Surface Preparation and Painting)"

NSTM, Chapter 670, "Stowage, Handling, and Disposal of Hazardous General Use Consummables"

Manual of Naval Preventive Medicine for Potable Water Shore-to-Ship Delivery, NAVMED P-5010-5

Manual of Naval Preventive Medicine for Potable Water Ship-to-Ship Delivery, NAVMED P-5010-6

Potable Water Standards, BUMEDINST 6240.3

TRAINING

By the time you have reached the EN2 level of experience, you have acquired many skills and a considerable amount of theoretical knowledge. As an EN2, you will be responsible for passing these skills and knowledges on to other, lower-rated Enginemen. Success in training others requires that you have or develop certain additional skills as an instructor.

TRAINING RESPONSIBILITIES

You must be technically competent before you can teach others, but your technical competence must be supplemented by the ability to organize information, to present it effectively, and to arouse and keep the interest of your trainees.

You will find excellent general information on how to plan, carry out, and evaluate an instructional program in *Military Requirements for Petty Officer Second Class*, NAVEDTRA 12045, and in *Military Requirements for Petty Officer First Class*, NAVED TRA 12046.

Our discussion does not include the basic information given in these references. Instead, it deals with some of the difficulties peculiar to the training of the engine-room and auxiliary personnel and some of the ways in which you can overcome or minimize these difficulties.

What kinds of things cause special problems in the training of engine-room personnel? For one thing, the interrelationship of propulsion plant operations. Each person must be trained to perform not only as an individual but also as a member of a team. Take for instance the duties of the watch standers. They are very closely related, and the actions taken by one person depend in some way upon the actions taken by other persons. From a long-range point of view, however, the teamwork required for engine-room operations can actually be turned to a training advantage. As a person is being trained for one specific duty, he or she will naturally learn something about the other duties. As a rule, therefore, the first part of a person's engine-room training may take quite a while, but the last part will take much less time.

The procedures for training a new person in engine-room operations vary considerably, depending upon such factors as the ship's steaming schedule, the condition of the engine-room machinery, the number of experienced personnel available to assist in the training, and the amount of time that can be devoted to the training. In general, however, you will probably begin by training the trainee to act as messenger. Then, before the trainee is assigned to any actual duty, he or she should be introduced to the engine room and become familiar with the location of all machinery, equipment, piping, and valves. The trainee must also be instructed in certain basic safety precautions and be specifically warned about the dangers of turning valve wheels or tampering with machinery. "IF IN DOUBT, ASK QUESTIONS!" is a pretty good rule for any new person in the engine room to follow.

A person ready to be trained in the duties of messenger should be shown all the gauges that are in use, told what the gauges indicate, and shown how to take readings. The trainee should understand why the readings are important, exactly how often each gauge must be read, and how to make accurate entries in the engine-room log. When you are sure the trainee understands everything about gauges, teach the trainee how to check lube-oil levels and how to clean metal edge-type filters and basket strainer-type.

For a while you will have to keep a close watch on the trainee's performance of these duties. When the trainee becomes proficient in the duties of messenger, start the training in the throttleman's duties. Fist, let the trainee observe the throttleman Then, if conditions permit, let the trainee start and secure machinery.

As far as manual skills are concerned, the throttleman's job is probably easier than the messenger's job. But the throttle watch requires the utmost vigilance and reliability, and a new person will have a lot to learn before being trusted to stand the throttle watch alone. Personnel should always start out under the supervision of an experienced throttleman and should remain under this supervision until the petty officer in charge of the engine room is fully satisfied that the trainee is completely qualified for this duty.

In training engine-room personnel who have not had previous engine-room experience, remember that an engine room can be a complicated and confusing place to someone who walks into it for the first time. A lot of equipment is crammed into a small space, and a lot of complex actions are going on at the same time. When training new personnel, try to think back to the time when you first went into an engine room. What aspects of engine-room operations were most confusing to you at first? What kind of training would have made your learning easier and faster? By analyzing your own early experience and reactions, you get a bearing on what a new person may experience and you may be able to provide more effective training.

When you train new personnel, remember that they vary widely in their methods and rates of learning. Some people will learn most effectively if you give them an overall view of main engine operations, including a certain amount of theory, before going into the details of the hardware and the manual operations. Others will learn most effectively if they are taught some manual skills before getting too involved with theory. Some people learn manual skills rapidly but take a long time to absorb the theory; for others, the reverse is true. And, of course, some people learn everything slowly. Some trainees benefit from patient, almost endless repetition of information; others may become bored and restless if you go over the same point too often. The important thing to remember is that your training efforts will be most successful if you are able to observe and allow for the individual differences that are bound to exist. Closely related to this point is another: Don't make snap judgments about people's abilities until they have had a chance to DEMONSTRATE them. You may turn out to be very wrong if you make snap judgments on the basis of a general impression, such as appearance, or the rate at which they learn when they first come into the engine room.

When training personnel who have already had some engine-room experience but who have been on some other type of ship, you may find that a certain amount of retraining is needed before the individual can qualify as an engine-room watch stander on your ship. No two engine rooms are precisely alike in all details, and no two main engines that appear to be identical behave in precisely the same way under all conditions. Each engine has its own individuality, and operating personnel must adjust to the engine to obtain the best results. Practically all Enginemen learn this sooner or later; you can speed up the learning process by encouraging engine-room personnel to notice and to discuss differences between engines.

SAFETY TRAINING

Because of the necessity for strict observance of safety precautions, all engine-room operational training must be rigidly controlled and supervised. On-the-job training is necessary if an individual is to acquire the actual skills needed for main engine operation;

however, the person must not be allowed to learn by trial and error, since errors could be too dangerous and too costly. Safety precautions should be taught from the very beginning and should be emphasized constantly throughout the training program.

Many of the *NSTMs*, manufacturer's technical manuals, and every Planned Maintenance System (PMS) maintenance requirement card (MRC) include safety precautions. Additionally, OPNAVINST 5100.19B. *Naval Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat*, and OPNAVINST *5100.23B, NAVOSH Program Manual*, provide safety and occupational health information. The safety precautions are for your protection and to protect equipment.

During preventive and corrective maintenance, the procedures may call for personal protective equipment (PPE) such as goggles, gloves, hearing protection, and respirators. When specified, your use of PPE is mandatory. You must select PPE appropriate for the job since the equipment is manufactured and approved for different levels of protection. If the procedure does not specify the PPE, and you aren't sure, ask your safety officer.

Most machinery, spaces, and tools requiring you to wear hearing protection are posted with hazardous noise signs or labels. Eye hazardous areas requiring you to wear goggles or safety glasses are also posted. In areas where corrosive chemicals are mixed or used, such as the morpholine tank or brominators, an emergency eye wash station must be installed.

All lubricating agents, oils, cleaning materials, refrigerants (R-12), and boiler water and feedwater chemicals used in maintenance and repair are hazardous materials. Hazardous materials require careful handling, storage, and disposal. PMS documentation provides hazard warnings or refers the maintenance person to the *Hazardous Materials User's Guide (HMUG).* Material safety data sheets (MSDSs) also provide safety precautions for hazardous materials. All commands are required to have an MSDS for each hazardous material they have in their inventory. You must be familiar with the dangers associated with the hazardous materials you use in your work Additional information is available from your command's hazardous material/hazardous waste coordinator.

Workers must always consider electrical safety when working around any electrical or electronic machinery or equipment. Procedures normally include special precautions and tag-out requirements for electrical safety. You should review your command's electrical safety program instruction and procedures before beginning any work on electrical or electronic equipment or before working with portable electrical tools.

TRAINING PROGRAMS

As an EN2, you are required to assist your EN1 or ENC in establishing or maintaining a training program for your work center. For this program you are required to teach the proper methods of equipment operation, repair, and safety. You should use all appropriate materials as teaching aids, such as manufacturer's manuals, instructions, and *NSTMs.* In addition, you should know what schools are available.

In recent years, one of the best ways to check on how well personnel retain the information being taught in the training program has been the use of the Personnel Qualification Standard (PQS).

A PQS is a written list of knowledge and skills required to qualify for a specific watch station, maintain a specific piece of equipment or system, or perform as a team member within an assigned unit. The PQS program is a method for qualifying personnel to perform their assigned duties.

Most standards are divided into four sections: Fundamentals, Systems, Watchstations, and a Qualification Card. The Fundamentals section contains the facts, principles, and fundamentals concerning the subject for which a person is qualifying. The Systems section deals with the major working parts of the installation, organization, or equipment with which the PQS is concerned. The Watchstation section defines the actual duties, assignments, and responsibilities needed for qualification. The Qualification Card has questions that match those in the Watchstation section and provides a space for the supervisor's or the qualifying officer's signature.

In addition to qualifying under PQS, both you and your subordinates must satisfy Maintenance and Material Management (3-M) Systems and general damage control qualification requirements.

ENGINEERING OPERATIONAL SEQUENCING SYSTEM (EOSS)

Each new ship that joins the Navy is more technically advanced and complex than the one before. The main propulsion plants call for engineering skills at ever higher levels of competence. That means more and better training of personnel who must keep the ships combat ready. The need for training and the problem of frequent turnover of trained personnel call for some kind of system that can be used to keep things going smoothly during the confusion. The EOSS was developed for that purpose.

EOSS is a set of manuals designed to eliminate problems due to operator error during the alignment of piping systems and the starting and stopping of machinery. It involves the participation of all personnel from the department head to the fireman on watch. EOSS consists of a set of detailed written procedures, using charts, instructions, and diagrams. These aids are developed for safe operation and casualty control of a specific ship's engineering plant and configuration. EOSS improves the operational readiness of the ship's engineering plant by providing positive control of the plant. This, in turn, reduces operational casualties and extends machinery life.

EOSS is divided into two subsystems: (1) engineering operational procedures (EOPs) and (2) engineering operational casualty control (EOCC).

ENGINEERING OPERATIONAL PROCEDURES (EOPs)

EOPs are prepared specifically for each level of operation: plant supervision (level l), space supervision (level 2), and component/system operator (level 3). The materials for each level or stage of operation contain only the information necessary at that level. All materials are interrelated. They must be used together to maintain the proper relationship and to ensure positive control and sequencing of operational events within the plant. Ships that do not have EOSS use operating instructions and a casualty control manual for plant operations.

ENGINEERING OPERATIONAL CASUALTY CONTROL (EOCC)

This subsystem of EOSS enables plant and space supervisors to RECOGNIZE the symptoms of a possible casualty. They can then CONTROL the casualty to prevent possible damage to machinery, and RESTORE plant operation to normal. The documents of the EOCC subsystem contain procedures and information that describe symptoms, causes, and actions to be taken in the most common engineering plant casualties.

ENGINEERING CASUALTY CONTROL

The best form of casualty control is prevention. If you do not let a casualty happen, you will not have to fix it.

Preventive maintenance is one of the principal factors of casualty control. Preventive inspections, tests, and maintenance are vital to casualty control. These actions minimize casualties caused by MATERIAL failures. Continuous detailed inspections are necessary to discover worn or partly damaged parts, which may fail at a critical time. These inspections eliminate maladjustments, improper lubrication, corrosion, erosion, and other enemies that could cause early failure of a vital piece of machinery.

The inspections, tests, and maintenance called for in the 3-M systems must be performed conscientiously since they are based on the known requirements of preventive maintenance.

Still, casualties do happen. When they do, the success of the mission, the safety of your ship, and the lives of your shipmates may depend on your ability to handle the situation. That means continuous training and frequent refresher drills to be sure you can do your part, and do it well.

Engineering casualty control is used to prevent, minimize, and correct the effects of operational and battle casualties. These casualties will be on engineering space machinery, related machinery outside of engineering spaces, and the piping installations associated with the various pieces of machinery. The mission of engineering department personnel is to maintain all engineering services in a state of maximum reliability under all conditions. If you cannot provide these services, the ship may not be able to fight.

The use of EOCC procedures was discussed at the beginning of this chapter. These procedures are prepared and approved for your ship.

Steps involved in handling engineering casualties can be divided into three general phases:

1. Immediate action to prevent further damage.

2. Supplementary action to stabilize the plant condition.

3. Restoration action to restore equipment to operation after a casualty. Where equipment damage has occurred, repairs may be necessary to restore machinery, plants, or systems to their original condition.

Communication of accurate information is one of the major problems in casualty control. Be sure you know the names and operations of the equipment at your normal watch station and your battle station. Be sure you know what the casualty is before you take corrective action. If you are reporting a casualty to the bridge or main control, be sure you use the correct terminology and ensure they understand what your casualty is.

The primary sources of instructions used to handle any engineering casualty and to maintain the overall damage resistance to your ship are listed as follows:

- The EOCC procedure
- The ship's casualty control manual (for a ship without EOCC)
- The ship's damage control manual
- The ship's damage control bills
- The ship's organization and regulation manual (SORM)

SYMPTOMS OF OPERATIONAL CASUALTIES

You must be on the alert for even the most minor sign of faulty operation of machinery. Pay particular and continuous attention to the following symptoms of malfunctioning:

– Unusual noises

– Vibrations

– Abnormal temperatures

– Abnormal pressures

– Abnormal operating speeds

– Leakage from systems or associated equipment

You should become thoroughly familiar with the normal operating temperatures, pressures, and speeds of equipment specified for each condition of operation; departures from normal will then be readily apparent. NEVER assume that an abnormal reading on a gauge or other indicating instrument is due to a problem with the instrument. Investigate each case to learn the cause of the abnormal reading. Substitute a spare instrument or perform a calibration test to quickly show whether an instrument error exists. Trace abnormal readings that are not caused by faulty instruments to their source. Some specific advance warnings of failure are outlined in the following paragraphs.

The safety factor commonly incorporated in pumps and similar equipment can allow a considerable loss of capacity before you see any external evidence of trouble. In pressure-governor-controlled equipment, view changes in operating speeds from normal for the existing load with suspicion. Variations from normal in chest pressures, lubricating oil temperatures, and system pressures indicate either improper operation or poor condition of the machinery. When a material failure occurs in any unit, promptly inspect all similar units to determine whether they are subject to the same type of failure. Prompt inspection may eliminate a wave of similar casualties.

Abnormal wear, fatigue, erosion, or corrosion of a part may indicate that the equipment is not being operated within its designed limits of loading, speed, and lubrication. It also may indicate a design or material deficiency. If any of these symptoms have appeared, you should routinely carry out special inspections to detect damage unless you can take action to ensure that such a condition will not recur.

ENGINE-ROOM CASUALTIES

Even with the best-trained personnel and the best-planned maintenance programs, casualties will occur. WHEN COMBATING AN ENGINE-ROOM CASUALTY, USE YOUR EOCC.

DIESEL ENGINE CASUALTIES

The Engineman's duties concerning engineering casualties and their control depend upon the type of ship–which may be anything from a torpedo weapons retriever (TWR) to a carrier. An Engineman operates engines of various sizes, made by various manufacturers, and intended for different types of services.

Some examples of the types of engineering casualties that may occur and the action to be taken are given in the sections that follow. The observance of all necessary safety precautions is essential in all casualty control procedures.

1. Inoperative speed governor

a. Control the engine manually, if possible.

b. Notify the engineer officer and the bridge, and request permission to secure the engine for repairs.

c. When you get permission, check the governor control mechanism.

d. Check the linkage for binding or sticking.

e. Check the lubrication; flush the governor sump and refill it with proper oil.

f. Check the setting of the needle valve.

g. Make repairs. When you have completed the repairs, start the engine and check its operation. When it is operating properly, notify the engineer officer and the bridge.

2. Engine cooling water temperature above the allowed limit

a. Notify the bridge.

b. Reduce the load and the speed of the engine.

c. Check the freshwater level in the expansion tank

d. Check the saltwater discharge pressure.

e. Check the sea suction and the discharge valves.

f. Vent the freshwater and the saltwater pumps.

g. Check the setting and operation of the temperature regulating valve,

3. Failed main engine lube oil pressure

a. Secure the engine immediately.

b. Notify the engineer officer and the bridge.

c. Check the sump oil level, the piping, the filters, the strainers, and the lube oil pump capacity. Make the repairs.

d. After you have completed the repairs, notify the engineer officer and the bridge.

For more generalized examples of main engine (diesel-drive) casualties, refer to "*Damage Control - Engineering* Casualty *Control,*" Chapter 079, Volume 3, of *NSTM.*

To obtain detailed information on diesel engine casualty control procedures, refer to the manufacturer's instructions, the pertinent type commander's instructions, and the ship's *Engineering Casualty Control Manual.*

WATCH STANDING

You will spend much of your time aboard ship as a watch stander. How you stand your watch is very important to the reliability of the engineering plant and the entire ship. To be a successful watch stander, you must do the following;

- Have the skills to detect unusua1 noises, vibrations, or odors that may indicate faulty machinery operation.
- Take appropriate and prompt corrective measures.
- Be ready, in emergencies, to act quickly and independently.
- Know the ship's piping systems and HOW, WHERE, and WHY they are controlled.
- Know each piece of machinery: how it is constucted, how it operates, how it fits into the engineering plant, and where related equipment is controlled.
- Be able to read and interpret measuring instruments.
- Understand how and why protective devices function (relief valves, speed limiting governors, overspeed trips, and cut-in and cutout devices).
- Recognize and remove fire hazards, stow gear that is adrift, and keep deck plates clean and dry.
- NEVER try to operate a piece of equipment that is defective.
- Report all unsafe conditions to the space or plant supervisor.
- Know the status of every piece of machinery at your station.
- Promptly handle any necessary change in speed or setup, and record correctly all data concerning the operation and maintenance of the machinery.
- Be sure the log is up-to-date and the status boards are current.
- Know what machinery is operating and what the night orders and standing orders are before you relieve the watch.

Above all, if you don't know-ASK! A noise, odor, or condition may seem abnormal to you, but you may not be certain whether it is a problem. When that happens, call your immediate watch supervisor.

You can best gain the respect and confidence of your supervisors and shipmates if you stand a good watch. Relieve the watch on time or even a little early if possible to be sure you know the condition of the machinery and what you need to do. DON'T TRY TO RELIEVE THE WATCH FIRST AND FIGURE OUT THE

SITUATION LATER. The same applies when you are being relieved; don't be in a big hurry to take off. Be sure your relief understands the situation completely. Before you are relieved, make sure your station is clean and squared away. These little considerations will get you a good reputation and improve the overall quality of watch standing within the department.

OTHER SOURCES OF INFORMATION

One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. Learn where to look for accurate, authoritative, up-to-date information on all subjects (military and occupational) related to your rating.

NAVSEA PUBLICATIONS

The publications, bulletins, and briefs issued by the Naval Sea Systems Command are of particular importance to engineering department personnel. Although you do not need to know everything in these publications, you should have a general idea of where to find the information they contain.

ENGINEERING HANDBOOKS

For certain types of information, you may need to consult various kinds of engineering handbooks, such as the mechanical engineering handbooks, marine engineering handbooks, piping handbooks, and other handbooks that provide detailed, specialized technical data.

NAVAL SAFETY CENTER BULLETINS

The bulletins such as *Safetyline, Flush,* and *Ship's* Safety *Bulletin* are published by the Naval Safety Center. The bulletins contain information about equipment and personnel safety that helps reduce personnel and material losses due to mishaps. You are encouraged to review these bulletins and pass them to your subordinates.

SHOP EQUIPMENT

In your work center or shop, there is equipment that will help you do your job easier and more quickly. This equipment, the sandblaster, hydraulic press, electric drill press, electric bench grinder, hydropneumatic test stand and other electric, hydro, pneumatic, and manually driven types, requires special knowledge of safe operation and proper maintenance.

You, as an EN2, will be involved in providing training on how to use this equipment. All shop personnel, including you, must complete the PQS for each piece of equipment before using it. In most cases, you will assist your supervisor in providing the information and training, although in some cases you may be given total responsibility for the training.

Normally in the shop or work center, every piece of equipment must have a posted operating procedure and a list of personnel who are qualified to use it. If a piece of equipment does not have posted operating procedures, post a copy of the procedures given in the manufacturer's manual.

QUALITY ASSURANCE PROGRAM

The quality assurance (QA) program was established to provide personnel with information and guidance necessary to administer a uniform policy of maintenance and repair of ships and submarines. The QA program is intended to introduce discipline into the repair of equipment, safety of personnel, and configuration control, thereby enhancing readiness.

The various QA manuals set forth minimum QA requirements for both the surface fleet and the submarine force. If more stringent requirements are imposed by higher authority, such requirements take precedence. If a conflict exists between the QA manual and previously issued letters and transmittals by the appropriate force commanders, the QA manual takes precedence. All such conflicts should be reported to the appropriate officials.

The instructions contained in the QA manual apply to every ship and activity of the force. Although the requirements are primarily applicable to the repair and maintenance done by the force IMAs, they also apply to maintenance done aboard ship by ship's force. In all cases where specifications cannot be met, a departure-from-specifications request must be completed and reported.

Because of the wide range of ship types and equipment and the varied resources available for maintenance and repair, the instructions set forth in the QA manual are necessarily general in nature. Each activity must implement its own QA program to meet the intent of the QA manual. The goal should be to have all repairs conform to QA specifications.

PROGRAM COMPONENTS

The basic thrust of the QA program is to make sure you comply with technical specifications during all work on ships of both the surface fleet and submarine force. The key elements of the program are as follows:

– Administrative. This includes training and qualifying personnel, monitoring and auditing programs, and completing the QA forms and records.

– Job execution. This includes preparing work procedures, meeting controlled material requirements, requisitioning material, conducting in-process control of fabrication and repairs, testing and recertifying, and documenting any departure from specifications.

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

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

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

3. To eliminate unnecessary man-hour and dollar expenses.

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

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

6. To distribute required technical information more effectively.

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

THE QUALITY ASSURANCE ORGANIZATION

The QA program for naval forces is organized into different levels of responsibility. For example, the COMNAVSURFPAC QA program is organized into the following levels of responsibility: type commander, readiness support group/area maintenance coordinator, and the IMAs. The QA program for the submarine force is organized into four levels of responsibility: type commander, group and squadron commanders, IMA commanding officers, and ship commanding officer/officers in charge. The QA program for the Naval Surface Force for the Atlantic Fleet is organized into five levels of responsibility: force commander, audits, squadron commanders, IMAs, and force ships.

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

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

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

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

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

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

The **ship quality control inspectors (SQCIs),** usually the work center supervisor and two others from the work center, must have a thorough understanding of the QA program. Some of the other responsibilities an SQCI will have are as follows:

1. Inspect all work for compliance with specifications.

2. Maintain ship records to support the QA program.

3. Ensure that only calibrated equipment is used in acceptance testing and inspection of work

4. Witness and document all tests.

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

LEVELS OF ESSENTIALITY

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

- verification of material, and
- confirmation of satisfactory completion of test and inspections required by the ordering data.

Levels of essentiality are codes, assigned by the ship according to the QA manual, that indicate the degree to which the ship's system, subsystem, or components are necessary in the performance of the ship's mission. These codes indicate the impact that catastrophic failure of the associated part or equipment would have on the ship's mission capability and personnel safety.

LEVELS OF ASSURANCE

QUALITY ASSURANCE IS DIVIDED INTO THREE LEVELS: A, B, or C. Each level reflects certain quality verification requirements of individual fabrication in process or repair items. Here, verification refers to the total level of quality controls, tests, and/or inspections. **Level A** assurance provides for the most stringent of restrictive verification techniques. This normally will require both quality controls and test or inspection methods. **Level B** assurance provides for adequate verification techniques. This normally will require limited quality controls and may or may not require tests or inspections. **Level C** assurance provides for minimum or "as necessary" verification techniques. This level will require very little quality control of tests or inspections.

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

By carefully following the methods and procedures outlined in your QA program manuals and by paying careful attention to the quality of work in your area, you will contribute greatly to the operational ***effectiveness*** of your ship as well as tended units. For further in-depth knowledge concerning the QA procedures and practices, consult your area COMNAVSURF LANT/ PACINST QA manual.

SUMMARY

In this chapter, we have discussed some of your important administrative and training responsibilities and the different methods you can use to properly perform these responsibilities. Remember, information is usually available when you need it. You just have to know where to look for it and make the effort to secure it.

CHAPTER 2

MEASURING AND REPAIR INSTRUMENTS

You, as an Engineman, must he able to identify the basic measuring and repair instruments and the basic components of these instruments. This chapter will help you to recognize the how and when to use and maintain basic measuring and repair instruments and engine test equipment.

Measuring instruments are used to check tolerances and specifications during inspections and repairs of internal combustion engines and auxiliary equipment. You, as an Engineman, need measuring instruments to determine what parts are worn and need to be repaired or replaced. The following measuring and repair instruments are discussed in this chapter: dial indicator, dial/vernier caliper, micrometer, snap gauge, bore gauge, strain gauge, borescope, stroboscope, torque wrench, multiplier, adapter, ridge reamer, cylinder hone, and dynamometer.

SENSITIVE MEASURING TOOLS

Sensitive measuring tools are measuring devices that provide measurement readings to a thousandth of an inch or less. The more common sensitive measuring tools you will use are the dial indicator, dial/vernier caliper, micrometer, snap gauge, bore gauge, and strain gauge.

DIAL INDICATOR

A dial indicator is used to measure shaft runout, shaft thrust, gear backlash, flywheel face runout, flywheel housing concentricity, and valve seat concentricity. You can mount a dial indicator on a test stand or, with clamps and a magnetic base, directly on the equipment to be measured. Figure 2-1 shows a typical dial indicator with mounting accessories,

Most dial indicators have components such as a bezel, indicator pointer, tool post and clamp, magnetic toolholder, and sensor button that are used in taking measurements.

The following procedures explain how to use the indicator to take shaft runout and crankshaft end play measurements. Procedures for taking other measurements are similar.

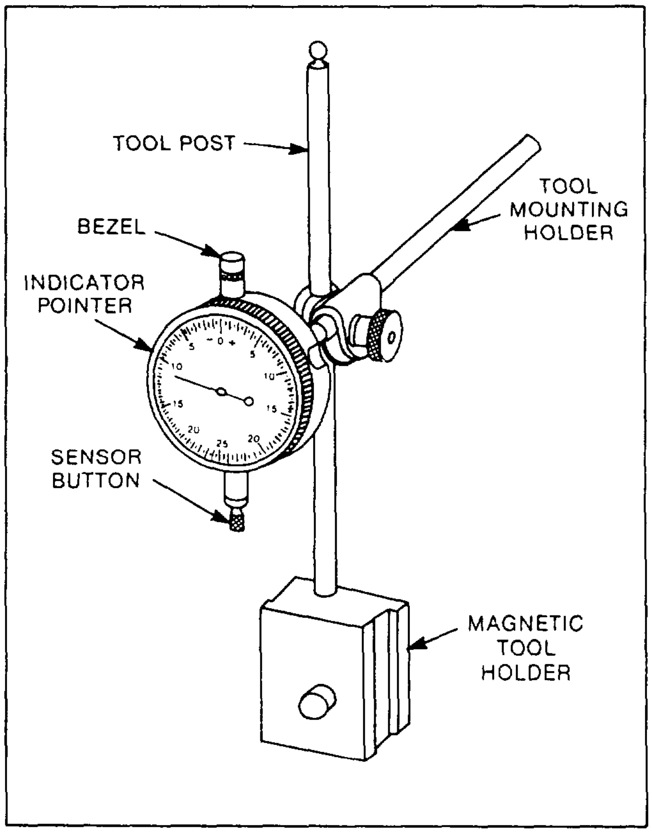


Figure 2-1.—Typical dial indicator wlth mounting accessories.

Shaft Runout

When you need to measure a shaft's runout, select a suitable position on the shaft, free of keyways, corrosion, or other damage. Clean the surface and remove any burrs around scratches or dents. To take the runout measurement, use the following procedure:

1. Place the shaft in well-oiled V-blocks. If the shaft is a crankshaft, place the bearing journals in the V-blocks.

2. Attach the magnetic base to a machined surface. Mount the dial indicator on a tool mounting holder and attach the holder to the base.

3. Adjust the mounting post so you can easily read the face of the dial.

4. Move the indicator toward the shaft until the sensor button just touches the surface you wish to measure.

5. Continue moving the indicator slowly toward the shaft until the dial pointer has moved to the midpoint of its travel on the dial face.

6. Leave the pointer at midtravel and turn the bezel until the zero on the dial is aligned with the pointer.

7. You can now rotate and watch the pointer to see if it moves. The total amount the pointer moves is called the total indicator reading (TIR). If the shaft is straight, the pointer should remain at zero.

Crankshaft End Play or Thrust Readings

To measure crankshaft end play or thrust, use the following procedure:

1. Attach the dial indicator to a convenient place near the vibration damper.

2. Position the dial indicator gauge so the contact point touches the front of the vibration damper and moves the dial indicator near the midpoint of its range.

3. Insert one end of a pry bar between a main bearing cap and a crankshaft counterweight.

NOTE: DO NOT INSERT THE PRYBAR BETWEEN THE VIBRATION DAMPER AND THE BLOCK TO MEASURE THE CRANKSHAFT END PLAY. You may dent the damper and render it ineffective.

4. Move the crankshaft toward the dial indicator. Be sure to maintain a constant pressure on the prybar.

5. Set the dial indicator to zero.

6. Remove the prybar and then reinsert it on the other side of the main bearing cap.

7. Carefully pry the crankshaft in the opposite direction to measure the crankshaft end play. Repeat your measurement a minimum of two times for accuracy.

DIAL/VERNIER CALIPER

The dial/vernier caliper is used to measure the inside or outside diameter of an object. Figure 2-2 shows a typical dial/vernier caliper.

Most dial/vernier calipers have a slide, slide lockscrew, thumb button, scale, dial with measured increments of 0.001 inch, and a bezel.

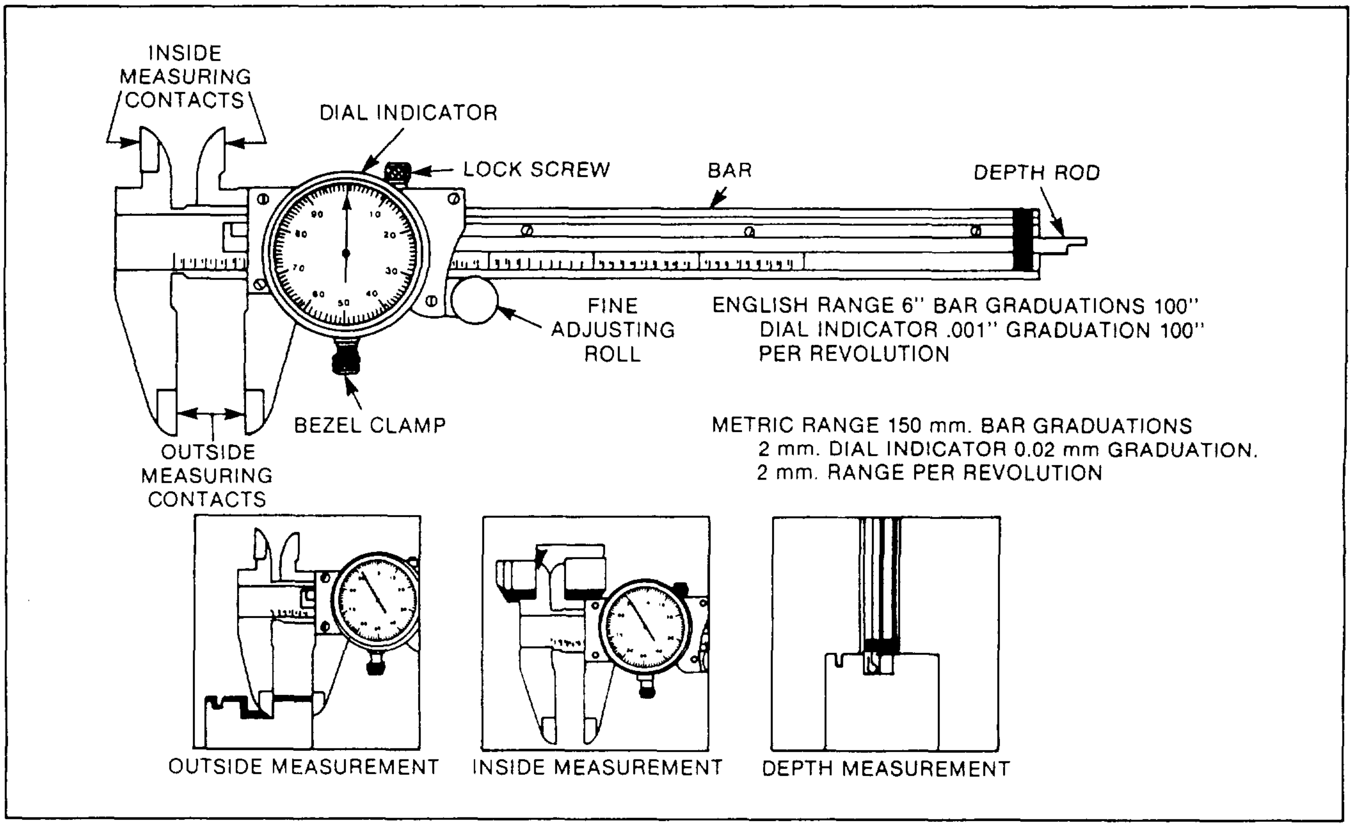


Figure 2-2.—Typical dial/vernier caliper.

For specific instructions on how to take measurements with a dial/vernier caliper, refer to either the manufacturer's instructions or to Tools and Their Uses, NAVEDTRA 10085-B2.

Regardless of what type of caliper you use, be sure to take the following precautions to avoid damaging the caliper:

1. Wash your hands before you handle the vernier caliper to remove dirt and oils that might damage the caliper.

2. Wipe the caliper components clean both before and after you use the caliper.

3. Do NOT drop or otherwise mishandle the caliper. Doing so may damage or destroy the caliper.

Figure 2-3 illustrates the use of a dial/vernier caliper in measuring the inside and outside diameters of two different components.

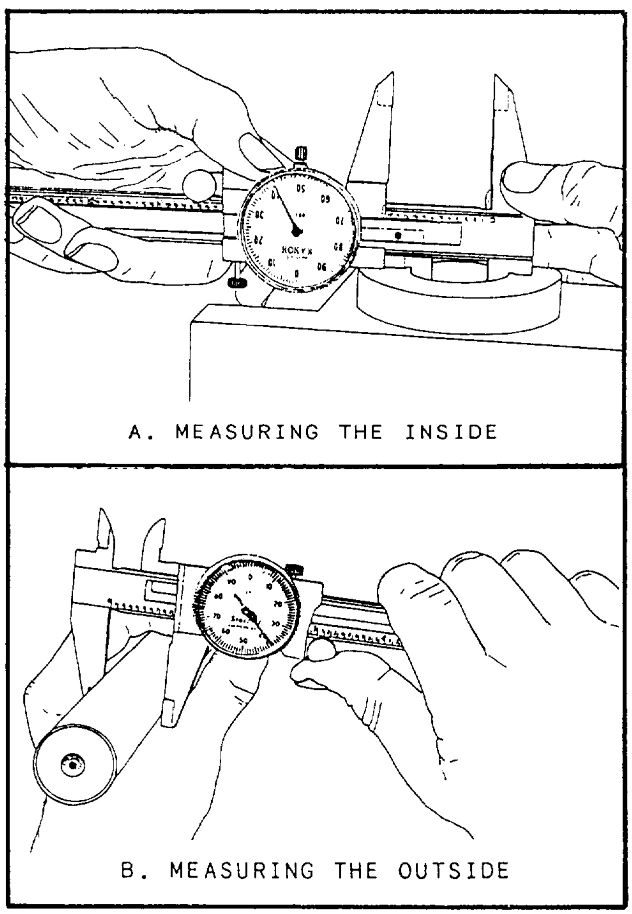


Figure 2-3.—Measuring (A) inside and (B) outside diameters with a dial/vernier caliper.

MICROMETER

The micrometer is a precision measuring instrument used to measure distances between surfaces in thousandths of an inch Figure 2-4 shows the most common types of micrometers.

Most micrometers have a frame, anvil, spindle, sleeve, thimble, and ratchet stop.

Micrometers are used to measure the outside diameters; inside diameters; the distance between parallel surfaces; the depth of holes, slots, counterbores, and recesses; and the distance from a surface to some recessed part. There are other uses of micrometers, but those mentioned here are uses you are most likely to encounter. Instructions on how to read a micrometer are given in the manufacturer's owner's manual and Tools and Their Uses, NAVEDTRA 10085-B2.

Whenever you use a micrometer, carefully observe the "DO's" and "DON'Ts" in the following list to obtain accurate measurements and to protect the instrument:

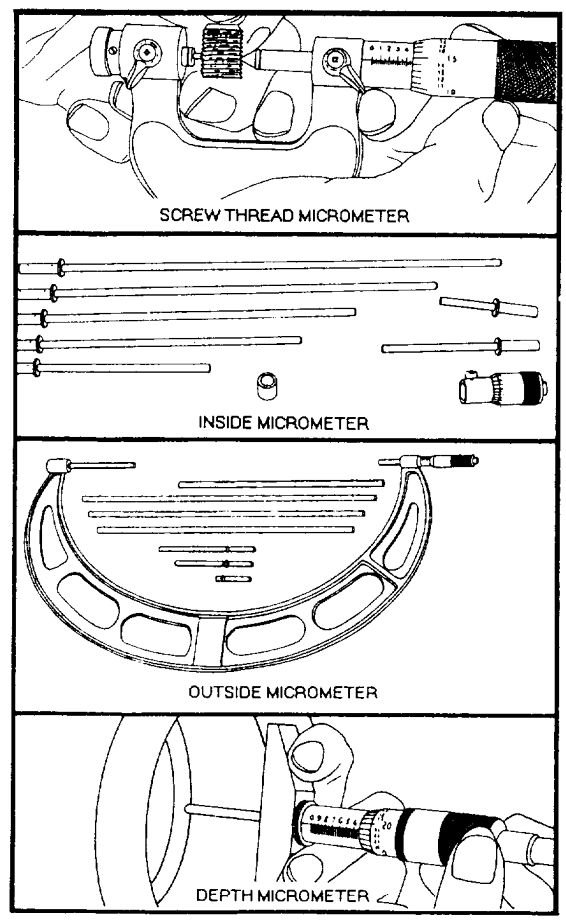


Figure 2-4.—Common types of micrometers.

1. Always stop the work before you take a measurement. DO NOT measure moving parts because the micrometer may get caught in the rotating work and be severely damaged.

2. Always open a micrometer by holding the frame with one hand and turning the knurled sleeve with the other hand. Never open a micrometer by twirling the frame, because such practice will put unnecessary strain on the instrument and cause excessive wear of the threads.

3. Apply only moderate force to the knurled thimble when you take a measurement. Always use the friction slip ratchet if there is one on the instrument. Too much pressure on the knurled sleeve will not only result in an inaccurate reading, but also will cause the frame to spring and force the measuring surface out of line.

4. When a micrometer is not in use, place it where it will not drop. Dropping a micrometer will cause the micrometer frame to spring. If you drop a micrometer, check it for accuracy before you take further readings.

5. Before you store a micrometer, back the spindle away from the anvil, wipe all exterior surfaces with a clean, soft cloth, and coat the surfaces with a light oil. Do not reset the measuring surfaces to close contact because the protecting film of oil on these surfaces will be squeezed out.

SNAP GAUGE

The snap gauge compares the outside diameters of parts such as shafts and journals to a standard. It can compare diameters from zero to 8 inches at an accuracy of 0.0001 inch. Figure 2-5 shows a typical snap gauge.

Most snap gauges consist of a frame with an insulated handle, a hex wrench mounted in the handle, dial indicator digits calibrated in 0.00l-inch divisions, a bezel clamp, adjustment wheels, locking wheels, a backstop, a lower anvil, an upper anvil, and a guard.

Whenever you use a snap gauge, use the handle and avoid touching the gauge proper because body heat may affect the reading. For the same reason, handle the standard plugs only by their plastic end. Clean the anvils and the backstop with a clean cloth. To use the snap gauge, follow the manufacturer's operating instructions.

After you record the readings and compare the readings with the design specifications, clean and store the snap gauge in its appropriate storage location.

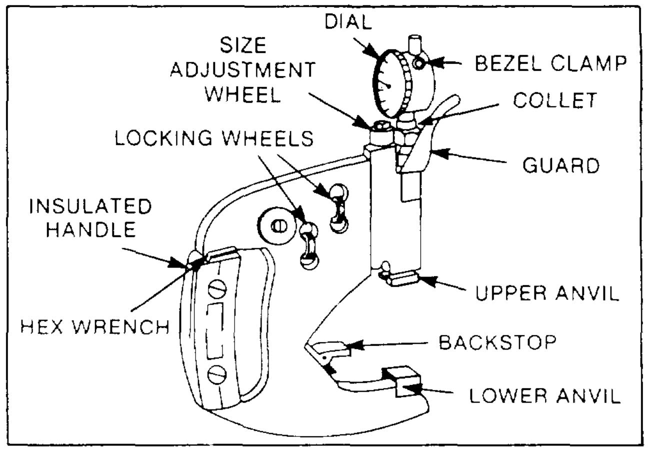


Figure 2-5.—Typical snap gauge.

BORE GAUGES

The dial bore gauge is one of the most accurate tools for measuring a cylindrical bore or for checking a bore for out-of-roundness or taper. The gauge does not give a direct measurement. It identifies the amount of deviation from a preset size or the amount of deviation from one part of the bore to another. A master ring gauge, outside micrometer, or vernier caliper can be used to preset the gauge. Figure 2-6 shows a typical bore gauge.

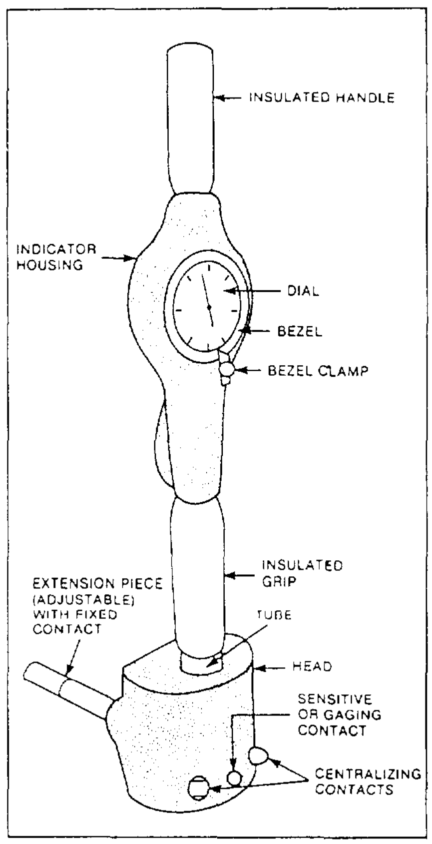


Figure 2-6.—Typical bore gauge.

Most bore gauges consist of a dial indicator, extension pieces, bezel and locknut, spring-loaded guide, and sensor button.

Before you start a measuring procedure, expose both the bore gauge and the master ring gauge, or any other tools used to preset the bore gauge, and the part to be measured to the same work place environment for one hour. If you fail to do this, a temperature differential may cause your readings to be inaccurate. When you use the bore gauge, touch only its insulated handle.

The gauge has two stationary spring-loaded points and an adjustable point to permit a variation in range. These points are evenly spaced to allow accurate centering of the tool in the bore. A fourth point, the tip of the dial indicator, is located between the two stationary points. By simply rocking the tool in the bore, you can observe the amount of variation on the dial. Figure 2-7 shows a bore gauge inside a bore being moved in a gentle rocking motion. Always follow the bore gauge manufacturer's operating manual. Measure the bore and mark the areas you measure. A good practice is to check the bore gauge in the standard after you take each set of measurements to ensure that readings are accurate.

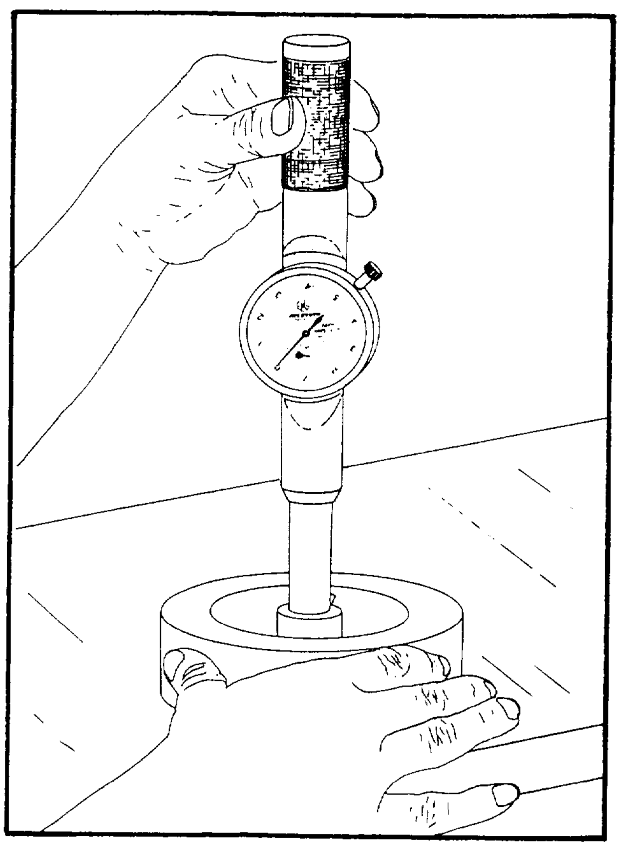


Figure 2-7.—Measuring a bore with a bore gauge.

STRAIN/DEFLECTION GAUGE

A strain or deflection gauge is used to check the crankshaft alignment on large diesel engines. It is a specially adapted dial indicator that fits between the crank webs. The strain gauge reads the flexing motion of the webs directly as the crankshaft is slowly rotated (correct engine rotation). The gauge dial reads in 0.00l-inch graduations.

The strain gauge consists of a dial indicator, contact point, balancing attachment, clamping nut, spring plunger, rods and extension, and bezel.

Before you take a reading, be sure the engine is completely assembled and cold. Place the strain gauge between the webs of a crankthrow, as far as possible from the axis of the crankpin. The ends of the indicator should rest in the prick-punch marks in the crank webs. If these marks are not present, consult the manufacturer's technical manual for the proper location of the marks. Ensure that the strain gauge is at the same temperature as the engine. A temperature differential may cause inaccurate readings. Readings are generally taken at the four crank positions; top dead center, inboard, near or at bottom dead center, and outboard However, the manufacturer's technical manual for the specific engine provides information concerning the proper positions of the crank for taking readings. In some situations, due to the position of the dial, you may need to use a mirror and a flashlight to read the gauge. Once you have placed the indicator in position for the first reading, DO NOT touch the gauge until you have taken and recorded all four readings. Variations in the readings taken at the four crank positions indicate distortion of the crank, which may be caused by any of several factors, such as a bent crankshaft, worn bearings, or improper engine alignment. The manufacturer's technical manual will provide you with the maximum allowable deflection. Figure 2-8 shows the locations for taking crankshaft deflection readings.

BORESCOPE

A borescope is used to inspect internal parts on an engine without having to disassemble the engine. This instrument helps a great deal in estimating the amount of repair work needed and the time required for the repair. Figure 2-9 shows a typical borescope.

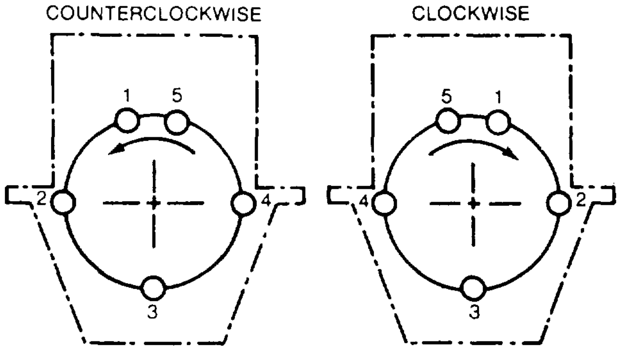


Figure 2-8.—Locations for taking crankshaft deflection readings.

Most borescopes have the following basic components:

1. Eyepiece (zoom or wide angle)
2. Scan control ring
3. Probe tube
4. Scan mirror
5. Quartz-lined lamp
6. Focus control ring
7. Other electrical accessories

As with any optical instrument, you should handle the borescope with care to avoid damaging its lenses and mirrors. The borescope is powered by alternating current. So, before you first use it, be sure to read and follow the manufacturer's operating instructions. The borescope can be inserted through any engine opening, such as a cylinder port, to identify problems, such as cracked pistons, cracks in the cylinder head, burned valves, and scuffed or pitted liners. You can remove the crankcase cover to inspect the bottom section of the engine.

STROBOSCOPE

A stroboscope is a flashing light source used to measure the speed of fast-moving objects. it produces the optical effect of stopping or slowing down an object to allow you to observe and analyze the object's motion. Figure 2-10 shows a typical stroboscope.

A stroboscope consists of a power switch, rpm control dial, range switch, calibration indicator light, calibration screws, combination adjustments, reflector lamp assembly, and other electrical accessories. For information about the functions of the components, consult the operator's manual.

Before you use the stroboscope, be sure to read and follow the manufacturer's operating instructions. The instrument commonly operates from a 120-volt, 60-Hz, alternating current supply. Any change in current frequency will affect the flashing speed and affect the stroboscope's accuracy for speed measurements. The stroboscope can be used to measure the speed and to observe the motion of rotating, reciprocating, or vibrating mechanisms. Never leave the stroboscope unattended while it is in use. Since the stroboscope makes a moving object appear to be standing still, someone could be seriously injured by the apparently "stationary" object.

TORQUE WRENCH

The torque wrench is used to measure an object's resistance to turning and to provide precise tightening

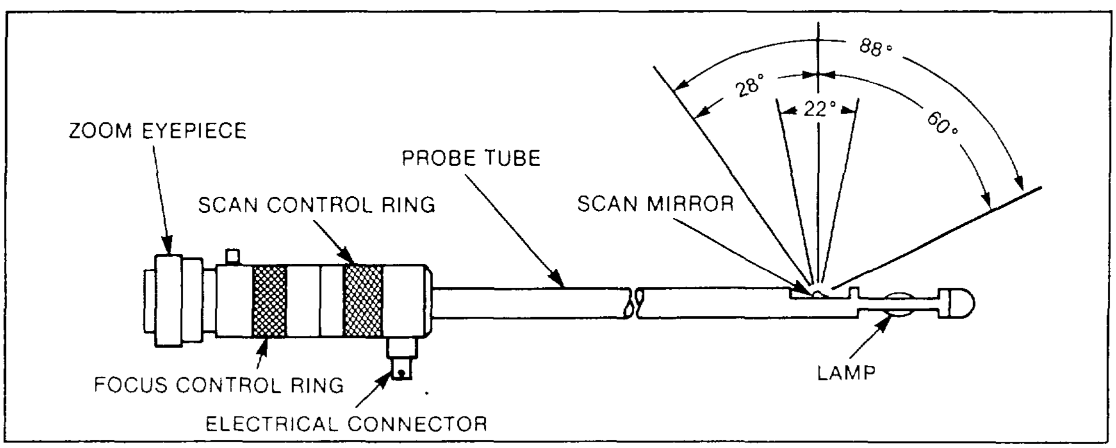


Figure 2-9.—Typical borescope.

of threaded fasteners. Figure 2-l1 shows three types of torque wrenches.

To use a torque wrench, first select the proper torque value for the torquing procedure you are using. Next,

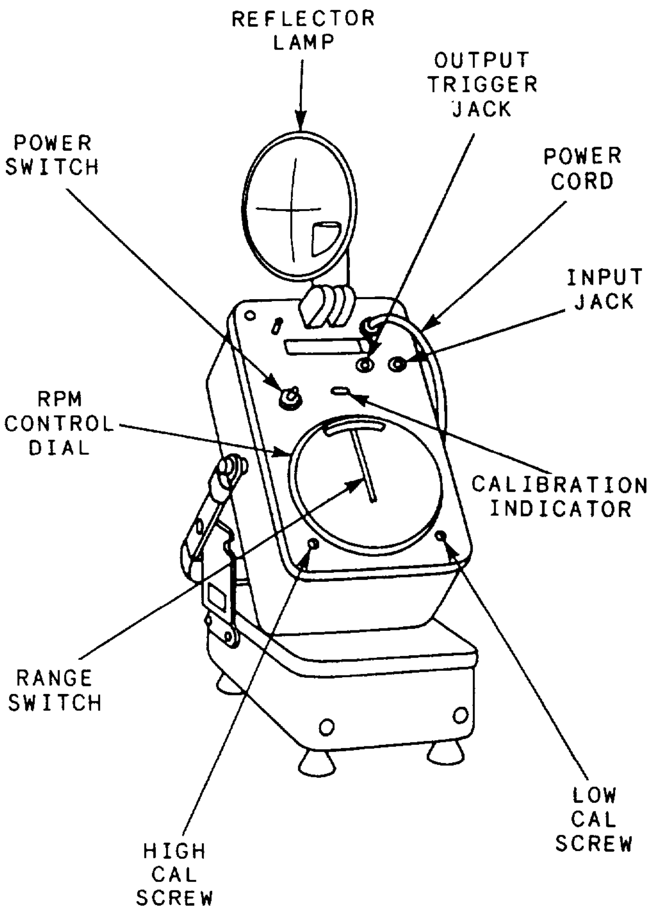


Figure 2-10.—A typical stroboscope.

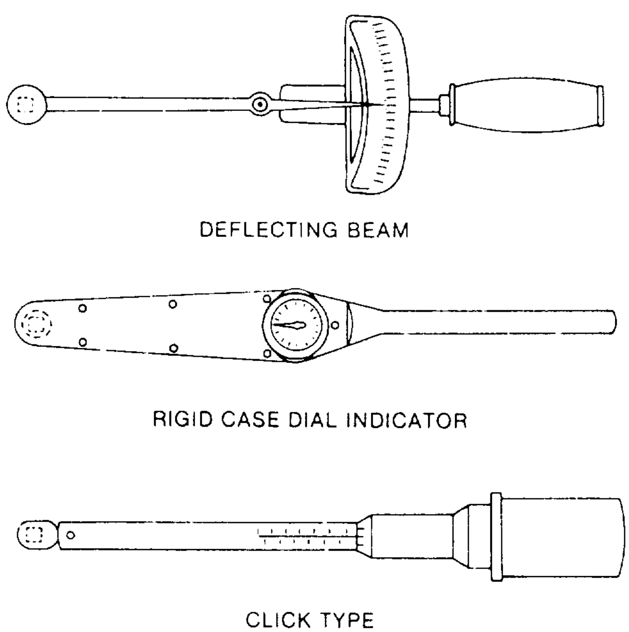


Figure 2-11.—Typical torque wrenches.

select the torque wrench with the correct capacity. The torque value should be in the second or third quarter of the wrench's torque scale because the first and last quarters of the scale are not as accurate as the middle quarters.

Torque wrenches are precision tools. Handle them with care and always follow the manufacturer's manual when you use them.

TORQUE MULTIPLIER

Torque multipliers are geared devices attached to the torque wrench to increase the force of torque. The most preferred ratio of the torque multiplier is 4 to 1. To use a torque multiplier, select one with an output capacity above the required torque. Be sure to follow the manufacturer's operating manual to avoid personnel injury and damage to the equipment.

TORQUE ADAPTERS

Torque adapters allow the torque wrench to be used to tighten parts and fasteners other than standard nuts and bolts. Adapters are available in a variety of shapes geared to the repair of different parts of the diesel engine. Several types of torque adapters are shown in figure 2-12.

When you use an extension adapter, the torque applied to the part or fastener will be greater than the torque indicated on the torque wrench. Therefore, you must account for the length of the adapter to apply the proper torque to the part or fastener. Figure 2-13 illustrates the points of measurement.

The torque applied by the adapter is directly related to the length of the adapter. As the length of the adapter increases, so does the applied torque.

To determine the actual torque applied to the part or fastener, assume that the length of the torque wrench is L and the length of the adapter is A. Assume also that Tw is the torque indicated on the scale of the torque wrench and Ta is the torque exerted at the end of the adapter.

To determine Ta, simply multiply the torque indicated on the torque wrench (Tw) by the ratio of the total effective length of the assembly (L + A) to the length of the torque wrench (L).

or

$$: Tw\ x\ \frac{(L+A)}{L}$$

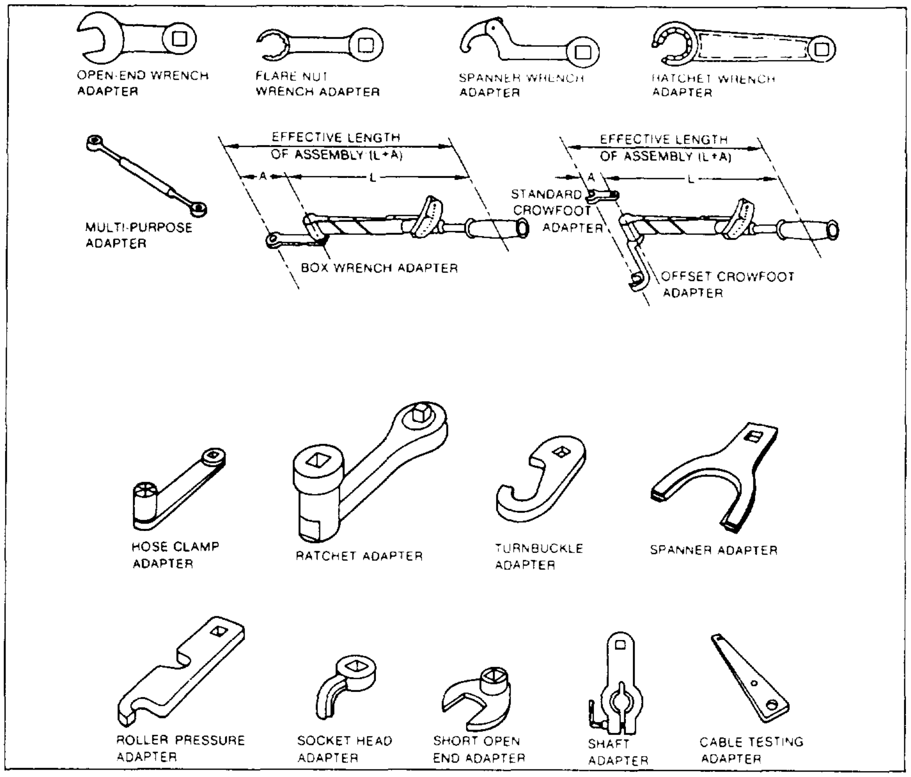


Figure 2-12.—Torque adapters.

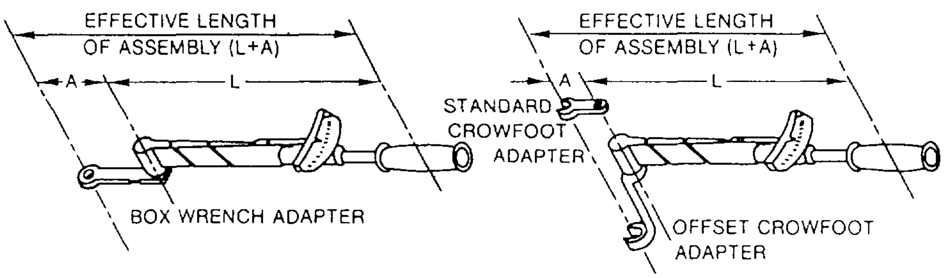


Figure 2-13.—Torque adapters and points of measurement.

An easy to remember rule of thumb is that the applied torque will be greater than the indicated torque by an amount equal to the length of the adapter compared to the length of the torque wrench. For example, if the adapter is the same length as the torque wrench, the applied torque will be twice as great as the indicated torque. If the adapter is one-third as long as the torque wrench, the applied torque will be one-third greater than the indicated torque.

Figures 2-14 and 2-15 illustrate how to calculate applied torque.

RIDGE REAMER

A ridge reamer is used to remove ridges formed at the tops of cylinders produced by piston rings moving up and down in the cylinders. Figure 2-16 illustrates a typical ridge reamer.

The ridge reamer consists of a carbon cutter, adjustable guides, adjustable cutter head, adjustable cutter, and threaded feed screw.

Whenever you use a ridge reamer, you must wear eye protection, such as a face shield or goggles.

Determining Applied torque	$Ta = Tw \, x \frac{(L+A)}{L}$ Ta = Torque exerted at the end of the adapter Tw = Wrench scale reading L = Lever length of the wrench A = Length of the adapter
Determining Indicated Torque (when desired torque is known)	$Tw = \frac{Ta \, x \, L}{(L+A)}$ Tw = Wrench scale reading Ta = Torque exerted at end of the adapter L = Lever length of the wrench A = Length of the adapter
Determining Adapter or Extension Length	$A = \frac{(Ta - Tw) \, x \, L}{Tw}$ A = Length of the adapter Ta = Torque exerted at end of the adapter Tw = Wrench scale reading L = Lever length of the wrench
At times it is necessary to calculate the wrench scale reading for several torques using the same wrench and adapter assembly. In such cases, it is convenient to determine a CONVERSION CONSTANT for the assembly which will simplify calculations.	The following formula shows the constant: $C = \frac{L}{L+A}$ CONVERSION CONSTANT C = Conversion constant for wrench and adapter assembly
This constant is a ratio of the lever length of the torque wrench to the total effective length of the assembly.	L = Lever length of wrench A = Length of adapter

Figure 2-14.—Torque calculation for eithcr adapters or extensions.

Remember that the cutter will take out the ridge with a lathelike cutting action. Read and follow the manufacturer's manual on how to use the reamer. After all the ridges are removed, take a measurement with a bore gauge, and verify that the cylinder is within specifications.

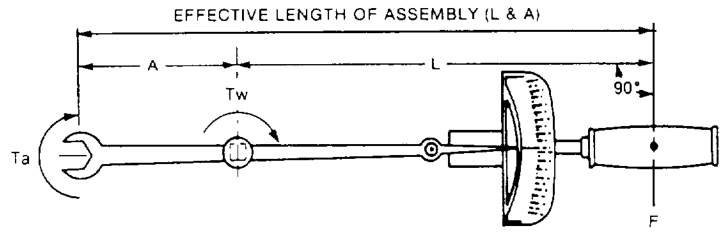
CYLINDER HONE

To reuse the cylinder sleeve, you must refinish the glazed surface caused by piston ring travel. Honing will remove high spots and a slight taper or out-of-roundness. Do not hone new or chromium-plated liners unless specified by the liner manufacturer. Figure 2-17 shows a typical cylinder hone.

Before you use a cylinder hone, read or review the operator's manual. When you use a hone, use only an approved cleaning solvent and ensure that there is adequate ventilation in the work area. When solvent fumes are present, do not allow eating, drinking, smoking, open flames, or lights in the work area. Dispose of hazardous materials, such as solvent-soaked rags and used solvents, properly.

Torque wrenches so constructed that the position of applied load can be varied on the frame or handle of the wrench WILL NOT work correctly with adapters or extensions.

The following calculations or formulas apply to either adapters or extensions having the axis of their work engaging member intersecting the extended center line of the torque wrench frame.



"Tw" is the torque indicated on the scale of the torque wrench and "Ta" is the torque exerted at the end of the adapter.

To calculate the TORQUE PRODUCED AT THE END OF THE ADAPTER (Ta) it is necessary to multiply the total effective length of the assembly (L plus A) by the force (F) exerted on the torque wrench handle.

$$Ta = (L + A) \times F$$

THE FORCE (F) EXERTED ON THE HANDLE OF THE WRENCH EQUALS THE TORQUE developed by the wrench at "Tw" . . . which is the torque indicated on the scale . . . divided by the lever length of the wrench (L).

$$F = \frac{Tw}{L}$$

ADAPTER FORMULA

Figure 2-15.—How to calculate applied torque.

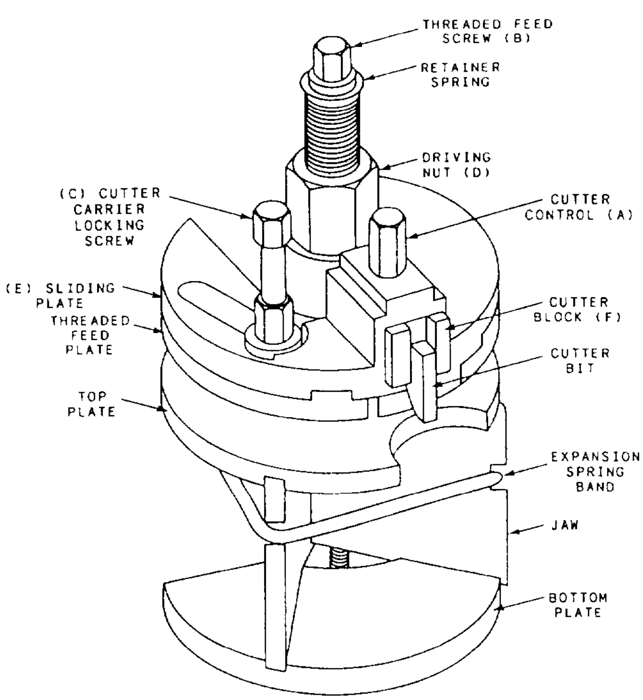


Figure 2-16.—A typical ridge reamer.

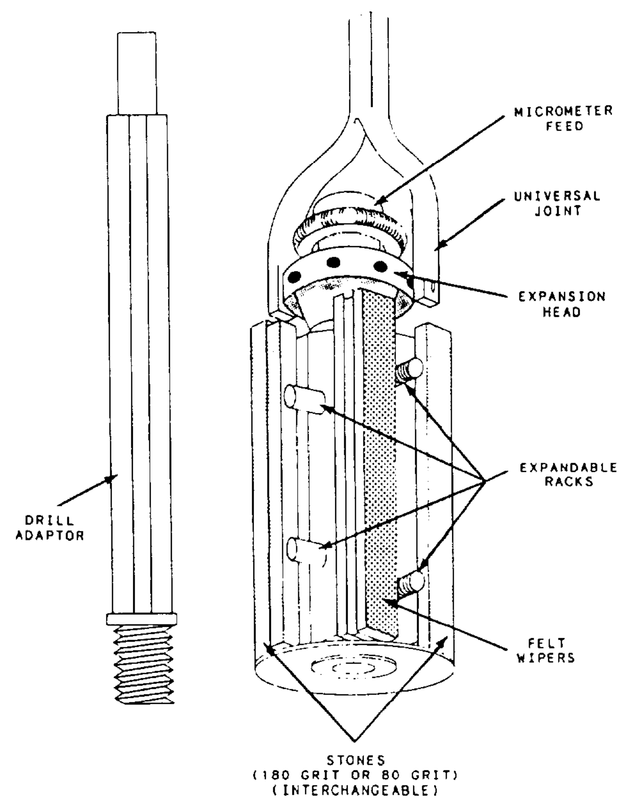


Figure 2-17.—A typical cylinder hone.

ENGINE TEST EQUIPMENT

When an engine has been repaired or overhauled, it may need to be tested for proper operation and power output. **A** piece of test equipment used to conduct such tests is the dynamometer. The following is a basic explanation of how a dynamometer works. For in-depth information about this test equipment, refer to the manufacturer's manual.

The dynamometer is used to apply specific loads to an engine. It allows the technician to inspect and check the engine while it is operating. The dynamometer absorbs and measures the engine's output. The basic components of a dynamometer are the frame, engine mounts, absorption unit, heat exchanger, and torque and measuring device. To properly operate a dynamometer you must complete a shop qualifications course. Dynamometers are found primarily in shore activity shops. For maintenance, refer to assigned PMS for the equipment. If your shop has no PMS maintenance for the dynamometer, follow the maintenance schedule recommended by the manufacturer.

SUMMARY

In this chapter, you have learned to identify the necessary measuring and repair instruments and their basic components and how to use them. Additionally, you have learned basic information about the dynamometer, its operation and maintenance. For additional information about basic measuring and repair instruments and the dynamometer, refer to each item's manufacturer's manual, assigned PMS, and your work center's shop equipment qualifications program.

CHAPTER 3

INTERNAL COMBUSTION ENGINES

This chapter is designed to help you understand the maintenance and repair of internal combustion engines. You as an EN2 should be able to describe the basic procedures used to test and repair diesel engines. Also, you should be able to identify the procedures used to troubleshoot diesel and gasoline engines. This chapter will cover the general procedures used to repair and overhaul gasoline engines; the procedures used to inspect, test, and repair jacking gear; and the procedures used to troubleshoot and repair fuel and oil purifiers.

To help ensure that an engine will operate efficiently, you must follow its preventive maintenance schedule. By following the preventive maintenance schedule, you will reduce engine casualties and help the engine achieve its normal number of operating hours between overhaul periods.

When you must finally perform an engine repair or overhaul, take the following precautions:

- Plan the work in definite steps, so you can perform it smoothly.

- Have the necessary tools and parts on hand before you begin a repair or overhaul.

- Have the necessary forms ready to record the clearances, dimensions, and other vital measurement readings that must be kept as part of the engine's history.

- Always check precision measuring instruments before you use them; then recheck your readings. The first reading may not be correct.

- Keep the work area clean. Do not allow oil to accumulate on the deck or on the tools. Place the tools or parts neatly away from the immediate area.

The test, maintenance, and repair procedures presented in this chapter are general in nature. The specific procedures vary with different engines. Before you begin a maintenance or repair procedure, consult the manufacturer's technical manual or the equipment's preventive maintenance schedules. They are valuable sources of information on tests, maintenance, and repairs.

INSPECTING AND TESTING THE ENGINE FRAME OR BLOCK

Before you begin an inspection or test, make sure the outside of the engine is cleaned thoroughly. This will help you spot cracks, leaks, and other problems more easily than if the engine is dirty. By cleaning the engine, you will also help prevent dirt and other contaminants from entering and damaging parts and accessories of the engine.

Some of the inspections and tests you may perform are listed in the following sections.

VISUAL INSPECTIONS

Inspect the top surface of the cylinder block, the top and bottom crankcase flanges, and the oil pan for warpage. You can use a straightedge, a feeler gauge, and a good light. Figure 3-1 illustrates how to use a straightedge and a feeler gauge to check the top surface of the cylinder block Compare your measurements to the manufacturer's specifications to determine if the surface is warped.

Visually inspect the cylinder block for cracks, breaks, or other damage.

MEASUREMENTS

Visually inspect the engine block's bolts to determine if they are bent, broken, or worn.

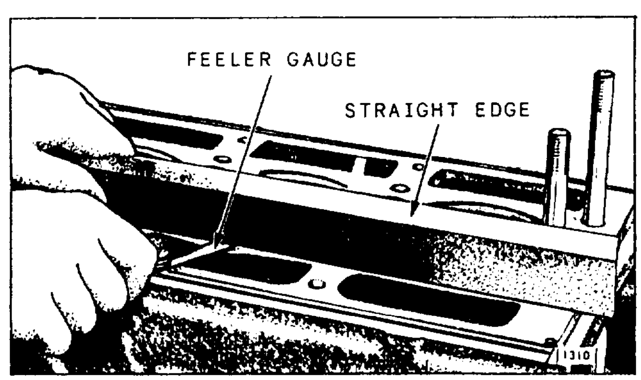


Figure 3-1.—Checking the top surface of a typical cylinder block.

Measure the bore in the cylinder block, with a dial indicating bore gauge, to determine if wear or an out-of-round condition exceeds the manufacturer's specification. Figure 3-2 illustrates the use of a bore gauge to measure a cylinder bore. You can use an inside micrometer as well, but a dial indicating bore gauge is easier to use.

Inspect and measure the engine block's hold-down bolt holes. Use a telescoping snap gauge to determine if wear has caused enlargement of the holes. If a telescoping snap gauge is not available, try to move each bolt from side to side with your fingers. If a bolt moves from side to side, its hole has enlarged and must be repaired. Always follow the manufacturer's instructions on how to correct a hole enlargement problem.

DYE PENETRANT TEST

Conduct a preliminary dye penetrant test on the engine block's surface to identify cracks that you cannot see otherwise. Be sure to follow the manufacturer's instructions on how to conduct this test. Remember that only a certified nondestructive testing technician can perform a dye penetrant test that meets the requirements of quality assurance.

AIR AND WATER PRESSURE TESTS

Test the cylinder block for cracks in the cylinder bores between the water jacket and the oil passages by using either air pressure or water pressure. The purpose of each test is to pressurize the water Jacket to the point, within safe limits, that leaks show.

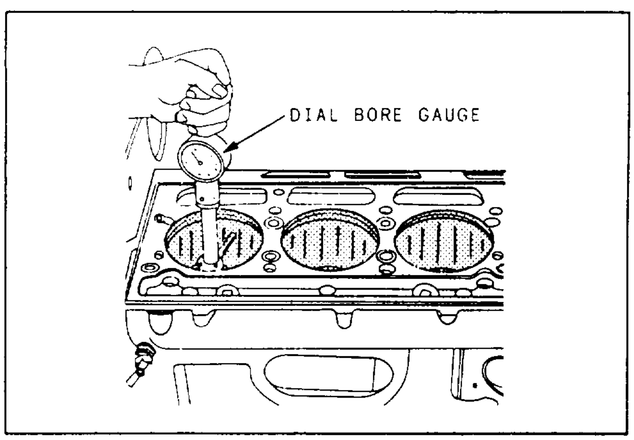


Figure 3-2.—Checking the cylinder bore for wear or out-of-roundness.

Air Pressure Test

Before you perform the air pressure test, make sure you completely strip and clean the block. Then, follow these basic procedures:

1. Seal all of the block's freshwater passages with gaskets and flanges.

2. Connect a low-pressure air hose to a fixture on one of the flanges.

3. Immerse the block into a tank of water heated to the engine's normal operating temperature. Allow the engine to soak for approximately 20 to 40 minutes, as specified by the manufacturer. This allows the block to warm to the temperature of the water.

4. Apply approximately 40 psi of pressure to the block and watch for bubbles. Bubbles indicate a crack or leak in the block. Determine what repair is needed or can be made when you identify the source of the bubbles.

If you cannot dip the block, you may still perform the air pressure test. Attach the hose to a fixture secured to an opening to the water jacket. Pressurize the water jacket. Carefully spray soapy water over the block and look for air bubbles caused by the pressurized air.

Water Pressure Test

The water pressure test is similar to the air pressure test, except that defects are indicated by water leaks rather than by air leaks. Before you perform the water pressure test, strip and clean the block Then, follow these procedures:

1. Seal off all but one of the freshwater openings with flanges and gaskets. Make seals airtight.

2. Fill the water jacket with fresh water until all air is purged from the water jacket. Seal the fill opening with a flange that contains an air hose coupling.

3. Attach an air hose and pressurize the water jacket to approximately 40 psi (see the manufacturer's manual). Maintain the pressure in the water jacket for at least 2 hours.

4. Inspect the cylinder bores, air box, oil passages, crankcase, and cylinder block exterior for the presence of water. The presence of water at any of these locations indicates that the water jacket has one or more defects.

REPAIRING THE ENGINE FRAME OR BLOCK

Some engine block repairs are cost efficient, while others are not. The following paragraphs briefly discuss basic repairs to the block itself. Later paragraphs discuss repairs to block components.

LEAKING WATER JACKET

Most engine blocks that have a leaking water jacket are not worth the cost to repair. To determine if such a block can be repaired economically, consult the appropriate MILSTD and technical manuals for the engine.

WARPED CYLINDER BLOCK OR CRANKCASE FLANGES

You may use a hand surface grinder to correct small amounts of surface warpage. Do not remove more metal than necessary. The manufacturer's manual will specify how much metal you may remove with the hand grinder. If the warpage exceeds the maximum allowed for hand grinding, send the block to the machine shop for machine grinding.

WORN BOLT HOLES

Over a period of time, bolt holes may become oversize due to wear from threading and unthreading the fasteners. You may correct a worn bolt problem by one of three primary methods, depending on the situation.

1. If the bolt hole is slightly oversize, you may be able to simply use a larger bolt in the hole, if such use is authorized for the component the bolt fastens down.

2. If enough metal remains around the hole, you may be able to install a helicoil. Check the helicoil installation instructions and appropriate technical manuals to determine whether or not a helicoil is acceptable.

3. You may also till the hole with weld metal and then drill and tap a new hole.

Whatever method you use to correct the problem, always check the bolt and bolt hole for proper fit.

INSPECTING, TESTING, AND REPAIRING CYLINDER LINERS

Cylinder liners may become damaged or worn excessively. The following paragraphs discuss the more common causes and repairs.

CRACKED, BROKEN, AND DISTORTED LINERS

You should suspect one or more cylinder liners whenever you notice one of the following indications:

- Excessive water in the lubricating oil
- An accumulation of water in one or more cylinders of a secured engine
- An abnormal loss of water in the cooling system
- High cooling water temperature or fluctuating pressure (caused by combustion gases blowing into the water jacket)
- Oil in the cooling water

When you suspect that a liner is cracked, try to locate the cracks visually. If you cannot locate the cracks visually, use another testing method, such as the water pressure test or air pressure test described earlier. To check liners with integral cooling passages, plug the outlets and fill the passages with glycol-type antifreeze. This liquid will leak from even the smallest cracks.

Cracks in dry liners may be more difficult to locate because there is no liquid to leak through the cracks. You may need to use magnaflux equipment or penetrating dye to locate these cracks.

Causes

Cylinder liners may crack because of poor cooling, improper fit of piston or pistons, incorrect installation, foreign bodies in the combustion space, or erosion and corrosion. Improper cooling, which generally results from restricted cooling passages, may cause hot spots in the liners, resulting in liner failure due to thermal stress. Scale formation on the cooling passage surfaces of liners may also cause hot spots; wet liners are subject to scale formation. You may remove the scale by following the procedures outlined in chapter 233 of the Naval Ships' Technical Manual (NSTM).

Proper cooling of dry liners requires clean contact surfaces between the liners and the cylinder block. Particles of dirt between these surfaces cause air spaces, which are poor conductors of heat. Films of oil or grease on these mating surfaces also resist the flow of heat.

Distortion, wear, or breakage may result if a liner is not properly seated. Causes of improper liner seating may be metal chips, nicks, or burrs, or improper fillets, In figure 3-3 an improper fillet on the cylinder deck prevents the liner from seating properly. To correct an

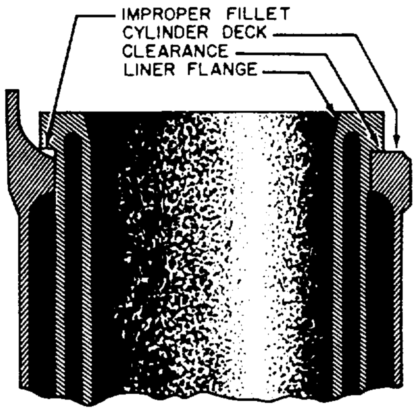


Figure 3-3.—Improperly seated cylinder liner.

improper fillet, grind it down until the lower surface of the flange seats properly on the mating surface of the cylinder deck.

An oversized sealing ring may cause improper positioning of the liner. As the sealing ring is overcompressed, the rubber loses its elasticity and becomes hard, which may cause the liner to become distorted.

Use feeler gauges to check the clearance between the mating surfaces. If the manufacturer's technical manual specifies the distance from the cylinder deck to the upper surface of the liner flange, use this dimension to check on the seating of the liner.

Obstructions in the combustion chamber may be destructive not only to the liner but also to the cylinder head and other parts.

Erosion and corrosion may take place in a few isolated spots and weaken a liner sufficiently to cause cracks.

Repairs

Replacement is the only satisfactory means of correcting cracked, broken, or badly distorted cylinder liners.

SCORED CYLINDER LINERS

Scored cylinder liners may become scored (scratched) by several means. These scratches degrade the engine's performance and require some type of repair.

Scored cylinder liners may be caused by broken piston rings, a defective piston, improper cooling, improper lubrication, or the presence of foreign particles or objects. Dust particles drawn into an engine cylinder will mix with the oil and become an effective but undesirable lapping compound that may cause extensive damage. The importance of keeping the intake air clean cannot be overemphasized.

Another precaution you should take is to make sure that when you replace a cylinder head, you leave no metal chips, nuts, bolts, screws, or tools in the cylinder.

Causes

Scoring may be in the form of deep or shallow scratches in the liner surface. With most liner scoring, there will be corresponding scratches on the piston and piston rings. The symptoms of scoring may be low firing or compression pressure and rapid wear of piston rings. The best method for detecting scoring is visual inspection through liner ports, through the crankcase housing with pistons in their top position, or when the engine is disassembled.

Badly worn pistons and rings may cause scoring because blowby of combustion gases increases the temperature of the liner and may reduce the oil film until metal-to-metal contact takes place. Inspect the pistons and rings carefully. A piston with a rough surface (such as one that has seized) will score the liner.

Scoring as a result of insufficient lubrication or dirt in the lubricating oil can be prevented if lubricating equipment (filters, strainers, and centrifuges) is maintained properly. Lube oil must be purified according to required procedures.

Repairs

Ship's force personnel normally do not repair scored liners; they replace them with spare liners. When necessary, liners with minor scoring may be kept in service, if the cause of scoring is eliminated and the minor defects can be corrected. The surface of the liner must be inspected carefully, especially in the region next to the ports, for any burrs, projections, or sharp edges that will interfere with piston and ring travel. Most projections can be removed by handstoning, using a fine stone. Figure 3-4 shows a liner before and after the ports were stoned.

EXCESSIVELY WORN LINERS

Over a period of time, cylinder liners become worn simply because of engine operation. The best method of finding excessive wear is to take measurements of the cylinder liner with an inside micrometer caliper. Two

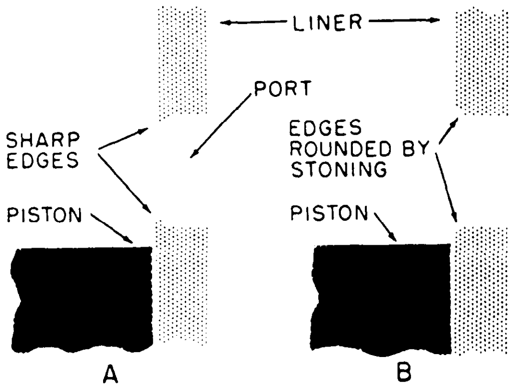


Figure 3-4.–Liner before and after stoning.

types of liner wear check are illustrated in figure 3-5. Excessive maximum diameter results from general wear equally around the cylinder. Out-of-roundness is produced by the piston thrusting against one or two sides of the cylinders.

Clearance between a piston and a liner is generally checked by measuring both parts with a micrometer. On smaller engines, you can use a feeler gauge. Clearance in excess of that specified by the manufacturer is generally due to liner wear, which normally is greater than piston wear.

To determine liner wear, take measurements at three levels in the liner. Take the first measurement slightly below the highest point to which the top ring travels; take the next measurement slightly above the lowest point of compression ring travel; and take the third measurement at a point about midway between the first two. (Record all readings, so that rapid wear of any particular cylinder liner will be evident.) If wear or out-of-roundness exists beyond specified limits, replace the liner. Figure 3-6 shows two examples of taking

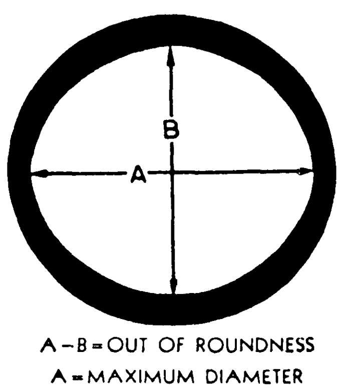


Figure 3-5.–Measurements for determining liner wear.

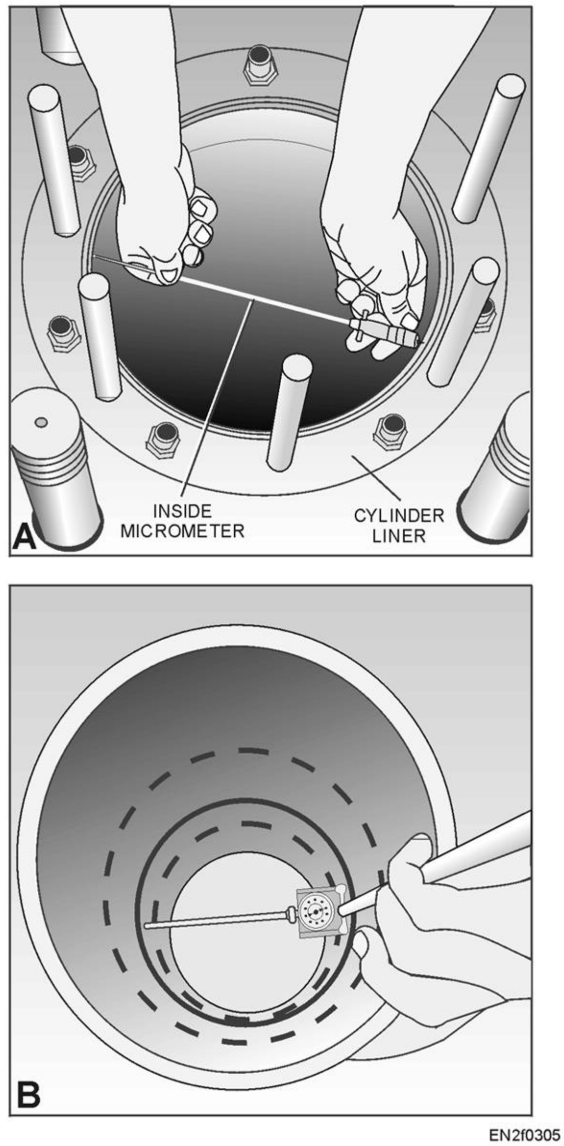


Figure 3-6.–Measuring the inside of a cylinder liner.

inside measurements. The liner shown in figure 3-6, view B, requires at least twice as many measurements as other types of liners because it is from an opposed piston.

You will not get accurate measurements unless you position the caliper or gauge properly in the liner. Common errors in positioning are illustrated in views A and B of figure 3-7. Hold one end of the caliper firmly against the liner wall as shown in view A of figure 3-6. Then move the free end back and forth, and up and down, until you establish the true diameter of the liner. The moving end will trace a patch similar to that illustrated in figure 3-8.

Considerable experience in using an inside micrometer or cylinder gauge is necessary to ensure accuracy. As a precaution against error, it is a good

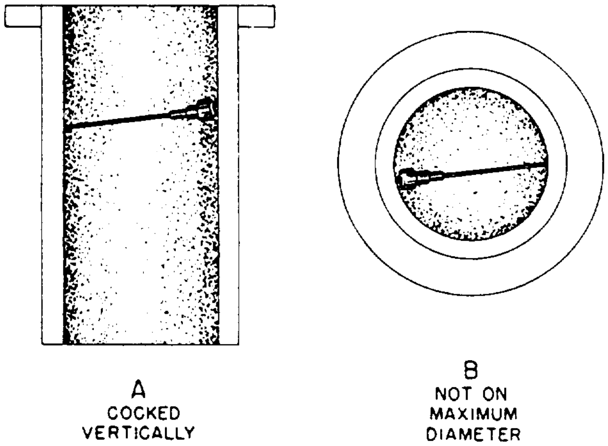


Figure 3-7.—Errors to avoid when taking liner measurements.

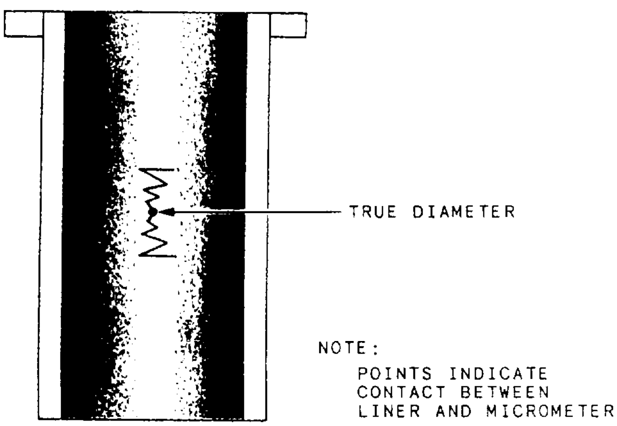


Figure 3-8.—Trace of caliper end when determining the true diameter of a liner.

practice for two persons to take the liner measurement; then any discrepancy between the two sets of readings can be rechecked.

Causes

Excessive or abnormal wear of cylinder liners may be caused by insufficient lubrication, dirt, improper starting procedures, or low cooling water temperature.

The lubricating system must be carefully maintained in proper working order. The method of cylinder liner lubrication varies with different engines. The proper grade of oil, according to engine specifications, should be used

The engine must not be operated in a dirty condition. The air box, crankcase, and manifold should be cleaned and maintained in a clean condition, to avoid cylinder wear and scoring. (Attention to the air cleaner, oil filters, and oil centrifuge are the best precautions against the entrance of dirt into the engine.)

Improper starting procedures will cause excessive wear on the liners and pistons. When an engine is first started, some time may elapse before the flow of lubricating oil is completed; also, the parts are cold and condensation of corrosive vapors is accelerated accordingly. These two factors (lack of lubrication and condensation of corrosive vapors) make the period immediately after starting a critical time for cylinder liners. If an independently driven oil pump is installed, it must be used to prime the lube oil system and build up oil pressure before the engine is started The engine should not be subjected to high load during the warm-up period. Follow the manufacturer's instruction manual concerning warm-up time and load application for the engine concerned

The cooling water of an engine should always be maintained within the specified temperature ranges. If the temperature is allowed to drop too low, corrosive vapors will condense on the liner walls.

Repairs

Cylinder liners worn beyond the maximum allowable limit should be replaced. You will find the maximum allowable wear limits for engines in the appropriate manufacturer's technical manual or the Diesel Engine Wear Limit Chart available from the Naval Sea Systems Command. In the absence of such specific information, the following wear limits (established by NAVSEA) apply in general to

1. two-stroke cycle engines with aluminum pistons: 0.0025 inch per inch diameter,

2. slow-speed engines over l8-inch bore: 0.005 inch per inch diameter, and

3. all other engines: 0.003 inch per inch diameter.

If you must remove a liner, follow the instructions given on the appropriate maintenance requirement card (MRC) or in the manufacturer's technical manual for the particular type of engine. Figure 3-9 illustrates the method generally used to remove a cylinder liner.

To remove the cylinder liner, proceed as follows:

1. Drain the water from the engine.

2. Remove the cylinder head.

3. Remove the piston(s).

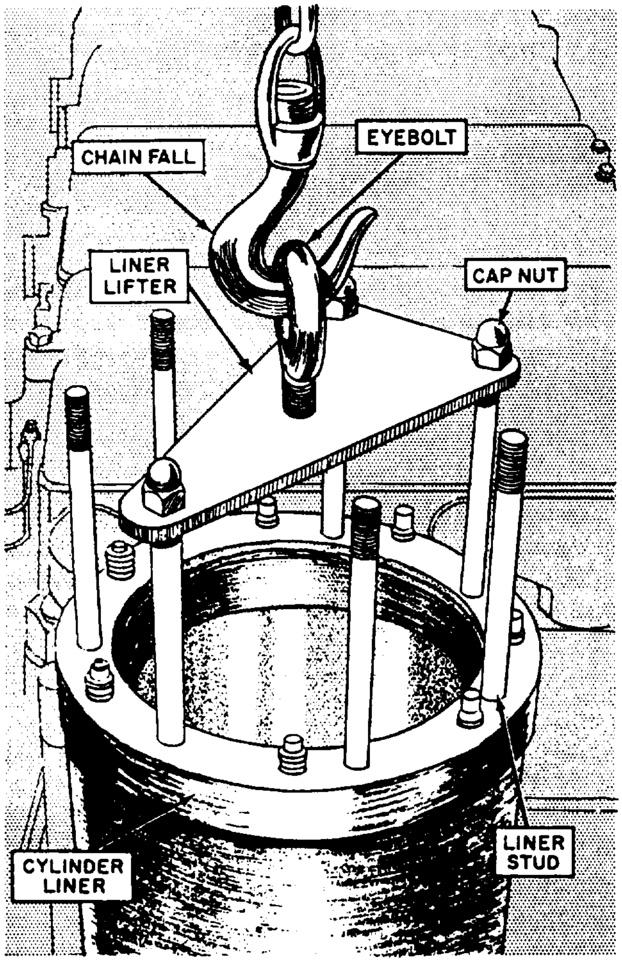


Figure 3-9.—Removing a cylinder liner.

4. Attach the special liner puller to the liner studs and tighten the nuts by hand. (The nuts must be hand tightened; if a wrench is used, the threads on both the nuts and the studs may be damaged.)

5. Attach the hook of the chain fall and pull slightly until the liner breaks free (fig. 3-9). If the liner fails to break loose immediately, apply pressure at the bottom of the liner. To do this, place a block of wood on the crankshaft throw, and force it up against the liner by rotating the turning gear.

6. Lift the liner up until it clears the top of the engine block and remove it to a safe place. You may need to rotate the liner slightly while removing it from the engine block.

INSPECTING, TESTING, AND REPAIRING CYLINDER HEADS

Conditions requiring repair of a cylinder head are similar to those for cylinder liners and can be grouped under cracks, corrosion, distortion, and fouling.

CRACKS

The symptoms of a cracked cylinder head are the same as those of a cracked liner. Cracks in cylinder heads are best located by either visual inspection or magnetic powder inspection. On some types of engines, a defective cylinder can be located by bringing the piston of each cylinder, in turn, to top dead center and applying compressed air. When air is applied to a damaged cylinder, a bubbling sound indicates leakage.

When the cylinder head is removed from the engine, it can be checked for cracks by the hydrostatic test used on cylinder liners equipped with integral cooling passages.

Cracks generally occur in cylinder heads on the narrow metal sections between such parts as valves and injectors. The cracks may be caused by adding cold water to a hot engine, by restricted cooling passages, by obstructions in the combustion space, or by improper tightening of studs.

Aboard ship, cracked cylinder heads usually must be replaced. It is possible to repair them by welding, but this process requires special equipment and highly skilled personnel normally found only at repair activities.

CORROSION

Burning and corrosion of the mating surfaces of a cylinder head may be caused by a defective gasket. Although regular planned maintenance ordinarily prevents this type of trouble, burning and corrosion may still take place under certain conditions. When corrosion and burning occur, there may be a loss of power due to combustion gas leakage out of or water leakage into the combustion space. Other symptoms of leakage may be (1) hissing or sizzling in the head where gases or water may be leaking between the cylinder head and the block, (2) bubbles in the cooling water expansion tank sight glass, or (3) overflow of the expansion tank.

Gaskets and grommets that seal combustion spaces and water passages must be in good condition; otherwise the fluids will leak and cause corrosion or burning of the area contacted. Improper cooling water treatment may also accelerate the rate of corrosion.

In general, cylinder heads that are burned or corroded by gas or water leakage are so damaged that they must be replaced.

DISTORTION

Warpage or distortion of cylinder heads becomes apparent when the mating surfaces of the head and block fail to match properly. If distortion is severe, the head will not lit over the studs. Distortion may be caused by improper welding of cracks or by improper tightening of the cylinder head studs. Occasionally, new heads may be warped because of improper casting or machining processes.

Repair of distorted or damaged cylinder heads is often impracticable. They should be replaced as soon as possible and turned in to the nearest supply activity, which will determine the extent of damage and the method of repair.

FOULING

If the combustion chambers become fouled, the efficiency of combustion will decrease. Combustion chambers are designed to create the desired turbulence for mixing the fuel and air; any accumulation of carbon deposits in the space will impair both turbulence and combustion by altering the shape and decreasing the volume of the combustion chamber.

Symptoms of fouling in the combustion chambers are smoky exhaust, loss of power, or high compression. Such symptoms may indicate the existence of extensive carbon formation or clogged passages. In some engines, these symptoms indicate that the shutoff valves for the auxiliary combustion chambers are stuck

Combustion chambers may also become fouled because of faulty injection equipment, improper assembly procedures, or excessive oil pumping.

Cleaning of fouled combustion spaces generally involves removing the carbon accumulation. The best method is to soak the dirty parts in an approved solvent and then wipe off all traces of carbon. You may use a scraper to remove carbon, but be careful to avoid damaging the surfaces. If oil pumping is the cause of carbon formation, check the wear of the rings, bearings, pistons, and liners. Replace or recondition excessively worn parts. Carbon formation resulting from improperly assembled parts can be avoided by following procedures described in the manufacturer’s technical manual.

INSPECTING, TESTING, AND REPAIRING VALVES AND VALVE ASSEMBLIES

Regardless of differences existing in engine construction, there are certain troubles common to all assemblies.

STICKING VALVES

Sticking valves will produce unusual noise at the cam followers, pushrods, and rocker arms and may cause the engine to misfire. Sticking is usually caused by resinous deposits left by improper lube oil or fuel.

To free sticking valves without having to disassemble the engine, use one of several approved commercial solvents. If the engine is disassembled, use either a commercial solvent or a mixture of half lube oil and half kerosene to remove the resins. Do NOT use the kerosene mixture on an assembled engine, since a small amount of this mixture settling in a cylinder could cause a serious explosion.

BENT VALVES

Bent or slightly warped valves tend to hang open. A valve that hangs open not only prevents the cylinder from firing, but also is likely to be struck by the piston and bent so that it cannot seat properly. Symptoms of warped or slightly bent valves will usually show up as damage to the surface of the valve head. To lessen the possibility that cylinder head valves will be bent or damaged during overhaul, NEVER place a cylinder head directly on a steel deck or grating; use a protective material such as wood or cardboard. Also, NEVER pry a valve open with a screwdriver or similar tool.

WEAK SPRINGS

Valves may close slowly, or fail to close completely, because of weak springs. At high speeds, valves may “float,” thus reducing engine efficiency. Valve springs wear quickly when exposed to excessive temperatures and to corrosion from moisture combining with sulfur present in the fuel.

BURNED VALVES

Burned valves are indicated by irregular exhaust gas temperatures and sometimes by excessive noise. In general, the principal causes of burned valves are carbon deposits, insufficient tappet clearance, defective valve seats, and valve heads that have been excessively reground.

The principal cause of burned exhaust valves is small particles of carbon that lodge between the valve head and the valve seat. These particles come from incomplete combustion of the fuel or oil left by the piston rings in the cylinder. The particles hold the valve open just enough to prevent the valve head from touching the valve seat. The valve is cooled by several means, including its contact with the valve seat. When carbon particles prevent contact, the heat normally transferred from the valve head to the seat remains in the valve head. The valve seat seldom burns because the water jackets surrounding the seat usually provide enough cooling to keep its temperature below a dangerous point.

When cleaning carbon from cylinder heads, remove all loose particles from the crevices; be extremely careful that you do not nick or scratch the valve or seat. Removing the valves from the engine will make it easier to clean the passages and remove the carbon deposits from the underside of the valve heads.

Check the tappet clearance adjustments at frequent intervals to be certain they are correct and that the locking devices are secure. The adjustment of valve clearances is discussed later in this chapter.

Most engines are equipped with valve seat inserts made of hard, heat-resisting, alloy steel. Occasionally, a seat will crack and allow the hot gases to leak, burning both the insert and the valve. Sometimes a poor contact between the valve seat insert and the counterbore prevents the heat from being conducted away, and the high temperatures deform the insert. When this occurs, both the seat and the valve will burn; the seat insert must be rep1aced.

LOOSE VALVE SEATS

You can avoid causing loose valve seats only by installing them properly. Clean the counterbore thoroughly to remove all carbon before shrinking in an insert. Chill the valve seat with dry ice and place the cylinder head in boiling water for approximately 30 minutes; then drive the insert into the counterbore with a valve insert installing tool, as illustrated in figure 3-10. Never strike a valve seat directly. Do the driving operation quickly, before the insert reaches the temperature of the cylinder head

When replacing a damaged valve with a new one, inspect the valve guides for excessive wear. If the valve moves from side to side as it seats, replace the guides.

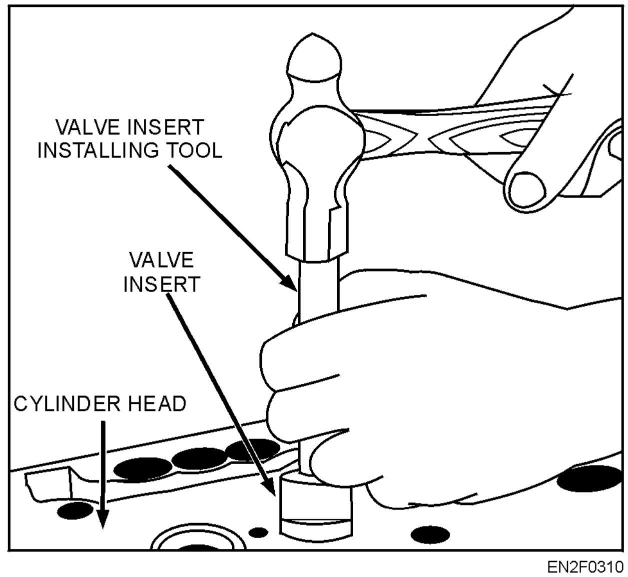


Figure 3-10.–Driving a valve iusert into the cylinder head counterbore.

PITTING

If the valve seat is secured firmly in the counterbore and is free of cracks and burns, you may remove slight damage such as pitting by hand grinding (fig. 3-11). Generally, you will use prussian blue to check the valve and valve seat, but if this is not available, use any thin dark oil-based paint. Allow the valve to seat by dropping it on the valve seat from a short distance. If the surfaces fail to make complete contact, regrinding is necessary.

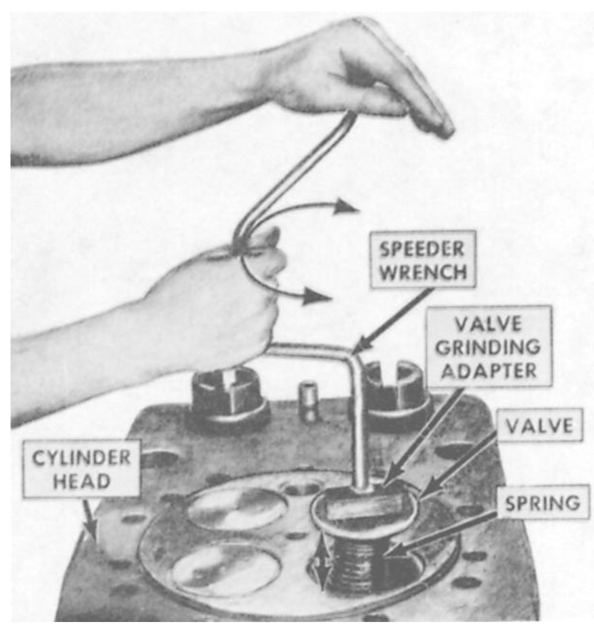


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Figure 3-11.–Hand grinding a valve and valve seat.

In any valve reconditioning job, the valve seat must be concentric with the valve guide. You can determine the concentricity with a dial indicator, as shown in figure 3-12.

If you must grind a valve seat, hold hand grinding to a minimum and never use it in place of machine grinding, in which a grinding stone is used to refinish the seat (fig. 3-13). Grind the seat a few seconds at a time until it is free of pits. Check the seat after each cut.

The primary objection to hand grinding the valve to the seat is that a groove or indentation may be formed in the valve face. Since the grinding is done when the valve is cold, the position of the groove with respect to the seat is displaced as the valve expands slightly when the engine is running. This condition is illustrated (greatly exaggerated) in figure 3-14. Note that when the valve is hot, its ground surface does not make contact at all with the ground surface of the seat. Therefore, hand grinding should be used only to remove slight pitting or as the final and finishing operation in a valve reconditioning job.

Some valves and seat are not pitted sufficiently to require replacement but are pitted to such an extent that hand grinding would be unsatisfactory. Such valves may be refaced on a lathe (fig. 3-15), and the valve seats may be reseated by power grinding equipment (fig. 3-13).

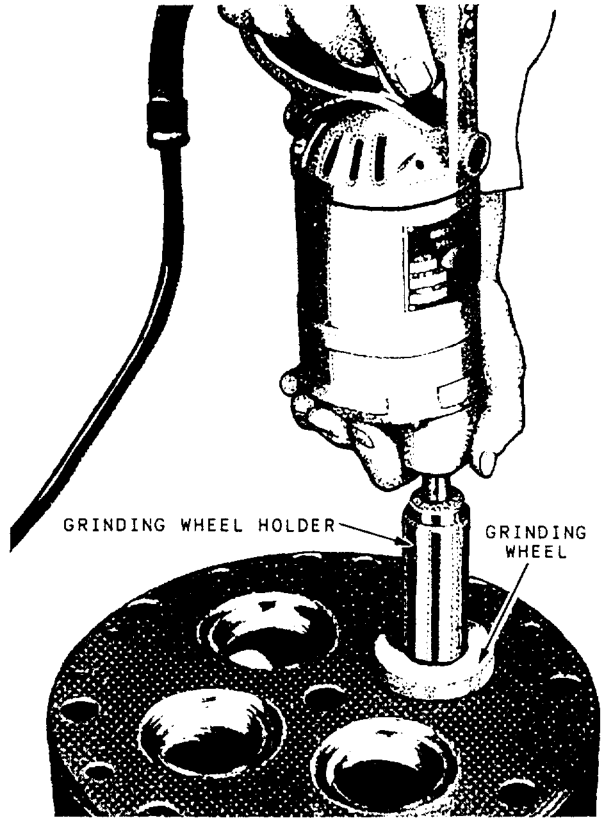

Figure 3-13.—Machine grinding a valve seat.

Normally, these operations are done at a repair base or naval shipyard.

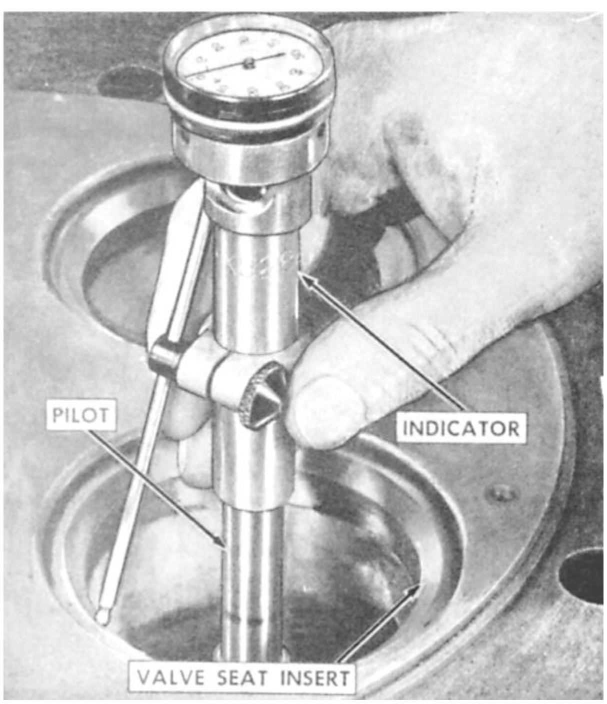

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Figure 3-12.—Determining concentricity of the valve seat with a dial indicator.

A valve head that is excessively reground to such an extent that its edge is sharp, or almost sharp, will soon burn. A sharp edge cannot conduct the heat away fast enough to prevent burning. This is the factor that limits the extent to which a valve may be refaced.

BROKEN VALVE SPRINGS

Broken valve springs cause excessive valve noise and may cause erratic exhaust gas temperatures. The actual breaking of the valve springs is not always the most serious consequence. Actions following the breaking cause the most serious damage to the engine. When a spring breaks, it may collapse just enough to allow the valve to drop into the cylinder, where it may be struck by the piston. In addition, the valve stem locks or keepers may release the valve and allow it to drop into the cylinder, causing severe damage to the piston, cylinder head, and other nearby parts.

You can take a number of precautions to prevent or minimize corrosion and metal fatigue, which cause valve springs to break Be reasonably careful when you

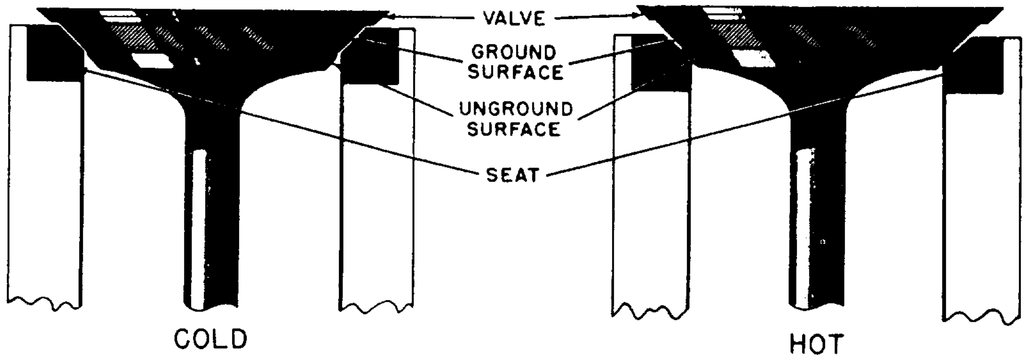

Figure 3-14.—Excessively band-ground valve.

assemble and disassemble a valve assembly. Before you reassemble a valve assembly, be sure to thoroughly clean and inspect the valve spring. (Use kerosene or diesel fuel for cleaning. NEVER use an alkaline solution; it will remove the protective coating.) The condition of the surface of a valve spring is the best indication of impending failure. (Use magnafluxing to help find cracks that would otherwise be invisible.)

The free length of a valve spring should be within the limits specified in the manufacturer's technical manual. If such information is not available, compare the length of a new spring with that of the used spring. If the length of the used spring is more than 3 percent shorter than that of the new spring, replace the used spring immediately. Remember, however, that loss of spring tension will NOT always show up as a loss in overall length. Springs may be the proper length, but they may have lost enough tension to warrant replacement.

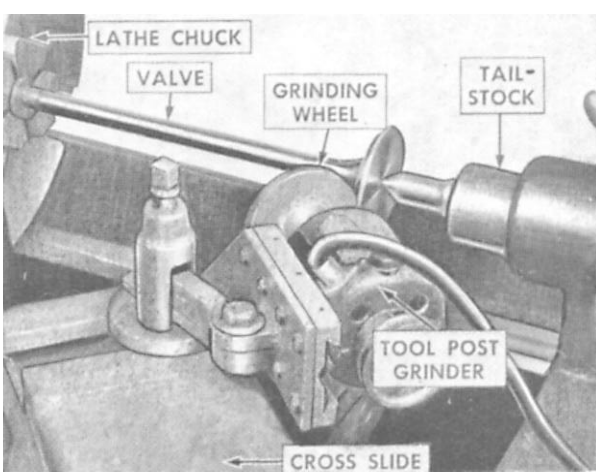

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Figure 3-15.—Facing a valve on a lathe.

Do not reinstall springs with nicks, cracks, or surface corrosion. Replace them. To minimize corrosive conditions, use clean lube oil, eliminate water leaks, and keep vents open and clean

WORN VALVE KEEPERS AND RETAINING WASHERS

Worn valve keepers and retaining washers may result if valve stem caps (used in some engines) are improperly fitted Caps are provided to protect and increase the service life of the valve stems. Trouble occurs when the cap does not bear directly on the end of the stem, but bears instead on the valve stem lock or the spring retaining washer. This transmits the actuating force from the cap to the lock or the retaining washer, and then to the stem, causing excessive wear on the stem groove and the valve stem lock As a result, the retaining washer wiIl loosen and the valve stem may break

An improper fit of a valve stem cap may be due to the use of improper parts or the omission of spacer shims. Steel spacer shims, required in some caps to provide proper clearance, are placed between the end of the valve stem and the cap; leaving out the shims will cause the shoulder of the cap to come in contact with the lock. When you disassemble a valve assembly, determine whether or not shims are used. If shims are used, record their location and exact thickness. Valve caps must be of the proper size, or troubles similar to those resulting from shim omission will occur. Never attempt to use caps or any other valve assembly parts that are worn.

BROKEN VALVE HEADS

Broken valve heads usually cause damage to the piston, liner, cylinder head, and other associated parts. This damage is generally repairable only by replacement of these parts.

Whether the causes of broken valve heads are mechanical deformation or metal fatigue, you must take every precaution to prevent their occurrence. If a valve head breaks loose, be sure to make a thorough inspection of all associated parts before you replace the valve.

ROCKER ARMS AND PUSHRODS

The principal trouble that rocker arms and pushrods may have is WEAR, which may occur in bushings, or on the pads, end fittings, or tappet adjusting screws.

Worn rocker arm bushings are usually caused by lubricating oil problems. A bushing with excessive wear must be replaced. When installing a new bushing, you usually need to use a reamer for the final fit.

Wear at the points of contact on a rocker arm is generally in the form of pitted, deformed, or scored surfaces. Wear on the rocker arm pads and end fittings is greatly accelerated if lubrication is insufficient or if there is excessive tappet clearance. Pushrods are usually positioned to the cam followers and rocker arms by end fittings. The pads are the rocker arm ends that bear the valve stem or valve stem cap. When the tappet clearance is excessive, the rods shift around, greatly increasing the rate of wear of both the rocker arm and the rod contact surfaces. Worn fittings necessitate the replacement of parts. Continued use of a poor fitting and worn pushrod is likely to result in further damage to the engine, especially if the rod should come loose.

Worn tappet adjusting screws and locknuts usually make maintaining proper clearances and keeping the locknuts tight very difficult. Wear of the adjusting screws is usually caused by loose locknuts, which allow the adjusting screw to work up and down on the threads each time the valve is opened and closed. To prevent this wear, tighten the locknuts after each adjustment and check the tightness at frequent intervals.

If the threads are worn, replace the entire rocker arm. Do NOT attempt to repair the threads or to use a new tappet adjusting screw except in cases of emergency.

The adjustment of the rocker arm assembly consists chiefly of adjusting the tappets for proper running clearance. The valve clearance for both intake and exhaust valves should be readjusted after overhaul. The procedure for adjusting the rocker arm tappets of a typical 4-stroke cycle engine is as follows:

1. Rotate the crankshaft and move the piston whose tappets you plan to adjust to top dead center of the compression stroke.

2. Loosen the locknut (jam nut) on the tappet screw, and insert a screwdriver in the slot of the screw.

3. Insert a feeler gauge of the proper thickness between the tappet bearing and the end of the valve stem.

4. Tighten the tappet screw (fig. 3-16) until the feeler gauge will just slide freely between the bearing and the valve stem.

5. lighten the jam nut and check the clearance. The jam nut has a tendency to increase the clearance when tightened; therefore, ALWAYS check the clearance after you tighten the jam nut.

The procedure just outlined is a preliminary, or cold engine check. Check and readjust the clearance, if necessary, after the engine has been in operation for a short time and has reached the normal operating temperature. The manufacturer’s technical manual will give the recommended valve clearances for a specific make and model of engine and will indicate whether the clearances given apply to cold or hot engines.

CAM FOLLOWERS AND LASH ADJUSTERS

Regardless of the type of cam follower, wear is the most common trouble. Worn rollers will usually develop holes or pit marks in the roller surfaces. The mushroom type may develop a shallow channel when the cam

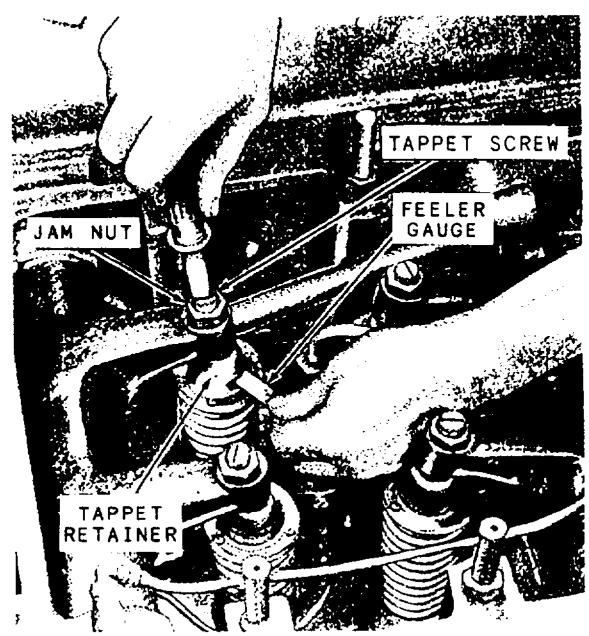

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Figure 3-16.—Adjusting valve clearance.

follower fails to revolve and the cams wipe the same surface each time the camshaft revolves.

Normal use will cause surface disintegration, usually as the hardened surfaces begin to fatigue. The condition is aggravated by abrasive particles. Nicks and dents on rollers will also cause disintegration.

You must make constant checks for defective rollers or surfaces and for nicks, scratches, or dents in the camshaft. Whenever you find a defective cam follower, you should replace it. In roller-type cam followers you must replace a worn cam follower body and guide or roller needle bearings (if used).

Defective or poorly operating valve adjusters allow clearance or lash in the valve gear. Noisy operation of a lash adjuster indicates that there is insufficient oil in the cylinder of the unit. When you discover a noisy lash adjuster and the oil supply or pressure is not the source of trouble, remove and disassemble the unit according to the manufacturer's instructions.

Since the parts of lash adjusters are not interchangeable, disassemble only one unit at a time. Check for resinous deposits, abrasive particles, a stuck ball check valve, a scored check valve seat, and excessive leakage. Carefully wash all parts of the hydraulic lash adjuster in kerosene or diesel fuel. Check such parts as the cam follower body, plunger or piston, and hydraulic cylinder for proper fit.

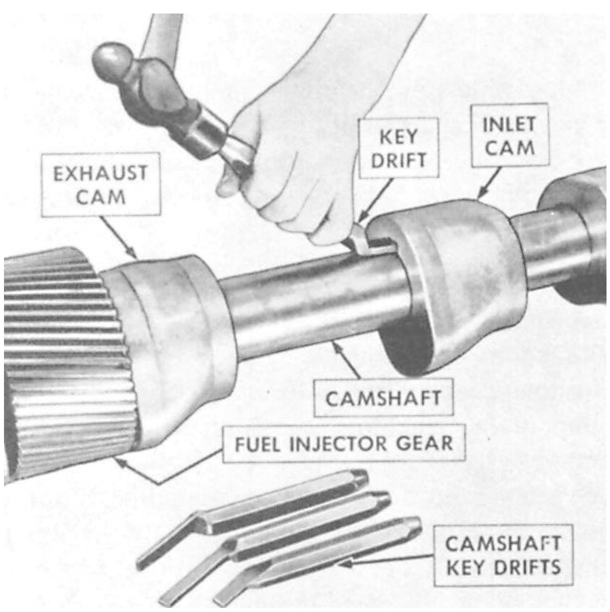

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Figure 3-17.—Removing an individual cam.

INSPECTING AND REPAIRING CAMSHAFTS

Camshafts can be saved when the cams alone are damaged, if the cams are of the individual type, since such cams may be removed and replaced. Figure 3-17 illustrates the method of removing an individual cam from its shaft.

When you remove a camshaft from an engine, clean it thoroughly with either kerosene or diesel fuel. After cleaning the shaft, dry it with compressed air. After cleaning the cam and journal surfaces, inspect them for any signs of scoring, pitting, or other damage.

When you remove or insert a camshaft through the end of the camshaft recess, rotate it slightly. Rotating the camshaft allows it to enter easily and reduces the possibility of damage to the cam lobes and bearings.

After you visually inspect a camshaft, place it on V-blocks and measure the shaft runout by using a dial indicator. When you measure the runout, take the out-of-roundness into consideration. Compare your measurements to the manufacturer's specifications. Also, measure the camshaft bearing journals with a micrometer. Figure 3-18 illustrates a camshaft with bearing journals.

A camshaft needs to be replaced if the following conditions occur:

1. The lobes are damaged, as lobes cannot be repaired.

2. Runout exceeds the manufacturer's specifications.

3. Wear on the shaft bearing journals exceeds the manufacturer's specifications.

4. The keyways are damaged.

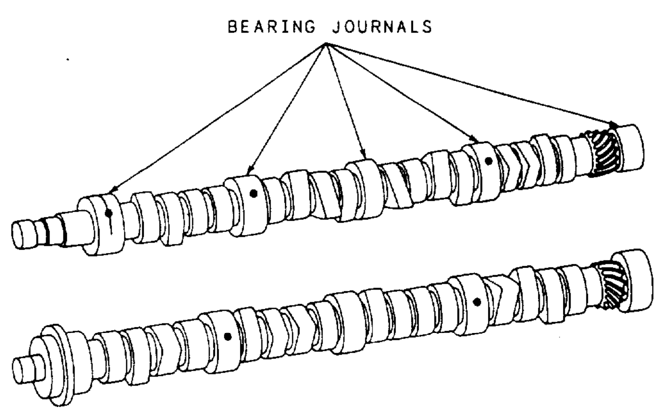

Figure 3-18.—Camshaft with bearing journals in a V-type engine.

Before you reinstall a good camshaft, remove the minor surface defects on the cams and the camshaft by using crocus cloth or a fine stone.

INSPECTING, MAINTAINING, AND REPLACING PISTON RINGS AND PISTONS

The following paragraphs are general procedures for inspections, maintenance, and replacement of piston rings and pistons. You must consult the manufacturer's technical manual for specific instructions.

PISTON RINGS

Over a period of time all piston rings wear. Some stick and may even break. While you may be able to free stuck rings and make them serviceable, you must replace excessively worn or broken rings with new ones. The installation of a new set of rings in an engine requires great care. Most of the damage that is done occurs when the rings are being placed in the grooves of a piston or when the piston is being inserted into the cylinder bore.

Be very careful when you remove the piston and connecting rod from the cylinder. In most engines, you should not remove a piston from a cylinder until you have scraped the cylinder surface above the ring travel area. In addition to removing all carbon, you must remove any appreciable ridge before removing the piston. Do not remove a ridge by grinding, as this will allow small abrasive particles from the stone to enter the engine. Use a metal scraper and place a cloth in the cylinder to catch all metal cuttings. You can usually scrape enough from the lip of a cylinder to allow the piston assembly to slide out of the liner. After removing the piston, you can make a more detailed inspection of the ridge.

Finish scraping the remaining ridge, but be careful not to go too deep. Finish the surface with a handstone. For large ridges, you may need to remove the liner and use a small power grinder.

With the piston and connecting rod removed, check the condition and wear of the piston pin bushing, both in the piston and in the connecting rod.

The best way to remove and install piston rings is with a tool similar to that shown in figure 3-19. These tools generally have a device that limits the amount the ring can be spread and prevents the rings from being deformed or broken.

A ring that is securely stuck in the groove will require additional work. You may need to soak the piston

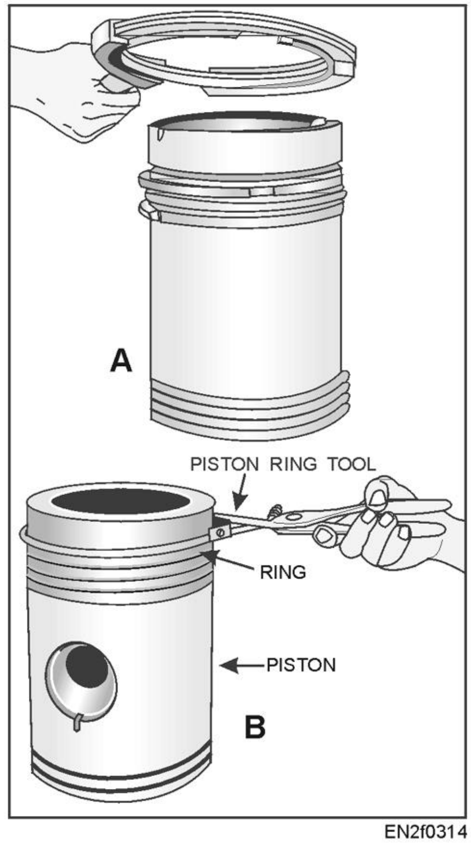

Figure 3-19.–Piston ring tools used for removal or installation.

overnight in an approved cleaning solvent or in diesel oil. If soaking does not free the ring, you must drive it out with a brass drift. The end of the drift should be shaped and ground to permit its use without damage to the lands.

After removing the rings, thoroughly clean the piston with special attention to the ring grooves. (Diesel oil or kerosene are satisfactory cleaning agents.) In addition, you may need to clean excessive deposits from the oil return holes in the bottom of the oil control ring grooves with a twist drill of a diameter corresponding to the original size of the holes.

Make another complete inspection after cleaning the piston. Check all parts for any defects that could require replacement of the piston. Give particular attention to the ring grooves, especially if the pistons have been in service for a long period of time. A certain amount of enlargement of the width of the grooves is normal, and SHOULDERING of the groove may occur. Shouldering, as illustrated in figure 3-20, results from the "hammering out" motion of the rings. The radial depth of thickness of the ring is much less than the groove depth, and while the ring wears away an amount of metal corresponding to its own width, the metal at the bottom of the groove remains unchanged. Shouldering

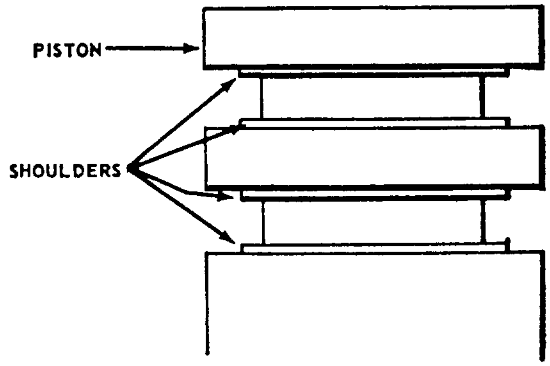

Figure 3-20.—Ring groove shoulders due to wear.

usually requires replacement of the piston since the shoulders prevent the proper fitting of new rings.

After determining that a piston is serviceable, inspect the rings carefully todetermine whether they can be reused. If they do not meet specifications, you must install new rings.

When installing rings, measure the gap with a feeler gauge. To measure the gap, place the new rings inside the cylinder liner (fig. 3-21, view A) or in a ring gauge. When the gap is measured with the ring in the liner (fig. 3-21, view B), two measurements are necessary—one just below the upper limit of ring travel, and the other within the lower limit of travel. These measurements are necessary because the liner may have a slight amount of taper caused by wear. The ring gap must be within the limits specified in the manufacturer's technical manual. If the gap of a new ring is less than specified, file the ends of the ring with a straight-cut mill file to obtain the proper gap. If the gap is more than specified, install oversized rings.

To measure the ring gap of used rings, hold the rings in place on the piston with a ring compressing tool (fig. 3-22). But before you measure the ring gap with the ring on the piston, first measure the piston for wear and out-of-roundness.

After ensuring the proper gap clearance, you can reinstall the piston pin and connecting rod. During reassembly and installation of a piston and connecting rod assembly, be sure that all parts are well lubricated. Install the rings on the piston with tools similar to those used for ring removal. When installing piston rings, spread them as little as possible to avoid breaking the rings. Insert the lowest ring first. When all the rings have

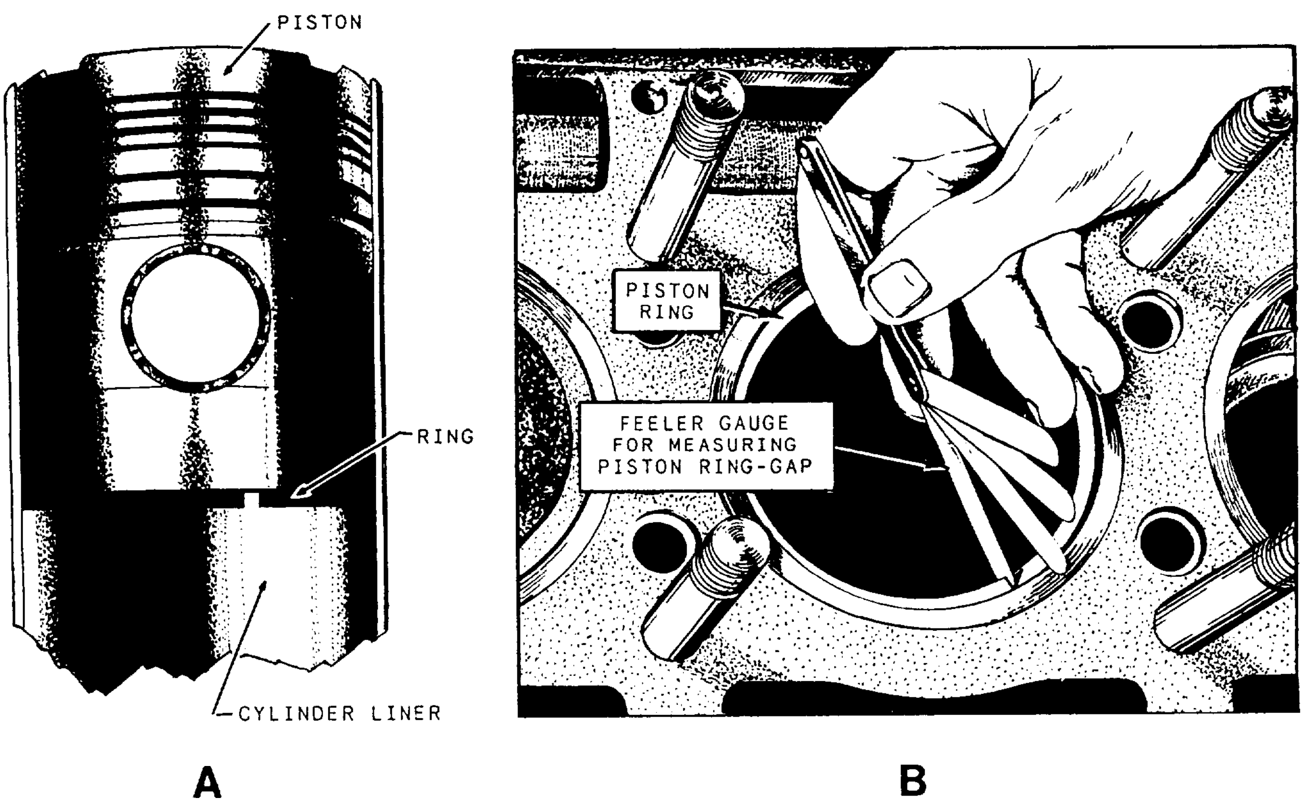

Figure 3-21.–A. Leveling a piston ring. B. Measuring ring gap clearance in a cylinder bore.

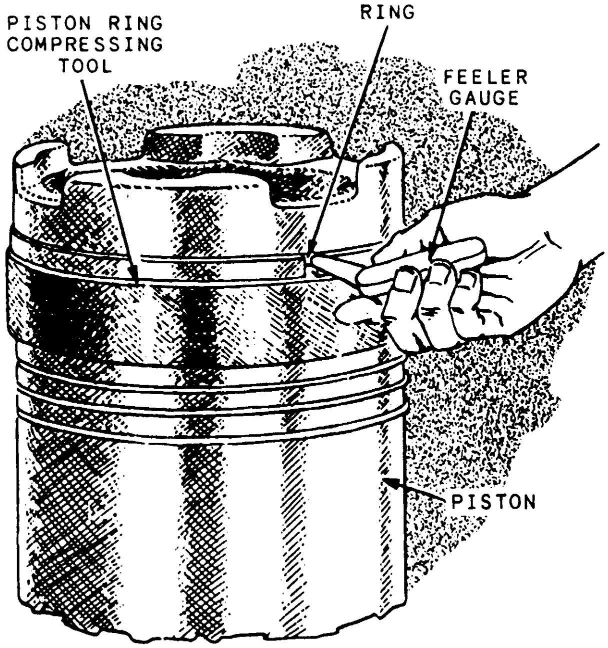

Figure 3-22.–Checking ring gap clearance.

been installed, check the ring-to-land clearance. (See fig. 3-23.) If the clearance is too small, the ring may bind or seize, allowing improper sealing and blowby to occur. If the clearance is excessive, the ring may flutter and break itself or the piston land.

After you have properly installed all the rings, coat the entire assembly with oil, then insert it into the cylinder bore. Position the rings so the gap of each successive ring is on an alternate side and the gaps are in line with the piston pin bosses. On large engines, use a chain fall to hold the piston assembly in position as you lower it into the cylinder. (See fig. 3-24.)

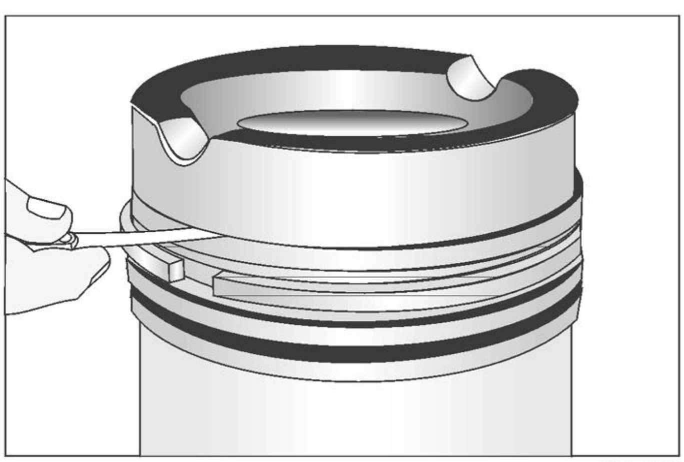

Figure 3-23.–Checking ring groove side clearance.

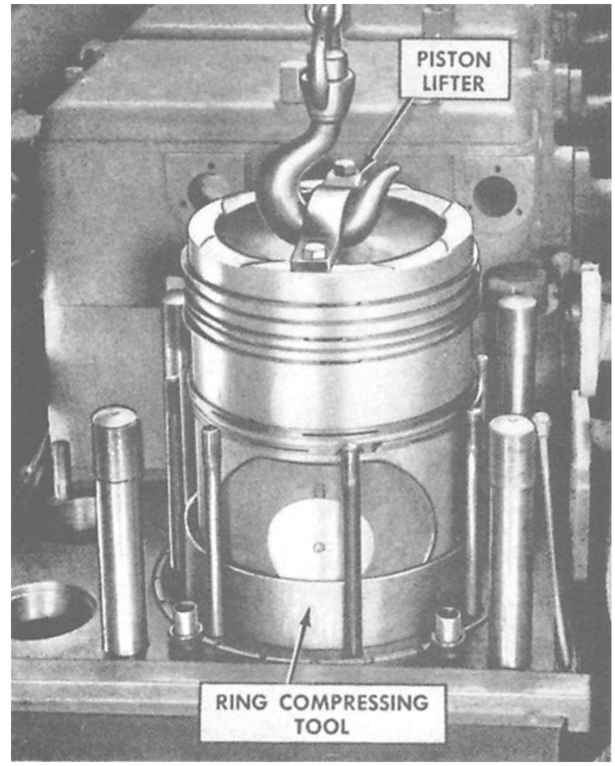

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Figure 3-24.–Installing a piston in a cylinder bore with a funnel-type ring compressor.

When a piston is being inserted into a cylinder, the piston rings must be compressed evenly. Special funnel-type tools, similar to the one shown in figure 3-24 are usually provided for this purpose. Another type of ring compressing tool is a steel band that can be placed around the ring and tightened.

PISTONS

Trunk-type pistons are subject to forces such as gas pressure, side thrust, inertia, and friction. These forces, together with overheating and the presence of foreign matter, may cause troubles such as undue piston wear, crown and land dragging, cracks, piston seizure, clogged oil holes, and piston pin bushing wear.

Excessive Piston-to-Liner Clearance

Symptoms of excessive clearance between a piston and its cylinder are piston slap and excessive oil consumption. Piston slap occurs just after top dead center and bottom dead center, as the piston shifts its thrust from one side to the other. As the cylinder taper increases with wear, oil consumption increases. Since taper causes the rings to flex on each stroke of the piston, excess ring wear occurs, allowing lube oil to pass and be burned in the cylinder. This results in the accumulation of excessive carbon deposits.

Crown and Land Dragging

Pistons and liners may become sufficiently worn to permit the piston to cock over in the cylinder. This allows the crown and ring lands to drag on the cylinder wall. The results of dragging can be determined by visually inspecting the parts of the piston in question.

Piston Wear

Although piston wear is normal in all engines, the amount and rate of piston wear depend on several controllable factors. (The causes of excessive piston wear, and crown and land dragging, are also the causes of other piston troubles.)

One of the controllable factors is LUBRICATION. An adequate supply of oil is essential to provide the film necessary to cushion the piston and other parts within the cylinder and prevent metal-to-metal contact. Inadequate lubrication will not only cause piston wear and crown and land dragging, but also may cause piston seizure, and piston pin busing wear.

Lack of lubrication is caused either by a lack of lube oil pressure or by restricted oil passages. The pressure-recording instruments usually give warning of low oil pressure before any great harm results. However, clogged passages offer no such warnings, and their discovery depends on the care that is exercised in inspecting and cleaning the piston and connecting rod assembly.

Another controllable factor that may be directly or indirectly responsible for many piston troubles is IMPROPER COOLING WATER TEMPERATURE.

If an engine is not operated within the specified temperature limits, lubrication troubles will develop. High cylinder surface temperatures will reduce the viscosity of the oil. As the cylinder lubricant thins, it will run off the surfaces. The resulting lack of lubrication leads to excessive piston and liner wear. However, if temperatures are below those specified for operation, viscosity will be increased, and the oil will not readily reach the parts requiring lubrication.

Oil plays an important role in the cooling of the piston crown. If the oil flow to the underside of the crown is restricted, deposits caused by oxidation of the oil will accumulate, lowering the rate of heat transfer. Therefore, the underside of the piston crown should be thoroughly cleaned whenever pistons are removed

While insufficient and uneven cooling may cause ring land failure, excessive temperatures may cause piston seizure; an increase in the rates of oxidation of the oil, resulting in clogged oil passages; or damage to piston pin bushings.

Seizure or excessive wear of pistons may be caused by IMPROPER PIT. New pistons or liners must be installed with the piston-to-cylinder clearances specified in the manufacturer’s instruction manual.

PISTON PINS AND SLEEVE BEARINGS OR BUSHINGS

Every time you remove a piston assembly from an engine, inspect it for wear. Measure the piston pins and sleeve bearings or bushings with a micrometer, as shown in figure 3-25, to determine whether wear is excessive. Do NOT measure areas that do not make contact. Such areas include those between the connecting rod and piston bosses and areas under the oil holes and grooves.

You can press bushings out of the rod with a mandrel and an arbor press or with special tools, as shown in figure 3-26. You can also remove bushings by firt shrinking them with dry ice. Dry ice will also make it easier to insert the new bushing.

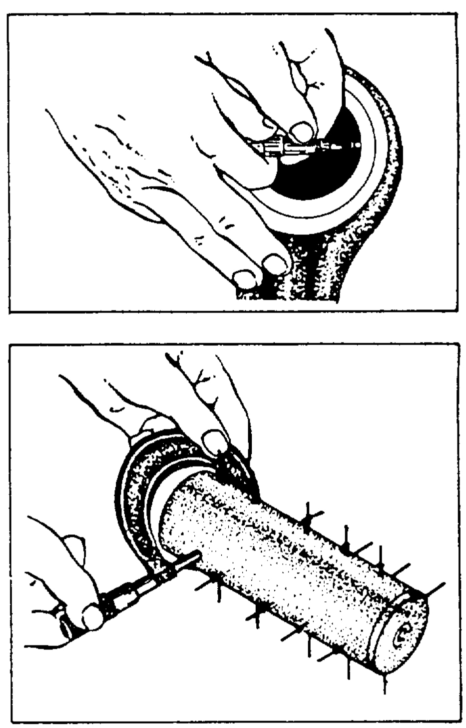

Figure 3-25.—Measuring a piston pin and piston bushing for wear.

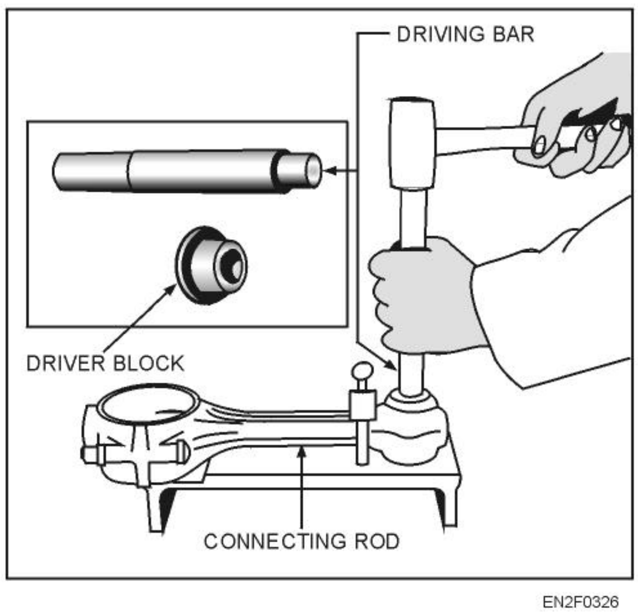

Figure 3-26.–Removing or installing a piston pin bushing.

When you insert new bushings, be sure that the bore into which they are pressed is clean and that the oil holes in the bushing and the oil passages in the rod are aligned. To obtain proper clearance, sometimes you will need to ream a piston pin bushing after it has been installed. Figure 3-27 shows equipment used to ream a bushing.

After installing a new bushing, check the alignment of the rod with equipment such as illustrated in figure 3-28. Be sure to check the manufacturer's technical manual for details concerning clearances and alignment procedures.

INSPECTING, MAINTAINING, AND REPAIRING CONNECTING RODS

Most connecting rod troubles involve either the connecting rod bearing or the piston pin bearing. You can avoid these troubles by performing proper maintenance procedures and by following instructions in the manufacturer's service manual. There are, however, certain unavoidable troubles, such as cracked connecting rods caused by defective material. Such cracks must be discovered before they develop to a point that the rod fails. Magniflux testing is considered the best method for locating cracks. If you discover a crack in a connecting rod, replace the rod; do not try to repair it. If you have to replace a damaged rod, send it, with other damaged parts, to a salvage center for possible reclamation.

Do not repair defective connecting rod bolts, except for removing small burrs by using a fine rectangular file. If you doubt the condition of a bolt or a nut, replace it.

Check the connecting rod bore for out-of-roundness with an inside micrometer. Make the correction and recheck the bore. If the distortion is permanent, replace the rod.

You can make plugged oil passages of connecting rods serviceable by running a wire through them. In extreme cases, you may need to drill the passages free of foreign matter.

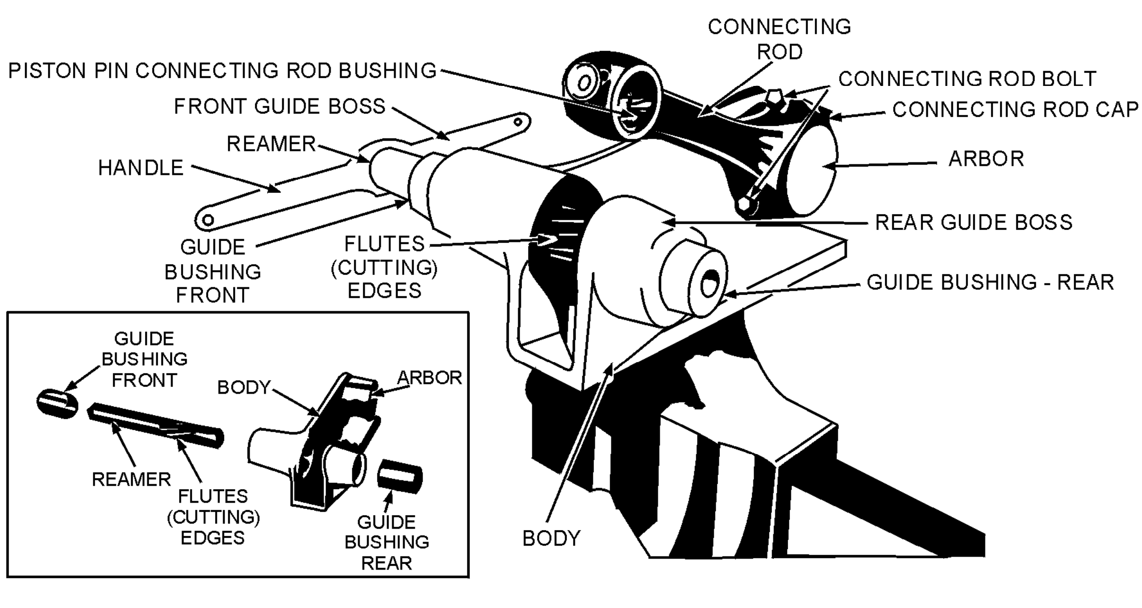

Figure 3-27.–Reaming equipment.

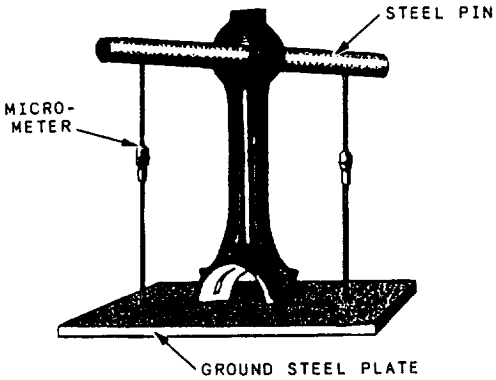

Figure 3-28.—Checking the alignment of a connecting rod.

REPAIRING CRANKSHAFTS AND JOURNAL BEARINGS

The repair of crankshafts and bearings varies depending on the extent of damage. There is no doubt about the necessity for replacing such items as broken or bent crankshafts. Out-of-round journals may be reground and undersize bearing shells may be installed, but this requires personnel skilled in the use of precision tools. If a new shaft is available, it should be installed and the damaged shaft should be sent to a salvage reclamation center. Under certain conditions, scored crankshaft journals or damaged journal bearings may be kept in service if proper repair is performed.

Repair of SCORED JOURNALS depends on the extent of scoring. If a crankshaft has been overheated, the effect of the original heat treatment will have been destroyed. In this case, the crankshaft should be replaced.

If journal scoring is only slight, you can use an oilstone for dressing purposes if you take precautionary measures with respect to abrasives during the procedure. During the dressing operation, plug all oil passages within the journal and those connecting the mainbearing journal and the adjacent connecting rod journal.

In the dressing procedure, use a fine oilstone, followed with crocus cloth, to polish the surface. After dressing journals, always wash them with diesel oil. This procedure must include washing the internal oil passages as well as the outside journal surfaces. Some passages are large enough to accommodate a cleaning brush; smaller passages can be cleaned by blowing them out with compressed air. Always dry the passages by blowing compressed air through them.

NEVER STOW A CRANKSHAFT OR BEARING PART ON ANY METAL SURFACE. When you remove a shaft from an engine, place it on a wooden plank with all journal surfaces protected. If the shaft is to be exposed for some time, protect each journal surface with a coating of heavy grease. Always place bearings on wooden boards or clean cloths.

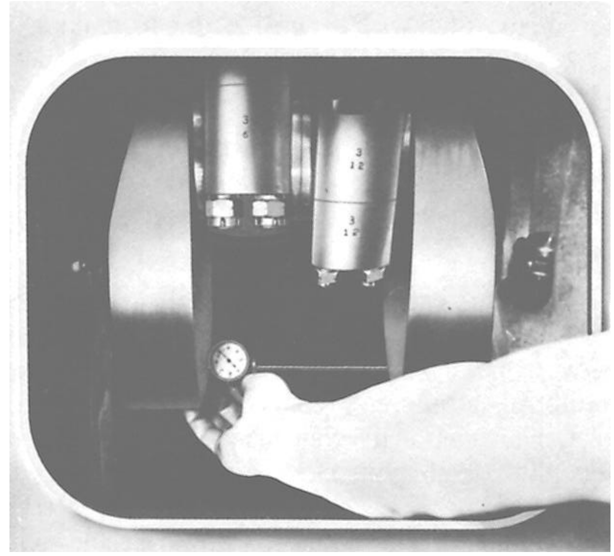

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Figure 3-29.—Using a strain or deflection gauge between crank webs.

CRANKSHAFT overhaul consists of an inspection, servicing for scoring and wear, and a determination of each crank web deflection. Take crank web deflection readings according to the Planned Maintenance System (PMS).

A strain gauge, often called a crank web deflection indicator, is used to take deflection readings. The gauge is merely a dial-reading inside micrometer used to measure the variation in the distance between adjacent crank webs as the engine shaft is barred over. Figure 3-29 shows a strain gauge between crank webs.

When you install the gauge, or indicator, between the webs of a crank throw, be sure to place the gauge as far as possible from the axis of the connecting rod journal. Rest the ends of the indicator in prick-punch marks in the crank webs. If these marks are not present, make them so that the indicator can be placed in its correct position. Consult the manufacturer’s technical manual for the proper location of new marks.

Readings are generally taken at the four crank positions: top dead center, inboard, near or at bottom dead center, and outboard. In some engines, it is possible to take readings at bottom dead center. In others, the connecting rod may interfere, making it necessary to take the reading as near as possible to bottom dead center without having the gauge come in contact with the connecting rod. When the gauge is in its lowest position, the dial will be upside down, making it necessary to use a mirror and flashlight to obtain a reading.

NOTE: Once you have placed the indicator in position for the first deflection reading, do not touch the gauge until you have taken and recorded all four readings.

Deflection readings are also used to determine correct alignment between the engine and the generator or between the engine and the coupling. However, when determining alignment, you should take a set of deflection readings at the crank nearest the generator or the coupling. In aligning an engine and generator, you may need to install new chocks between the generator and its base to bring the deflection within the allowable value. You may also need to shift the generator horizontally to obtain proper alignment. To align an engine and a coupling, first, correctly align the coupling with the drive shaft; then, properly align the engine to the coupling, rather than aligning the coupling to the engine.

BEARING TROUBLES

Bearings become a continual source of trouble unless personnel entrusted with operating the engine follow the recommended operation and maintenance procedures exactly.

Severe bearing failures are indicated during engine operation by a pounding noise or by the presence of smoke in the vicinity of the crankcase. Impending failures may sometimes be identified by a rise in the lubricating oil temperature or a lowering of the lubricating oil pressure. Impending bearing failure may be detected during periodic maintenance checks or during engine overhauls by inspection of the bearing shells and backs for pits, grooves, scratches, or evidence of corrosion.

The indication of an impending failure does not necessarily mean that the bearing has completed its useful life. Journal bearings may perform satisfactorily with as much as 10 percent of the load-carrying area removed by fatigue failure. Other minor casualties may be repaired so that a bearing will give additional hours of satisfactory service.

Bearings should not be rejected or discarded for minor pits or minute scratches; however, areas indicating metallic contact between the bearing surface and the journal do mean replacement is needed. Use a bearing scraping tool to smooth minute pits and raised

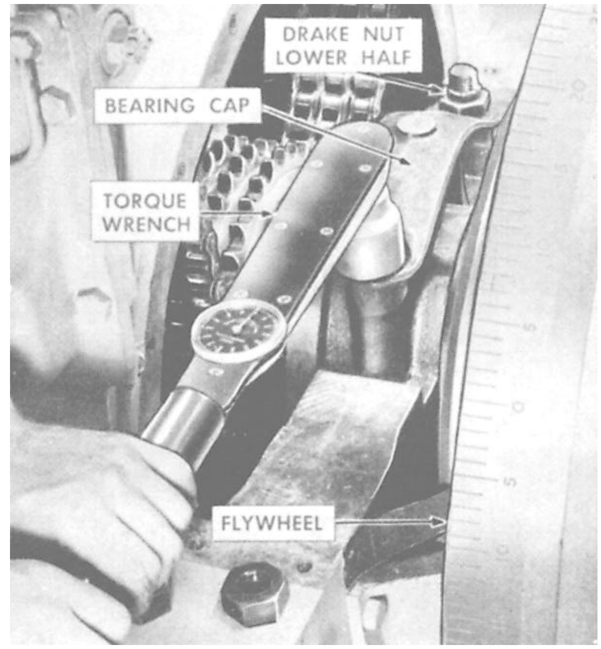

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Figure 3-30.—Using a torque wrench to tighten a main bearing.

surfaces. After working on bearings, make every effort to ensure that the bearing surfaces are clean. This also applies to the bearing back and the connecting rod journal Place a film of clean lubricating oil on the journals and the bearing surfaces before you reinstall them.

INSTALLING JOURNAL BEARINGS

Always check the markings of the lower and upper bearing halves so you install them correctly. Many bearings are interchangeable when new, but once they have become worn to tit a particular journal they must be reinstalled on that particular journal. You must mark or stamp each bearing half with its location (cylinder number) and the bearing position (upper or lower) to prevent incorrect installation.

You must also pull the connecting rod bearing cap nuts down evenly on the connecting rod bolts to prevent possible distortion of the lower bearing cap and consequent damage to the bearing shells, cap, and bolts. Use a torque wrench (fig. 3-30) to measure the torque applied to each bolt and nut assembly. Apply the same torque to each bolt. If a manufacturer recommends the use of a torque wrench, the specified torque will be listed in the manufacturer's technical manual.

Another method for pulling down the nuts evenly is to stretch each bolt an equal amount and measure the distance from end to end of the bolt before and after tightening. Figure 3-31 shows the type of gauge used,

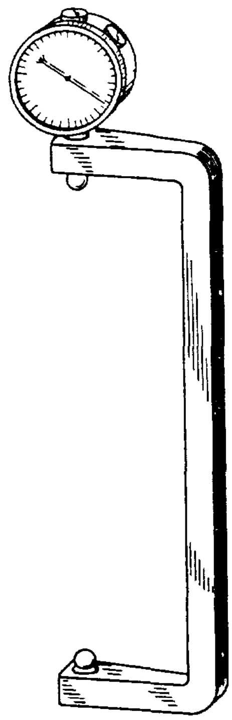


Figure 3-31.—Gauge used for measuring bolt elongation.

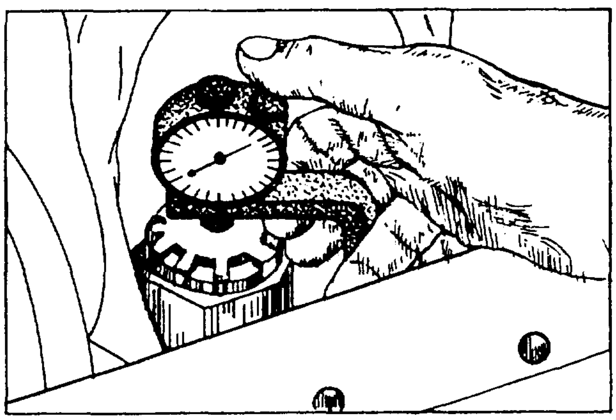


Figure 3-32.—Measuring bolt elongation.

and figure 3-32 illustrates the gauge in use. The proper elongation is listed in the engine manufacturer's technical manual.

After you reassemble a bearing, always bar or jack over the engine by hand through several revolutions. Check to see that all reciprocating and rotating parts function freely and that the main and connecting rod bearings do not bind on the crankshaft. Turn larger diesel engines over first by the manual jacking gear provided and then by the engine starting system.

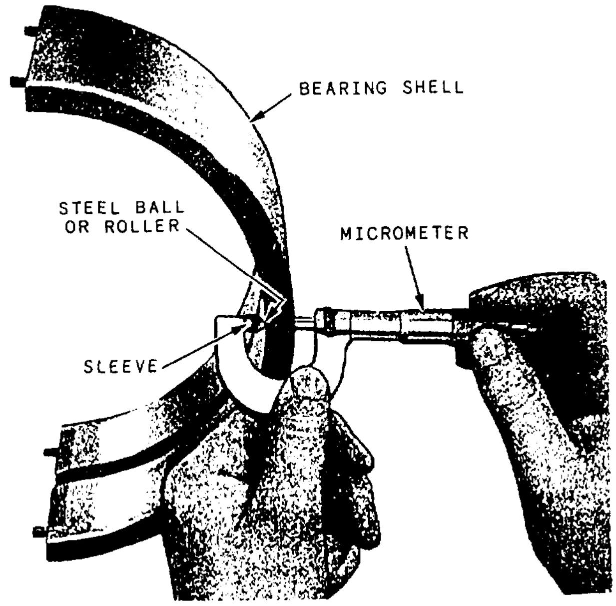


Figure 3-33.—Measuring bearing shell thickness.

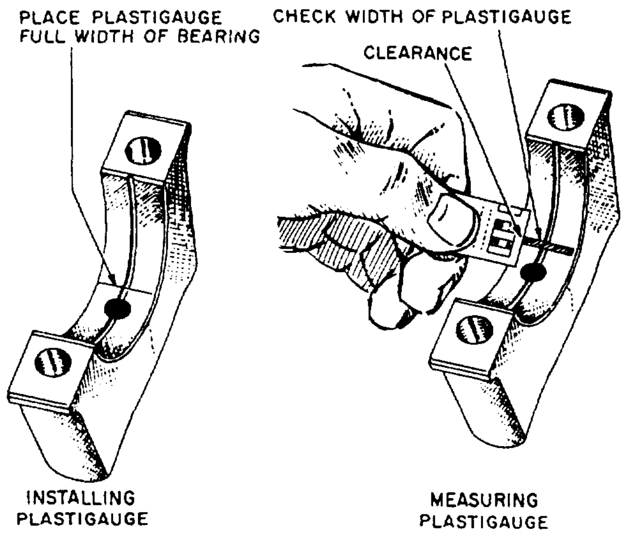


Figure 3-34.—Checking bearing clearance with a Plastlgage.

MEASURING BEARING CLEARANCES

Do not use leads, shim stock, or other such items to determine clearance of precision bearings. These items may seriously damage the soft bearing material. Instead, use a micrometer fitted with a spherical seat to measure the thickness of bearing shells. Place the spherical tip against the inside of the bearing shell to obtain an accurate reading and to prevent injury to the bearing material. Figure 3-33 shows a micrometer caliper fitted with a steel ball for measuring bearing thickness.

An alternate method for determining clearance is with a Plastigage (fig. 3-34). The Plastigage will not

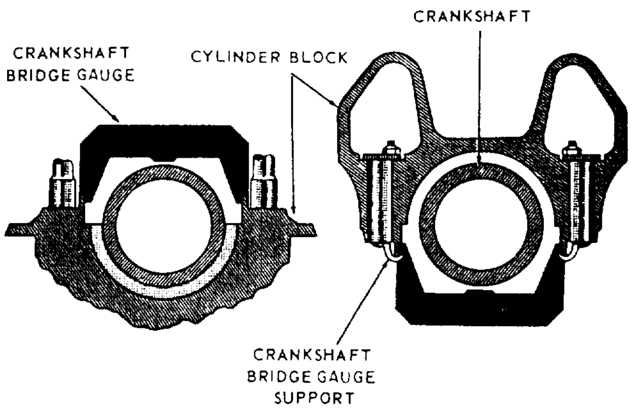


Figure 3-35.—Crankshaft bridge gauge.

leave an impression in the soft bearing metal because the gauge material is softer than the bearing. To use this method, place a length of the Plastigage of proper gauge across the bearing. Then, assemble the bearing cap and tighten it in place. DO NOT TURN the crankshaft, as that will destroy the Plastigage. After you install and properly fasten the bearing cap, remove it. Compare the width of the crushed Plastigage with the Plastigage chart to determine the exact clearance.

You must take measurements at specified intervals, usually at every overhaul, to establish the amount of bearing wear. Also take a sufficient number of crankshaft journal diameter measurements at suitable points to determine possible out-of-roundness.

With some types of engines, a crankshaft bridge gauge (fig. 3-35) is used to check the wear of the main bearing shells. To use the gauge, place it on the crankshaft and measure the clearance between the bridge gauge and the shaft with a feeler gauge. Any variation between the measured clearance and the correct clearance (usually stamped on the housing of each bearing) indicates that main bearing wear has occurred. The maximum limits of wear are listed in the manufacturer's technical manual. Some engine manufacturers recommend that bridge gauge readings be taken at every overhaul in conjunction with crank web deflection measurements.

The important point to remember is that if you cannot overhaul an engine due to lack of space, manpower, or expertise, you may request outside help by using an OPNAV Form 4790/2K. This form, when used as a work request, will be sent to a ship intermediate maintenance activity (SIMA). The SIMA will then accept or reject the work request. If the work request is accepted, the SIMA will order all repair parts, overhaul the engine, and perform an operational test according to the manufacturers' technical manuals and the NSTM, chapter 233.

As stated earlier in this section, maintenance cards, manufacturers' maintenance manuals, and various other instructions discuss repair procedures in detail. Therefore, this chapter will be limited to general information on some of the troubles encountered during overhaul, the causes of such troubles, and the methods of repair.

TROUBLESHOOTING INTERNAL-COMBUSTION ENGINES

The procedures for troubleshooting internal-combustion engines are somewhat similar for both diesel and gasoline engines. In many instances, the information that follows will apply to both types of engine. However, it also discusses principal differences. Since most of the internal-combustion engines used by the Navy are diesel, the following sections deal primarily with this type of engine.

This chapter is concerned with troubles that occur both when an engine is starting and running. The troubles are chiefly the kind that can be identified by erratic engine operation, warnings by instruments, or inspection of the engine parts and systems and that can be corrected without major repair or overhaul. There is also a section devoted to the systems of the gasoline engine that are basically different from those of the diesel engine.

Keep in mind that the troubles listed here are general and may or may not apply to a particular diesel engine. When you work with a specific engine, check the manufacturer's technical manual and any instructions issued by the Naval Sea Systems Command.

An engine may continue to operate even when a serious casualty is imminent. However, symptoms are usually present. Your success as a troubleshooter depends partially upon your ability to recognize these symptoms when they occur. You will use most of your senses to detect trouble symptoms. You may see, hear, smell, or feel the warning of trouble to come. Of course, common sense is also a requisite. Another factor in your success as a troubleshooter is your ability to locate the trouble once you decide something is wrong with the equipment. Then, you must be able to determine as rapidly as possible what corrective action to take. In learning to recognize and locate engine troubles, experience is the best teacher.

Instruments play an important part in detecting engine troubles. You should read the instruments and record their indications regularly. If the recorded indications vary radically from those specified by engine operating instructions, the engine is not operating properly and some type of corrective action must be taken. You must be familiar with the specifications in the engine operating instructions, especially those pertaining to temperatures, pressures, and speeds. You should know the probable effect on the engine when instrument indications vary considerably from the specified values. When variations occur in instrument indications, before taking any corrective action be sure the instruments are not at fault before you try corrective actions on the engine. Check the instruments immediately if you suspect them of being inaccurate.

Periodic inspections are also important in detecting engine troubles. Such inspections will reveal the failure of visible parts, presence of smoke, or leakage of oil, fuel, or water. Cleanliness is probably one of the greatest aids in detecting leakage.

When you secure an engine because of trouble, your procedure for repairing the casualty should follow an established pattern, if you have diagnosed the trouble. If you do not know the location of the trouble, find it. To inspect every part of an engine whenever trouble occurs would be an almost endless task. You can find the cause of the trouble much more quickly by following a systematic and logical method of inspection, Genernlly speaking, a well-trained troubleshooter can isolate the trouble by identifying it with one of the engine systems. Once you have associated the trouble with a particular system, the next step is to trace out the system until you find the cause of the trouble. Troubles generally originate in only one system, but remember that troubles in one system may cause damage to another system or to basic engine parts. When a casualty involves more than one system of the engine, trace each system separately and make corrections as necessary. It is obvious that you must know the construction, function, and operation of the various systems as well as the parts of each system for a specific engine before you can satisfactorily locate and remedy troubles.

Even though there are many troubles that may affect the operation of a diesel engine, satisfactory performance depends primarily on sufficiently high compression pressure and injection of the right amount of fuel at the proper time. Proper compression depends basically on the pistons, piston rings, and valve gear, while the right amount of fuel obviously depends on the fuel injectors and their actuating mechanism. Such troubles as lack of engine power, unusual or erratic operation, and excessive vibration may be caused by either insufficient compression or faulty injector action.

You can avoid many troubles by following the prescribed instructions for starting and operating the engine, The troubles discussed in the following sections do not comprise a complete list, nor do they all necessarily apply to all diesel engines because of differences in design. Specific information on troubleshooting for all the diesel engines used by the Navy would require more space than is available here.

Even though a successful troubleshooter generally associates certain troubles with a particular system or assembly, the following sections discuss troubles according to when they might be encountered, either before or after the engine starts.

ENGINE FAILS TO START

In general, the troubles that prevent an engine from starting are (1) the engine can neither be cranked nor barred over, (2) the engine cannot be cranked, but it can be barred over, and (3) the engine can be cranked, but it still fails to start. Figure 3-36 illustrates various conditions that commonly cause difficulties in cranking, jacking over, or starting the engine.

Engine Cannot Be Cranked nor Barred Over

Most prestarting instructions for large engines require you to turn the crankshaft one or more revolutions before applying starting power. If you cannot turn the crankshaft over, check the turning gear to be sure it is properly engaged. If the turning gear is properly engaged and the crankshaft still fails to turn over, check to see whether the cylinder test valves or indicator valves are closed and are holding water or oil in the cylinder. When the turning gear operates properly and the cylinder test valves are open but the engine still cannot be cranked or barred over, check for a serious problem. A piston or other part may be seized or a bearing may be fitting too tightly. Sometimes you may need to remove a part of an assembly to remedy the difficulty.

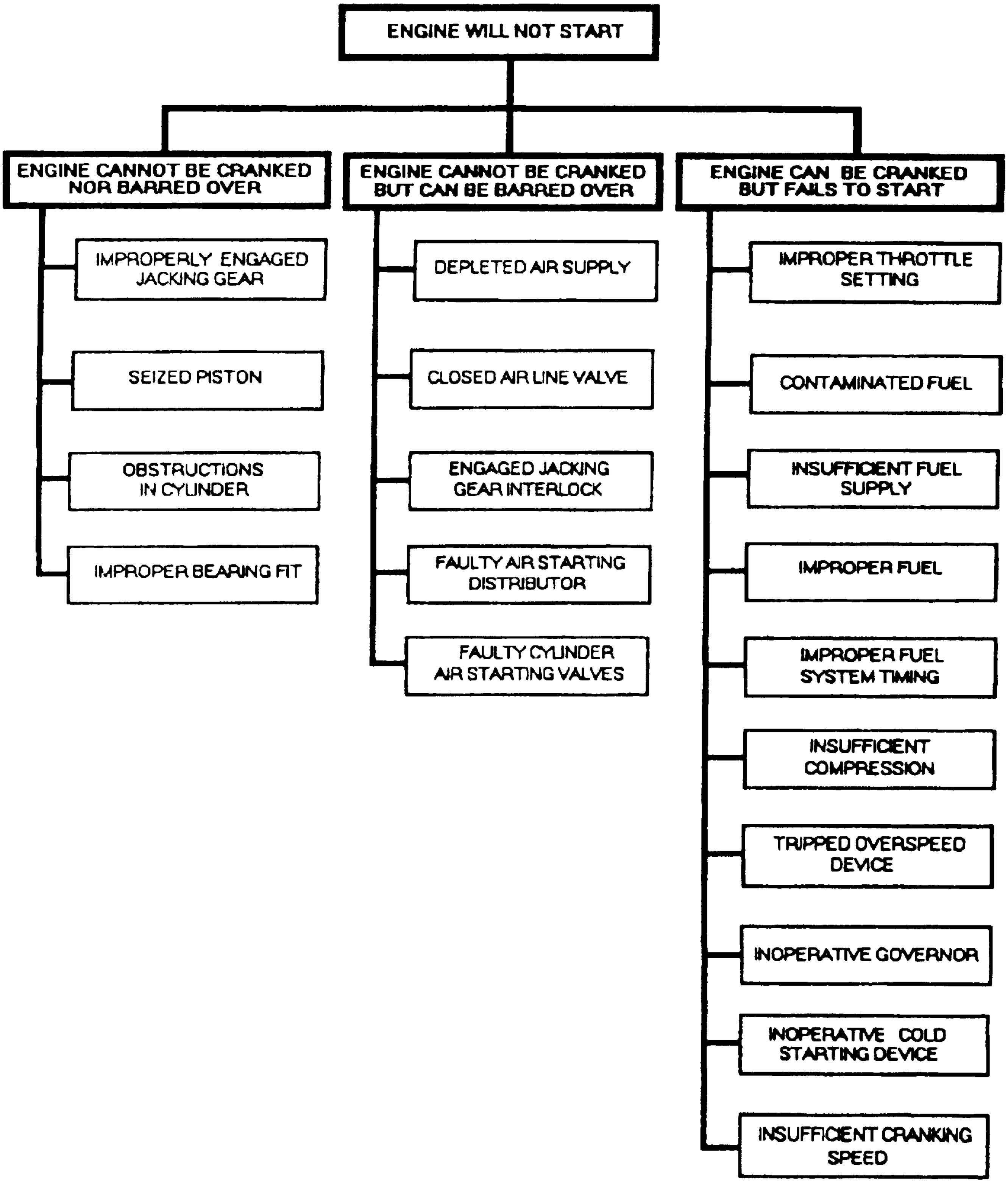


Figure 3-36.—Troubles that may prevent a diesel engine from starting.

Some engines have ports through which pistons can be inspected. If inspection reveals that the piston is defective, remove the piston assembly. Figure 3-37 illustrates testing for stuck piston rings through the scavenging-air port.

If the condition of an engine without cylinder ports indicates that a piston inspection is required, you must take the whole piston assembly out of the cylinder.

Engine bearings must be carefully fitted or installed according to the manufacturer's instructions. When an engine cannot be jacked over because of an improperly fitted bearing, someone probably failed to follow instructions when the unit was being reassembled.

Engine Cannot Be Cranked but Can Be Barred Over

You can trace most of the troubles that prevent an engine from cranking, but not serious enough to prevent barring over, to the starting system. Although other factors may prevent an engine from cranking, only troubles related to starting systems are identified in this chapter.

If an engine fails to crank when you apply starting power, first check the turning or jacking gear to be sure it is disengaged. If this gear is not the source of the trouble, the trouble is probably with the starting system.

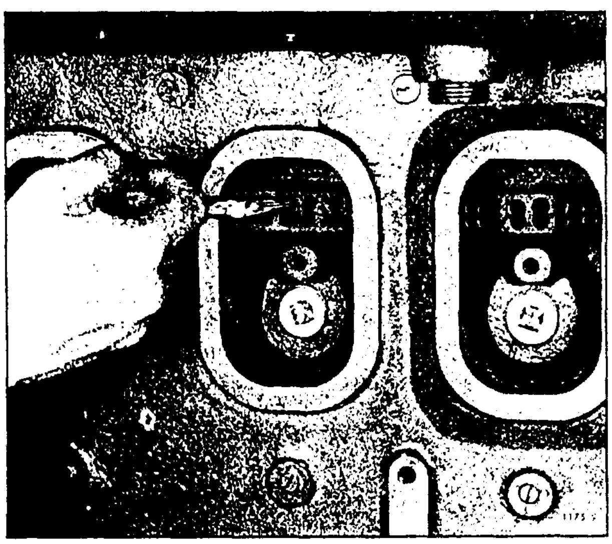


Figure 3-37.—Checking the condition of the piston rings.

Engine Can Be Cranked, but Fails to Start

Although the design of air starting systems may vary, the function remains the same. In general, such systems must have a source of air, such as the compressor or the ship's air system; a storage tank; air flask(s); an air timing mechanism; and a valve in the engine cylinder to admit the air during starting and to seal the cylinder while the engine is running.

All air starting systems have a unit that admits starting air to the proper cylinder at the proper time. The type of unit as well as its name-timer, distributor, air starting pilot valve, air starting distributor, or air distributor-may vary from one system to another. The types of air timing mechanisms are the direct mechanical lift, the rotary distributor, and the plunger-type distributor valve. The timing mechanism of an air starting system is relatively trouble-free except as noted in the following situations.

DIRECT MECHANICAL LIFT.—The direct mechanical lift air timing mechanism includes cams, pushrods, and rocker arms. These parts are subject to the same failures as engine cams, pushrods, and rocker arms. Therefore, you can find the causes of trouble in the actuating gear and the necessary maintenance procedures under information covering similar engine parts.

Most troubles are a result of improper adjustment. Generally, this involves the lift of the starting air cam or the timing of the air starting valve. The starting air cam must lift the air starting valve enough to give a proper clearance between the cam and the cam valve follower when the engine is running. If there is not enough clearance between these two parts, hot gases will flow between the valve and the valve seat, overheating them. Since the starting air cam regulates the opening of the air starting valve, check those with adjustable cam lobes frequently to ensure that the adjusting screws are tight.

Obtain the proper values for lift, tappet clearance, and time of valve opening for a direct mechanical lift timing mechanism from the manufacturer's technical manual for the particular engine. Make adjustments only as specified.

ROTARY DISTRIBUTOR.—The rotary distributor timing mechanism requires a minimum of maintenance, but there may be times when the unit becomes inoperative and you will need to disassemble and inspect it. Generally, the difficulty is caused by a scored rotor, a broken spring, or improper timing.

Foreign particles in the air can score the rotor, resulting in excessive air leakage. You must, therefore, keep the air supply as clean as possible. Lack of lubrication also causes scoring. If the rotor in a hand-oiled system becomes scored because of insufficient lubrication, the equipment could be at fault, or the lubrication instructions may not have been followed. To prevent problems in either a hand-oiled or pressure-lubricated system, check the piping and the passages to see that they are open. When scoring is not too serious, lap the rotor and body together. Use a thin coat of prussian blue to determine whether the rotor contacts the distributor body.

A broken spring may be the cause of an inoperative timing mechanism if a coil spring is used to maintain the rotor seal. If the spring is broken, replace it to ensure an effective seal.

An improperly timed rotary distributor will prevent an engine from cranking. Use the information given in the instructions for the specific engine to check the timing.

PLUNGER-TYPE DISTRIBUTOR VALVE.—In a plunger-type distributor valve timing mechanism, the valve requires little attention. However, it may stick occasionally and prevent the air starting system from functioning properly. On some engine installations, the pilot air valve of the distributor may not open, while on other installations this valve may not close. The trouble may be caused by dirt and gum deposits, broken return springs, or lack of lubrication. Deposits and lack of lubrication will cause the unit valve plungers to bind and stick in the guides, while a broken valve return spring will keep the plunger from following the cam profile. Disassemble and thoroughly clean a distributor valve that sticks; replace any broken springs.

Faulty Air Starting Valves

Air starting valves admit starting air into the engine cylinder and then seal the cylinder while the engine is running. These valves may be the pressure-actuated or mechanical-lift type.

PRESSURE-ACTUATED VALVES.—In a pressure-actuated valve, the most frequent trouble is sticking. The valve may stick open for a number of reasons. A gummy or resinous deposit may cause the upper and lower pistons to stick to the cylinders. (This deposit is formed by the oil and condensate that may be carried into the actuating cylinders and lower cylinders. Oil is necessary in the cylinders to provide lubrication and to act as a seal; however, moisture should be eliminated.) You can prevent this resinous deposit from forming by draining the system storage tanks and water traps as specified in the operating instruction. The deposit on the lower piston may be greater than that in the actuating cylinder because of the heat and combustion gases that add to the formation if the valve remains open. When the upper piston is the source of trouble, you can usually relieve the sticking, without removing the valve, by using light oil or diesel fuel and working the valve up and down. When you use this method, be sure that the valve surfaces are not burned or deformed. If this method does not relieve the sticking condition, you will need to remove, disassemble, and clean the valve.

Pressure-actuated starting valves sometimes fall to operate because of broken or weak valve return springs. Replacement is generally the only solution to this condition; however, some valves are constructed with a means of adjusting spring tension. In such valves, increasing the spring tension may eliminate the trouble.

Occasionally the actuating pressure of a valve will not release, and the valve will stick open or be sluggish in closing. The cause is usually clogged or restricted air passages. Combustion gases will enter the air passageways, burning the valve surfaces. These burned surfaces usually must be reconditioned before they will maintain a tight seal. Keeping the air passages open will eliminate extra maintenance work on the valve surfaces.

MECHANICAL LIFT VALVES.—The mechanical lift-type air starting valve is subject to leakage which, in general, is caused when the valve sticks open. Any air starting valve that sticks or leaks creates a condition that makes an engine hard to start. If the leakage in the air starting valve is excessive, the loss in pressure may prevent the engine from starting.

Leakage in this type of valve can be caused by an overtightened packing nut. The packing nut is sometimes overtightened to stop minor leaks around the valve stem when starting pressure is applied, but overtightening may prevent the air valve from seating. As in the pressure-actuated valve, there may not be enough return spring tension to return the valve to the valve seat after admitting the air charge.

Obstructions such as particles of carbon between the valve and valve seat will hold the valve open, permitting combustion gases to pass. A valve stem bent by careless handling during installation may also prevent a valve from closing properly.

If a valve hangs open for any of these reasons, hot combustion gases will leak past the valve and valve seat.

The gases burn the valve and seat and may cause a leak between these two surfaces even though the original causes of the sticking are eliminated.

Completely disassemble and inspect a leaking valve. It is subject to a resinous deposit similar to that found in a pressure-actuated air valve. Use a specified cleaning compound to remove the deposit. Be sure the valve stem is not bent. Check the valve and valve seat surfaces carefully. Eliminate scoring or discoloration by lapping with a fine lapping compound. You may use jewelers' rouge or talcum powder with fuel oil for lapping.

From the preceding discussion, you have learned that the air starting system may be the source of many troubles that will prevent an engine from cranking even though it can be barred over. You will avoid a few of these troubles by following prestarting and starting instructions. One such instruction, sometimes overlooked, is that of opening the valve in the air line. Obviously, with this valve closed the engine will not crank. Recheck the instructions for such oversights as a closed valve, an empty air storage receiver, or an engaged jacking gear before starting any disassembly.

ELECTRIC START MALFUNCTION

Electric starting system malfunctions fall into the following categories:

1. Nothing happens when the starter switch is closed.

2. The starter motor runs, but it does not engage the engine.

3. The starter motor engages, but it cannot turn the engine.

If nothing happens when you close the starter switch, there is a failure in the electrical system. The failure could be an open circuit caused by broken connections or burned out components. Test the circuit continuity to make sure the relay closes and the battery provides sufficient voltage and current to the starter circuit. If the circuit is complete, there may be resistance through faulty battery connections. Considerable current is needed to operate the solenoid and starter motor.

If the starter runs without engaging, it will produce a distinctive hum or whine. The lack of engagement is usually caused by dirt or corrosion, which keeps the solenoid or Bendix gears from operating properly.

If the starter motor engages the flywheel ring gear but is not able to turn the engine or cannot turn it quickly enough to obtain starting speed, the cause may be lack of battery power or, more likely, a mechanical problem. If the engine can be barred over, there is excessive friction in the meshing of the starter pinion and the ring gear. Either the teeth are burred, or the starter pinion is out of alignment. Either case would have been preceded by noise the last time the starter was used. A major repair may be necessary.

Other problems and malfunctions of electric starting systems are discussed in association with gasoline engines at the end of this chapter.

ENGINE CRANKS BUT FAILS TO START

Even when the starting equipment is in an operating condition, an engine may fail to start. Most troubles that prevent an engine from starting are associated with fuel and the fuel system. However, defective or inoperative parts or assemblies may be the source of some trouble. Failure to follow instructions may be the cause of an engine failing to start. The corrective action is obvious for such items as leaving the fuel throttle in the OFF position and leaving the cylinder indicator valves open. If an engine fails to start, follow the prescribed starting instructions and recheck the procedure.

Foreign Matter in the Fuel Oil System

In the operation of an internal-combustion engine, cleanliness is of paramount importance. This is especially true in the handling and care of diesel fuel oil. Impurities are the prime source of fuel pump and injection system troubles. Sediment and water cause wear, gumming, corrosion, and rust in a fuel system. Even though fuel oil is generally delivered clean from the refinery, handling and transferring increase the chances that fuel oil will become contaminated.

Corrosion often leads to replacement or at least to repair of the part. You must continually take steps to prevent water from accumulating in a fuel system, not only to eliminate the cause of corrosion but **also** to ensure proper combustion in the cylinders. Centrifuge all fuel, and drain the fuel filter cases periodically to prevent excessive collection of water.

Water in fuel will cause irreparable damage to the entire fuel system in a short time. It corrodes the fuel injection pump, where close clearances must be maintained, and also corrodes and erodes the injection nozzles. The slightest corrosion can cause a fuel injection pump to bind and seize which, if not corrected, will lead to excessive leakage. Water will erode the orifices of injection nozzles until they will not spray the fuel properly, thus preventing proper atomization. When this occurs, incomplete combustion and engine knocks result.

Air in the fuel system is another possible trouble that may prevent an engine from starting. Even if the engine will start, air in the fuel system will cause the engine to miss and knock, and perhaps to stall.

When an engine fails to operate, stalls, misfires, or knocks, there may be air in the high-pressure pumps and lines. In many systems, the expansion and compression of such air may take place even if the injection valves do not open. If this occurs, the pump is AIRBOUND. To determine if there is air in a fuel system, bleed a small amount of fuel from the top of the fuel filter; if the fuel appears quite cloudy, there are probably small bubbles of air in the fuel.

Insufficient Fuel Supply

An insufficient fuel supply may result from a defective or inoperative part in the system. Such items as a closed inlet valve in the fuel piping or an empty supply tank are more likely to be the fault of the operator than of the equipment. But an empty tank may be caused by leakage, either in the lines or in the tank

LEAKAGE.-You can usually trace leakage in the low-pressure lines of a fuel system to cracks in the piping. Usually these cracks occur on threaded pipe joints at the root of the threads. Such breakage is caused by the inability of the nipples and pipe joints to withstand shock, vibration, and strains resulting from the relative motion between smaller pipes and the equipment to which they are attached.

Metal fatigue can also cause breakage. Each system should have a systematic inspection of its fittings and piping to determine if all the parts are satisfactorily supported and sufficiently strong. In some instances, nipples may be connected to relatively heavy parts, such as valves and strainers, which are free to vibrate. Since vibration contributes materially to the fatigue of nipples, rigid bracing should be installed. When practicable, bracing should be secured to the unit itself, instead of to the hull or other equipment.

Breakage can also cause leakage in the high-pressure lines of a fuel system. The breakage usually occurs on either of the two end fittings of a line and is caused by lack of proper supports or by excessive nozzle opening pressure. Supports are usually supplied with an engine and should not be discarded. Excessive opening pressure of a nozzle-generally due to improper spring adjustment or to clogged nozzle orifices-may rupture the high-pressure fuel lines. A faulty nozzle usually requires removal, inspection, and repair plus the use of a nozzle tester.

Leakage from fuel lines may also be caused by improper replacement or repairs. When a replacement is necessary, always use a line of the same length and diameter as the one you remove. Varying the length and diameter of a high-pressure fuel line will change the injection characteristics of the injection nozzle.

In an emergency, you can usually repair a high-pressure fuel line by silver soldering a new fitting to the line. After making the silver solder repair, test the line for leaks and be certain no restrictions exist.

Most leakage trouble occurs in the fuel lines, but leaks may occasionally develop in the fuel tank. These leaks must be eliminated immediately because of potential fire hazard.

The principal causes of fuel tank leakage are improper welds and metal fatigue. Metal fatigue is usually the result of inadequate support; excessive stresses develop in the tank and cause cracks.

CLOGGED FUEL FILTERS-Another problem that can limit the fuel supply to such an extent that an engine will not start is clogged fuel filters. Definite rules for filter replacement cannot be established for all engines. But instructions generally state that elements will not be used longer than a specified time. Since there are reasons that an element may not always function properly for its expected service life, it should be replaced whenever it is suspected of being clogged.

Filter elements may become clogged because of dirty fuel, too small filter capacity, failure to drain the filter sump, and failure to use the primary strainer. Usually, clogging is indicated by such symptoms as stoppage of fuel flow, increase in pressure drop across the filter, increase in pressure upstream of the filter, or excessive accumulation of dirt on the element (observed when the filter is removed for inspection). Symptoms of clogged filters vary in different installations, and each installation should be studied for external symptoms, such as abnormal instrument indications and engine operation. If external indications are not apparent, visual inspection of the element will be necessary, especially if it is known or suspected that dirty fuel is being used.

Fuel filter capacity should at least equal fuel supply pump capacity. A filter with a small capacity clogs more rapidly than a larger one, because the space available for dirt accumulation is more limited. There are two standardized sizes of fuel filter elements-large and small. The small element is the same diameter as the large but is only one-half as long. This construction permits substitution of two small elements for one large element.

You can increase the interval of time between element changes by using the drain cocks on a filter sump. Removal of dirt through the drain cock will make room for more dirt to collect.

If new filter elements are not available for replacement and the engine must be operated, you can wash some types of totally clogged elements and get limited additional service. This procedure is for emergencies only. An engine must never be operated unless all the fuel is filtered; therefore, a “washed filter” is better than none at all.

Fuel must never flow from the supply tanks to the nozzles without passing through all stages of filtration. Strainers, as the primary stage in the fuel filtration system, must be kept in good condition if sufficient fuel is to flow in the system. Most strainers have a blade mechanism that can be turned by hand. If you cannot readily turn the scraper by hand, disassemble and clean the strainer. This minor preventive maintenance will prevent the scraping mechanism from breaking.

TRANSFER PUMPS.—If the supply of fuel oil to the system is to be maintained in an even and uninterrupted flow, the fuel transfer pumps must function properly. These pumps may become inoperative or defective to the point that they fail to discharge sufficient fuel for engine starting. Generally, when a pump fails to operate, some parts have to be replaced or reconditioned. For some types of pump, it is customary to replace the entire unit. However, for worn packing or seals, satisfactory repairs may be made. If plunger-type pumps fail to operate because the valves have become dirty, submerge and clean the pump in a bath of diesel oil.

Repairs of fuel transfer pumps should be made according to maintenance manuals supplied by the individual pump manufacturers.

Malfunctioning of the Injection System

The fuel injection system is the most intricate of the systems in a diesel engine. Since the function of an injection system is to deliver fuel to the cylinder at a high pressure, at the proper time, in the proper quantity, and properly atomized, special care and precautions must be taken in making adjustments and repairs.

HIGH-PRESSURE PUMP.-If a high-pressure pump in a fuel injection system becomes inoperative, an engine may fail to start. Information on the causes and remedies for an inoperative pump can be found in the manufacturer’s technical manual. Any ship using fuel injection equipment should have available copies of the applicable manufacturer’s technical manual.

TIMING.-Regardless of the installation or the type of fuel injection system used, the timing of the injection system must be correct to obtain maximum energy from the fuel. Early or late injection timing may prevent an engine from starting. Operation will be uneven and vibration will be greater than usual.

If fuel enters a cylinder too early, detonation generally occurs, causing the gas pressure to rise too rapidly before the piston reaches top dead center. This in turn causes a loss of power and high combustion pressure. Low exhaust temperature may be an indication that fuel injection is too early.

If fuel is injected too late in the engine cycle, overheating, lowered firing pressure, smoky exhaust, high exhaust temperature, or loss of power may occur.

Follow the instructions in the manufacturer’s technical manual to correct an improperly timed injection system.

Insufficient Compression

Proper compression pressures are essential if a diesel engine is to operate satisfactorily. Insufficient compression may cause an engine to fail to start. If you suspect low pressure as the reason, check the compression with the appropriate instrument. If the test indicates pressures below standard, disassembly is required for complete inspection and correction.

Inoperative Engine Governor

There are many troubles that may cause a governor to become inoperative. The most frequent trouble associated with starting an engine is generally caused by bound control linkage or, if the governor is hydraulic, by low oil level. Whether the governor is mechanical or hydraulic, binding of linkage is generally due to distorted, misaligned, defective, or dirty parts. If you suspect binding, move the linkage and governor parts by hand and check their movement. Eliminate any undue stiffness or sluggishness in the movement of the linkage.

Low oil level in hydraulic governors may be caused by oil leaking from the governor or failure to maintain the proper oil level. Leakage of oil from a governor can generally be traced to a faulty oil seal on the drive shaft or power piston rod, or to a poor gasket seal between parts of the governor case.

Check the condition of the oil seals if oil must be added too frequently to governors with independent oil supplies. Oil seal leakage may or may not be visible on external surfaces. There will be no external sign if leakage occurs through the seal around the drive shaft, while leakage through the seal around the power piston will be visible.

Oil seals must be kept clean and pliable. Store them properly so they do not become dirty or dry and brittle. Leaky oil seals cannot be repaired. They must be replaced. You can prevent some leakage troubles simply by following proper installation and storage instructions for the seals.

Most manufacturer's technical manuals supply information on the governor. Special hydraulic governor maintenance manuals made available by the Naval Sea Systems Command are the Marquette Governor Manual, NAVSHIPS 341-5505 (0341-LP-550-5000), and the Woodward Governor Manual, NAVSHIPS 341-5017 (0341-LP-501-7000).

Inoperative Overspeed Safety Devices

Overspeed safety devices are designed to shut off fuel or air in case of excessive engine speed. These devices must be maintained in operable condition at all times. Inoperative overspeed devices may also cause an engine not to start. They may be inoperative because of improper adjustment, faulty linkage, or a broken spring, or the overspeed device may have been accidentally tripped during the attempt to start the engine.

If the overspeed device fails to operate when the engine overspeeds, the engine may be secured by manually cutting off the fuel oil or the air supply to the engine. Most engines have special devices or valves to cut off the air or fuel in an emergency.

Insufficient Cranking Speed

If the engine cranks slowly, the necessary compression temperature cannot be reached. Low starting air pressure may be the cause of such trouble.

Slow cranking speed may also be the result of an increase in the viscosity of the lubricating oil. This trouble occurs during periods when the air temperature is lower than usual. The oil specified for use during normal operation and temperature is not generally suitable for cold climate operation.

IRREGULAR ENGINE OPERATION

As the engine operator, you must constantly be alert to detect any symptoms that might indicate trouble. Such symptoms may be sudden or abnormal changes in the supply, temperature, or pressure of the lubricating oil or cooling water. Color and temperature of the exhaust may also indicate abnormal conditions. Check them frequently. Fuel, oil, and water leaks indicate possible troubles. Keep the engine clean to make such leaks easier to spot.

You will soon become accustomed to the normal sounds and vibrations of a properly operating engine. If you are alert, an abnormal or unexpected change in the pitch or tone of an engine's noise or a change in the magnitude or frequency of a vibration will warn you that all is not well. A new sound such as a knock a drop in the fuel injection pressure, or a misfiring cylinder are other trouble warnings for which you should be constantly alert during engine operation.

The following discussion on possible troubles, their causes, and the corrective action necessary is general rather than specific. The information is based on instructions for some of the engines used by the Navy and is typical of most. A few troubles listed may apply to only one model. For specific information on any particular engine, consult the manufacturer's technical manual.

ENGINE STALLS FREQUENTLY OR STOPS SUDDENLY

We discussed earlier several of the troubles that may cause an engine to stall or stop. Such troubles as air in the fuel system, clogged fuel filters, unsatisfactory operation of fuel injection equipment, and incorrect governor action not only cause starting failures or stalling but also cause other troubles as well. For example, clogged fuel oil filters and strainers may lead to a loss of power, to misfires or erratic firing, or to low fuel oil pressure. Unfortunately, a single engine trouble does not always manifest itself as a single difficulty but may be the cause of several major difficulties.

Factors that may cause an engine to stall include misfiring, low cooling water temperature, improper application of load, improper timing, obstruction in the combustion space or in the exhaust system, insufficient intake air, piston seizure, and defective auxiliary drive mechanisms.

Misfiring

When an engine misfires or fires erratically or when one cylinder misfires regularly, the possible troubles are usually associated with the fuel or fuel system, worn parts, or the air cleaner or silencer. In determining what causes a cylinder to misfire, you should follow prescribed procedures in the appropriate technical manual. Procedures will vary among engines because of differences in the design of parts and equipment.

Many of the troubles caused by fuel contamination require overhaul and repair. However, a cylinder may misfire regularly in some systems because of the fuel pump cutout mechanism. Some fuel pumps have this type of mechanism so the fuel supply can be cut off from a cylinder to measure compression pressures. When a cylinder is misfiring, check first for an engaged cutout mechanism (if installed), and disengage it during normal engine operation.

LOSS OF COMPRESSION.–A cylinder may misfire due to loss of compression, which may be caused by a leaking cylinder head gasket, leaking or sticking cylinder valves, worn pistons, liners or rings, or a cracked cylinder head or block If loss of compression pressure causes an engine to misfire, check the compression pressure of each cylinder. Some indicators measure compression as well as firing pressure while the engine is running at full speed. Others check only the compression pressures with the engine running at a relatively slow speed. Figure 3-38 illustrates the application of some different types of pressure indicators.

After you install an indicator, operate the engine at the specified rpm and record the cylinder compression pressure. Follow this procedure on each cylinder in turn. The pressure in any one cylinder should not be lower than the specified psi, nor should the pressure for any one cylinder be excessively lower than the pressures in the other cylinders. The maximum pressure variation permitted between cylinders is given on engine data sheets or in the manufacturer's technical manual. A compression leak is indicated when the pressure in one cylinder is considerably lower than that in the other cylinders.

If a test indicates a compression leak, you will have to do some disassembly, inspection, and repair. Check the valve seats and cylinder head gaskets for leaks, and inspect the valve stems for sticking. A cylinder head or block may be cracked. If these parts are not the source of trouble, compression is probably leaking past the piston because of insufficient sealing of the piston rings.

Improper Cooling Water Temperature

If an engine is to operate properly, the cooling water temperature must be maintained within specified temperature limits. When cooling water temperature drops lower than recommended for a diesel engine,

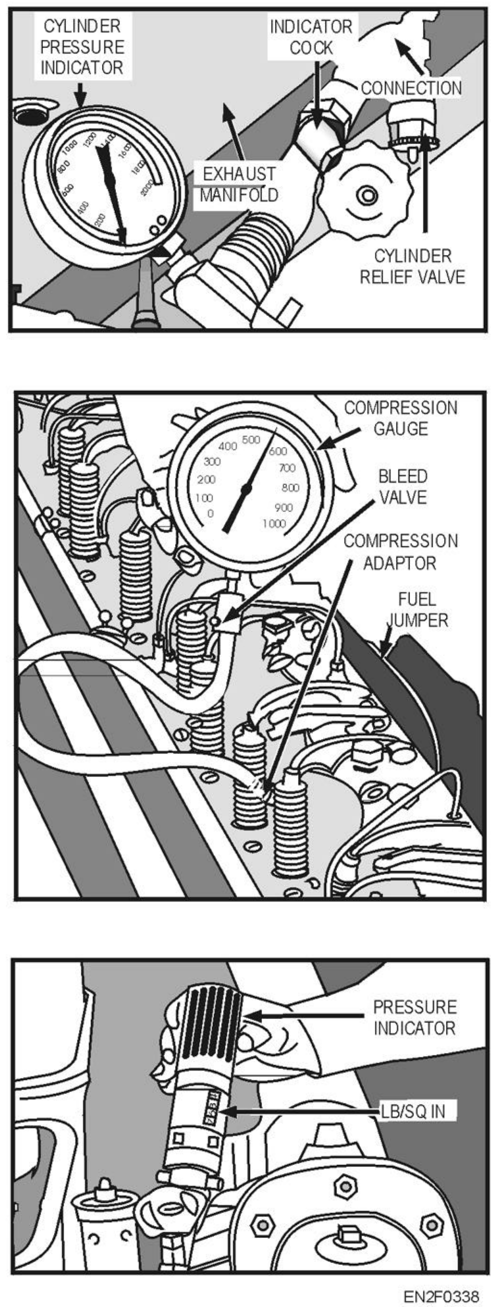


Figure 3-38.–Engine cylinder pressure indicator application.

ignition lag is increased, causing detonation, which results in rough operation. This may cause the engine to stall.

If the water temperature is higher than normal, the engine may not cool properly and may suffer heat damage. Water temperature is controlled primarily by a thermostatic valve (thermostat). The thermostat normally operates with a minimum of trouble. High or low cooling water temperature may indicate a malfunctioning thermostat. But before you remove the thermostat to check it, check to see whether the improper temperature may be caused by an insufficient engine load or an inaccurate temperature gauge.

When you suspect that the thermostat is not operating properly, remove it from the engine and test it. Use the following procedure to test the thermostat:

1. Obtain an open-topped container such as a bucket or a pot.

2. Heat the water to the temperature at which the thermostat is supposed to start opening. This temperature is usually specified in the appropriate technical manual. Use an accurate thermometer to check the water temperature. Use a hot plate or a burner as a source of heat. Stir the water frequently to ensure uniform distribution of the heat.

3. Suspend the thermostat by a string or a wire so that operation of the bellows will not be restricted.

4. Immerse the thermostat and observe its action. Check the thermometer readings carefully to see whether the thermostat begins to open at the recommended temperature. (The thermostat and thermometer must NOT touch the container.)

5. Increase the temperature of the water until the specified FULL OPEN temperature is reached. The immersed thermostat should be fully open at this temperature.

Replace the thermostat if it does not open when you test it, or if the temperatures at which the thermostat opens and closes vary more than allowed from the manufacturer's specifications.

The Fulton-Sylphon automatic temperature regulator is relatively trouble-free. The unit controls temperatures by a valve that bypasses some water around the cooler. This system provides a full flow of the water, although only a portion may be cooled. In other words, the full volume of cooling water is circulated at the proper velocity, which eliminates the possibility of steam pockets in the system.

Usually, if the automatic temperature regulator fails to maintain cooling water at the proper temperature, it simply needs to be readjusted. However, the element of the valve may be leaking or some part of the valve may be defective. Failure to follow the proper adjustment procedure is the only cause for improper adjustment of an automatic temperature regulator. Check and follow the proper procedure in the manufacturer's technical manual issued for the specific equipment.

Adjust the regulator by changing the tension of the spring (which opposes the action of the thermostatic bellows) with a special tool that turns the adjusting stem knob or wheel. Increasing the spring tension raises the temperature range of the regulator, and decreasing it lowers the temperature range.

When you place a new valve of this type into service, you must take a number of steps to ensure that the valve stem is the proper length and that all scale pointers make accurate indications. Make all adjustments according to the valve manufacturer's technical manual.

Obstruction in the Exhaust System

This type of trouble seldom occurs if proper installation and maintenance procedures are followed. When a part of an engine exhaust system is restricted, there will be an increase in the exhaust back pressure. This may cause high exhaust temperatures, loss of power, or even stalling. An obstruction that causes excessive back pressure in an exhaust system is generally associated with the silencer or muffler.

The manifolds of an exhaust system are relatively trouble-free if related equipment is designed and installed properly. Improper design or installation may cause water to back up into the exhaust manifold. In some installations, the design of the silencer may cause water to flow into the engine. The source of water that may enter an engine must be found and eliminated. This may require replacing some parts of the exhaust system with components of an improved design or may require relocating such items as the silencer and piping.

Inspect exhaust manifolds for water or symptoms of water. Accumulation of salt or scale in the manifold usually indicates that water has been entering from the silencer. Turbochargers on some engines have been known to seize because salt water entered the exhaust gas turhine from the silencer. Entry of water into an engine may also be detected by the presence of corrosion or of salt deposits on the engine exhaust valves.

If inspection reveals signs of water in an engine or in the exhaust manifold, take steps immediately to correct the trouble. Check the unit for proper installation. Wet-type silencers must be installed with the proper sizes of piping. If the inlet water piping is too large, too much water may be injected into the silencer. There must be continuous-type water drains on the silencer. If a silencer has no continuous drain and if the engine is at a lower level than the exhaust outlet, water may back up into the engine.

Dry-type silencers may become clogged with an excessive accumulation of oil or soot. When this occurs, exhaust back pressure increases, causing troubles such as high exhaust temperature, loss of power, or possible stalling. A dry-type silencer clogged with oil or soot is also subject to fire. Clogging can usually be detected by fire, soot, or sparks coming from the exhaust stack An excessive accumulation of oil or soot in a dry-type silencer may be due to a number of factors, such as failure to drain the silencer, poor condition of the engine, or improper engine operating conditions.

Insufficient Intake Air

Insufficient intake air, which may cause an engine to stall or stop, may be due to blower failure or to a clogged air silencer or air filter. Even though all other engine parts function perfectly, efficient engine operation is impossible if the air intake system fails to supply a sufficient quantity of air for complete combustion of the fuel.

CLOGGED AIR CLEANERS AND SILENCERS.—Sometimes an engine will fire erratically or misfire because of a clogged air cleaner or silencer. Air cleaners must be cleaned at specified intervals, as recommended in the engine manufacturer's technical manuals. A clogged cleaner reduces the intake air, thereby affecting the operation of the engine. Clogged air cleaners may cause not only misfiring or erratic firing but also such difficulties as hard starting, loss of power, engine smoke, and overheating.

When you clean an air cleaner element, if you use a volatile solvent, be SURE the element is dry before you reinstall it on the engine. Volatile solvents are excellent cleaning agents but, if permitted to remain in the filter, may cause engine overspeeding or a serious explosion.

Oil-bath type air cleaners and filters cause very little trouble if serviced properly. Cleaning directions are usually given on the cleaner housing. The frequency of cleaning is usually based on a specified number of operating hours, but more frequent cleaning may be necessary where unfavorable conditions exist.

When you fill an oil bath-type cleaner, follow the manufacturer's instructions. Most air cleaners of this type have a FULL mark on the oil reservoir. Filling beyond this mark does not increase the efficiency of the unit and may lead to serious trouble. When the oil bath is too full, the intake air may draw oil into the cylinders. This excess oil-air mixture, over which there is no control, may cause an engine to "run away," resulting in serious damage.

BLOWER FAILURE.—Troubles that may prevent a centrifugal blower from performing its function usually involve damage to the rotor shaft, thrust bearings, turbine blading, nozzle ring, or blower impeller. Damage to the rotor shaft and thrust bearings usually results from insufficient lubrication, an unbalanced rotor, or operation with excessive exhaust temperature.

Centrifugal blower lubrication problems may be caused by failure of the oil pump to prime, low lube oil level, clogged oil passages or oil filter, or a defective relief valve, which is designed to maintain proper lube oil pressure.

If an unbalanced rotor is the cause of shaft or bearing trouble, there will be excessive vibration. Unbalance may be caused by a damaged turbine wheel blading or by a damaged blower impeller.

Operating a blower when the exhaust temperature is above the specified maximum safe temperature generally causes severe damage to turbocharger bearings and other parts. Make every effort to find and eliminate causes of excessive exhaust temperature before the turbocharger is damaged.

Turbine blading damage may be caused by operating with an excessive exhaust temperature, operating at excessive speeds, bearing failures, failure to drain the turbine casing, the entrance of foreign bodies, or by turbine blades that break loose.

Damage to an impeller may be caused by thrust or shaft bearing failure, entrance of foreign bodies, or loosening of the impeller on the shaft.

Since blowers are high-speed units and operate with a very small clearance between parts, minor damage to a part could cause extensive blower damage and failure.

Although there is considerable difference in operating principle and construction between the positive-displacement blower (Roots) and the axial-flow positive-displacement blower (Hamilton-Whitfield), the problems of operation and maintenance are similar.

Some of the troubles in a positive-displacement blower are similar to those already mentioned in our discussion of the centrifugal-type blowers. However, the source of some troubles may be different because of construction differences.

Positive-displacement blowers have a set of gears to drive and synchronize the rotation of the rotors. Many of these blowers are driven by a serrated shaft. Regardless of construction differences, the basic problem in both types of blowers is in maintaining the necessary small clearances. If these clearances are not maintained, the rotors and the case will be damaged and the blower will fail to perform its function.

Worn gears are one source of trouble in positive-displacement blowers. A certain amount of gear wear is expected, but damage caused by excessively worn gears indicates improper maintenance procedures. Whenever you inspect a positive-displacement blower, record the backlash values, according to PMS. You can use this record to establish the rate of increase in wear, to estimate the life of the gears, and to determine when it will be necessary to replace the gears.

Scored rotor lobes and casing may cause blower failure. Scoring of blower parts may be caused by worn gears, improper timing, bearing failure, improper end clearance, or by foreign matter. Any of these troubles may be serious enough to cause the rotors to contact and damage the blower extensively.

Timing of blower rotors involves both gear backlash and the clearances between the leading and trailing edges of the rotor lobes and between rotor lobes and the casing. You can measure the clearance between these parts with thickness gauges, as illustrated in figure 3-39. If the clearances are incorrect, check the backlash of the drive gear first. Then retime the rotors according to the method outlined in the manufacturer's technical manual.

Failure of serrated blower shafts may be due to failure to inspect the parts or of improper replacement of parts. When you inspect serrated shafts, be sure that they fit snugly and that wear is not excessive. When

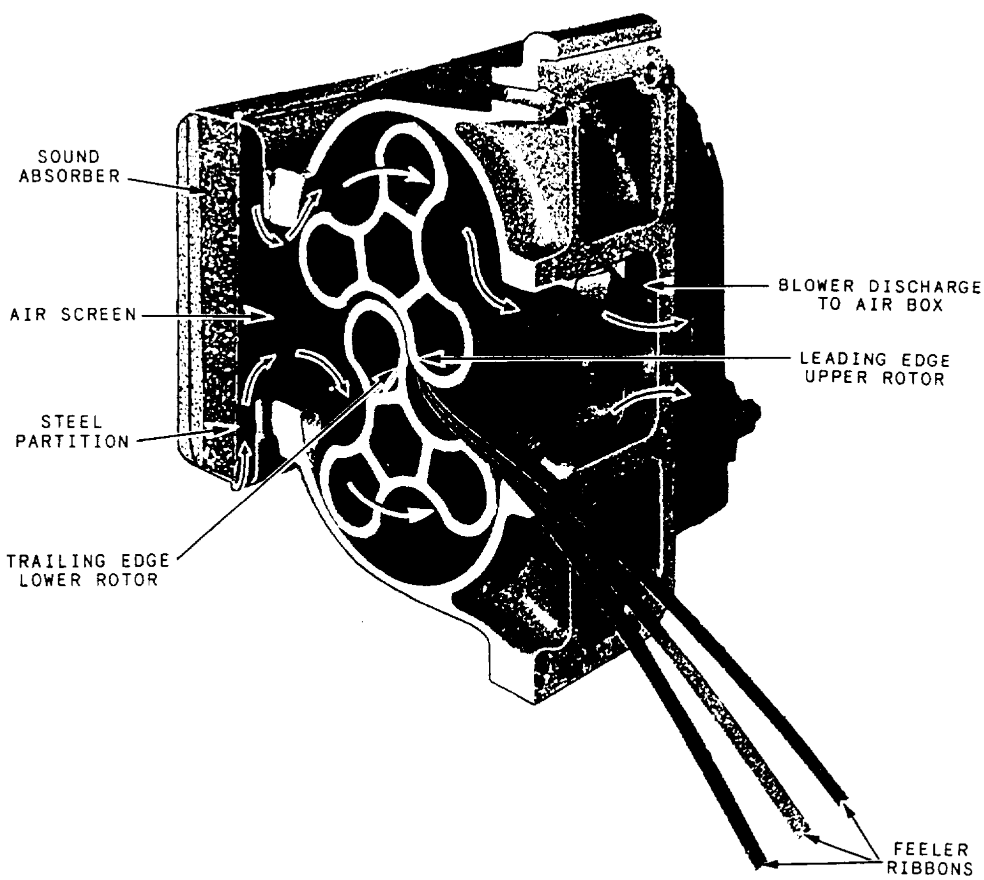


Figure 3-39.—Checking clearances of positive-displacement blower lobes.

serrations of either the shaft or the hub have failed for any reason, replace both parts.

Obstruction in the Combustion Space

Such items as broken valve heads and valve stem locks or keepers that come loose because of a broken valve spring may cause an engine to come to an abrupt stop. If an engine continues to run when such obstructions are in the combustion chamber, the piston, liner, head, and injection nozzle will be severely damaged.

Piston Seizure

Piston seizure may also cause an engine to stop suddenly. The piston becomes galled and scuffed. When this occurs, the piston may possibly break or extensive damage may be done to other major engine parts. The principal causes of piston seizure are insufficient clearance, excessive temperatures, or inadequate lubrication.

Defective Auxiliary Drive Mechanisms

Defects in auxiliary drive mechanisms may cause an engine to stop suddenly. Since most troubles in gear trains or chain drives require some disassembly, this discussion will be limited to the causes of such troubles.

Gear failure is the principal trouble in gear trains. Engine failure and extensive damage can occur because of a broken or chipped gear. If you hear a metallic clicking noise in the vicinity of a gear housing, it is almost a certain indication that a gear tooth has broken.

Gears are most likely to fail because of improper lubrication, corrosion, misalignment, torsional vibration, excessive backlash, wiped bearings and bushings, metal obstructions, or improper manufacturing procedures.

Gear shafts, bushings and bearings, and gear teeth must be checked during periodic inspections for scoring, wear, and pitting. All oil passages, jets, and sprays should be cleaned to ensure proper oil flow. All gear-locking devices must fit tightly to prevent longitudinal gear movement.

Chains are used in some engines for camshaft and auxiliary drives; in other engines, chains are used to drive *certain* auxiliary rotating parts. Troubles in chain drives are usually caused by wear or breakage. Troubles of this nature may be caused by improper chain tension, lack of lubrication, sheared cotter pins, or misalignment.

Figure 3-40 is a summary of the possible troubles that may cause an engine to stall frequently or stop suddenly. There may be some doubt as to the difference between stalling and stopping. In reality, there is none unless we associate certain troubles with each. In general, troubles that cause FREQUENT STALLING are those that can be eliminated with minor adjustments or maintenance. If such troubles are not eliminated, it is quite possible that the engine can be started, only to stall again. Failure to eliminate some of the troubles that cause frequent stalling may lead to troubles that cause SUDDEN STOPPING.

ENGINE WILL NOT CARRY A LOAD

Many of the troubles that can lead to loss of power in an engine may also cause the engine to stop and stall suddenly or may even prevent it from starting. Compare the list of some of the troubles that may cause a power loss (fig. 3-41) with those in figures 3-36 and 3-40. Such items as insufficient air, insufficient fuel, and faulty operation of the governor appear on all three charts. Many of the troubles listed are closely related, and the elimination of one may eliminate others.

The operator of an internal-combustion engine may be confronted with additional major difficulties, such as those indicated in figure 3-42. Here, again, you can see that many of these possible troubles are similar to those that have already been discussed in connection with starting failures and with engine stalling and stopping. The discussion that follows covers only those troubles not previously considered.

ENGINE OVERSPEEDS

When an engine overspeeds, the trouble is usually caused by either the governor mechanism or the fuel control linkage, as previously discussed When you need information on a specific fuel system or speed control system, check the manufacturer’s technical manual and the special technical manuals for the particular system. These special manuals are available for the most widely used models of hydraulic governors and overspeed trips, and they contain specific details on testing, adjusting, and repairing each controlling device.

ENGINE HUNTS OR WILL NOT STOP

Some troubles that may cause an engine to hunt, or vary its rpm at constant throttle setting, are similar to those that may cause an engine to resist stopping. Generally, these two forms of irregular engine operation

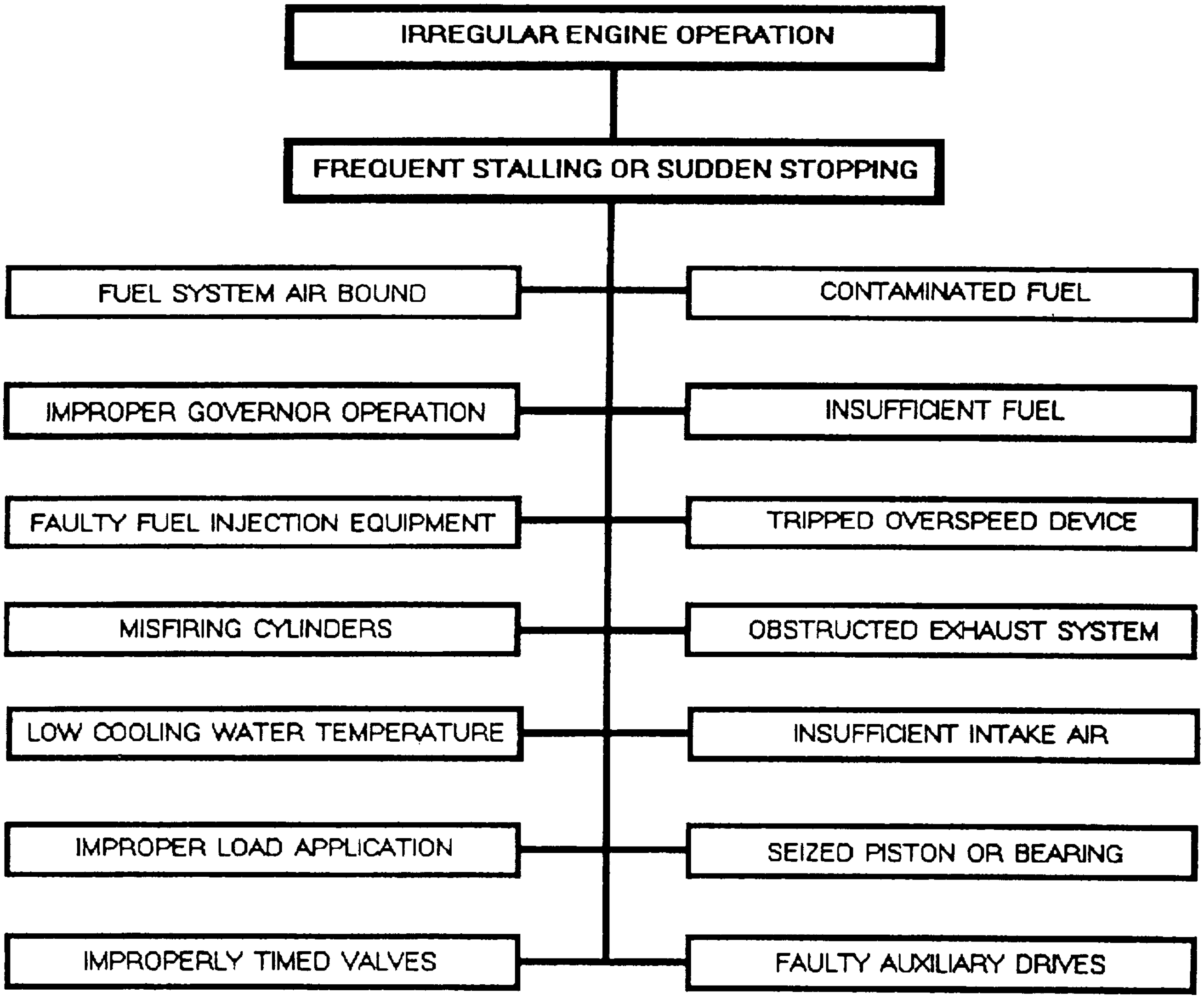


Figure 3-40.—Possible troubles that may cause an engine to stall frequently or to stop suddenly.

are caused by troubles originating in the speed control system and the fuel system.

Speed Control System

The speed control system of an internal-combustion engine includes those parts designed to maintain the engine speed at some exact value or between desired limits, regardless of changes in the load on the engine. Governors are provided to regulate fuel injection so the speed of the engine can be controlled as the load is applied. Governors also prevent overspeeding as may happen in rough seas when the load is suddenly reduced as the propellers leave the water.

Fuel Control Racks

Fuel control racks that have become sticky or jammed may cause governing difficulties. If the control rack of a fuel system is not functioning properly, the engine speed may increase as the load is removed, the engine may hunt continuously, or it may hunt only when the load is changed. A sticky or jammed control rack may prevent the engine from responding to changes in throttle setting and may even prevent it from stopping. Any such condition could be serious in an emergency situation. Your job is to make every effort possible to prevent such conditions from occurring.

You can check for a sticky rack by stopping the engine, disconnecting the linkage to the governor, and then attempting to move the rack by hand. There should

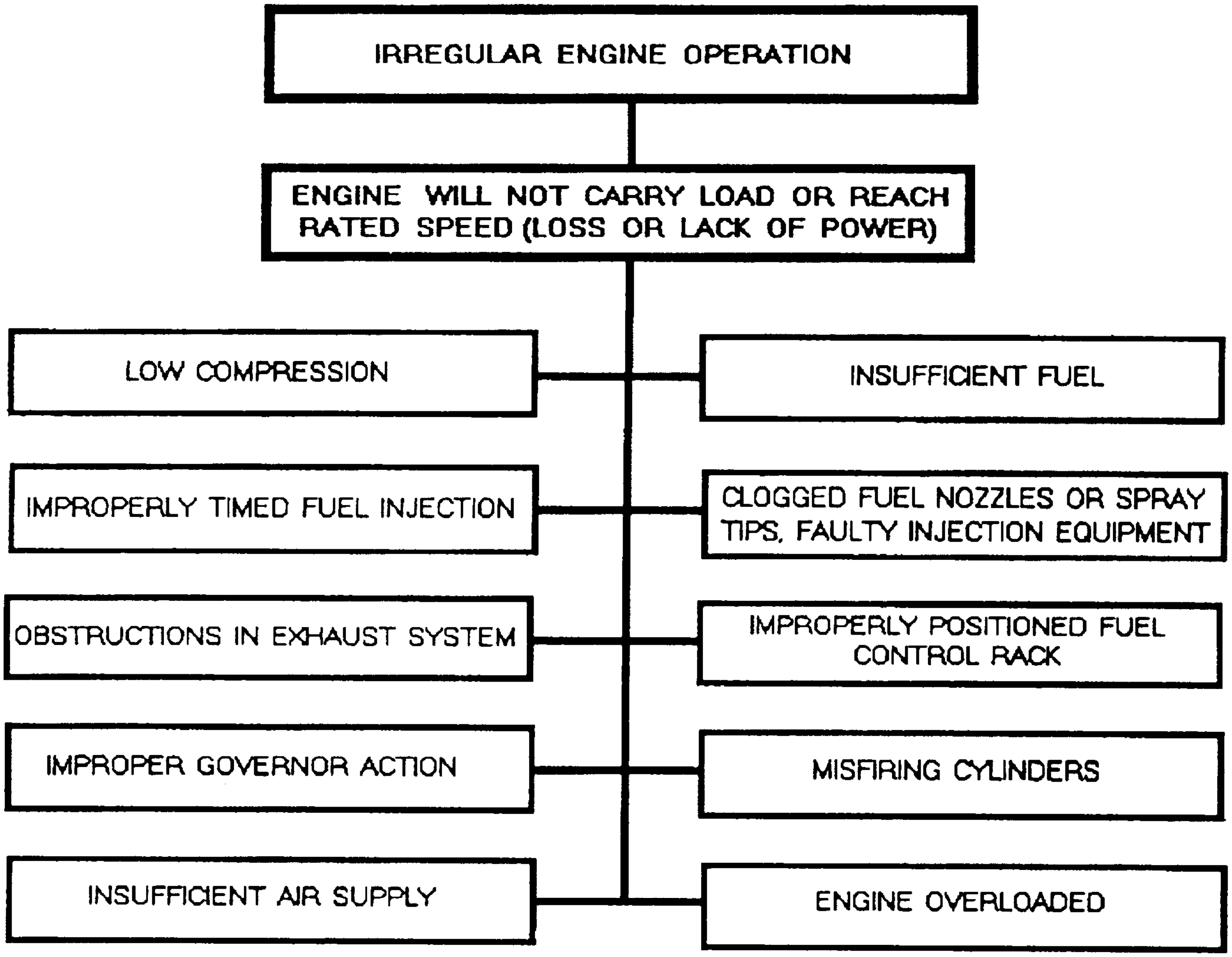


Figure 3-41.—Possible causes of insufficient power in an engine.

be no apparent resistance to the motion of the rack if the return springs and linkage are disconnected. A stuck control rack may be caused by the plunger's sticking in the pump barrel; dirt in the rack mechanism; damage to the rack, sleeve, or gear; or improper assembly of the injector pump.

If the rack sticks or jams, you must determine the cause and replace any damaged parts. If sticking is due to dirt, thoroughly clean all the parts to correct the trouble. You can avoid errors in assembly by carefully studying the assembly drawings and instructions.

Leakage of Fuel Oil

Leakage of fuel oil from the injectors may cause an engine to continue to operate when you attempt to shut it down. Regardless of the type of fuel system, the results of internal leakage from injection equipment are, in general, somewhat the same. Injector leakage will cause unsatisfactory engine operation **because** of the excessive amount of fuel entering the cylinder. Leakage may also cause detonation, crankcase dilution, smoky exhaust, loss of power, and excessive carbon formation on the spray tips of nozzles and other surfaces of the combustion chamber.

Accumulation of Lube Oil

Another trouble that may prevent you from stopping an engine is accumulation of lube oil in the intake air passages-manifold or air box. Such an accumulation creates an extremely dangerous condition. You can detect excess oil by removing the inspection plates on the covers and examining the air box and manifold. If you discover oil, remove it and perform the necessary

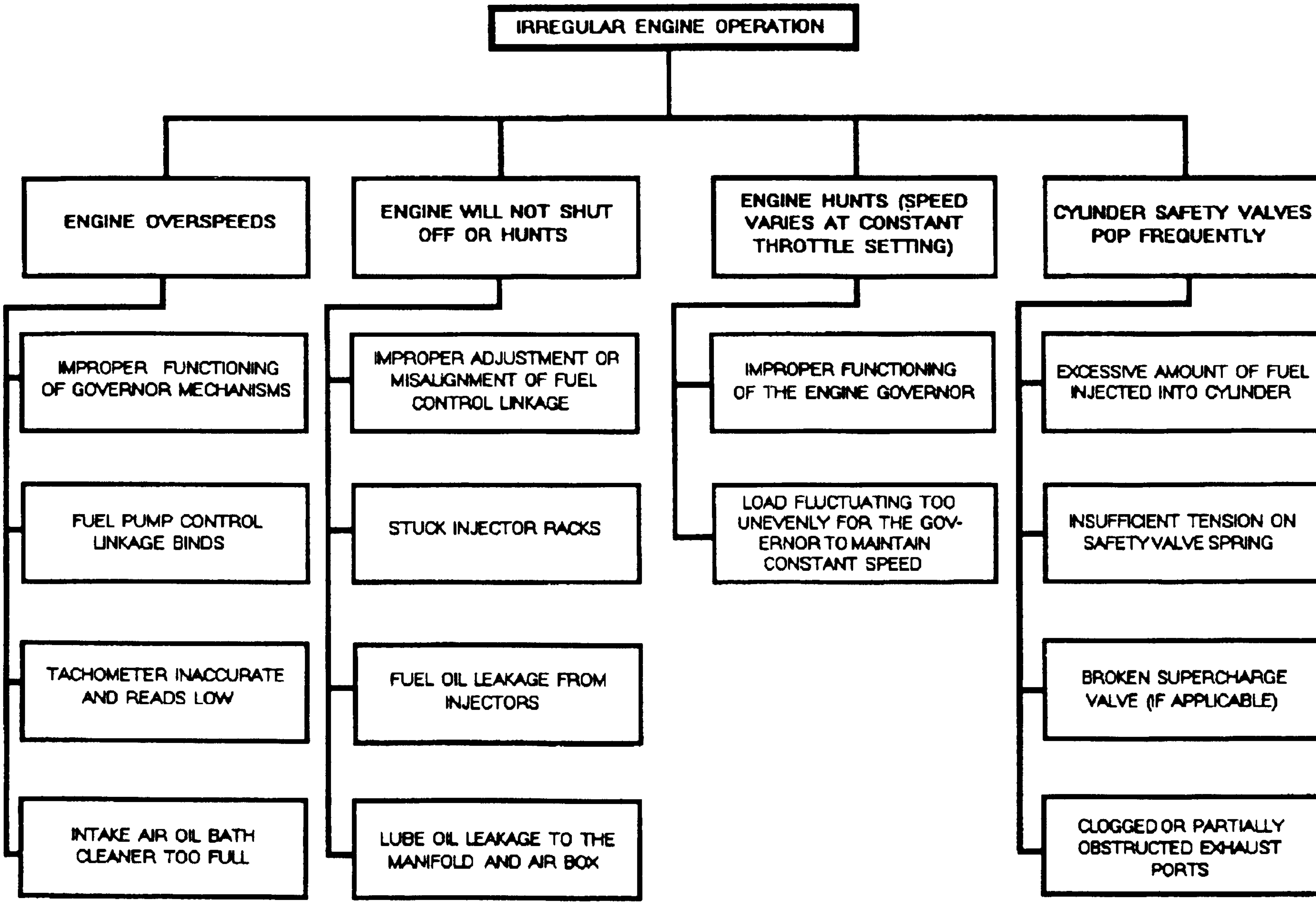


Figure 3-42.–Additional causes of irregular engine operation.

corrective maintenance. If oil is drawn suddenly in large quantities from the manifold or air box into the cylinder of the engine and burns, the engine may run away. The engine governor has no control over the sudden increase in speed.

An air box or air manifold explosion is also a possibility if excess oil is allowed to accumulate. Some engine manufacturers have provided safety devices to reduce the hazards of such explosions.

Excess oil in the air box or manifold of an engine also increases the tendency of carbon to form on liner ports, cylinder valves, and other parts of the combustion chamber.

The causes of excessive lube oil accumulation in the air box or manifold will vary depending on the specific engine. Generally, the accumulation is due to an obstruction in either the air box or separator drains.

In an effort to reduce the possibility of crankcase explosions and runaways, some engine manufacturers have designed a means to ventilate the crankcase. In some engines, a passage between the crankcase and the intake side of the blower provides ventilation. In other engines, an oil separator or air maze in the passage between the crankcase and blower intake provides ventilation.

In either type of installation, stopped up drains will cause an excessive accumulation of oil. Drain passages must be kept open by proper cleaning whenever necessary.

Oil may enter the air box or manifold from sources other than crankcase vapors. A defective blower oil seal, a carryover from an oil-type air cleaner, or defective oil piping may be the source of trouble.

Another possible source may be an excessively high oil level in the crankcase. Under this condition, an oil fog is created in some engines by the moving parts. An oil fog may also be caused by excessive clearance in the connecting rod and main journal bearings. In some types of crankcase ventilating systems, the oil fog will be drawn into the blower. When this occurs, an abnormal amount of oil may accumulate in the air box. Removal of the oil will not remove the trouble. The cause of the accumulation must be determined and the necessary repair made.

If a blower oil seal is defective, replacement is the only satisfactory method of correction. When you install new seals, be sure the shafts are not scored and the bearings are in satisfactory condition. Take special precautions during the installation to avoid damaging the oil seals. Damage to an oil seal during installation is usually not discovered until the blower has been reinstalled and the engine has been put into operation. Be sure an oil seal gets the necessary lubrication. The oil not only lubricates the seal, reducing friction, but also carries away any heat that is generated. For most purposes, soak new oil seals in clean, light lube oil before you install them.

CYLINDER SAFETY VALVES

On some engines, a cylinder relief (safety valve) is provided for each cylinder. The valve opens when the cylinder pressure exceeds a safe operating limit. The valve opens or closes a passage leading from the combustion chamber to the outside of the cylinder. The valve face is held against the valve seat by spring pressure. Tension on the spring is varied by an adjusting nut, which is locked when the desired setting is attained. The desired setting varies with the type of engine and may be found in the manufacturer’s technical manual.

Cylinder relief valves should be set at the specified lifting pressure. Continual lifting (popping) of the valves indicates excessive cylinder pressure or malfunction of the valves, either of which should be corrected immediately. Repeated lifting of a relief valve indicates that the engine is being overloaded, the load is being applied improperly, or the engine is too cold. Also, repeated lifting may indicate that the valve spring has become weakened, ignition or fuel injection is occurring too early, the injector is sticking and leaking, too much fuel is being supplied, or, in air injection engines, the spray valve air pressure is too high. When frequent popping occurs, stop the engine and determine and remedy the cause of the trouble. In an emergency, cut off the fuel supply in the affected cylinder. NEVER lock relief valves closed, except in an emergency. When you must take emergency measures, be sure to repair or replace the valves, as necessary, as soon as possible.

When excessive fuel is the cause of frequent safety valve lifting, the trouble may be due to the improper functioning of a high-pressure injection pump, a leaky nozzle or spray valve, or a loose fuel cam (if adjustable). In some systems, such as the common rail, the fuel pressure may be too high.

A safety valve that is not operating properly should be removed, disassembled, cleaned, and inspected. Check the valve and valve seat for pitting and excessive wear and the vale spring for possible defective conditions. When you remove a safety valve for any reason, you must reset the spring tension. This procedure varies to some extent, depending on the valve construction.

Except in emergencies, it is advisable to shut the engine down when troubles cause safety valve popping.

Clogged or partially obstructed exhaust ports may also cause the cylinder safety valve to lift. This condition will not occur often if proper planned maintenance procedures are followed. If it does occur, the resulting increase in cylinder pressure may be enough to cause safety valve popping. Clogged exhaust ports will also cause overheating of the engine, high exhaust temperatures, and sluggish engine operation.

You can prevent clogged cylinder ports by removing carbon deposits at prescribed intervals. Some engine manufacturers make special tools for port cleaning. Round wire brushes of the proper size are satisfactory for this work You must be careful in cleaning cylinder ports to prevent carbon from entering the cylinder-bar the engine to such a position that the piston blocks the port.

SYMPTOMS OF ENGINE TROUBLE

In learning to recognize the symptoms that may help locate the causes of engine trouble, you will find that experience is the best teacher. Even though written instructions are essential for efficient troubleshooting, the information usually given serves only as a guide. It is very difficult to describe the sensation that you should feel when checking the temperature of a bearing by hand; the specific color of exhaust smoke when pistons and rings are worn excessively; and, for some engines, the sound that you will hear if the crankshaft counterweights come loose. You must actually work with the equipment to associate a particular symptom with a particular trouble. Written information, however, can save you a great deal of time and eliminate much unnecessary work. Written instructions will make detection of troubles much easier in practical situations.

A symptom that indicates that trouble exists may be in the form of an unusual noise or instrument indication, smoke, or excessive consumption or contamination of the lube oil, fuel, or water. Figure 3-43 is a general listing of various trouble symptoms that you may encounter.

NOISES

The unusual noises that may indicate that trouble exists or is impending may be classified as pounding, knocking, clicking, and rattling. Each type of noise must be associated with certain engine parts or systems that might be the source of trouble.

Pounding or hammering is a mechanical knock (not to be confused with a fuel knock). It may be caused by a loose, excessively worn, or broken engine part. Generally, troubles of this nature will require major repairs.

Detonation (knocking) is caused by the presence of fuel or lubricating oil in the air charge of the cylinders during the compression stroke. Excessive pressures accompany detonation. If detonation is occurring in one or more cylinders, stop the engine immediately to prevent possible damage.

Clicking noises are generally associated with an improperly functioning valve mechanism or timing gear. If the cylinder or valve mechanism is the source of metallic clicking, the trouble may be due to a loose valve stem and guide, insufficient or excessive valve tappet clearances, a loose cam follower or guide, broken valve springs, or a valve that is stuck open. A clicking in the timing gear usually indicates that there are some damaged or broken gear teeth.

Rattling noises are generally due to vibration of loose engine parts. However, an improperly functioning vibration damper, a failed antifriction bearing, or a gear-type pump operating without prime are also possible sources of rattling noises.

When you hear a noise, first make sure it is a trouble symptom. Each diesel engine has a characteristic noise at any specific speed and load. The noise will change with a change in speed or load. As an operator, you must become familiar with the normal sounds of the engine. Investigate all abnormal sounds promptly. Knocks that indicate a trouble may be detected and located by special instruments or by the use of a “sounding bar,” such as a solid iron screwdriver or bar.

INSTRUMENT INDICATIONS

As an engine operator, you will probably rely more on the instruments to warn you of impending troubles than on all the other trouble symptoms combined. Regardless of the type of instrument being used, the indications are of no value if the instrument is inaccurate. Be sure an instrument is accurate and operating properly before you accept a low or high reading. Test all instruments at specified intervals or whenever you suspect them of being inaccurate.

SMOKE

Smoke can be quite useful as an aid in locating some types of trouble, especially if used in conjunction with other trouble symptoms.

The color of exhaust smoke, a good indication of engine performance, can also be used as a guide in troubleshooting. The exhaust of an efficiently operating engine has little or no color. A dark, smoky exhaust indicates incomplete combustion; the darker the color, the greater the amount of unburned fuel in the exhaust. Incomplete combustion may be due to a number of troubles. Some manufacturers associate a particular type of trouble with the color of the exhaust. The more serious troubles are generally identified with either black or bluish-white exhaust colors.

NOISES	INSTRUMENT INDICATIONS			SMOKE	CONTAMINATIOF OF LUBE OIL, FUEL, OR WATER
	PRESSURE	TEMPERATURE	SPEED		
Pounding (mechanical)	Low lube oil pressure	Low lube oil temperature	Idling speed not normal	Black exhaust smoke	Fuel oil in the lube oil
	High lube oil pressure	High lube oil temperature	Maximum speed not normal	Bluish-white exhaust smoke	Water in the lube oil
Knocking (detonation)	Low fuel oil pressure (in low-pressure fuel supply system)	Low cooling water tempera-ture (fresh)		Smoke arising from crankcase	Oil or grease in the water Water in the fuel oil
Clicking (metallic)	Low cooling water pressure (fresh)	High cooling water tempera-ture (fresh)		Smoke arising from cylinder head Smoke from engine auxiliary equip ment (blowers, pumps, etc.)	Air or gas in the water Metal particles in lube oil
	Low cooling water pressure (salt)	Low cylinder ex-haust temperature			
Rattling	High cooling water pressure (salt)	High exhaust temperature in one cylinder			
	Low compres-sion pressure				
	Low firing pressure				
	High firing pressure				
	Low scavenging air receiver pres-sure (super-charge engine)				
	High exhaust back pressure				

Figure 3-43.—Symptoms of engine troubles.

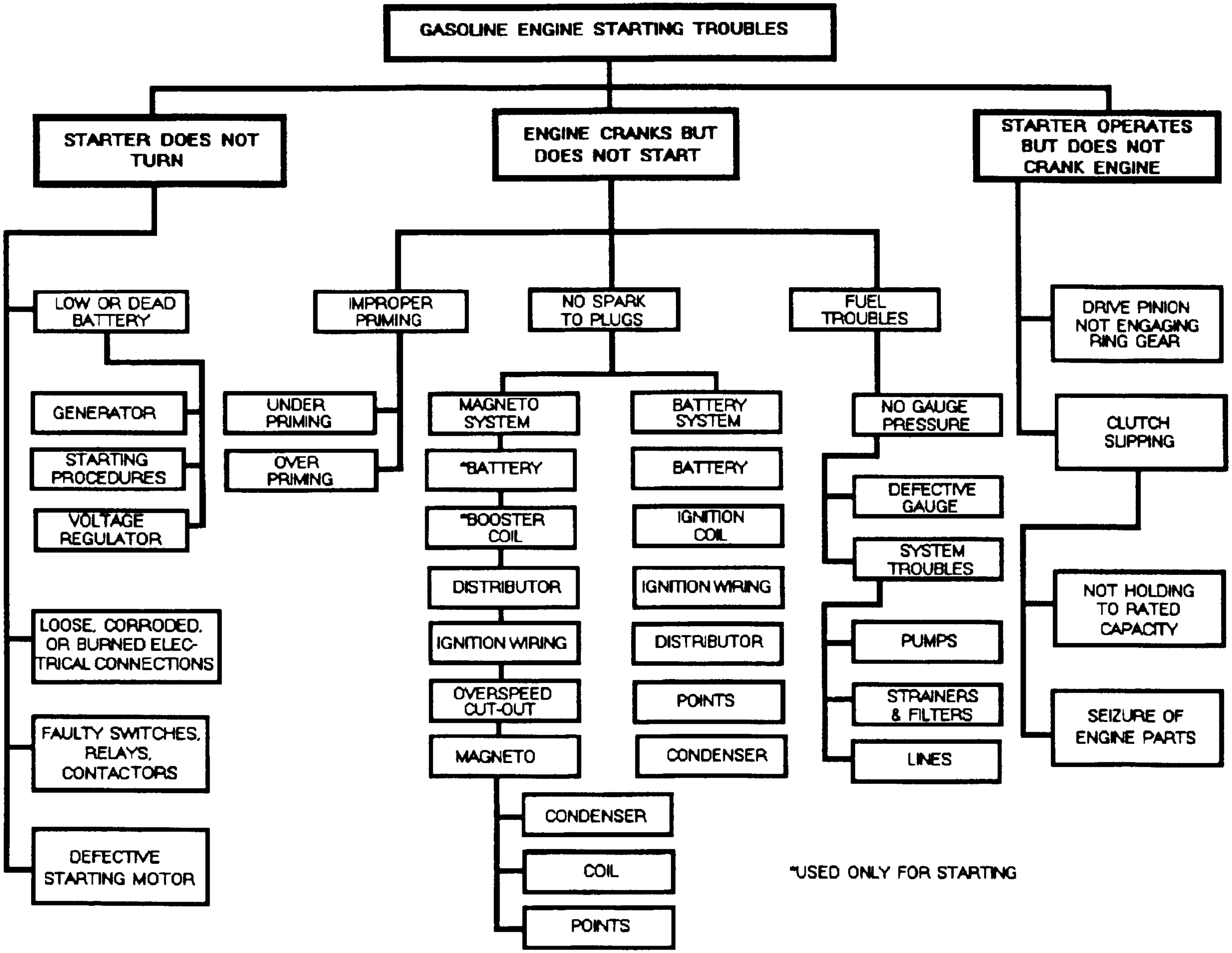


Figure 3-44.–Possible sources of trouble when a gasoline engine fails to start.

EXCESSIVE CONSUMPTION OF LUBE OIL, FUEL, OR WATER

You should suspect engine trouble whenever excessive consumption of any of the essential liquids occurs. The possible troubles indicated by excessive consumption will depend on the system in question. Leakage, however, is one trouble that may be common to all. Before you start any disassembly, check for leaks in the system in which excessive consumption occurs.

TROUBLESHOOTING GASOLINE ENGINES

The troubleshooting procedures used for a marine gasoline engine are, in many ways, similar to those for a diesel engine. The two types of engines are quite similar with two exceptions, the manner of getting fuel and air into the cylinders and the method of ignition.

This section deals primarily with the systems that differ in the gasoline and diesel engines. In addition, troubleshooting information is given on the electrical systems.

Even though most electrical maintenance and repair is the responsibility of an Electrician's Mate, you, as an Engineman, can reduce the amount of electrical troubles by following the correct operating procedures. Most electrical system troubles develop from improper use, care, or maintenance.

The following information will help you detect electrical troubles and take corrective action.

When a gasoline engine fails to start, one of three conditions exists. The engine is not free to turn, the starter does not crank the engine, or the engine cranks but does not start. Figure 3-44 lists many of the conditions and sources of such difficulties,

If the engine will not turn over, some part is probably seized In this case you should make a through inspection, which may necessarily include some disassembly.

STARTER DOES NOT RUN

If the starter fails to turn, the trouble can usually be traced to the battery, connections, switch, or starter motor.

Symptoms of battery trouble generally occur before the charge gets too low to perform the required work Battery failure is normally preceded by a gradual decline in the strength of the battery charge. A dead battery may be the result of insufficient charging, damaged plates, or improper starting technique.

The generator, used to maintain the charge of the starting battery, may become defective. The normal symptoms are a low battery charge when the engine is started and a zero or low ammeter reading when the engine is running.

The battery must be in good condition to ensure the proper operation of the ignition system. A starter draws a heavy current from the best of batteries. When the battery is weak, it will be unable to operate the ignition system satisfactorily for starting because the heavy starting current will drop the voltage to an extremely low value.

NOTE: Keep flames and sparks of all kinds away from the vicinity of storage batteries. A certain amount of hydrogen gas is given off from a battery at all times. In confined spaces this gas can form a dangerous explosive mixture.

When you use tools around a battery, be careful not to short circuit the battery terminals. Never use a tool or metal object to make a so-called test of a storage battery.

Keep batteries in exposed locations subject to low temperatures fully charged during cold weather. In extreme cold weather, remove storage batteries and place them in a warm compartment, if possible.

Electrical connections are another possible source of trouble if the starter does not turn. All connections must be tight and free from corrosion to provide maximum voltage and amperage from the battery. Battery terminals, since they are more vulnerable to corrosion, looseness, and burning, are the principal sources of trouble.

Burned battery terminals may be caused by a loose connection, a corroded terminal, or a short circuit. Burning of terminals usually occurs when an engine is being started Burning may be indicated by such things as smoke, a flash, or a spattering of molten metal in the vicinity of the battery. Usually, the starting motor will cease to turn after these symptoms appear.

Switches, electrical relays, or contactors that are defective or inoperative may be the reason a starter will not turn. Contactors, being subject to extremely high current, must be maintained in the best possible condition. Starting contactors are either manually or magnetically operated and are designed to be operated for only short periods of time.

Starter motor troubles can be traced for the most part to the commutator, brushes, or insulation. If motors are to function properly, they must be kept clean and dry. Dirt and moisture make good commutation impossible. Dirty and fouled starter motors may be caused by failure to replace the cover band, by water leakage, or by excess lubrication.

Most starter motors have a cover to protect the commutator and windings. If you neglect to replace the cover or remove it as an aid to ventilation and cooling, dirt and water are sure to damage the equipment.

Although lubrication of bearings is essential for proper operation, excessive lubrication may lead to trouble in a starter motor. Excess lubricant in the shaft bearings may leak or be forced past the seal and foul the insulating material, commutator, and brushes. The lubricant prevents a good electrical contact between the brushes and the commutator, causing the commutator to spark and heat and the brushes to burn.

Burned brushes are another possible source of trouble if the starter motor is inoperative. Burning may be caused by loose brush holders, improper brush spring tension, a brush stuck in the holder, a dirty commutator, improper brush seating surface, or overloading the starter.

STARTER MOTOR OPERATES BUT DOES NOT CRANK ENGINE

If the starter motor and battery are in good operating condition but the starter fails to crank the engine, the trouble will usually be in the drive connection between the motor and the ring gear on the flywheel. Troubles in the drive assembly are usually in the form of broken parts or a slipping clutch (if applicable). A slipping clutch may be the result of the engine not being free to turn or of the clutch not holding up to its rated capacity.

Even though seldom encountered, a stripped ring gear on the flywheel may be the source of trouble if the starter motor does not turn the engine.

ENGINE CRANKS BUT FAILS TO START

Starting troubles and their causes and corrections may vary to some degree, depending on the particular engine. If the prescribed prestarting and starting procedures are followed and a gasoline engine fails to start, the source of trouble will probably be improper priming or choking, a lack of fuel at various points in the system, or a lack of spark at the spark plugs.

Improper priming may be either underpriming or overpriming. Priming instructions differ, depending on the engine. Information on priming also applies to engines equipped with chokes. **A** warm engine should never be primed. Some engines may require no priming except when they are started under cold weather conditions.

On some installations, underpriming can be checked by the feel of the primer pump as it is operated On other installations, underpriming may be due to insufficient use of the choke.

Over-priming is undesirable because it results in a flooded engine and makes starting difficult. It also causes excess gasoline to condense in the intake manifolds, run down into the cylinders, wash away the lubricating oil film, and cause pistons or rings to stick

You can determine flooding by removing and inspecting a spark plug. A wet plug indicates flooding. If you find the engine to be flooded, be sure to dry out or deflood it according to prescribed instructions. Some installations specify that the ignition switch must be ON, while others state the switch must be OFF; therefore it is important for you to follow the engine manufacturer’s instructions.

Improper carburetion may be the source of trouble if a gasoline engine fails to start. On some engines a check of the fuel pressure gauge will indicate whether lack of fuel is the cause. If the gauge shows the prescribed pressure, the trouble is not lack of fuel; if the gauge shows little or no fuel pressure, you should check the various parts of the delivery system to locate the fault.

In some installations, you can determine whether the trouble is in the gauge or in the fuel system by using the following procedure: (1) remove the carburetor plug next to the fuel pressure gauge connection; and (2) use a suitable container to catch the gasoline, and operate the pump used to build up starting fuel pressure. If fuel is reaching the carburetor, gasoline will spurt out of the open plug hole; this indicates that the gauge is inoperative. If no fuel flows from the plug opening, the trouble is probably in the fuel system somewhere between the fuel tank and carburetor. Even though all installations do not have a fuel pressure gauge, the procedure for checking the fuel system is much the same.

If a wobble pump is installed to build up starting fuel pressure, you can determine whether the pump is operating correctly by the feel and sound of the pump. If the pump feels or sounds dry, the trouble is between the pump and the supply tanks. The trouble might be caused by a clogged fuel line strainer or by an air leak in the line. If the wobble pump is pumping, the trouble may be in the line to the engine fuel pump or in the engine fuel pump itself.

Check the fuel lines for cracks, dents, loose connections, sharpbends, andclogging. You can remove the fuel line at the pump and use air to determine if the line is open.

Check fuel pumps for leaks at the pump gaskets ***or*** in the fuel line connections. Check fuel pump filters or sediment bowl screens for restrictions. Check the bypass for operation. If the bypass valve is defective, replace the fuel pump. In diaphragm-type fuel pumps, the filter bowl gasket, the diaphragm, or the valves may be the source of trouble. Check for air leaks in the diaphragm by submerging the discharge end of the fuel line in gasoline and looking for air bubbles while cranking the engine. If the engine will run, a leaky diaphragm is indicated by gasoline leakage from the pump air vent.

Carburetor trouble may be the cause if fuel does not reach the cylinders. You can check this by removing the spark plugs and looking for moisture. If there is no trace of gasoline on the plugs, the carburetor may be out of adjustment, the float level may be too low, or the jets may be clogged. If the fuel level in the carburetor float bowl is low, the float valve is probably stuck on the seat. If the fuel level in the float is correct, yet no fuel is delivered to the carburetor throat, the carburetor will have to be removed, disassembled, and cleaned.

Faulty ignition system parts may be the source of starting difficulties. You may encounter two kinds of ignition systems-the MAGNETO type and the BATTERY type. Even though the parts of these systems differ in some respects, their function is the same; namely, to produce a spark in each cylinder of the engine at exactly the proper time in relation to the position of the pistons and the crankshaft. Also, the system is designed so the sparks in all cylinders follow each other in proper sequence.

ENGINE FAILS TO STOP

If a gasoline engine fails to stop when the ignition switch is turned to the OFF position, the trouble is usually caused by a faulty ignition circuit, improper timing, the octane rating number of the fuel being too low for the design of the engine, or the engine being overheated.

In a magneto-type ignition system, an open ground connection may cause an engine to run after the ignition switch is turned off. When a magneto ground connection is open, the magneto will continue to produce sparks as long as the magneto armature magnets rotate, and the engine will continue to run. In other words, when the magneto ignition switch contact points are closed, the ignition should be SHUT OFF. This is not true of the booster coil circuit of a magneto-type system, nor of the usual battery-type ignition system. In these systems, an open ground or open switch points prevent current flow. If the switch of a battery-type ignition system fails to stop the engine, the contact switch points have probably remained closed.

If the ignition switch and the circuit are in good condition, failure to stop may be caused by overheating. If the engine is overheated, normal compression temperature may become high enough to ignite the fuel mixture even though no spark is being produced in the cylinders. When this happens in a gasoline engine, the engine is, in reality, operating on the diesel principle.

Normally, you will detect the symptoms of overheating before the temperature gets too high. The causes of overheating in a gasoline engine are much the same as those for a diesel engine.

Other troubles and their symptoms, causes, and corrections that may occur in a gasoline engine are similar to those found in a diesel engine. Troubles leading to the loss of rpm, irregular operation, unusual noises, abnormal instrument indications, and excessive consumption or contamination of the lube oil, fuel, or water can usually be handled in the same way for gasoline and diesel engines. Of course, there are always exceptions, so it is best to consult the manufacturer’s technical manual.

Most gasoline engines in the Navy are used by shore activities. Afloat, gasoline engines are used to drive portable pumps like the P-250, a piece of fire-fighting and dewatering equipment. Although pumps like the P-250 are primarily maintained by members of the Damage Controlman (DC) rating, Enginemen are involved to some extent in repairing or overhauling the P-250.

Before you disassemble a P-250 for repair, make sure that all the repair parts are available and on hand. When repairs are not within your ship’s force capability, you must turn the unit in to an IMA or SRF for repair. Attach an OPNAV 4790/2K (work order form) to the pump. Figure 3-45 illustrates a typical P-250 pump unit.

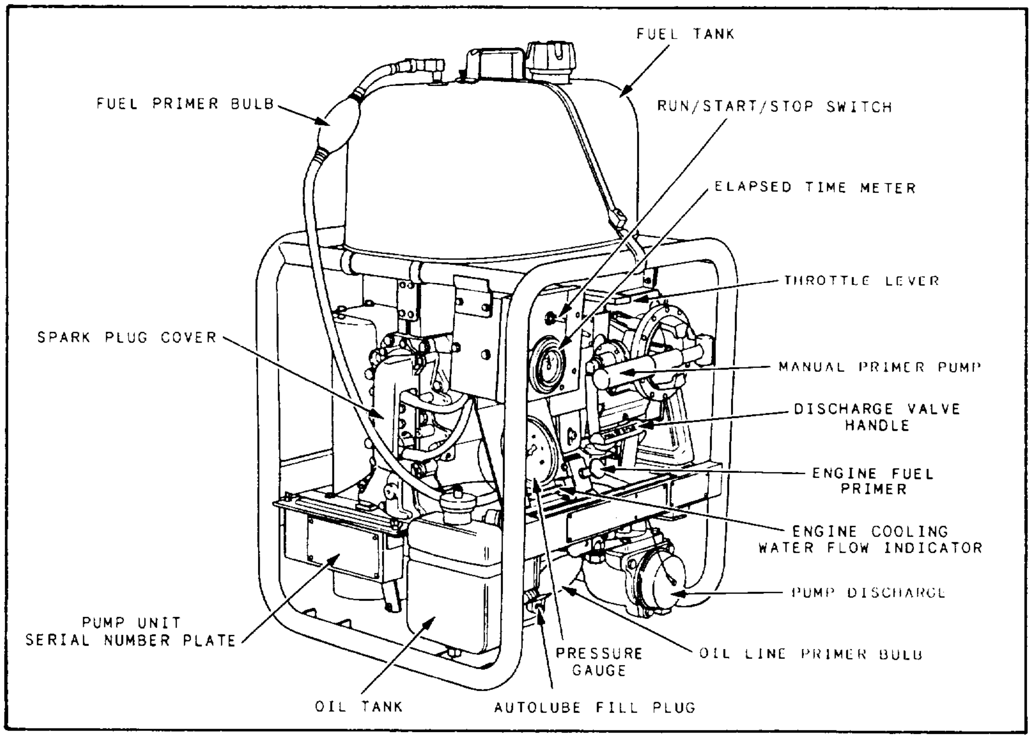


Figure 3-45.—A typical P-250 pump unit.

For more detailed information concerning operation, maintenance and repair of the P-250, refer to the NAVSEA technical manual, *Firefighter Pump P-250 Mod 1,* S6225-BW-MM0-010.

Some gasoline engines serve as outboard motors to power small boats. A high percentage of the motors' problems are electrical. A large number of problems are also caused by the use of fuel with a lower octane content than specified by the manufacturer. To gain knowledge about operating, maintaining, and repairing outboard motors, review manufacturers' service manuals and assigned PMS publications. Most outboard motor manufacturers offer a high quality training course, free of charge.

JACKING GEAR

The *Engineman 3,* NAVEDTRA 10539, introduced the two primary types of jacking gear, the ring gear, and the pinion assembly, and described their use. The only maintenance required for jacking gear is periodic inspection for wear and minor lubrication of the moving parts of the pinion assembly.

FUEL AND OIL PURIFIERS

Specific directions for operating a purifier are given in the manufacturer's instructions provided with the unit. The following information is general and applies to both the fuel and the oil purifiers.

For maximum efficiency, purifiers should be operated at their maximum designed speed and rated capacity. An exception to operating a purifier at its designed rated capacity is when the unit is used as a separator with 9000 series detergent oil. Some engines using the 9000 series oils are exposed to large quantities of water. When the oil becomes contaminated with water, it has a tendency to emulsify. The tendency to emulsify is most pronounced when the oil is new and gradually decreases during the first 50 to 75 hours of engine operation. During this period, the purifier capacity should be reduced to approximately 80 percent of its rated capacity.

Most oils used in Navy installations can be heated to 180°F without damage to the oils. Prolonged heating at higher temperatures is not recommended because such oils tend to oxidize at high temperatures. Oxidation results in rapid deterioration. In general, oil should be heated enough to produce a viscosity of approximately 90 seconds Saybolt universal (90 SSU), but the temperature should not exceed 180°F. The following temperatures are recommended for purifying oils in the 9000 series:

Military Symbol	Temperature (°F)
9110	140
9170	160
9250	175
9500	180

Pressure should not be increased above normal to force a high viscosity oil through the purifier. Instead, the viscosity should be decreased by heating the oil. Pressure in excess of that normally used to force oil through the purifier will result in less efficient purification. On the other hand, a reduction in the pressure that forces the oil into the purifier will increase the length of time the oil is under the influence of centrifugal force and, therefore, will tend to improve results.

DISCHARGE RING (RING DAM)

If the oil discharged from a purifier is to be free of water, dirt, and sludge and if the water discharged from the bowl is not to be mixed with oil, the proper size discharge ring (ring dam) must be used. The size of the discharge ring depends on the specific gravity of the oil being purified; diesel fuel oil, JP-5, and lubricating oils all have different specific gravities and, therefore, require different sized discharge rings. While all discharge rings have the same outside diameter, their inside diameters vary. Ring sizes are indicated by even numbers; the smaller the number, the smaller the ring size. The inside diameter in millimeters is stamped on each ring. Sizes vary in increments of 2 millimeters. Charts, provided in the manufacturers' technical manuals, specify the proper ring size to be used with an oil of a given specific gravity. Generally, the ring size indicated on such a chart will produce satisfactory results. If the recommended ring fails to produce satisfactory purification, you must determine the correct size by trial and error. In general, you will obtain the most satisfactory purification of the oil when the ring is the largest size that can be used without losing oil along with the discharged water.

MAINTENANCE OF PURIFIERS

Clean the bowl of the purifier daily according to the PMS, and carefully remove all sediment. The amount of dirt, grit, sludge, and other foreign matter in the oil may warrant more frequent cleaning. If you do not know the amount of foreign matter in an oil, have the purifier shut down and examined and cleaned once each watch, or more often if necessary. The amount of sediment found in the bowl indicates how long the purifier may be operated between cleaning.

Have periodic tests made to make sure the purifier is working properly. When the oil in the system is being purified by the batch process, tests should be made at approximately 30-minute intervals. When the continuous process of purification is used, tests should be made once each watch. Analysis of oil drawn from the purifier is the best method of determining the efficiency of the purifier. However, the clarity of the purified oil and the amount of oil discharged with the separated water will also indicate whether the unit is operating satisfactorily.

SUMMARY

This chapter covered the general procedures concerning repairs, troubleshooting, maintenance, and overhaul of internal combustion engines. Additionally, it covered the general maintenance of jacking gear and fuel and oil purifiers. Read and use the correct references, such as the manufacturers' manuals and the PMS to operate and care for your equipment.

CHAPTER 4

SPEED CONTROLLING DEVICES

In the EN3 TRAMAN, you learned some basic information about the methods and the devices that control the output of the injection pumps and injectors. The purpose of these devices is to ensure control of engine operation.

This chapter contains general information about maintenance and repair of speed controlling devices known as governors. You should refer to the appropriate manufacturer's technical manuals and the maintenance requirements (3-M) for more specific information. *Woodward Diesel Engine Speed Governors Operation and Maintenance Manual,* NAVSHIPS 341-5017, *Marquette Governor Maintenance Manual,* NAVSHIPS 341-5505, and *Naval Ships' Technical Manual,* Chapter 233, "Diesel Engines," are good sources of information.

GOVERNORS

To control an engine means to keep it running at a desired speed, either with, or regardless of, the changes in the load carried by the engine. The degree of control required depends on the following factors:

- The engine's performance characteristics
- The type of load it drives

In diesel engines, the speed and power output is determined by varying the amount of fuel injected into the cylinders to control combustion. Hydraulic and mechanical are the two principal types of governors.

HYDRAULIC GOVERNORS

This chapter will deal only with the most common troubles that may be encountered with hydraulic governors. Poor regulation of speed may be due to the faulty adjustment of the governor or to the faulty action of an engine. Or it could be a problem with a synchronizing motor, a voltage regulator, or any piece of equipment that has a direct bearing on the operation of the engine.

Manufacturers stated that 50 percent of all governor troubles are caused by dirty oil. For this reason, you should take every precaution to prevent the oil from becoming contaminated. Most hydraulic governors use the same type of oil that is used in the engine crankcase, provided it is absolutely clean and does not foam. You should change the oil in the governor at regular intervals, depending upon the type of operation. But regardless of the operation or the preventive maintenance schedule, it must be changed at least every 6 months. You must make sure the oil containers used to fill the governors are clean and that only clean, new, or filtered oil is used. You should also check the oil level frequently to make sure the proper level is maintained and the oil does not foam. Foaming oil is usually an indication that water is present in the oil. Water in the oil will cause serious damage to the governor.

When a new or overhauled governor is installed, you should adjust the governor compensating needle valve (even though it has been adjusted previously at the factory or repair facility). This adjustment is made with the governor controlling an engine with a load. If this adjustment is not made, high overspeeds and low underspeeds after load changes will result and the return to normal speeds will be slowed. Follow the procedure listed in the manufacturer's maintenance manual and the PMS.

When a governor problem is suspected, before performing any maintenance or adjustments, disconnect the governor fuel rod end from the fuel control rack and make sure there is no binding or sticking of the fuel control rack. This procedure will determine if the trouble is actually the governor.

The chart in table 4-1 lists some of the probable causes of problems that are common to most hydraulic governors. This chart is for your general information, and it should not be used as a guide to troubleshoot a governor. You should use the applicable manufacturer's instruction manual for troubleshooting.

The following are the definitions of some terms used in the chart:

HUNTS: Rhythmic variations of speed that can be eliminated by blocking the fuel linkage manually. They will reappear when returned to governor control.

SURGES: Rhythmic variations of speed of large magnitude that can be eliminated by blocking the fuel linkage manually. They will not reappear when returned

Table 4-1.—Governor Probable Causes and Corrective Actions Chart

Problem	Probable Cause	Corrective Action
Engine hunts or surges	Compensating needle valve adjustment incorrect	Make needle valve adjustment; ensure that the opposite needle valve is closed
	Dirty oil in governor	Drain oil; flush governor; refill
	Low oil level	Fill to correct level with clean oil
	Foamy oil in governor	Drain oil; refill
	Lost motion in engine governor linkage or fuel pumps	Repair linkage and realign pumps
	Governor worn or incorrectly adjusted	Remove governor and make internal checks for clearances according to applicable instructions
	Engine misfiring	Test and replace injectors
	External fuel linkage sticking or binding	Disconnect fuel rack from governor and manually move linkage and progressively disconnect fuel pump links until binding area is found (dirt, paint, and misalignment are the usual causes of binding)
Governor rod end jiggles	Rough engine drive	Check alignment of gears; inspect for rough gear teeth; check backlash of gear
	Governor base not bolted down evenly	Loosen bolts; realign and secure

to governor control unless the speed adjustment of the load changes.

JIGGLES: High-frequency vibrations of the governor fuel rod end or engine fuel linkage. Do not confuse jiggle with the normal regulating action of the governor.

When normal governor adjustments do not give the desired response, the hydraulic governor should be removed and you should send it to a repair activity for cleaning, overhaul, and recalibration. You should have a spare governor so that the engine can be operated during the governor overhaul period and other PMS that require removal of the original governor.

MECHANICAL GOVERNORS

The Navy generally uses the spring-loaded flyball-type mechanical governors. All flyball-type mechanical governors have speed droop. This means, as the load is increased at a constant throttle setting, the speed of the engine will drop or droop slightly, rather than remain constant. Consequently, mechanical governors of this type are never used where absolute constant speeds are necessary.

Besides the spring-loaded flyball-type governors, there are several other types of mechanical governors. The two most common types are used on GM 71 engines. One type, the constant-speed governor, is used on generator sets and is designed to hold the speed of the engine at a predetermined operating speed. The other type, similar in construction, is used primarily for propulsion engines. It has a throttle plate designed so that intermediate speeds may be obtained by manual adjustment. Notice that there is no buffer spring adjustment on the constant-speed governor. The following description applies to both types of governors.

In the idling speed range, control is effected by centrifugal force on the two sets of large and small flyweights, as shown in figure 4-1. This flyweight force acts against a light (low-speed) spring. Maximum speed

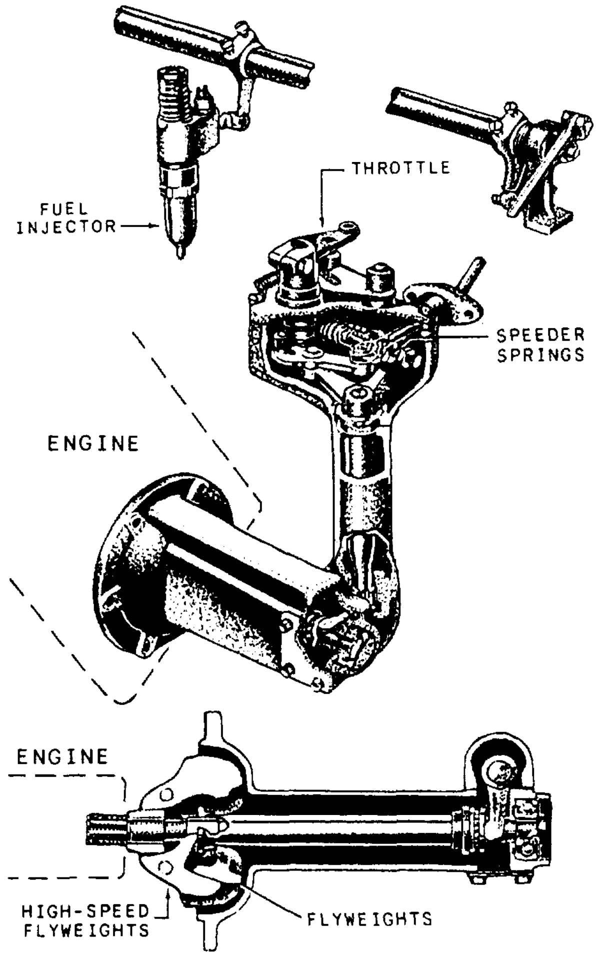


Figure 4-1.—GM mechanical governor.

control is effected by the action of the high-speed (small) flyweights acting against a heavy (high-speed) spring. See figure 4-2. If you have any questions or need more illustrations to understand the concept of governor operations, refer to chapter 9 of *Engineman 3,* NAVEDTRA 10539.

Mechanical governor faults are usually revealed in speed variations. But not all speed variations are faults of the governor. When abnormal speed variations appear, you should first do the following procedures:

1. Check the load to be sure the speed changes are not the result of load fluctuations.

2. If the load is steady, check the engine to make sure all the cylinders are firing properly.

3. Make sure there is no binding in the governor mechanism or operating linkage between the governor and the engine. There should be no binding in the injector control rack shaft or its mounting brackets. If you find no binding anywhere and the governor still fails

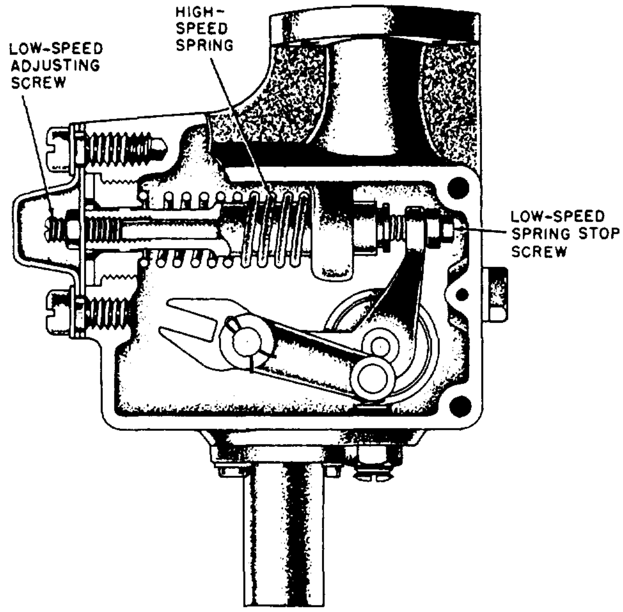


Figure 4-2.—Mechanical governor control mechanism.

to control the engine properly, you may assume that the governor is worn or inoperative.

If the governor is the cause of improper speed variations, it must be completely disassembled, inspected, and rebuilt or replaced. When it is necessary to disassemble and reassemble the governor, you should secure a copy of the manufacturer's instruction book and follow the instructions given. During reassembly of the governor, use only hard grease on the gasket! Under NO circumstances should you use shellac on the gasket. Adjustment procedures for the replacement of any governor are listed in the manufacturer's instruction manual and should be followed with particular attention given to the precautions listed.

OVERSPEED SAFETY DEVICES

Mechanical overspeed trips depend upon the centrifugal forces developed by the engine and must be maintained in good working condition. A faulty overspeed device can endanger not only the engine but also the personnel. The engine could explode or fly apart because of the uncontrolled speed.

The engine instruction manual contains information as to the speed at which the overspeed device is designed to function. Most overspeed trips are adjustable. Before making any changes in the adjustment of the overspeed trip, you must determine the cause. If the engine did not trip out, was it for some reason other than the action of the element of the overspeed trip? You should first check the accuracy of the tachometer and then test the overspeed trip. Remember that all spring tension and linkage adjustments to an overspeed are critical. Instructions for these adjustments are found in the manufacturer's instruction manual. You MUST follow these instructions!

Hydraulic overspeedtrips are extremely sensitive to dirt. Dirt or lacquer like deposits may cause the trip to bind internally. The speed-sensitive element and all parts of the linkage and mechanisms incorporated with the speed-sensitive element must be kept clean. When painting around the engine, you must avoid allowing paint to fall on joints, springs, pins, or other critical points in the linkage.

The overspeed trip will not function properly if parts arc bent, badly worn, improperly installed, or dirty, or if their motion is restricted by some other part of the engine. In some situations the driveshaft of the overspeed trip may be broken; this would prevent rotation of the flyweight and the overspeed trip. Insufficient oil in the hydraulic trip may be another source of trouble. You should maintain a proper oil level as specified by the instruction manual.

The following are some general procedures you should follow to keep the overspeed safety devices in proper operation:

– Keep the overspeed trip and its linkage clean.

– Remove the source of binding.

– Replace faulty parts.

– Maintain a proper oil level in the hydraulic overspeed trip.

– Adjust the speed-sensitive element according to the instruction manual.

– If the trip has been damaged, replace it with a spare and completely rebuild or overhaul the damaged one according to the instruction manual.

Test overspeed trips and governor mechanisms once each quarter and after each major engine overhaul. To verify if the safety device is in proper working order, overspeed the engine. When you are making this test, use a tachometer to check the speed at which the overspeed mechanism will operate. These safety devices should operate at the speed specified in the engine instruction manual. If this information is not available, the following values should be used for the test:

- For large, slow-speed engines, the value is 107 percent maximum-rated speed.

- For high-speed engines, the value is 110 percent maximum-rated speed.

If there is any irregularity during testing, stop the test and check the overspeed safety device and correct the problem before continuing the test procedure.

SUMMARY

This chapter has presented several common facts in maintenance, repair, and overhaul of speed controlling devices. Maintenance personnel must secure the appropriate manufacturer's instruction manual. No repair, maintenance, or overhaul of these precision pieces of equipment should be made until the appropriate manual is obtained. You must read, understand, and strictly follow the instructions from the manufacturer. Be sure to pay particular attention to any safety precautions given in these instructions.

CHAPTER 5

REFRIGERATION AND AIR CONDITIONING

As an EN3, you have learned the principles of refrigeration and air conditioning; the components and accessories that make up the system; and how to start, operate, and secure refrigeration and air-conditioning plants. As an EN2, you will perform routine maintenance jobs, such as cleaning, lubricating, troubleshooting, servicing the system, using correct procedures for leak detecting, and charging the refrigeration and air-conditioning plants. As you advance in rate, you will be expected to have a greater knowledge of the construction and operating principles of refrigeration and air-conditioning plants. You will be required to perform more complicated maintenance jobs, to make repairs as required, and to determine the causes of inefficient plant operation and accomplish the necessary corrective procedures. This chapter provides some general information on the construction and maintenance of refrigeration and air-conditioning equipment and the detection and correction of operating difficulties.

Refer to the manufacturer's technical manual for details of the plant on your ship. If you have any questions about the basic theory of refrigeration and air conditioning, refer to *EN3,* chapters 16 and 17.

R-12 REFRIGERATION SYSTEM

We will present the R-12 system as though it had only one evaporator, one compressor, and one condenser. A refrigeration system may (and usually does) include more than one evaporator, and it may include an additional compressor and condenser units.

COMPRESSORS

Many different types and sizes of compressors are used in refrigeration and air-conditioning systems. They vary from the small hermetic units used in drinking fountains and refrigerators to the large centrifugal units used for air conditioning.

One of the most common compressors on modem ships is a high-speed unit with a variable capacity. This compressor is a multicylinder, reciprocating design with an automatic device built into the compressor to control its output. This automatic capacity control provides for continuous compressor operation under normal load conditions. The capacity of the compressor is controlled by unloading and loading the cylinders. This is a very desirable design feature of the unit. If the compressor had to be started under a load, or with all cylinders working, a much greater amount of torque would be required, and it would be necessary to have a much larger drive motor. Also, if the compressor ran at constant capacity or output, it would reach the low-temperature or low-pressure limits or be constantly starting and stopping, thereby putting excessive work on the unit.

Unloading of the cylinders in the compressor is accomplished by lifting the suction valves off their seats and holding them open. This method of capacity control unloads the cylinders completely but still allows the compressor to work at as little as 25 percent of its rated capacity .

Unloader Mechanism

When the compressor is not in operation, the unloader mechanism is in the unloaded position as shown in figure 5-1. The mechanism is operated by oil pressure from the capacity control valve. The oil pressure pushes the unloader spring against the unloader piston. This action moves the unloader rod to the left, thereby rotating the cam rings. As the cam rings are rotated, the lifting pins are forced upward, raising the suction valve off its seat. The suction valve is held in this position until the compressor is started and oil pressure of approximately 30 psi is reached. At that time, the oil pressure from the capacity control valve pushes the unloader piston back to the right against the unloader spring. The motion transmitted through the pushrod rotates the cam ring. This lowers the lifting pins and allows the suction valve to close or operate normally and the cylinder to become loaded (fig. 5-2). On most compressors the unloader is connected to the cylinders in pairs.

Capacity Control Valve

The capacity control valve (fig. 5-3) is located in the compressor crankcase cover. The valve is actuated by oil pressure from the main oil pump. It admits or relieves oil to or from the individual unloader power elements,

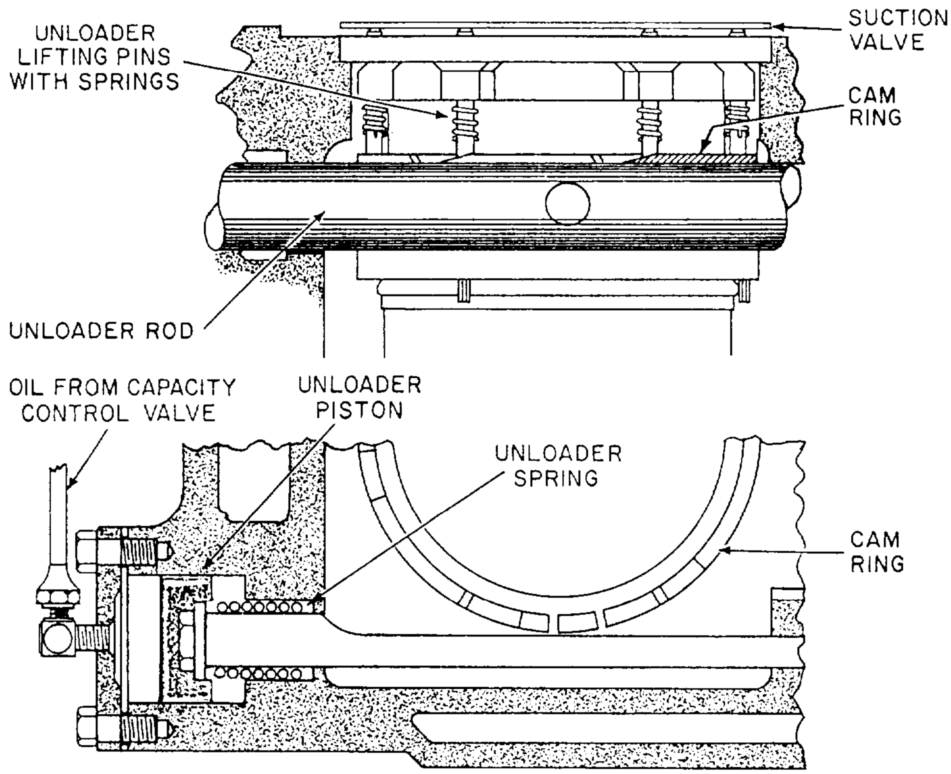


Figure 5-1.—Unloader mechanism in the unloaded position.

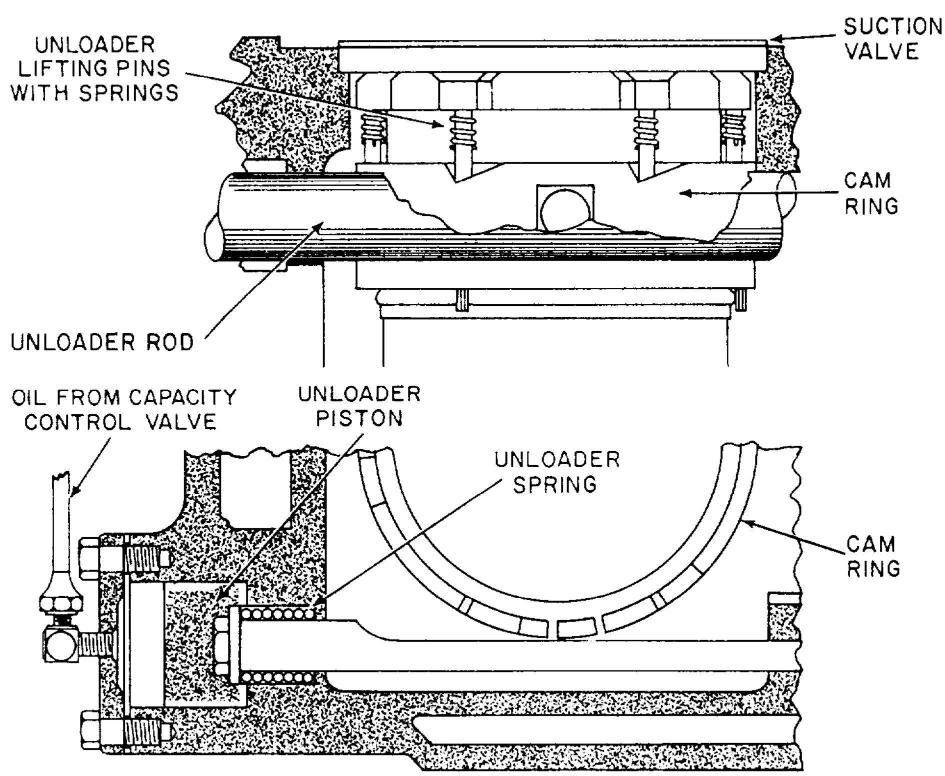


Figure 5-2.—Unloader mechanism in the loaded position.

depending on suction or crankcase pressure. Figure 5-3 shows the compressor at rest. The two cylinders equipped with the unloader element are unloaded and will remain unloaded until the compressor is started and the oil pressure reaches normal operating pressure.

The high-pressure oil from the pump enters chamber A of the capacity control valve. It then passes through an orifice in the top of the piston to chamber B, forcing the piston to the end of its stroke against spring A. When the piston of the valve is forced against spring

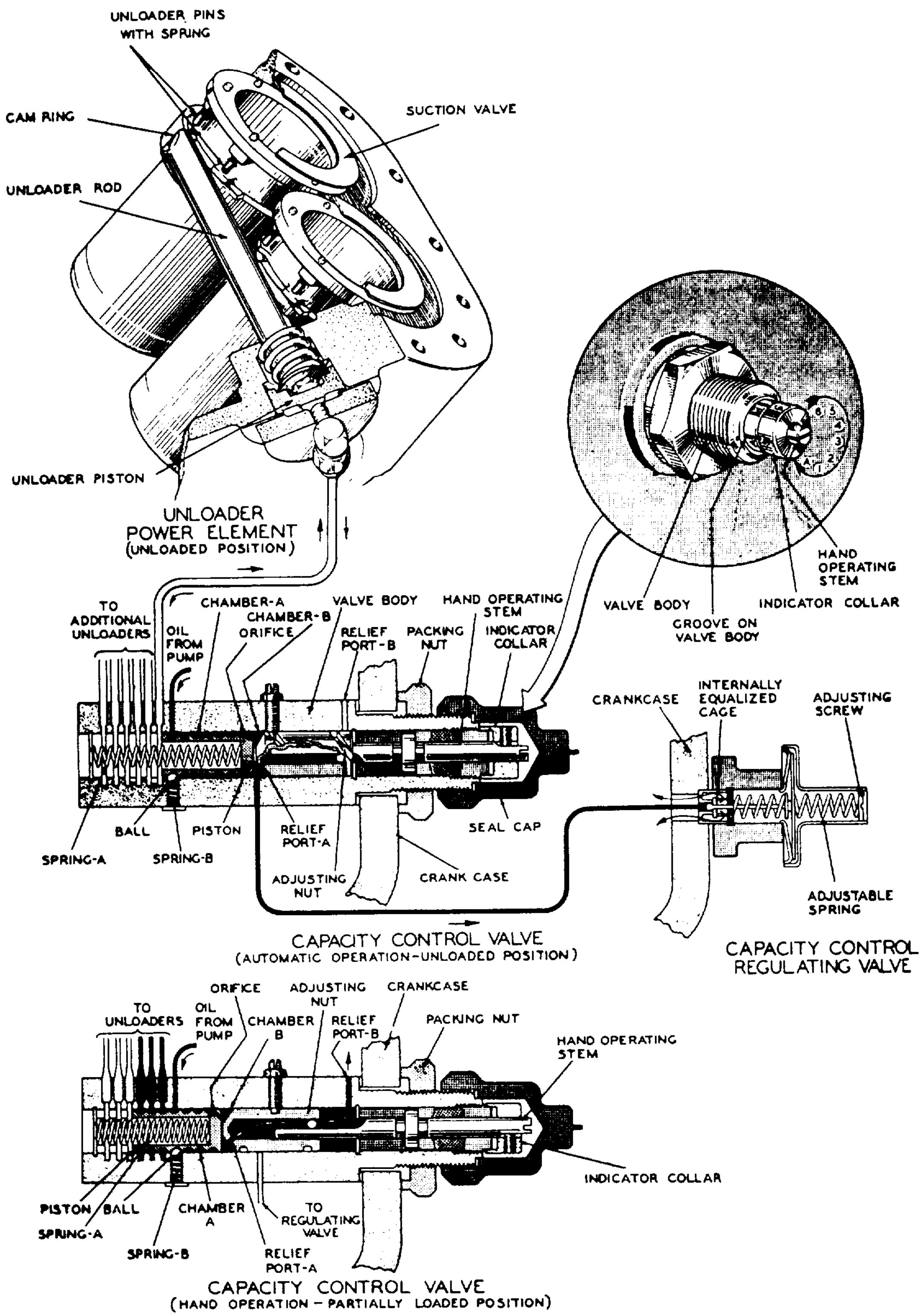


Figure 5-3.—Capacity control system.

A, the circular grooves that form chamber A are put in communication with the unloader connections. This admits high-pressure oil to the unloader cylinder and actuates the unloader mechanism.

A capacity control regulating valve controls oil pressure from the capacity control valve. It is connected to the crankcase and has an oil-connecting line to chamber B of the capacity control valve. As the crankcase or suction pressure pulls down slightly below the setting of the regulating valve, the regulator opens and relieves oil pressure from chamber B of the capacity control valve. This permits spring A to push the capacity control piston one step toward chamber B, uncovering the unloader connection nearest the end of the capacity control valve. This relieves oil pressure from the power element and allows the power element spring to rotate the cam rings and unload the cylinder.

If the suction pressure continues to drop, the regulator will relieve more oil pressure and unload more cylinders. If the heat load increases, the suction pressure will increase, causing the regulating valve to close and load more cylinders.

MAINTENANCE

As an Engineman, maintaining the refrigeration and air-conditioning plants may be one of your responsibilities. To do this, you must understand the maintenance procedures. In most instances, personnel who are assigned to maintain refrigeration plants are graduates of the Navy's air-conditioning and refrigeration school. This school teaches most operating and maintenance procedures. However, you should refer to the manufacturer's technical manuals for the details of the plants on your ship.

Testing Suction and Discharge Valves

Faulty compressor valves may be indicated by either a gradual or a sudden decrease in the normal compressor capacity. Either the compressor will fail to pump, or the suction pressure cannot be pumped down to the designed value, and the compressor will run for abnormally long intervals or continuously. You may get a rapid buildup of suction (crankcase) pressure during an off cycle. This causes the compressor to start after a very short off-period and indicates leaking discharge valves.

If the refrigeration plant is not operating satisfactory, you should first shift the compressors and then check the operation of the plant. If the operation of the plant is satisfactory when the compressors have been shifted, the trouble is in the compressor and not in the system.

To test the compressor discharge valves, pump down the compressor to 2 psig. Then stop the compressor and quickly close the suction and discharge line valves. If the discharge pressure drops at a rate in excess of 3 pounds in a minute and the crankcase suction pressure rises, this is evidence of compressor discharge valve leakage. If you must remove the discharge valves with the compressor pumped down, open the connection to the discharge pressure gauge to release discharge pressure on the head. Then remove the compressor top head and discharge valve plate. Be careful not to damage the gaskets.

If the discharge valves are defective, replace the entire discharge valve assembly. Any attempt to repair them would probably involve relapping and would require highly specialized equipment. Except in an emergency, such repair should never be undertaken aboard ship.

You can check the compressor internal suction valves for leakage by following these steps:

1. Start the compressor by using the manual control switch on the motor controller.

2. Close the suction line stop valve gradually to prevent violent foaming of the compressor crankcase lubricating oil charge.

3. With this stop valve closed, pump a vacuum of approximately 20 in.Hg. If this vacuum can be readily obtained, the compressor suction valves are satisfactory.

Do not expect the vacuum to be maintained after the compressor stops, because the refrigerant is being released from the crankcase oil. Do not check the compressor suction valve efficiency of operation for at least 3 days. It may be necessary for the valves to wear in.

However, if any of the compressor suction valves are defective, you can pump down the compressor, open it, and inspect the valves. Replace defective valves or pistons with spare assemblies.

Crankcase Seal Repairs

There are several types of crankcase seals, depending on the manufacturer. On reciprocating compressors, the crankshaft extends through the compressor housing to provide a mount for the pulley wheel or flexible coupling. Now the shaft must be sealed to prevent leakage of lubricating oil and refrigerant. The crankshaft seal is bathed in lubricating oil at a pressure equal to the suction pressure of the refrigerant. The first indication of crankshaft seal failure is excessive oil leaking at the shaft.

When the seal must be replaced or when it shows signs of abnormal wear or damage to the running surfaces, a definite reason can be found for the abnormal conditions. Make an inspection to locate and correct the trouble, or the failure will recur.

Seal failure is very often caused by faulty lubrication, usually because of the condition of the crankcase oil. A dirty or broken oil seal is generally caused by one or both of the following conditions:

- Dirt or foreign material is in the system or system piping. Dirt frequently enters the system at the time of installation. After a period of operation, foreign material will accumulate in the compressor crankcase, tending to concentrate in the oil chamber surrounding the shaft seal. When the oil contains grit, it is only a matter of time until the highly finished running faces become damaged, causing failure of the shaft seal.

- Moisture is frequently the cause of an acid condition of the lubricating oil. Oil in this condition will not provide satisfactory lubrication and will cause failure of the compressor parts. Use a refrigerant dehydrator when the compressor is put into operation if you suspect that moisture may be a problem. Anytime foreign material is found in the lubricating oil, thoroughly clean the entire system (piping, valves, and strainers).

REMOVING A SHAFT SEAL.—If a shaft seal must be removed, proceed as follows:

If the seal is broken to the extent that it permits excessive oil leakage, do NOT attempt to pump the refrigerant out of the compressor. If you do, air containing moisture will be drawn into the system through the damaged seal. Moisture entering the refrigerant system may cause expansion valves to freeze. This can cause acid formation and other problems. If oil is leaking excessively, close the compressor suction and discharge valves and relieve the pressure to the atmosphere by loosening a connection on the compressor discharge gauge line.

Next, drain the oil from the compressor crankcase. Since the oil contains refrigerant, it will foam while being drained. Leave the oil drain valve or plug open while you are working on the seal. This ensures that refrigerant escaping from the oil remaining in the crankcase will not build up pressure and blow out the seal while it is being removed.

Remove the compressor flywheel (or coupling) and carefully remove the shaft seal assembly. If the assembly cannot be readily removed, build up a slight pressure in the compressor crankcase. To do this, slightly open the compressor suction valve. Take the necessary precautions to support the seal and to prevent it from being blown from the compressor and damaged.

INSTALLING A SHAFT SEAL.—Clean and replace the entire seal assembly according to the manufacturer's instructions.

Wipe the shaft clean with a linen or silk cloth; do not use a dirty or lint-bearing cloth. Be careful not to touch the bearing surfaces with your hands as you unwrap the seal. Rinse the seal in an approved solvent and allow it to air-dry. (Do NOT wipe the seal dry!) Dip the seal in clean refrigerant oil. Follow the instructions found in the manufacturer's technical manual to insert the assembly. Bolt the seal cover in place and tighten the bolts evenly. Replace the flywheel and belts or coupling and check and correct the motor and compressor shaft alignment. To test the unit for leaks, open the suction and discharge valves and use a halide leak detector.

Evacuating the Compressor

Whenever repairs to a compressor allow any appreciable amount of air to enter the unit, the compressor should be evacuated after assembly is completed and before it is ready for operation The proper procedure is as follows:

1. Disconnect a connection in the compressor discharge gauge line between the discharge line stop valve and the compressor.

2. Start the compressor and let it run until the greatest possible vacuum is obtained.

3. Stop the compressor and immediately open the suction stop valve slightly. This will blow refrigerant through the compressor valves and purge the air above the discharge valves through the open gauge line.

4. Close the discharge gauge line and open the discharge line stop valve.

5. Remove all oil from the exterior of the compressor.

6. Test the compressor joints for leakage using the halide leak detector.

Cleaning Suction Strainers

When putting a new unit into operation, you should clean the suction strainers after a few hours of operation. Refrigerants have a solvent action and will loosen any foreign matter in the system. This foreign matter will eventually reach the suction strainers. After a few days of operation, the strainers will need another cleaning. Inspect them frequently during the first few weeks of plant operation and clean as necessary.

The suction strainers are located in the compressor housing or in the suction piping. The procedure for cleaning the strainers is as follows:

1. Pump down the compressor.

2. Remove the strainer and inspect it for foreign matter.

3. Dip the strainer screen in an approved solvent and allow it to dry.

4. Replace the strainer and evacuate the air from the compressor.

5. Test the housing for leaks by wiping up all oil and then using a halide leak detector.

Maintenance Precautions

Sometimes a compressor cannot be pumped down and is damaged to the extent that it has to be opened for repairs. If so, you should first close the suction and discharge valves. Then allow all refrigerant in the compressor to vent to the atmosphere through a gauge line.

When you must remove, replace, or repair internal parts of the compressor, observe the following precautions:

1. Carefully disassemble and remove parts; note the correct relative position so that errors will not be made when you reassemble.

2. Inspect all parts that become accessible.

3. Make certain that all parts and surfaces are free of dirt and moisture.

4. Freely apply clean compressor oil to all bearing and rubbing surfaces of parts being replaced or reinstalled.

5. If the compressor is not equipped with an oil pump, make certain that the oil dipper on the lower connecting rod is in the correct position for dipping oil when the unit is in operation.

6. Position the ends of the piston rings so that alternate joints are on the opposite side of the piston

7. Take care not to score gasket surfaces.

8. Replace all gaskets.

9. Clean the crankcase and replace the oil.

CONDENSERS

The compressor discharge line terminates at the refrigerant condenser. In shipboard installations, these condensers are usually of the multipass shell-and-tube type, with water circulating through the tubes. The tubes are expanded into grooved holes in the tube sheet to make a tight joint between the shell and the circulating water. Refrigerant vapor is admitted to the shell and condenses on the outer surfaces of the tubes.

Any air or noncondensable gases that may accidentally enter the refrigeration system will be drawn through the piping and eventually discharged into the condenser with the refrigerant. The air or noncondensable gases accumulated in the condenser are lighter than the refrigerant gas. They will rise to the top of the condenser when the plant is shut down. A purge valve, for purging the refrigeration system (when necessary), is installed at the top of the condenser or at a high point in the compressor discharge line.

Cleaning Condenser Tubes

To clean the condenser tubes properly, first drain the cooling water from the condenser. Then disconnect the water connections and remove the condenser heads. Be careful not to damage the gaskets between the tube sheet and the waterside of the condenser heads. Inspect tubes as often as practical and clean them as necessary, using an approved method. Use rubber plugs and an air lance or a water lance to remove foreign deposits. You must keep the tube surfaces clear of particles of foreign matter. However, you must not destroy the thin protective coating on the inner surfaces of the tubes. If the tubes become badly corroded, replace them. Replacement avoids the possibility of losing the charge and admitting salt water to the system.

Cleaning Air-Cooled Condensers

Although the large plants are equipped with water-cooled condensers, auxiliary units are commonly provided with air-cooled condensers. The use of air-cooled condensers eliminates the necessity for circulating water pumps and piping.

Keep the exterior surface of the tubes and the fins on an air-cooled condenser free of dirt or any matter that might obstruct heat flow and air circulation. The finned surface should be brushed clean with a stiff bristle brush as often as necessary. Low-pressure air is very useful in removing dirt in hard-to-reach places on condensers. When installations are exposed to salt spray and rain through open doors or hatches, you should take steps to minimize corrosion of the exterior surfaces.

Testing For Leaks

To prevent serious loss of refrigerant through leaky condenser tubes, test the condenser for leakage by following the PMS.

To test for leaky condenser tubes, drain the waterside of the condenser. Then insert the exploring tube of the leak detector through one of the drain plug openings. If this test indicates that Freon gas is present, you can find the exact location of the leak by following these steps:

1. Remove the condenser heads.

2. Clean and dry the tube sheets and the ends of the tubes.

3. Check both ends of each tube with a leak detector. Mark any tubes that show leakage. If you cannot determine that a tube is leaking internally or around the tube sheet joint, plug the suspected tube and again check around the tube sheet joint. Mark the adjacent tube, if necessary, to isolate the suspected area.

4. To locate or isolate very small leaks in the condenser tubes, hold the exploring tube at one end of the condenser tube for about 10 seconds to draw fresh air through the tube. Repeat this procedure with all the tubes in the condenser. Allow the condenser tubes to remain plugged for 4 to 6 hours; then, remove the plugs one at a time and check each tube for leakage. If a leaky tube is detected, replace the plug immediately to reduce the amount of refrigerant escaping. Make appropriate repairs or mark and plug all leaky tubes for later repairs.

Plugging or Retubing Condensers

The general procedures for plugging or retubing condensers can be found in *Naval Ship's Technical Manual (NSTM)*, Chapter 254, “Condensers, Heat Exchangers, and Air Ejectors.” When plugging or retubing a specific condenser, follow the procedures in the manufacturer’s technical manual.

THERMOSTATIC EXPANSION VALVES

The thermostatic expansion valve is essentially a reducing valve between the high-pressure side and the low-pressure side of the system. The valve is designed to proportion the rate at which the refrigerant enters the cooling coil to the rate of evaporation of the liquid refrigerant in the coil; the amount depends, of course, on the amount of heat being removed from the refrigerated space.

When the thermostatic expansion valve is operating properly, the temperature at the outlet side of the valve is much lower than that at the inlet side. If this temperature difference does not exist when the system is in operation, the valve seat is probably dirty and clogged with foreign matter.

Once a valve is properly adjusted, further adjustment should not be necessary. The major trouble can usually be traced to moisture or dirt collecting at the valve seat and orifice.

Testing and Adjustment

The thermostatic expansion valves used in most shipboard systems can be adjusted by means of a gear and screw arrangement to maintain a superheat ranging from about 4°F to 12°F at the cooling coil outlet. The proper superheat adjustment varies with the design and service operating conditions of the valve and the design of the particular plant. Increased spring pressure increases the degree of superheat at the coil outlet. Decreased spring pressure decreases the degree of superheat at the coil outlet.

Some thermostatic expansion valves have a fixed (nonadjustable) superheat. These valves are used primarily in self-contained equipment where the piping configuration and evaporating conditions are constant.

If expansion valves are adjusted to give a high superheat at the coil outlet or if the valve is stuck shut, the amount of refrigerant admitted to the cooling coil will be reduced. With an insufficient amount of refrigerant, the coil will be “starved” and will operate at a reduced capacity. Also, the velocity of the refrigerant through the coil may not be adequate to carry oil through the coil. This robs the compressor crankcase and provides a condition where slugs of lubricating oil may be drawn back into the compressor. If the expansion valve is adjusted for too low a degree of superheat or if the valve is stuck open, liquid refrigerant may flood from the cooling coils back into the compressor. When liquid refrigerant collects at a low point in the suction line or coil and is drawn back into the compressor intermittently in slugs, there is danger of injury to the moving parts of the compressor.

In general, the expansion valves for air-conditioning and water-cooling plants (high-temperature installations) normally are adjusted for higher superheat than the expansion valves for cold storage refrigeration and ship's service store equipment (low-temperature installations).

You may not be able to adjust expansion valves to the desired settings, or you may suspect that the expansion valve assembly is defective and requires replacement. In either case, you should make appropriate tests. First you should be sure that the liquid strainers are clean, that the solenoid valves are operative, and that the system is sufficiently charged with refrigerant.

The major pieces of equipment required for expansion valve tests is as follows:

- A service drum of R-12 or a supply of clean, dry air at 70 to 100 psig. The service drum is used to supply gas under pressure. The gas does not have to be the same as that used in the thermal element of the valve being tested.

- A high-pressure and a low-pressure gauge. The low-pressure gauge should be accurate and in good condition so that the pointer does not have any appreciable lost motion. The high-pressure gauge, while not absolutely necessary, will be useful in showing the pressure on the inlet side of the valve. Refrigeration plants are provided with suitable replacement and test pressure gauges.

The procedure for testing is as follows:

1. Connect the valve inlet to the gas supply with the high-pressure gauge attached to indicate the gas pressure to the valve. Connect the low-pressure gauge loosely to the expansion valve outlet. The reason the low-pressure gauge is connected loosely is to allow a small amount of leakage through the connection.

2. Insert the expansion valve thermal element in a bath of crushed ice. Do NOT attempt to perform this test with a container full of water in which a small amount of crushed ice is floating.

3. Open the valve on either the service drum or in the air supply line. Make certain that the gas supply is sufficient to build up the pressure to at least 70 psi on the high-pressure gauge connected in the line to the valve inlet.

4. The expansion valve can now be adjusted. If you want to adjust for 10°F superheat, the pressure on the outlet gauge should be 22.5 psig. This is equivalent to an R-12 evaporating temperature of 22°F. Since the ice maintains the bulb at 32°F. the valve adjustment is for 10°F superheat (difference between 32 and 22). For a 5°F superheat adjustment, the valve should be adjusted to give a pressure of approximately 26.1 psig. There must be a small amount of leakage through the low-pressure gauge connection while this adjustment is being made.

5. To determine if the valve operates smoothly, tap the valve body lightly with a small weight. The low-pressure gauge needle should not jump more than 1 psi.

6. Now tighten the low-pressure gauge connection to stop the leakage at the joint and determine if the expansion valve seats tightly. If the valve is in good condition, the pressure will increase a few pounds and then either stop or build up very slowly. But with a leaking valve, the pressure will build up rapidly until it equals the inlet pressure. With externally equalized valves, the equalizer line must be connected to the piping from the valve outlet to the test gauge to obtain an accurate superheat setting.

7. Again loosen the gauge to permit leakage at the gauge connection. Remove the thermal element, or control bulb, from the crushed ice. Warm it with your hands or place it in water that is at room temperature. When this is done, the pressure should increase rapidly, showing that the power element has not lost its charge. If there is no increase in pressure, the power element is dead.

8. With high pressure readings showing on both gauges, the valve can be tested to determine if the body joints or the bellows leak This can be done by using a halide leak detector. When you perform this test, it is important that the body of the valve have a fairly high pressure applied to it. In addition, the gauges and other fittings should be made up tightly at the joints to eliminate leakage at these points.

Replacement of Valves

If the expansion valve is defective, it must be replaced. Most valves used on naval ships have replaceable assemblies. Sometimes it is possible to replace a faulty power element or some other part of the valve without having to replace the entire assembly. When replacement of an expansion valve is necessary, you must replace the unit with a valve of the same capacity and type.

ADDITIONAL SYSTEM MAINTENANCE

In addition to the maintenance of the components previously described, other parts of the system will need periodic maintenance to keep the plant operating properly.

Vibration may cause leakage in the piping system. This leakage may allow air and moisture to be drawn in or a loss of refrigerant charge. If this happens, the plant operation will become erratic and inefficient, and the cause of trouble must be corrected.

CHARGING THE SYSTEM

Information concerning the charging of refrigeration systems may be found in *NSTM*, Chapter 516, “Refrigeration System.” The amount of refrigerant charge must be sufficient to maintain a liquid seal between the condensing and evaporating sides of the system. Under normal operating conditions, when the compressor stops, the receiver of a properly charged system is about 85 percent full of refrigerant. The proper charge for a specific system or unit can be found in the manufacturer’s technical manual or on the ship’s blueprints.

A refrigeration system should not be charged if it has leaks or if you have a reason to believe the system has a leak. The leaks must be found and corrected. Immediately following-or during-the process of charging, you should carefully check the system for leaks.

A refrigeration system must have an adequate charge of refrigerant at all times; otherwise, its efficiency and capacity will be impaired.

PURGING THE SYSTEM

To determine if the system contains noncondensable gases, operate the system for 30 minutes. Stop the compressor for 10 to 15 minutes, leaving all the valves in their normal positions. Observe the pressure and temperature as indicated on the high-pressure gauge. Read the thermometer in the liquid line, or read the temperature of the cooling water discharge from the condenser. Compare the temperature reading with the temperature conversion figures shown on the discharge pressure gauge. If the temperature of the liquid leaving the receiver is more than 5°F lower than the temperature corresponding to the discharge pressure, the system should be purged. Pump the system down and secure the compressor; then open the purge valve on the condenser. Purge very slowly, at intervals, until the air is expelled from the system and the temperature difference drops below 5°F.

CLEANING LIQUID LINE STRAINERS

Where a liquid line strainer is installed, it should be cleaned at the same intervals as the suction strainer. If a liquid line strainer becomes clogged to the extent that it needs cleaning, a loss of refrigeration will take place. The tubing on the outlet side of the strainer will be much colder than the tubing on the inlet side.

To clean the liquid line strainer, secure the receiver outlet valve and wait a few minutes to allow any liquid in the strainer to flow to the cooling coils. Then close the strainer outlet valve and very carefully loosen the cap that is bolted to the strainer body. (Use goggles to protect your eyes!) When all the pressure is bled out of the strainer, remove the cap and lift out the strainer screen. Clean the strainer screen with an approved solvent and a small brush. Reinstall the spring and screen in the strainer body; then replace the strainer cap loosely. Purge the air out of the strainer by blowing refrigerant through it; then tighten the cap. After the assembly is complete, test the unit for leaks.

CLEANING OIL FILTERS AND STRAINERS

Compressors arranged for forced-feed lubrication have lubricating oil strainers in the suction line of the lube-oil pump. An oil filter may be installed in the pump discharge line. A gradual decrease in lubricating oil pressure indicates that these units need cleaning. This cleaning is done in much the same manner as described for cleaning suction strainers.

When cleaning is necessary, drain the lubricating oil in the crankcase from the compressor. Add a new charge of oil, equal to the amount drained, before restarting the unit. When the compressor is put back into operation, adjust the lube-oil pressure to the proper setting by adjusting the oil pressure regulator.

MAINTAINING COOLING COILS

You should inspect the cooling coils regularly and clean them as required. Defrost the cooling coils as often as necessary to maintain the effectiveness of the cooling surface. Excessive buildup of frost on the cooling coils will result in reduced capacity of the plant, low compressor suction pressure, and a tendency for the compressor to short-cycle. The maximum time interval between defrostings depends on such factors as condition of door gaskets, moisture content of supplies placed in boxes, frequency of opening doors, atmospheric humidity, and refrigerant evaporating temperatures.

You should always defrost the cooling coils before the frost thickness reaches three-sixteenths of an inch. When defrosting the coils, be sure that you do NOT try to scrape or break the frost off. Improper defrosting will cause serious damage to the coils.

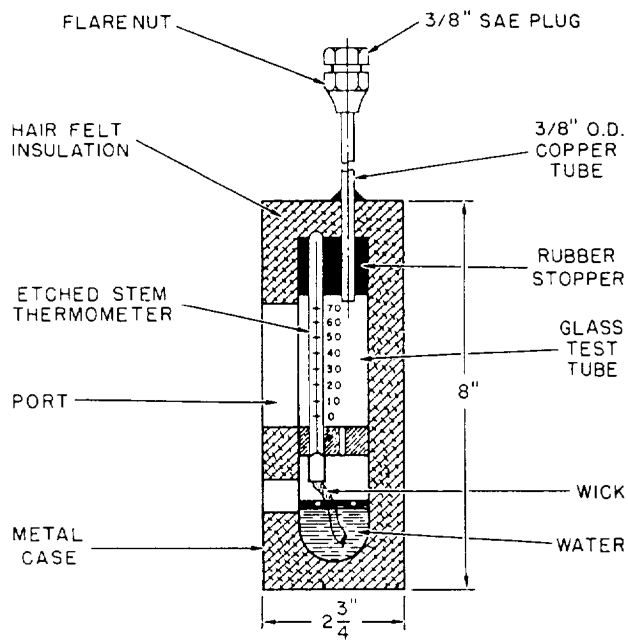
EVACUATING AND DEHYDRATING THE SYSTEM

In areas where moisture accumulation must be corrected, the system should first be cleared of refrigerant and air. The time required will depend upon the size of the system and the amount of moisture present. It is a good engineering practice to circulate heated air through a large dehydrator system for several hours, or as long as the dehydrator drying agent remains effective, before proceeding with the evacuation process. If possible, the dehydrated air should be heated to about 240°F.

Large dehydrators, suitable for preliminary dehydration of refrigeration systems, are usually available at naval shipyards and on board tenders and repair ships. After the preliminary dehydration, the remaining moisture is evacuated by means of a two-stage, high-efficiency vacuum pump having a vacuum indicator. (These vacuum pumps are available on board tenders and repair ships.)

The vacuum indicator shown in figure 5-4 consists of an insulated test tube containing a wet-bulb thermometer with its wick immersed in distilled water. The indicator is connected in the vacuum pump suction line. The suction line from the vacuum pump is connected to the refrigeration system. The refrigerant circuit should be closed to the atmosphere and the charging connection opened to the vacuum pump.

A two-stage vacuum pump is started for operation in PARALLEL so that maximum displacement may be obtained during the initial pump-down stages. When the indicator shows a temperature of about 55°F (0.43 in.Hg, absolute), the pumps are placed in SERIES operation (where the discharge from the first step enters the suction of the second step pump). The dehydration process will produce a temperature drop of the vacuum



CONVERSION TEMPERATURE °F TO ABSOLUTE PRESSURE INCHES MERCURY

TEMPERATURE °F	ABSOLUTE PRESSURE INCHES MERCURY
60	0.521
55	0.436
50	0.362
45	0.300
40	0.248
35	0.204
32	0.181

Figure 5-4.—Dehydrator vacuum indicator.

indicator as shown in figure 5-5. Readings will initially reflect ambient temperatures, then show rapidly falling temperatures until the water in the system starts to boil.

When most of the evaporated moisture has been evacuated from the system, the indicator will show a

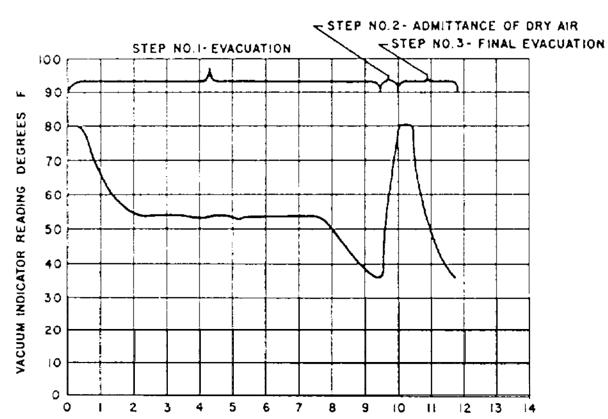


Figure 5-5.—Vacuum indicator readings plotted during dehydration.

decrease in temperature. When the temperature reaches 35°F (0.2 in.Hg, absolute), dry air should be admitted through a chemical dehydrator into the system at a point farthest from the pump. Continue operating the pump so the dry air will mix with and dilute any remaining moisture. Secure the opening that feeds the dry air into the system. Continue evacuating the system until the indicator again shows a temperature of 35°F. The dehydration process is complete. Close the valves and disconnect the vacuum pump.

Sometimes obtaining a temperature as low as 35°F in the vacuum indicator will be impossible. The probable reasons for such a failure and the corrective procedures to take are as follows:

- Excess moisture in the system. The dehydration procedure should be conducted for longer periods.
- Absorbed refrigerant in the lubricating oil contained in the compressor crankcase. Remove the lubricating oil from the crankcase before proceeding with the dehydration process.
- Leakage of air into the system. The leak must be found and stopped. You must then repeat the procedure required for detecting leaks in the system.
- Inefficient vacuum or defective vacuum indicator. The defective unit(s) should be repaired or replaced.

Immediately after each period of use or after the system has been opened for repairs, replace the drying agent in the dehydrator. If a replacement cartridge is not available, reactivate the drying agent and use it until a replacement is available.

You can reactivate the drying agent by removing and heating it for 12 hours at a temperature of 300°F to bake out the moisture. Place the drying agent in an oven or circulate a stream of hot air through the cartridge. Both methods are satisfactory for reactivating commonly used dehydrating agents such as activated alumina or silica gel. The specific instructions furnished by the manufacturer should be followed to reactivate special drying agents.

After reactivation, replace the drying agent in the dehydrator shell and seal it as quickly as possible. This prevents absorption of atmospheric moisture. When the drying agent becomes fouled or saturated with lubricating oil, replace it with a fresh charge, or dehydrator cartridge, taken from a sealed container.

Remember that the dehydrators permanently installed in refrigeration systems of naval ships are designed to remove only the minute quantities of moisture unavoidably introduced into the system. You must be careful to prevent moisture or moisture-laden air from entering the system.

CLEANING THE SYSTEM

Systems may accumulate dirt and scale as a result of improper techniques used during repair or installation of the system. If such dirt is excessive and a tank-type cleaner is available, connect the cleaner to the compressor suction strainer. When such a cleaner is not available, a hard, wool felt filter about five-sixteenths inch thick should be inserted into the suction strainer screen. Run the plant with an operator in attendance for at least 36 hours or until the system is clean. The length of time required for a clean system depends upon the size and condition of the plant.

AIR-CONDITIONING SYSTEM

Most of the information presented so far applies to the refrigeration side of a system, whether it is used for a refrigeration plant or for air conditioning. The compressor controls for both types of systems are nearly identical; however, the devices used to control space temperatures differ, The two-position dual control, called 2PD, is used for the automatic control of most shipboard air-conditioning systems.

TWO-POSITION DUAL CONTROL (2PD)

This control is used on three types of systems:

Type 1. Systems employing a simple thermostatically controlled single-pole switch to control flow of refrigerant to the cooling coil

Type 2. Systems using reheaters, employing a ther- mostatic element actuating two interlocked switches

Type 3. Systems using reheaters in the same manner as those in type 2, with control of humidity added where specified

The type 1 system, because of its simplicity, requires little explanation. The thermostat consists of a temperature-sensing element actuating a single-pole, single-throw switch. It opens and closes a magnetic valve to start and stop the flow of refrigerant-chilled water or commercial refrigerant. This type of control is similar to the thermostatic control for the refrigeration plant. The type 1 system requires single-pole thermostats, but type 2 and type 3 systems can use two-position dual controls (2PD). The cooling switch would then be connected in the normal manner with the heating switch inoperative.

The type 2 system is most commonly used to make living and working spaces more habitable and for various types of weapons systems that require cooling. These systems often use a common cooling coil serving several different spaces. Since load changes seldom occur simultaneously, electric or steam reheaters are installed in the cooling air ducts. The cooling thermostats of the various spaces are connected in parallel so that any one of the thermostats may open the cooling coil valve.

Suppose three spaces are being cooled by a common coil. Space B in figure 5-6 has a load change and spaces A and C do not. With the coil operating to take care of space B, these spaces would become too cold for comfort. To prevent this condition, the thermostat would close the heating switch and energize the reheaters for spaces A and C.

The type 3 system is identical to the type 2 system, except that a humidistat is wired in parallel with the thermostatic heating switch. This type of system is used mostly in weapons and electronic spaces. The humidistat is set for the relative humidity desired. In most installations, it is only necessary to prevent the humidity from exceeding 55 percent. Where the humidistat is installed, an increase in temperature beyond the thermostat setting will close the thermostat cooling switch. An increase in relative humidity beyond the humidistat setting will close the heating switch and energize the reheaters.

MAINTENANCE

Proper attention to the planned maintenance system often exposes developing troubles in time to take corrective action. Since most breakdowns occur at the most inopportune times, periodic checks and maintenance will help to avoid malfunctions.

The 2PD control system can easily be checked out in a reasonably short time. The checkout should be made at least every 3 months or more often if necessary. Inspections and checks should be made at the beginning of, and midway through, the cooling season and heating season.

You should inspect the sensing elements and remove any dust accumulations. Remove dust and dirt from thermostatic sensing elements with a soft brush. Use air to gently blow off any dust on the sensing elements in humidistats. The air will not damage the element but will remove any problem-causing dust.

Magnetic valves should be checked for operation. Be sure that they open and close completely.

Set points of the thermostats and the humidistats should be checked with a calibrated thermometer and a reliable humidity indicator.

When servicing the two-position control system, look for three possible sources of trouble:

- The sensing element and its associated mechanism

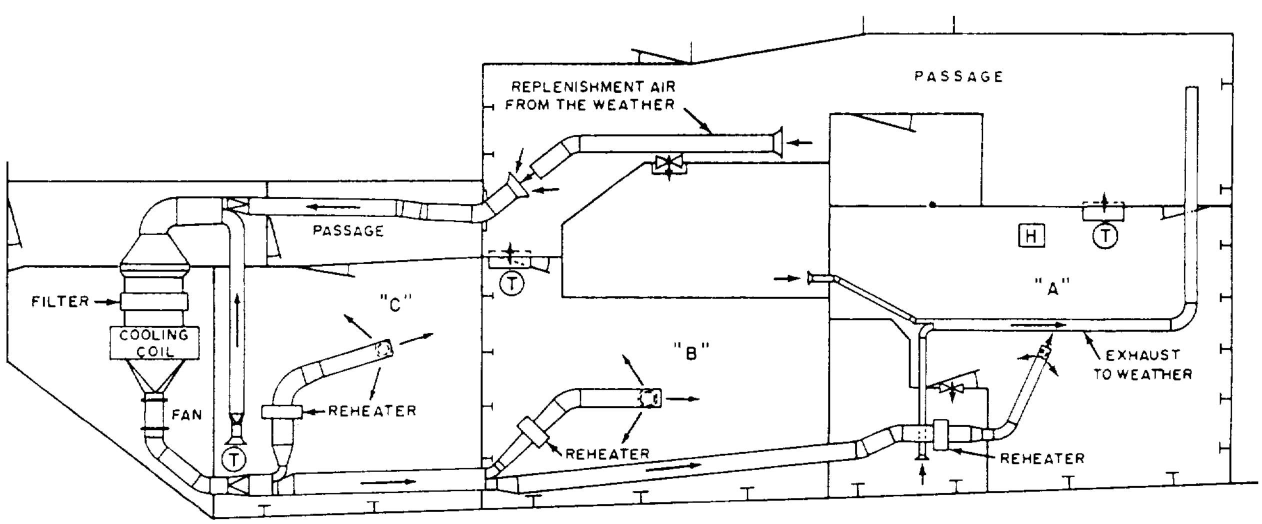


Figure 5-6.—A typical air-conditioning system.

- The magnetic valves that control the flow of refrigerant
- The wiring system that connects the sensing elements to the solenoids of the magnetic valves and the controller of the electric heaters

DETECTING AND CORRECTING PROBLEMS

A number of symptoms indicate faulty operation of refrigeration and air-conditioning plants. Figures 5-7, 5-8, and 5-9 list some of the problems along with

Trouble	Possible Cause	Corrective Measure
High condensing pressure.	Air on noncondensable gas in system.	Purge air from condenser
	Inlet water warm.	Increase quantity of condensing water.
	Insufficient water flowing through condenser.	Increase quantity of water.
	Condenser tubes clogged or scaled.	Clean condenser water tubes.
	Too much liquid in receiver, condenser tubes submerged in liquid refrigerant.	Draw off liquid into service cylinder.
Low condensing pressure.	Too much water flowing through condenser.	Reduce quantity of water.
	Water too cold.	Reduce quantity of water.
	Liquid refrigerant flooding back from evaporator.	Change expansion valve adjustment, examine fastening of thermal bulb.
	Leaky discharge valve.	Remove head, examine valves. Replace any found defective.
High suction pressure.	Overfeeding of expansion valve.	Regulate expansion valve, check bulb attachment.
	Leaky suction valve.	Remove head, examine valve and replace if worn.
Low suction pressure.	Restricted liquid line and expansion valve or suction screens.	Rump down, remove, examine and clean screens,
	Insufficient refrigerant in system.	Check for refrigerant storage.
	Too much oil circulating in system.	Check for too much oil in circulation. Remove oil.
	Improper adjustment of expansion valves.	Adjust valve to give more flow.
	Expansion valve power element dead or weak	Replace expansion valve power element.

Figure 5-7.—Trouble diagnosis chart.

Trouble	Possible Cause	Corrective Measure
Compressor short cycles on low- pressure control.	Low refrigerant charge.	Locate and repair leaks. Charge refrigerant.
	Thermal expansion valve not feeding properly. (a) Dirty strainers. (b) Moisture frozen in orifice or orifice plugged with dirt. (c) Power element dead or weak	Adjust, repair or replace thermal expansion valve. (a) Clean strainers. (b) Remove moisture or dirt (use system dehydrator). (c) Replace power element.
	Water flow through evaporators restricted or stopped. Evaporator coils plugged, dirty, or clogged with frost.	Remove restriction. Check water flow. Clean coils or tubes.
	Defective low-pressure control switch.	Repair or replace low-pressure control switch.
Compressor runs continuously.	Shortage of refrigerant.	Repair leak and recharge system.
	Leaking discharge valves.	Replace discharge valves.
Compressor short cycles on high- pressure control switch.	Insufficient water flowing through condenser, clogged condenser.	Determine if water has been turned off. Check for scaled or fouled condenser.
	Defective high-pressure control switch.	Repair or replace high-pressure control switch.
Compressor will not run.	Seized compressor.	Repair or replace compressor.
	Cut-in point of low-pressure control switch too high.	Set L. P. control switch to cut-in at correct pressure.
	High-pressure control switch does not cut-in. 1. Defective switch. 2. Electric power cut off. 3. Service or disconnect switch open.	Check discharge pressure and reset H. P. control switch. 1. Repair or replace switch. 2. Check power supply. 3. Close switches.

Figure 5-8.—Trouble diagnosis chart-Continued.

Trouble	Possible Cause	Corrective Measure
Compressor will not run (Cont'd)	4. Fuses blown.	4. Test fuses and renew if necessary.
	5. Over-load relays tripped.	5. Re-set relays and find cause of overload.
	6. Low voltage.	6. Check voltage (should be within 10 percent of nameplate rating).
	7. Electrical motor in trouble.	7. Repair or replace motor.
	8. Trouble in starting switch or control circuit.	8. Close switch manually to test power supply. If OK, check control circuit including temperature and pressure controls.
	9. Compressor motor stopped by oil pressure differential switch.	9. Check oil level in crankcase. Check oil pump pressure.
Sudden loss of oil from crankcase.	Liquid refrigerant slugging back to compressor crank case.	Adjust or replace expansion valve.
Capacity reduction system falls to unload cylinders.	Hand operating stem of capacity control valve not turned to automatic position.	Set hand operating stem to automatic position.
Compressor continues to operate at full **or** partial load.	Pressure regulating valve not opening.	Adjust or repair pressure regulating valve.
Capacity reduction system fails to load cylinders.	Broken or leaking oil tube between pump and power element.	Repair leak.
Compressor continues to operate unloaded.	Pressure regulating valve not closing.	Adjust or repair pressure regulating valve.

Figure 5-9.—Trouble diagnosis chart-Continued.

possible causes and corrective measures. Figure 5-10 also lists some of the problems, causes, and corrective measures and includes recommended test procedures that may be used to isolate the problems.

SAFETY PRECAUTIONS USED WHEN HANDLING REFRIGERANTS

The following safety precautions are the minimum required when you are using refrigerants:

1. Two people must be present at all times while refrigerant is being charged into a refrigeration system. NEVER leave the area unattended while charging is in progress.

2. Ensure that ventilation in the space is adequate to keep the concentration of refrigerant below 1,000 parts per million. If necessary, use portable blowers.

3. If refrigerant is being charged into or being removed from a system, prohibit all nonessential

TROUBLE	POSSIBLE CAUSE	TEST	REMEDY
Space temperature higher than thermostat setting	Bad location of thermostat	Carefully read temperature at the sensing element.	Relocate thermostat to a place more representa-tive of average space temperatre
	Thermostat out of adjust-ment or sticking	Calibrate with good ther-mometer.	Clean, adjust, or replace the thermostat
	Cooling coil magnetic valve not opening	Test solenoid valve for sticking valve	Replace solenoid coil. Clean valve or adjust pilots.
Space temperature lower than thermostat setting	Bad location of thermostat (this will also affect cooling)	Test with reliable ther-mometer at location.	Move the thermostat to a better location.
	Cooling coil magnetic valve stuck in open position	Stuck valve.	Disassemble and clean.
	Heating coil magnetic valve stuck or bad solenoid	Test solenoid. Test valve.	Replace solenoid coil. Clean the valve.
Thermostat or humidistat time constant too long, causing wide deviation from set point	Sensing element fouled with lint and dirt	Examine.	Clean.
Electric heater does not cut out	Controller contacts stuck	Use test lamp to determine.	Replace contacts, springs or other parts as found defective.
Electric heater does not cut in	Overheat protection not reset or defective	Place test lamp across.	Repair or replace.

Figure 5-10.—Trouble diagnosis chart with recommended test included.

personnel from being in or entering the space while the refrigerant is being transferred.

4. Locate an emergency self-contained breathing apparatus for each person in the space to permit safe evacuation in the event of a large accidental leak

5. When you suspect refrigerant may be present in the atmosphere, leave the space immediately if:

- You smell something that is unusual.
- You feel light-headed.
- You feel giddy.
- You experience shortness of breath.
- You feel a tingling sensation in your fingers or toes.
- You suddenly start to feel warm.
- You experience rapid heartbeat,

6. Before using refrigerant, ensure that all hot work in the space is suspended.

7. Use chemical safety goggles or a full face shield while handling refrigerant.

8. Exercise care to ensure that liquid refrigerant does not come in contact with your skin.

9. Where available, use a halide monitor with an alarm to continuously monitor the atmosphere in the space where refrigerant is used

10. Post a caution sign in the area to read as follows:

CAUTION

No open flame, smoking, or welding. Do not enter without testing the air for refrigerant.

11. Establish and document emergency rescue procedures to ensure all personnel can be safely removed from potentially hazardous exposures.

SUMMARY

This chapter has given you some information on the construction and maintenance of refrigeration and air-conditioning equipment. A helpful chart for the detection and correction of operating difficulties was provided. While the chapter was not intended as a substitute for information found in the maintenance manuals, it should help to identify the correct procedures to safely inspect, repair, maintain, and troubleshoot refrigeration and air-conditioning systems. If you have any questions pertaining to performing routine maintenance on refrigeration and air-conditioning plants, reread this chapter or refer to your specific manufacturer’s manual.

CHAPTER 6

COMPRESSED AIR SYSTEMS

In the EN3 TRAMAN, we learned about the types of air compressors that an Engineman is required to operate. We also learned how the air is compressed; the requirements and methods of providing oil-free air; how moisture is removed from the air; and some of the safety precautions used when operating or working with compressed air systems.

This chapter contains general information about maintenance and repair of compressed air systems. You should refer to the appropriate manufacturer's technical manuals, maintenance requirements (3-M), and various information books for more specific information. *Naval Ships' Technical Manual*, Chapter 551, "Compressed Air Plants and Systems," is one good source of information.

AIR SYSTEMS

Compressed air is a form of power that has many important uses. An air compressor plant (fig. 6-1) is required to supply air of adequate volume, quality, and pressure at the various points of applications. This supply of air is measured as pounds per square inch gauge (psig). Air compressor plants or systems are classified as low-pressure (0 to 150 psig), medium-pressure (151 to 1,000 psig), or high-pressure (1,000 psig and above).

Aboard Navy vessels, the A division or repair division is responsible for maintenance and repair of compressed air systems.

LOW-PRESSURE SYSTEMS

Low-pressure (LP) systems provide compressed air up to 150 psig pressure. For branches requiring lower pressures, pressure is usually reduced at reducing stations. The following list contains examples of air pressure requirements for LP air:

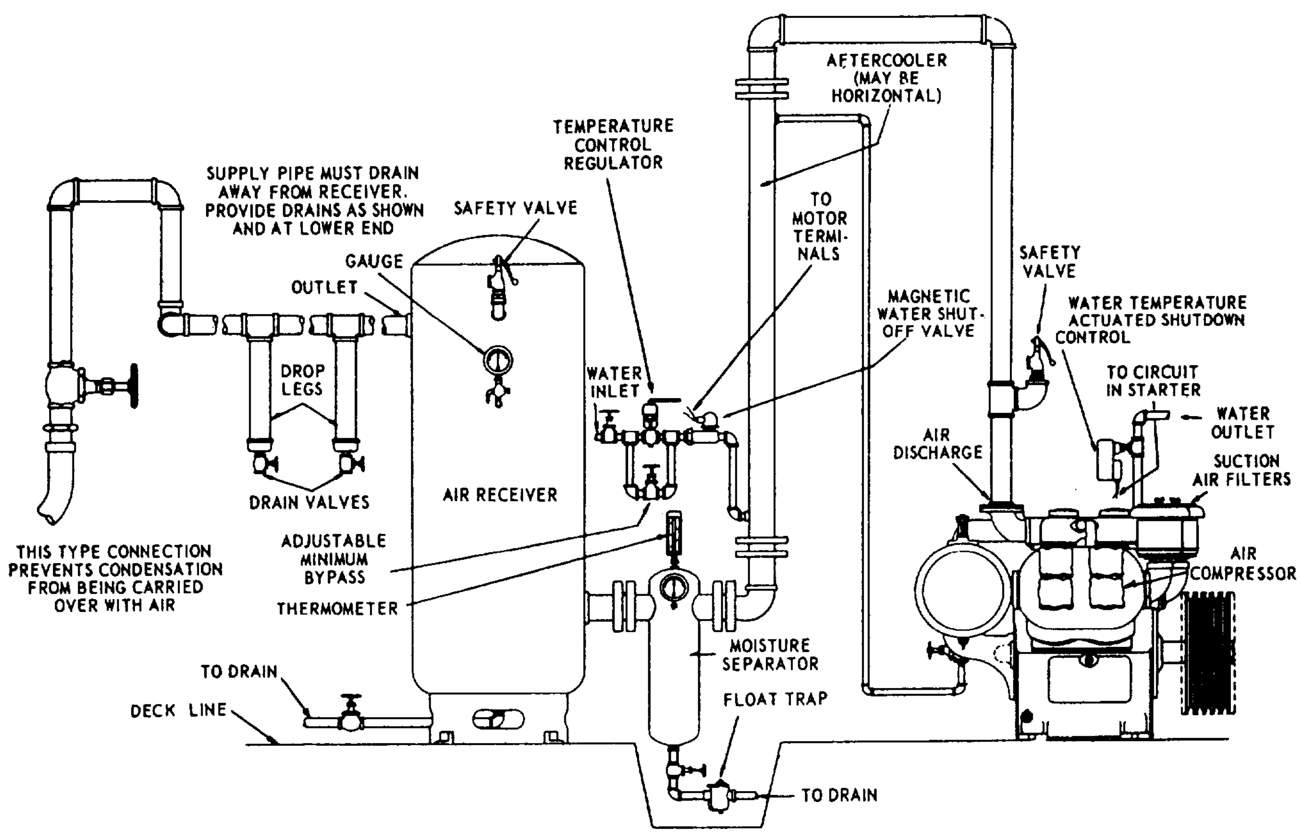


Figure 6-1.—Typical components of a compressed air system.

Laboratories	5 to 50 psig
Shops	60 to 125 psig
Laundries and dry cleaning plants	70 to 100 psig
Hospitals	20 to 50 psig
Ordinary service	
(tools, painting, and so forth)	60 to 80 psig
Soot blowing for boilers	80 to 125 psig

You will probably be called upon to fix some problem on one of these stations. The three most common problems are wet air, not enough air, or no air at all. First you must trace the system to the station and isolate the problem. It could be just an air valve that is halfway open, a piping leak, a malfunctioning air reducer, an empty air receiver, or an overfilled moisture separator. Figures 6-2, 6-3, and 6-4 are maintenance requirements for LP air compressor systems.

SHIP SYSTEM, SYSTEM, SUBSYSTEM, OR EQUIPMENT	REFERENCE PUBLICATIONS	DATE
Low-Pressure Air Compressor Level 4 - Equipment Test		August 1990

TEST	OTHER	SYSCOM MRC CONTROL NO	MAINTENANCE REQUIREMENT DESCRIPTION	PERIODICITY CODE	RATES	MAN HOURS	RELATED MAINTENANCE
			Scheduling aids: 1. MRCs Q-1 and R-10W contain blanks to be filled in by ship's force. Data should be available in T/M or certification data sheets. Advise via PMS feedback report if required "fill-in" data is not available to ship's force. 2. "U" MRC (Unscheduled Maintenance Requirement) is provided to assist in restoring system/equipment to an operational condition. Its use may be directed by a scheduled MRC, scheduling aid, or system/equipment failures. 3. Review MRCs Q-3, Q-7R, S-3, S-4, A-1R, A-2R, R-8, and R-9. Omit maintenance requirement(s) if not applicable; no feedback report required. 4. DDEOC ships that have completed a baseline overhaul and entered an extended operating cycle are not to schedule maintenance requirement 72M-1 as a planned requirement. Action is handled automatically by DDEOC program. 5. MRC Q-7R applies to DDG-38, 41, 42, 43, 45, and 46 only. 6. Review MRC Q-1. Omit Maintenance Requirement if EOSS is installed that accomplishes maintenance requirement; no feedback report required. 7. Maintenance requirement R-1 applies to compressors used to supply diver's air only. ‡ Mandatory scheduling required. **For scheduling purposes only; no MRC is provided.				
‡		57 X72T N	1. Test low oil pressure shutdown switch. 2. Test high temperature shutdown switches.	Q-1	EN/MM2 FN	0.8 0.8	None
		50 B6ET N	1. Obtain and forward lube oil sample for laboratory analysis.	Q-2	EN/MM3	0.2	None
		80 X72U N	1. Clean and inspect spacer cylinder filter; inspect and clean spacer cylinder.	Q-3	EN/MM3	1.0	None
		50 X72W N	1. Clean and inspect compressor air intake filter element.	Q-5	EN/MM3	0.5	None
‡		50 X72X N	1. Test compressor drain failure shutdown probe/relay switch.	Q-6	EN/MM2 EM3	0.4 0.4	None
‡		80 V52H N	1. Test low-pressure air system. NOTE: Accomplish quarterly in port and when determination of operational readiness of compressor is required.	Q-7R	EN/MM2 FN	2.0 2.0	None
		A8 A9YL N	1. Inspect drive belt(s).	S-1	EN/MM3	0.5	None
		50 X72Y N	1. Clean and inspect compressor fresh water/condensate drain strainers.	S-3	EN/MM3	1.0	A-5R‡
		80 X72Z N	1. Clean and inspect compressor unloader air strainer.	S-4	EN/MM3	0.2	None
‡		A8 X73A Y	1. Test relief valves. NOTE: Accomplish annually or every 2000 hours of compressor operation.	A-1R	EN/MM3	1.0	None

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Figure 6-2.—A maintenance index page for low-pressure air compressor systems (page 1 of 3).

TEST	OTHER	SYSCOM MRC CONTROL NO.	MAINTENANCE REQUIREMENT DESCRIPTION	PERIODICITY CODE	RATES	MAN HOURS	RELATED MAINTENANCE
4		A8 B3PU N	1. Inspect compressor unit resilient mounts. NOTE: Accomplish annually and after any rework.	A-2R	EN/MM3	0.2	None
		50 X73G N	1. Treat fresh water cooling system. NOTE: Accomplish annually and when cooling water system has been drained.	A-5R	FN	0.4	None
			1. Submit work request to Intermediate Maintenance Activity (IMA) to recertify air receivers as per NSTM S9086-Sy-STM-010/CH-551.	72M-1 **			
			1. Obtain air sample for analysis NOTE: Accomplish each time the compressor is disassembled or overhauled which can cause possible contamination of air supply for Diver's air. Accomplish by qualified divers only.	R-1 **			
		35 X73B Y	1. Clean and inspect compressor suction and and discharge valves. NOTE: Accomplish every 4000 hours of compressor operation.	R-2	EN/MM2 FN	6.0 6.0	None
		44 X73D N	1. Clean and inspect fresh water expansion tank vent breather. NOTE: Accomplish every 2000 hours of compressor operation.	R-8	EN/MM3	1.0	None
		53 X73E N	1. Clean, inspect, and adjust air-flow control valve. NOTE: Accomplish every 4000 hours of compressor operation.	R-9	EN/MM3 FN	1.0 1.0	None
4		53 X73F N	1. Test operate idle compressor. NOTE: Idle is defined as not having been operated within the past 7 days.	R-10W	EN/MM3 FN	0.5 0.5	None
		57 X73H Y	1. Renew compressor oil filter and lube oil; clean breather.	U-2			None
			INACTIVE EQUIPMENT MAINTENANCE				
			The following requirements will be scheduled when equipment is inactivated for periods of prolonged idleness.				
			Lay-Up Maintenance				
		42 W17J N	1. Install protective cover on air filter/silencer. NOTE: Cover must be installed before exposure to industrial hazards.	LU-1	FN	0.2	None
			Periodic Maintenance				
		10 B5VB N	1. Turn idle compressor by hand. NOTE: Accomplish every 7 days during inactive period.	PM-1	EN/MM3	0.2	None
			Start-Up Maintenance				
		A8 B3PT N	1. Remove protective cover from air filter/ silencer. NOTE: Accomplish before starting compressor.	SU-1	FN	0.1	None
			1. Obtain and forward lube oil sample for laboratory analysis. NOTE: Use MRC Q-2.				

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Figure 6-3.—A maintenance index page for low-pressure air compressor systems (page 2 of 3).

MEDIUM-PRESSURE SYSTEMS

Medium-pressure systems provide compressed air within the range of 151 to 1,000 psig pressure. These systems are not extensive and are generally provided with individual compressors located near the loads. Medium-pressure systems are mainly used for the starting of diesel engines, soot blowing of boilers and high-temperature water (HTW) generators, and hydraulic lifts.

Some Navy vessels do not have a separate air compressor to supply a direct medium-air pressure. Instead, compressed air from HP air systems is stored in the user's air flasks (banks) at high pressure. Then when needed, the air is routed through a pressure-reducing

TEST	OTHER	SYSCOM MRC CONTROL NO.	MAINTENANCE REQUIREMENT DESCRIPTION	PERIODICITY CODE	RATES	MAN HOURS	RELATED MAINTENANCE
			Operational Test 1. Test operate idle compressor. NOTE: Use MRC R-10W. DISTRIBUTION STATEMENT D: DISTRIBUTION AUTHORIZED TO DOD COMPONENTS AND DOD CONTRACTORS ONLY; CRITICAL TECHNOLOGY; AUGUST 1990; OTHER REQUESTS SHALL BE REFERRED TO THE NAVAL SEA SYSTEMS COMMAND (SEA 04TD). DESTROY BY ANY METHOD THAT WILL PREVENT DISCLOSURE OF CONTENTS OR RECONSTRUCTION OF THE DOCUMENT.				

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Figure 6-4.—A maintenance Index page for low-pressure air compressor systems (page 3 of 3).

manifold. In this case, medium-air pressure maintenance requirements are coupled with the HP air system's PMS. Troubles and repairs to medium-pressure systems are the same as the LP and HP air systems. Those medium-pressure air systems equipped with air compressors should have a separate preventive maintenance schedule.

HIGH-PRESSURE SYSTEMS

These systems provide compressed air within the range of 1,000 to 6,000 psig pressure. Hazards that increase with higher pressures and capacities can be minimized by using separate compressors for each required pressure. Systems operating at 3,000 psig may require small amounts of air at lower pressures, which is supplied through pressure-reducing stations.

Always use caution with HP systems! When HP air enters suddenly into pockets or dead ends, the air temperature in the confined space increases dramatically. If there is any combustible material in the space and the air temperature increases to the ignition point of the material, an explosion may occur. Explosions of this type may set up shock waves that travel through the compressed air system. This travel may cause explosions at remote points. Even a small amount of oil residue or a small cotton thread may be sufficient to cause ignition.

Some common pressure requirements for HP systems may be as follows:

Torpedo workshop	600 to 3,000 psig
Ammunition depot	100, 750, 1,500, 2,000, and 4,500 psig
Wind tunnels	Over 3,000 psig
Testing laboratories	Up to 6,000 psig

Figures 6-5 and 6-6 show a maintenance index page (MIP) for one design and make of an HP air compressor system. This will give you an idea of the differences in planned maintenance requirements between the LP air (see figs. 6-2, 6-3, and 6-4 for comparison) and HP air systems. It is very important that the PMS you are using are the correct ones.

You should inspect air flasks, receivers, separators, and piping for damage or external corrosion once every 6 months. Enter the inspection date and results in the Maintenance and Material Management (3-M) Systems by submitting a work request for any discrepancies found. You must document completion of all inspection results through PMS.

AIR DRYERS OR DEHYDRATORS

The Navy uses three types of air dehydrators for drying LP air. These are the refrigeration (type I), desiccant (type II), and combination of both refrigeration and desiccant (type III). HP air application uses only the type III. The Navy is replacing the various types of desiccant used in the fleet with activated alumina beads in 1/8-inch diameter spheres. This type of desiccant is also intended to reduce dust problems produced by the other various types. The dust causes clogged filters and other component malfunctions.

MAINTENANCE OF LP AND HP AIR DEHYDRATORS

Follow the scheduled maintenance of LP or HP air dehydrators according to the PMS requirements. The following is a sample LP air dehydrator maintenance schedule and is for general information only:

1. Daily:

– Check applicable power on lights, flowmeter readings, cooling water temperatures, heater temperatures, and outlet air temperatures for proper operation.

– Note any dehydrator filter element pressure drops for element replacement.

– Periodically blow down and clean the condenser water strainer.

– Blow down type I and type III dehydrators. Dump the valve if more than 1/2 pint of water drains out; the automatic feature is not working.

– Check the purge pressure and the free movement of the purge flowmeter float of type II and type III dehydrators.

2. Weekly: Blow down the inlet separator, prefilter, and trap dump valve of dehydrators by opening the manual drain valve.

3. Monthly:

– Check the outlet air moisture content. The dew point should be below -40°F at 80 lb/in^2 for both type II and type III dehydrators, and below 40°F at 80 lb/in^2 for type I dehydrators. An excessive dew point indicates a malfunction.

– Check the inlet and outlet filters and the purge filter for the type II and type III dehydrators. Replace the filter elements if necessary.

4. Quarterly:

– Clean the condenser water tubes.

– Disassemble and clean the inlet and interstage separators and purge the solenoid valves.

5. Annually:

– Remove and calibrate the pressure gauges. Adjust them to give maximum error 2 lb/in^2 (1 percent of full scale).

– Disassemble the desiccant chambers. Clean the assembly of dust, oil, and dirt. Replace the desiccant

SHIP SYSTEM, SYSTEM, SUBSYSTEM, OR EQUIPMENT	REFERENCE PUBLICATIONS	DATE
High-Pressure Air Compressor Level 4 - Equipment Test		May 1990

TEST	QMHR	SYSCOM MRC CONTROL NO.	MAINTENANCE REQUIREMENT DESCRIPTION	PERIODICITY CODE	RATES	MAN HOURS	RELATED MAINTENANCE
			Scheduling aids: 1. MRC A-1 contains blank spaces to be filled in by ship's force before implementation. Until these "fill-in" data elements are applied, maintenance requirement cannot be effectively accomplished. Advise via PMS feedback report if required "fill in" data is not available to ship's force. 2. "U" MRC (Unscheduled Maintenance Requirement) is provided to assist in restoring system/equipment to an operational condition. Its use may be directed by a scheduled MRC, scheduling aid, or system/equipment failures. 3. Maintenance requirement R-4 applies to compressors used to supply diver's air only. 4. MRC A-5R applies if MACHALT 551-44012 (ECP 254) has been accomplished. **For scheduling purposes only; no MRC is provided.				
		A8 Y57D Y	1. Clean and inspect zincs.	Q-1	EN/MM3	0.5	None
		59 A7WE N	1. Test low oil pressure shutdown switch. 2. Test low air pressure switch.	Q-2	EN/MM3	0.5	None
		50 B6EF N	1. Obtain and forward lube oil sample for laboratory analysis.	Q-3	EN/MM3	0.2	None
		50 B6EG N	1. Inspect HPAC and dehydrator piping for air leaks.	Q-10	EN/MM3	1.0	None
4		45 V16T N	1. Test compressor air relief valves.	A-1	EN/MM3	2.0	None
		A7 B1XF N	1. Inspect resilient mounts. NOTE: Accomplish annually and after any rework.	A-5R	FN	0.3	None
		50 B2YE N	1. Treat fresh water cooling system. NOTE: Accomplish annually and when cooling system has been drained.	A-10R	FN	1.0	None
			1. Inspect air flasks recertification record to determine recertification due dates. If due, submit work request to Intermediate Maintenance Activity (IMA) to recertify air flasks as per NSTM S9086-SY-STM-010/CH-551.	36M-1 **			
4		A8 Q56E N	1. Test operate compressor. NOTE: Accomplish when determination of compressor operational readiness is required.	R-1	EN/MM3	0.4	None
		44 Q56F N	1. Clean air intake filter. NOTE: Accomplish every 500 hours of compressor operation.	R-2	EN/MM3	0.5	None
			1. Obtain air sample for analysis NOTE: Accomplish each time the compressor is disassembled or overhauled which can cause possible contamination of air supply for diver's air. Accomplish by qualified divers only.	R-4 **			

MAINTENANCE INDEX PAGE (MIP)
OPNAV 4790/84 (REV 2-82) PAGE 1 OF 2 SYSCOM MIP CONTROL NUMBER A - 003/096-50

Figure 6-5.—A maintenance Index page (MIP) for one design and make of high-pressure air compressor systems (page 1 of 2).

if it is significantly powdered, burned, or discolored with oil carry-over.

– Remove the desiccant chamber check valves. Discard and replace them with new items. Adjustment and repair of the dehydrators and their components should be accomplished according to the appropriate equipment technical manuals.

AIR QUALITY TESTING

Air quality testing is the daily monitoring of the dry air dew point at the dehydrator's outlet. Testing is conducted with a LP frost point indicator, MIL-I-24144.

TEST	OTHER	SYSCOM MRC CONTROL NO	MAINTENANCE REQUIREMENT DESCRIPTION	PERIODICITY CODE	RATES	MAN HOURS	RELATED MAINTENANCE
		44 Q56M N	1. Renew automatic drain valve gear reducer lube oil. NOTE: Accomplish every 2000 hours of compressor operation.	R-12	EM/MM3	0.3	None
		44 Q56J Y	1. Renew compressor lube oil and filter; clean breather.	U-1			None
			INACTIVE EQUIPMENT MAINTENANCE				
			The following requirements will be scheduled when equipment is inactivated for periods of prolonged idleness.				
			Lay-Up Maintenance				
		45 W67G N	1. Flush sea water side of cooling system.	LU-1	EN/MM3 FN	0.5 0.5	None
		63 X83M N	1. Install protective cover on air filter/silencer. NOTE: Cover must be installed if equipment is to be subjected to industrial hazards.	LU-2	FN	0.2	None
			Periodic Maintenance				
		50 B6EH N	1. Turn idle compressor shaft by hand. NOTE: Accomplish every 7 days during inactive period.	PM-1	EN/MM3	0.2	None
			Start-Up Maintenance				
		B3 Y25S N	1. Remove protective cover from air filter/ silencer. NOTE: Accomplish before starting compressor	SU-1	FN	0.1	None
			1. Obtain and forward lube oil sample for laboratory analysis. NOTE: Use MRC Q-3.				
			Operational Test				
			1. Test operate compressor. NOTE: Use MRC R-1.				
			DISTRIBUTION STATEMENT D: DISTRIBUTION AUTHORIZED TO DOD COMPONENTS AND DOD CONTRACTORS ONLY; CRITICAL TECHNOLOGY; MAY 1990; OTHER REQUESTS SHALL BE REFERRED TO THE NAVAL SEA SYSTEMS COMMAND (CEL-TD). DESTROY BY ANY METHOD THAT WILL PREVENT DISCLOSURE OF CONTENTS OR RECONSTRUCTION OF THE DOCUMENT.				

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OPNAV 4790/85 (REV. 2-82) PAGE 2 OF 2 SYSCOM MIP CONTROL NUMBER A - 003/096-50

Figure 6-6.—A maintenance index page (MIP) for one design and make of high-pressure air compressor systems (page 2 of 2).

DEHYDRATOR DEW POINT READINGS

This reading is taken every 4 hours of dehydrator service. Readings verify that the dehydrator is operating correctly. The normal readings of the various types of air dehydrators are as follows:

1. LP air (type I) dehydrator's normal dew point reading is a dew point temperature reading of 40°F or lower at 80 lb/in^2. This indicates that the dehydrator is delivering an air quality within its design capability. A reading of 50°F or higher at 80 lb/in^2 indicates that the dehydrator is not working properly, and you should check the applicable technical manual.

2. A dew point temperature reading of -40°F or lower at 80 lb/in^2 is normal for LP (type II and type III) dehydrators. A reading of -20°F or higher at 80 lb/in indicates that the dehydrator is not operating properly, and you should check the applicable technical manual to correct the problem.

3. For HP air dehydrators, a dew point temperature reading of -60°F or lower at atmospheric pressure is normal. A reading higher than -60°F at atmospheric pressure indicates that the dehydrator is not working properly, and you should check the technical manual for the solution to the problem.

MAINTENANCE OF RECIPROCATING AIR COMPRESSORS

To keep the ship's air compressors operating efficiently at all times, you must know what common troubles may occur and their causes. You must know how to care for the air intakes; how to maintain and replace air valves; how to take care of air cylinders and pistons; and how to adjust bearings, wrist pins, and couplings. You must be able to maintain, troubleshoot, and repair the lubrication, cooling, control, and air systems.

AIR INTAKES

A supply of clean, cool, dry air is essential to the satisfactory operation of compressors. To ensure this, the *air intake filters* must be regularly inspected and cleaned; otherwise, the filter becomes clogged and causes loss of capacity. A clogged air intake screen or filter may also cause a compressor to draw oil from its own crankcase, around rings, or through oil seals, resulting in an explosion.

Remove the filter element and clean it with a jet of hot water or steam, or plunge it into a strong solution of sal soda. The filter body should be drained and replaced. If the filter is the oil-wetted type, dip it in clean, medium-grade oil and allow it to drain thoroughly before replacing the filter in the intake. **Do not use gasoline or kerosene for cleaning filters!** The fumes may collect and explode in the compressor or receiver.

Take care to prevent entrance of rain or spray into *intake pipes*, and provide a means for draining the intake pipe of any water that may collect. The lines should be as short and direct as possible.

For air compressors used to supply air for the divers, you must prevent the compressor from taking in exhaust gases coming from any internal combustion engines. You must also prevent any possible intake of fumes coming from fuel tank vents, spilled oil, or gasoline.

AIR VALVES

Air inlet and discharge valves must be kept clean and in good working order. Leaky valves are generally dirty valves, and they cause capacity loss. The valves are removed by first loosening their setscrews or clamps, and then removing their cover plates. Each valve and valve unloader, if fitted, may then be lifted out. Each valve should be marked to make certain that it is returned to the same port from which it was removed.

Valves removed for inspection should not be taken apart for cleaning unless their conditions make it necessary. Dirt or carbon in valve ports can usually be removed without taking the valve apart. This is done by soaking the valves in kerosene, and then giving them a stiff brushing or a light scraping. Valve action should be tested by inserting a screwdriver through the seat ports; the valve should lift and close freely.

If it becomes necessary to disassemble the valve, note the arrangement of the various parts so that the proper relationship will be kept when the valve is reassembled. (Periodic shipboard reports indicate damage to pistons and associated valve parts frequently results from improperly assembled valves that protrude in the way of the oncoming piston.)

Before replacing air valves in a cylinder, inspect the gaskets and replace any that are damaged. Copper-covered asbestos or plain, thin copper gaskets should be used. If these are not available, 1/16-inch compressed-asbestos sheet gaskets may be used temporarily. Each valve assembly should be inserted in the same hole from which it was removed. Since it may be difficult, in many cases, to distinguish between suction or discharge valves, extreme care must be taken when the valves are being inserted in the cylinder. Make certain that suction valves open TOWARD, and the discharge valves AWAY FROM, the center of the cylinder; otherwise, serious damage or loss of capacity will result. Then place the valve cover on the cylinder, making certain that its gasket is squarely in place; draw down on the cover nuts evenly, and in turn, so as not to tilt the cover. Tighten down the valve setscrew or clamping bolt, drawing it tight to hold the valve on its seat. If special locknuts are not provided to seal against leakage at the threads of the valve setscrew, a turn of solder or fuse wire should be placed around the screw and set down into a recess by a locking nut.

CYLINDERS AND PISTONS

The cylinders on pistons should be inspected only AFTER the manufacturer's technical manual has been consulted. Be careful when removing heads, particularly where metal-to-metal joints are involved, to prevent damage to the joint.

If replacement of piston rings is required because they are worn or broken, take accurate measurements of the cylinder liners. Standard size rings may be used in oversize cylinders if the oversize does not exceed 0.003 inch per inch of cylinder diameter. The liner may also need to be replaced if it is badly worn or out of round. When replacing piston rings, first fit them to the cylinder to check for proper end clearance. You can file the ends, if necessary, to make them fit. The side clearance of the rings should be such that the rings will fall easily into the piston grooves, which should be deep enough for the ring thickness. Ring splits should be staggered. After you assemble the piston, wire the rings tight with a soft copper wire so that they will enter the bore easily. This wire can be removed through the valve ports after the ring has started into the cylinder bore.

When reassembling the air cylinders and heads, be sure they are all drawn down evenly, especially on multistage compressors where the heads contain cylinders for third and fourth stages. Otherwise, the result will be excess wear on the cylinders and pistons.

When a compressor piston has been replaced, the piston end clearance must be checked. This is done by inserting a lead wire through a valve port or indicator connection. Jack the compressor over. When the piston has moved to the end of its stroke, the lead will be flattened to the exact amount of clearance. The wire should be long enough to permit a reading near the center of the piston. These readings should be taken after any adjustment or replacement of the main, crank pin, wrist pin, or crosshead bearings. Methods of adjusting the clearances vary according to the compressor design. You should consult the manufacturer's instructions for suggested adjustment.

MISCELLANEOUS ADJUSTMENTS

From time to time other miscellaneous adjustments are required on compressors, including those pertaining to wrist pins, crosshead shoes, reduction gears, couplings, and V-belt drives. The manufacturer's technical manual will give you specific information for the care, adjustment, and replacement of all fitted bearings. Refer to the manufacturer's instructions for detailed information on when and how to make these adjustments.

Wrist pin bushings are replaced when necessary. This is done when they are worn to the point of becoming noisy. In making a replacement, be sure the oil hole in the bushing is properly lined up with the oil hole in the connecting rod. After being pressed into the rod, the new bushing must be reamed.

Crosshead shoes are provided with shim or wedge adjustment. Wear should be slight, but adjustment should be made when the travel of the piston rod causes a movement in the stuffing boxes.

Alignment of reduction gears and pinions should be checked periodically, especially on a new compressor. Misalignment may be caused later by settling, straining, or springing of foundations; pipe strains on turbine-driven compressors; bearing wear; or springing due to heat from a turbine.

Flexible couplings require very little maintenance when they are properly lined up. Some types require occasional lubrication to prevent excessive wear of springs and bushings. A noisy coupling is an indication that the bushing is worn and requires replacement.

V-belt drives require adjustment for belt tension. Belts generally stretch slightly during the first few months of use. A loose belt will slip on the motor pulley and cause undue heating and wear on the belt. A tight belt will overload the bearings. Belts should be protected against oil and high temperatures. To prevent rapid deterioration, belts should not be used at temperatures above 130°F. V-belts are usually installed in sets of two or three. If a single belt is worn or deteriorated, the complete set should be replaced to ensure that each belt will carry its share of the load.

LUBRICATION SYSTEM

Proper care of a compressor lubrication system includes the following:

– Keep the oil at a normal level in the reservoir at all times to maintain proper oil temperature.

– Change crankcase oil periodically, and at the same time clean and flush the crankcase and clean the oil filter.

– Maintain proper lube-oil pressure by keeping the oil pump in good working order and adjusting the bypass relief valve.

– Keep the oil cooler free from leaks (since pressure on the water side exceeds that of the oil) to prevent oil contamination and emulsification.

– Properly adjust the lubricator for the specified quantity of oil feed.

COOLING SYSTEM

Proper care of a compressor cooling system includes the following inspections and maintenance procedures:

– Periodically inspect the intercoolers and aftercoolers.

– Remove collections of gummy oils or tarry substances from the cooler tubes by washing tube nests with a suitable solvent and drying them thoroughly before reassembling.

– Correct any leakage in tube nests to prevent leaks of water into the compressor while secured or leaks of air into the water side during operation.

– Inspect and clean the cylinder water jackets periodically with a cleaning nozzle.

When filling the cooling water system after the compressor has been drained, open the water inlet slightly to allow the water to rise slowly in the cooler shells and water jackets. Vent valves fitted to the water spaces should be opened to permit entrapped air to escape and to remove any air pockets.

CONTROL DEVICES

Because of the great variety of regulating and unloading devices used on compressors, you will have to consult the manufacturer's technical manual for information regarding the adjustment of these devices on particular compressors.

If a control valve fails to work properly, it should be taken apart and cleaned Some valves are fitted with a filter filled with a sponge or woolen yarn to prevent particles of dust or grit from being carried into the valve chamber. These filters remove gummy deposits from the oil used in the compressor cylinders. When repacking, use only genuine wool. Cotton will pack and stop the airflow. Relief valves are very important for safe compressor operation. They should be set as specified by the manufacturer and lift-tested by hand each time the compressor is placed in operation. To check the setting periodically, test by raising the pressure in the spaces to which they are attached.

SUMMARY

Since an Engineman may encounter so many types of compressed air systems, air dryers, and air compressors both ashore and aboard Navy vessels, this chapter presented only general procedures and facts. To maintain, repair, and overhaul specific compressed air systems, air dryers, or reciprocating air compressors, you must refer to the manufacturer's technical manuals. A definite preventive maintenance schedule with frequency and assignment of responsibility is required. You should have the manufacturer's manual handy to establish minimum requirements and to follow its recommendations for maintenance.

CHAPTER 7

LAUNDRY, MESS DECK, GALLEY, AND SCULLERY EQUIPMENT

This chapter presents some information on ways to maintain, repair, and troubleshoot the common types of equipment in the laundry, mess deck, galley, and scullery. Because of the differences in types of equipment you are expected to maintain, only general information is presentedin this chapter. Remember, you should study the manufacturer's manual that comes with the equipment before you attempt to maintain it. Although Enginemen are not the operators of this equipment, you as an Engineman are responsible for any repairs, replacements, or adjustments of this equipment. The exception is where there is a need for any electrical work

Because you are familiar with this equipment, you can help the operator learn to properly clean and maintain these pieces of equipment. Laundry, mess deck, galley, and scullery equipment should have assigned PMS requirements.

For any particular information on laundry, mess deck, galley, and scullery equipment, refer to the equipment's technical manual or the *Naval Ships' Technical Manual (NSTM)*, Chapter 655, "Laundry," and Chapter 9340, "Commissary Equipment."

LAUNDRY EQUIPMENT

All laundry equipment must be in good operating condition, especially on deploying ships that stay at sea most of the time. It is also important that all safety devices that protect the equipment and operator are working. Safety devices that are not working, or that have been removed for any reason, must be replaced before they can be used.

NAVSEA S6152-B1-CAT-010 is a technical manual catalog for Navy laundry and dry-cleaning equipment. This catalog lists standard laundry and dry-cleaning equipment identified by national stock numbers, allowance parts lists, and part numbers. You should obtain a copy of this catalog. Currently, the Naval Supply System supports approximately 600 different laundry equipment types, most of which are now obsolete. You can help reduce this number by assisting in the selection of the standard items described in this catalog.

WASHING MACHINES

You can avoid problems with washing machines if the operator will do the following:

– Do not overload the machine.

Strictly follow the operating instructions.

Report to the auxiliary or repair division any malfunctioning safety device and any abnormal condition, such as excessive vibration, leaks, or missing parts.

Wipe all excess oil, dirt, and laundry supplies from the machine at the end of each day.

Inspections

Inspect washing machines at regular intervals to ensure that they work properly. If an inspection reveals adjustments or repairs are needed, make them promptly. Some of the important items to be covered in an inspection are as follows:

1. Ensure the machine is level.
2. See that bolts, nuts, and screws are tight.
3. See that latches on cylinder doors work properly.
4. Make sure the thermometers are accurate.
5. Have an electrician check the switches to be sure they are properly adjusted and working correctly.
6. Have an electrician check the timer to ensure it is in working order.
7. Check water level gauges to determine if they are correct.
8. Have an electrician check all the controls to be sure they are working properly.

Maintenance, Repairs, or Overhauls

You should prevent water from entering gear casings on washing machines. To do this, make sure all gear gasket covers and stuffing boxes are tight. Examine and lubricate, at frequent and regular intervals, all the bearings and gearing. Advise the division responsible for the equipment that any requests for repairs and parts replacements must be submitted on Ship's Maintenance Action Form, OPNAV 4790/2K. By following this procedure, you can determine what part or parts are failing. And, you will have clear documentation of all requested parts and repairs. You should follow the applicable MRCs for maintenance.

TUMBLER DRYERS

A properly maintained and not overloaded tumbler dryer will dry a load of laundry in approximately 20 minutes. If drying is not completed within this period, you should look for the following conditions or troubles:

- Has the water from the laundry been properly extracted?
- Is the tumbler overloaded?
- Are the lint screens clean?
- Is there enough steam pressure?
- Is the tumbler rotating in the right direction?

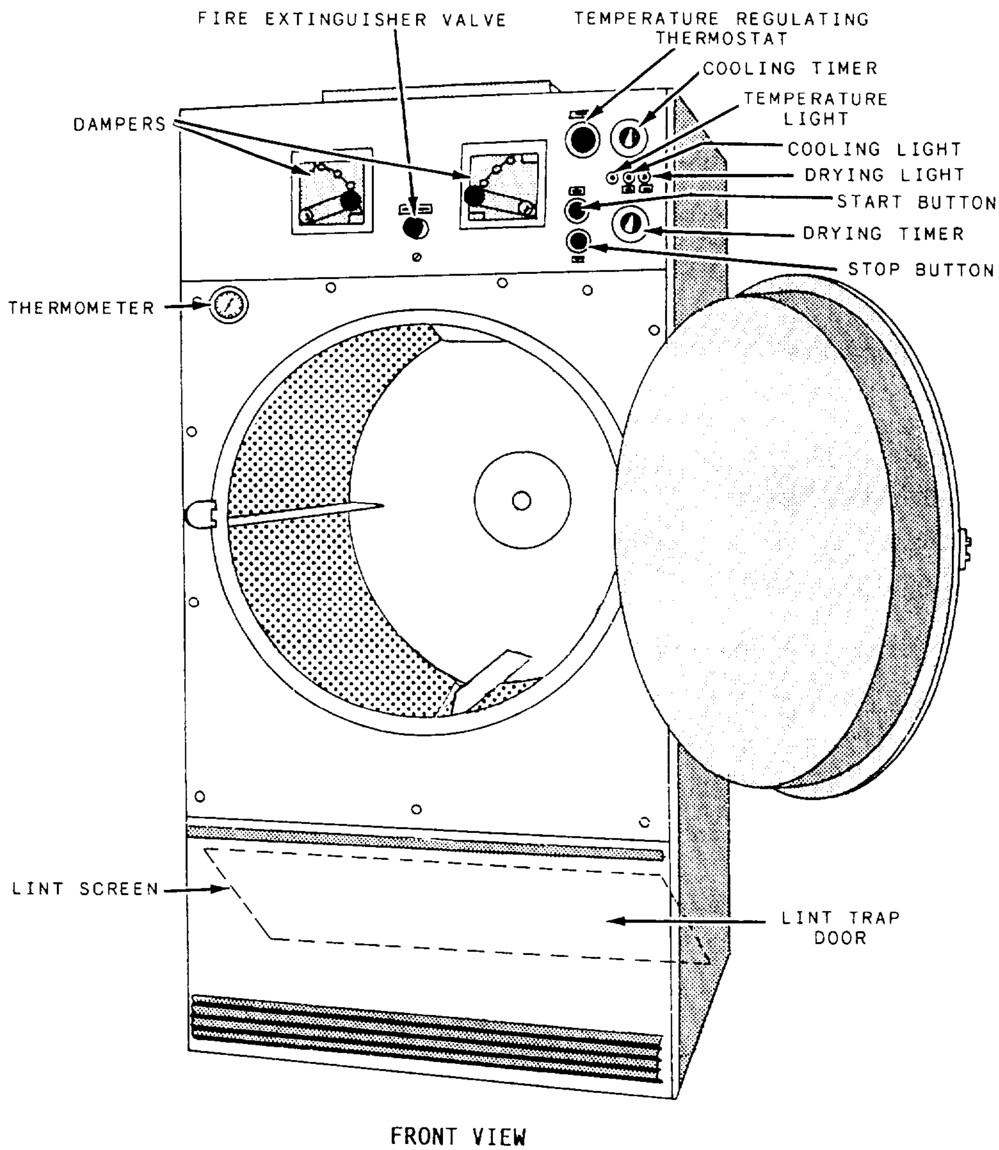

Figure 7-1.—A front view of a typical shipboard laundry dryer.

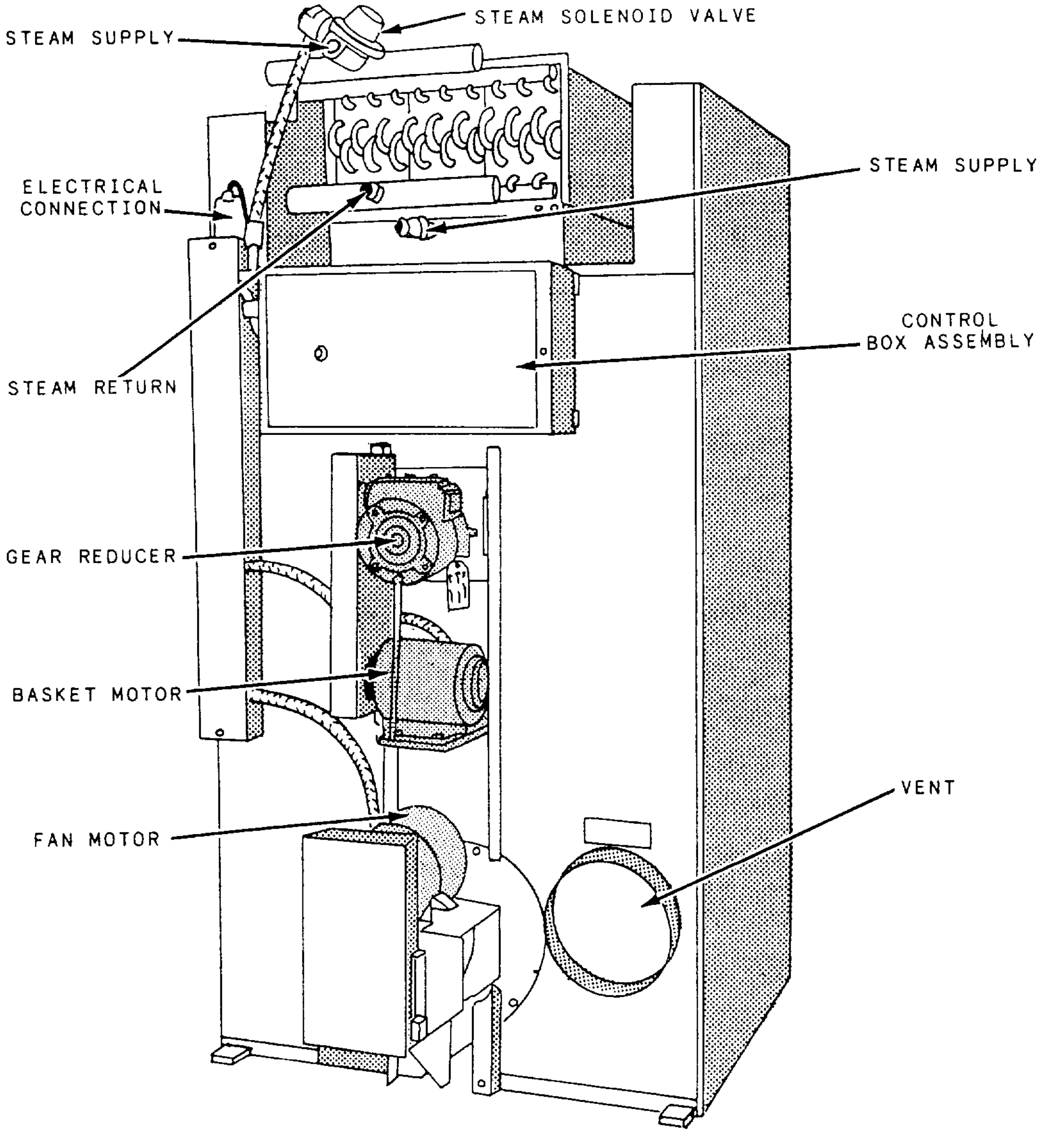

Figure 7-2.—A rear view of a typical shipboard laundry dryer.

Figures 7-1 and 7-2 illustrate a typical shipboard laundry dryer. You should pay particular attention to the location of the parts.

Troubleshooting

Tables 7-1 and 7-2 list some common troubles, causes, and remedies on shipboard laundry dryers. These tables do not replace any procedures on your shipboard dryer manuals, nor do they replace the procedures specified by the equipment's PMS.

Repairs or Overhauls

You should lubricate all dryer bearings at regular intervals according to the manufacturer's technical manual. Advise the division responsible for the equipment to submit the request for repairs and parts replacements on Ship's Maintenance Action Form, OPNAV 4790/2K. This procedure will help you determine parts that are failing and provide you with documentation of repairs. You should follow the applicable MRCs for maintenance.

LAUNDRY PRESSES

Some ships are equipped with air-operated presses and others with steam-operated presses. But both types of presses use steam for heating. The trouble the operator will most often encounter is insufficient supply of air pressure for the air-operated presses, and not enough steam pressure for the steam-operated laundry

Table 7-1.—CommonTroubles, Causes, and Remedies on Shipboard Laundry Dryers

TROUBLE	CAUSE	REMEDY
No steam to steam bonnet	Trap installed incorrectly	Check trap for inlet and outlet markings. Install trap according to markings.
	Supply line valve closed	Open valves in supply and in the return lines.
	Check valve installed incorrectly	Check for inlet and outlet marking on check valve, and invert if necessary.
	Strainer clogged	Remove plug and blow down strainer or remove and clean thoroughly if heavily clogged.
Water in steam line	Steam piping installed incorrectly	Check piping per steam installation instructions.
	Trap not functioning	Check trap for size and capacity. If dirty and sluggish clean thoroughly or replace. Check return line for high back pressure, or another trap charging against the trap functioning improperly.
Motors won't start	No power	Check fuses on circuit breakers, make sure main control switch is on. Request an electrician.
	Incorrect current	Check power source. Voltage, phase, and frequency must be the same as specified on electrical rating plate. Request an electrician.
	Time off Overload relays tripped	Turn timer clockwise to desired time setting. Rush reset buttons on control box. Request an electrican.
	Loose wiring Connections	Check all terminal connections. Request an electrician.
	Defective starting relay	Check coils and contacts. Request an electrician.
Fan motor only runs	Loading door open	Close door.
	Door switch out of adjustment	Adjust switch by removing cover and bending actuator lever to clear switch button 3/8" with cover in place.
	Defective Door switch	Replace switch.
Dryer runs no steam to coils	Valves closed	Check all valves in steam supply & return to make sure they are open.
	Steam trap blocked	Remove and clean. Replace if defective.

presses. Both types of presses require the right amount of steam pressure for heating. You, as the maintenanceman, must make sure safety devices are not bypassed. All press heads and bucks should be hydrostatically tested annually as specified by the manufacturer's manual. If not specified in the manufacturer's manual, test to 150 lb/sq. inch according to chapter 655 of *NSTM* for 1 minute.

Table 7-2.—Common Troubles, Causes, and Remedies on Shipboard Laundry Dryers-Continued

TROUBLE	CAUSE	REMEDY
Dryer runs, steam passing through coil, dryer doesn't heat.	Inadequate venting Inadequate makeup air Lint trap blocked	Proper operation of steam dryers depends on air flow through the coils. Venting must be done with the least possible restriction. Make up air opening of at least 350 sq. inches free area must be available in the vicinity of the dryer to replace the air being exhausted out by the dryer. Lint traps must be kept clean.
	Coil fins clogged with lint	Coil fins must be kept clean.
	Steam supply & return	Must be properly installed and adequately sized. See piping installation sheet.
	8-stage heat control	Check for loose dampers. Adjust dampers and tighten set screw in contol handle.
Tumbler Noisy or Vibrating	Not level	Check manual for proper leveling procedure.
	Fan out of balance	Accidental damage to the fan blade can change the dynamic balance. Damaged fans should be replaced.
	Basket rubbing V-Belt sheaves	Adjust basket clearances. Tighten set screws. Make sure sheaves are in proper alignment.
	Belt	Adjust belt tension.
	Foreign objects	Occasionally screws, nails, etc. will hang in the basket perforations and drag against the sweep sheets surrounding the basket. Such foreign objects should be removed immediately.

You should lubricate all bearings, the dashpot, and the air cylinder regularly as specified by the manufacturer's manual or by the applicable MRCs. Advise the division responsible for the equipment to submit requests for repairs and parts replacements on Ship's Maintenance Action Form, OPNAV 4790/2K. This procedure will help you, as the maintenanceman, track the parts that are failing and provide you with documented repairs. The maintenance of all laundry presses should be according to the applicable MRCs.

MESS DECK EQUIPMENT

Common mess deck equipment on most Navy ships is either used for chilling or warming foods. For chilling foods, there are salad bar tables, beverage dispensers, and milk dispensers. Some of the troubles that a maintenanceman may encounter on this equipment are too much frost buildup, not getting cold, or not working at all. Some problems can easily be corrected or prevented by training the operator on the proper usage of the machine. Trained personnel can avoid troubles by correctly loading refrigerators, properly securing the dispenser door, and using proper defrosting techniques. Improper defrosting, such as the use of a pointed object to scale out thick frost buildup, often results in pin holes on the cooling coil and loss of refrigerant charge. If you train and encourage mess deck operators to practice proper equipment use and maintenance, your job and theirs will be easier.

For warming foods, there are electric and steam-operated food warmers. Troubles with steam-operated warmers are normally either not getting enough steam pressure or not getting any steam at all. You as a maintenanceman can troubleshoot this by inspecting the steam line and checking it for leakage or restrictions such as water in the steam line. Restrictions can be detected by a hammering noise in the line. When bleeding a steam line, be sure you are well protected by wearing a face shield and thick gloves. To release any water trapped inside the steam line, you should slowly

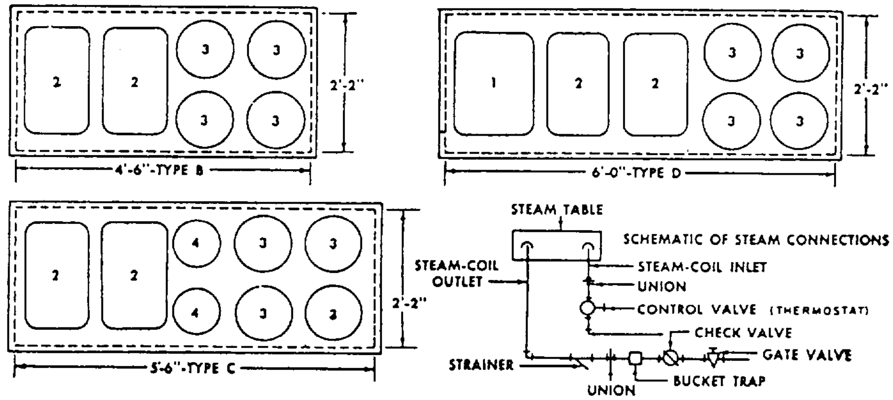

Figure 7-3.—Schematic drawing of a steam table.

open or lift the bleeder valve. Figure 7-3 is a typical schematic drawing of a steam table. Notice the steam table's piping system in this figure.

The food service division is responsible for routine preventive maintenance of all mess deck equipment. Any major troubleshooting, repairs, or overhauls are the responsibility of the repair or auxiliary division. You should advise the division responsible to submit all requests for repairs and parts replacements on Ship's Maintenance Action Form, OPNAV 4790/2K.

GALLEY EQUIPMENT

Galley equipment must be maintained in a safe, sanitary, and economical way. Enginemen maintain this equipment, and they frequently tram the food service personnel on how to properly operate the equipment. It is always a good practice to post operating instructions near the equipment. This will help to ensure that the operators do not abuse the machines. You may be called on to help inspect galley equipment. You can also help determine the type of maintenance and the extent of repairs required to keep the equipment safe and efficient. Remember, the medical department is responsible for conducting sanitary inspections. The supply department is responsible for keeping food-handling equipment clean. And, the engineering department is responsible for maintaining the operation of this equipment.

REFRIGERATORS (SELF-CONTAINED)

Galley refrigerators will not have any problems if the user will do the following:

- Allow proper clearance in the back of the refrigerator. The refrigerator must have a distance of at least 4 inches away from the bulkhead. Any obstruction will reduce the airflow required for an air-cooled condenser.
- Do not overload the refrigerator.
- Properly store foods with space for air circulation.
- Follow the MRC for routine maintenance like defrosting and cleaning.
- Do not use any sharp objects like knives or scrapers when defrosting the refrigerator. This is not an acceptable procedure for removing frost buildup on a refrigerator.

When repairing or overhauling a refrigerator, refer to the manufacturer's manual. "Refrigeration System," Chapter 516 of *NSTM* contains general procedures on how to maintain or repair a self-contained refrigerator. Follow all the necessary safety precautions when handling and disposing of a refrigerant!

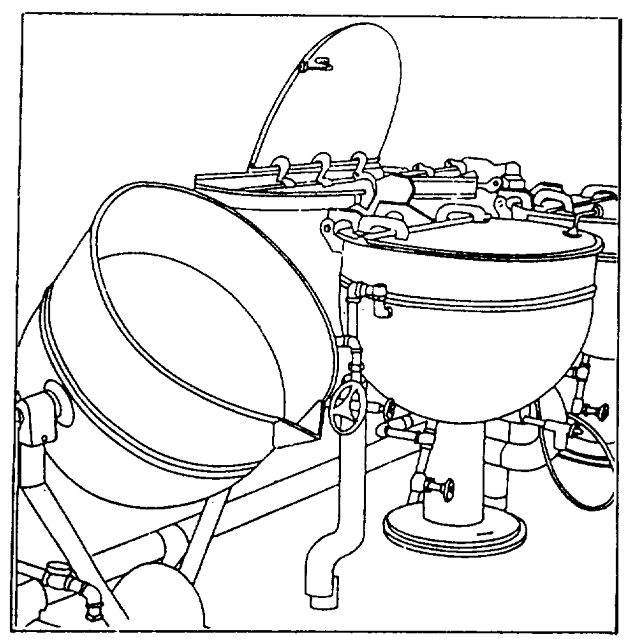

Figure 7-4.—An arrangement of steam-jacketed kettles.

STEAM- JACKETED KETTLES

Kettles require, as a minimum, monthly inspections. Figure 7-4 illustrates an arrangement of shipboard steam-jacketed kettles. An annual preventive maintenance inspection is also important. Here are a few factors to keep in mind while inspecting steam-jacketed kettles.

When making a MONTHLY inspection, check the draw-off faucets, valves, and piping for leaks. Check the steam pressure-reducing valve to ensure it is in good condition and is functioning properly. Lubricate the hinges of the kettle cover with mineral oil.

During the ANNUAL inspection, check each kettle for leaks, cracks, and dents. Examine the cover, hinges, and latch for warp and alignment. Check the steam piping and the condensate piping, the valves, and the traps for leaks and obstructions. Remove the safety valves; then clean, lubricate, and calibrate them before reinstalling. Remove any rust and corrosion by using Navy approved solvents. Other than visual inspections, each individual piece of galley equipment requires its own type of preventive maintenance.

During each ship's regularly scheduled overhaul, steam-jacketed kettles should be tested using the following procedure:

1. Put each kettle into a cold-water pressure test of 90 psi for not less than 30 minutes.

2. Check the safety valves on each kettle. The testing of safety valves should he covered by the PMS. In general, kettle safety valves are set to release at a pressure of 45 psig.

3. Replace kettles that are cracked, badly pitted, or bulge under a pressure test.

4. Replace all malfunctioning safety valves.

Table 7-3 shows some common troubles and repair recommendations on steam-jacketed kettles and other steam-heated equipment.

Table 7-3.—Common Troubles and Repair Recommendations on Steam-Jacketed Kettles and Other Steam-heated Equipment

Inspection Point	Symptoms	Time	Possible Troubles/Causes	Possible Corrections
Steam jacket	Not beating	When noted	No steam; valve stuck closed; trap malfunctioning	Check steam supply; free stuck valve
Steam jacket	Stays hot	When noted	Valve partly open or scored seat	Repair or replace valve
Steam jacket	Leaks	Monthly	Rapid changes in temperature causing cracks; faulty weld	Raise heat slower, reweld bust or crack
Pipe joints	Leaks	Monthly	Joints made incorrectly; not tight	Unscrew, clean and repair joint
Pipe joints	Corrosion	Monthly	Leaks or condensation	Repair and/or clean
Control valves	Stuck open or closed	When noted	No steam or too much steam; packing too tight or valve frozen	Loosen packing gland or free frozen valve stem
Control valves	Leaks at stem	Weekly	Packing not tight enough	Tighten packing
Condensate strainer	No flow	When noted	Restricted strainer	Clean strainer
Steam trap	Malfunctioning	Every 6 months	Parts dirty or worn	Disassemble, clean, and repair
Lagging	Broken or crushed	Quarterly	Water soaked; stepped on	Replace defective sections
Reducing valve	Incorrect pressure	When noted	Parts dirty or worn	Disassemble, clean, and repair; clean and adjust pressure every 6 months
Safety valve	Stuck open or lifting under pressure	When noted	Leaks or corrosion	Replace or repair valve
Covers	Tight operation	When noted	Hinges dirty	Clean and lubricate binges
Drawoff valve	Leaks	When noted	Scored	Resurface or replace. DO NOT REPLACE WITH REGULAR GATE VALVE

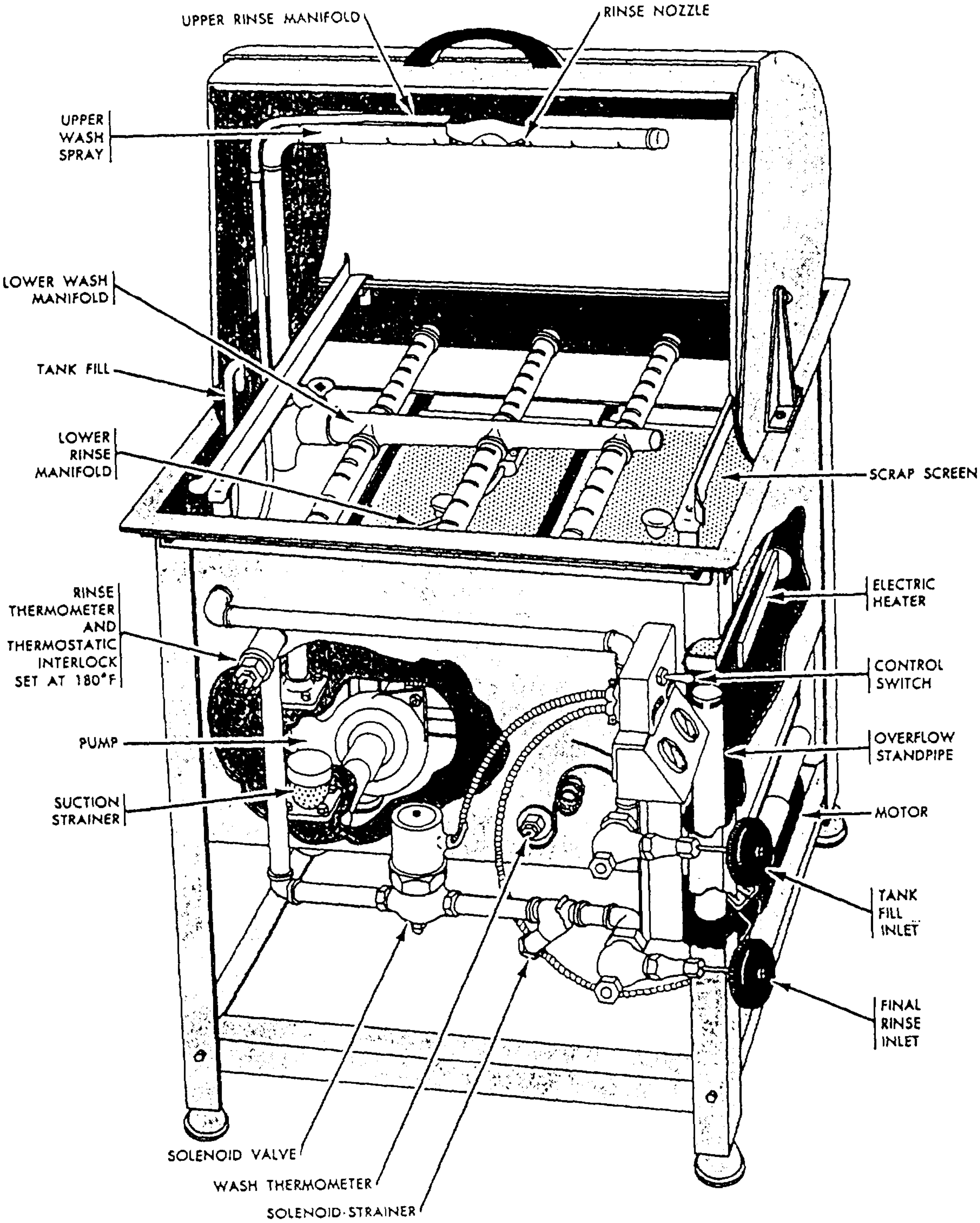

Figure 7-5.—Semiautomatic singie-tank dishwasher machine for use in and messes.

SCULLERY EQUIPMENT

You must read the manufacturer's instruction book for each machine and become familiar with all its operating characteristics and its basic design. If routinely cleaned, descaled, and properly maintained, scullery machines will not have any problems. But these procedures must be done on time as specified by the planned maintenance schedule or by the manufacturer's manual. Any necessary repairs and parts replacement requests must be submitted by the responsible division on Ship's Maintenance Action Form, OPNAV 4790/2K. Following this procedure and using this form will provide you, as the maintenance person, a document of repairs and parts that failed.

TROUBLESHOOTING

From time to time, you may be called upon to repair scullery machines that have become defective. Figures 7-5 and 7-6 illustrate the types of scullery machines used by the Navy. Some common difficulties, the usual reasons for their occurrence, and possible remedies for those difficulties are listed in table 7-4.

REPAIRS OR OVERHAULS

Scullery machines must be inspected by the maintenance personnel according to the PMS schedule. Listed here are some common inspections, maintenance, repairs, or overhauls you may encounter with these machines. You should perform the following:

1. Check the adjustment of tension on the *conveyor* chains if the machine is equipped with a conveyor. If the chain is equipped with lugs, make sure the lugs on both chains are directly opposite each other.

2. See that the guide sprockets are properly located on their shaft so that the conveyor chain will ride properly on the track assembly.

3. Inspect the operation of the doors and make sure all the counterweights are properly attached and the doors are held in the open position when raised.

4. Check the operation of thermometers, pressure gauges, thermostats, and automatic mixing valves or boosters.

5. Adjust the thermostat so that the machine will not start up unless the desired temperature is reached.

6. Inspect the pump packing and adjust as necessary to stop leakage around the pump shaft.

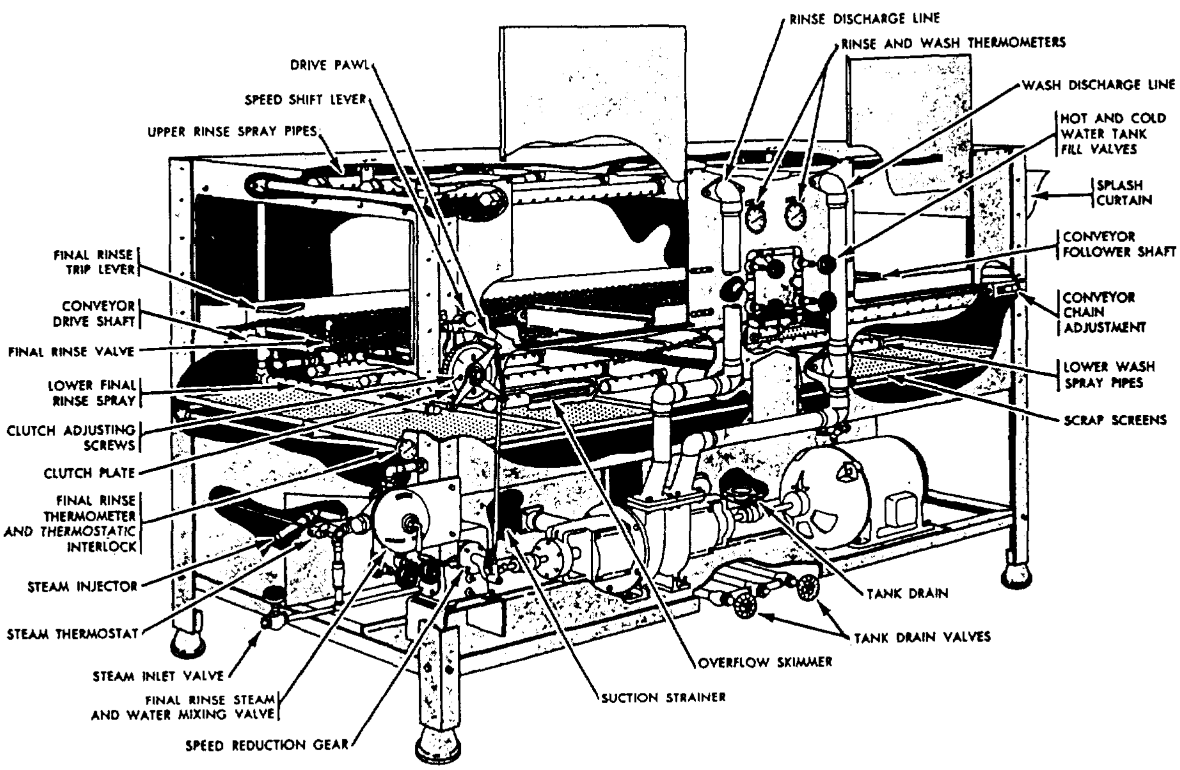

Figure 7-6.—Cutaway view of a double-tank automatic dishwasher.

7. Lubricate the motor and pump bearings.

8. Lubricate, as necessary, the gear reducer unit.

9. Lubricate the conveyor shaft bearings, drive mechanisms, sprocket chains, and so on.

10. Replace any missing lubrication fittings.

11. Inspect all steam and water valves.

12. Disassemble and inspect pumps internally for undue erosion or corrosion at least annually.

SUMMARY

This chapter has presented some general information on maintenance and repairs of laundry, mess deck, galley, and scullery equipment. Maintenance personnel should make use of the manufacturer's technical manual, the PMS, and other related *NSTMs*, which are furnished to all Navy ships.

Table 7-4.—Troubleshooting Chart for Scullery Machines

Trouble	Probable cause	Possible remedy
Dish racks slide off chain conveyor.	Change of tension on either chain.	Reset idler sprockets to proper tension on each chain.
Water pressure too low.	Spray nozzles or slot plugged. Strainer baskets plugged. Slipped belts on pumps.	Dismantle spray assembly. Wash out piping; clean parts. Disassemble and clean strainer. If belts are frayed or tom, replace them. Adjust tension by resetting idler pulley or by moving motor on sliding base.
Water splashing on floor or into wrong compartment.	Leaks around doors; torn curtains or curtains not in proper position.	Realign door. Repair or replace gasket. Repair or realign curtain. Readjust spray to keep it within limits of tank.
Rinse water temperature is less than 180°F.	Insufficient heat from booster heater.	Remove scale from steam coil. Correct leaking fittings. Calibrate or replace thermostat.
Spot or film on eating utensils after final rinse.	Wash water saturated with grease. Dirty tank Weak sprays in wrong direction. Improper detergent mixture.	Stop operation and clean all Equipment. Adjust speed of conveyor. Examine spray equipment. Clean nozzles, spray pipes, scrap trays, and strainers. Check piping for leaks. Check to see if valves are operating properly. Examine pump. Clean impeller if necesssary.

CHAPTER 8

OTHER AUXILIARY EQUIPMENT

This chapter provides general information on the maintenance and repair of a variety of auxiliary machinery that you will be called upon to repair, replace, or adjust. Auxiliary machinery includes controllable pitch propellers, low-pressure steam drain systems, high-pressure steam drain systems, distilling plants, hydraulic systems, external hydraulics, hydraulic cargo hatch covers, boat davits, bow ramp and door machinery, elevators, conveyors, cranes, dumbwaiters, and escalators. You as an EN3 must have already completed personnel qualification standards (PQSs) on some of this auxiliary equipment.

CONTROLLABLE PITCH PROPELLERS

This section will discuss some general facts about the maintenance and repair of controllable pitch propellers. For more information you can refer to technical manual system-oriented instructions, *Controllable Pitch Propellers*, *LST 1182* through *LST 1198,* NAVSEA 0944-LP-007-1018, or *Maintenance Manual for Controllable Pitch Propellers in DD-963 Class, DDG-993 Class, and DD-997 Class*, S9245-BF-MMM-010.

Keeping the hydraulic system clean is of the greatest importance. During a dismantling, there is always a possibility of foreign matter entering the system. You must avoid any unnecessary dismantlings as long as the system is working satisfactorily. If the system or a part has to be dismantled, you must be sure that all parts and pipes are clean before reassembling.

Wipe up any oil or dirt found on or near the hydraulic valve manifold, the oil distribution (O.D.) box, or the control plate assembly. Keep bilge water levels below the lower oil tank manhole cover. And, if possible, keep bilge water below the O.D. box shaft packing glands. Check all fittings and locking devices periodically to be sure they have not vibrated loose. Lubricate all moving parts weekly and wipe up excess oil. Periodically check the water near the stem of the ship for oil slicks that could result in oil leakage from hub or blade seals. Very minor leaks can be detected on the surface of the water. Follow the maintenance according to the maintenance requirement cards (MRCs). Make sure the MRCs are all tailored for your equipment. If you find an error, you must submit a feedback report.

LOW-PRESSURE STEAM DRAIN SYSTEMS

Service steam (low-pressure) drainage systems collect the uncontaminated drains from low-pressure (below 150 psi) steam piping systems and steam equipment outside the machinery spaces. Space heaters as well as equipment used in the laundry, the tailor shop, and the galley are typical sources of drains for the service steam drainage system. Aboard some ships, these drains discharge into the most conveniently located freshwater drain collecting tank. On other ships, particularly large combatant ships, such as carriers, the service steam drains discharge into special service steam drain collecting tanks located in the machinery spaces. The contents of the service steam drain collecting tanks are discharged to the condensate system. In addition, each tank has a gravity drain connection to the freshwater drain collecting tank and to the bilge sump tank located in the same space.

Notice that the service steam drainage system collects only clean drains that are suitable for use as boiler feed. Contaminated service steam drains, such as those from laundry presses, are discharged overboard.

Service steam drain system components consist of various pipings, steam traps, valves, and flanges. In the event you need to make repairs on this system, make sure the system is properly tagged. If needed you can request assistance from the Hull Technicians, who are well trained for this job.

HIGH-PRESSURE STEAM DRAIN SYSTEMS

High-pressure drainage systems generally include drains from superheater headers, throttle valves, main and auxiliary steam lines, steam catapults (on carriers), and other steam equipment or systems that operate at pressures of 150 psi or more. The high-pressure drains aboard some ships lead directly into the deaerating feed tank (DFT). Aboard some newer ships, the high-pressure drains empty into the auxiliary exhaust line just before the auxiliary exhaust steam enters the DFT. In either case, the high-pressure drains end up in the DFT.

These systems have basically the same components as the low-pressure steam drain systems. Components specifically designed for high-pressure steam and the addition of orifices are the only major differences. Whichever system is to be repaired, the system must be tagged. When dealing with repairs on both low-pressure and high-pressure steam systems, there should be a controlled work procedure package. You should review the QA manual concerning repairs on steam systems. Remember you can request assistance from the personnel who are trained to do the repairs. For more general information concerning steam plants, read *Boiler Technician 3&2,* NAVEDTRA 10535-H.

DISTILLING PLANTS

This section will deal with inspections, troubleshooting, and repairing of low-pressure steam distilling plants. The two most common types used by the Navy are the submerged-tube and the flash-type distilling plants. Additionally, this section will mention some facts about the heat recovery type of distilling plant the Navy also uses.

SUBMERGED-TUBE PLANTS

Low-pressure submerged-tube distilling plants differ from ship to ship, but the operating conditions and the maintenance procedures are basically the same. In almost all instances, the personnel who stand watches on the distilling plants are also responsible for the maintenance of the plants. When operating problems do occur, it is the responsibility of the EN2, ENl, or ENC on duty to locate the trouble and to make the necessary adjustments or repairs.

Distilling plant reliability and consistent operating conditions are essential for satisfactory results. Except under emergency conditions, no plant should be forced beyond its rated capacity. Requirements for higher steam pressures result in higher temperatures, which will cause more rapid scaling of the evaporator tubes.

During operation, the various elements of any plant depend on the heat and fluid balances throughout the plant. Adjustment of any one control can produce widespread changes to these balances. For example, an increase in the feed to the first effect will raise the liquid level in the first effect. More heat will be required to raise the feed to the boiling point, so that less heat will be available for evaporation in the first-effect shell and a smaller amount of heat will flow to the second-effect tube nest. These changes produce a new balanced condition, and other adjustments would be required to make the new balance satisfactory. Under such circumstances, overcontrolling could require many readjustments. The operator will always find it better to make small adjustments, one at a time. This will allow enough time between each adjustment for all the conditions to become steady.

Causes of Low Plant Output

Failure to obtain full rated capacity is one of the most frequent problems encountered during the operation of a distilling plant. The problem may be very difficult to remedy since it may result from a combination of things. Adecrease in the distilling output efficiency may result if any of these factors are not met. Full output requires the following:

1. Proper steam pressure above the orifice
   a. Ample steam supply
   b. Proper operation of reducing valves
2. Highest possible vacuum in the first-effect tube nest
   a. No air leaks
   b. Proper water levels in the evaporator shells
   c. Continuously vented evaporator tube nests
   d. Reasonably clean evaporator tube nests
      (1) Continuous feed treatment
      (2) Mechanically cleaned tubes
   e. Density of brine overboard not over 1.5/32
      (1) Reasonably clean overboard piping
      (2) Proper valve settings
      (3) Proper operation of brine pump (clean piping and strainers, proper speed and direction of rotation, properly vented pump, properly packed and sealed gland, and no air leaks in the piping)
   f. Properly drained tube nests
      (1) Proper operation of all drain regulators
      (2) Proper operation of the tube nest drain pump
3. Highest possible vacuum in the last-effect shell
   a. No air leaks

b. Proper air ejector operation

(1) Clean nozzle and strainer

(2) Correct quality and quantity of steam

c. Ample flow of circulating water

(1) Clean strainer, pipeline, and tubes

(2) Proper valve settings

(3) Proper operation of the circulating pump

d. Effective surface in the distilling condenser

(1) No undue deposits inside the tubes

(2) Proper venting of the condenser

(3) Proper operation of the condensate pump

Steam Pressure

A distilling plant cannot maintain its full output unless it is supplied with dry steam at the designed pressure. The orifices were constructed to pass the proper amount of steam plus about 5 psig pressure to safely produce the designed plant output. Orifices should be inspected annually. An orifice should be measured and the reading compared with the figure stamped on the plate. If necessary, the orifice should be renewed.

If the steam pressure above the orifice varies, the exact source of trouble should be located and corrected. First the weight-loaded regulating valve and then the pressure-reducing valve (if installed) should be checked to determine whether or not each valve is operating properly. If they are functioning properly and the pressure cannot be maintained above the orifice, you may assume that an insufficient amount of steam is being supplied to the plant.

The auxiliary exhaust steam supply for the distilling plants, after passing through the regulating valve, is usually slightly superheated because of the pressure drop through the reducing valve and the orifice plate. A small amount of superheat has little or no effect on the plant operation or the prevention of scale formation. However, when live steam must be used, the installed desuperheater spray connection should be used to control the superheat. The water for desuperheating must be taken from the boiler feed system, preferably from the first-effect tube nest drain pump. Water for desuperheating must NEVER be taken directly from the fresh water distilled by the distilling plant.

Fluctuations in the first-effect generating steam pressure and temperature cause fluctuations of pressure and temperature throughout the entire plant. With increased salinity of the distillate, the fluctuations may cause priming, as well as erratic water levels in the shells. These fluctuations may he eliminated by proper operation of the automatic pressure regulators in the steam supply line.

First-Effect Tube Nest Vacuum

The range of the pressure maintained in the first-effect tube must be between 16 inches of mercury (in.Hg), with clean tubes, to 1 to 2 in.Hg as scale forms. The output of a submerged-tube type of distilling plant is not greatly reduced until the deposits on the tubes have caused the vacuum to drop to about atmospheric pressure. When the first-effect tube nest vacuum is lost entirely, the reduction in output becomes very great. Assuming the reduction in vacuum is due to scale and not to improper operating conditions, the tubes must be cleaned.

Keeping the vacuum in the first-effect tube nest as high as possible reduces scale formation to a minimum, enabling the plant to’operate at full capacity.

A vacuum reduction that results from any factor other than deposits on tube surfaces should be corrected to reduce deposits and greatly extend the intervals between cleanings. The primary factors affecting the first-effect tube nest vacuum are air leakage, low water levels in the evaporator shells, improper venting of the evaporator shells, scale or other deposits on the tubes, and improper draining of the evaporator tube nests.

Loss of vacuum resulting from deposits on evaporator tubes should be gradual. Under normal conditions, there will be no major loss of vacuum for any one day’s operation. Any sudden drop in vacuum can be traced to causes other than scale deposits.

The generating steam circuit operates under vacuum and is subject to air leaks. Leaks from the steam side of the first-effect tube nest to the first-effect shell space cause losses of capacity and economy. Loss of vacuum and loss of capacity may be due to air leaks. The air leaks may he from the atmosphere into the generating steam line (downstream from the orifice plate); from the first-effect tube nest front header; or from the first-effect tube nest drain piping. Air leaks in this part of the distilling plant may be less noticeable than air or water leaks elsewhere, because the effect on the plant is similar to the scaling of the tube surfaces.

Proper Water Levels

A reduced first-effect tube nest vacuum can result from low water level in any evaporator shell. On older plants, the water levels are controlled by manually regulating the feed valves. On newer plants, the water levels are automatically controlled by weir-type feed regulators. Inability to feed the first effect is usually due either to scale deposits in the seawater sides of the air ejector condenser and the vapor feed heater or to obstructions in the feed line. Inability to feed the second or third effects is due to air leakage or heavy scale deposits in the feed lines between the effects. It is important that you keep the gauge glass and the gauge glass fittings free from scale and air leaks. Air leaks or scale will result in false water level indication readings.

Once the distilling plant is in operation, the feeding must be maintained at a steady rate. A sudden rise of the water levels or too high a water level will cause carryover of small particles of brine within the vapor (priming). Maintain the level of water in the shell at the highest level that can be held and still prevent the carrying over of saltwater particles within the freshwater vapor. If this constant water level is not maintained, scales will form rapidly on the exposed tube surfaces.

The pressure differential between the first and second effects permits the second-effect feed to be discharged into the second-effect shell. A partial or total loss of pressure differential indicates that air leaks have occurred between the first-effect and second-effect shells in the two-effect distilling plants. Large air leaks between the first effect and second effect can be readily detected, because the vacuum gauge for the first effect will read approximately the same as the vacuum gauge for the second effect. Large air leaks of this type will disrupt the operation of the plant and must be located and repaired before the plant will operate properly.

Improper Venting of Evaporator Tube Nests

Improper venting of the evaporator tube nests can cause either an accumulation of air in the tubes or an excessive loss of tube nest steam to the distilling condenser. A loss of tube nest air or steam results in a loss of capacity or a loss of economy. Problems of this type usually result from improper operations, rather than from material failures.

Scale Deposits on Evaporator Tubes

Scale deposits on evaporator tube nests have been a serious cause of operating difficulties. The rate of scale formation is affected by the density of the brine and by the types of solids present in the feed. Although the major constituents of seawater (sodium chloride, magnesium chloride, and others) do not form scale under normal plant operating conditions, they may do so when the last-effect brine density exceeds 1.5/32. The primary scale-fomling constituent of seawater, calcium carbonate, will form scale even under normal plant conditions. But, the rate of scaling depends on the brine density. For this reason, you must maintain the last-effect brine density at 1.5/32.

Another method to control scale formation is by the use of scale preventive compound. This material helps retard scale formation and foaming in distilling plants. The only authorized distiller scale preventive compound for surface ships is DOD-D-24577 (SH), *Distiller Scale Preventive Treatment Formulutions,* available from the Navy Supply System under National Stock Number (NSN) 9G6850-00-173-7243. Ships that were not originally equipped with chemical injection equipment conforming to MIL-P-21397, *Chemical (For Distilling Plants Naval Shipboard Use) Proportioning Unit,* should install such equipment through a ship alteration (SHIPALT). Note that all plants require 24 gallons of solution regardless of plant capacity. You will use 1 pint of scale preventive compound for each 4,000 gallons per day of distilling plant capacity. You must combine the total amount of scale preventive compound in the mixing tank with enough fresh water to make 24 gallons of solution.

WARNING

Concentrated scale preventive compound is strongly alkaline. Avoid contact of the liquid with skin or eyes. Wash hands thoroughly after using. In case of contact with eyes, flush with fresh water for at least 15 minutes and report to sick bay immediately.

Last-Effect Shell Vacuum

A vacuum of approximately 26 in.Hg should be obtained in the last-effect shell when the temperature of seawater is 85°F. The vacuum should be higher when the seawater is colder. Failure to obtain a vacuum of 26 in.Hg, or more, can generally be traced to one of several factors or a combination of these factors. It could be air leaks, improper operation of air ejectors, insufficient flow of seawater, or ineffective use of heat transfer surface in the distilling condenser.

Air Leaks

Many distilling plant troubles are direct results of air leaks. Air leaks in the shells of distilling plants cause a loss of vacuum and capacity. You must take extreme care when making up joints, for they must be kept tight. Periodically test the joints under pressure for leaks. When the plant is in operation, use a candle flame to test all joints and parts under vacuum. When the plant is secured, you can use air pressure or soapsuds for testing.

Air leakage may also be detected by hydrostatically testing the various parts of the plant. You should take the necessary precautions not to exceed the maximum limit of the test pressure specified by the manufacturer.

Saltwater Leaks

Defective tube(s) on the heat exchangers can be located by means of an air or a hydrostatic test. You should follow the recommended procedure according to the manufacturer's instructions.

Air Ejector

The steam pressure at the nozzle inlet of the air ejector must not be less than that for which the ejector is designed (stamped on the nameplate). Pressures at the air ejector nozzles may be 10 to 15 psig higher than the minimum specified by the manufacturer.

The primary causes of air ejector problems are low steam pressure, wet steam, an obstructed nozzle, or a clogged steam strainer. Problems are usually indicated by a failure to obtain or to maintain the required vacuum. If a problem is due to low steam pressure or wet steam, you should increase the steam pressure, install a drainage trap, or devise a manual solution. A clogged nozzle or strainer must be removed and cleaned. You should use special reamers to clean the air ejector nozzles. You should NEVER use a sharpedged tool to clean nozzles! Improper tools will damage the nozzle surfaces and impair the efficiency of the air ejecter.

Procedures for testing air ejectors can be found in the manufacturer's technical manual. In general, the same maintenance procedures should be followed for distilling plant air ejectors as for air ejectors for the main condensers.

You should inspect the air ejector strainer according to the PMS. Failure to keep the strainer clean will cause a reduced or fluctuating vacuum. When a strainer or a nozzle becomes damaged, you should replace it.

Insufficient Circulating Water

An insufficient flow of circulating water is indicated when the temperature of the water rises more than 20°F while passing through the condensing section of the distiller condenser. The last-effect shell pressure is directly dependent upon the distiller condenser vacuum. The vacuum is dependent upon the temperature and quantity of the circulating water and the proper operation of the air ejectors. Too low an overboard discharge temperature of the distiller condenser circulating water is accompanied by efficiency losses in the distilling plant. The overboard discharge temperature should be kept as high as possible, without exceeding the desired 20°F temperature rise through the distiller condenser. In addition, limiting the quantity of circulating water tends to prolong the service life of the tubes and tube sheets. When troubles occur which are not caused by improper operating procedures, you should inspect the condenser circulating water system to determine the true cause of the faulty operation.

You must carry out preventive maintenance procedures to ensure that the circulating water pump is maintained in good material condition. You should also carry out routine procedures to ensure the proper setting and maintenance of the back-pressure regulating valve. A regulating valve that is not working properly must be disassembled and repaired before its faulty operation interferes with the operation of the distilling plant.

You should inspect the condenser circulating water system pipings at regular intervals for cleanliness as well as for scale or foreign matter. The operators of the distilling plant should inspect and clean the strainers according to the PMS.

Improper Drainage

If the distilling plant fails to produce the designed output when the pressure above the orifice is 5 psig and the first-effect tube nest is several inches of mercury, this is an indication of improper drainage of the distiller condenser or of one of the evaporator tube nests subsequent to the first effect. Complete flooding of the flash chamber gauge glass is also a positive indication of improper draining of the condenser. Because the level appears to be in the gauge glass or below is not necessarily an indication of improper drainage. Air leaks at the gauge glass fittings may indicate a false liquid level.

Brine Density

Proper brine density should be maintained at 1.5/32. If the brine concentration is too low, there will he a loss in capacity and economy. If the brine concentration is too high, there will an increase in the rate of scaling of the evaporator heating surfaces.

FLASH-TYPE DISTILLING PLANTS

Many maintenance procedures for flash-type distilling plants are similar to the maintenance procedures required for submerged-tube distilling plants. Both types of plants are subject to air leakage, saltwater leakage, and malfunctioning of pumps and other auxiliary equipment.

HEAT-RECOVERY DISTILLING PLANTS

Heat-recovery distilling plants are single-effect distilling plants with a submerged-tube heat exchanger. This heat exchanger uses heat energy contained in the jacket cooling water circulated through diesel main propulsion engines and ship's service diesel generators. This unit requires no steam for air ejectors because feed is used as the motive power to operate eductors for air and brine removal To supplement the heat in the jacket cooling water when engines are running at low rates, the plant has electric heating modules and steam heaters. This ensures that the jacket cooling water will be at the required temperature when it enters the submerged-tube heat exchanger. The jacket water passes through all the heat exchangers (whether energized or not) to the inlet of the submerged-tube bundle. Here the heat is transferred through the tubes to the feed in the boiling compartment. The jacket water then exits the tube bundle and returns to the engine. The heat-recovery system is fitted with a circulating pump and an expansion tank

Most heat-recovery distillers aboard Navy ships have a secondary heat exchanger between the engine jacket cooling water system and the distiller unit. This heat exchanger isolates the engine coolant, with all its chemical additives, from the distiller. Systems not having this secondary heat exchanger get heat directly from the engine coolant to support the distiller. This is called a single-loop system. A single-loop system must be monitored continuously to ensure that no engine coolant leaks through the distiller submerged-tube heat exchanger. For more information on the monitoring requirements, refer to *NSTM* Chapter 233, "Diesel Engines." For cleaning heat-recovery plants, follow the applicable instructions as you would for cleaning the submerged-tube or the flash-type distilling plants. For more detailed information concerning the distilling units the Navy uses, refer to the manufacturer's manual and *NSTM*, Chapter 531, Volumes 1, 2, and 3, "Desalination Low-Pressure Distilling Plants."

HYDRAULIC SYSTEMS

The overall efficiency of the hydraulic installations used to control or drive auxiliary machines is basically dependent upon the size, oil pressure, speed, and stroke of the hydraulic installation. The efficiency of the hydraulic speed gears and the components of the system will depend upon the care that is given to them. Except for piping and fittings, major repairs of hydraulic gear are generally done in a naval shipyard or by the manufacturers. This section will deal primarily with troubleshooting and preventive maintenance of hydraulic systems, including external hydraulics.

Hydraulic transmissions are sturdy, service-proven machines, inspected and tested with such care that casualties seldom occur. When casualties do occur it is usually the result of faulty assembly, installation, or maintenance. A correctly installed hydraulic system, operated regularly and serviced with proper care, will retain its design characteristics of power, speed, and control. The need for costly repair and replacement will seldom occur if the equipment has been maintained properly.

TROUBLESHOOTING

Troubleshooting an electrohydraulic system involves the systematic elimination of the possible causes, one by one, until the actual cause of a casualty is found. In attempting to locate the source of any trouble in an electrohydraulic system, remember that all troubles fit into one of three categories. It is either hydraulic, electrical, or mechanical. Isolating a trouble into one of these categories is one of the main steps in finding the source of trouble.

Hydraulic Troubles

Casualties in a hydraulic system are generally the result of low oil levels, external or internal leakage, clogged lines or fittings, or improper adjustment of valves and other working parts. Do NOT disassemble a unit unless you are certain that the trouble exists within that unit! Unnecessary disassembly may create conditions that lead to additional trouble, since dirt may enter an open system.

Leaks are a frequent cause of trouble in hydraulic equipment. Generally, leaks are a result of excessively worn parts, abnormal and continuous vibration, excessively high operating pressures, or faulty or careless assembly. External leaks usually have little effect on the operation of equipment other than a steady draining of the oil supply. Even a small leak wastes oil, and the resulting unsightly appearance of a machine is indicative of poor maintenance procedures.

External leaks may result from improperly tightened threaded fittings; crossed threads in fittings; improperly fitted or damaged gaskets; distorted or scored sealing rings, oil seals, or packing rings; scored surfaces of working parts; improperly flared tube ends; or flanged joints not seating squarely.

Internal leaks usually result in unsatisfactory operation of the equipment. Large internal leaks are signified by a loss of pressure and the failure of equipment. While large internal leaks can usually be located by installing pressure gauges in various parts of the equipment, the location of small leaks generally requires disassembly and visual inspection of the parts. Internal leaks may result from worn or scored valves, pistons, valve plates or bushings, or improperly fitted or damaged gaskets.

The most common symptom of trouble in a hydraulic system is an unusual noise. Some noises are characteristics of normal operation and can be disregarded, while others are evidence of serious trouble. Even though the exact sound indicating a specific trouble can be learned only through practical experience, the following descriptive terms will give a general idea of which noises are trouble warnings.

If *popping* and *sputtering* noises occur, air is entering the pump intake line. Air entering the system at this point may be the result of too small an intake pipe, an air leak in the suction line, a low oil level in the supply tank, cold or heavy oil, or possibly the use of improper oil.

If air becomes trapped in a hydraulic system, *hammering* will occur in the equipment or transmission lines. When this occurs, check for improper venting. Sometimes, a *pounding* or *rattling* noise occurs as the result of a partial vacuum produced in the active fluid during high-speed operation or when a heavy load is applied. This noise may be unavoidable under the conditions stated and can be ignored if it stops when speed or load is reduced. If the noise persists at low speeds or light loads, the system needs to be vented of air. Air in a hydraulic system can also cause uneven motion of the hydraulic motors.

When a *grinding* noise occurs, it can usually be traced to dry bearings, foreign matter in the oil, worn or scored parts, or overtightness of some adjustments.

The term *hydraulic chatter* is sometimes used to identify noises caused by a vibrating spring-actuated valve, by long pipes improperly secured, by air in lines, or by binding of some part of the equipment.

Squeals or *squeaks* indicate that the packing is too tight around some moving part or that a high-frequency vibration is occurring in a relief valve.

Electrical Troubles

Even though troubles occurring in electrical equipment are the responsibility of the Electrician's Mate, the Engineman can help maintain the equipment by making a few simple checks when electrical troubles occur. Failure to have a switch in the ON position will cause unnecessary delay in operating electrical equipment. If the switch is closed and the equipment still fails to operate, check for blown fuses or tripped circuit breakers. Troubles of this type are usually the result of an overload on the equipment. If a circuit breaker continues to cut out, the trouble may be caused by damaged equipment, excessive binding in the hydraulic transmission lines, or faulty operation of the circuit breaker. Check for visual indication of open or shorted leads, faulty switches, or loose connections. Do not make repairs to the electrical equipment or system. Do not open enclosures of electrical equipment, but do report evidence of possible electrical failure to the Electrician's Mate.

Mechanical Troubles

When electrohydraulically driven auxiliary machinery becomes inoperative because of a mechanical failure, a check should be made. Look for improper adjustment or misalignment of parts; shearing of pins or keys; or breakage of gearing, shafting, or linkage. Elimination of these causes should be done according to the manufacturer's instructions for the specific piece of equipment.

MAINTENANCE

The principal requirements necessary to keep a hydraulic transmission in satisfactory operating condition are regular operation, proper lubrication, and the required state of cleanliness of all the units and their fluids. Regular operation of hydraulic equipment prevents the accumulation of sludge and the freezing of adjacent parts. Regular use also aids in preventing corrosion. The necessity for proper lubrication and cleanliness cannot be too strongly emphasized

Detailed instructions on the maintenance of a specific unit should be obtained from the appropriate manufacturer's technical manual, but the following general information will also be useful.

The Fluid System

If an inspection of an oil sample drawn from a hydraulic system reveals evidence of water, sludge, or acidity, the system must *be drained,* then *cleaned* with prescribed acid-free cleaning fluid (flushing oil), and *filled* with clean hydraulic oil. A hydraulic system may be drained and cleaned as follows:

1. Remove the permanent filters and wash them in flushing oil. Then use low-pressure air for drying purposes. If the filters have replaceable elements, install new elements.

2. Drain the system of old hydraulic oils as completely as possible.

3. Close all connections, and fill the system with acid-free cleaning fluid.

4. Start andoperate the unit under idling conditions to fill the system thoroughly with cleaning fluid.

5. Secure the unit and allow it to stand idle for the prescribed period (usually about an hour). This period of idleness permits the cleaning fluid to dissolve any sludge.

6. Start and operate the unit with a light load for 3 to 5 minutes, unless otherwise specified. Allow the equipment to stand idle for about 15 minutes, then repeat the whole cleaning process. Do this two or three times.

Never operate a hydraulic unit with a full load when it is filled with cleaning fluid. Keep the operating pressure as low as possible.

7. If time permits, allow the system to stand idle for an additional hour following the series of short operating periods.

8. Drain the system of cleaning fluid. Reclean permanent filters or, if necessary, install new replaceable filters. Close the system, and fill it with the proper hydraulic oil.

As the system is filled, strain the hydraulic oil through a fine wire screen of 180 or 200 mesh. If the oil is not clean, run it through a centrifuge. You should provide adequate protection against dust and moisture entering the system. Moisture should be expelled from the oil before it is poured into a system. Oil with noticeable water content should be rejected or centrifuged

When a hydraulic system is being filled, sufficient hydraulic fluid should be used to completely fill the active parts of the mechanism, leaving no air pockets. Air valves should he opened during the filling process, so that air can escape to the oil expansion box. Be sure the valves are closed tightly after the system has been filled. For more information on hydraulic fluid filtration, read *NSTM,* Chapter 556, "Hydraulic Equipment (Power Transmission and Control)." For additional information on hydraulic fluids, refer to *NSTM,* Chapter 262, "Lubricating Oils, Greases, and Hydraulic Fluids and Lubricating Systems."

Pumps and Motors

Whether the pumps and motors of hydraulic transmission are of the axial or radial piston type, the maintenance procedures, as well as the operating principles, are relatively the same. In general, maintenance information on other types of pumps also applies to hydraulic pumps and motors. For more information concerning hydraulic pumps and motors, read section 2 of *NSTM,* Chapter 556, "Hydraulic Equipment (Power Transmission and Control)."

Neoprene is the most commonly used seal around the shafts of most modern hydraulic pumps and motors, but other types of shaft packing are also used.

On some modern hydraulic transmissions, *shaft stuffing box packing* is of the square-braided pure asbestos type. This packing is easily removed, but you must take care to be sure that it is not replaced too tightly. If properly installed, this packing makes a tight joint when you apply light pressure. If packing wears quickly, the shaft should be inspected for roughness. If a lathe is available, you may be able to eliminate the roughness from the shaft by a finishing cut to smooth the surface. If a lathe is not available, it may be necessary to replace the shaft. Packing should be renewed at prescribed intervals to eliminate the possibility of the packing becoming hard and scoring the shaft. When packing is being replaced, make certain there is a uniform thickness around the shaft. An excess of packing on one side of the shaft will cause breakage. Stuffing boxes should be packed loosely and the packing gland set up lightly to allow adequate leakage for cooling and lubrication. See *NSTM,* Chapter 078, "Gaskets, Packings, and Seals," for more detailed discussion of O-rings and other types of seals for hydraulic system equipment.

There is very little likelihood of poor alignment between the driving and driven members of a hydraulic transmission if the wedges, shims, jacking screws, or adjusting setscrews were properly set and secured when the connecting units were installed. However, when a casualty occurs or a unit is replaced, it is possible for the unit to become misaligned enough to cause severe stress and strain on the coupling and connected parts. Excessive misalignment should be eliminated as soon as possible by replacing any defective parts and by readjusting the aligning devices. If this is not done, pins, bushings, and bearings will wear out too fast and will have to be replaced frequently.

Since there is no end play to either the pump shaft or the motor shaft, flexible couplings are generally used in hydraulic transmissions. Such couplings permit satisfactory operation with a slight misalignment, without requiring frequent renewal of parts.

Pipings and Fittings

If properly installed, the piping and valves of a hydraulic system are seldom a source of a trouble, except for leakage. Some leaks, however, can be serious enough to cause a reduction in the efficiency of the unit. You should make frequent inspections for leakage and take steps to eliminate any leakage found. Guidance and requirements for the installation, inspection, and maintenance of piping and associated fittings are contained in *NSTM,* Chapter 505, "Piping Systems,"

If leaks occur at a flanged joint in the line of a hydraulic system, tighten the flange bolts evenly, but not excessively. If the leaks persist, use the auxiliary gear while the leaking flange is being refitted with copper asbestos or O-ring packing. Be sure the flange surfaces are cleaned carefully before the packing is applied.

CAUTION

Exposure to asbestos fibers is a recognized health hazard. Refer to *NSTM,* Chapter 635, "Thermal, Fire, and Acoustic Insulation," for safety requirements applicable to handling asbestos packing and gaskets.

If certain measures are taken, operation of hydraulic equipment may be continued while leakage repairs arc being made in some parts of the system. When the lines in an auxiliary system leak, they should be valved off from the main line connection to prevent leakage between the two systems. If leaks occur in the pumping connections to the three-way valves of a steering gear installation, the pump can be cut out with the valve, and another pump cut in. If the three-way valves fail to cut out the leaking unit, and it becomes necessary to cut out both pumps of a steering gear installation, the valves may be closed at the ram cylinder. Hydraulic systems will work without pressure control. So by closing the valves in the lines where they join the main piping, leaking pressure control pipes or cylinders can be cut out of the system for repairs.

Expansion lines and replenishment lines in hydraulic systems of older ships are seldom a source of leakage or breakage, since they are not under any appreciable pressure. However, all hydraulic line connections must be maintained intact. in more recent installations, however, replenishing lines are under pressure as much as 300 psi. In these modern installations, the hydraulic systems should not be operated during the repair of these lines.

Relief valves and shuttle valves of a hydraulic system may also be a source of trouble. The seats of relief valves that are leaking should be reground. Loss of power is a symptom of a leaking relief valve. Shuttle valves may stick and fail to cut off. This condition is evidenced either by the escape of oil from the high-pressure side of the line into the expansion tank or by the failure of the pressure control. When a shuttle valve fails to operate, the stop valves should be closed and the defective valve removed and repaired.

Incorrectly adjusted needle valves can be another source of trouble. Needle valves that are adjusted too fine may cause the device operated by the valve to stop short of its intended stopping point. This may happen because the valve adjustment allows more fluid to pass through leakage points in the system than through the valve. *NSTM,* chapter 556, provides a good source of general information concerning different types of valves used in hydraulic systems and their maintenance.

HYDRAULIC CARGO HATCH COVERS

Cargo hatch cover opening and closing operations are supplied by an electrohydraulic power unit. The system consists of an electric motor-driven hydraulic pump mounted on a hydraulic fluid reservoir tank and an air-driven hydraulic intensifier. Adjacent to the power unit is a hydraulic fluid control valve panel. An emergency air-hydraulic pump is also provided with the system. Fluid pressure is transmitted to either the undogging or dogging side of the hydraulic cylinders. You must read the specific manufacturer's manual or NAVSEA 0916-LP-018-2010, Hydraulic Operated Cargo Hatch Cover, to understand the full details of the system. Along with this, you should trace the system in your ship and complete the required PQS. During repairs, follow the procedures specified by the PMS.

BOAT DAVITS

Gravity davits are found on most Navy ships. Figures 8-1, 8-2, and 8-3 illustrate the types of gravity davits that you will be maintaining.

For general information about boat davits, read *Boatswain's Mate,* Volume 1, NAVEDTRA 10101. You, as the maintenanceman, must also be familiar with the proper operation of the boat davit. Some common problems with the boat davit are rusting of parts, loss of lubrication, contaminated oil in the gearcase, and faulty centrifugal brakes. Because of the location of the boat davit on the weather deck, the machinery is highly exposed to sea spray, even though it is covered by protective covering. You must lubricate the boat davit and winch after adverse weather conditions. For maintenance and repair of the boat davit, follow the PMS assigned for this machinery. If your ship is equipped with a double-pivoted link davit and a 50-hp winch, NAVSHIPS 0920-072-1013 provides information concerning maintenance instructions. Your work center PMS Manual 43P1, under Maintenance Index Page should provide you with the correct reference publications for each piece of equipment.

BOW RAMP AND DOOR MACHINERY

The ramp and door system consists of the bow ramp, bow doors, tracks, winches with their wire rope rigging, fixed and positive guidance rollers, vangs, seating device, pivot post, control consoles, various interlock and limit switches, and the interlock control panels.

In time, repairs will become necessary to correct the results of wear or to repair damage caused by various casualty conditions. You must know and use the correct sources of information necessary to efficiently disassemble and reassemble the machinery. You must

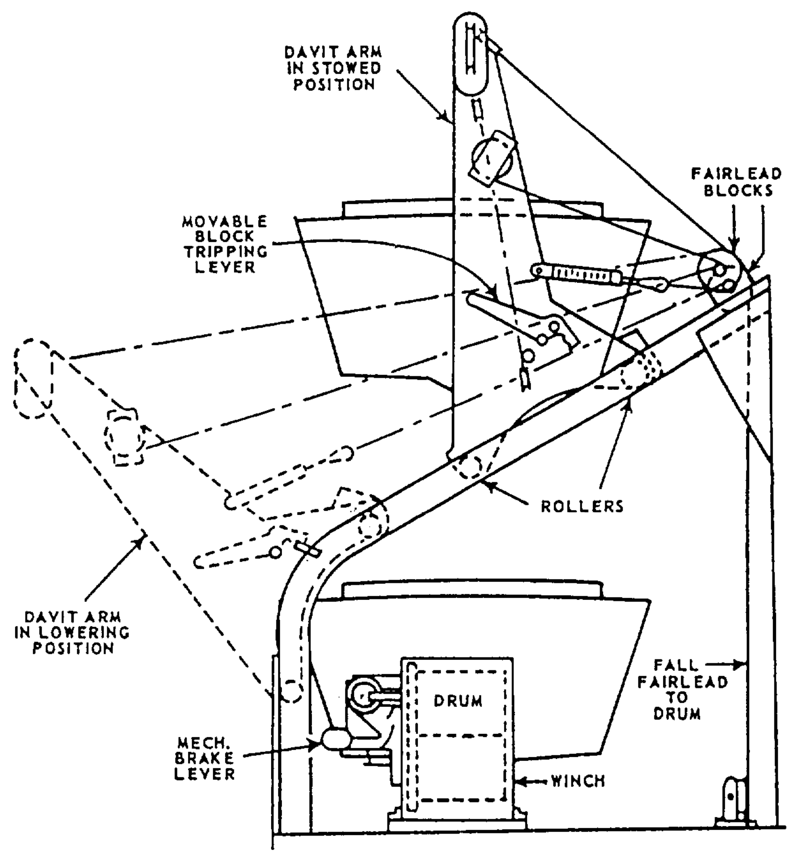

Figure 8-1.—Trackway gravity davit.

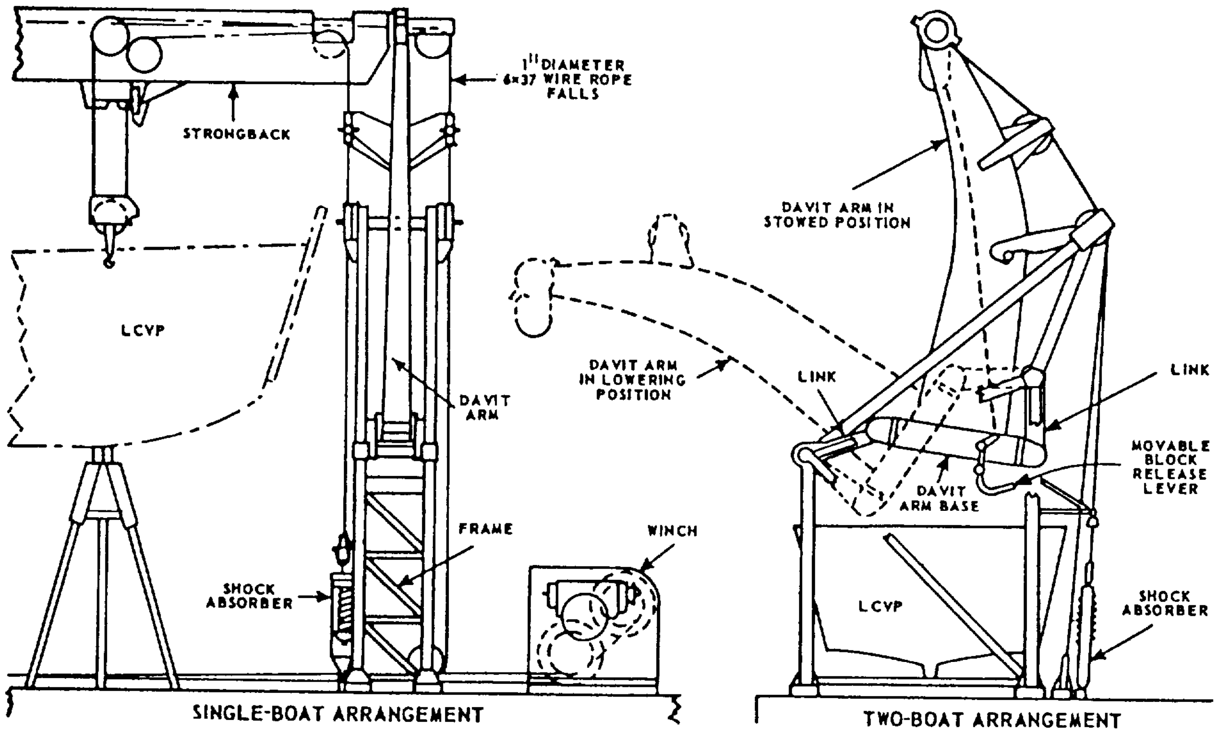

Figure 8-2.—Double-link pivoted gravity davit.

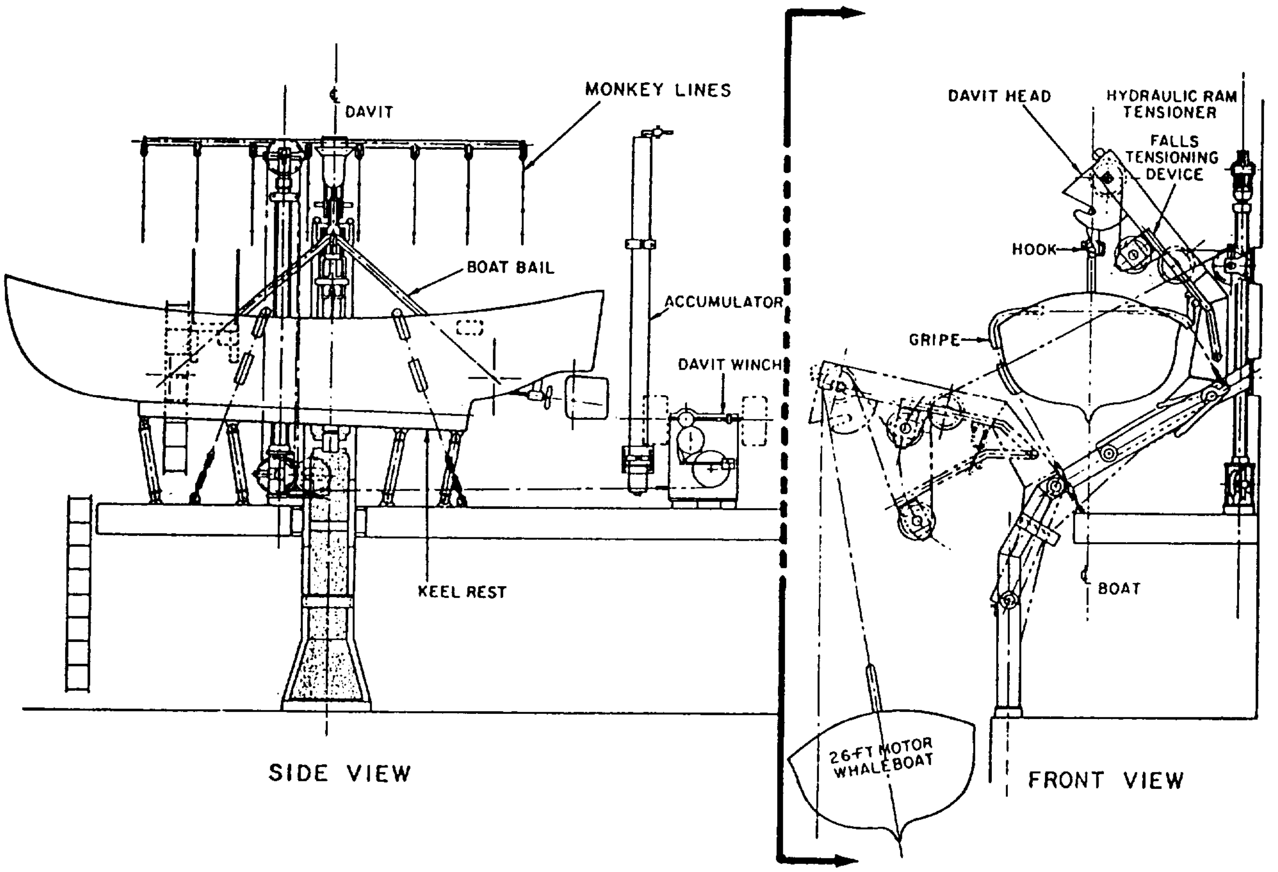

Figure 8-3.—Single-arm trackway gravity davit.

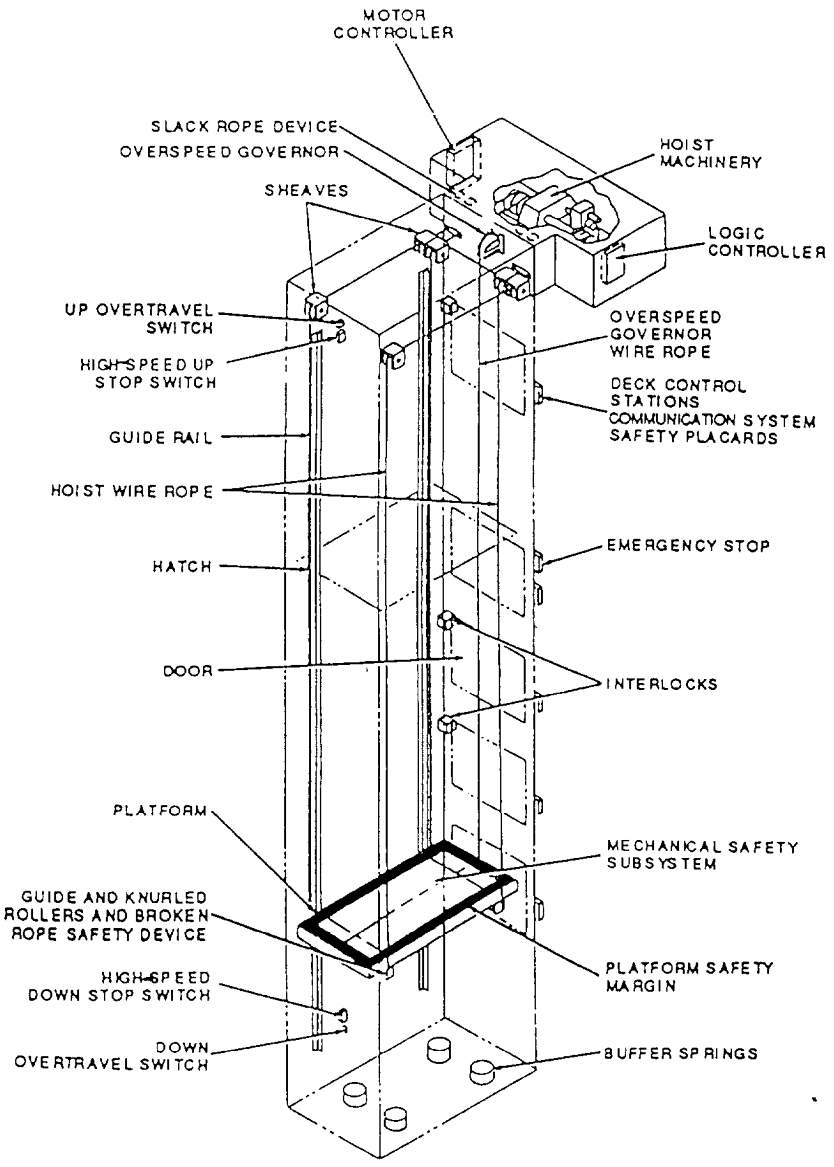

Figure 8-4.—Aircraft carrier weapons elevator.

read and heed any of the safety precautions and warnings like the following:

WARNING

Before starting disassembly of any piece of equipment, be certain the power is off and the switch is tagged. Do not re-energize any tagged circuit until safety of doing so is definitely established.

When you determine that a repair or replacement of part(s) will require disassembly, tag the system out. Remove any interfering guards or obstructions. To reduce the chance of dirt and other contaminants from getting into the works as the parts are disassembled, you must take the time to properly clean the machinery. Keep the dirt out of open gear cases and be sure parts are cleaned before reassembly. If the oil becomes contaminated, drain and flush the system with light oil and refill it with proper lubricant. Water in the oil will cause rust, and dirt can act as an abrasive to wear out the machinery. You must match marked parts that could be installed in more than one way so that you can return the machinery parts to their original position.

Components like winches and other actuating machinery are covered in considerable detail by their manufacturer’s technical manuals. Any repairs to be done must be done according to the applicable technical manual as specified by PMS. You must complete the required PQS for this equipment. For more detailed information, refer to *NSTM*, Chapter 584, “Stern Gates, Ramps, Bow Doors, Turntables, and Water Barriers.” Also, a copy of NAVSEA 0916-LP-018-5010, *Operation Manual for Bow Ramp System (U) LST 1182-1198*, may be very useful.

ELEVATORS

U.S. Navy shipboard elevators are either the electromechanical winch type or the electrohydraulic ram type. Elevators are classified by their functional use. The following designations are typical of elevators installed in Navy ships:

- Cargo elevator
- Weapons elevator
- Ammunition elevator
- Personnel elevator
- Medical evacuation (MEDEVAC) (casualty) elevator
- Aircraft elevator

Some elevators serve several functions. For example, aircraft elevators are used to move weapons, cargo, personnel, and support equipment. Weapons elevators can serve as cargo elevators and can be used to evacuate personnel casualties in a mass or medical emergency situation. Figures 8-4, 8-5, and 8-6 illustrate some of the types of elevators aboard U.S. Navy vessels. Pay particular attention to the location of components and safety devices on each type of elevator.

The complexity of elevator systems is increasing and so is the degree of maintenance and training required to keep them operational. It is a must that you qualify and pass a PQS, Ordnance/Cargo Elevators, Operation/Maintenance. Only qualified personnel can work on elevators. When doing an elevator maintenance

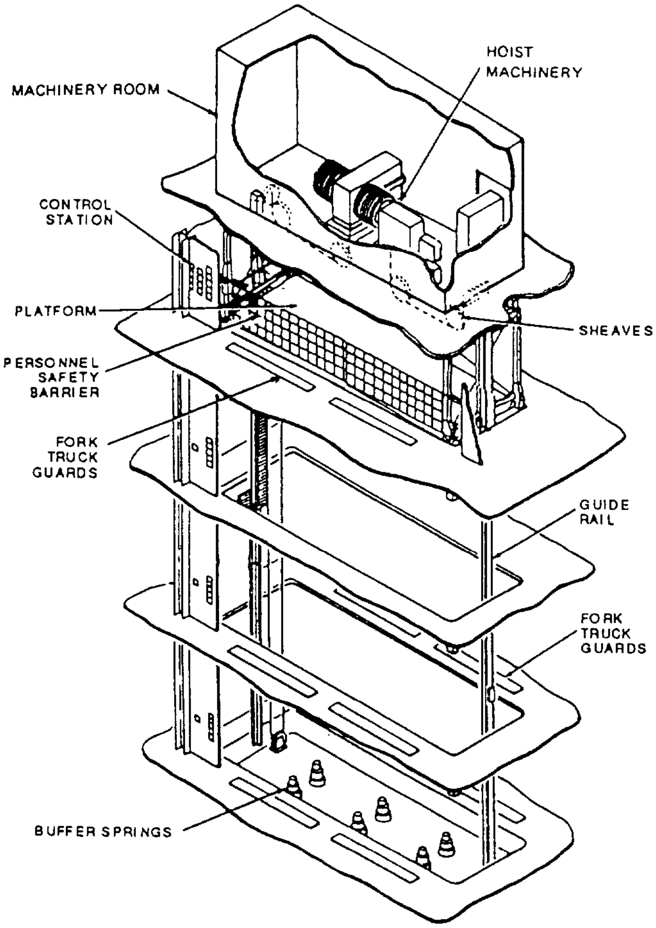

Figure 8-5.—Auxiliary ship elevator.

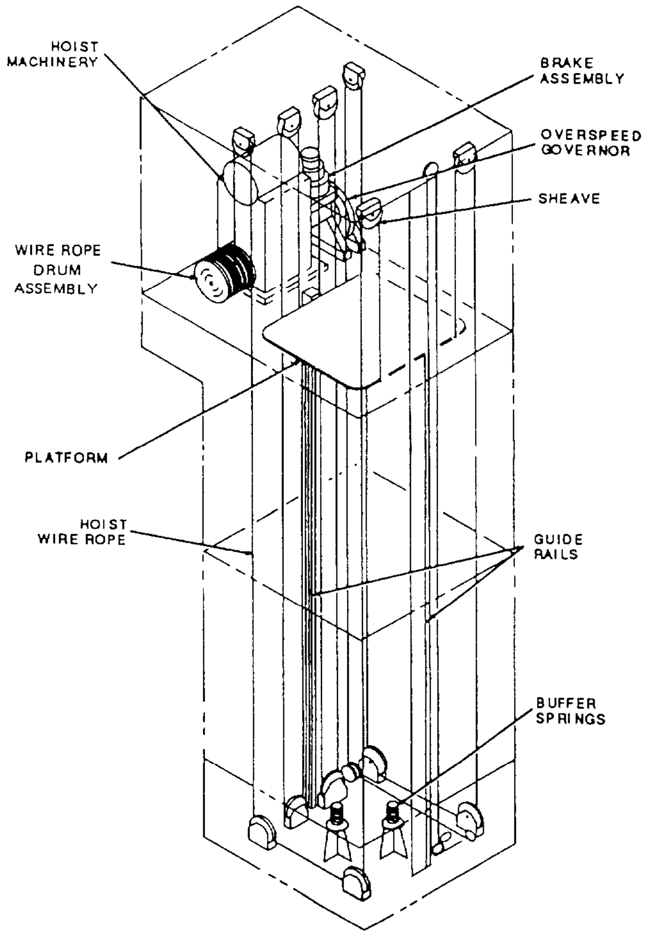

Figure 8-6.—Combatant (DD-963) elevator.

procedure, comply with all the procedures specified by the PMS.

CONVEYORS

The two types of conveyors the Navy uses for shipboard handling are gravity and powered. This section will deal with the general concepts of maintaining, troubleshooting, and repairing the conveyors within ship's force capability. When working on a conveyor, always follow the manufacturer's manual or the PMS. For more general information concerning conveyors, read *NSTM*, Chapter 572, "Shipboard Stores and Provision Handling." Figures 8-7, 8-8, and 8-9 are examples of some conveyors the Navy uses.

The difficulties most likely to be encountered during the operation of powered conveyors are not due to a malfunctioning of the mechanical equipment, but to the electrical equipment and the related interlocks. The following list contains common conveyor troubles that you may experience, the probable causes, and remedies for each of the troubles listed. The cause for improper operation is best diagnosed with adequate testing equipment and a thorough understanding of the complete system. Remember that with any electrical problem, you will need the help of an Electrician's Mate, who is fully trained for electrical work

Trouble	Probable Cause	Solution
Conveyor will not start.	Power fails.	Determine and correct cause of power failure.
	Main line fuse is blown.	Replace fuse.
Conveyor will not hoist.	Selector switch or switches are improperly set.	Check and reset selector switches.
Conveyor will not lower.	Selector switch or switches are improperly set.	Check and reset selector switches.
	Loading/unloading platform is set in horizontal position.	Reposition platform in either stowed or decline position.
Conveyor runs continuously when set at INDEX.	Limit switch is inoperative.	Adjust limit switch to actuate when bell crank passes.

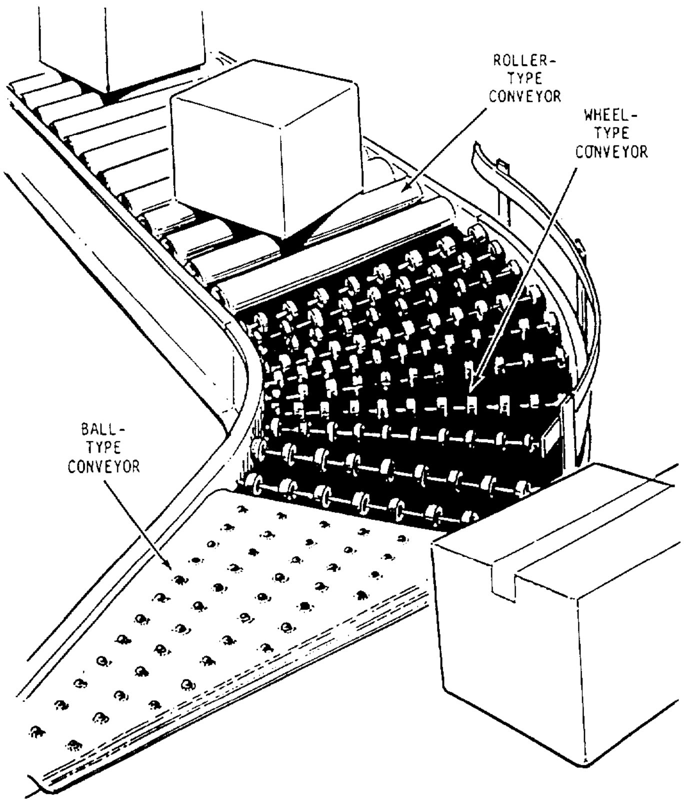

Figure 8-7.—Gravity conveyor.

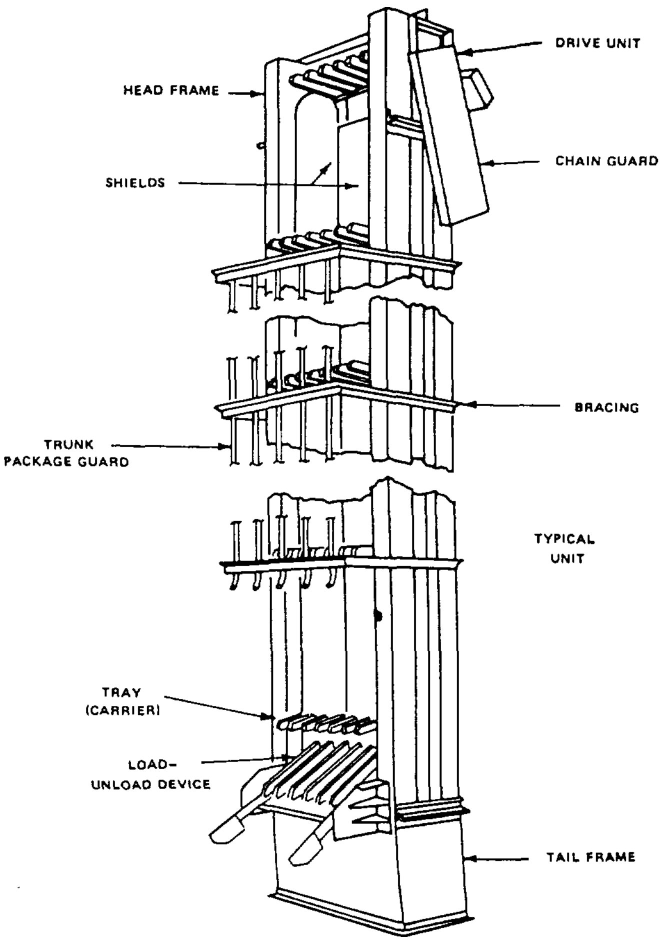

Figure 8-8.—Vertical conveyer, package, tray type.

For general maintenance and repair, always follow the requirements of the PMS. If the conveyor has been out of use for some time, inspect and service it before use, even if the maintenance period has not elapsed.

CRANES

Before you begin to adjust, repair, or do inspections on a crane, the following precautions must be observed and implemented as applicable:

1. The crane to he repaired must be positioned in a location where it will cause the least interference with other cranes or ship's operations.

2. The boom must be placed in the stowed position when work on the topping system is to be accomplished.

3. All controls must he placed in the OFF position.

4. The power supplies must be de-energized and the power supply breaker (in the OFF position) must be tagged DANGER, except as required for testing or adjustments.

5. Maintenance may be performed on energized electrical equipment only when specifically authorized by the commanding officer.

6. After completion of adjustments or repairs, the crane should not be restored to service until all guards have been reinstalled; safety devices are reactivated; maintenance equipment is removed; and all required testing is completed.

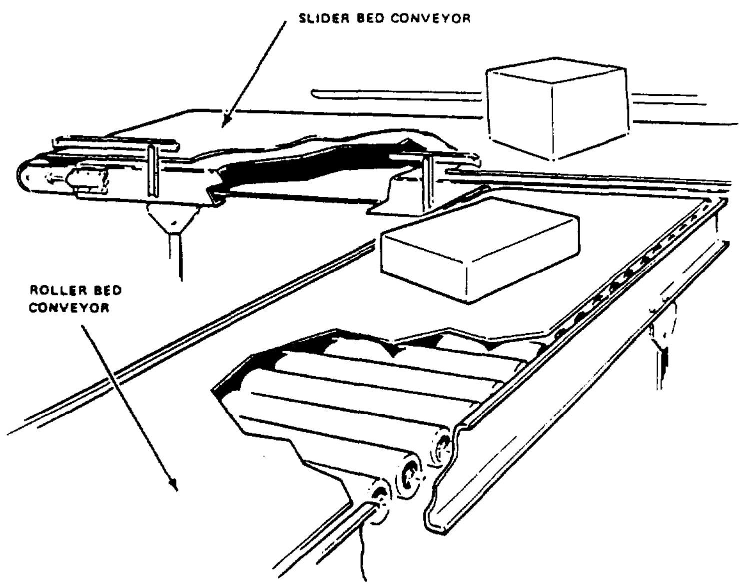

Figure 8-9.—Powered belt conveyor.

7. Maintenance on cranes should be performed only by formally qualified personnel, unless authorized by an authorizing officer on a single case basis for unusual repairs.

You must do all the maintenance requirements according to the instructions provided on the applicable MRCs. If the MRCs do not exist for a particular piece of equipment, your supervisor or you should institute interim maintenance according to the manufacturer's recommendations.

The following maintenance items should be included in the crane PMS package:

- Lubrication
- Safety inspection
- Lube oil maintenance
- Wire rope
- Brakes
- Instrumentation
- Electrical

For more general information on crane maintenance, repairs, and inspections, read ***NSTM,*** Chapter 589, "Cranes." Your ship should have a copy of the manufacturer's technical manual for in-depth individualized information of your ship's crane.

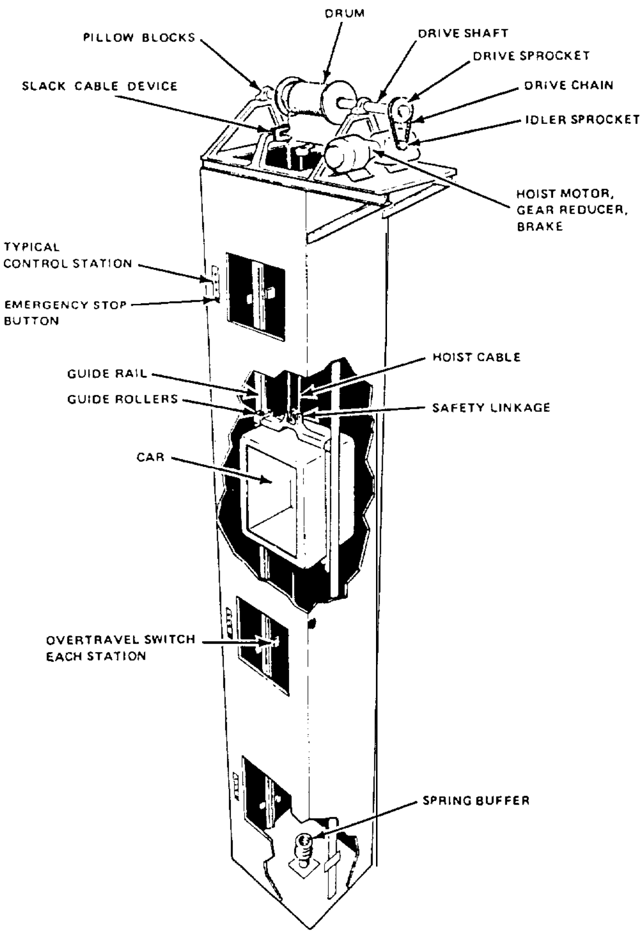

Figure 8-10.—Dumbwaiter.

DUMBWAITERS

A dumbwaiter is a semiautomatic electro-mechanical hoist operating in a structural trunk. The car of a dumbwaiter is arranged to carry ship's stores of varying weights and package sizes. Figure 8-10 illustrates the parts and controlling mechanisms of a dumbwaiter.

You should inspect the dumbwaiter car and hoist every 3 months. Check the condition of the load cable (it could be a chain or wire rope cable), motor brake, friction clutches, overtravel limit devices, door interlock control switches, and safety devices. You must follow the manufacturer's manual or the procedures specified by the PMS when making repairs. You are required to complete a PQS for this equipment. For more general information, read NSTM, Chapter 572, "Shipboard Stores and Provision Handling."

ESCALATORS

Only aircraft carriers have escalators aboard, and each aircraft carrier has two escalators. Each is chain driven by a horizontally mounted worm gear machine. An escalator can operate in either direction and is designed to operate at a speed of 120 feet per minute, carrying flight personnel at the rate of 44 persons per minute. For full details of this equipment, read NAVSEA 0316-LP-020-7000, *Shipboard Escalators (Aircraft Carriers).* You must complete the required PQS for this equipment. When making repairs, follow the necessary safety precautions and the procedures specified by the manufacturer's manual or the PMS.

SUMMARY

This chapter has provided you with some general information on the maintenance and repair of auxiliary machinery. For you to do your job properly, you must be totally familiar with each piece of machinery; you must complete the required PQS; and you must know where ‘to find additional information on repairs and safety. In your work center PMS Manual 43P1, under the Maintenance Index Page, each piece of equipment has reference publications or publications for maintenance and repairs. You should check your equipment with the reference publications to make sure they are the right references. If you find an error in these references, you should submit a feedback report as soon as possible.

CHAPTER 9

LATHES AND LATHE MACHINING OPERATIONS

The engine lathe, its use, and its principal parts and their uses are knowledges and skills expected of an EN2. Although machine shop work is generally done by personnel in the Machinery Repairman (MR) rating, there may be times that you will find the lathe essential to complete a repair job. This chapter will help you to identify the engine lathe's attachments, accessories, and their uses. Also, it will identify and explain different machining operations and the factors related to machining operations. Of course, you will be expected to know and to follow the safety precautions associated with machining operations.

There are a number of different types of lathes installed in the machine shops in various Navy ships. These include the engine lathe, the horizontal turret lathe, and several variations of the basic engine lathe, such as bench, toolroom, and gap lathes. All lathes, except the vertical turret type, have one thing in common. For all usual machining operations, the workpiece is held and rotated about a horizontal axis, while being formed to size and shape by a cutting tool. In the vertical turret lathe, the workpiece is rotated about a vertical axis. Of the various types of lathes, the type you are most likely to use is the engine lathe. Therefore, this chapter deals only with engine lathes and the machining operations you may have to perform.

NOTE: Before you attempt to operate any lathe, make sure you know how to operate it. Read all operating instructions supplied with the machine. Learn the locations of the various controls and how to operate them.

ENGINE LATHE

An engine lathe similar to the one shown in figure 9-1 is found in every machine shop. It is used mostly for

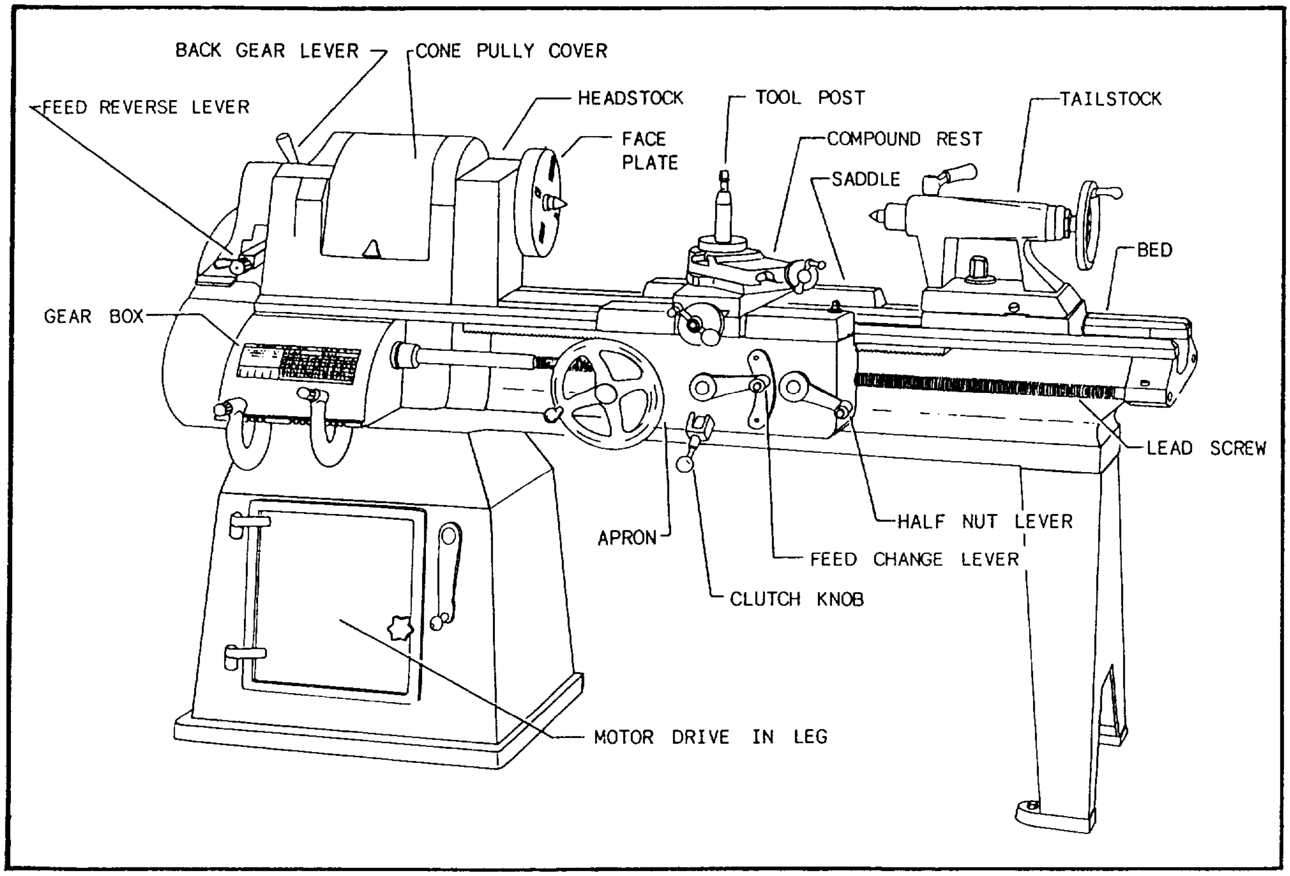

Figure 9-1.—Typical engine lathe.

turning, boring, facing, and thread cutting. But it may also be used for drilling, reaming, knurling, grinding, spinning, and spring winding. Since you will primarily be concerned with turning, boring, facing, and thread cutting, we will deal primarily with those operations in this chapter.

The work held in the engine lathe can be revolved at any one of a number of different speeds, and the cutting tool can be accurately controlled by hand or power for longitudinal feed and crossfeed. (Longitudinal feed is the movement of the cutting tool parallel to the axis of the lathe; crossfeed is the movement of the cutting tool perpendicular to the axis of the lathe.)

Lathe size is determined by two measurements: (1) the diameter of work it will swing (turn) over the ways and (2) the length of the bed. For example, a 14-inch by 6-foot lathe will swing work up to 14 inches in diameter and has a bed that is 6 feet long.

Engine lathes vary in size from small bench lathes that have a swing of 9 inches to very large lathes for turning large diameter work such as low-pressure turbine rotors. The 16-inch lathe is the average size for general purposes and is the size usually installed in ships that have only one lathe.

PRINCIPAL PARTS

To learn the operation of the lathe, you must be familiar with the names and functions of the principal parts. Lathes from different manufacturers differ somewhat in construction, but all are built to perform the same general functions. As you read the description of each part, find its location on the lathe in figure 9-1 and the figures that follow. (For specific details of features of construction and operating techniques, refer to the manufacturer's technical manual for your machine.)

Bed and Ways

The bed is the base or foundation of the parts of the lathe. The main feature of the bed is the ways, which are formed on the bed's upper surface and run the full length of the bed. The ways keep the tailstock and the carriage, which slide on them, in alignment with the headstock.

Headstock

The headstock contains the headstock spindle and the mechanism for driving it. In the belt-driven type, shown in figure 9-2, the driving mechanism consists of a motor-driven cone pulley that drives the spindle cone pulley through a drive belt. The spindle can be rotated either directly or through back gears.

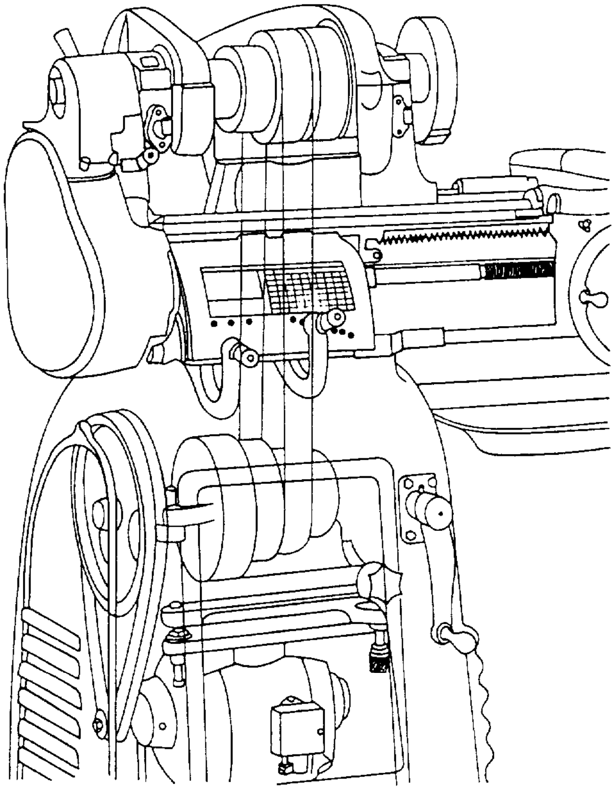

Figure 9-2.—Belt-driven type of headstock.

When the headstock is set up for direct drive, a bull-gear pin, located under a cover to the right of the spindle pulley, connects the pulley to the spindle. This connection causes the spindle to turn at the same speed as the spindle pulley.

When the headstock is set up for gear drive, the bull-gear pin is pulled out, disconnecting the spindle pulley from the spindle. This allows the spindle to turn freely inside the spindle pulley. The back-gear lever, on the left end of the headstock, is moved to engage the back-gear set with a gear on the end of the spindle and a gear on the end of the spindle pulley. In this drive mode, the drive belt turns the spindle pulley, which turns the back-gear set, which turns the spindle.

Each drive mode provides four spindle speeds, for a total of eight. The back-gear drive speeds are less slower than the direct-drive speeds.

Tailstock

The primary purpose of the tailstock is to hold the dead center to support one end of the work being

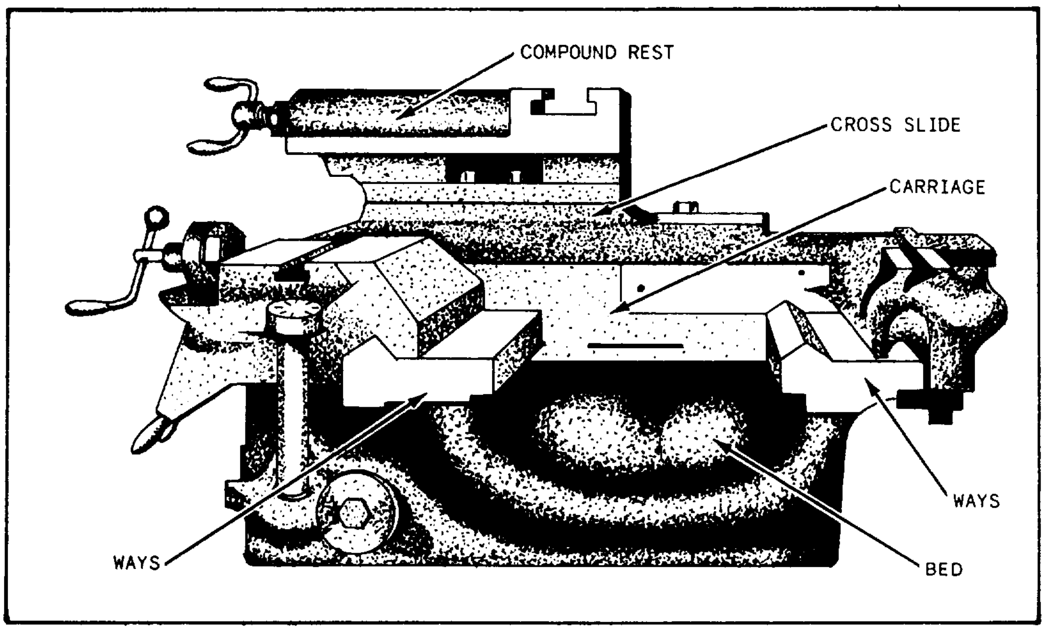

Figure 9-3.—Side view of a carriage mounted on a bed.

machined. However, the tailstock can also be used to hold tapered shank drills, reamers, and drill chucks. It can be moved on the ways along the length of the bed and can be clamped in the desired position by tightening the tailstock clamping nut. This movement allows for the turning of different lengths of work. The tailstock can be adjusted laterally (front to back) to cut a taper by loosening the clamping screws at the bottom of the tailstock. (see fig. 9-1.)

Before you insert a dead center, drill, or reamer, carefully clean the tapered shank and wipe out the tapered hole of the tailstock spindle. When you hold drills or reamers in the tapered hole of the spindle, be sure they are tight enough so they will not revolve. If you allow them to revolve, they will score the tapered hole and destroy its accuracy.

Carriage

The carriage is the movable support for the crossfeed slide and the compound rest. The compound rest carries the cutting tool in the tool post. Figure 9-3 shows how the carriage travels along the bed over which it slides on the outboard ways.

The carriage has T-slots or tapped holes to use for clamping work for boring or milling. When the carriage is used for boring and milling operations, carriage movement feeds the work to the cutting tool, which is rotated by the headstock spindle.

You can lock the carriage in any position on the bed by tightening the carriage clamp screw. But you do this only when you do such work as facing or parting-off, for which longitudinal feed is not required. Normally the carriage clamp is kept in the released position. Always move the carriage by hand to be sure it is free before you engage its automatic feed.

Apron

The apron is attached to the front of the carriage and contains the mechanism that controls the movement of the carriage and the crossslide.

Feed Rod

The feed rod transmits power to the apron to drive the longitudinal feed and crossfeed mechanisms. The feed rod is driven by the spindle through a train of gears. The ratio of feed rod speed to spindle speed can be varied by using change gears to produce various rates of feed.

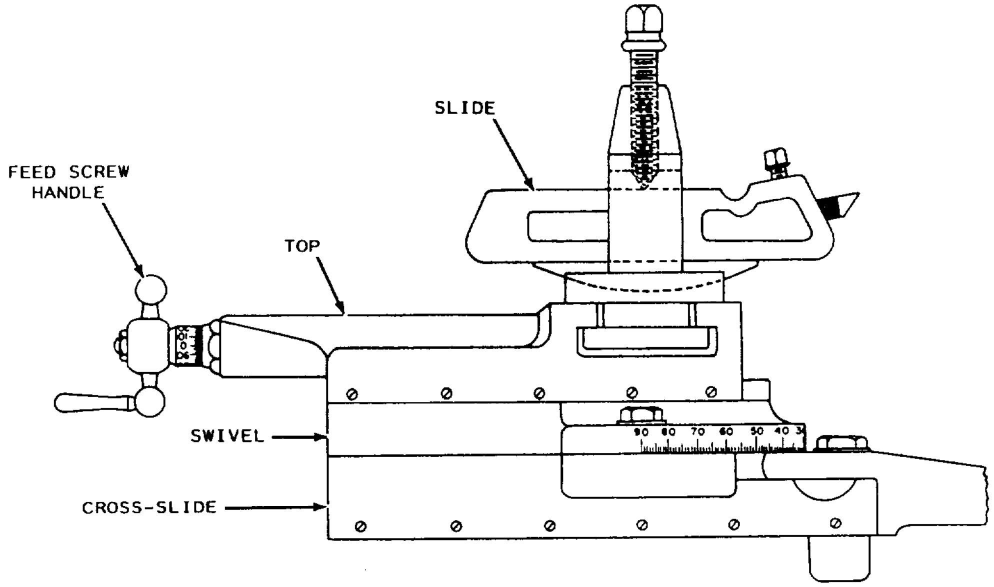

Figure 9-4.—Compound rest.

The rotating feed rod drives gears in the apron; these gears in turn drive the longitudinal feed and crossfeed mechanisms through friction clutches.

Some lathes do not have a separate feed rod, but use a spline in the lead screw for the same purpose.

Lead Screw

The lead screw is used for thread cutting. It has accurately cut Acme threads along its length that engage the threads of half-nuts in the apron when the half-nuts are clamped over it. The lead screw is driven by the spindle through a gear train. Therefore, the rotation of the lead screw bears a direct relation to the rotation of the spindle. When the half-nuts are engaged, the longitudinal movement of the carriage is controlled directly by the spindle rotation. Consequently, the cutting tool is moved a definite distance along the work for each revolution that the spindle makes.

Crossfeed Slide

The crossfeed slide is mounted to the top of the carriage in a dovetail and moves on the carriage at a right angle to the axis of the lathe. A crossfeed screw allows the slide to be moved toward or away from the work in accurate increments.

Compound Rest

The compound rest (fig. 9-4), mounted on the compound slide, provides a rigid adjustable mounting for the cutting tool. The compound rest assembly has the following principal parts:

1. The compound rest **SWIVEL,** which can be swung around to any desired angle and clamped in position. It is graduated over an arc of 90° on each side of its center position for easier setting to the angle selected. This feature is used for machining short, steep tapers, such as the angle on bevel gears, valve disks, and lathe centers.

2. The compound rest, or **TOP SLIDE,** which is mounted on the swivel section on a dovetailed slide. It is moved by the compound rest feed screw.

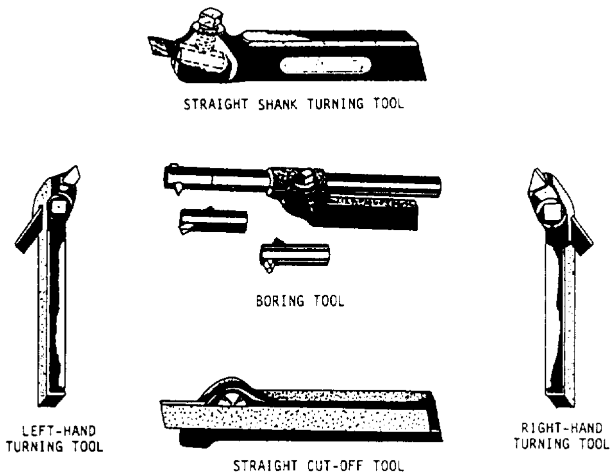

Figure 9-5.—Common types of toolholders.

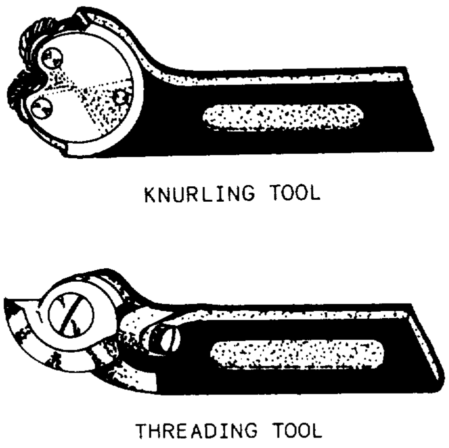

Figure 9-6.—Knurling and threading toolholders.

This arrangement permits feeding the tool to the work at any angle (determined by the angular setting of the swivel section). The graduated collars on the crossfeed and compound rest feed screws read in thousandths of an inch for fine adjustment in regulating the depth of cut.

Accessories and Attachments

Accessories are the tools and equipment used in routine lathe machining operations. Attachments are special fixtures that may be mounted on the lathe to expand the use of the lathe to include taper cutting, milling, and grinding. Some of the common accessories and attachments are described in the following paragraphs.

TOOL POST.—The sole purpose of the tool post is to provide a rigid support for the tool. It is mounted in the T-slot of the compound rest. A forged tool or a toolholder is inserted in the slot in the tool post. By tightening a setscrew, you will firmly clamp the whole unit in place with the tool in the desired position.

TOOLHOLDERS—Some of the common toolholders used in lathe work are illustrated in figure 9-5. Notice the angles at which the tool bits are set in the various holders. These angles must be considered with respect to the angles ground on the tools and the angle that the toolholder is set with respect to the axis of the work.

Two types of toolholders that differ slightly from the common toolholders are those used for threading and knurling. (See fig. 9-6.)

The threading toolholder has a formed cutter which needs to be ground only on the top surface for sharpening. Since the thread form is accurately shaped over a large arc of the tool, as the surface is worn away by grinding, the cutter can be rotated to the correct position and secured by the setscrew.

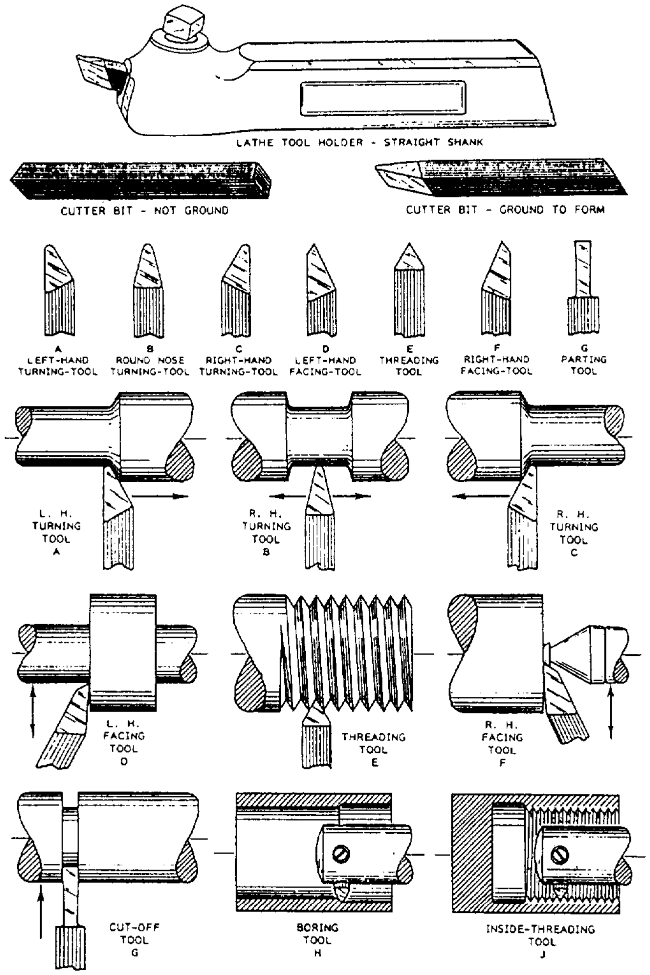

Figure 9-7.—Lathe tools and their applications.

A knurling toolholder carries two knurled rollers which impress their patterns on the work as it revolves. The purpose of the knurling tool is to provide a roughened surface on round metal parts, such as knobs, to give a better grip in handling. The knurled rollers come in a variety of patterns.

ENGINE LATHE TOOLS.—Figure 9-7 shows the most popular shapes of ground lathe cutter bits and their applications. In the following paragraphs we will discuss each of the types shown.

Left-Hand Turning Tool.—This tool is ground for machining work when it is fed from left to right, as indicated in figure 9-7, view A. The cutting edge is on the right side of the tool, and the top of the tool slopes down away from the cutting edge.

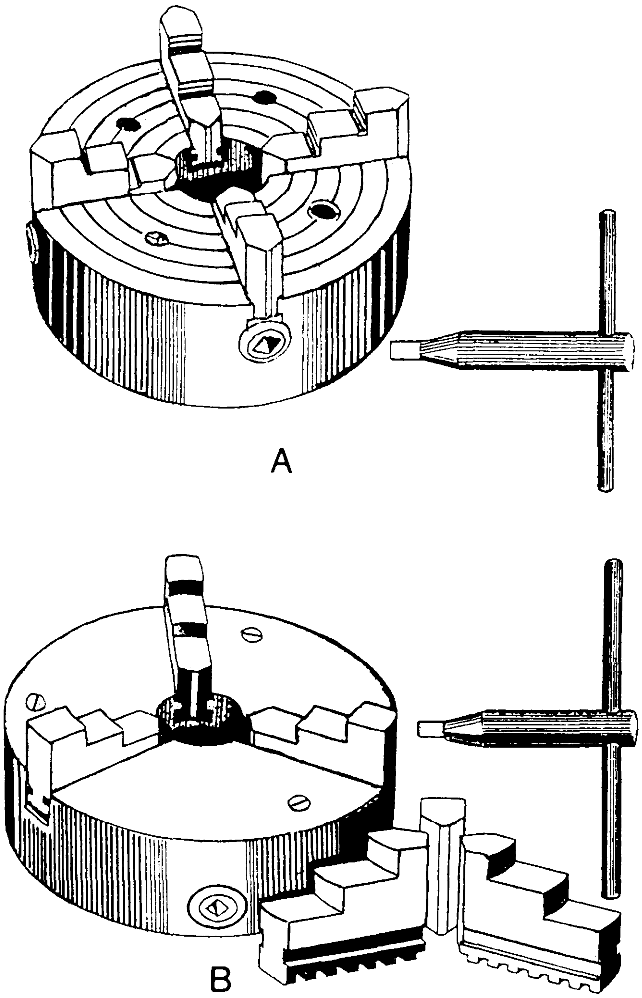

Figure 9-8.–A. Four-Jaw chuck. B. Three-Jaw chuck.

Round-Nosed Turning Tool.–This tool is for general-purpose machine work and is used for taking light roughing cuts and finishing cuts. Usually, the top of the cutter bit is ground with side rake so the tool may be fed from right to left. Sometimes this cutter bit is ground flat on top so the tool may be fed in either direction (fig. 9-7, view B).

Right-Hand Turning Tool.–This is just the opposite of the left-hand turning tool and is designed to cut when it is fed from right to left (fig. 9-7, view C). The cutting edge is on the left side. This is an ideal tool for taking roughing cuts and for all-around machine work.

Left-Hand Facing Tool.–This tool is intended for facing on the left-hand side of the work (fig. 9-7, view D). The direction of feed is away from the lathe center. The cutting edge is on the right-hand side of the tool, and the point of the tool is sharp to permit machining a square corner.

Threading Tool.–The point of the threading tool is ground to a 60-degree included angle for machining V-form screw threads (fig. 9-7, view E). Usually, the top of the tool is ground flat, and there is clearance on both sides of the tool so it will cut on both sides.

Right-Hand Facing Tool.–This tool is just the opposite of the left-hand facing tool and is intended for facing the right end of the work and for machining the right side of a shoulder (fig. 9-7, view F).

Square-Nosed Parting (Cutoff) Tool.–The principal cutting edge of this tool is on the front (fig. 9-7, view G). Both sides of the tool must have sufficient clearance to prevent binding and should be ground slightly narrower at the back than at the cutting edge. This tool is convenient for machining necks and grooves and for squaring comers and cutting off.

Boring Tool.–The boring tool (fig. 9-7, view H) is usually ground the same shape as the left-hand turning

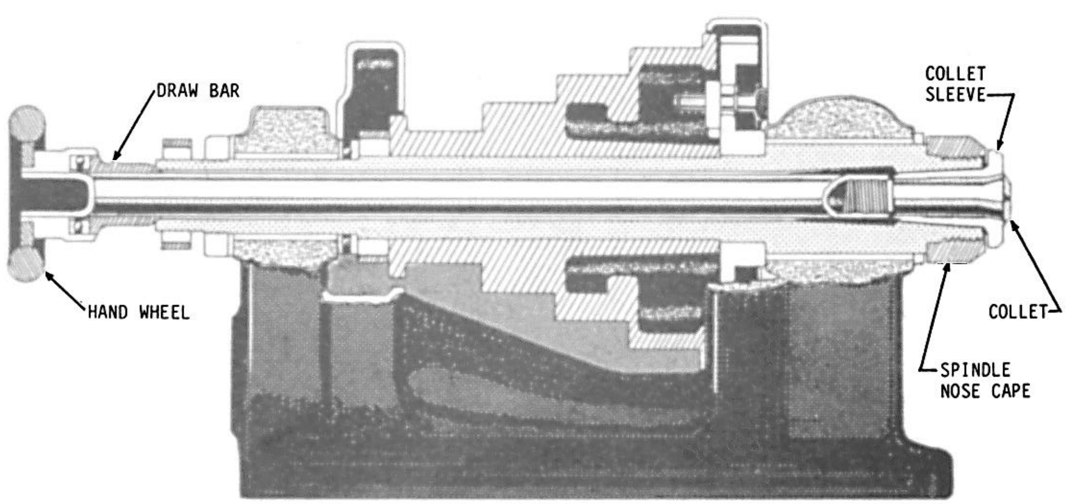

Figure 9-9.–Draw-in collet chuck.

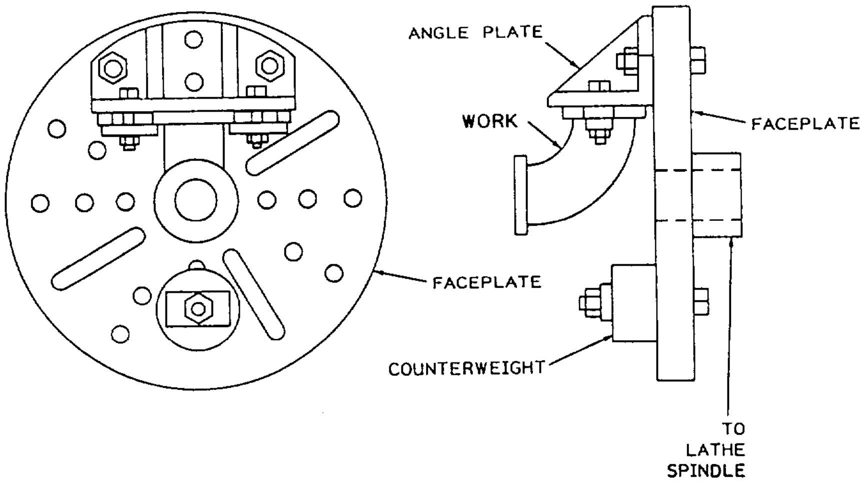

Figure 9-10.—Faceplate.

tool so that the cutting edge is on the right side of the cutter bit and may be fed in toward the headstock.

Inside-Threading Tool.—The inside-threading tool (fig. 9-7, view J) has the same shape as the threading tool in figure 9-7, view E, but it is usually much smaller. Boring and inside-threading tools may require larger relief angles when used in small diameter holes.

LATHE CHUCKS.—The lathe chuck is a device for holding lathe work. It is mounted on the nose of the spindle. The work is held by jaws which can be moved in radial slots toward the center of the chuck to clamp down on the sides of the work. These jaws are moved in and out by screws turned by a special chuck wrench.

The four-jaw independent lathe chuck, view A in figure 9-8, is the most practical chuck for general work The four jaws are adjusted one at a time, making it possible to hold work of various shapes and to adjust the center of the work to coincide with the axis of the spindle. The jaws are reversible.

The three-jaw universal or scroll chuck, view B in figure 9-8, can be used only for holding round or hexagonal work All three jaws move in and out together in one operation and bring the work on center automatically. This chuck is easier to operate than the four-jaw type, but, when its parts become worn, its accuracy in centering cannot be relied upon. Proper lubrication and constant care are necessary to ensure reliability.

The draw-in collet chuck is used to hold small work for machining in the lathe. It is the most accurate type of chuck made and is intended for precision work. Figure 9-9 shows the parts assembled in place in the lathe spindle. The collet, which holds the work, is a split-cylinder with an outside taper that fits into the tapered closing sleeve and screws into the threaded end of the hollow drawbar. As the handwheel is turned clockwise, the drawbar is moved toward the handwheel. This tightening up on the drawbar pulls the collet back into the tapered sleeve, thereby closing it firmly over the work and centering the work accurately and quickly. The size of the hole in the collet determines the diameter of the work the chuck can handle.

Faceplates

The faceplate is used for holding work that, because of its shape and dimensions, cannot be swung between centers or in a chuck. The T-slots and other openings on its surface provide convenient anchors for bolts and clamps used in securing the work to it. The faceplate is mounted on the nose of the spindle. (See fig. 9-10.)

The driving plate is similar to a small faceplate and is used mainly for driving work that is held between centers. The primary difference between a faceplate and a driving plate is that a faceplate has a machined face for precision mounting, while the face of a driving plate is left rough. When a driving plate is used, the bent tail of a dog clamped to the work is inserted into a slot in the faceplate. This transmits rotary motion to the work.

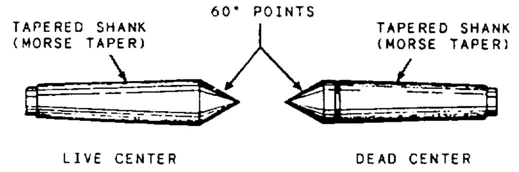

Figure 9-11.—60-degree lathe centers.

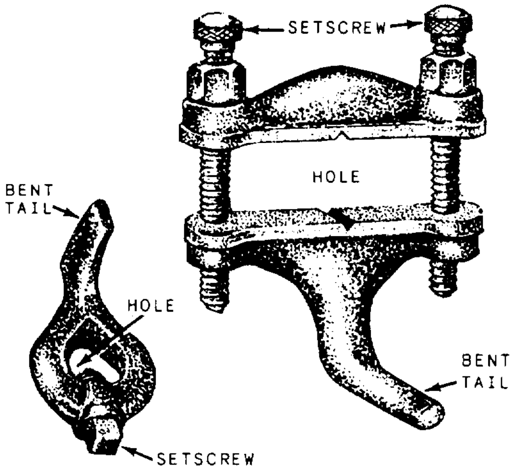

Figure 9-12.—Lathe dogs.

Lathe Centers

The 60-degree lathe centers shown in figure 9-11 provide a way to hold the work so it can be turned accurately on its axis. The headstock spindle center is called the **LIVE CENTER** because it revolves with the work. The tailstock center is called the **DEAD CENTER** because it does not turn. Both live and dead centers have shanks turned to a Morse taper to fit the tapered holes in the spindles; both have points finished to an angle of 60°. They differ only in that the dead center is hardened and tempered to resist the wearing effect of the work revolving on it. The live center revolves with the work and is usually left soft. The dead center and live center must **NEVER** be interchanged. (There is a groove around the hardened dead center to distinguish it from the live center.)

The centers fit snugly in the tapered holes of the headstock and tailstock spindles. If chips, dirt, or burrs prevent a perfect fit in the spindles, the centers will not run true.

To remove the headstock center, insert a brass rod through the spindle hole and tap the center to jar it loose; then pull it out with your hand. To remove the tailstock center, run the spindle back as far as it will go by turning the handwheel to the left. When the end of the tailstock screw bumps the back of the center, it will force the center out of the tapered hole.

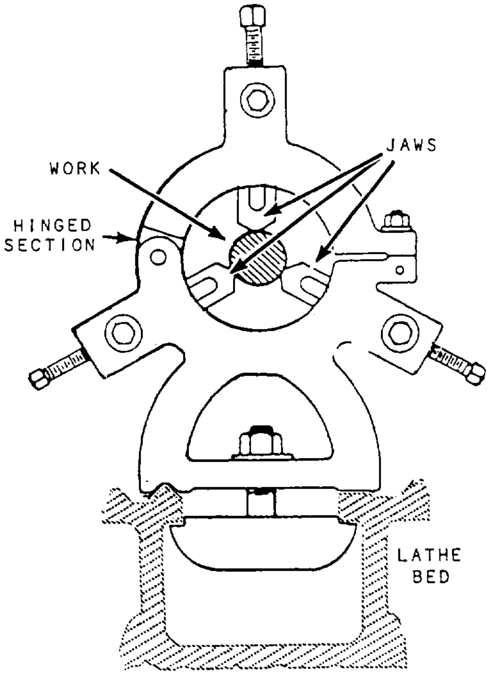

Figure 9-13.—Center rest.

Lathe Dogs

Lathe dogs are used with a driving plate or faceplate to drive work being machined on centers; the frictional contact alone between the live center and the work is not sufficient to drive the work

The common lathe dog, shown at the left in figure 9-12, is used for round work or work having a regular section (square, hexagon, octagon). The piece to be turned is held firmly in the hole (A) by the setscrew (B). The bent tail (C) projects through a slot or hole in the driving plate or faceplate so that when the tail revolves with the spindle it turns the work with it. The clamp dog, illustrated at the right in figure 9-12, may be used for rectangular or irregularly shaped work. Such work is clamped between the jaws,

Center Rest

The center rest, also called the steady rest, is used for the following purposes:

1. To provide an intermediate support for long slender bars or shafts being machined between centers. The center rest prevents them from springing, or sagging, as a result of their otherwise unsupported weight.

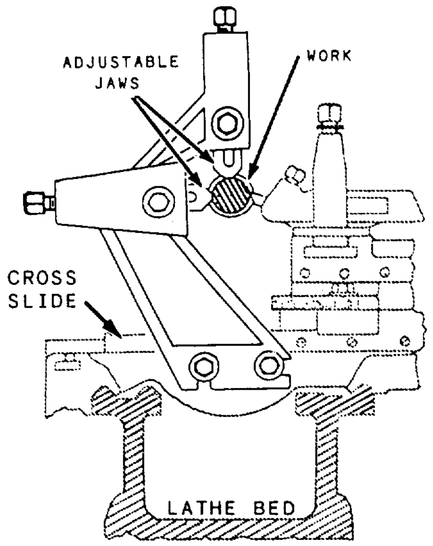

Figure 9-14.—Follower rest.

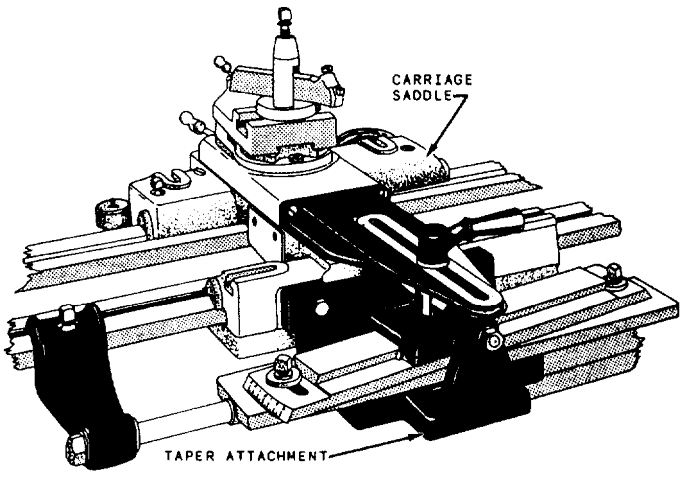

Figure 9-15.—Taper attachment.

2. To support and provide a center bearing for one end of the work, such as a shaft, being bored or drilled from the end when it is too long to be supported by a chuck alone. The center rest is clamped in the desired position on the bed and is kept aligned by the ways, as illustrated in figure 9-13. The jaws (A) must be carefully adjusted to allow the work (B) to turn freely and at the same time remain accurately centered on the axis of the lathe. The top half of the frame is a hinged section (C) for easier positioning without having to remove the work from the centers or to change the position of the jaws.

Follower Rest

The follower rest is used to back up small diameter work to keep it from springing under the cutting

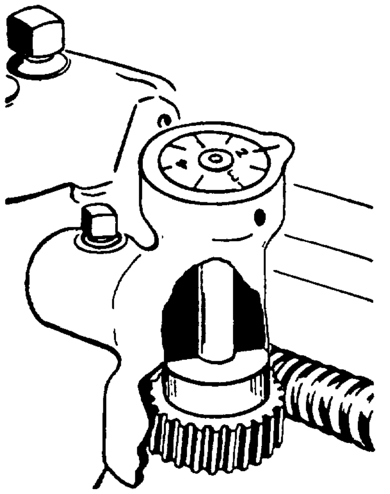

Figure 9-16.—Thread dial Indicator.

pressure. It can be set to either precede or follow the cutting action. As shown in figure 9-14, it is attached directly to the saddle by bolts (B). The adjustable jaws bear directly on the part of the work opposite the cutting tool.

Taper Attachment

The taper attachment, illustrated in figure 9-15, is used for turning and boring tapers. It is bolted to the back of the carriage. In operation, it is connected to the cross slide so that it moves the cross slide traversely as the carriage moves longitudinally, thereby causing the cutting tool to move at an angle to the axis of the work to produce a taper.

The desired angle of taper is set on the guide bar of the attachment. The guide bar support is clamped to the lathe bed Since the cross slide is connected to a shoe that slides on this guide bar, the tool follows along a line parallel to the guide bar and at an angle to the work axis corresponding to the desired taper.

The operation of the taper attachment will be further explained under the subject of taper work

Thread Dial Indicator

The thread dial indicator, shown in figure 9-16, eliminates the need to reverse the lathe to return the carriage to the starting point each time a successive threading cut is taken. The dial, which is geared to the lead screw, indicates when to clamp the half-nuts on the lead screw for the next cut.

The threading dial consists of a worm wheel which is attached to the lower end of a shaft and meshed with

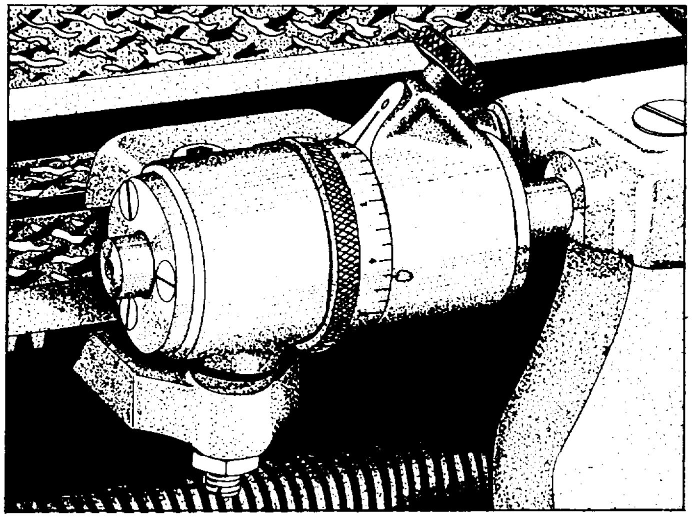

Figure 9-17.—Micrometer carriage stop.

the lead screw. On the upper end of the shaft is the dial. As the lead screw revolves, the dial is turned and the graduations on the dial indicate points at which the half-nuts may be engaged.

Carriage Stop

The carriage stop can be attached to the bed at any point where the carriage should stop. It is used primarily for turning, facing, or boring duplicate parts, as it eliminates taking repeated measurements of the same dimension. In operation, the stop is set at the point where the feed should stop. To use the stop, just before the carriage reaches the stopping point, shut off the automatic feed and manually run the carriage up against the stop. Carriage stops are provided with or without micrometer adjustment. Figure 9-17 shows a micrometer carriage stop. Clamp it on the ways in the approximate position required, and then adjust it to the exact setting by using the micrometer adjustment. (Do not confuse this stop with the automatic carriage stop that automatically stops the carriage by disengaging the feed or stopping the lathe.)

MAINTENANCE

Every lathe must be maintained strictly according to requirements of the Maintenance and Material Management (3-M) Systems. The first requirement of maintenance to your lathe is proper lubrication. Make it a point to oil your lathe daily where oil holes are provided. Oil the ways daily-not only for lubrication but to protect their scraped surfaces. Oil the lead screw often while it is in use; this is necessary to preserve its accuracy, for a worn lead screw lacks precision in thread cutting. Make sure the headstock is filled to the proper oil level; drain the oil out and replace it when it becomes dirty or gummy. If your lathe is equipped with an automatic oiling system for some parts, make sure all those parts are getting oil. Make it a habit to **CHECK** frequently to see that all moving parts are being lubricated.

Before engaging the longitudinal ‘feed, be certain that the carriage clamp screw is loose and that the carriage can be moved by hand. Avoid running the carriage against the headstock or tailstock while it is under the power feed; running the carriage against the headstock or tailstock puts an unnecessary strain on the lathe and may jam the gears.

Do not neglect the motor just because it may be out of sight; check its lubrication. If it does not run properly, notify the Electrician’s Mate who is responsible for caring for it. He or she will cooperate with you to keep it in good condition. On lathes with a belt driven from the motor, avoid getting oil or grease on the belt when you oil the lathe or motor.

Keep your lathe clean. A clean and orderly machine is an indication of a good mechanic. Dirt and chips on the ways, on the lead screw, and on the crossfeed screws will cause serious wear and impair the accuracy of the machine.

NEVER put wrenches, files, or other tools on the ways. If you must keep tools on the bed, use a board to protect the finished surfaces of the ways.

NEVER use the bed or carriage as an anvil. Remember, the lathe is a precision machine, and nothing must be allowed to destroy its accuracy.

BASIC SETUP

A knowledge of the basic setup is required if you are to become proficient in performing machine work with a lathe. Some of these setups are considered in the following sections.

Cutting Speeds and Feeds

Cutting speed is the rate at which the surface of the work passes the point of the cutting tool. It is expressed in feet per minute (fpm).

Feed is the amount the tool advances for each revolution of the work. It is usually expressed in thousandths of an inch per revolution of the spindle.

Cutting speeds and tool feeds are determined by various considerations: the hardness and toughness of the metal being cut; the quality, shape, and sharpness of the cutting tool; the depth of the cut; the tendency of the work to spring away from the tool; and the strength and power of the lathe. Since conditions vary, it is good practice to find out what the tool and work will stand and then select the most practical and efficient speed and feed for the finish desired.

When **ROUGHING** parts down to size, use the greatest depth of cut and feed per revolution that the work, the machine, and the tool will stand at the highest practical speed. On many pieces where tool failure is the limiting factor in the size of the roughing cut, you may be able to reduce the speed slightly and increase the feed to remove more metal. This will prolong tool life. Consider an example where the depth of cut is 1/4 inch, the feed 0.020 inch per revolution, and the speed 80 fpm. If the tool will not permit additional feed at this speed, you can drop the speed to 60 fpm and increase the feed to about 0.040 inch per revolution without having tool trouble. The speed is therefore reduced 25 percent, but the feed is increased 100 percent. Thus the actual time required to complete the work is less with the second setup.

For the **FINISH TURNING OPERATION,** take a very light cut, since you removed most of the stock during the roughing cut. Use a fine feed to run at a high surface speed. Try a 50 percent increase in speed over the roughing speed. In some cases, the finishing speed may be twice the roughing speed. In any event, run the work as fast as the tool will withstand to obtain the maximum speed during this operation. Be sure to use a sharp tool when you are finish turning.

COOLANTS

A cutting lubricant serves two main purposes: (1) It cools the tool by absorbing a portion of the heat and reducing the friction between the tool and the metal being cut. (2) It also keeps the cutting edge of the tool flushed clean.

The best lubricants to use for cutting metal must often be determined by experiment. Water-soluble oil is acceptable for most common metals. Special cutting compounds containing such ingredients as tallow, graphite, and lard, marketed under various names, are also used. But these are expensive and used mainly in manufacturing where high cutting speeds are the rule.

Some common materials and their cutting lubricants are as follows:

Metal	Lubricant
Cast iron	Usually worked dry
Mild steel	Oil or soluble oil
Hard steel	Mineral lard oil
Monel metal	Dry (or soluble oil)
Bronze	Dry (or soluble oil)
Brass	Dry (or soluble oil)
Copper	Dry (or soluble oil)
Babbitt	Dry (or soluble oil)
Aluminum	Dry (or soluble oil)

A lubricant is more important for threading than for straight turning. Mineral lard oil is recommended for threading the majority of metals that are used by the Navy.

CHATTER

Chatter is vibration in either the tool or the work The finished work surface appears to have a grooved or lined finish instead of a smooth surface. The vibration is set up by a weakness in the work, work support, tool, or tool support and is probably the most elusive thing you will find in the entire field of machine work As a general rule, strengthening the various parts of the tool support train will help. It is also advisable to support the work by a center rest or follower rest.

The fault may be in the machine adjustments. Gibs may be too loose; hearings may, after a long period of heavy service, be worn; the tool may be sharpened improperly, and so on. If the machine is in excellent condition, the fault may be in the tool or tool setup. Grind the tool with a point or as near a point as the finish specified will permit; avoid a wide, round leading edge on the tool. Reduce the overhang of the tool as much as possible. Be sure all the gib and bearing adjustments are properly made. See that the work receives proper support for the cut and, above all, do not try to turn at a surface speed that is too high. Excessive speed is probably the greatest cause of chatter. The first thing you should do when chatter occurs is reduce the speed.

Direction of Feed

Regardless of how the work is held in the lathe, the tool should feed toward the headstock. This causes most

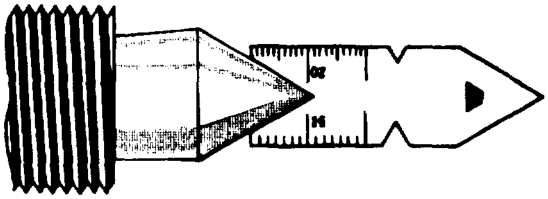

Figure 9-18.—Checking a center's point with a center gauge.

of the pressure of the cut to bear on the work-holding device and the spindle thrust bearings. When you must feed the cutting tool toward the tailstock, take lighter cuts at reduced feeds. In facing, the general practice is to feed the tool from the center of the workpiece outward.

PRELIMINARY PROCEDURES

Before starting a lathe machining operation, always ensure that the machine is set up properly. If the work is mounted between centers, check the alignment of the dead center and the live center and make any necessary changes. Ensure that the toolholder and cutting tool are set at the proper height and angle. Check the work-holding accessory to ensure that the workpiece is held securely. Use the center rest or follower rest to support long workpieces.

PREPARING THE CENTERS

The first step in preparing the centers is to see that they are accurately mounted in the headstock and tailstock spindles. The centers and the tapered holes in which they are fitted must be perfectly clean. Chips and dirt left on the contact surfaces prevent the bearing surfaces from fitting perfectly. This will decrease the accuracy of your work. Make sure that there are no burrs in the spindle hole. If you find burrs, remove them by carefully scraping and reaming the hole with a Morse taper reamer. Burrs will produce the same inaccuracies as chips or dirt.

A center's point must be finished accurately to an angle of 60°. Figure 9-18 shows the method of checking this angle with a center gauge. The large notch of the center gauge is intended for this purpose. If this test shows that the point is not perfect, you must true it in the lathe by taking a cut over the point with the compound rest set at 30°. You must anneal the hardened tail center before it can be machined in this manner, or you can grind it if a grinding attachment is available.

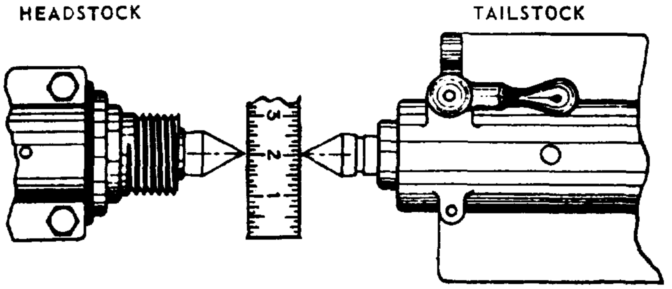

Figure 9-19.—Aligning lathe centers.

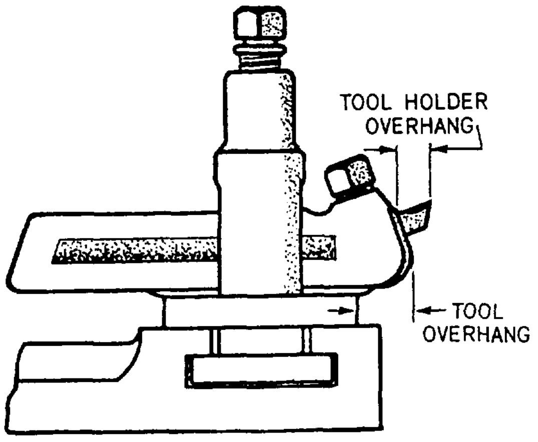

Figure 9-20.—Tool overhang.

CHECKING ALIGNMENT

To turn a shaft straight and true between centers, be sure the centers are aligned in a plane parallel to the ways of the lathe. You can check the approximate alignment of the centers by moving the tailstockup until the centers almost touch and observing their relative positions as shown in figure 9-19.

To test center alignment for very accurate work, take a light cut over at each end with a micrometer and, if readings are found to differ, adjust the tailstock accordingly. Repeat the procedure until alignment is obtained.

SETTING THE TOOLHOLDER AND THE CUTTING TOOL

The first requirement for setting the tool is to have it rigidly mounted on the tool post holder. Be sure the tool sets squarely in the tool post and that the setscrew is tight. Reduce overhang as much as possible to prevent the tool bit from springing during cutting. If the tool has too much spring, the point of the tool will catch in the work, causing chatter and damaging both the tool and the work The distances represented by A and B in figure

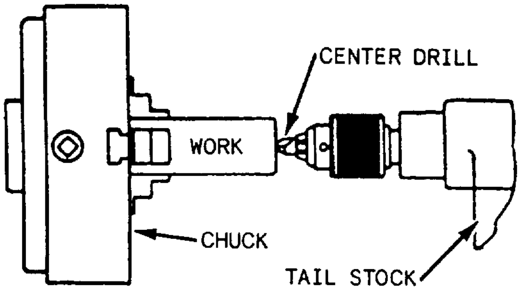

Figure 9-21.—Drilling a center hole.

9-20 show the correct overhang for the tool bit and the holder.

The point of the tool must be correctly positioned on the work Place the cutting edge. slightly above the center for straight turning of steel and cast iron and exactly on the center for all other work To set the tool at the height desired, raise or lower the point of the tool by moving the wedge in or out of the tool post ring. By placing the point opposite the tailstock center point, you can adjust the setting accurately.

HOLDING THE WORK

You cannot perform accurate work if the workpiece is improperly mounted. The requirements for proper mounting are as follows:

1. The work center line must be accurately centered along the axis of the lathe spindle.
2. The work must be held rigidly while being turned.
3. The work must **NOT** be sprung out of shape by the holding device.
4. The work must be adequately supported against any sagging caused by its own weight and against springing caused by the action of the cutting tool.

There are four general methods of holding work in the lathe: (1) between centers, (2) on a mandrel, (3) in a chuck, and (4) on a faceplate. Work may also be clamped to the carriage for boring and milling, in which case the boring bar or milling cutter is held and driven by the headstock spindle.

Other methods of holding work to suit special conditions are (1) one end on the live center or in a chuck and the other end supported in a center rest, and (2) one end in a chuck and the other end on the dead center.

Holding Work Between Centers

To machine a workpiece between centers, drill center holes in each end to receive the lathe centers. Secure a lathe dog to the workpiece. Then mount the work between the live and dead centers of the lathe.

CENTERING THE WORK.—To center round stock where the ends are to be turned and must be concentric with the unturned body, mount the work on the head spindle in a universal chuck or a draw-in collet chuck If the work is long and too large to pass through the spindle, use a center rest to support one end. Mount a center drill in a drill chuck in the tailstock spindle and feed it to the work by turning the tailstock handwheel (fig. 9-21).

For center drilling a workpiece, the combined drill and countersink is the most practical tool. These combined drills and countersinks vary in size and the drill points also vary. Sometimes a drill point on one end will be 1/8 inch in diameter, and the drill point on the opposite end will be 3/16 inch in diameter. The angle of the center drill must always be 60° so that the countersunk hole will fit the angle of the lathe center point.

If a center drill is not available, center the work with a small twist drill. Let the drill enter the work a sufficient distance on each end; then follow with a 60° countersink.

In center drilling, use a drop or two of oil on the drill. Feed the drill slowly and carefully to prevent breaking the tip. Take extreme care when the work is heavy, because you will be less able to “feel” the proper feed of the work on the center drill.

If the center drill breaks during countersinking and part of the broken drill remains in the work, you must remove this part. Sometimes you can drive the broken piece out by a chisel or by jarring it loose, but it may stick so hard that you cannot remove it this way. Then you must anneal the broken part of the drill and drill it out.

We cannot overemphasize the importance of proper center holes in the work and a correct angle on the point of the lathe centers. To do an accurate job between centers on the lathe, you must ensure that the center-drilled holes are the proper size and depth and that the points of the lathe centers are true and accurate.

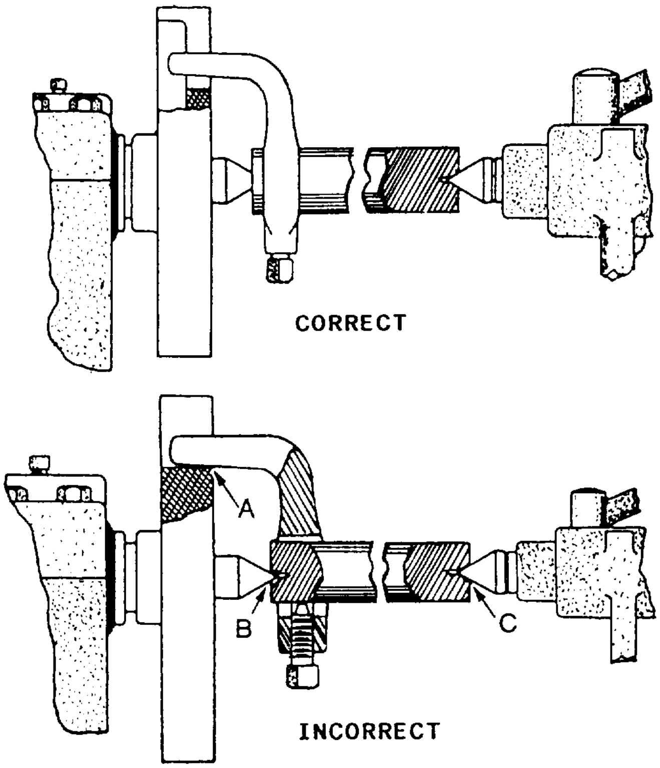

Figure 9-22.—Examples of work mounted between centers.

MOUNTING THE WORK.—Figure 9-22 shows correct and incorrect ways to mount work between centers. In the correct example, the driving dog is attached to the work and held rigidly by the setscrew. The tail of the dog rests in the slot of the faceplate, without touching the bottom of the slot. The tail extends beyond the base of the slot so that the work rests firmly on both the headstock center and the tailstock center.

In the incorrect example, note that the tail of the dog rests on the bottom of the slot on the faceplate at A and pulls the work away from the center's point, as shown at B and C. This causes the work to revolve eccentrically.

In mounting work between centers for machining, be sure there is no end play between the work and the dead center. However, do not have the work held too tightly by the tailstock center. If you do, as the work revolves, it will heat the center's point, destroying both itself and the center. To help prevent overheating, lubricate the tailstock center with grease or oil.

Holding Work on a Mandrel

Many parts, such as bushings, gears, collars, and pulleys, require all the finished external surfaces to run true with their center hole, or bore.

General practice is to finish the bore to a standard size within the limit of the accuracy desired. Thus a 3/4-inch standard bore would have a finished diameter of from 0.7495 to 0.7505 inch This variation is due to a tolerance of 0.0005 inch below and above the true standard of exactly 0.750 inch. First drill the hole to within a few thousandths of an inch of the finished size; then remove the remainder of the material with a machine reamer, following with a hand reamer if the limits are extremely close.

Then press the piece on a mandrel tightly enough so the work will not slip while being machined Clamp a dog on the mandrel, which is mounted between centers. Since the mandrel surface runs true with respect to the lathe axis, the turned surfaces of the work on the mandrel will be true with respect to the bore of the piece.

A mandrel is simply a round piece of steel of convenient length which has been center drilled and ground true with the center holes. Commercial mandrels are made of tool steel, hardened and ground with a slight taper (usually 0.0005 inch per inch). This taper allows the standard hole in the work to vary according to the usual shop practice and still provides a drive to the work when the mandrel is pressed into the hole. The taper is not great enough to distort the hole in the work The center-drilled centers of the mandrel are lapped for accuracy. The ends are turned smaller than the body of the mandrel and provided with flats, which give a driving surface for the lathe dog.

Holding Work in Chucks

The independent chuck and universal chuck are used more often than other work-holding devices in lathe operations. The universal chuck is used for holding relatively true cylindrical work when the time required to do the job is more important than the concentricity of the machined surface and the holding power of the chuck When the work is irregular in shape, must be accurately centered, or must be held securely for heavy feeds and depth of cuts, an independent chuck is used.

FOUR- JAW INDEPENDENT CHUCK.-Figure 9-23 shows a rough cylindrical casting mounted in a four-jaw independent lathe chuck on the spindle of the lathe. Before truing the work, determine which part you wish to have turned true. To mount this casting in the chuck, proceed as follows:

1. Adjust the chuck jaws to receive the casting. The same point on each jaw should touch the same ring on the face of the chuck If there are no

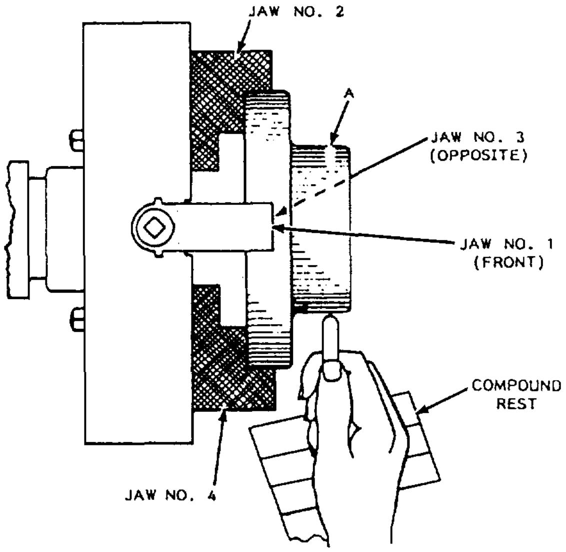

Figure 9-23.—Work mounted in a four-jaw chuck.

rings, put each jaw the same distance from the outside edge of the body of the chuck.

2. Fasten the work in the chuck by turning the adjusting screw on jaw 1 and then on jaw 3, a pair of jaws which are opposite each other. Next, tighten jaws 2 and 4.
3. At this stage the work should be held in the jaws just tightly enough so it will not fall out of the chuck while you turn it.
4. Revolve the spindle slowly by hand and, with a piece of chalk, mark the high spot (A in fig. 9-23) on the work while it is revolving. Steady your hand on the tool post while holding the chalk.
5. Stop the spindle. Locate the high spot on the work and move the high spot toward the center of the chuck by releasing the jaw opposite the chalk mark and tightening the one nearest the mark
6. Sometimes the high spot on the work will be located between adjacent jaws. In that case, loosen the two opposite jaws and tighten the jaws adjacent to the high spot.

THREE-JAW UNIVERSAL CHUCK.—The three-jaw universal or scroll chuck is made so that all jaws move at the same time. A universal chuck will center almost exactly at the first clamping, but after a long period of use may develop inaccuracies of up to 0.010 inch in centering the work. You can usually correct the inaccuracy by inserting a piece of paper or thin shim stock between the jaw and the work on the high side.

When you chuck thin sections, be careful not to clamp the work too tightly because the work will distort. If you machine distorted work, the finished work will have as many high spots as there are jaws, and the turned surface will not be true.

Care of Chucks

To preserve the accuracy of a chuck, handle it carefully and keep it clean and free from grit. **NEVER** force a chuck jaw by using a pipe as an extension on the chuck wrench.

Before mounting a chuck, remove the live center and fill the hole with a rag to prevent chips and dirt from getting into the tapered hole of the spindle.

Clean and oil the threads of the chuck and the spindle nose. Dirt or chips on the threads will not allow the chuck to run true when it is screwed up to the shoulder. Screw the chuck on carefully, tightening it just enough to make it difficult to remove. Never use mechanical power to install a chuck.

To remove a chuck, place a spanner wrench on the collar of the chuck and strike a smart blow on the handle of the wrench with your hand. When you mount or remove a heavy chuck, lay a board across the bed ways to protect them; the board will support the chuck as you put it on or take it off.

The comments on mounting and removing chucks also apply to faceplates.

Holding Work on a Faceplate

A faceplate is used for mounting work that cannot be chucked or turned between centers because of its size or shape.

Work is secured to the faceplate by bolts, clamps, or any suitable clamping means. The holes and slots in the faceplate are used for anchoring the holding bolts. Angle plates may be used to position the work at the desired

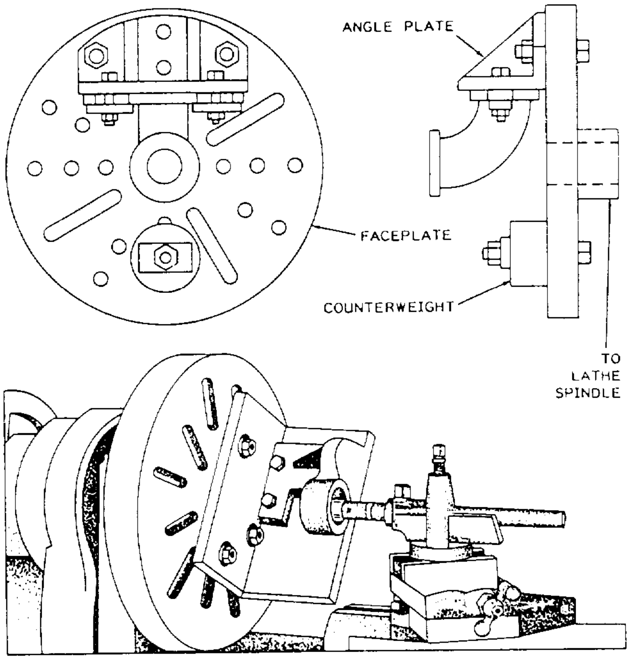

Figure 9-24.—Work clamped to an angle plate.

angle, as shown in figure 9-24. Note the counterweight added for balance.

For work to be mounted accurately on a faceplate, the surface of the work in contact with the faceplate must be accurately faced. It is good practice to place a piece of paper between the work and the faceplate to prevent slipping.

Before you clamp the work securely, move it about on the surface of the faceplate until the point to be machined is centered accurately with the axis of the lathe. Suppose you wish to bore a hole, the center of which has been laid out and marked with a prick punch. First, clamp the work to the approximate position on the faceplate. Slide the tailstock up until the dead center just touches the work. (NOTE: The dead center should have a sharp, true point.) Now revolve the work slowly; if the work is off center, the point will scribe a circle on the work. If the work is on center, the point of the dead center will coincide with the prick punch mark.

Using the Center Rest and Follower Rest

Place the center rest on the ways where it will give the greatest support to the workpiece. This is usually at about the middle of its length.

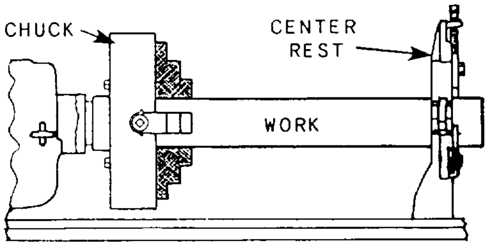

Figure 9-25.—Work mounted in a chuck and center rest.

Ensure that the jaws of the center rest are adjusted to support the work while allowing it to turn freely. Figure 9-25 shows how a chuck and center rest are used for machining the end of a workpiece.

The follower rest differs from the center rest in that it moves with the carriage and provides support against the forces of the cut only. Set the tool to the diameter selected, and turn a “spot” about 5/8 to 3/4 inch wide. Then adjust the follower rest jaws to the finished diameter to follow the tool along the entire length to be turned.

Use a thick oil on the center rest and follower rest to prevent “seizing” and scoring of the workpiece. Check the jaws frequently to see that they do not become hot. The jaws may expand slightly if they get hot, pushing the work out of alignment (when using the follower rest) or binding (when using the center rest).

Holding Work in a Draw-In Collet Chuck

The draw-in collet chuck is used for very fine, accurate work of small diameter. Long work can be passed through the hollow drawbar. Short work can be placed directly into the collet from the front. The collet is tightened on the work by rotating the drawbar to the right; this draws the collet into the tapered closing sleeve. The opposite operation releases the collet.

Accurate results are obtained when the diameter of the work is exactly the same size as the dimension stamped on the collet. In some cases, the diameter may vary as much as 0.002 inch; that is, the work may be 0.001 inch smaller or larger than the collet size. If the work diameter varies more than this, it will impair the accuracy and efficiency of the collet. That is why a separate collet should be used for each small variation or work diameter, especially if precision is desired.

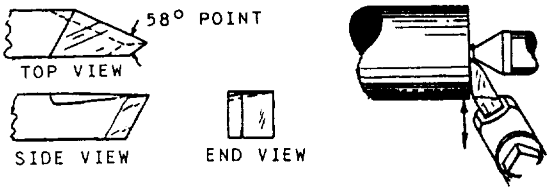

Figure 9-26.—Facing a cylindrical piece.

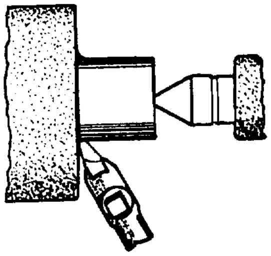

Figure 9-27.—Facing a shoulder.

MACHINING OPERATIONS

Up to this point, you have studied the preliminary steps leading to the performance of machine work in the lathe. You have learned how to mount the work and the tool and which tools are used for various purposes. Now, you need to consider how to use the proper tools in combination with the lathe to perform various machining operations.

FACING

Facing is the machining of the end surfaces and shoulders of a workpiece. In addition to squaring the ends of the work, facing provides a way to cut work to length accurately. Generally, only light cuts are required since the work will have been cut to approximate length or rough machined to the shoulder.

Figure 9-26 shows the facing of a cylindrical piece. The work is placed between centers and driven by a dog. A right-hand side tool is used as shown. Take a light cut on the end of the work, feeding the tool (by hand crossfeed) from the center toward the outside. Take one or two light cuts to remove enough stock to true the work Then reverse the workpiece, install the dog on the just finished end, and face the other end to make the work the proper length. To provide an accurate base from which to measure, hold another rule or straightedge on the end you faced first. Be sure there is no burr on the edge to keep the straightedge from bearing accurately on the finished end. Use a sharp scribe to mark off the dimension desired.

Figure 9-27 shows the use of a turning tool in finishing a shouldered job having a fillet corner. Take a finish cut on the small diameter. Machine the fillet with a light cut. Then use the tool to face the work from the fillet to the outside of the work.

In facing large surfaces, lock the carriage in position, since only crossfeed is required to traverse the tool across the work. With the compound rest set at 90° (parallel to the axis of the lathe), you can use the micrometer collar to feed the tool to the proper depth of cut.

TURNING

Turning is the machining of excess stock from the periphery of the workpiece to reduce the diameter. In most lathe machining operations requiring removal of large amounts of stock, a series of roughing cuts is taken to remove most of the excess stock Then a finishing cut is taken to accurately “size” the workpiece.

Rough Turning

When a great deal of stock is to be removed, you should take heavy cuts to complete the job in the least possible time. This is called rough turning.

Select the proper tool for taking a heavy chip. The speed of the work and the amount of feed of the tool should be as great as the tool will stand.

When you take a roughing cut on steel, cast iron, or any other metal that has a scale on its surface, be sure to set the tool deep enough to get under the scale in the first cut. Unless you do, the scale on the metal will dull or break the point of the tool.

Rough machine the work to almost the finished size; then take careful measurements.

Bear in mind that the diameter of the work being turned is reduced by an amount equal to twice the depth of the cuts; thus, if you desire to reduce the diameter of a piece by 1/4 inch, you must remove 1/8 inch of metal from the surface.

Figure 9-28 shows the position of the tool for taking a heavy cut on large work. Set the tool so that if anything

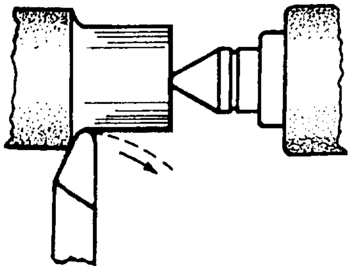

Figure 9-28.—Position of the tool for a heavy cut.

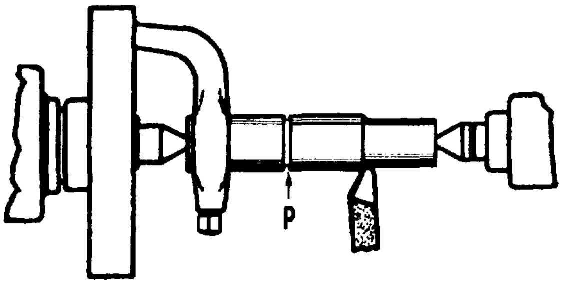

Figure 9-29.—Machining to a shoulder.

occurs during machining to change the position of the tool, it will not dig into the work, but rather will move in the direction of the arrow-away from the work

Finish Turning

When you have rough turned the work to within about 1/32 inch of the finished size, take a finishing cut. A fine feed, the proper lubricant, and, above all, a keen-edged tool are necessary to produce a smooth finish. Measure carefully to be sure you are machining the work to the proper dimension. Stop the lathe when you take measurements.

If you must finish the work to close tolerances, be sure the work is not hot when you take the finish cut. If you turn the workpiece to exact size when it is hot, it will be undersize when it has cooled.

Perhaps the most difficult operation for a beginner in machine work is to make accurate measurements. So much depends on the accuracy of the work that you should make every effort to become proficient in the use of measuring instruments. You will develop a certain “feel” in the application of micrometers through experience alone; do not be discouraged if your first efforts do not produce perfect results. Practice taking micrometer measurements on pieces of known dimensions. You will acquire skill if you are persistent.

Turning to a Shoulder

Machining to a shoulder is often done by locating the shoulder with a parting tool. Insert the parting tool about 1/32 inch from the shoulder line toward the small diameter end of the work Cut to a depth 1/32 inch larger than the small diameter of the work. Then machine the stock by taking heavy chips up to the shoulder. This procedure eliminates detailed measuring and speeds up production.

Figure 9-29 illustrates this method of shouldering. A parting tool has been used at P and the turning tool is taking a chip. It will be unnecessary to waste any time in taking measurements. You can devote your time to rough machining until the necessary stock is removed. Then you can take a finishing cut to accurate measurement.

Boring

Boring is the machining of holes or any interior cylindrical surface. The piece to be bored must have a drilled or cored hole, and the hole must be large enough to insert the tool. The boring process merely enlarges the hole to the desired size or shape. The advantage of boring is that a true round hole is obtained, and two or more holes of the same or different diameters may be bored at one setting, thus ensuring absolute alignment of the axis of the holes.

Work to be bored may be held in a chuck, bolted to the faceplate, or bolted to the carriage. Long pieces must be supported at the free end in a center rest.

When the boring tool is fed into the hole of work being rotated on a chuck or faceplate, the process is called single point boring. It is the same as turning except that the cutting chip is taken from the inside. The cutting edge of the boring tool resembles that of a turning tool. Boring tools may be the solid forged type or the inserted cutter bit type.

When the work to be bored is clamped to the top of the carriage, a boring bar is held between centers and driven by a dog. The work is fed to the tool by the automatic longitudinal feed of the carriage. Three types of boring bars are shown in figure 9-30. Note the center holes at the ends to fit the lathe centers.

Figure 9-30, view A, shows a boring bar fitted with a fly cutter held by a headless setscrew. The other setscrew, bearing on the end of the cutter, is for adjusting the cutter to the work

Figure 9-30, view B, shows a boring bar fitted with a two-edged cutter held by a taper key. This is more of a finishing or sizing cutter, as it cuts on both sides and is used for production work.

The boring bar shown in figure 9-30, view C, is fitted with a cast-iron head to adapt it for boring work

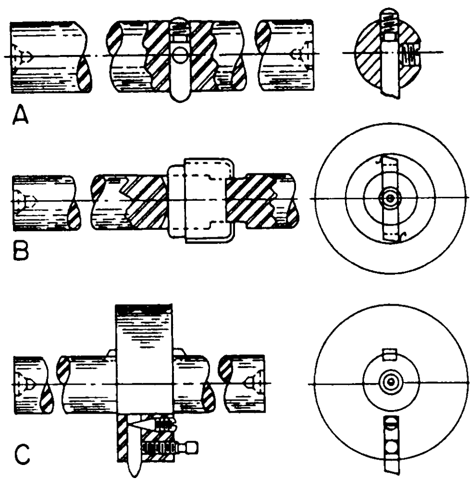

Figure 9-30.–Boring bars.

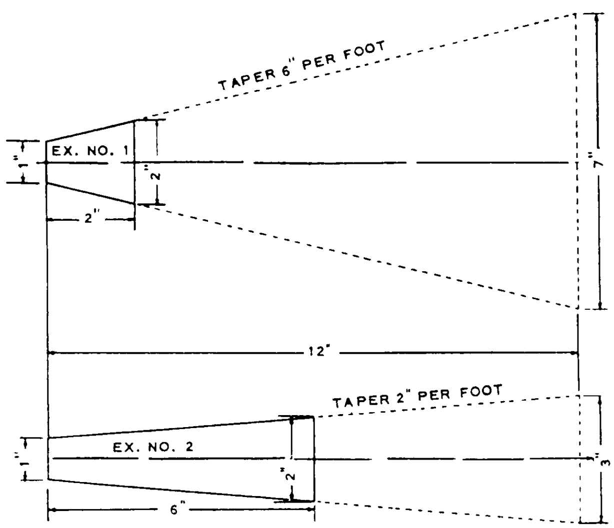

Figure 9-31.–Tapers.

of large diameter. The head is fitted with a fly cutter similar to the one shown in view A of figure 9-30. The setscrew with the tapered point adjusts the cutter to the work

TAPERS

Although you will probably have little need to machine tapers, we have provided the following explanation for your basic knowledge.

A taper is the gradual decrease in the diameter of a piece of work toward one end. The amount of taper in any given length of work is found by subtracting the size of the small end from the size of the large end. Taper is usually expressed as the amount of taper per foot of length or taper per inch of length. We will take two examples. (See fig. 9-31.)

Example l.–Find the taper per foot of a piece of work 2 inches long. The diameter of the small end is 1 inch; the diameter of the large end is 2 inches.

The amount of taper is 2 inches minus 1 inch, which equals 1 inch. The length of the taper is given as 2 inches. Therefore, the taper is 1 inch in 2 inches of length. In 12 inches of length the taper is 6 inches. (See fig. 9-31.)

Example 2.–Find the taper per foot of a piece 6 inches long. The diameter of the small end is 1 inch; the diameter of the large end is 2 inches.

The amount of taper is the same as in example 1, that is, 1 inch. However, the length of this taper is 6 inches; hence the taper per foot is 1 inch times 12/6, which equals 2 inches per foot (fig. 9-31).

SAFETY PRECAUTIONS

In machining operations, always keep safety in mind, no matter how important the job is or how well you know the machine you are operating. Listed here are some safety precautions that you MUST follow:

1. Before starting any lathe operations, always prepare yourself by rolling up your shirt sleeves and removing your watch, rings, and other jewelry that might become caught while you operate the machine.

2. Wear goggles or an approved face shield at all times whenever you operate a lathe or when you are near a lathe that is being operated.

3. Be sure the work area is clear of obstructions that you might fall or trip over.

4. Keep the deck area around your machine clear of oil or grease to prevent the possibility of slipping or falling into the machine.

5. Always use assistance when handling large workpieces or large chucks.

6. NEVER remove chips with your bare hands. Use a stick or brush, and always stop the machine.

7. Always secure power to the machine when you take measurements or make adjustments to the chuck.

8. Be attentive, not only to the operation of your machine, but also to events going on around it. **NEVER** permit skylarking in the area.

9. Should it become necessary to operate the lathe while the ship is underway, be especially safety conscious. (Machines should be operated **ONLY** in relatively calm seas.)

10. Be alert to the location of the cutting tool while you take measurements or make adjustments.

11. Always observe the specific safety precautions posted for the machine you are operating.

SUMMARY

In this chapter, you have learned the principal parts, the attachments and accessories, the uses and the basic operation of the engine lathe. Additionally, you have learned the basic operational safety precautions. For additional information on the operation of the engine lathes, refer to *Machinery Repairman 3 & 2*, NAVEDTRA 10530-E1.

APPENDIX I

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APPENDIX II

UNITS OF MEASUREMENT CHARTS

U. S. CUSTOMARY AND METRIC SYSTEM UNITS OF MEASUREMENTS

THESE PREFIXES MAY BE APPLIED TO ALL SI UNITS

MULTIPLES AND SUBMULTIPLES

	Prefixes	Symbols
1 000 000 000 000 = 10^{12}	tera (tĕr'ȧ)	T
1 000 000 000 = 10^{9}	giga (jĭ'gȧ)	G
1 000 000 = 10^{6}	mega (mĕg'ȧ)	M*
1 000 = 10^{3}	kilo (kĭl'ō)	k*
100 = 10^{2}	hecto (hĕk'tō)	h
10 = 10	deka (dĕk'ȧ)	da
0.1 = 10^{-1}	deci (dĕs'ĭ)	d
0.01 = 10^{-2}	centi (sĕn'tĭ)	c*
0.001 = 10^{-3}	milli (mĭl'ĭ)	m*
0.000 001 = 10^{-6}	micro (mī'krō)	μ*
0.000 000 001 = 10^{-9}	nano (năn'ō)	n
0.000 000 000 001 = 10^{-12}	pico (pē'kō)	p
0.000 000 000 000 001 = 10^{-15}	femto (fĕm'tō)	f
0.000 000 000 000 000 001 = 10^{-18}	atto (ăt'tō)	a

* MOST COMMONLY USED

ENGLISH AND METRIC SYSTEM UNITS OF MEASUREMENT
COMMON EQUIVALENTS AND CONVERSIONS

Approximate Common Equivalents		Conversions Accurate to Parts Per Million (units stated in abbreviated form)	
		Number × Factor	
1 inch	= 25 millimeters	in × 25.4	= mm
1 foot	= 0.3 meter	ft × 0.3048*	= m
1 yard	= 0.9 meter	yd × 0.9144*	= m
1 mile **	= 1.6 kilometers	mix 1.60934	= km
1 square inch	= 6.5 square centimeters	in^2 × 6.4516*	= cm^2
1 square foot	= 0.09 square meter	ft^2 × 0.0929030	= m^2
1 square yard	= 0.8 square meter	yd^2 × 0.836127	= m^2
1 acre	= 0.4 hectare	acres × 0.404686	= ha
1 cubic inch	= 16 cubic centimeters	in^3 × 16.3871	= cm^3
1 cubic foot	= 0.03 cubic meter	ft^3 × 0.0283168	= m^3
1 cubic yard	= 0.8 cubic meter	yd^3 × 0.764555	= m^3
1 quart (lq.)	= 1 liter	qt (lq.) × 0.946353	= *l*
1 gallon	= 0.004 cubic meter	gal × 0.00378541	= m^3
1 ounce (avdp)	= 28 grams	oz (avdp) × 28.3495	= g
1 pound (avdp)	= 0.45 kilogram	lb (avdp) × 0.453592	= kg
1 horsepower	= 0.75 kilowatt	hp × 0.745700	= kW
1 pound per square inch	= 0.07 kilogram per square centimeter	psi × 0.0703224	= kg/cm^2
1 millimeter	= 0.04 inch	mm × 0.0393701	= in
1 meter	= 3.3 feet	m × 3.28084	= ft
1 meter	= 1.1 yards	m × 1.09361	= yd
1 kilometer	= 0.6 mile	km × 0.621371	= mi
1 square centimeter	= 0.16 square inch	cm^2 × 0.155000	= in^2
1 square meter	= 11 square feet	m^2 × 10.7639	= ft^2
1 square meter	= 1.2 square yards	m^2 × 1.19599	= yd^2
1 hectare	= 2.5 acres	ha × 2.47105	= acres
1 cubic centimeter	= 0.06 cubic inch	cm^3 × 0.0610237	= in^3
1 cubic meter	= 35 cubic feet	m^3 × 35.3147	= ft^3
1 cubic meter	= 1.3 cubic yards	m^3 × 1.30795	= yd^3
1 liter	= 1 quart (lq.)	*l* × 1.05669	= qt (lq.)
1 cubic meter	= 250 gallons	m^3 × 264.172	= gal
1 gram	= 0.035 ounces (avdp)	g × 0.0352740	= oz (avdp)
1 kilogram	= 2.2 pounds (avdp)	kg × 2.20462	= lb (avdp)
1 kilowatt	= 1.3 horsepower	kW × 1.34102	= hp
1 kilogram per square centimeter	= 14.2 pounds per square inch	kg/cm^2 × 14.223226	= psi

**nautical mile = 1.852 kilometers

*exact

INDEX

F

T

U

V

W

Assignment Questions

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

ASSIGNMENT 1

Textbook Assignment: "Administration and Training," chapter 1, pages l-l through 1-28.

---

l-l. The standard forms for the logs and records are prepared by the various systems commands and the CNO.

1. True
2. False

1-2. Which of the following entries is NOT required in the Engineering Log?

1. The total engine miles steamed for the day
2. Any injuries to engineering department personnel
3. The amount of fuel consumed for the day
4. Draft and displacement upon getting underway

1-3. Which of the following engineering department records must be preserved as permanent legal records?

1. Engineering Log and Fuel and Water Report
2. Engineer's Bell Book and Monthly Summary
3. Engineering Log and Engineer's Bell Book
4. Machinery History and Boiler Room Operating Record

1-4. Which of the following statements pertaining to the Engineering Log is correct?

1. Remarks must include all minor speed changes and boilers in use
2. Spaces are provided for recording the total engine miles steamed for the day and draft and displacement upon getting underway and anchoring
3. Only erasures that are neat and the reentries that are legible are allowed
4. It must be prepared and signed by the senior petty officer of the watch only

1-5. Instructions for making entries in the Engineering Log are contained in which of the following sources?

1. *Naval Ships' Technical Manual*, chapter 090
2. Type commander's directives
3. Engineering Log form, NAVSHIPS 3120/2D
4. All of the above

1-6. You are in charge of the entire underway watch when Fireman Jones slips and breaks his arm in the engine room. Where should you record this injury?

1. In the Monthly Summary
2. In the Engineering Log
3. In the Engineer's Bell Book
4. All of the above

1-7. If an error is made in an entry to the Engineering Log, what should you do about the erroneous entry?

1. Erase the error and insert the correction
2. Line through the error once, rewrite it correctly, and initial in the margin
3. Underline the error and enter an explanatory note in the margin
4. Circle the error and write an explanatory note at the bottom of the page

1-8. What person is reponsible for reviewing and signing the Engineering Log each day to indicate that all entries are complete and accurate?

1. Petty officer of the watch
2. CPO with the day's duty
3. Engineer officer
4. Main propulsion assistant

1-9. The commanding officer signs the Engineering Log on what calendar day of each month?

1. Fifth
2. Tenth
3. Twentieth
4. Last

1-10. A new series of page numbers added to the Engineering Log are used starting with the first day of each

1. month
2. quarter
3. fiscal year
4. calendar year

1-11. No one may enter changes or additions to the Engineering Log after it has been signed by the commanding officer, without first having obtained permission.

1. True
2. False

1-12. Which of the following statements pertaining to the Engineer's Bell Book is correct?

1. Entries are made in the Bell Book by the throttleman (or an assistant) as soon as an order is received
2. It is a record of all bells, signals, and other orders received by the throttleman
3. Engineer's Bell Book is a legal record compiled by the engineering department
4. Each of the above

1-13. If the bridge signals ahead 1/3 on the engine order telegraph and ahead 35 on the engine revolution telegraph, what entry should the throttleman make in (a) column 2 and (b) column 3 of the Engineer's Bell Book?

1. (a) II; (b) 35
2. (a) I; (b) 2/3
3. (a) I; (b) 35
4. (a) 1/3; (b) 35

1-14. Neat corrections and erasures are permitted in the Engineer's Bell Book if they are made only by the person required to sign the record for the watch and if those changes are neatly initialed in the margin of the page.

1. True
2. False

1-15. The Diesel Engine Operating Record--All Ships (NAVSEA 9231/2) may be destroyed after what minimum length of time??

1. 6 months
2. 12 months
3. 24 months
4. 36 months

1-16. The Daily Fuel and Water Account is maintained by the engineering department for which of the following reasons?

1. It may be used to form the basis of other department's reports
2. It informs selected personnel of the appropriate water usage
3. Both 1 and 2 above
4. It tells the engineer officer the status of the ship's liquid load and forms the basis of engineering reports submitted to the higher authority

1-17. If you are assigned to compute the amount of burnable fuel aboard ship, you should consider which of the following factors?

1. The fuel in the service, storage, and settling tanks
2. The fuel in the service and storage tanks only
3. The fuel above the service and storage tank suction line
4. The fuel above the service tank suction line only

1-18. When computing the amount of burnable fuel on board, all the fuel below the fuel suction line is considered not burnable.

1. True
2. False

1-19. Which of the following engineering department records/reports must be submitted daily to the commanding officer?

1. Daily Boat Fueling Record
2. Daily Engineering Log
3. Fuel and Water Report
4. Each of the above

1-20. After the Monthly Summary has been prepared, what person must verify the fuel received for the month?

1. The commanding officer
2. The supply officer
3. The type commander
4. The engineer officer

1-21. Which of the following statements is true about a ship's Monthly Summary for a given month?

1. The commanding officer signs the copy that goes to the type commander
2. The supply officer prepares the report
3. The engineer officer verifies the fuel receipt figures
4. Each of the above

1-22. Where may you find additional information regarding the use of definitions and explanations in the preparation of the Monthly Summary?

1. Chief engineer instructions
2. CO instructions
3. Fleet commander instructions
4. Supply officer instructions

1-23. Which of the following documents indicates the amount of fuel oil on hand as of midnight, the previous day?

1. Daily Boat Fueling Record
2. Fuel and Water Report
3. Fuel and Water Accounts
4. Diesel Engine Operating Record

1-24. Information about engineering records that must be kept permanently is contained in which of the following publications?

1. Naval Ships' Technical Manual, chapter 080
2. SECNAVINST P5212.5 (revised)
3. NAVSHIPS 5083
4. NAVSHIPS 3648

1-25. The Engineering Log must be retained aboard ship for what minimum length of time?

1. 1 year
2. 2 years
3. 3 years
4. 4 years

1-26. If a ship is scrapped, what disposition is made of the ship's Engineer's Bell Book?

1. It is destroyed
2. It is sent to the nearest Naval Records Management Center
3. It is sent to NAVSHIPS
4. It is sent to BUDOCKS

1-27. A NAVSEA report that has served its purpose and is no longer useful may be destroyed after how many months?

1. 6
2. 12
3. 18
4. 24

1-28. The METER card is composed of how many parts?

1. Five
2. Two
3. Three
4. Four

1-29. What color copy of a completed METER card is sent to the MOCC?

1. Buff
2. Pink
3. White
4. Green

1-30. Which of the following MEASURE reports is sent to you each month as an inventory of all your items?

1. Format 210
2. Format 310
3. Format 350
4. Format 802

1-31. In regards to equipment tag-out procedures, what person is responsible for ensuring the item being tagged is in the prescribed position or condition?

1. The authorizing officer
2. The person attaching the tag
3. The second person
4. The OOD

1-32. Checks and audits of all tag-outs are usually done at which of the following times?

1. At the end of each workday
2. Every Friday
3. Every 2 weeks
4. At the end of each quarter

1-33. When a piece of equipment fails, you must take which of the following actions before repairs can begin?

1. Isolate and tag-out the piece of equipment
2. Notify the commanding officer
3. Submit OPNAV Form 4790.2Q
4. Request permission from the OOD to begin work

1-34. What person specifies the number of tag-out logs needed and their location?

1. The individual force commander
2. The Chief of Naval Operations
3. The commanding officer
4. The engineer officer

1-35. In regard to proper tag-out procedure, what person verifies the completeness of the tag-out action?

1. The person initiating the tag-out
2. The authorizing officer
3. The EOOW
4. The second person that made an independent check

1-36. Before starting the tag-out procedure, the authorizing officer must obtain permission from which of the following individuals?

1. The commanding officer
2. The responsible department head
3. Both 1 and 2 above
4. The type commander

1-37. When repairs have been completed on a piece of equipment, which of the following actions must be taken before it can be tested?

1. Complete the work request
2. Clear the tag
3. Clear the piece of equipment from the out-of-commission log
4. Warm up the system

1-38. Which of the following statements about label and tag enforcement is NOT correct?

1. All outstanding tags listed on each tag-out record sheet must be checked to ensure they are installed correctly
2. Results of audits are reported to the responsible department head
3. Testing the operation of a valve or switch is authorized as part of a routine tag-out audit
4. Spot checks of installed tags are conducted to ensure the tags are effective

1-39. Which of the following methods is used to determine if an engine needs to be overhauled or just temporarily shut down for simple maintenance?

1. The current engine operating data is compared with the previous operating data
2. The operating data of the engine is compared with that of the engine of the same type
3. The temperature of the lube oil entering the cooler is compared to that leaving the cooler
4. The present amount of lube oil consumption is compared with previous lube oil consumption

1-40. What can you determine from a spectrographic analysis?

1. The extent of accelerated wear of an internal combustion engine
2. The amount of oil the engine uses per month
3. The rate of flow of cooling water to the lube oil cooler
4. The amount of oil pressure produced by the lube oil pump

1-41. In regard to ship-to-shop work, who is responsible for witnessing any test required?

1. The ship QA personnel assigned to the job
2. The workcenter representative who requested the work
3. The repair facility supervisor
4. The repair facility quality assurance representative

1-42. When the shipyard or IMA laboratory receives the oil samples, which of the following tests is/are performed?

1. Acid test
2. Physical test
3. Spectrometric analysis
4. Both 2 and 3 above

1-43. You are aboard a destroyer home-ported on the West Coast and you need additional information concerning trend analysis and oil spectrometric analysis. You should refer to what Navy instruction?

1. OPNAVINST 43P1
2. COMNAVSURFLANTINST 9000.1C
3. COMNAVSURFPACINST 4700.1B
4. SECNAVINST P5212.5

1-44. Fresh water is not potable unless it meets which of the following conditions?

1. It is safe for engine operation
2. It is safe for human consumption
3. It is safe for cooling systems
4. It is 100 percent salt-free

1-45. Along with the engineering department, what other department is reponsible for the receipt, distribution, and quality testing of potable water systems?

1. Supply
2. Medical
3. Weapons
4. Operations

1-46. In addition to technical competence, which of the following characteristics should you possess before you can teach others?

1. Ability to organize information
2. Loud, strong voice
3. Formal training as an instructor
4. Each of the above

1-47. Which of the following factors does NOT help to determine the procedures for training a new person in engine-room operations?

1. Ship's operating schedule
2. Number of experienced personnel available
3. Condition of engine-room machinery
4. Trainee's manual skill level

1-48. An Engineman striker who is newly assigned to the engine room is not ready for messenger duty training until he or she becomes familiar with which of the following factors?

1. Duties of the throttleman
2. Technique of reading pressure gauges
3. Procedures of starting or securing the main propulsion plant
4. Locations of all machinery, equipment, piping, and valves

1-49. During what part of an engine-room watchstander's training should a trainee learn how to take gauge readings?

1. While learning the duties of a throttleman
2. While learning the duties of a messenger
3. After becoming proficient with the duties of the throttleman
4. After learning to perform the duties of the throttleman

1-50. When should an Engineman striker be trained to perform the duties of a throttleman?

1. After becoming competent in administrative requirements
2. After becoming proficient in the duties of the messenger
3. While learning the duties of the messenger
4. While learning specific basic safety precautions

1-51. Which of the following factors should be included in the training of engine-room personnel?

1. Consideration of individual difference in the learning rates of personnel
2. Time to be spent on engine theory before manual operation
3. Encouragement of personnel to notice and discuss differences in engine behavior during operation
4. All of the above

1-52. Which of the following factors should be emphasized constantly throughout an engine-room training program?

1. Safety precautions
2. Trial-and-error techniques
3. Emergency repair procedures
4. Machinery characteristics

1-53. What section of the PQS defines the actual duties, assignments, and responsibilities needed for qualification?

1. Fundamentals
2. Systems
3. Watchstations
4. Qualification Card

1-54. What section of the PQS deals with the major working parts of the installation, organization, or equipment?

1. Fundamentals
2. Systems
3. Watchstations
4. Qualification Card

1-55. What is the main purpose of the EOSS?

1. To restore plant operation after a casualty
2. To shorten communication lines to the bridge
3. To recognize the three levels of operation
4. To keep things going smoothly during confusion

1-56. Which of the following information is contained in the Engineering Operational Casualty Control (EOCC) subsystem?

1. Watch qualifications
2. Casualty symptoms
3. Casualty reporting to the type commander
4. Casualty reports to BUMED

1-57. What is the best form of casualty control?

1. Casualty prevention
2. Effective organization
3. Minimizing the casualty
4. Restoring the casualty

1-58. What is the best source for studying engineering casualty control?

1. The Naval Ships' Technical Manual
2. This training manual
3. The Watch, Quarter, and Station Bill
4. The EOCC procedure

1-59. All engine-room watchstanders can increase their ability to control and prevent casualties by studying which of the following publications?

1. The user's guide
2. The EOCC manual
3. The EOP manual, stage I
4. The EOP manual, stage II

1-60. What is the first step you should take when handling a diesel casualty with an inoperative speed governor?

1. Notify the engineer officer and the bridge and request permission to secure the engine for repairs
2. Check the setting of the needle valve
3. Check the linkage for binding or sticking
4. Control the engine manually, if possible

1-61. The Quality Assurance (QA) program was established for which of the following purposes?

1. To provide personnel with information and guidance necessary to administer a uniform policy of maintenance and repairs
2. To provide personnel with necessary information concerning MSD reporting procedures
3. To control casualty reporting procedures
4. To enhance the PQS program

1-62. The QA program organization (Navy) begins with what officer(s)?

1. Type commanders
2. Commanding officers
3. Commander in chief of the fleets
4. QA officer

1-63. Which of the following officers provide(s) instruction, policy, and overall direction for the implementation and operation of the force QA program?

1. Commanding officers only
2. Commander in chief of the fleets
3. Type commanders only
4. Type commanders and commanding officers

1-64. The quality assurance officer (QAO) is responsible to which of the following officers for the organization, administration, and execution of the ship's QA program?

1. Type commander
2. Commander in chief of the fleet
3. Commanding officer
4. Chief engineer

1-65. Which of the following duties is NOT the responsibility of the quality assurance officer?

1. Coordinating the ship's QA training program
2. Maintaining the ship's records of test and inspection reports
3. Conducting QA audits as required
4. Monitoring work procedure for quality assurance

1-66. Which of the following persons are assigned as the ship's quality control inspector?

1. The CO and the division officer
2. The engineer officer and the QAO
3. The work center supervisor and two others from the work center
4. The 3-M coordinator and the LCPO

1-67. Level A assurance provides which of the following levels of assurance?

1. The most stringent of restrictive verification
2. The least verification
3. Limited verification
4. Adequate verification

1-68. Level B assurance provides which of the following levels of assurance?

1. Minimum verification
2. Limited verification
3. The most stringent of restrictive verification
4. Adequate verification

1-69. Which of the following statements is NOT correct about levels of essentiality?

1. They are codes assigned by supply
2. They indicate the degree of impact on the ship's mission
3. They indicate the impact on personnel safety
4. They reflect the degree of confidence that procurement specifications have been met

1-70. What person implemented the system for periodic maintenance of equipment requiring calibration or servicing?

1. Chief of Naval Operations
2. Chief of Naval Education and Training
3. Chief of Naval Material
4. Chief of Naval Personnel

ASSIGNMENT 2

Textbook Assignment: "Measuring and Repair Instruments" and "Internal Combustion Engines," chapters 2 and 3, pages 2-1 through 3-23.

2-1. To ensure accuracy when measuring crankshaft end play, you should take the measurement what minimum number of times?

1. Five
2. Two
3. Three
4. Four

2-2. Which of the following procedures is the correct method to follow when opening a micrometer?

1. Hold the frame with one hand and turn the knurled sleeve with the other hand
2. Twirl the frame
3. Hold the knurled sleeve with both hands and twirl the frame
4. Twirl the knurled sleeve

2-3. Which of the following statements concerning a bore gauge is NOT correct?

1. It gives a direct measurement
2. It is one of the most accurate tools for measuring a cylinder bore
3. It checks the cylinder for out-of-roundness or taper
4. It has two stationary spring-loaded points and an adjustable point

2-4. Why must you expose the bore gauge, the master ring gauge, or other tools used to preset the bore gauge, and the part to be measured to the same environment before measuring?

1. Because it is a good practice to have all the tools and the part to be measured in one place
2. Because a temperature differential may cause your readings to be inaccurate
3. Because by doinq so. you can check what else you need before starting a measurement
4. Because by doing so, this will give you some time to read the bore gauge operating manual

2-5. A strain/deflection gauge is used for which of the following measurements?

1. Crankshaft run-out
2. Crankshaft end play
3. Both 1 and 2 above
4. Crankshaft alignment

2-6. When a strain/deflection gauge is used, readings are generally taken in how many crank positions?

1. Six
2. Five
3. Three
4. Four

2-7. Once you have placed the deflection gauge indicator in position for the first reading. you do not touch the gauge until all the required readings are taken and recorded.

1. True
2. False

2-8. What is the most preferred ratio of the torque multiplier?

1. 5 to 1
2. 2 to 1
3. 3 to 1
4. 4 to 1

2-9. If you use an extension to a torque adapter, how should the torque applied to the part or fastener compare to the torque indicated on the torque wrench?

1. It will be the same
2. It will be greater
3. It will be less

2-10. Before you begin an inspection or test of an engine frame or block, what should you do first?

1. Consult the manufacturer's manual because specific procedures vary with different engines
2. Check the engine's preventive maintenance schedule
3. Clean the outside of the engine thoroughly
4. Warm up the engine

2-11. A dye penetrant test meets the requirements for quality assurance when it is conducted by what person?

1. A QA inspector
2. Any qualified person
3. A certified nondestructive testing technician
4. A well-trained engineman

2-12. Which of the following conditions could indicate a crack in the cylinder liner of an engine?

1. Water standing atop the cylinder's piston after the engine is secured
2. Abnormally high cooling temperature when the engine is operating
3. Large amount of water in the lubricating oil
4. Each of the above

2-13. Which of the following is NOT the result of an improperly cooled cylinder liner?

1. Liner failure
2. Thermal stress
3. Uneven heating
4. Fluctuation in rpm

2-14. Which of the following conditions is NOT a cause for the liner to be improperly seated?

1. Metal chips
2. Oversized liner
3. Nicks or burrs
4. Improper fillets

2-15. Broken piston rings will cause which of the following problems?

1. Scored cylinder liners
2. Connecting bearing failure
3. High lube oil temperature
4. High freshwater temperature

2-16. Which of the following symptoms is an indication of a scored cylinder?

1. High compression pressure
2. Rapid wearing out of strainers and liner parts
3. Low compression pressure
4. Cracked or broken piston rings

2-17. Which of the following conditions will produce out-of-round cylinder liners?

1. Operating the engine at too low a temperature
2. Defective main bearing
3. Piston side thrust
4. Improperly seated head

2-18. How do you determine liner wear?

1. Take piston and liner measurements and qet the difference
2. Take measurements at three levels in the liner
3. Compare wear of piston rings
4. Compare compression readings

2-19. As a precaution against error, it is a good practice for two persons to take the liner measurement and then compare and check any discrepancy between the two sets of readings.

1. True
2. False

2-20. Which of the following conditions is NOT a cause of abnormal liner wear?

1. Insufficient lubrication
2. Dirt in the lube oil
3. Improper starting procedure
4. High cooling water temperature

2-21. Under which of the following conditions are corrosive vapors most likely to condense on the cylinder liner walls of an engine?

1. While operating at temperatures exceeding normal
2. While operating with the lube oil pressure below normal
3. While warming up after it is first started
4. While operating in such a way that normal lube oil pressure is exceeded

2-22. You are removing a cylinder liner from an engine. When fastening the special liner puller to the liner studs, why must you tighten the cap nuts by hand instead of by wrench?

1. Because the nuts cannot be reached with a wrench
2. Because the cylinder liner could be scratched with a wrench
3. Because threads on both nuts and studs could be damaged by a wrench
4. Because there is some danger that a wrench could be left in the cylinder liner

2-23. You are inspecting a cylinder head for cracks. Which of the following is NOT a correct procedure to use?

1. Perform a compression test
2. After bringing the piston of each cylinder to top dead center. apply compressed air
3. Examine by sight or with magnetic powder
4. Perform the hydrostatic test that is used on a water-jacketed cylinder

2-24. The gaskets, which are used between the mating surfaces of the head and the block of an engine, give this joint which of the following characteristics?

1. Acid resistance
2. Protection against leakage
3. Rigidity
4. Correct shape

2-25. What should you do if you discover a warped or distorted cylinder head during an inspection?

1. Machine the head to correct tolerance
2. Replace the head as soon as possible
3. Overtorque the head to compensate for the warpage
4. Reduce the load on the engine

2-26. Which of the following symptoms does NOT indicate fouling in the combustion chambers?

1. Excessive oil pumping
2. Smoky exhaust
3. Loss of power
4. Low compression

2-27. Which of the following valve problems will cause a valve to hang open?

1. Burned valve
2. Floating valve
3. Sticking valve
4. Bent valve

2-28. In a two-stroke cycle engine with aluminum pistons, what is the maximum wear limit for the liner?

1. 0.0015 in. per inch diameter
2. 0.0025 in. per inch diameter
3. 0.0030 in. per inch diameter
4. 0.0050 in. per inch diameter

2-29. Which of the following conditions will NOT cause cracks on an engine cylinder head?

1. Obstruction in the combustion space
2. Restriction of cooling passage
3. Addition of hot water to a cold enqine
4. Improperly tightened studs

2-30. What valve casualty is usually caused by resinous deposits left by improper lube oil or fuel?

1. Burned valves
2. Sticking valves
3. Weak springs
4. Bent valves

2-31. After inspecting the engine intake valves, you discovered that the surface of the valve head has damage. Which of the following casualties is the most probable cause?

1. It is sticking
2. It has a weak spring
3. It is bent
4. It has a loose valve seat

2-32. Which of the following valve casualties will cause the valve to fail to close completely?

1. A burned valve
2. A valve float
3. A sticking valve
4. A valve that has a weak spring

2-33. Failure to properly prepare the counterbore area before placing a valve seat insert in it will cause what problem?

1. Uneven heat transfer between the seat and the counterbore
2. Scratching of the insert
3. Misalignment of the valve head in the seat
4. Loose fit of the insert in the counterbore

2-34. When replacing a valve seat insert, which of the following procedures should you follow?

1. Plan the operation so that the insert is placed slowly and precisely
2. Use boiling water to heat the valve seat
3. Drive the insert down with a special tool
4. Shrink the valve guides or counterbore with dry ice

2-35. Minor pits and flaws may be removed from the valve seat by what method?

1. Buffing
2. Hand grinding
3. Insert replacement
4. Rubbing with prussian blue

2-36. How are valves refaced?

1. On a lathe
2. Against the valve seat
3. By machine qrinding
4. Each of the above

2-37. Which of the following conditions will cause valve springs to break?

1. Compression and corrosion
2. Misalignment and compression
3. Corrosion and fatique
4. Fatique and compression

2-38. Which of the following defects does NOT warrant valve spring replacement?

1. Loss of 2 percent of length
2. Damage to protective coating
3. Hairline cracks
4. Rust pits

2-39. Which of the following results will occur if shims are not properly placed between a valve stem and valve stem cap?

1. Damaged valve stem cap
2. Damaged or broken valve stem
3. Dropped valve
4. Each of the above

2-40. What is the most important factor in keeping a properly adjusted valve actuating gear in good condition?

1. Minimum clearance
2. Control of corrosion
3. Proper materials
4. Adequate lubrication

2-41. If the threads on a rocker arm adjusting screw become worn, what must you do?

1. Replace the rocker arm, screw, and locknut
2. Replace the screw only
3. Replace the screw and locknut only
4. Dress the threads on the screw

2-42. To adjust the tappet to the intake valve of a 4-stroke cycle engine, the piston must be in what position?

1. On the intake stroke
2. On the compression stroke
3. Between the compression and power strokes
4. Between the intake and compression strokes

2-43. What is the most frequent maintenance requirement for rocker arms?

1. Reaming the bushings in the rocker arms
2. Inspecting the rocker arm ends for wear
3. Checking tappet clearances and locknut tightness
4. Replacing tappet adjusting screws and locknuts

2-44. After setting a tappet clearance and locking the adjusting screw with the locknut, what is your next step?

1. Recheck the clearance
2. Adjust the next tappet
3. Warm the engine up and reset the clearance
4. Check the manufacturer's manual to see if the clearance is correct

2-45. When a lash adjuster is adequately supplied with oil, what will most likely cause it to operate noisily?

1. Excessive clearance
2. Broken parts
3. Dirt,resin, or abrasive particles
4. Missing check ball or spring

2-46. Which of the following actions should you take to insert a camshaft into the camshaft recess?

1. Rotate it as you push it in
2. Shake it up and down
3. Apply grease to it
4. Hit it with a sledge

2-47. Why is it necessary to scrape around the top of a cylinder bore before pulling the piston?

1. To remove any metal ridges and carbon deposits
2. To increase clearance for the piston
3. To remove abrasive particles and gum
4. To free the piston rings

2-48. To scrape the top of a cylinder bore before pulling the piston, you should use which of the following tools?

1. A power grinder
2. A file
3. A metal scraper
4. An emery cloth

2-49. When using a brass drift to remove a frozen piston ring, you must avoid damaging which of the following parts?

1. The ring
2. The drift
3. The camshaft
4. The land

2-50. Piston ring gaps are measured (a) with what tool and (b) in what location?

1. (a) A micrometer; (b) on the piston
2. (a) A feeler gauge; (b) in the cylinder liner
3. (a) A feeler gauge; (b) in the vise
4. (a) A micrometer; (b) in the cylinder liner

2-51. In addition to ring gap, what other factor must you measure to ensure correct ring fit?

1. Ring end gap
2. Ring-to-land clearance
3. Ring width
4. Ring circumference

2-52. Operation of an internal combustion engine above the specified temperature limits may result in which of the following problems?

1. Lack of lubrication of the cylinder walls
2. Low cylinder temperatures
3. Increased oil viscosity
4. Low oil temperatures

2-53. If the oil flow to a piston is restricted, where will the deposits caused by oxidation or the oil form?

1. On the underside or the piston crown
2. Behind the compression rings
3. On the piston walls
4. On the topside of the piston crown

2-54. You are installing a new sleeve bearing. Which of the following procedures will make it easier to insert the new sleeve bearing?

1. Apply plenty of grease to the bushing
2. Shrink the piston with dry ice
3. Shrink the sleeve bearing with dry ice
4. Heat the sleeve bearing in the oven

2-55. What is the primary reason piston pin bushings are reamed?

1. To enlarge oil holes
2. To obtain correct lubricating flukes
3. To obtain proper bore clearance
4. To correct oil hole positioning

2-56. To measure the clearance between a piston pin and its bushing, which of the following items should you use?

1. Micrometers
2. Feeler gauges
3. Leads
4. Prussian blue

2-57. When inserting new piston pin bushings, what are the three things you must check?

1. Alignment, clearance, and appearance
2. Cleanliness, appearance, and clearance
3. Appearance, alignment, and cleanliness
4. Cleanliness, alignment, and clearance

2-58. Crankshaft journals that exceed the specified tolerances for out-of-roundness should be refinished by which of the following means?

1. Stoning
2. Grinding
3. Filing
4. Scraping

2-59. A rough spot or slight score on a crankshaft journal should be removed by dressing with which of the following materials?

1. A fine sandpaper
2. A crocus cloth
3. A fine oilstone
4. Both 2 and 3 above

2-60. What instrument is used to take crankweb deflection readings?

1. A feeler gauge
2. An outside micrometer
3. A strain gauge
4. A gauge block

2-61. Impending bearing failures may be indicated by which of the following factors?

1. Lower than normal lubricating oil pressure and temperature
2. Higher than normal lubricating oil pressure and temperature
3. Lower than normal lube oil pressure and higher than normal lube oil temperature
4. Higher than normal lube oil pressure and lower than normal lube oil temperature

2-62. What is the recommended corrective action for journal bearings that have small raised surfaces or minor pits?

1. Replace the bearing
2. Stone down the raised surfaces and fill in the pits with solder
3. Grind the surfaces with a hand grinder
4. Smooth down the surfaces with a bearing scraper

2-63. Before installing new or restored bearings, what should you do?

1. Wipe oil on the journal surfaces only
2. Wipe oil on the bearing surfaces only
3. Ensure that the surfaces are clean and place a film of clean oil on both the journals and bearing surfaces
4. Clean the bearings with solvent and wipe dry

2-64. Certain information is indicated by markings placed on each half of the connecting rod bearings when they are removed from an engine. These markings ensure that the halves will be installed in their original positions. Which or the following is an example of sufficient and necessary information being shown by a marking?

1. No. 2 cylinder
2. No. 2 cylinder. upper half
3. No. 2 cylinder, engine No. 311645
4. Upper half, engine No. 311645

2-65. Which of the following procedures are acceptable for tightening connecting rod bolts?

1. Bolt elongation and bearing cap compression
2. Bearing cap compression and slugging wrench tightening
3. Torque wrench tightening and bolt elongation
4. Slugging wrench tightening and using a wrench extender

2-66. Which of the following means of determining clearances will NOT leave an impression in the soft bearing metal?

1. Leads
2. Shim stock
3. Feeler gauge
4. Plastigage

2-67. Which of the following senses is NOT used by the diesel engine troubleshooter?

1. Smell
2. Sight
3. Hearing
4. Taste

2-68. Frequently, instruments give the first symptoms of trouble. To detect a variation from normal, the troubleshooter must take which of the following actions?

1. Memorize the specified engine-operating instructions
2. Report the instrument readings to the EOOW
3. Read the instruments and record their indications regularly
4. Each of the above

2-69. Which of the following actions will be the greatest aid in detecting minor leakage?

1. Standing watch
2. Conducting material inspection
3. Conducting administrative inspection
4. Conducting routine cleaning

2-70. When a diesel engine can neither be cranked nor barred over, which of the following troubles is most probably indicated?

1. A depleted air supply
2. An open cylinder relief valve
3. An improperly engaged turning gear
4. An out-of-time air-starting motor

2-71. Which of the followinq is a symptom of excessive clearance between a piston and its cylinder.?

1. Piston slap
2. Less oil consumption
3. Minimal carbon deposits
4. Each of the above

2-72. Which of the following factors could cause piston seizure?

1. Excessive temperatures
2. Excessive cooling
3. Decrease in the rate of oxidation
4. Both 2 and 3 above

2-73. The best method for locating cracks in connecting rods is with an inside micrometer.

1. True
2. False

2-74. Which, if any, of the following measurements, indicates that main bearing wear has occurred?

1. Clearance between the bridge gauge and shaft
2. Variation between the measured clearance and the clearance stamped on the bearing housing
3. Variation between last crank web deflation and present
4. None of the above

2-75. When troubleshooting diesel engines, you should associate lack of engine power with which of the following systems?

1. Lubrication
2. Cooling
3. Fuel
4. Each of the above

ASSIGNMENT 3

Textbook Assignment: "Internal Combustion Engines," "Speed Controlling Devices," and "Refrigeration and Air Conditioning," chapters 3, 4, and 5, pages 3-23 through 5-9.

3-1. An engine cannot be cranked, but it can be barred over. Which of the following is the most probable fault?

1. Improper throttle setting
2. Tripped overspeed device
3. Engaged jacking gear interlock
4. Seized piston

3-2. In an engine that cannot be cranked, but can be barred over, which of the following systems is the most probable source of trouble?

1. Starting
2. Fuel
3. Ignition
4. Lubrication

3-3. Which of the following troubles may be detected through the scavenging air port?

1. Stuck piston rings
2. Seized bearing
3. Faulty air-starting distributor
4. Scored bearing

3-4. What causes most of the troubles in a direct mechanical lift air-starting system?

1. Insufficient lubrication
2. Improper adjustments
3. Dirt and gum deposits
4. Inadequate cooling

3-5. On a rotary distributor timing mechanism, what should you use to check the contact between the rotor and the body?

1. Feeler gauge
2. Prussian blue
3. Clearance light
4. Micrometer

3-6. Which of the following practices tends to reduce or eliminate the formation of gummy deposits that cause upper and lower pistons of pressure-activated air-starting valves to stick in the cylinders?

1. Increasing the tension of the valve return springs
2. Draining the storage tanks and water traps of the air-starting system
3. Jacking the engine over manually before starting to free any valves that may be stuck
4. Decreasing the tension of the valve return springs

3-7. If the upper piston of an air-actuated starting valve sticks because of gummy deposits, what action should you take?

1. Force alcohol around the pistons
2. Blow clean hot air around the pistons
3. Put light oil or diesel fuel around the piston and work the valve up and down
4. Remove the piston and buff it with jeweler's rouge

3-8. In general, what should you do if a pressure-actuated air-starting valve is not functioning properly because of a weak return spring?

1. Place another washer on top of the valve stem
2. Replace the castellated nut with a heavier one
3. Restress the valve return spring
4. Install a new valve return spring

3-9. What is the main source of fuel pump and injection system troubles?

1. Contaminated fuel
2. Improper adjustments
3. Coated fuel lines
4. Excessive vibration

3-10. Metal fatigue in the nipples of a fuel system is usually caused by which of the following factors?

1. Leakage
2. High injection pressure
3. Vibration
4. Erosion

3-11. What are the two main causes of leakage in fuel tanks?

1. Corrosion and excessive fuel line pressure
2. Metal fatigue and improper welds
3. Vibration and metal fatigue
4. Clogged fuel lines and corrosion

3-12. Which of the following problems is likely to cause failure of a diesel engine mechanical governor?

1. Faulty oil seals
2. Bound control linkage
3. Defective cold starting valve
4. Low oil level

3-13. Which of the following actions will cause the overspeed safety device of an engine to become inoperative?

1. Trying to start the engine with low air-starting pressure
2. Tripping the device accidentally while trying to start the engine
3. Shutting off the fuel supply after starting the engine
4. Shutting off the air supply after starting the engine

3-14. Most diesel engines are equipped with a special means of cutting off their air or fuel supply in an emergency. In which of the following situations would the special means be used?

1. Engine cannot be cranked or barred over
2. Parts of the exhaust system are obstructed
3. Fuel oil injection system is not properly timed
4. Overspeed safety device does not operate when speed becomes excessive

3-15. Slow cranking of a cold diesel engine may be caused by the use of which of the following substances?

1. Detergent lube oil
2. High viscosity lube oil
3. Centrifuged lube oil
4. Low viscosity lube oil

3-16. What diesel engine system is likely to be at fault if a cylinder misfires regularly?

1. Lubrication
2. Fuel
3. Exhaust
4. Ignition

3-17. A cylinder compression leak is indicated when the pressure in a particular cylinder of an engine signals which of the following conditions?

1. It is much higher than the pressure in the other cylinders
2. It is much lower than the pressure in the other cylinders
3. It fluctuates from normal to much below specified pressure
4. It fluctuates from normal to much above specified pressure

3-18. If the water in the cooling system of a diesel emergency generator overheats because the thermostat fails to function, what corrective action should you take?

1. Clean the bellows of the element
2. Adjust the tension of the regulator spring
3. Clean the freshwater cooler
4. Replace the thermostat

3-19. In the Fulton-Sylphon automatic temperature regulator, what happens if you decrease the spring tension?

1. The velocity of the cooling water decreases
2. The temperature range of the regulator increases
3. The temperature range of the regulator decreases
4. The velocity of the cooling water increases

3-20. Which of the following troubles in the engine exhaust system will cause back pressure?

1. Obstruction in the combustion space
2. Thermostat failure
3. Restricted exhaust
4. Restricted oil filter

3-21. After being cleaned, most oil bath-type engine air cleaners should be refilled to what level?

1. To the full mark
2. Slightly above the full mark
3. To the halfway mark
4. Slightly less than the halfway mark

3-22. Which of the following conditions can damage the turbine blading of a turbocharger?

1. Foreign objects
2. Bearing failure
3. Overspeeding
4. Each of the above

3-23. Which of the following conditions will NOT cause scoring of blower parts?

1. Dirty lube oil
2. Worn gears
3. Improper timing
4. Improper end clearance

3-24. How can you determine whether blower rotor gears are worn excessively?

1. Measure the clearance between the leading and the trailing edges of the rotor lobes
2. Measure the backlash of the gear set
3. Measure the clearance between the rotor lobes and the casing
4. Check the timing of the rotors

3-25. Which of the following conditions is a major contributing factor to diesel engine power loss, starting failure, and frequent stalling?

1. High cooling water temperature
2. Faulty operation of the governor
3. Improperly engaged jacking gear
4. Faulty air-starting distributor

3-26. If you are checking an engine for a stuck fuel control rack, what should you do immediately after disconnecting the linkage to the governor?

1. Visually inspect the rack
2. Try to move the rack by hand
3. Test the return springs
4. Clean the removed rack

3-27. A leaking fuel injector may cause an engine to

1. stop
2. overheat
3. operate better
4. continue to operate when you attempt to shut it down

3-28. Under which of the following conditions will a properly operating engine governor fail to have any control over a sudden increase in speed?

1. Injector leakage during operation
2. Sudden drawing of lube oil into the cylinders from the air box
3. Manifold explosion due to excessive accumulation of oil
4. Inoperative cylinder relief valve due to a stuck spring

3-29. Before installing a new blower oil seal, what must you do to the oil seal first?

1. Wash it in a detergent
2. Spray it with paraffin
3. Blow some air through it
4. Soak it in clean, light lube oil

3-30. What must you do to an improperly operating safety valve when it is removed from an engine cylinder?

1. Reset the spring tension
2. Replace the shear pin
3. Machine and lap the valve
4. Replace it with a new one

3-31. If the exhaust ports of an engine become clogged during operation, which of the following conditions is a possible result?

1. High exhaust temperatures
2. Overheating of the engine
3. Popping of the cylinder safety valves
4. Each of the above

3-32. When cleaning the cylinder ports of an engine, you can prevent carbon from entering the cylinder by performing which of the following actions?

1. Using a vacuum cleaner while brushing off the carbon
2. Jacking the engine over to a position that the piston blocks the port
3. Covering the inside of the cylinder
4. Brushing off the carbon away from the cylinder direction

3-33. What kind of noise will most likely be coming from an engine operating with a broken engine part?

1. Rattling
2. Clicking
3. Pounding
4. Knocking

3-34. The color of the exhaust smoke of an engine can NOT be used as an aid in which of the following circumstances?

1. Troubleshooting
2. Testing for fuel contamination
3. Determining engine performance
4. Determining serious engine troubles

3-35. An explosion may occur if a cigarette is lit near a storage battery because of the presence of

1. hydrogen gas
2. carbon monoxide
3. sulphuric acid
4. gasoline fumes

3-36. Failure of a gasoline engine starting motor to run may be caused by corroded, loose, or burned battery terminals.

1. True
2. False

3-37. When the starting motor of a gasoline engine turns but fails to crank the engine, the trouble is usually found in the

1. drive assembly
2. engine timing
3. fuel system
4. ignition system

3-38. Which of the following problems can result from overpriming a gasoline engine?

1. An overheated engine
2. An inoperative fuel pressure gauge
3. Stuck piston rings
4. Corroded piston crowns

3-39. You are checking for trouble in a fuel system that has a wobble pump. If the pump feels or sounds dry, where is the trouble probably located?

1. In the carburetor
2. In the line to the fuel pump
3. In the fuel pump
4. Between the fuel pump and the supply tanks

3-40. If a gasoline engine with a battery-type ignition system fails to stop, what is the most likely cause?

1. The switch contact points are open
2. The ground connection is open
3. The switch contact points are closed
4. The battery terminals are burned

3-41. Oil purifiers are designed to give maximum efficiency when you operate the purifier at what limits?

1. Minimum speed
2. A speed determined by prevailing conditions
3. A speed between minimum and maximum and below the rated capacity
4. Maximum designed speed and rated capacity

3-42. Most oil used by the Navy can be heated to what maximum temperature without damaging the oil?

1. 195°F
2. 190°F
3. 185°F
4. 180°F

3-43. When the military symbol 9250 lube oil is to be purified, it should be heated to what specific temperature?

1. 140°F
2. 160°F
3. 175°F
4. 180°F

3-44. The size of the discharge ring used in a purifier is determined by which of the following factors?

1. Viscosity of the oil
2. Moisture content of the oil
3. Sediment content of the oil
4. Specific gravity of the oil

3-45. What is the best method of determining the efficiency of a purifier?

1. Oil clarity check
2. Oil analysis
3. Batch process
4. Bowl sediment check

3-46. Which of the following corrective measures should you use to reduce the number of engine governor difficulties?

1. Reduce the engine speed
2. Increase the engine load
3. Use clean oil
4. Adjust the fuel linkage

3-47. When installing a new or overhauled governor, which of the following governor components should you adjust?

1. Governor linkage
2. Compensating needle valve
3. Speed adjusting screw
4. Speeder spring

3-48. When the governor compensating needle valve is correctly adjusted, the engine will behave in which of the following manners during load changes?

1. Maintain low underspeeds
2. Maintain high overspeeds
3. Return slowly to normal speeds
4. Return quickly to normal speeds

3-49. An increase in load for any constant throttle setting of a mechanical governor will be accompanied by a decrease in

1. engine speed
2. spring length
3. fuel pressure
4. oil temperature

3-50. The mechanical governor controls the engine maximum speed when the centrifugal force of both sets of flyweights act against which of the following parts?

1. The buffer spring
2. The light spring
3. The heavy spring
4. Each of the above

3-51. Which of the following is NOT a cause of improper speed fluctuation of an engine equipped with a mechanical governor?

1. Constantly changing loads
2. Misfiring engine cylinders
3. A binding governor linkage
4. High lube oil temperature

3-52. When you are in the process of assembling a governor, which of the following materials is recommended for use on the sealing gasket?

1. Shellac
2. Hard grease
3. Soft grease
4. Lube oil

3-53. An overspeed trip will stop a diesel engine that is equipped with a speed governor when the regular speed governor fails to perform which of the following actions?

1. Limit the load on the engine
2. Keep the engine within its maximum designed limit
3. Adjust to higher engine loads
4. Reduce engine hunt

3-54. A broken drive shaft of a hydraulic overspeed trip will cause uncontrolled engine speed because the flyweights would

1. disconnect from the shaft
2. remain in the distended position
3. cease to exert centrifugal force
4. increase in rotative speed

3-55. What controls the output of a high-speed refrigeration compressor?

1. The box temperature
2. The loading and unloading of compressor cylinders
3. The low-pressure switch
4. The solenoid valve

IN ANSWERING QUESTION 3-56, REFER TO FIGURE 5-3 OF THE TEXTBOOK.

3-56. What will happen when an increase in oil pump pressure causes the piston of the capacity control valve to move against spring A?

1. More cylinders will become loaded and the compressor output will increase
2. More cylinders will become unloaded and the compressor output will decrease
3. The regulating valves will relieve the oil pressure
4. The compressor output will remain the same

3-57. A refrigerant compressor has been overhauled. What is the first step you should take to remove the air from the compressor?

1. Disconnect the connection in the discharged gauge line between the stop valve and the compressor
2. Disconnect the connection on the compressor suction line
3. Start the compressor and let it run until a vacuum is obtained
4. Remove all oil from the compressor crankcase

3-58. You are trying to locate the refrigeration purge valve. Most likely you can find the valve in which of the following locations?

1. At the bottom of the condenser
2. At the top of the condenser
3. At the midsection of the condenser
4. On the condenser gauge line

3-59. In which of the following areas would air that enters a refrigeration plant tend to collect?

1. Upper part of the receiver
2. Upper part of the condenser
3. Inlet end of the condenser
4. Downstream end of the cooling coil

3-60. In a refrigeration system, what is the purpose of the purge valve?

1. To take out unpleasant fumes from the refrigerant
2. To vent off excess refrigerant during an emergency
3. To remove any air that may accumulate in the system
4. To permit the opening of the refrigeration system for cleaning and inspecting

3-61. On an air-cooled condenser, the exterior surfaces of the tubes and fins are dirty and restricting air circulation. Which of the following items should you use to clean these surfaces?

1. Jets of steam
2. Hot-water lances
3. Compressed-air lances
4. Stiff-bristled brushes

3-62. You are testing the condenser tubes for leakage. Why do you hold the exploring tube of the leak detector at one end of each condenser tube for about 10 seconds before driving a cork into each end of the tube?

1. To dry the tube heads
2. To detect the presence of R-12
3. To draw fresh air through the tube
4. To vaporize any water left in the tube

3-63. You are attempting to locate leaks in a refrigeration condenser. Before continuing the tests, you should allow the condenser to remain idle for what minimum period of time after all tubes in the suspected section have been corked?

1. 2 to 4 hr
2. 4 to 6 hr
3. 6 to 8 hr
4. 8 to 10 hr

3-64. When the thermostatic valve is operating properly, how does the temperature at the outlet side of the valve compare with the temperature at the inlet side?

1. The temperature is lower at the outlet side
2. The temperature is lower at the inlet side
3. The temperature is approximately the same at the outlet and the inlet sides

3-65. Which of the following factors can cause a thermostatic expansion valve to operate improperly?

1. A collection of dirt on the control bulb
2. A collection of Freon at the valve seat
3. A collection of dirt at the valve orifice
4. Each of the above

3-66. As a rule, about how many degrees of superheat are picked up by the refrigerant vapor before it leaves the cooling coil?

1. Between 4°F and 12°F
2. Between 15°F and 20°F
3. Between 30°F and 38°F
4. Between 45°F and 50°F

3-67. In a refrigerant plant, liquid refrigerant may flood back to the compressor from the evaporator if the thermostatic expansion valve is in which of the following situations?

1. Stuck shut
2. Adjusted for too high a degree of superheat at the outlet
3. Adjusted for too low a degree of superheat at the outlet

3-68. If you suspect that the expansion valve assembly requires replacement, which of the following conditions should be met before making an expansion valve test?

1. The liquid strainers should be cleaned
2. The solenoid valves should be operational
3. The system should be sufficiently charged
4. All of the above

3-69. A service drum that is used for testing an expansion valve should contain which of the following gases?

1. Pressurized R-12
2. Wet compressed air
3. Oxygen gas
4. Each of the above

3-70. You are testing the thermostatic expansion valve of a refrigeration plant. When should you immerse the thermal element in a bath of crushed ice?

1. Before the valve inlet is attached to the gas source
2. After the high-pressure and low-pressure gauges have been connected
3. Before the high-pressure gauge is connected to the valve outlet
4. After the valve on the air supply line has been opened

3-71. A thermostatic expansion valve is set for 5°F of superheat. What should be the outlet pressure on the gauge?

1. 16.1 psig
2. 22.5 psiq
3. 26.1 psig
4. 32.5 psiq

3-72. Which of the following operating conditions is an indication that the expansion valve is seating properly?

1. Pressure stops increasing after a few pounds
2. Pressure will build up slowly
3. Both 1 and 2 above
4. Pressure increases rapidly and equals the inlet pressure

3-73. You have removed the ice packing from the control bulb. Which of the following outlet pressure conditions indicates that the valve is operating properly?

1. The pressure does not change
2. The pressure decreases rapidly
3. The pressure decreases a few pounds and then stabilizes
4. The pressure increases rapidly

3-74. Under normal operating conditions, the receiver of a properly charged refrigeration system should be at what level when the compressor stops?

1. 25 percent full
2. 50 percent full
3. 85 percent full
4. 100 percent full

3-75. Which of the following actions should you take before tightening the cap on a cleaned liquid line strainer?

1. Test the strainer for leaks
2. Open the strainer outlet valve
3. Purge the air out of the strainer
4. Replace the strainer screen spring

ASSIGNMENT 4

Textbook Assignment: "Refrigeration and Air Conditioning," "Compressed Air Systems," "Laundry, Mess Decks, Galley, and Scullery Equipment," "Other Auxiliary Equipment," and "Lathe and Machining Operations," chapters 5 through 9, pages 5-9 through 9-20.

4-1. Which of the following conditions may be caused by excessive buildup of frost on the cooling coils?

1. Low suction pressure
2. High suction pressure
3. Low suction temperature
4. High condensing pressure

4-2. The maximum time between defrosting of the cooling coils depends on which of the following factors?

1. Amount of refrigerant in the system
2. Moisture content of the supplies placed in the box
3. Amount of heat to be removed
4. All of the above

4-3. You must defrost the cooling coils before the frost reaches what maximum thickness?

1. 1/8 inch
2. 3/16 inch
3. 1/4 inch
4. 5/16 inch

IN ANSWERING QUESTION 4-4, REFER TO FIGURE 5-4 OF THE TEXTBOOK.

4-4. Approximately how many inches of mercury represent the difference in temperature between points B and D?

1. 0.200 inch absolute
2. 0.232 inch absolute
3. 0.436 inch absolute
4. 0.640 inch absolute

4-5. While you are evacuating and dehydrating a refrigeration system, the vacuum indicator fails to attain 35°F. Which of the following conditions may be the cause of this failure?

1. Lack of lubricating oil in the compressor crankcase
2. Lack of moisture in the system
3. Presence of R-12 in the lubricating oil
4. Each of the above

4-6. To be properly reactivated, dehydrating agents should be heated (a) at what specific temperature and (b) for what approximate length of time?

1. (a) 200°F; (b) 12 hr
2. (a) 300°F; (b) 12 hr
3. (a) 400°F; (b) 6 hr
4. (a) 500°F; (b) 6 hr

4-7. If you do not have a tank-type cleaner, you can clean an R-12 system by which of the following methods?

1. By flushing boiling water through the system three times
2. By blowing hot air through the system for 24 hours
3. By inserting a hard, wool felt filter in the suction strainer screen and operating the plant
4. Each of the above methods

4-8. On the two-position, dual control (2PD), which of the following system types uses one common cooling coil to service several different spaces?

1. 1
2. 2
3. 3

4-9. What technique must you use to clean the sensing elements in the humidistats?

1. Use of a soft brush
2. Use of gently blown air
3. Use of a spray of soap and water solution
4. Use of a hard brush

4-10. To correct a low condensing pressure in an operating refrigeration system, you should perform which of the following actions?

1. Reduce the water supply
2. Increase the water pressure
3. Clean the valves and the valve seats
4. Adjust the high-pressure cutout switch

4-11. Insufficient refrigerant in a refrigeration plant may cause which of the following problems?

1. High discharge pressure
2. Low suction pressure
3. Frosting of the crankcase
4. High temperature of the overboard water

4-12. Which of the following actions should you take to correct a low condensing pressure in a refrigeration system?

1. Add refrigerant
2. Purge the condenser
3. Increase the compressor speed
4. Adjust the thermostatic expansion valve

4-13. In an R-12 refrigeration plant, a compressor runs continuously. What is the probable cause?

1. An open solenoid valve switch
2. An inadequate supply of refrigerant
3. Clogged condenser tubes
4. An excess of liquid refrigerant

4-14. Which of the following symptoms indicates that an inadequate supply of water is passing through the condenser of a refrigeration plant?

1. Excessively low temperature of the overboard water and low discharge pressure
2. High suction pressure and high temperature of the suction line
3. High condensing pressure and compressor short cycling on the high-pressure switch
4. High suction line temperature and high discharge pressure

4-15. The cut-in point is set too high on the low-pressure control switch of an R-12 refrigeration system. How will this effect the functioning of the compressor?

1. It will short cycle
2. It will not operate
3. It will operate unloaded
4. It will operate continuously

4-16. Which of the following conditions is probably caused by liquid refrigerant slugging back to the compressor crankcase of a refrigeration system?

1. Bubbles in the refrigerant
2. A sudden loss of oil from the crankcase
3. The compressor continues to operate unloaded
4. Failure of oil to return to the compressor crankcase

4-17. Aboard Navy ships, in which of the following situations would you most likely use MP air?

1. To clean machinery
2. To start diesel engines
3. To operate pneumatic tools
4. Each of the above

4-18. What type of air dehydrator is used to reduce dust problems produced by the other various types?

1. Refrigeration (type I)
2. Desiccant (type II)
3. Activated alumina beads
4. Combination refrigeration and desiccant (type III)

4-19. Which of the following statements is correct about the dehydrator dew point readings?

1. They are taken only to verify suspected operational problems
2. They are taken every 8 hours of dehydrator service
3. They are taken as required by the PMS
4. They are taken every 4 hours of dehydrator service

4-20. Which of the following statements describes the recommended procedures for cleaning an oil-wetted filter element that was removed from a compressor intake?

1. Clean with gasoline or kerosene, dip in lightweight oil, and drain excess oil
2. Clean with steam or strong sal soda solution, dip in clean medium viscosity oil, and drain excess oil
3. Clean with a jet of hot water, dip in kerosene, and drain excess kerosene
4. Clean with kerosene, drain excess kerosene, dip in medium viscosity oil. and drain excess oil

4-21. Leakage through the discharge valves of an air compressor is usually caused by which of the following factors?

1. Dirt in the valves
2. Moisture in the air
3. Overcompression of air in the cylinders
4. Insufficient compression of air in the cylinders

4-22. Carbonized air compressor valves should be cleaned by soaking them in which of the following solvents?

1. Gasoline
2. Solution of kerosene and mineral oil
3. Kerosene only
4. Strong soda solution

4-23. When you are inserting valves in a compressor cylinder, in which of the following directions should the (a) discharge valves and (b) suction valves open?

1. (a) Toward the center;
   (b) away from the center
2. (a) Away from the center of the cylinder;
   (b) toward the center
3. (a) Toward the center of the cylinder;
   (b) toward the center of the cylinder
4. (a) Away from the center of the cylinder;
   (b) away from the center of the cylinder

4-24. What material is used to repack the filter of air compressor control valves?

1. Wool
2. Cotton
3. Linen
4. Nylon

4-25. Which of the following valves of a compressed air system is vital for its safe operation?

1. Control
2. Discharge
3. Suction
4. Relief

4-26. Which of the following checks is NOT a requirement during an inspection of a washing machine?

1. Test for correct steam pressure
2. See that the bolts, nuts, and screws are tight
3. Ensure the machine is level
4. See that the latches on the cylinder doors work properly

4-27. A well-maintained and properly used tumbler will dry a load of laundry in what minimum amount of time?

1. 10 minutes
2. 20 minutes
3. 30 minutes
4. 40 minutes

4-28. Steam kettles safety valves are set to release at what pressure?

1. 15 psig
2. 25 psig
3. 35 psig
4. 45 psig

4-29. Varied operating conditions of the distilling plants are a primary cause of which of the following problems?

1. Changes in feed level
2. Scaling of evaporator tubes
3. Improper liquid level in the first-effect tube nest
4. Excessive steam pressure

4-30. You are making adjustments on distilling plant controls to bring heat and fluid conditions into balance. Which of the following techniques should you use?

1. Adjust all controls simultaneously
2. Adjust all heat controls one at a time and quickly
3. Adjust controls one at a time and in small adjustments
4. Adjust each control at 10-minute intervals

4-31. Which of the following factors is NOT likely to cause a decrease in the distilling plant's efficiency?

1. Air leaks in the first-effect tube nest
2. Low vacuum in the last-effect shell
3. Dirty circulating water strainer
4. No undue deposits inside the tubes

4-32. You should inspect distilling plant steam orifices a minimum of how often?

1. Monthly
2. Twice a year
3. Annually
4. At each overhaul

4-33. From which of the following sources should you take water to be used to desuperheat live steam?

1. The first-effect tube nest drain pump
2. The second-effect tube nest drain pump
3. The freshwater supply
4. The steam feed system

4-34. Fluctuations in the first-effect steam pressure and temperature will cause similar fluctuations in which of the following parts of the plant?

1. The second-effect shell only
2. The steam supply line only
3. The water levels only
4. The entire plant

4-35. When you keep the vacuum in the first-effect tube nest of a distilling plant as high as possible, you will reduce which of the following factors?

1. The amount of brine pumped overboard
2. The pressure rate of the steam lines
3. The rate of evaporator tube scaling
4. The rate of distillate formation

4-36. When you cannot feed water into the first-effect tube nest of a distilling plant, you should look for which of the following causes?

1. Scale deposits in the air ejector
2. Scale deposits in the vapor feed heater
3. Obstructions in the feed line
4. Each of the above

4-37. Once the distilling plant is in operation, which of the following problems is/are likely to cause priming?

1. A sudden rise of the water level
2. A water level that is too high
3. Both 1 and 2 above
4. A sudden drop in the water level

4-38. The vacuum gauge readings are nearly identical on the first- and second-effect shells of a distilling plant. What is the most likely cause?

1. Air leaks between the first and second effect
2. Equally low water levels in both effects
3. Equally high water levels in both effects
4. Obstructions in the flow between the first and second effects

4-39. Improper venting of evaporator tube nests can cause which of the following problems?

1. Condensation of steam in the vapor feed heater
2. Accumulation of air in the tubes
3. Excessive increase of tube nest steam to the distilling condenser
4. Excessive increase of scale deposits on the evaporator tube nest

4-40. How much scale preventive compound is needed for each 4,000 gallons per day of distilling plant capacity?

1. 1.0 pint
2. 2.0 pints
3. 3.0 pints
4. 1.5 pints

4-41. You have an air leak in the distilling plant last-effect shell and the watch stander has been operating the air ejectors improperly. These conditions can produce which of the following vacuum readings in the last-effect shell?

1. 34 in.Hg
2. 30 in.Hg
3. 26 in.Hg
4. 10 in.Hg

4-42. When a distilling plant is in operation, which of the following vacuum tests should you use on joints?

1. Candle flame
2. Air pressure
3. Soapsuds
4. Hydrostatic

4-43. You must clean air ejector nozzles with which of the following tools?

1. Special reamer
2. Rat-tail file
3. Sharp scraper
4. Metal hole brush

4-44. The temperature of circulating water has exceeded the allowable 20°F as it passes through the distiller condenser. You know that this situation is not normal. What action should you take first?

1. Clean the air ejectors
2. Inspect the condenser circulating water systems
3. Check for improper operating procedures
4. Reset the back pressure-regulating valve

4-45. Which of the following indicators suggest(s) improper drainage of the distiller condenser?

1. The flash chamber gauge line is flooded
2. The first-effect tube nest vacuum is several inches of mercury
3. The plant does not produce the designed output when the orifice is 5 psig
4. Each of the above

4-46. All sources of troubles in electrohydraulic systems fit into one of three categories. Which of the following is NOT a category?

1. Hydraulic
2. Cooling
3. Electrical
4. Mechanical

4-47. What is the recommended method for locating small internal leaks in hydraulic systems?

1. Use magnetic flux
2. Install pressure gauges
3. Listen for identifying sounds
4. Visually inspect the disassembled parts

4-48. A popping or sputtering noise in a hydraulic system indicates which of the following conditions?

1. An oil leak in the pressure line
2. An air leak in the pressure line
3. An air leak in the suction line
4. An air pocket in the cylinder

4-49. Which of the following conditions should you suspect if a pounding or rattling noise occurs in a hydraulic system?

1. Overtight adjustment of parts
2. Defective spring-activated valve
3. Improperly adjusted relief valve
4. Overloaded system or high-speed operation

4-50. Foreign matter in the oil of a hydraulic transmission usually causes which of the following types of noise?

1. Rattling
2. Popping
3. Squealing
4. Grinding

4-51. When a squealing or squeaking noise occurs in a hydraulic system, it is usually caused by which of the following conditions?

1. Wiped bearings
2. Air pocket in the cylinder
3. Overtight packing around moving parts
4. Overloaded system during high-speed operation

4-52. What should you, as an Engineman, do upon discovering a faulty operation of a circuit breaker of a hydraulic system?

1. Repair the circuit breaker
2. Check for excessive binding in the electric motor
3. Replace any damaged equipment in the plant
4. Report the condition to the Electrician's Mate

4-53. If a hydraulic system is left to idle for a long period of time, which of the following difficulties might you expect to develop?

1. Misalignment of linkage
2. Accumulation of sludge
3. External leakage
4. Internal leakage

4-54. What is the purpose of securing a hydraulic system for 1 hour after filling it with clean oil?

1. To permit the settling of foreign matter
2. To dissolve the sludge
3. To permit the venting of air
4. To dissolve corrosive deposits

4-55. Which of the following actions is a part of the procedure for cleaning a hydraulic system?

1. Allow the system to remain idle for 15 minutes after operating it with a light load for 4 minutes
2. Operate the system for 1 hour while it is filled with cleaning fluid
3. Operate the system at high pressure while it is filled with cleaning fluid
4. Dilute the old hydraulic oil with cleaning fluid and operate the system for 15 minutes, then allow the system to remain idle for about 5 minutes

4-56. You are replenishing the hydraulic system with oil. What strainer should you use with the oil?

1. A cheese cloth
2. An aluminum filter
3. A 200-mesh wire screen
4. A 400-mesh wire screen

4-57. If you are filling a hydraulic system and notice water in the oil, which of the following actions should you take?

1. Centrifuge the oil or reject it
2. Run the oil through a 180-mesh wire screen
3. Heat the oil to permit the water to evaporate
4. Allow the oil to stand until the water settles to the bottom

4-58. What material is used to form the shaft seal of most modern hydraulic pumps?

1. Rubber
2. Neoprene
3. Asbestos
4. Flax

4-59. Which of the following conditions can cause the packing of a shaft stuffing box to wear out quickly?

1. Hard packing
2. Rough shaft
3. Shaft deflection
4. Excessive packing

4-60. What is the main purpose of packing a shaft packing gland uniformly and lightly?

1. To allow for cooling and lubrication
2. To prevent scoring of the shaft
3. To prevent leakage of seawater
4. To prevent binding of the shaft

4-61. A routine inspection revealed a leak in the line of a hydraulic system at a flanged joint. If the leak persists after you have tightened the bolts evenly, what corrective action should you take next?

1. Replace the flange
2. Install new packing
3. Inspect the fluids for contaminants
4. Install square-braided asbestos packing

4-62. The relief valve in a hydraulic system leaks. What should you do to the valve seat?

1. Reface it
2. Replace it
3. Regrind it
4. Fit the valve with a seat insert

4-63. The selector switch on the conveyor is improperly set. Which of the following troubles is most likely to occur?

1. Conveyor will not start
2. Conveyor will not hoist
3. Conveyor will run continuously
4. Conveyor will not lower

4-64. The engine lathe in a machine shop should NOT be used for which of the following jobs?

1. Turning and boring
2. Facing and thread cutting
3. Drilling and grinding
4. Bending and shaping

4-65. In ships with a one lathe allowance, what is usually the size of the lathe?

1. 14 in.
2. 16 in.
3. 18 in.
4. 20 in.

4-66. When an engine lathe is used for milling, the workpiece is usually mounted on which of the following lathe parts?

1. Headstock
2. Tailstock spindle
3. Carriage
4. Faceplate

4-67. On an engine lathe, which of the following operations is usually performed with the carriage locked in position?

1. Turning
2. Facing
3. Boring
4. Drilling

4-68. Gears in the apron of an engine lathe are driven by which of the following lathe parts?

1. Control rod
2. Lead rod
3. Reverse rod
4. Feed rod

4-69. Which of the following cutter bits is sometimes ground flat on top so it may be fed in both directions?

1. Left-hand turning tool
2. Right-hand facing tool
3. Square-nosed parting tool
4. Round-nosed turning tool

4-70. What type of lathe chuck can be used to automatically center round workpieces of many sizes?

1. Scroll chuck
2. 4-jaw chuck
3. Standard collet chuck
4. Hexagonal collet chuck

4-71. A carriage stop may be used on an engine lathe to eliminate the need for which of the following actions?

1. Individual measurements of duplicate parts
2. Manually shutting off the automatic feed
3. Setup measurements made directly on the workpiece
4. Variable rates of feed across a workpiece

4-72. Which of the following lubricants is to be used for general machine work on brass or Monel rods?

1. Mineral lard oil
2. Turpentine
3. Soluble oil
4. White lead

4-73. What lathe accessory is used for mounting odd-shaped workpieces that cannot be turned between centers?

1. Mandrel
2. 3-jaw chuck
3. Collet chuck
4. Faceplate

4-74. A depth of cut of 0.040 inch reduces the diameter of a lathe workpiece by what measurement?

1. 0.020 in.
2. 0.040 in.
3. 0.080 in.
4. 0.120 in.

4-75. Shoulders are commonly located with a parting tool to eliminate the need for which of the following steps?

1. Using a pointed turning tool
2. Facing the shoulder
3. Cutting a fillet
4. Measuring during the rough turning