

NONRESIDENT TRAINING COURSE

September 1996



Machinist's Mate 1 & C (Surface)

NAVEDTRA 14150

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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.

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ERRATA #l 29 Jul 1999

Specific Instructions and Errata for
Nonresident Training Course

MACHINIST'S MATE 1&C (SURFACE)

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

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

3. Assignment Booklet

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

4-13

4-15

5-9

6-39

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: management programs; propulsion turbines; reduction gears; steam-driven generators; heat exchangers and air ejectors; pumps; distilling plants; refrigeration and air conditioning; auxiliary equipment; propulsion plant efficiency; quality assurance; record systems; boiler firesides and watersides; boiler fittings and instruments; and environmental policies and procedures.

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

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

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

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Published by
NAVAL EDUCATION AND TRAINING
PROFESSIONAL DEVELOPMENT
AND TECHNOLOGY CENTER

NAVSUP Logistics Tracking Number
0504-LP-026-8030

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."

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INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

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

SELECTING YOUR ANSWERS

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

SUBMITTING YOUR ASSIGNMENTS

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

Grading on the Internet: Advantages to Internet grading are:

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

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

https://courses.cnet.navy.mil

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

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

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

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

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

COMPLETION TIME

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

PASS/FAIL ASSIGNMENT PROCEDURES

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

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

COMPLETION CONFIRMATION

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

ERRATA

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

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

STUDENT FEEDBACK QUESTIONS

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

For subject matter questions:

E-mail: n314.products@cnet.navy.mil5
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N314
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

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

If you are a member of the Naval Reserve, you may earn retirement points for successfully completing this course, if authorized under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 12 points. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty,* BUPERSINST 1001.39, for more information about retirement points.)

Student Comments

Course Title: *Machinist's Mate 1 & C (Surface)*

NAVEDTRA: 14150 **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

MANAGEMENT PROGRAMS

This chapter deals with some of the information needed to administer the management programs used by engineering departments. Notice that only a few of the programs are covered here. For specific information you will need to consult the appropriate instructions and *Naval Ships' Technical Manual* chapters. Information on additional programs is contained in *Engineering Administration,* NAVEDTRA 12147.

MANAGEMENT PROGRAM ADMINISTRATION

There are management programs designed to cover many aspects of engineering. From electrical safety to lube oil quality, there is a management program that dictates who, what, when, where, and how. How a program is to be administered is spelled out in the appropriate instruction or manual. The effectiveness of a program depends upon quality personnel doing a quality job of administering that program.

To administer any management program effectively, you must be thoroughly versed in the instructions. You must also have the most current revision of these instructions to work from. Constant evaluation of both the personnel involved and the results will help you maintain the program effectiveness. Daily involvement in every aspect of these programs is necessary to maintain quality. Day-to-day maintenance of a program keeps you out of the "crisis management" mode. It is easier to keep up than to catch up on what should be on—going.

There are some programs that are annual, such as hearing conservation. However, you should review the records more often to help maintain continuity. One way to track these types of programs is to add them to the work center PQS charts.

BOILER WATER/FEEDWATER TEST AND TREATMENT PROGRAM

The Boiler Water/Feedwater program requires that you understand the importance of using quality feedwater. Using good quality feedwater will help prevent damage to the boiler watersides. You should know and appreciate the principles of the treatments that prevent scale corrosion and carryover.

The nature of feedwater depends on its history. Water is the universal solvent as it tends to dissolve everything it touches. Water can absorb gases such as ammonia oxygen, and carbon dioxide from the air. The type and amount of dissolved and suspended solids and the dissolved gases in the water influence water chemistry.

With the high steam generation rates of modem naval boilers, control of contaminants entering the boiler is critical. The chemical composition of water changes as a boiler is steamed. The level of contamination builds up. Boilers are known as trash cans, everything that enters stays. At 50 percent steaming rate, the contamination will increase tenfold per hour. At this rate, a boiler with chloride at 0.01 epm will increase to 0.1 epm in 1 hour.

Hardness in feedwater contributes to scale buildup in boilers. Hardness is caused primarily by calcium and magnesium. Scale deposits act as insulators in the boiler. Scale reduces heat transfer through the boiler tube. Scale deposits will cause the temperature of the metal to increase to the point of becoming plastic. Overheating, blistering, and failure may occur. Naval boilers can tolerate only a few thousandths of an inch of scale deposits without suffering tube ruptures.

Chloride is an aggressive ion. The chloride ion attacks and inhibits the formation of the magnetite layer on the boiler metal. Chloride is present in seawater, the major source of distillation. Chloride causes pitting action in boilers and also can cause stress corrosion cracking of stainless-steel superheater tubes.

Dissolved oxygen causes localized corrosion and pitting. Dissolved oxygen is absorbed into the water when in contact with air. As dissolved oxygen contacts the boiler metal it forms an anode. The anode dissolves the metal to forma black iron oxide that covers the pit. You can see active oxygen attack in the boiler by the presence of these scabs.

PURPOSE AND GOALS

The Navy uses two types of boiler water treatments. The older treatment method is the coordinated phosphate (Cophos) treatment. The newer treatment method is the CHELANT treatment. Both treatments work to protect the boiler metal from damage caused by contaminants. However, they work in much differing fashions.

Coordinated Phosphate Control

The boiler is a receiver for all contaminants the feedwater system puts into it. One way to prevent these contaminants from damaging the boiler is to precipitate them into a sludge. The Cophos system does this in the following ways:

1. Preventing the formation of scale by maintaining a phosphate residual in alkaline water sufficient to precipitate calcium and magnesium as sludge. These sludges are less likely to adhere to boiler metal than scale.
2. Keeping the boiler water alkaline to stop acid attack on boiler watersides.
3. Maintaining the proper relationship of Ph and phosphate to prevent caustic corrosion.
4. Maintaining dissolved and suspended solids sufficiently low to prevent carryover.

You can see that the relationships between the chemicals used is important. Sludge is formed when the relationship is correct. The sludge is removed by bottom blowdown. Bottom blowdown also keeps the dissolved and suspended solids low to prevent carryover.

The Navy uses three treatment chemicals to maintain the phosphate-pH relationship. The chemicals are trisodium phosphate (TSP), disodium phosphate (DSP), and caustic soda.

TSP is used to control pH and add some of the needed phosphates. If TSP was the only chemical used, then treatment would necessarily follow the Cophos curve. Adding disodium phosphate does not noticeably change the pH of the boiler water. Cophos allows for the assignment of a range, or box, to work with. As long as you stay within the box, you are protecting the boiler waterside. Use of TSP and DSP cannot force the boiler into the free caustic zone. Free caustic occurs when there is a pH rise above the Cophos curve. Caustic corrosion of boiler metal can occur in free caustic.

You use caustic soda as a treatment chemical only in casualty situations and only with the approval of the chief engineer. Inject caustic soda at the rate of 1 ounce per 1,000 gallons of boiler water and only when boiler is steaming. The boiler water must have a pH lower than the low limit and a phosphate level above the high limit.

Boilers using the Cophos treatment are designated as either type A or type B boilers. The rate of heat transfer determines this designation. Refer to figure 1-1 for type A boilers, and figure 1-2 for type B boilers. These charts illustrate the zones used in Cophos treatment. Type B boilers have a higher rate of heat transfer and, therefore, a lower tolerance to contamination. All 1200 psi and some 600 psi boilers are designated as type B. Note that type B boilers have lower treatment limits.

Further information on Cophos treatment of boiler water is contained in “Boiler Water/Feedwater Test and Treatment,” *NSTM*, chapter 220, volume 2.

CHELANT Boiler Water Treatment

The CHELANT system of boiler water treatment uses ethylene-diamine-tetraacetate trihydrate (EDTA) as a chelating agent. EDTA chelates dissolved metals, including calcium and magnesium, by surrounding and bonding to the metal at several places. The metal chelate remains soluble in water. But the metal is no longer available for other reactions such as bonding to boiler metal. Since the metals remain dissolved, they make no contribution to sludge formation. The metal chelates are removed from the boiler by continuous blowdown. Other dissolved metals from the feedwater system react with the EDTA. This reaction removes the dissolved metals from the feed system and further reduces sludge formation in the boiler.

CHELANT boiler water/feedwater treatment uses an automated treatment system to continuously inject treatment solution. The treatment solution is injected directly into the DFT. The treatment system is shown in figure 1-3. The treatment solution is prepared using trisodium EDTA, hydrazine, and TSP or DSP. TSP is used for boilers that operate at 700 psi or less. DSP is used for 1200 psi boilers. The treatment solution is automatically injected into the DFT at a rate proportional to feedwater flow. The system receives a signal from the feed flow transmitters to determine injection flow. Sodium phosphate is added to maintain a phosphate residual to protect against excessive contamination.

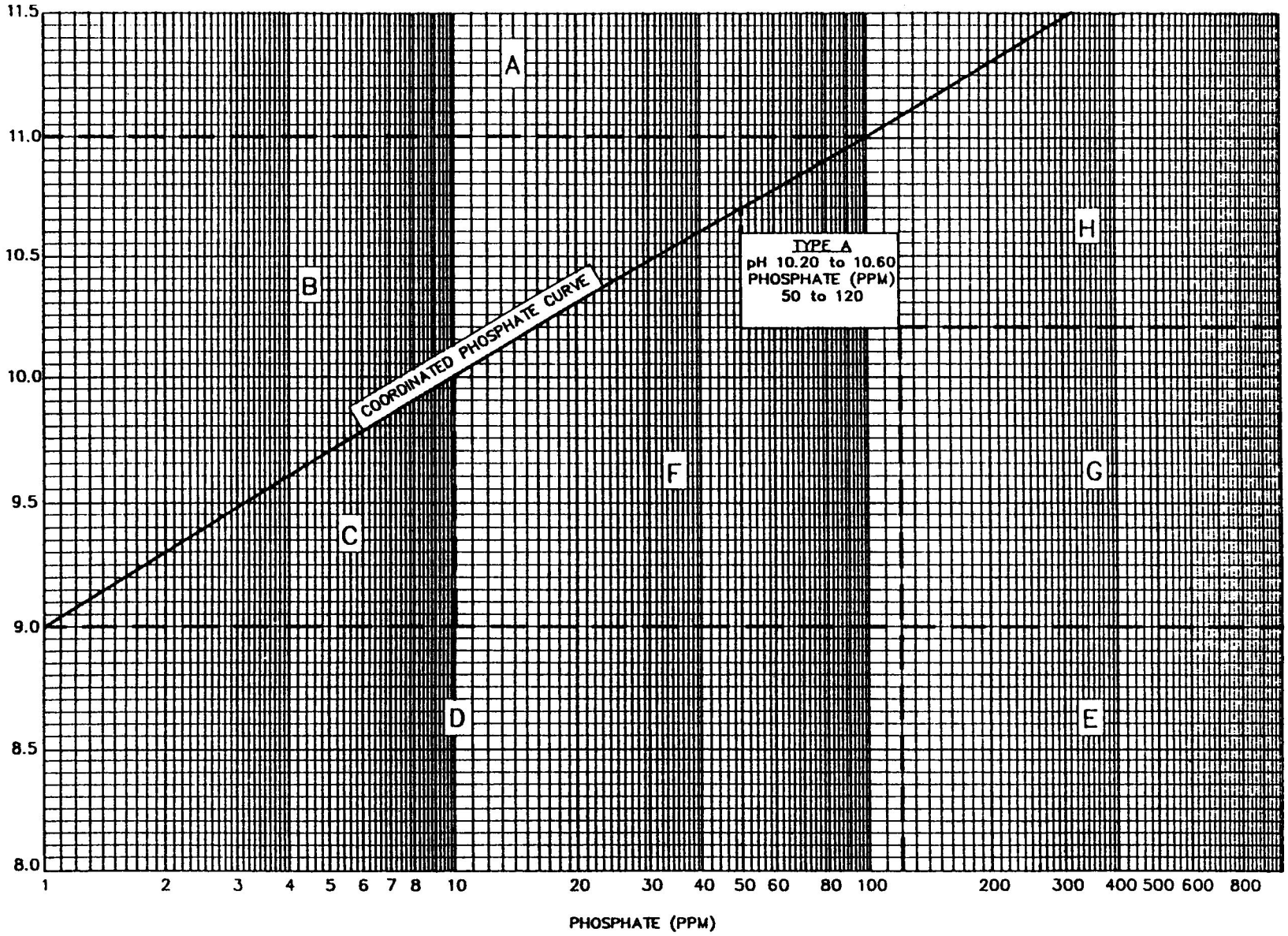


Figure 1-1.—Coordinated phosphate treatment zone chart for type A boilers.

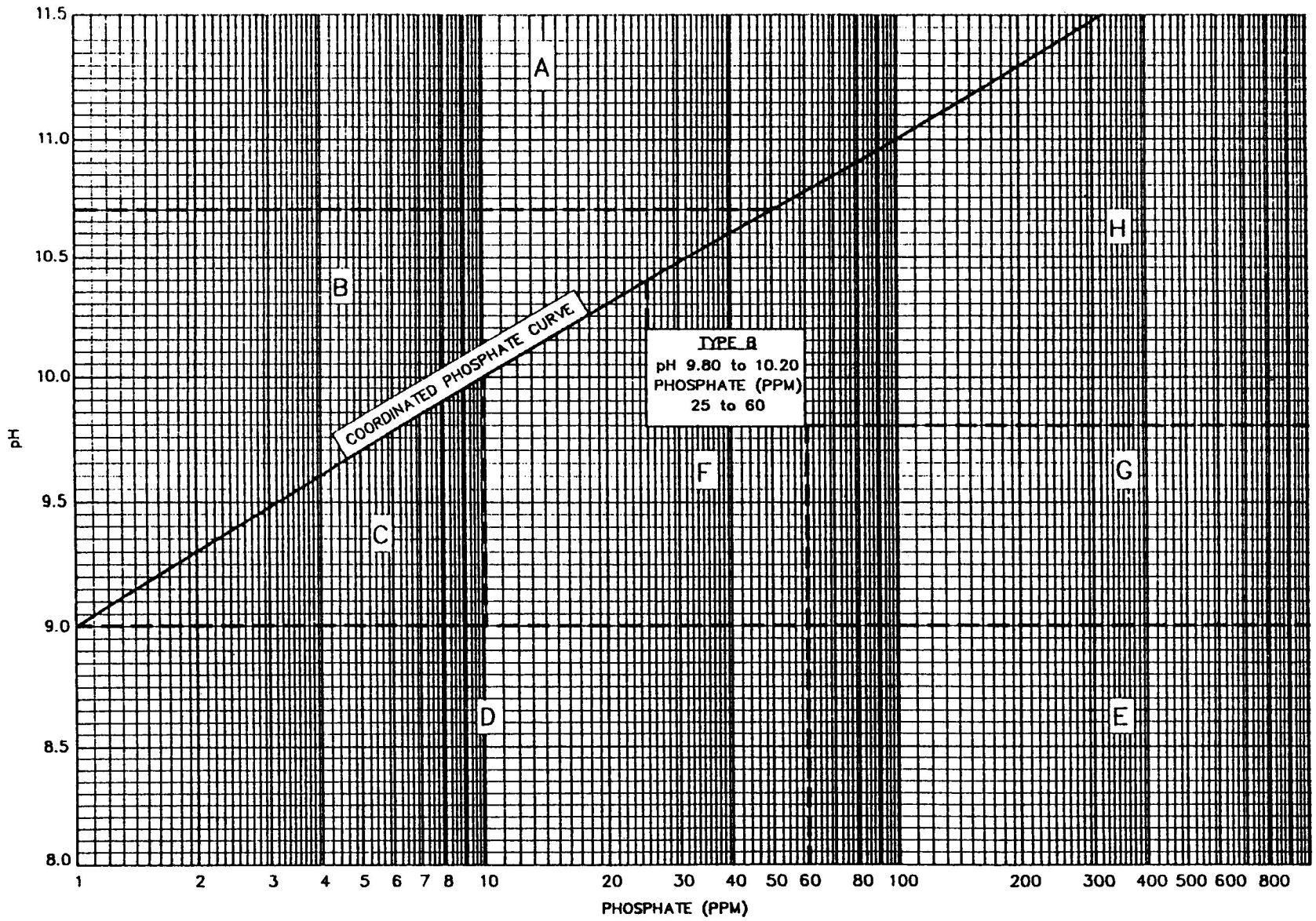
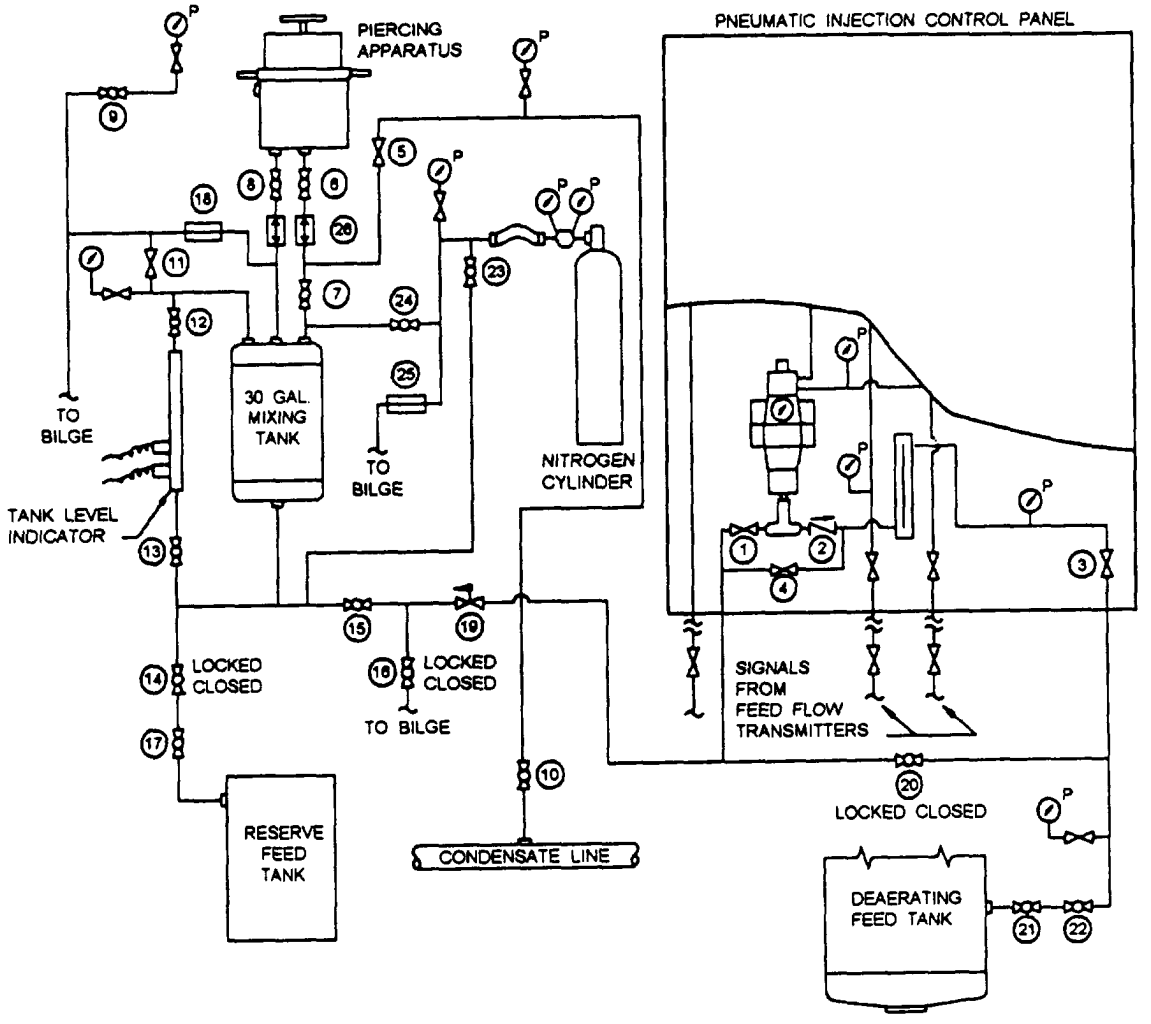


Figure 1-2.—Coordinated phosphate treatment zone chart for type B boilers.



1. Automated control cutout valve
2. Control panel check valve
3. Treatment cutout valve
4. Automated control bypass valve
5. Condensate flush/fill local cutout valve
6. Piercing apparatus condensate flushing cutout valve
7. Mixing tank fill cutout valve
8. Piercing apparatus drain cutout valve to mixing tank
9. Piercing apparatus vent cutout valve
10. Condensate flush/fill root valve
11. Mixing tank vent cutout valve
12. Tank level indicator cutout valve
13. Tank level indicator drain cutout valve
14. Hydrazine supply for boiler layup cutout valve
15. Hydrazine supply to control panel cutout valve
16. Hydrazine injection system drain cutout valve
17. Hydrazine supply to reserve feedwater cutout valve
18. Mixing tank relief valve (set at 100 psig)
19. Solenoid valve (closes at 2 gallon level)
20. Hydrazine supply to control panel bypass valve
21. Hydrazine supply to deaerating feed tank cutout valve
22. Hydrazine supply to deaerating feed tank cutout valve
23. Nitrogen chemical mixing cutout valve
24. Nitrogen supply to mixing tank cutout valve
25. Nitrogen relief valve (set at 100 psi)
26. Sight flows

Figure 1-3.-Continuous automated boiler feed water treatment system.

Another important aspect of EDTA is that it gencrates a protective magnetite film on steel surfaces at boiler operating temperatures. The protective layer forms in place and helps prevent corrosion of the base metal. Unlike Cophos treatment, where magnetite forms primarily as a result of temperature, EDTA participates directly in the rapid formation of a continuous magnetite layer. As previously stated, the magnetite layer provides excellent protection to the base metal. Since the magnetite layer is being continuously formed, you have more flexibility in the area of corrosion control. Therefore, it is not required that the pH and phosphate be maintained in the coordinated region.

CHELANT treatment does not maintain the boiler water parameters under the Cophos curve. Phosphate

levels required to maintain boiler water parameters under the tune cannot be used with CHELANT treatment. At the phosphate levels used in Cophos, the scale formers would react with the phosphate instead of the EDTA. The sludge formed would cause waterside deposits and eventually require waterside cleaning. Therefore, you maintain a low phosphate level. Due to the enhanced magnetite layer formed by the EDTA, caustic corrosion does not occur at normal treatment levels. Caustic corrosion may still occur if boiler water alkalinity becomes excessive. You control high levels of alkalinity by blowdown.

Coupled with the continuous injection of treatment solution is a continuous blowdown. The continuous blowdown is accomplished using a low, controlled flow of boiler water through the sample cooler to the bilge. Continuous blowdown amounts to about a 4 percent blowdown daily at normal boiler loads. Feedwater losses, due to continuous blowdown, are about equivalent to losses under Cophos treatment. Continuous blowdown also reduces the levels of dissolved solids. Some suspended solids are removed by the continuous blowdown, while others are removed by bottom blowdown.

Initial treatment with the CHELANT system is achieved by batch treatment. Batch treatment also is used during periods of contamination. EDTA and hydrazine are not injected during batch treatment. Batch treatment chemicals are TSP, DSP, and caustic soda.

Another advantage of using the CHELANT treatment system is the reduced testing requirements when the conductivity system is installed. The boiler is tested as often as required to maintain limits, but must not exceed 24 hours. Without the conductivity system, testing reverts to the 8 hour maximum.

Boiler water conditions are determined by sampling and testing for alkalinity, phosphate, conductivity, and chloride. Note that the pH meter test is not used for the CHELANT treatment systems.

For more information on the CHELANT treatment system, you should refer to "Boiler Water/Feedwater Test and Treatment," *NSTM,* chapter 220, volume 2.

LOGS AND RECORDS

The importance of the data on the boiler water chemistry logs must never be underestimated. You will use this data to recommend treatment action and to measure performance, efficiency, and the state of readiness of the engineering plant. Reviewing these logs and records will aid you in making decisions about the water chemistry program.

Review

Daily review of boiler water/feedwater chemistry logs and records involves several people. The oil king maintains the logs and ensures their accuracy. The leading chief supervises the log maintenance and reviews the records daily.

The leading chief should read the logs thoroughly. This first review should reveal any problems overlooked by the oil king. The leading chief should verify that any reading that is out-of-limits has been thoroughly explained in the Remarks section of the log. You should note any reading that is not consistent with the other readings. Watch carefully for an unusual change in chemistry that may indicate a problem in the plant.

Logs and records must stand on their own merit. Describe fully any unusual conditions and record the action(s) taken. If you are unsure about commenting on a condition or reading, then enter a remark on the log. Insufficient comment hurts log integrity.

Review the logs and records as if you know nothing about the plant. Remember, your logs are subjected to many reviews and inspections.

Daily review of the logs and records shall be conducted by the main propulsion assistant (MPA) and the chief engineer. The chief engineer is responsible for the decisions regarding boiler water/feedwater chemistry. The engineering officer of the watch (EOOW) shall be cognizant of the logs and initial all boiler water tests and out-of-limits readings on the feedwater logs. The commanding officer (CO) reviews the monthly water treatment log package.

There are several entries required to be made on the logs, These required entries are listed in *NSTM,* chapter 220, volume 2.

Rough and Smooth Records

Each time data is transferred from one piece of paper to another, the likelihood of error exists. Any practice that increases the number of times data is transferred is prohibited. This rule includes keeping rough logs and then preparing smooth logs for filing. The person who records the data should record it on the proper log only. No erasure is allowed on the boiler

water chemistry worksheet/log or the feedwater worksheet/log. You make corrections only by lining out and initialing the error. Then you enter the correct data.

The oil king who performs the analysis must maintain the logs. You may maintain a record of the data in another area such as main engine control, for convenience. However, the boiler water chemistry and feedwater worksheet/logs submitted in the monthly package must be those maintained by the oil king.

LABORATORY CONDITION

The oil shack is essentially a shipboard laboratory. Since space is usually limited, it is important that the laboratory and equipment be maintained clean and neat. You must remove all material not needed for proper operation of the oil lab, The material condition of the lab and equipment should be as follows:

- Laboratory environment will be clean, orderly, well lighted, ventilated, and heated or cooled as appropriate. Temperature of the laboratory should be maintained below 100°F.
- Test cabinet and electrical equipment should have operable lighting, approved wiring, and three-pronged plugs with electrical safety tags.
- Test cabinet interior and exterior should be clean and well preserved. Latch and door should be functional. Contents shall be stowed neatly and the cabinet interior base must be lined with paper towels or a clean rubber sheet.
- Glassware and plastic ware shall be clean and free of nicks and chips.
- Buret stopcocks must be clean, well lubricated, and held in place with rubber washers.
- Stock solutions, reagents, and indicator bottle caps should be easily operable and clear of deposits.
- Outdated chemicals should be removed from the laboratory and disposed of properly
- Chemical disposal procedures should be readily available.
- All containers must be properly labeled.
- A workbook with all procedures for tests and procedures (protected by plastic covers and maintained current) is recommended.
- The boiler water treatment volume must be posted on the exterior of the cabinet and referenced from *NSTM*, chapter 220, volume 2.
- All required reference materials shall be maintained current and in the oil laboratory.

This is not a complete listing of the requirements of an oil laboratory. It is meant to give you an idea of the many requirements involved in maintaining the oil lab.

FUEL AND LUBE OIL MANAGEMENT PROGRAMS

An effective fuel oil management program provides clean, quality fuel for boiler use. The goal of the lube oil quality management program is to prevent damage to main and auxiliary machinery by providing clean, quality lube oil. Another goal of these programs is to allow tracking of the amounts of fuel and lube oil on board and expended.

TESTING

The primary fuel tests are visual, bottom sediment and water (BS&W), flash point, and API gravity. There are other tests for use when you receive fuel from non-Navy sources. The most common fuel tests are the visual and BS&W.

Fuel often contains water and insoluble impurities. These materials are objectional because of possible nozzle blockage and poor fuel combustion. Water is slightly soluble in fuel. Only water in mechanical suspension is of concern to the engineer. The suspended water is referred to as “free water.” Water and sediment are expressed as a single percentage by combined volume. However, it is more accurate to record them separately.

The visual test is the most common test for lube oil. The other onboard test is the BS&W test. The BS&W test is used when the visual test cannot determine if there is contamination, such as in a cloudy sample, or if contamination is suspected.

The visual test must meet the clear and bright criteria. Clear refers to the lack of particulate matter in the sample. Particulate matter cannot cover more than one quarter of the bottom of the sample bottle. The bright criteria refers to the lack of free water in the sample. Entrained water can dull the lube oil sample. If the sample is dull, try to read a PMS card through the sample. If you can read the PMS card, it

passes this test. If it does not pass the visual test, you need to run a BS&W test. Be careful of entrained air that may dull the sample. If you are unsure whether air or water is the cause of the dullness, let the sample settle a few minutes. Air will clear to the top of the sample, water will settle to the bottom.

Sample operating machinery as required. Maintain the lube oil samples in a rack designated for that purpose. The latest sample should be compared to the reference sample. The reference sample is the sample of the oil when it was last renewed.

The Navy Oil Analysis Program (NOAP) provides spectrometric analysis of lube oil at a designated laboratory. This program detects accelerated wear in the machinery long before any trouble is indicated. Lube oil samples are submitted to the laboratory on designated machinery at specified periods. The ship is notified of the test results and any recommended action(s). The ship must maintain accurate records of operating hours, oil changes, and repairs on the NOAP designated equipment.

The procedures for testing fuel oil are found in *NSTM,* chapter 541. The test procedures for testing lube oil are found in *NSTM,* chapter 262.

LOGS

The logs used in fuel and lube oil testing are locally prepared. The logs have spaces for entering the time of the samples, the types of tests, and the results of the tests. When test results exceed the required parameters, a notation should be made about the action taken to correct the problem. Any time a sample fails testing, the EOOW and chief engineer should be notified and appropriate corrective action initiated.

REFUELING

During ship refueling operations, the oil king has many responsibilities. The major responsibilities are as follows:

- Organizing fueling details
- Checking equipment
- Assigning and training personnel for fueling stations
- Supervising personnel
- Making preliminary preparation and alignment checks
- Computing the amount of oil received or discharged

Refueling a ship is a big job. It requires skill, knowledge, and leadership. Experience plays a large role in a smooth refueling operation. The sections that follow contain a few tips and guidelines that maybe of help when you are the oil king.

Organization

As oil king, you will be an integral part of the fueling organization on your ship. Find out what your duties and responsibilities are. You should know who you report to, what you report, and when you report it. Know the level of knowledge and experience of the personnel assigned to you. You need to know what to expect from your personnel.

Equipment

When you are assigned as the ship's oil king, there are several things you should do. You need to check all the equipment used for receiving, transferring, and discharging fuel. Learn where the equipment is located. Verify the operation, use, and maintenance of the equipment. Verify the EOSS and enforce its use.

Check the equipment at all fueling stations before each fueling operation. Test the IC phone circuits. You need to be sure that all gauges and thermometers are calibrated, if needed.

Inventory the equipment needed for each fueling station and be sure it is ready to go. Store equipment for topside fueling stations in a secure location near the fueling rigs. Make sure you have spares and repair parts for your equipment.

Personnel and Training

As oil king, you are responsible for assigning personnel to fueling stations and ensuring they are properly trained. All personnel assigned to fueling stations must be qualified and experienced.

A basic requirement of fueling station personnel is a thorough knowledge of the fuel receiving system. You can train personnel by requiring individuals to trace the fueling systems. PQS and EOSS are good training aids.

Assigning new personnel to fueling stations under the instruction of a more experienced person is a good way to give them experience and training.

Most problems, such as oil spills, can be prevented with a constant and effective training program. You must enforce consistent use of proper operational procedures. The training program you develop must include all personnel in the fueling detail.

Computing Amount Received

The first number an oil king needs to know, when computing the amount of fuel received, is how much fuel was aboard at the start of the fueling operation. You should take soundings on every tank just before the start of refueling.

When fuel is coming aboard, the oil king must keep a constant check on all tanks being filled. Use a systematic procedure for checking the progress of tank filling. Using this procedure will allow all tanks to be filled without loss of time. This procedure also allows the oil king to figure the amount of fuel being received per minute. With this information you can give accurate estimates for stop pumping stand-bys.

Tanks should be filled only to the 95 percent mark. The final level of a tank should not exceed 95 percent. Inport refueling regulations may not allow you to fill to the 95 percent level, so check the local regulations.

The final soundings, after temperature and gravity corrections, will determine the amount of fuel received. The corrections for temperature and gravity are necessary because of the expansion of fuel at different temperatures. Measure the volume and gravity at a standard temperature of 60°F.

The procedures for making the temperature and gravity corrections and for using connection tables are given in *NSTM*, chapter 541.

Stability

The ship's refueling bill should specify the correct order in which tanks are to be filled. The fueling bill also should specify the order in which storage tanks are used to replenish service tanks. The specific order of refueling is necessary to maintain the ship's stability. You can find this information in the Ship's Information Book (SIB)

The ship's oil king cannot transfer liquid around on a whim. When liquid is shifted, it affects the list arid trim of the ship. The oil king must work closely with damage control personnel, making sure that Damage Control Central (DCC) always has accurate and complete information on the distribution of liquid.

Some knowledge of stability problems is required of the oil king. During an accident, the oil king may need to move liquid around to help improve stability. The DCC has the responsibility of making the final decision on transferring liquid.

Ballasting and Deballasting

Most ships in service have systems for ballasting and deballasting tanks. The ballasting system allows controlled flooding of designated fuel tanks for stability control. Seawater is used for ballast. You can ballast the tanks directly from the firemain system on most ships. Make sure EOSS is used and all safety procedures followed during ballasting and deballasting operations,

Admit ballast water only to the tanks designated for ballasting. Ensure tanks are stripped of all fuel before ballasting. Normally, these tanks are stripped to contaminated fuel tanks. After water ballast has been used in any tank, ensure the tank is free of as much water as possible before refilling it with fuel. After refueling a tank, further stripping may be necessary before use.

Ballasting and deballasting is performed following sequence tables furnished with each ship class. When ballasting or deballasting, you should ensure that all oil pollution regulations are followed. Consult OPNAVINST 5090.1 before pumping contaminated fuel off the ship.

Tank Inspections

Periodically, all tanks will require inspection. Storage tanks are normally cleaned and inspected during regular overhauls or ship repair availabilities. Service tanks are inspected more frequently according to PMS. Newer ships require inspection of one service tank per fireroom every 36 months. For older ships the interval is 18 months.

Before entering a fuel tank, you should take several precautions. The primary precaution is to have the ship's gas free engineer verify that the tank is safe to enter. You should never enter a tank alone. You must have someone standing by at the tank entrance. The tank should be well ventilated. You cannot perform hot work in a fuel tank without approval. Consult

OPNAVINST 5100.19 for additional safety precautions.

While in the tank, you need to look at material condition, structural integrity, and cleanliness of the tank. You should make note of other items for your own information. You should note the suction and stripping pipe level, and if the sounding tube is clear. The fuel heating systems on most ships have been removed or deactivated. Note whether the heating system piping is in place or capped off. Make note of anything that does not appear normal. Last, document everything you found, or learned, in the tank.

ELECTRICAL SAFETY PROGRAM

Until now, we have discussed only the programs most related to the MM rating. However, electrical safety is an all hands effort. When you reported aboard your ship, you should have been given an electrical safety program indoctrination. You should be given electrical safety training at least annually thereafter.

Most people have a healthy respect for the 440 volts the generators put out. However, few people really respect the 110 volts that most equipment uses. This lack of respect for 110 volts is what gets most people hurt, or even killed. Shipboard electricity is not the same as the electricity in your home. Sure, it is the same voltage and still uses wiring to carry it. The similarity ends there. Leave electrical repairs to the EMs.

Most MMs come in contact with portable electric power tools. You should be sure that portable electric power tools are clean, properly maintained, and in good operating condition. When you receive a power tool from electric tool issue, look it over. Is the power cord frayed or are bare wires showing? Is the plug in good condition, and does it have three prongs? Is the electrical safety tag up to date? Are there any obvious breaks in the housing? If any of these defects are present, return it to tool issue immediately.

There are certain rules for use of portable electric power tools. Most are common sense, but take a minute to review them. Never use power tools in or around water. When you use an extension cord, hook it to the tool before plugging it into the power source/outlet. Arrange the power cords so no one will trip over them. Never use jury-rigged extension cords, The extension cord should not exceed 25 feet in length. Do not unplug cords by yanking on the cord. Unplug the extension cord from the receptacle before unplugging the power tool. Rubber gloves are required when using a power tool. Eye protection is required also. Hearing protection is required if the tool produces hazardous noise. Better safe than sorry is more than a slogan, it is a life saver!

TAG-OUT PROGRAM

The tag-out program provides a procedure to prevent improper operation of equipment, components, or systems. The program is designed to protect equipment from damage and personnel from injury when maintenance or repairs are being affected. Tag-out also is used to prevent operation of equipment that is unsafe. The tag-out program also provides a procedure for use when an instrument is unreliable or not in normal operating condition.

The CO is responsible for the safety of the entire command. The CO is required to ensure that all personnel concerned know the applicable safety precautions and comply with the procedures of the tag-out program. Department heads are responsible for ensuring that personnel assigned understand and comply with the program.

When repairs are performed by a repair activity, there is a dual responsibility for the safety of personnel. The tended ship is responsible for the tag-out and will control the tag-out system. The repair ship is responsible for ensuring that the ship is in compliance with the program. A representative of the repair ship will sign all tags involved with the repair work.

When a requirement for tag-out has been identified, the tag-out procedures shall be followed exactly. Use standard tag-out procedures for all corrective maintenance on all ships and for PMS.

The person who will perform the work will initiate the tag-out. Use ship's prints and EOSS to determine the number of tags needed. As a minimum, all electrical systems require two tags to isolate the component. Use enough tags to assure complete isolation.

Never violate the tag-out system. To test a piece of repaired equipment, the tags must be cleared. If further work is needed, the equipment will need to be tagged out again.

If you are unsure of the actual position of a tagged valve, you may test it by turning it towards the closed position. Testing must be conducted by two individuals and only when authorized by the OOD or EOOW. The specific department head, if available, must be notified of this check.

All outstanding record sheets are audited on a regular basis, but no less often than every 2 weeks. Any discrepancy will be noted, with its corrective action, on the record sheet. Report the discrepancy to the cognizant duty officer. The conduct of the record sheets audit shall be noted on the index/audit record sheet. Specific procedures for tag-outs are contained in OPNAVINST 3120.32.

HEAT STRESS

Heat stress has been encountered in the engineering spaces aboard U.S. Navy ships. Reports by the president of the Board of Inspection and Survey (INSURV) have continued to identify conditions of unwarranted, excessively high heat stress and humidity in ships' engineering spaces. The primary causes of heat stress in these spaces has been:

- Excessive steam and water leaks
- Missing, damaged, improperly installed, or deteriorated thermal insulation on steam piping, valves, and machinery
- Ventilation system deficiencies, including design deficiencies, missing or damaged duct work, misdirected terminals, improper or clogged screens, closed or partially closed "Circle William" dampers, dirty ventilation ducting, and inoperative fan motors and controllers

Heat stress conditions within the engineering spaces can be improved by preventing heat stress-related deficiencies and identifying and systematically correcting deficiencies within the spaces. Prevention is accomplished by training personnel to properly perform corrective and preventive maintenance actions. The identification of deficiencies should be accomplished by a thorough examination of equipment and spaces by formal inspections and by walks through the spaces while on watch or during the work day. Assigned personnel should be trained to report deficiencies identified during operations or while on watch. Identified deficiencies should be systematically corrected. Correction of deficiencies should be planned and executed on a priority basis.

Heat stress control and personnel protection is predicated upon an effective monitoring program. Watch and work stations subjected to heat stress should have a permanent, hanging, alcohol in glass, dry-bulb thermometer installed. The thermometer should be mounted in such a manner that it will not be affected by adjacent or local heat sources. The temperature should be read and the temperature recorded at least once each watch period (normally 4 hours). Personnel should be trained to notify the EOOW if the dry-bulb temperature reaches or exceeds 100°F, all watch stations within the space should be monitored with a Wet Bulb Globe Temperature (WBGT) meter. As a result of WBGT meter monitoring, Physiological Heat Exposure Limits (PHELs) should be determined for each watch station. These limits are the maximum time that a healthy, well-rested person may work at the location without suffering heat injury. Watch standers should be informed of their PHELs. If any PHEL is less than the watch or work period the engineer officer should be notified and action taken to reduce the heat stress at the location and limit the individual's exposure. (Note that the engineer officer is responsible for notifying the CO.)

All personnel who work or stand watch in the fireroom shall be trained regarding heat stress upon reporting aboard and annually thereafter. Heat stress training shall include the following:

- Heat stress health hazards
- Heat stress symptoms
- Heat stress first aid procedures
- Heat stress monitoring
- Causes of heat stress

Heat stress training shall also include viewing the videotapes *Heat Stress Monster* or *If* You *Can't Stand the Heat.*

Further information and guidance on the Navy Heat Stress Control and Prevention Program may be found in OPNAVINST 5100.20. *Shipboard Heat Stress Control and Personnel Protection;* OPNAVINST 5100.19, *Navy Occupational Safety and Health Program Manual for Forces Afloat;* and NAVMED P-5010-3, *Manual of Naval Preventive Medicine,* Chapter 3, "Ventilation and Thermal Stress Ashore and Afloat."

TRAINING PROGRAM

By this point in your career, you are aware of the importance of continuous training. Training your personnel to operate and maintain their systems and equipment affects the operational readiness and performance of the entire command.

The basic features of an effective training program are compatibility, evaluation and instruction, and analysis and improvement. First, the training must be compatible with the mission of the unit and work within the framework and schedule of the unit. Second, the training program requires instruction of personnel and the evaluation of their individual progress. Each training lecture should be accompanied by a short test or quiz. Tests and quizzes will help you to determine the effectiveness of the training. You should be sure that the petty officers conducting the training are knowledgeable and have the practical skills needed to demonstrate and communicate the subject matter clearly. Last, analyze the training by observing group and individual performance. Correct any training deficiencies and make the needed improvements to have an effective training program.

The ship's organization should include provisions for training. The time to conduct the training should be standardized and regular. Training schedules are made out for 18-month periods. Make the quarterly training schedule from this schedule. GMTs and scheduled training exercises should be included on your training schedules.

Effective training depends upon the quality of the information and the presentation. Petty officers who write the training lectures must use the most current manuals and instructions. You should review the lectures for accuracy and content. The presenter should be motivated and dynamic, The lecture should be organized to flow smoothly. The more time devoted to effective training the easier your job becomes.

You should maintain records of each individual's training. A training folder should have sections for the different types of training, such as GMT or OJT. Keep your schedule of training updated. Stick to your training plan. You have accumulated a wealth of experience and knowledge, pass it on to your personnel. Remember, you are training the future of the Navy.

Information on training programs, duties of personnel involved in training, and scheduling training is contained in OPNAVINST 3120.32.

SUMMARY

In this chapter, we have discussed some of the Navy's management programs. There are many more programs involved. For more information on management programs consult *Engineering Administration,* NAVEDTRA 12147.

Staying on top of these programs can be a tough job. It requires a dedication that cannot be taught, However, this dedication can be learned.

CHAPTER 2

PROPULSION TURBINES

For a ship to answer bells and meet commitments, the turbines must be available for propulsion at all times. If propulsion equipment, including turbines, is to be ready at all times, it must receive the best of care in operation, maintenance, and repair.

This chapter presents selected information on the operation, maintenance, and repair of the most common types of main turbines; it is meant only as basic training. You should always use technical manuals and detailed drawings when you inspect and repair turbines. Whenever practical, follow manufacturer's recommendations on operation, methods of assembling, and fitting of parts. Carry out all periodic inspections and preventive maintenance according to the planned maintenance system and the applicable equipment technical manuals.

TURBINE DESCRIPTION

The turbines used in naval ships differ with respect to power level requirements, fuel economy, and the extent of operational capability when there is some turbine derangement. They have evolved to the point that they now maintain high turbine efficiency in cruising and full-power modes. The five major types of turbines used in naval ships are described below:

1. Type I (single-casing unit)—The Type I propulsion unit consists of one or more ahead elements, each contained in a separate casing and identified as a single-casing turbine. Each turbine delivers approximately equal power to a reduction gear.

2. Type II-A (straight-through unit)—The Type II-A propulsion unit is a two-element straight-through unit. It consists of two ahead elements: a high-pressure (HP) element and a low-pressure (LP) element. The HP and LP elements are contained in a separate casing and are commonly known as the HP and LP turbines, respectively. The turbines deliver power to a single shaft through a gear train and are coupled separately to the reduction gear. Steam is admitted to the HP turbine and flows straight through the turbine axially without bypassing any stages. (There is partial bypassing of the first row of blades at high power.) The steam is then exhausted to the LP turbine through a crossover pipe.

3. Type II-B (external bypass unit)—The Type II-B propulsion unit is similar to the Type II-A. The exception is a provision to bypass steam around the first stage or the first several stages of the HP turbine at powers above the most economical point of operation. Bypass valves are located in the HP turbine steam chest, with the nozzle control valves.

4. Type II-C (internal bypass unit)—The Type II-C is similar to the Type II-A. The exception is a provision to bypass steam from the first-stage shell around the next several (one or more) stages of the HP turbine at powers above the most economical point of operation. Bypass valves and steam connections are usually integral with the HP turbine casing. However, in some installations, the valves are separate and bolted directly to the casing, with suitable connecting piping between the first-stage shell and valve to the bypass belt.

5. Type III (series-parallel unit)—The Type III propulsion unit consists of three ahead elements, known as the HP element, intermediate pressure (IP) element, and LP element. The HP and IP elements are combined in a single casing and known as the HP-IP turbine. Steam is admitted to the HP-IP turbine and exhausted to the LP turbine through a crossover pipe. For powers up to the most economical point of operation, only the HP element receives inlet steam. The IP element is supplied in series with steam from the HP element exhaust. At powers above this point of operation, both elements receive inlet steam in a manner similar to that in a double-flow turbine. During ahead operation, no ahead blading is bypassed. Series-parallel units are being used on some of the more recent naval combatant vessels.

All of these types of turbines contain an astern element for emergency stopping, backing, and maneuvering. An astern element is located in each end of a double-flow LP turbine.

CONTROLS

As Machinist's Mates, we must be able to adjust the quantity of steam flow to control the turbine through its power range. A system of nozzle control valves performs this function. The nozzle control valve transfers steam from the turbine chest to the inlet area of the first-stage nozzles in the quantity required to produce the desired power level. The methods of controlling these valves differ on various turbines. One example is the cam and bar lift method (fig. 2-1), which controls speed by varying the number of nozzle valves that are opened. This arrangement consists of a horizontal bar with a series of vertically bored holes. one for each control-stem valve. The bar itself is supported and moved in a vertical plane by two lift rods. The nozzle valves, commonly known as poppets, hang on a button that rests on top of the valve seat. In the closed position, the valves are supported by their valve seats and held down by steam pressure. The valve stems are of varying lengths. Therefore, the valves are opened sequentially by the bar as it lifts. The shortest stem valve will lift first, then the longer ones. The bar is lowered by a spring return and closes the valves. The cam, usually connected to a remotely located throttle handwheel, raises and lowers the lifting bar as the throttle wheel is opened and closed.

OPERATION OF TURBINES

Each ship should have a detailed procedure for starting up the main propulsion turbines.

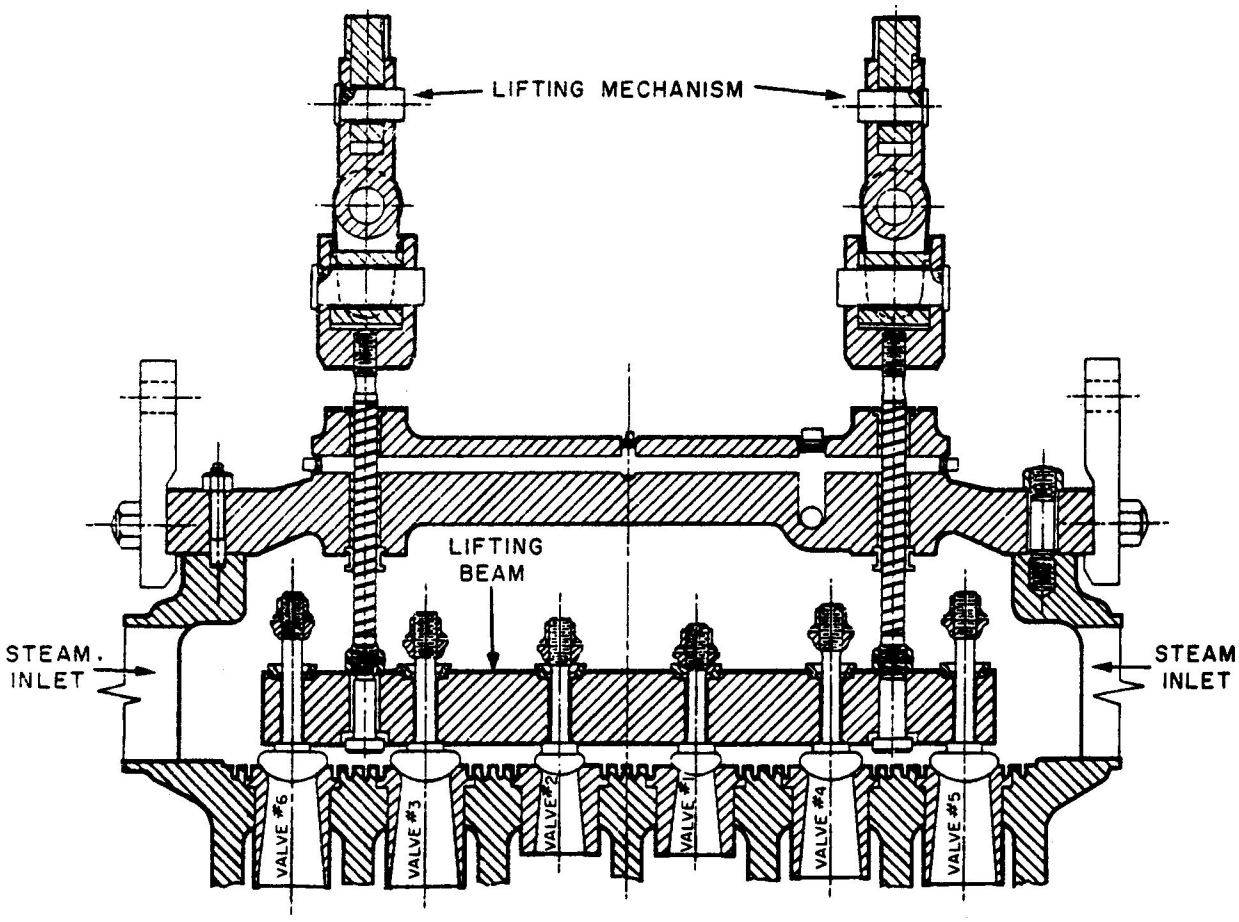


Figure 2-1.—Arrangement of nozzle control valves.

These procedures can be found in the manufacturer's technical manual and the engineering operational sequencing system (EOSS).

The simple fact that turbine materials expand when heated has an influence on the design. Since most of the clearances are specified in thousandths of an inch, warm-up of the turbine becomes critically important. Here are some of the most important procedures to be used for proper warm-up:

1. Heat the lube oil to a minimum of 90°F and establish the lubricating-oil system pressure.
2. Turn the turbine rotors with the turning gear until just before the steam is admitted to the turbine chest.
3. Maintain a reduced vacuum.
4. Spin the engine, alternately ahead and astern, every 2 minutes.

Follow these procedures and holding conditions for the times specified. In this way, turbine metal temperatures will be brought uniformly as close to operating temperature as heat sources (lube oil, gland seal steam, and small quantities of main steam) will allow. A start-up after an improper warm-up can cause any number of problems. Some of the most common are excessive thermal stress, rotor-to-casing rubs from differential expansions, or excessive vibration from a bowed rotor.

To minimize the amount of bowing at the rotors, keep turning them slowly during the warming or cooling of the turbines. You can use the turning gear or spin the rotors at slow speeds by alternately opening and closing the ahead and astern throttle valves. Usually, a combination of both methods is used.

To secure the turbines, close the throttle that admits main steam to the turbine; open the drains; and shut down the oil, gland, and vacuum systems. The equipment manuals and the EOSS explain the order in which these should be done and the amount of time various systems should be left in operation during cool-down periods.

LUBRICATION OF TURBINES

One of the more important factors in the operation and maintenance of main turbines is an adequate supply of lube oil having the correct physical and chemical qualities. The main lube-oil system provides a continuous supply of oil to the turbine and reduction gear bearings. It is provided. at the best temperature for proper lubrication of the bearings and to remove heat.

Under normal operating conditions, the temperature of the oil leaving the lube-oil cooler should be between 120°F and 130°F. The outlet temperature of the bearing should be between 140°F to 160°F but not greater than 180°F. The maximum temperature rise allowable in the bearing is 50°F, even though this maximum rise may result in a temperature less than the 180°F maximum.

Bearing temperatures are indicated by the temperature of oil flowing from the bearings. A thermometer fitted in each bearing as near as possible to the point from which the oil drains from the bearing shell registers the temperature of the oil.

The bearings and gears require a high-grade mineral oil (2190 TEP). The oil is kept free from water and impurities by the lube-oil purifier and the settling tank. To keep a continuous check on the condition of the lube oil, follow a routine procedure of taking oil samples. Test the lube oil at regular intervals as specified in PMS. To determine the neutralization number, flash point, viscosity, and other physical or chemical properties that govern the effectiveness of oil as a lubricant, submit a sample of lube oil to the U.S. Navy Petroleum Testing Laboratory. When operating the turbines, do not rotate them if they have a lube-oil temperature below 90°F. The lube-oil purifier should be operated at least 12 hours a day when the ship is underway.

You must stay on the alert for signs that equipment or systems are about to fail. Your sight and hearing, helped by reference to operating instruments and logged data, provide the normal means to evaluate the condition of the propulsion system. Investigate promptly any deviation from the normal. Prompt and proper action can usually confine a casualty to a specific piece of equipment or system.

Report any casualty to the supervising watch stander immediately. This ensures that the impact of the casualty on the system or the entire ship can be properly assessed and that appropriate action can be taken.

FAILURE OF LUBE-OIL SUPPLY

Loss of lubrication will have an almost immediate harmful effect on the turbine journal and thrust bearings. The lube oil takes away heat generated at the bearing and reduces friction between moving and stationary load-bearing surfaces. Therefore, reducing or stopping the oil flow causes rapid overheating, which will eventually cause the babbit to melt. The turbine bearings are among the most sensitive to overheating because of their high running speeds.

In many instances, loss of lube-oil pressure has been caused by improper operational procedures rather than by material failure. All concerned personnel must understand that even a momentary loss of lube-oil flow will cause localized overheating and probably slight warping of one or more bearings. You must thoroughly understand the precautions and procedures used to prevent low lube-oil pressure. You must also be trained in a sound casualty control procedure, in case this condition occurs.

A loss of lube-oil pressure maybe caused by a failure of the power supply to the main lube-oil pumps, either steam or electric. The lube-oil system may fail because it is clogged by rags, dirt, or other foreign matter. Lube-oil pressure may also be lost because piping or an operating pump failed or because a standby pump did not start .

The low-lube-oil alarm should be tested and adjusted as required to ensure that it will warn operating personnel of a low lube-oil pressure. To ensure that a failure of the lube-oil supply is handled properly, you should ensure all personnel are trained in the casualty procedures outlined in the engineering operating casualty control (EOCC) books.

HOT BEARINGS

During turbine operation, temperature is the sole criterion available to the operator for judging the conditions of individual bearings. Watch standers should monitor and log temperatures periodically. This ensures that any tendency of bearings to overheat can be detected early and appropriate action can be taken.

Bearing temperatures increase with speed and a change in speed. There is a normal temperature range over which the bearings operate. To ensure proper operation of the turbine bearings, you should establish a temperature-versus-speed standard for reference. The temperature of oil supplied to the bearings ranges between 120°F and 130°F, and comparisons should be made on the basis of equal inlet temperature.

If a bearing temperature increases above the normal running temperature, check the system oil pressure to ensure a normal value. Also check the temperature of the oil from the cooler to ensure that the oil temperature is in its normal operating range. Any bearing temperature increase above normal operating temperature is considered a hot bearing. You should begin casualty control procedures according to the EOCC book.

If the oil temperature through the bearing continues to rise, either to a maximum temperature rise from inlet to outlet of 50°F or to a maximum temperature on the outlet thermometer of 180°F, you have an uncontrollable hot bearing. Stop the propulsion shaft for further investigation.

ABNORMAL NOISE OR VIBRATION

Propulsion turbine rotors are precisely manufactured components. They are balanced to the degree that vibration is almost nonexistent. However, a moderate increase in the vibration level is expected because of the rotor's attachment to the driven unit and because of changes in operating temperatures.

Turbine rotors should not remain at rest for more than 5 minutes while steam, including gland seal steam, is being admitted to the turbines. Roll the turbine with turning gears before admitting steam to the turbine glands. Maintain a vacuum of 25 inches of mercury during warm-up to allow for even heat distribution.

Be sure the glands are properly sealed in order to maintain a vacuum on the turbine. Air leaking in along the shaft could cause distortion of the shaft and rotor. Take extreme care to warm up the turbine properly. Otherwise, serious damage may be done.

If the turbine is in operation and suddenly begins to vibrate abnormally, look for any one of the following problems:

- Water in the turbine
- Bearing failure
- Bent or broken propeller blades
- Unbalance because of broken or missing turbine blades
- Rubbing of blading labyrinth packing or oil seal rings
- Bowed rotor
- Excessive differential expansion between rotor and casing
- Loss of flexibility in coupling between turbine and reduction gear
- Change in alignment of turbine to reduction gear

If you hear a rumbling sound from the turbine when it begins to vibrate, the trouble is probably caused by water or foreign matter in the turbine. Water in the turbine casing maybe caused by either boiler priming or improper casing and steam line drainage. Immediately slow down the turbine until the abnormal vibration disappears. If the vibration still exists after you slow down the turbine, correct the boiler operation, check the casing and HP drains, shut down the turbine, and inspect the interior of the turbine at the earliest opportunity.

When bearing troubles occur, stop the turbine as soon as practical to prevent damage to the turbine blading. Inspect the bearings and replace or repair as necessary. Determine the cause of the trouble and take appropriate steps to prevent similar troubles from recurring.

Rubbing of shaft packing or oil seal rings will cause the shaft to overheat in the rubbing area because of friction. The shaft will start to show heating discoloration. When this happens, make an immediate inspection to determine the cause of the trouble. If defective bearings are found, replace them. A bowed rotor can be straightened by operating the turbine at low speeds. The shaft packing or oil seals may require refitting or renewal to give proper clearances.

When rubbing of turbine blading occurs, the cause will probably be a bowed rotor, a defective thrust bearing assembly, a wiped journal bearing, foreign material inside the casing, or differential expansion of the turbine rotor and casing. When a rubbing noise in a turbine is heard, stop the turbine immediately and determine the cause.

Foreign matter may enter a turbine casing through a defective steam strainer or because of improper protection of a turbine that has been opened for inspection or repair. When any part of a turbine has been opened, use the greatest care to prevent the entry of foreign matter. Never leave inspection plates off overnight or for any length of time unless the openings are well covered. Before reassembling a turbine after it has been opened, make a very careful examination of the rotor and the interior of the casing for any articles left behind. Make an examination before the rotor is lowered into place and another before the casing cover is lowered into place.

Another cause of vibration is bent or broken propeller blades. Normally, this condition is first indicated by excess vibration of the main shaft and by a lesser vibration in the main reduction gears. When these conditions exist, slow the main turbines until the noise and vibration stops or is within safe limits. Make an immediate inspection to determine the cause of vibration.

If vibration of the turbine is caused by bent or broken turbine blading, the turbine should not be used until effective repairs can be made by experienced personnel.

TURBINE MAINTENANCE

We must have maximum operational reliability and efficiency of steam propulsion turbines. This requires a carefully planned and executed program of inspections and preventive maintenance and strict adherence to prescribed operating instructions and safety precautions. Proper maintenance procedures usually prevent abnormal conditions.

The interior of main turbines should be inspected through available inspection openings. Table 2-1 lists maintenance items that should be inspected according to the planned maintenance system. Make the appropriate entries in the engineering log.

MEASUREMENTS AND ADJUSTMENTS

The satisfactory operation of a turbine depends, along with other factors, on the fixing of the proper radial and axial positions of the rotor. The radial position is maintained by the journal bearings, and the axial position by the thrust bearing.

A depth gauge micrometers the quickest means of detecting any change in the relief position of the rotor caused by bearing wear. Take the measurements at each turbine journal bearing without removing the bearing caps. The bearing caps have plugged openings for inserting the depth micrometers.

When a turbine is first installed, take a reading at each bearing with the depth micrometer. Log this reading for reference when you take future readings. Take the readings when the units are cold and the rotors are stationary. Always inspect bearings when the depth gauge shows that the clearances have reached the maximum values outlined in the manufacturer's technical manual and the planned maintenance system. When the bearing is opened for inspection; measure the outside diameter of the rotor journal and the inside diameter of the bearing to determine actual oil clearances. The difference between the old and new oil clearance readings will be the amount of bearing wear. The decision to replace the bearing should be based on these measurements and not on the depth gauge readings.

The axial position of a turbine rotor is maintained by means of a thrust bearing, usually a Kingsbury type. The installed rotor position indicator is a quick and constant means of checking the axial position of the rotor shaft.

Table 2-1.—Maintenance Items and Purpose

Item	Purpose
Verification of radial and axial position of the rotor by appropriate clearance measurements.	Avoid internal rubs that can make turbine inoperable.
A clean lube oil system and proper lubricant quality and quantity.	Avoid wiping of bearing, scoring of journals and thrust collar, and chemical attack on those and other critical surfaces.
Freedom of control and trip valve mechanisms.	Avoid slow action or hang-up of throttle or trip valves.
Check condition of oil deflectors and waste oil drains.	Avoid ingress of oil into steam system.
Check condition of water drains.	Avoid ingress of water into lubricating oil system, blade erosion, and water slugging.
Check condition of shaft and gland packing.	Avoid blowing steam into engine spaces or pulling air into turbine or condenser.
Check cleanliness of turbine internals.	Avoid ingress of foreign material through access openings or through connected piping, which restricts internal damage (mechanical or chemical).

One way to measure the thrust clearance is to jack the rotor fore and aft while taking readings on a dial indicator to show the total axial movement of the rotor. The thrust bearing must be completely assembled and the upper half of the bearing cap bolted in place while readings are taken. Attach a dial indicator to some fixed point, such as the bearing bracket. Arrange it so that the indicator spindle touches the shaft. Jack the rotor as far as possible in one direction. Make sure that the indicator spindle is just touching the shaft, and set the indicator dial at zero. Jack the rotor fore and aft at least three times, using the average of the readings to determine the thrust clearance. Exert just enough pressure to hold the rotor firmly against the thrust shoes in each direction. Avoid bumping the rotor too hard; this could cause false readings. Do not bar the rotor with the thrust shoes removed; the packing teeth or blade shrouds may be damaged from bumping.

Any large increase in the thrust clearance will allow the clearances between the rotating and stationary blading to decrease. If this problem continues, it will cause rubbing of the parts. When thrust clearance has increased to the maximum value, adjust the thrust to bring it back to its original designed clearance Use the taper gauge to check the clearance between the rotating and stationary blading of the high-pressure and low-pressure turbines.

TURBINE BEARING MAINTENANCE

When you open a bearing, inspect it carefully for ridges and scores. Take oil clearance readings to determine the amount of wear. Note whether or not the babbitt lining has remained anchored to the shell. If the bearing is slightly wiped, you can probably scrape it to a good bearing surface and restore it to service. In this case, the clearance readings of the reconditioned bearing on the originally designed value should be within tolerance.

THRUST BEARING REPAIR

When trouble occurs or is suspected in a thrust bearing, measure the oil clearance in the bearing before the bearing is disassembled. If the readings are beyond allowable tolerances, disassemble the bearing for inspection.

When it is necessary to disassemble a thrust bearing, make a careful inspection of all parts. If there is slight rusting of the collar surfaces, remove the rust with fine crocus cloth to assure that metal is not removed from the collar. The work should be done slowly and carefully by experienced personnel. Renew the shoes if wear exceeds allowable limits. When taking measurements of the shoes, consult the detailed drawings for the location and design value of such a measurement.

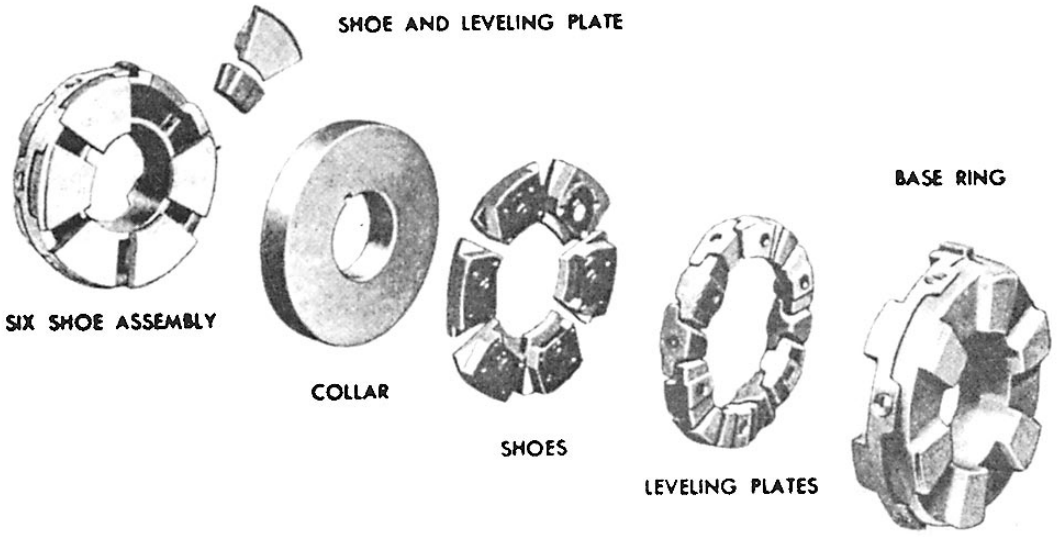
If damaged thrust shoes cannot be reconditioned by the ship's force, send them to a repair activity to be rebabbitted and machined. The radial edges of the shoes should be slightly rounded; otherwise, the sharp edges will tend to scrape the oil film off the thrust collar.

If a thrust collar is badly scored or if deep rust pits cause rapid wear and frequent replacement of shoes, the collar should be repaired. On some turbines, you can remove the thrust collar without lifting the casing and without disturbing the lower half of the forward journal bearing. Removal and installation procedures may be found in the applicable technical equipment manual.

When a thrust collar is to be remachined, the bore should be square with the faces. The faces should be machined flat and smooth, and the thickness should meet the required specifications as stipulated on the blueprint or in the manufacturer's technical manual. The marks left by machining or grinding must be removed by lapping.

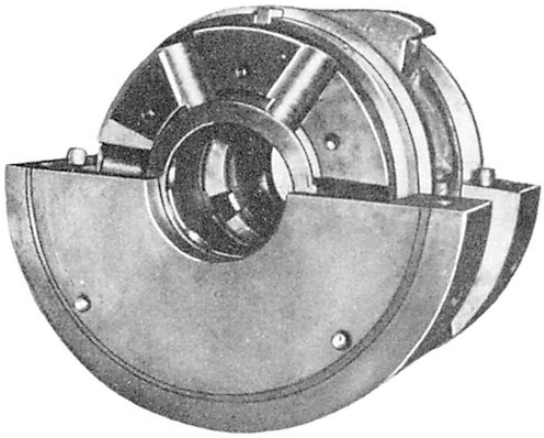
When the thrust bearing has been reassembled and the oil clearance taken, compute the thickness of the shim to be added. Take, for example, a thrust bearing that has the following clearance specifications: designed clearance 0.010 inch, maximum clearance 0.020 inch, and minimum clearance 0.007 inch. If you get a reading of 0.025 inch, install a shim of 0.015 inch. Never use more than one shim to obtain the proper oil clearance.

An exploded view of a (two-way) six-shoe thrust bearing is illustrated in figure 2-2. An assembled thrust bearing and a lower inner casing are shown in figure 2-3. For more technical information concerning thrust bearing



96.53

Figure 2-2.—Small double (two-way) six-shoe thrust bearing.



96.54

Figure 2-3.-Thrust bearing (assembled) and lower inner Casing.

repairs, consult your manufacturer's technical manual and NSTM, chapter 231, "Propulsion Turbines."

Journal Bearing Repair

Journal bearings need not be disassembled periodically for inspection. However, if a maintenance requirement card (MRC) action discloses an out-of-tolerance measurement or if an operational difficulty develops, disassembly and inspection may be necessary. When an inspection becomes necessary, make a detailed visual examination of the various bearing surfaces and take appropriate wear measurements.

Bearing wear would be almost eliminated under ideal conditions. However, some journal-to- bearing rubbing contact is made on each start. A properly installed bearing that has been in service for some time will usually display a worn or polished area centered in the lower half of the bearing.

Discoloration of bearing surfaces almost always indicates lubrication problems. The moisture in the oil and operation under high temperatures can produce a tin oxide coating on the bearings. The coating is very hard and builds up to reduce bearing clearance. Thin castings can normally be scraped off without exceeding oil clearances.

Bearings should be disassembled only with justification because of the dangers of improper reassembly. If disassembly is necessary, it is important that the work be done, or closely supervised, by qualified personnel.

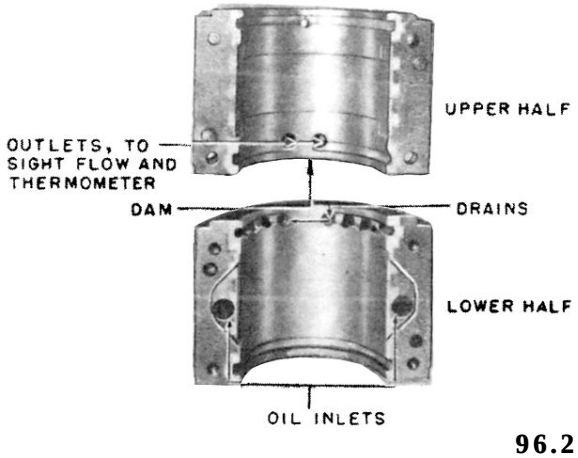
Replacement of Journal Bearings

When a bearing surface is scored, uneven, considerably worn, wiped, or burned out, or if

the metal is loose, it must be rebabbitted or replaced. The detailed procedure for replacing turbine bearings will vary somewhat for different sizes and types of turbines. For those types in which the upper and lower half of a bearing may be accidentally interchanged or the axial position reversed, take care to properly mark all parts while the bearing is being disassembled. A bearing improperly installed will not receive adequate lubrication. A typical turbine bearing is shown in figure 2-4.

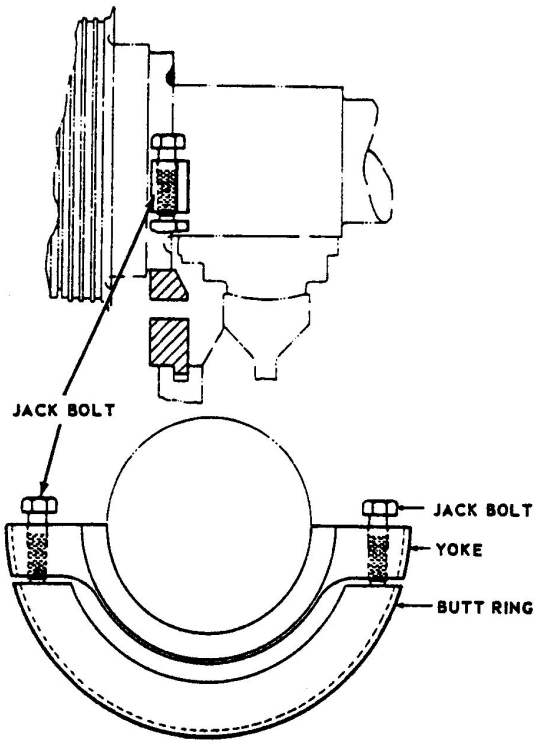
When you are getting a spare bearing ready for installation, clean and inspect it carefully. Bolt or clamp the two bearing halves together and measure the inside diameter of the bearing with an inside micrometer. The inside diameter of the bearing should equal the outside diameter of the journal plus the designed oil clearance. You can find the dimensions for a bearing in the manufacturer's technical manual or the applicable blueprints. Ensure that a bearing that has been rebabbitted complies with dimensional specifications. Thermal distortion from heating and cooling the bearing shells during rebabbitting often results in dimensional variations of the spherical contour.

After you remove the bearing cap and the upper half of the bearing, lift the weight of the rotor with a jacking device (fig. 2-5). Lift the rotor vertically about 0.005 inch, as determined by a dial indication reading. This permits the lower half of the bearing to be rolled out. Lifting the rotor too much will damage the shaft packing, and the



96.2

Figure 2-4.–A typical propulsion turbine Journal bearing.



96.3

Figure 2-5.–Special jack used to remove the lower half of a journal bearing.

bearing half might bind. Before removing the lower half of the bearing, ensure that the thermocouples are removed and the RTEs are disconnected (if applicable), When the lower half of the spare bearing is installed, remove the jack and reassemble the bearing. Then take a depth gauge reading to reestablish a constant.

When a defective bearing has been replaced by a spare, the old bearing should be rebabbitted as soon as possible if it is a reusable type. The usual procedure is to have a repair ship or shipyard rebabbitt and machine the bearing. The appropriate blueprints or manufacturer's technical manual will have to be furnished to the repair activity. These sources contain the necessary detailed information concerning the bearing dimensions.

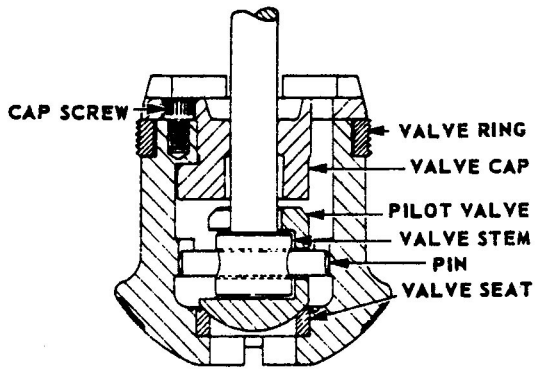
NOZZLE CONTROL VALVE REPAIR

The nozzle control valves for the main high-pressure turbines normally will operate for a long period of time without maintenance or repairs.

However, they are subjected to high steam pressures and temperatures, and in time they will require repairs.

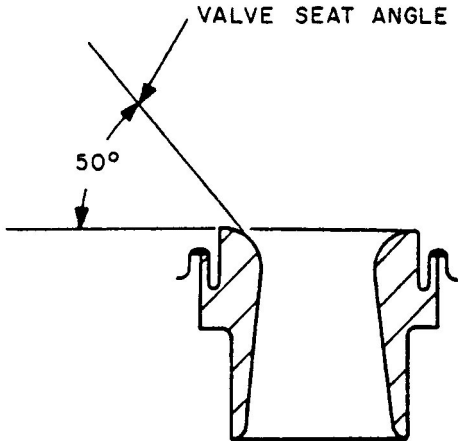
One of the more common troubles with nozzle control valves is the leakage of steam between the valve seat and disk. If leakage is suspected, visually inspect the contact area of each valve for steam cuts, pits, and erosion. Clean the contact area of the valve disk and its seat and then check by bluing each valve. If the valve disk does not make a good contact with its seat, do not use the valve disk to lap the seat. If you do, you will make a flat spot on both the valve and seat and destroy the spherical surface of the valve. Figure 2-6 shows an enlarged section of one type of nozzle control valve.

Most valve seats have flat, angular surfaces at the line of contact with the spherical surfaces of the valve disks. Resurface the valve seat using the following suggested method: Turn a cast-iron cone with an angle the same as the valve seat angle, as shown in figure 2-7. Leave a tip on the upper end of the cone. It can then be held in and turned by hand or driven by an air motor if consider-able metal is to be removed. With this cone and some grinding compound, you can re-surface the flat angle of the valve seat. Use a mechanical guide to keep the lap square with the seat and take care not to grind off any more metal than is necessary. The surface of the valve may not be spherical because of pits or wear. If so, place the valve in the lathe and polish it with emery cloth and



96.4

Figure 2-6.—Section of a nozzle control valve (pilot valve details).



96.6

Figure 2-7.—Valve seat angle.

oil until the surface is smooth and there is less than a 0.0005-inch runout. In this way the valve disk will maintain a spherical surface and seat tightly even if slightly out of line. Badly cut or damaged seats and disks should be replaced rather than reconditioned.

SHAFT PACKING

Because the main turbine rotor must penetrate and turn with respect to the casing and because internal pressures differ from atmospheric pressure, sealing is required to prevent leakage. Shaft packing in conjunction with the gland seal system keeps steam from leaking out of, or keeps air from leaking into, the turbine. The type used in modern propulsion turbine design is labyrinth packing.

Labyrinth packing rings may experience rubs during turbine operation. They are caused by a misalignment of the rotor and the condition of the packing. These rubs increase the packing clearance, which will cause some loss of turbine operating efficiency and economy. Therefore, packing clearances should be maintained within the minimum and maximums specified in the manufacturer's instruction book. This will ensure the best turbine performance.

Worn labyrinth packing should be replaced. However, if spare rings are not available, you can repair the packing by using a chisel

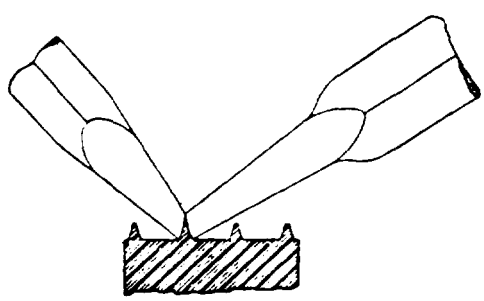
bar and a hand chisel as shown in figure 2-8. Place these tools as indicated in the figure. Strike the chisel with a hammer and then advance around the periphery of the packing a trifle less than the tool's width. Take care that each new position of the chisel overlaps the preceding position. This procedure increases the height of the tooth and draws it out to its original featheredge. Continue drawing out each tooth to give the packing clearance specified on manufacturer's drawings or in manufacturer's technical manuals.

GLAND SEAL SYSTEM

In the discussion of shaft packing, we pointed out that packing limits the steam or air flow to small quantities, but it does not cut off the flow completely. The gland seal system includes supply and leak-off sections. It provides the positive control required to keep steam from leaking out to the engine space and/or to keep air from leaking into the main condenser through the turbine casings.

The system can be, and usually is, automated by use of pressure-regulating valves. These valves hold supply pressure over a narrow pressure range; they use one valve to supply steam when pressure is below a set point and another valve to dump steam when pressure is above the set point.

The entire gland seal system, with the exception of the supply and dump valves, is nearly maintenance free. Maintain the supply and dump valves according to the manufacturer's technical manual.



96.43

Figure 2-8.–Restoring the height of labyrinth packing lands.

LIFTING THE TURBINE CASING AND ROTOR

Only a limited number of internal turbine parts can be inspected without lifting the turbine cover or breaking high-pressure joints. Two of the most common occasions for removing turbine covers are to inspect internals prior to overhaul and when operating conditions suggest internal damage. A request to lift a turbine cover must be for a cause other than accumulated time or operating hours.

Make a request to lift casings only when there is knowledge or strong suspicion of internal damage or hazards. Before you make such a request, first try all other means, such as inspections and diagnosis.

Regulation for Lifting Turbines

There are two situations that deal with lifting turbines. The first situation occurs when there is knowledge or suspicion of internal damage and a request to lift is made. In this case, you should get technical determination of the necessity to disassemble the casing directly from Naval Sea Systems Command (NAVSEA) or Naval Ships Systems Engineering Station (NAVSSES). Forward all correspondence regarding approval to disassemble to NAVSEA and NAVSSES for approval.

The second situation occurs 3 months prior to each regular overhaul. At that time, submit a report to the type commander concerning the condition of each propulsion turbine. Consult NSTM, chapter 231, for the information required in the report.

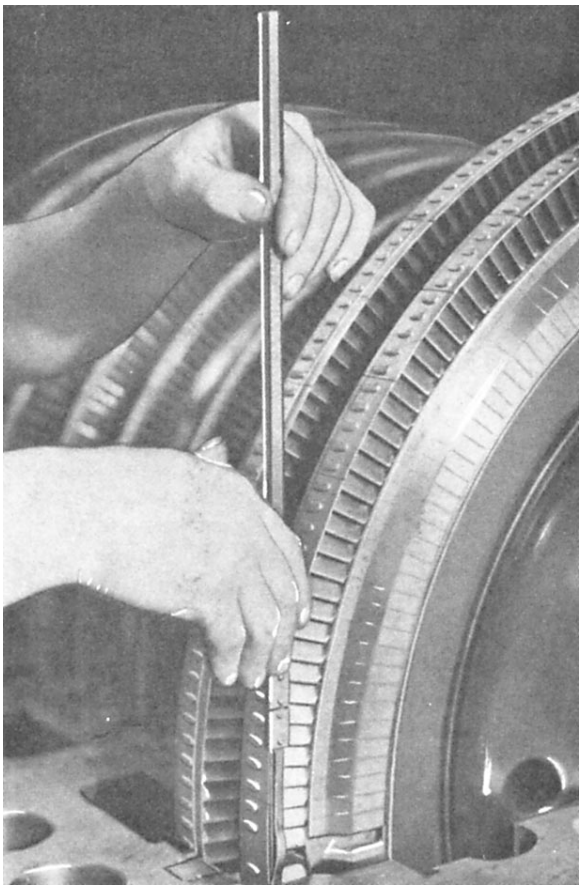
In both situations, direct recommendations to disassemble the turbine or to perform additional tasks or inspections to the type commander, who will make the final authorization to lift casings. The decision will be based on NAVSEA technical evaluations of the conditions reported, schedules, and funds available.

Lifting Casing and Rotor

Whenever turbine casings are lifted for any purpose, take advantage of the opportunity to observe the condition of all nozzles, blading, packing rings, and other internal parts. When practial, make such examinations when adequate facilities are available for necessary repairs that are beyond the capability of the ship's force.

Take all turbine measurements and clearances before and after repairs; maintain a permanent record of these measurements (fig. 2-9 shows the method of checking the rotor position with a taper gauge). The record must also include the material condition revealed when the turbine is opened and after repairs are made. Forward a report of these facts to the Naval Sea Systems Command.

Before the casing can be lifted, you must do the following preliminary work: Remove the covers over the flexible couplings between the turbines and the reduction gears. Disconnect and remove sections of the main steam lines. If an HP or LP turbine casing is to be lifted, remove the crossover line between these turbines. Remove drain lines and gland seal lines if necessary. In some turbine installations, you may have to remove obstructions to lifting, such as steam lines and ventilation ducts. It may also be necessary to remove some of the insulation from the turbine.



96.7

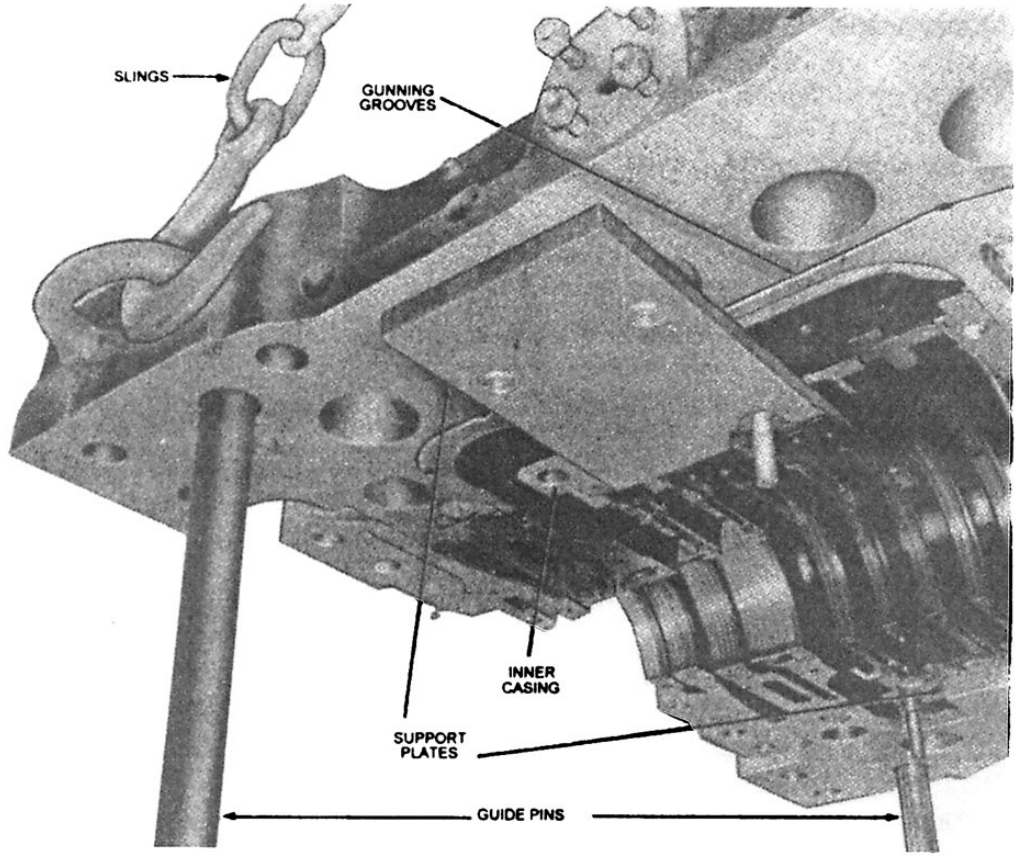
Figure 2-9.—Using a taper gauge to check the position of a rotor.

Provide proper temporary stowage of the piping, valves, nuts, bolts, tools, and other necessary materials either in or out of the engine room. Keep passageways and working areas free of tools and materials being used. Avoid damage to the piping, gauges, gauge lines, lagging, and other material.

After the preliminary work has been completed, remove the turbine-casing horizontal joint bolts. As a rule, you should not remove the vertical joint bolts on the high-pressure turbine except when repairs require the joint to be opened. Most inspection covers have caution plates that call attention to internal bolts or fittings which must be removed. Remove the upper housings and upper halves of main turbine bearings. When disassembling turbine-casing bolts that were tightened by heat, you must apply heat to loosen these bolts. After all the bolts have been removed, break loose the joint by means of jack bolts if necessary.

When the ship is built, pad eyes are welded into the overhead of the engine room for attaching chain falls to lift heavy objects. The manufacturer's technical manual and the ship's blueprints give detailed information on the arrangement, number, and size of the chain falls, wire slings, and shackles to be used to lift any particular piece of machinery. The lifting arrangement for a turbine casing allows the four corners of the upper casing to be lifted in a plane parallel to the flange of the lower casing. Four upper casing guide pins are then installed. If there is a scale on the guide pin, this scale should face outboard where it can be readily seen. The location of the upper casing guide pins is shown in figure 2-10. The guide pins are used to prevent any damage to the turbine blading and shaft packing. As the turbine casing is raised or lowered, handle it in a manner to prevent tilting or swaying so that it will not strike the turbine blading or shaft packing.

When the turbine casing is ready to be lifted, assign personnel to the various jobs and stations. Ten or twelve people are usually needed to raise or lower a main turbine casing. Four people operate the chain falls. Four persons, one at each corner of the turbine casing, take measurement readings from the guide pins. Usually an observer is stationed at each side of the turbine, and one person supervises the entire operation.



96.8

Figure 2-10.—Lifting or lowering upper casing of a high-pressure turbine.

Raise the casing slowly, keeping uniform heights at the graduated guide pins to ensure that the casing is level and not tilted. The usual procedure is to slowly raise the casing about 1 inch at a time until the upper casing is clear of the rotor. As a safety precaution, insert blocks under the upper casing flange as the casing is raised. When the casing is clear of the rotor, swing it clear of the turbine or secure it in a position above the turbine.

After the casing has been raised to the desired height (not higher than the guide pins) and if it is not to be swung clear, install the four upper casing supports. Have blueprints on hand to show where to install the various turbine supports and guide pieces. Bolt the upper casing support pieces to the upper and lower casing flanges.

The procedure used to lift a turbine rotor is similar to that used to lift the upper casing. Attach four rotor guides to the lower casing of the turbine, as shown in figure 2-11. There are different methods of attaching the wire slings to the turbine rotor. One method, shown in figure 2-11, is used for a small turbine rotor. Another method uses a special lifting yoke and a lifting plate to raise the rotor. In the latter method, the lifting yoke, a form of clamp, is attached to the forward end of the rotor. The lifting plate, a pad eye welded to a plate, is attached to the after face of the shaft coupling flange. Shackles are attached to lifting devices so that chain hoists maybe used in lifting the rotor.

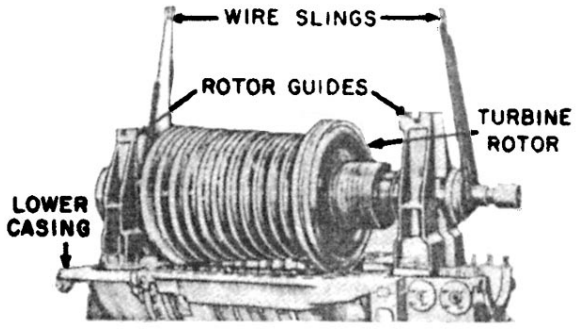


Figure 2-11.–Lifting a high-pressure rotor.

The rotor guide piece performs two functions: when the rotor is being raised, the guide pieces keep it in a vertical plane passing through the center line of the rotor shaft. Machined surfaces on the inside comers of the rotor guide pieces prevent the rotor from moving forward or aft. The machined surfaces bear with a small clearance against shoulders of the forward and aft ends of the shaft. In many cases, special bushings are at t ached to the rotor shaft. These bushings are located on the sections of the shaft between the pairs of rotor guide pieces.

After all preliminary work has been completed, slowly lift the turbine rotor from the lower casing. Lift the rotor approximately 1 inch at a time and take measurements at each end to ensure that both ends have been raised evenly. Make adjustments in height as necessary. Repeat this procedure until the rotor has cleared the lower casing.

When a turbine rotor is to be placed in its raised position, you will need special securing devices such as rotor guide saddles, rotor supporting bars, rotor guide tie brackets, and rotor guide spacer bolts. Secure these attachments in place to properly support the weight of the rotor. Use the same procedures to lift and support the high-pressure and the low-pressure turbine rotors.

Rotor Balance

The turbine rotors are carefully balanced, both statically and dynamically. If, under any circumstances, a rotor becomes unbalanced, it must be rebalanced.

Damage to the turbine rotor blading and balance weights will, understandably, cause unbalance of the rotor. You should thoroughly investigate the causes of turbine vibration before having a rotor balanced. *Operating forces should not try to balance a rotor.*

If turbine rotor unbalance is suspected, check the rotor for balance while it is still in the casing. The normal procedure is to notify the type commander, who will determine the repair activity that will conduct the necessary tests and inspections. All turbine rotors must be rebalanced when any of their blading has been renewed or their balance has been altered by repairs.

Reassembling a Turbine

Immediately before you permanently close any opening that has been uncovered, make an inspection to be certain that there are no foreign objects in the turbine and that there are no unsatisfactory conditions. Make a very careful examination of the rotor and the interior of the casing for any articles left behind. Make the examination before the rotor is lowered into place and again before the upper casing is lowered and secured into place.

Maintain strict accountability for tools and parts when working on turbines to ensure that none of these items are left inside. Personnel who work around or inspect uncovered turbines should not carry objects that may fall into the equipment. Secure flashlights with lanyards.

The final inspection should be made by responsible officers, one from the ship and one from the repair activity. Record this inspection and the name of the inspectors in the engineering log.

Sealing a Flange Joint

Before the upper half of the turbine casing is lowered into place, clean the horizontal joints with a solvent. If the solvent fails to clean the flange, mechanical cleaning methods may be necessary. DO NOT use belt sanders, files, or other heavy adhesives. Use only mild scraping material like a crocus cloth.

Apply a thin film of prussian blue to the joint on the upper half casing and to the horizontal joint of internal stationary parts assembled in the upper half casing. Carefully lower the upper half casing onto the lower half. Install all joint studs; lubricate threads and faces of nuts and all washers, and assemble nuts. Cold tighten all studs to approximately one-half the normal operating stud stress to obtain a proper joint check. Disassemble joint nuts and studs and carefully raise the upper half casing; observe the blue contact on the joint of the lower half casing.

If the blue check indicates a poor contact because of local high areas, scrape or stone these areas with a large surface plate (minimum 12 x 18 inches) to obtain a proper blue check. In some cases, the joint may contain eroded areas and grooves caused by steam leakage. To seal these areas and grooves and prevent subsequent leakage, you may find it necessary to apply a small amount of weld. The welding should be done under the supervision of a capable welding engineer and in accordance with approved procedures in NSTMs.

Whenever a casing joint is opened for any reason, a final contact check is required. It is accomplished by taking a red and blue check of the made-up joint. Contact required is as follows:

1. Seventy-five percent contact over the entire joint plus a 1/2-inch minimum continuous contact band inside the bolts and across each pressure section
2. For joints with pumping grooves, 75 percent contact over the entire joint plus a 1/4-inch minimum continuous contact band inside the groove and across each pressure section

The entire joint surface on each casing should be lightly coated with a thin, even film of one of the joint compounds permitted by the NSTM. The use of sheet packing for flange joints is prohibited.

The main horizontal and vertical joints in some turbine casings have a system of grooves in the joint faces for pressure pumping with sealing compound during emergency repairs. These grooves should not be filled with sealing compound during routine overhaul.

Tightening a Flange Joint

Turbine-casing horizontal joint and valve chest-cover bolting must be properly tightened to obtain the clamping force required for satisfactory performance of metal-to-metal steam joints. There are three acceptable measurements in determining the exerted clamping force:

1. The bolt length before and after tightening
2. The torque applied to the nut
3. The advancement of the nut on the bolt thread

Detailed instructions for making up turbine-casing bolting are usually included in the manufacturer's instruction book. If provided, they should be followed.

The preparatory work should consist of clearing all joint studs, nuts, and washers thoroughly. This will remove any previously used thread compound or foreign material. Replace any studs or nuts with damaged threads. Prior to final installation, coat stud threads and nut faces with antiseize compound.

DOCK TRIALS

When a main propulsion turbine has been opened for inspection and repair, the work is not considered complete until a dock trial and a postrepair trial have been satisfactorily completed and any deficiencies found have been corrected.

The engineer officer of each ship may issue instructions for operating the plant during a dock or postrepair trial; however, the general procedure will be as follows:

Before oil is circulated through the lube-oil system, fit muslin bags in the lube-oil strainers. The muslin bags, available at naval shipyards, will prevent very fine particles of dirt from entering the bearings and gears. Start a lube-oil pump and circulate oil through the system. Change the muslin bags often (the interval of time between changes is usually set by the engineer officer). When dirt or other foreign matter is no longer found in the muslin bags, engage the turning gear. Station personnel at various points around the turbine to listen for unusual noises. If no abnormal conditions are detected, consider the turbine ready for a dock trial.

During a dock trial, the ship will remain tied to a pier, and the engines will be turned by steam. The commanding officer usually determines the maximum number of rpm the engines will be permitted to turn. On a ship with two engines, turn one engine in the ahead direction and the other in the astern direction; then reverse the engines.

Warm up the main plants according to the engineer officer's instructions. When the engines are ready to be tested, station the special sea detail. The officer of the deck will shift his watch from the quarterdeck to the bridge, and personnel will be stationed around the turbines to detect unusual noises or other abnormalities. When all stations are manned and the engineering plant is ready, the engineer officer will request permission from the bridge to test the main engines. When the OOD is certain that the area around the fantail is clear of boats, mooring lines, and so forth, he will grant permission to test the main engines. When the main engines have been tested and found satisfactory, the engineer officer will report to the bridge that the main engines are ready for dock trial. One main engine will then be designated to go in the ahead direction and the other in the astern direction. The appropriate orders will be rung up on the engine-order telegraph, and the required rpm will be indicated on the engine revolution indicator. When these orders are

received in the engine room, the engine itself will be turned, by steam, at the indicated rpm. If no abnormal conditions are found, the engineer officer will request an increase in speed. The OOD will order the rpm increase in speed. The OOD will order the rpm increased (about 5 rpm each change) until the maximum allowable rpm is reached. If no abnormal conditions are detected, the main engines may be considered ready for a postrepair trial.

Information on postrepair trials is given in a later chapter of this training manual.

SAFETY PRECAUTIONS

Observe the following safety precautions. They apply to the operation, care, and maintenance of main turbines found on Navy ships. For more detailed safety precautions, consult your manufacturer's technical manual and your EOSS books.

1. Do not admit steam to operate the turbine until the exhaust system has been prepared to receive turbine exhaust and the entire system has been properly drained.

2. Do not use auxiliary exhaust steam for warming up the turbines.

3. Be sure that the lubrication system is operating properly before turning over the main engines.

4. Investigate unusual noises at once; operate the turbine cautiously, or stop it, until the cause for the noise has been discovered and remedied.

5. Never fail to investigate any unusual noise coming from a turbine.

6. Do not put way on the ship when turning over the main engines during warm-up.

7. If a turbine vibrates, slow it down, investigate, and locate the cause.

8. Except in an emergent y, do not admit steam to the astern turbine until steam to the ahead turbine is secured, and vice versa.

9. Before getting underway, be sure that all steam lines are properly drained of condensate.

10. When steam pressure drops, do not open the throttle to such an extent that the operating pressure of the steam drops to a dangerously low point.

11. Stop the engines immediately if the oil supply fails.

12. No inspection plate, connection, fitting, or cover that permits access to the turbine should be removed without authority of the engineer officer.

13. When turbines are opened, take precautions to prevent the entry of foreign matter. Do not leave the openings unattended.

14. Inspect lifting devices carefully before using them and do not overload them.

15. Avoid air being drawn through turbine glands with the rotor at rest.

SUMMARY

In this chapter, you were given information on the operation, maintenance, and repair of main turbines. When inspecting and repairing tubines, you should refer to the manufacturer's technical manuals.

For more detailed information on propulsion turbines, you should consult NSTM, chapter 231.

CHAPTER 3

REDUCTION GEARS

This chapter contains information on the operation, care, and maintenance of the main reduction gear used on Navy ships. As an MM1 and MMC, you must be familiar with the design and construction details of naval reduction gears. To acquire this information, we recommend that you study this book and review chapter 3 of *Machinist's Mate 3 & 2* and chapter 9420 of the *Naval Ships' Technical Manual.* Details of any particular reduction gear installation will be found in the manufacturer's technical manual.

MAIN REDUCTION GEAR

The main reduction gear is one of the largest and most expensive units of machinery found in the engineering department. It is made up of a number of smaller gears. A main reduction gear that is installed properly and operated properly will give years of satisfactory service. However, a serious casualty to a main reduction gear will either put the ship out of commission or force it to operate at reduced speed. Extensive repairs to the main reduction gear can be very expensive because they usually have to be made at a shipyard.

TYPES OF GEARS

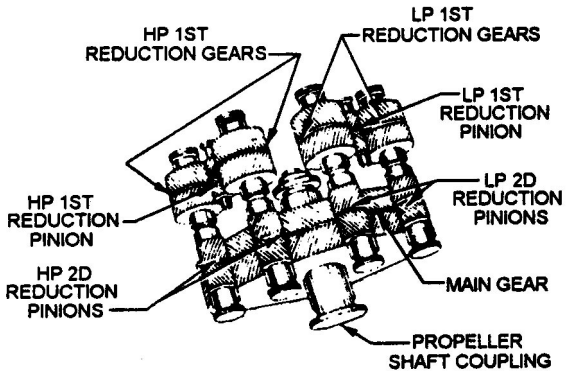
Reduction gears are coupled to the turbine shaft through various arrangements of gears. These gears reduce the speed of the turbine to the speed required by the propulsion shaft and propeller.

Reduction gears are classified according to the number of steps used to reduce speed and the arrangement of the gearing. A combination of gears is called a "train."

The two most commonly used arrangements are the articulated, locked-train, double-reduction gear and the articulated, double-reduction gear. These two types use the double-helical gears.

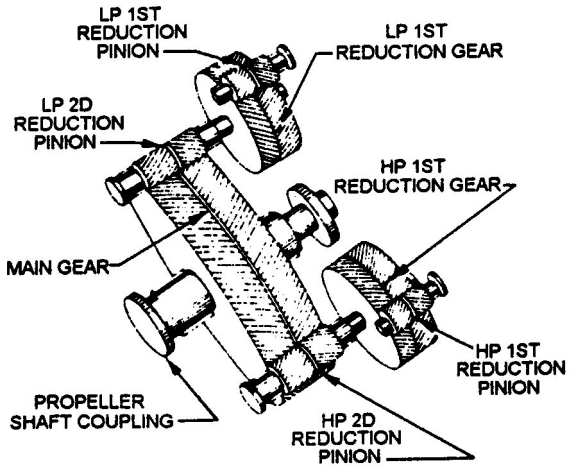
The articulated, locked-train, double-reduction gear is principally used on combatant-type ships. Figure 3-1 shows the major parts of this type of gear. This gear is used in auxiliary-type ship installations and has replaced the nested-type gear arrangement. It has advantages such as the capability of transmitting higher powers, lower sensitivity to misalignments, and ease of maintenance.

Figure 3-2 shows the articulated, double-reduction gear. This gear has one or more power



96.55

Figure 3-1.—Articulated lock-train double reduction gear.



96.56

Figure 3-2.—Articulated double reduction gear.

inputs. It has replaced the nested-type gear arrangement and is usually found in auxiliary-type ships.

OPERATION OF THE MAIN REDUCTION GEAR

The following procedures are essential for the proper operation of reduction gears:

- Supply the required amount of oil to the gears and bearings, and keep the lube oil clean and at proper temperatures. If these requirements are met and if the gears are properly aligned, reduction gears should give reliable service for the lifetime of the ship.

- Lock and unlock the shaft in accordance with the engineering operational sequencing system (EOSS).

- Use the motor-driven turning gears to keep the gears and turbine rotors rotating slowly during cooling-down periods.

- Investigate noises and vibrations and take corrective action.

- Inspect gears in accordance with the planned maintenance system.

LUBRICATION OF GEARS AND BEARINGS

Proper lubrication of reduction gears and bearings is of the utmost importance. The correct quantity and quality of lubricating oil must, at all times, be available in the main sump. The oil must be clean, and it must be supplied to the gears and bearings at the pressure and temperature specified by the manufacturer.

Several conditions must be met for proper lubrication of gears and bearings. The lube-oil service pump must deliver the proper discharge pressure. All relief valves in the lube-oil system must be set to function at their designed pressure. The quantity of oil to each bearing is controlled by an orifice in the supply line; the orifice opening must be in accordance with the manufacturer's instructions, or the supply of oil will be affected. Too small a quantity of oil will cause the bearing to run hot. If too much oil is delivered to the bearing, the excessive pressure may cause the oil to leak at the oil seal rings. Too much oil may also cause a bearing to overheat.

Lube oil must reach the bearings at the proper temperature. If the oil is too cold, one of the effects is insufficient oil flow for cooling purposes. If the oil supply is too hot, some lubricating capacity is lost.

For most main reduction gears, the normal temperature of oil leaving the lube-oil cooler should be between 120°F and 130°F. For full power operation, the temperature of the oil leaving the bearings should be between 140°F and 160°F. The maximum temperature rise of oil passing through any gear or bearing, under any operating conditions, should not exceed 50°F; and the final temperature of the oil leaving the gear or bearing should not exceed 180°F. This temperature rise and limitation may be determined by installed thermometers or resistance temperature elements.

Cleanliness of lubricating oil cannot be overstressed. Keep it free from impurities, such as water, grit, metal, and dirt. Take particular care to clean out metal flakes and dirt when new gears are wearing in or when gears have been opened for inspection. Lint or dirt, if left in the system, may clog the oil spray nozzles; keep the spray nozzles open at all times. Spray nozzles must never be altered without the authorization of the Naval Sea Systems Command.

The lube-oil strainers cannot trap particles of metal and dirt that are fine enough to pass through the mesh. These fine particles can become embedded in the bearing metal and cause wear on the bearings and journals. These fine abrasive particles passing through the gear teeth act like a lapping compound and remove metal from the teeth.

Main Sump Oil Level

Lubricating oil is supplied to the gears from the main engine lubricating system. The system has a connection to each bearing. Nozzles are located so that a constant spray of oil is directed over the gears. This constant spray of oil over the gears lubricates and cools the gears. In reduction gears, the maximum oil level in the sump may reach the bottom of the bull gear. An oil excluding pan is fitted around the bottom of the bull gear to ensure that the bull gear does not dip into the oil.

If the gear dips into the oil, the churning action of the gear will produce foam. Under normal conditions, only a small quantity of oil comes in contact with the bull gear; therefore, no dangerous vibration and no churning effect will

occur. Oil from the gears is swept out of the pan by the bull gear and drained into the sump. A drain hole on the bottom of the pan is located to drain any accumulated water when the ship is on an even keel. When there is too much oil in the sump, the gear will churn and aerate the oil. Because the aerated oil is a poor lubricant, there will be an increase in engine and oil temperature. If this occurs, the engines must be slowed or stopped until the excess oil can be removed and normal conditions restored. Make routine checks to see that the lubricating oil is maintained at the proper level. Any sudden loss or gain in the amount of oil in the main sump should be investigated immediately.

Effects of Acid and Water in Oil

Water and acid in oil are extremely dangerous. Test oil frequently for water and at regular periods for acid. Even a small amount of water in oil can cause pitting and rusting. Freshwater can accumulate because of leaking turbine packing glands or from condensation. Where main sump tanks are located at the skin of the ship, salt water may leak into the lube oil. Salt water may also enter through leaks in the lube-oil cooler. When salt water is found in a lube-oil system, take corrective steps to find and seal off the source of the salt water. Remove the contaminated oil from the system by flushing with clean oil.

When oil is contaminated with freshwater, adequate purification will prevent an accumulation of water in the oil. However, you must find and eliminate the source of water. Under normal operating conditions, operate the lube-oil purifier 12 hours a day while underway. However, if the presence of freshwater is noted, operate the purifier until there is no visual indication of water in the oil and no water is discharged from the purifier. If, with additional purifier operating time, the oil does not clear up, check the purifier for improper operation. Never ignore the presence of salt water or freshwater in lube oil. Check the system immediately and eliminate the source of contamination.

When the main engines are secured, keep a lube-oil pump running and keep the jacking gear engaged and turning until the engines have cooled to approximately room temperature (ambient). While oil is circulating, leave the lube-oil cooler in use and operate the purifier. Circulating oil will carry away the heat from the engines, which might otherwise reach the bearings. Turning the engines will prevent the rotors from becoming bowed. Operating the purifier will eliminate water caused by condensation on the interior of the reduction gear casing.

Ships should take every opportunity to have laboratory tests made of the lube oil. Good engineering practice dictates that this be done every 3 months, or more frequently in unusual conditions. Samples should be tested for water, acid, and sediment content. When the neutralization number exceeds 0.50, replace the lube oil.

Oil Emulsion

With continuous use, the lube oil will increase in acidity. The free fatty acids will form mineral soaps that can form a stable oil and water emulsion. Once the emulsion has formed, the removal of water becomes more difficult. More important, the oil loses its lubricating quality, the formation of an oil film becomes impossible, and the oil must be renovated. Emulsified oil will cause wiped bearings and worn gear teeth.

PREPARATION TO GET UNDERWAY

To prevent misunderstanding and confusion in preparing to get underway, use EOSS. It provides a convenient and simple procedure for checking the required steps in proper sequence. It ensures that no important step is overlooked or forgotten. Some of the most important steps are listed below:

1. Inspect the sump or supply to ensure there is enough oil for system operation.
2. Inspect for water in the lube oil at the bottom of the lube-oil sump.
3. Determine if circulating water is available at the lube-oil cooler.
4. The lube oil in the sump should be about 90°F when you start the lube-oil pumps. It may be necessary to heat the oil before starting the lube-oil pump if it is below this temperature.
5. Make sure that oil is flowing freely at correct pressure to all gear shaft bearings, spray nozzles, and line shaft components. When the oil is flowing at operating temperature to all bearings and sprays, check the operating level in the sump or supply tank.

When the ship is underway, observe all oil pressures and temperatures to see that they remain normal. Record these pressures and temperatures hourly. Check the oil level in the sump frequently;

if the level changes, check for leaks. Take and post oil samples frequently. For more information on oil sampling, purification, and cleaning procedures, refer to NSTM, chapter 9450.

NOISES AND VIBRATIONS

Once the ship is underway, you will need to be alert for any unusual noises and vibrations. On steam-turbine-driven ships, noises may occur at low speeds, when maneuvering, or when passing through shallow water. Generally, these noises do not result from any defect in the propulsion machinery and will not occur during normal operation. A rumbling sound that occurs at low-shaft rpm is generally caused by the low-pressure turbine gearing floating through its backlash. The rumbling and thumping noises that may occur during maneuvering or during operation in shallow water are caused by vibrations initiated by the propeller. These noises are characteristic only of some ships and should be regarded as normal sounds for these units. These sounds will disappear with a change of propeller rpm or when the other causes mentioned are no longer present. These noises can usually be noticed in destroyers when the ship is backing, especially in choppy seas or in ground swells.

Unusual Noises

A properly operating reduction gear has a definite sound. An experienced watch stander should be able to recognize these sounds at different speeds and under various operating conditions.

If any abnormal sounds occur, investigate immediately. Your investigation should depend on how you interpret the sound or noise.

The lube-oil temperature and pressure may or may not help you determine the reasons for the abnormal sounds. A badly wiped bearing may be indicated by a rapid rise in oil temperature for the individual bearing. A certain sound or noise may indicate misalignment or improper meshing of the gears. If unusual sounds are caused by misalignment of gears or foreign matter passing through the gear teeth, stop the shaft and make a thorough investigation before the gears are operated again.

For a wiped bearing or any other bearing casualty that has caused a very high temperature, follow this procedure: If the temperature of the lube oil leaving any bearing has exceeded the permissible limits, slow or stop the unit, and inspect the bearing for wear. The bearing may be wiped only a small amount, and the shaft may be operated at a reduced speed until the tactical situation allows sufficient time to inspect the bearing.

Vibration

The most common causes of vibration in a main reduction gear are faulty alignment, bent shafting, damaged propellers, and improper balance.

A gradual increase in the vibration in a main reduction gear that has been operating satisfactorily for a long period of time can usually be traced to a cause outside of the reduction gears. The turbine rotors, rather than the gears, are more likely to be out of balance.

When reduction gears are built, the gears are carefully balanced (both statically and dynamically). A small amount of unbalance in the gears will cause unusual noise, vibration, and abnormal wear of bearings.

When the ship has been damaged, vibration of the main reduction gear installation may be caused by misalignment of the turbine, the main shafting, the main shaft bearings, or the main reduction gear foundation. When vibration occurs within the main reduction gear, damage to the propeller should be one of the first things to be considered. The vulnerable position of the propellers makes them more Liable to damage than other parts of the plant. Bent or broken propeller blades will transmit vibration to the main reduction gear. Propellers can also become fouled with line or cable, which will cause the gears to vibrate. No reduction gear vibration is too trivial to overlook. Always make a complete investigation.

LOCKING AND UNLOCKING THE MAIN SHAFT

There may be times when you need to stop and lock the main propeller shaft for an emergency or casualty. It may be necessary to stop the shaft in these conditions to prevent damage to the machinery while you resolve the problem. The best way to lock a propeller shaft while the ship is underway is to wait for the shaft to stop, engage the turning gear, and then apply the brake.

CAUTION

During drills the shaft should not be locked more than 5 minutes, if possible. The ahead throttle should NEVER be opened when the turning gear is engaged. The torque produced by the ahead engines is in the same direction as the torque of the locked shaft; to open the ahead throttle would result in damage to the turning gear.

Locking the Main Shaft

Engine-room personnel should be trained through drills to safely lock and unlock the main shaft. Each steaming watch should have enough trained personnel available for this purpose.

The maximum safe operating speed of a ship with a locked shaft can be found in the manufacturer's technical manual. Additional information on the safe maximum speed that your ship can steam with a locked shaft can be found in NSTM, chapter 9420.

Unlocking the Main Shaft

If practical, the simplest way to unlock the shaft is to stop the ship, release the turning gear and brake, and warm the turbines. If the shaft has been locked for 5 minutes or more, the turbine rotors may have become bowed, and special precautions are recommended.

Before the shaft is turned, station personnel at the turbines to check for unusual noises and vibration. If, when the propeller starts to turn, vibration indicates a bowed rotor, the ship's speed should be reduced to the point that you notice little or no turbine vibration. Maintain this speed until the rotor is straightened. When the shaft is operated at that speed, the steam passing through the ahead throttle will warm the rotor and help straighten it. You can lower the main condenser vacuum to add additional heat to the turbines; this will increase the exhaust pressure and temperature.

As the vibration decreases, increase the shaft speed slowly and continue to check for vibration. The turbine is not ready for normal operation until vibration has disappeared at all possible speeds.

MAINTENANCE OF A MAIN REDUCTION GEAR

Under normal conditions, a shipyard should handle major repairs and major items of maintenance on a main reduction gear. When a ship is deployed overseas and at other times when shipyard facilities are not available, emergency repairs should be done, if possible, by a repair ship or an advanced base. Inspections, checks, and minor repairs should be done by the ship's force.

BEARING MAINTENANCE

Under normal conditions, the main reduction gear bearings and gears will operate for an indefinite period. Enough spares are carried aboard to replace 50 percent of the number of bearings in the main reduction gear. Usually each bearing is interchangeable for the starboard or port installation. Check the manufacturer's technical manual to determine interchangeability of gear bearings.

Special tools and equipment needed to lift main reduction gear covers, to handle the quill shaft when removing bearings from it, and to take required readings and measurements are normally carried aboard. These items are carried in case emergency repairs have to be made by repair ships or bases not required to carry these items.

The manufacturer's technical manual is the best source of information concerning repairs and maintenance of any specific reduction gear installation.

Journal Bearings

Each babbitted bearing shell of the reduction gear may be considered as having a pressure bearing half and a nonpressure bearing half. The nonpressure bearing half has a radial scribe line at one end of the geometric center. The pressure bearing half has three radial scribe lines at one end. The central scribe is at the geometric center, and the additional scribes on either side of the central scribe are at an angle of 45°. These scribes are placed by the manufacturer. The crown thickness of each shell, at these scribe points, is measured with a micrometer, usually 1 1/4 inches from the end of the shell. Such measurements are taken during the initial alignment by the manufacturer. They are stenciled adjacent to each scribe line to be used as constants for future alignment checks. In this way the amount of wear can always

be determined whether the wear is against the upper or lower half of the shell.

Some older ships are not equipped to check alignment by the crown-thickness and proof-staff methods. On these ships, the gears are first checked for alignment by measuring the percentage of tooth contact in accordance with NSTM, chapter 9420.

After alignment is established, remove and mark the bearings. Measure the crown thickness of the bearing and stencil the measurement adjacent to each scribe line. Measure subsequent bearing wear by using the crown-thickness method based on the constants as stenciled.

The amount of bearing clearance allowed should not be great enough to allow incorrect gear tooth contact. The designed bearing clearances are given in the manufacturer's technical manual. These clearances are also given in the blueprints for the main reduction gear. The maximum allowable clearance can be found in NSTM, chapter 9420.

Replacing bearings in the main reduction gear is a major undertaking. When a casualty (such as the loss of lube oil) occurs, the high-speed pinion shaft bearings are more likely to be wiped than the other main gear bearings. These high-speed pinion shafts are coupled to the high-pressure and low-pressure turbines. They will have a higher rotary speed than other shafts in the reduction gear. If the bearings are inspected, the high-speed pinion bearings should be checked first. If these bearings are not wiped, it is safe to assume that the bearings that rotate at lower speeds are not wiped. If you make repairs, first study the manufacturer's technical manual and the blueprints for the main reduction gear. As an MM1 or MMC, you should be able to decide whether the repair work should be attempted. You should also have a clear understanding of the construction details and repair procedures before starting a repair job. ther factors to be considered are location of the ship, available repair facilities, available repair parts, and the operating schedule of the ship.

In making repairs, the first step is to engage the turning gear and set the brake to ensure that the shaft will not turn while repairs are being made. Pump all oil out of the main sump tank. Store the oil in a clean settling or storage tank until it is ready for use again. Next, lift a section of the reduction gear cover by using chain falls and wire slings. When the gear cover is moved out of the way, remove the bearing cover. Next, turn the bearing so that the bearing split is on the horizontal plane and the top half of the bearing can be lifted off. The gear shaft must be supported when the bottom half of the bearing is removed. Roll a dummy bearing in while the lower half is rolled out. The dummy bearing supports the weight of the shaft and keeps the shaft in position. Take special precautions to prevent the shaft from being turned or lifted, which may allow the gear teeth to become unmeshed. If the gear teeth become unmeshed and are not matchmarked, a complicated and detailed procedure must be followed to reassemble and time the gears. The setting up of the locked-train gear system is done at the factory and at shipyards.

If the bearing has excessive clearance, is badly wiped, or is heavily scored, examine other representative bearings to determine the extent of the damage. Replace all bearings on that particular shaft to maintain correct gear alignment.

To replace a bearing, proceed as follows:

1. Review the maintenance history of the reduction gears to determine if special bearings are necessary.
2. Measure the diameter of the journal (with a micrometer) and compare the present readings with the original readings, as recorded.
3. Check the crown thicknesses of installed and replacement bearings and compare readings. If scraping is required for the replacement baring, use a full-sized mandrel and prussian blue to check the work. Shaft parallelism must be maintained.
4. To maintain shaft parallelism, ensure that bearings on the ends of gear or pinion shafts do not differ more than 0.002 inch.
5. When a spare bearing is installed or a damaged bearing is scraped to maintain correct tooth contact, stamp the crown thickness on the bearing shell.
6. Use dowels between the bearing halves to locate the bearings in the upper casing. Upper and lower bearing halves must be mated parts. Interchanging of upper and lower bearing halves is prohibited.
7. Examine the condition of the journal whenever bearings are removed. If the surface of the journal is slightly scored, it must be stoned very lightly and polished. Only experienced personnel should stone a journal. Always oil a journal before rolling in a new bearing.

NOTE: If journals are badly scored, they may be ground undersize or restored to design diameter by chrome plating. If a journal is ground

undersize, it might be necessary to provide undersize bearings. This should be done only by a shipyard and in accordance with existing NAVSEA instructions. The new journal diameters and bearing clearances must be recorded.

When installing a spare bearing, make sure it is well oiled; then roll the lower half into position, removing the dummy bearing. Place the upper half in position, and then shift the complete bearing to its proper position. Ensure that the dowels are in place and that the bearing assembly is in its required position, in accordance with the manufacturer's instructions. Lower the bearing cap into position and securely bolt it down.

Before the gear cover is lowered into position, make a careful inspection to see that the inside of the gear installation is free of all dirt, tools, rags, and other foreign matter that would be harmful to the gears. After the gear cover is lowered into position and bolted down, pump the lube oil to the sump. Before the oil is circulated through the system, place muslin bags in oil strainers. The muslin bags will trap any dirt or foreign matter that is too fine to be stopped by the strainer. Start a lube-oil service pump to circulate oil through the system. Change the muslin bags at 30-minute intervals until they no longer pick up dirt. Then you can engage and start the turning gear.

Thrust Bearings

This chapter contains only general information on different methods of taking end-play readings on the main thrust bearing. See the manufacturer's technical manual for specific information on any given unit.

Always check the end play for any six- or eight-shoe thrust bearing with the top half of the bearing bolted down solidly; otherwise, the base rings will tilt because of the freedom of movement given the leveling plates, and you will get a false reading.

Keep and refer to a record of the main thrust readings when you check the main thrust bearing. Over a period of years, the normal wear of a pivoted-shoe thrust bearing is negligible. However, when the bearing is new, the leveling plate may settle slightly. If any increase occurs in the end play of a main thrust bearing, inspect the surfaces of the thrust shoes and make necessary repairs.

Some main thrust bearings have a port (in the main thrust bearing cap over the thrust shoes) for inspection purposes. This port has a removable cover of sufficient size to permit the withdrawal of thrust shoes that are in line with it.

CHECKING THRUST WHILE UNDERWAY.— The simplest means of checking end play is to use a dial indicator on any accessible flange on the main shaft while the engines are going slowly ahead and then astern. This can usually be done when the ship is maneuvering to approach a pier or an anchorage. The speeds should be slow enough to avoid adding deflections of bearings parts and housing to the actual end play. But, the speed should be sufficient enough to ensure that the full end play is actually taken up.

Some ships have the main thrust bearing located at the forward end of the main reduction gear and constructed as a component part of the gear. Use a spring-loaded pin gauge (located in the bearing end cover housing) and a micrometer depth gauge to measure the end play. Remove the pin gauge cover and place the anvil of the depth gauge on the machined surface of the pin gauge housing. Carefully turn the micrometer so that the spindle pushes the installed pin against the main shaft. Take up all slack; but do not use excessive force, as it will lift the micrometer anvil from the machined surface.

Take another reading with the main shaft operating in the opposite direction. The difference between the two readings is the end play. It is always good practice to take more than one set of readings to ensure that the total end play was taken up and that the readings are accurate.

JACKING ON A SHAFT FLANGE.— If it is not practical to measure the end play while the engine is running, the next choice is to jack the shaft (while it is still warm) fore and aft at some convenient main shaft flange. Mount a dial indicator on a rigid support, convenient to some main shaft flange, and jack the shaft forward and then astern. Make certain that the shaft movement is free-but do not use too great a force; excessive force might cause deflections of metal parts to be added to the actual end play. The main difficulty in using the jacking method is finding suitable supports where no structural damage will be done.

GEAR TEETH

The importance of proper gear tooth contact cannot be overemphasized. Any abnormal condition that may be revealed by operational sounds or by inspections should be corrected as soon as possible. Any abnormal condition that is not

corrected will cause excessive wear, which may result in general disintegration of the tooth surfaces.

If proper tooth contact is obtained when the gears are installed, little wear of teeth will occur. Excessive wear cannot take place without metallic contact. Proper clearances and adquate lubrication will prevent most gear tooth trouble.

Wear-in of Gear Teeth

Gears that have been realigned and new gears should be given a wearing-in period at low power before they are subjected to the maximum tooth pressure at full power.

Tooth Contact

For proper operation of the gears, the total tooth pressure must be uniformly distributed over the total area of the tooth faces. This uniform pressure is accomplished by accurate alignment and adherence to the designed clearance.

Maintain the designed center-to-center distance of the axes of the rotating elements as accurately as practical. However, the axes of pinions and gear shafts must always be parallel. If the shafts are not parallel, the load is concentrated on one end of a helix. The result may be flaking, galling, pitting, featheredges on teeth, deformation of tooth contour, or breakage of tooth ends.

Checking Tooth Contact

The length of tooth contact across the face of the pinion is a means of determining if reduction gear alignment is satisfactory. One method used to static check the length of tooth contact is to apply a thin coat of prussian blue to a band of teeth on one element and to coat a similar band on the mating element with red lead. The coatings must be thin and even. Rotate the two bands into contact by jacking back and forth three or four times.

Use either copper sulfate or blue or red Dykem to determine tooth contact for operating conditions. Use Dykem for dock trials, because it will show markings for light load conditions. Copper sulfate markings will remain visible longer after high-power operations than will Dykem markings. Remove lubricating oil from the gear teeth with a cleaning agent before you apply the compound. After the tooth contact is determined, remove the compound from the gear teeth to prevent possible contamination of the lubricating oil. Then oil the gear teeth.

Remember that some gear teeth are cut with a very slight taper to offset the effects of torsional twist and bending. In such gearing, full contact across the teeth will not be obtained.

Tooth Contour

The designed tooth contour must be maintained. A lack of this tooth contour can cause load concentrations with consequent scoring.

Tooth Surface Wear

If proper contact is obtained when the gears are installed, the initial wearing, which takes place under conditions of normal load and adequate lubrication, will smooth out rough and uneven places on the gear teeth. This initial wearing is referred to as *normal wear* or *running in*. As long as operating conditions remain normal, no further wear will occur.

Small shallow pits, starting near the pitch line, will frequently form during the initial stage of operation; this process is called *initial pitting.* Often the pits (about the size of a pinhead or even smaller) can be seen only under a magnifying glass. These pits are not detrimental and usually disappear in the course of normal wear.

Pitting that is progressive and continues at an increasing rate is known as *destructive pitting.* The pits are fairly large and are relatively deep. Destructive pitting is not likely to occur under proper operating conditions. It can be caused by excessive loading, too soft material, or improper lubrication. This type of pitting is usually caused by misalignment or improper lubrication.

The condition in which groups of scratches appear on the teeth (from the bottom to the top of the tooth) is termed abrasion, or scratching, It maybe caused by inadequate lubrication or by foreign matter in the lubricating oil. When abrasion, or scratching, is noted, you should immediately examine the lubricating system and the gear spray fixtures. If you find that dirty oil is responsible, the system must be thoroughly cleaned and the whole charge of oil centrifuged.

The term *scoring* denotes a general roughening of the whole tooth surface. Scoring marks are deeper and more pronounced than scratching; they cover an area of the tooth instead of occurring haphazardly, as in scratching, or abrasion. Small areas of scoring may occur in the same position on all teeth. Scoring, with proper

alignment and operation, usually results from inadequate lubrication and is intensified by the use of dirty oil. If these conditions are not corrected, continued operation will result in a general disintegration of the tooth surfaces.

Spotting Gear Teeth

If you find any abnormal conditions that may be revealed by operational sounds or by inspections, correct them with the least possible delay. Stone rough gear teeth until they are smooth if you are certain that the roughening was caused by the passage of some foreign matter, Investigate any tooth deterioration that cannot be traced to a casualty. Give special attention to the condition of the bearing, to lubrication, and to the possibility of a change in the supporting structure, which has disturbed the parallelism of the rotors.

To spot-in surfaces of reduction gear teeth, coat the pinion teeth lightly with prussian blue. Then turn the gear in its ahead direction by using the jacking gear. As the gear teeth come in contact with the marked pinion teeth, an impression is left on the high part of the gear tooth. After the gear is turned one-fourth turn or is in a convenient position for stoning, use a small handstone to remove all high spots indicated by the marks. You will need to replace the bluing on the pinion teeth repeatedly; but if the bluing is applied too thickly, false impressions will be left on the teeth.

You may scrape gear teeth to remove a local hump or deformation; however, you may not scrape gear teeth to obtain contact without the approval of the Naval Sea Systems Command.

Backlash

Backlash is the play between the unloaded surfaces of the teeth in mesh on the pitch circle. Backlash increases with wear and can increase considerably without causing trouble.

Root Clearance

The designed root clearance with gear and pinion operating on their designed centers can be obtained from the manufacturer's blueprints. The actual clearance can be found by taking leads or by inserting a long feeler gauge or wedge. The actual clearance should check with the designed clearance. If the root clearance is considerably different at the two ends, the pinion and gear shaft will not be parallel. There should be sufficient backlash, and the teeth should not mesh so closely that lubrication is poor or that clearance is reduced below specified limits. If these conditions are present, the tolerance will be satisfactory.

SHAFT ALIGNMENT

Under normal conditions all alignment inspections and checks, plus the necessary repairs, are done by naval shipyards. Incorrect alignment will be indicated by abnormal vibration, unusual noise, and wear of the flexible couplings or main reduction gears. When misalignment is indicated, a detailed inspection should be made by shipyard personnel.

Main Propeller Shafting

Two sets of readings are required to get an accurate check of the propulsion shafting. One set of readings is taken with the ship in drydock; and another set is taken with the ship waterborne-under normal loading conditions. The main shaft is disconnected, marked, and turned so that a set of readings can be taken in four different positions. These readings are taken on the top, bottom, and on both sides. The alignment of the shaft can be determined by studying the different readings. The naval shipyard will decide whether or not corrections in alignment are necessary.

Turbine Shafting

The high-pressure turbine shaft and the low-pressure turbine shaft are connected to their respective first-reduction pinions by flexible couplings. Each of the first-reduction couplings consists of two sleeves with internal teeth that mate with external teeth on a distance piece or extension shaft. One sleeve is bolted to the turbine flange, and the other is bolted to the first-reduction pinion flange. Lubricating oil is fed to the meshing-sleeve and distance-piece teeth from nozzles supplied with oil from the adjacent bearing. The couplings are fitted with rings that dam the oil flow through the teeth. This causes the oil level to be as deep as the tooth height and ensures lubrication to all contacting surfaces.

Flexible couplings permit axial motion and expansion of turbine rotors but will compensate for only a very small amount of misalignment. Therefore, correct alignment of turbine shafts and first-reduction pinion shafts is extremely important. When a new unit is installed properly, there is little difficulty with misalignment.

However, abnormal clearance in a turbine bearing or pinion bearing will cause misalignment of the flexible coupling.

INSPECTIONS

The minimum tests and inspections should be conducted in accordance with the shipboard preventive maintenance program. An example of the requirements are shown on the maintenance index page (fig. 3-3). When defects are suspected or operating conditions indicate the necessity, you should make inspections at more frequent intervals.

> **CAUTION**
>
> Any disassembly and assembly of a large reduction gear should be done in a shipyard under the guidance of trained personnel or manufacturers' representatives. When the ship is not in a shipyard, permission to open any portion of the gear casing or the access openings, plugs, piping, or attached fixtures must come from the ship's officers.

Before replacing any cover, connection, or inspection plate that permits access to the gear casing, an officer of the engineering department should make a careful inspection to ensure that no foreign matter has entered, or remains in, the casing. If the work is being done by a repair activity, an officer from that activity must also inspect the gear casing. The inspections and the name of the officer or officers must be entered in the engineering log.

Shipyard Overhaul

During shipyard overhauls, the following inspections should be made:

- Inspect condition and clearance of thrust shoes to ensure proper position of gears. Blow out thrusts with dry air after the inspection. Record the readings. Inspect the thrust collar, nut, and locking device.

- If turbine coupling inspection has indicated undue wear, check alignment between pinions and turbines.

- Pump the oil out of the gear sump and clean the sump internally, Scrape off and remove rust deposits from the sump.

- Inspect turning gear assemblies for proper operation and condition.

Ten-year Inspection

When conditions warrant or if trouble is suspected, submit a work request to a naval shipyard to perform a 10-year inspection of the main reduction gear. Shipyard personnel should perform the following inspections and related actions:

- Inspect to determine the condition of all bearings, journals, and gear teeth. Record the bearing crown thickness or lead readings of all main pinion and gear bearings.

- Check the intermediate coupling bolts for tightness.

- Take and record alignment readings of the prime mover to the gear. Do this with the ship waterborne and the propulsion plant in the ready-to-operate condition.

Naval Sea Systems Command authorization is not necessary to lift reduction gear covers. These covers should be lifted when you suspect trouble. However, an open gear case is a serious hazard to the main plant. Through this opening, rags can get in oil lines, and tools can get in gear teeth. These kinds of mistakes have caused serious and expensive casualties that were attributable directly to a lifted gear cover. Before you lift a gear cover, carefully consider the dangers of uncovering the gear against the reasons for suspecting internal trouble. The 10-year inspection may be extended by the type commander when operating conditions indicate that a longer interval between inspections is desirable.

Before Trials

Before a trial, you should make the following inspections, in addition to those which may be directed by proper authority: Open the inspection plates; examine the tooth contact, the condition of teeth, and the operation of the spray nozzles. You should not open gear cases, bearings, and thrusts immediately before trials.

System, Subsystem, or Component	Reference Publications
Reduction Gears	

Bureau Card Control No.					Maintenance Requirement	M.R. No.	Rate Req'd.	Man Hours	Related Maintenance
MB	ZZZFGE5	35	5025	Q	1. Inspect the reduction gear including spray nozzles.	Q-1	EO MM1 MM3	 1.0 1.0	None
MB	ZZ2FSC1	65	4290	Q	1. Measure main shaft thrust clearance.	Q-2	EO MM1 MM2	 0.3 0.3	None
MB	ZZZFGE1	84	5064	S	1. Inspect and clean oil sump and reduction gear casing.	S-1	EO MM1 MM3 2FN	 5.0 6.0 12.0	None
MB	ZZ1FCW4	65	A188	A	1. Inspect flexible couplings. Measure clearances.	A-1	MMC MM1 2FN	2.0 8.0 16.0	None
MB	ZZZFGE5	78	6669	A	1. Sound and tighten foundation bolts.	A-2	FN	1.0	None

Figure 3-3.—Maintenance index page.

After Trials

After a trial, you should make the following inspections, in addition to those which may be directed by proper authority: Open the inspection plates and examine the tooth contact and the condition of the teeth to note changes that may have occurred during the trials. Running the engines for a few hours at high power will show any possible condition of improper contact or abnormal wear that would not have shown up in months of operation at lower power. Check the clearance of the main thrust bearing.

REDUCTION GEAR SECURITY

All inspection covers, whether hinged, pinned, or bolted, should be secured by locks of a high-security type. The custody of keys for these locks is the responsibility of the engineering officer. Plates and panels secured with more than 12 bolts or nuts need not be locked. Piping and fixtures need not be locked but should be secured to prevent unauthorized access to gear internals. You should carry out an ongoing program of security training of engineering personnel. Encourage all hands to recognize and report instances that may lead to unauthorized entry into the main reduction gear. For detailed information on ways to improve reduction gear security, refer to NSTM, chapter 9420.

SAFETY PRECAUTIONS

Anyone who works around a main reduction gear should understand and use the following safety precautions:

- If churning or emulsification of oil and water occurs in the gear case, slow down or stop the gear until the defect is remedied.

- If the supply of oil to the gear fails, stop the gear until the cause can be located and remedied.

- When bearings have been overheated, do not operate the gear, except in extreme emergencies, until bearings have been examined and defects remedied.

- If excessive flaking of metal from the gear teeth occurs, do not adjust the gears, except in an emergency, until the cause has been corrected.

- Investigate unusual noises at once, and operate the gear cautiously until the cause for the noise has been discovered and corrected.

- Do not remove any inspection plate, connection, fitting, or cover that permits access to the gear casing without specific authorization by the engineering officer.

- Keep the immediate vicinity of an inspection plate free from paint and dirt.

- When gear cases are open, take precautions to prevent the entry of foreign matter. Never leave the openings unattended unless satisfactory temporary closures have been installed.

- Inspect lifting devices carefully before using them, and do not overload them.

- When ships are anchored in localities where there are strong currents or tides, lock the main shaft.

- When the rotation of the propellers may cause injury to a diver over the side or damage to the equipment, lock the propeller shafts.

- When a ship is being towed, lock the propellers unless it is permissible and advantageous to allow the shafts to trail with the movement of the ship.

- When a shaft is allowed to turn or trail, the lubrication system must be in operation. In addition, keep a careful watch on the temperature within the low-pressure turbine casing to see that windage temperatures cannot be built up to a dangerous degree. This can be controlled either by the speed of the ship or by maintaining vacuum in the main condenser.

- Bring the main propeller shaft to a complete stop before engaging the clutch of the turning gear. (If the shaft is turning, it will cause considerable damage to the turning gear.)

- When the turning gear is engaged, set the brake quickly and securely to prevent the shaft from turning and damaging the turning gear.

- When a main shaft is to be unlocked, take precautions to disengage the turning gear clutch before releasing the brake. If the brake is released first, the main shaft may begin to rotate and cause injury to the turning gear and to personnel.

- In An emergency, when the ship is steaming at a high speed you can stop the main shaft and hold it stationary by the astern turbine until the ship has slowed down to a speed at which you can safely lock the main shaft.

- When there is a limiting maximum safe speed at which a ship can steam with a locked propeller shaft, know this speed and do not exceed it.

- Before the turning gear is engaged and started, check to see that the turning gear is properly lubricated. Some ships have a valve in the oil supply line leading to the turning gear. See that a lube-oil service pump is in operation and that the proper oil pressure is being supplied to the turning gear before the motor is started.

- Definitely determine that the turning gear has been disengaged before the main engines are turned over.

- While working on or inspecting an open main reduction gear, the person or persons performing the work should not have any article about their person that may accidentally fall into the gear case.

- Tools, lights, and mirrors used to work on or inspect gears, bearings, and so forth, should be lashed and secured to prevent them from being accidentally dropped into the gear case.

SUMMARY

This chapter has given you an overview of main reduction gears. It is not intended as a substitute for information on cperations and maintenance manuals; we have referred to three publications where it was appropriate.

You were introduced to the types of reduction gears and their operations. You were given information on lubrication, getting underway, checking for unusual noises, and some of the procedures used to maintain the gears and their related parts. Last, you were given some pointers on reduction gear security and safety precautions.

If some of these areas are not as clear as they should be to you, review them now while you remember the gaps in your knowledge.

CHAPTER 4

STEAM-DRIVEN GENERATORS

Electrical power, a vital part of today's modem Navy, is provided throughout naval ships by steam-driven turbogenerators. The number and size of the generators aboard each class of ship are determined by such factors as safety, reliability, and power requirements. Now, in the computer age, the demand for turbogenerator reliability is greater than ever.

In this chapter, we will discuss the factors that contribute to generator reliability, operation, inspection, maintenance, and repair. Before studying the material in this chapter, you may find it helpful to review chapter 2, "Steam Turbines" in Machinist's Mate 3 & 2.

OPERATING GENERATOR TURBINES

The following paragraphs will discuss the operation of generator turbines. This will include both starting and securing procedures.

STARTING GENERATOR TURBINE

When a turbine is first put into service, it is subject to variable expansion caused by changing conditions in internal pressure and temperature. Therefore, you need to allow a reasonable length of time for the turbine to warm up, to gradually come up to speed, and to apply its load. If the instructions of the turbine manufacturer and the engineering operational sequencing system (EOSS) are carefully observed, you will have a successful operation.

When starting a turbine that is driving an electric generator, follow these procedures

1. Ensure that the turbine is free of all loose material and that all working parts are clean and well lubricated. Test all safety devices where practical, tripping them by hand to ensure proper functioning.

2. Be sure that the temperature of oil in the sump is at least 60°F. The level of oil in the sump should be approximately at the maximum mark on the oil level gauge.

3. Take and record the cold reading of the axial setting of the rotor. This can be done with a rotor position indicator or micrometer.

4. Turn the unit by hand if a strap wrench is provided. It should turn easily and without noise or grinding of any kind.

5. Ensure the overspeed trip mechanism is properly set.

6. Open the drain valves ahead of the throttle valve; warm the piping gradually and drain all condensate.

7. Place the auxiliary condenser into service and bring up the vacuum to about 15 inches of mercury.

8. Start the oil pump, and pump oil to the bearings. Some older generators may have a hand oil pump. In that case, turn the hand oil pump continuously until the attached pump takes charge. Check pressure gauges and sight flows to be sure that all bearings are receiving oil. The controlling valves generally are lifted by oil pressure from the pump, after which the throttle valve can be opened sufficiently to start the rotor spinning. Once the rotor has started revolving, immediately trip the throttle valve by hand to see that the tripping mechanism operates properly. Then reset the overspeed trip and again open the throttle valve to keep the rotor turning slowly.

9. Admit gland sealing steam to the shaft packings.

10. Bring the rotor to half speed and run at that speed for several minutes to warm up the casing and rotor. During the warming period, watch all bearing oil temperatures and listen for any rubbing, vibration, or other unusual noise.

11. When the temperature of the oil leaving the bearings reaches about 100°'F, start circulating water in the oil cooler. Regulate the flow to maintain the temperature of the oil.

12. When the turbine is satisfactorily warmed up, close the drain valves, increase vacuum, and bring the turbine up to operating speed.

When the unit is operating properly under control of the governor, the generator may be placed on the line in accordance with EOP. During normal operations of the turbine-driven generator, make periodic checks of sight flows, strainer baskets, pressures, and bearing temperatures. Record them on the appropriate logs. The satisfactory operation of the generator depends largely on the care it receives. Watch standing, as well as tests and inspections, should be performed in accordance with the requirements of the applicable technical manuals, the EOSS, and the engineering operation casualty control (EOCC).

SECURING GENERATOR TURBINES

One essential step to long life and successful operation of a turbine-driven generator is to ensure that it is properly secured. Improper securing may lead to corrosion of internal parts. The following are general procedures used to secure a generator turbine:

1. Remove the electrical load from the generator.
2. Close the throttle valve by striking the hand trip or overspeed tripping mechanism.
3. If the generator is equipped with **a** hand pump, operate that pump until the rotor stops to avoid unnecessary bearing wear.
4. Secure the steam supply to the packing.
5. Shut off the water to the oil cooler.
6. Close the root steam valve and open the drain valves to relieve pressure and drain the lines.
7. After all the condensate has drained out and the casing has cooled to engine-room temperature, close all the drains. To prevent corrosion, take every precaution to guard against steam bleeding into the turbine casing.

If you use the above procedures and correctly follow the EOSS, the turbine-driven generators will require less maintenance and repairs. This will increase the reliability of each unit.

TURBOGENERATOR MAINTENANCE

Satisfactory operation of turbogenerators depends largely on the care they receive. Perform all tests, inspections, preventive maintenance, and repairs in accordance with the planned maintenance system (PMS) and applicable technical equipment manuals.

One operating trouble that may result from improper maintenance is vibration. Before going into the actual details of maintenance, therefore, we will take a look at some of the causes of vibration.

VIBRATION

Vibration in a turbine indicates that the unit is not in proper working condition. As soon as this condition is noted, make a thorough investigation to determine the cause of the trouble. If you do not deal with the trouble immediately, defects will accumulate. Bearing and packing clearances will become excessive, and the bearings and packing will soon be ruined. If the turbine is kept in operation, further trouble may develop, which may result in complete disablement of the unit.

All rotating parts are balanced statically and dynamically before the unit is installed. Improper balance is not usually caused by excessive vibration. Instead, excessive vibration can almost always be traced to one or more of the following defects caused by improper maintenance:

- Wiped bearings or excessive oil clearance
- Worn thrust bearings
- Parts rubbing or binding (gland seal rings)
- Loose or broken foundation bolts
- Carbon or labyrinth packing clearances too small
- Misalignment between turbine and generator
- A bent shaft
- Damaged blading

Should a turbine vibrate to such an extent that you suspect an out-of-balance condition, take the following steps:

1. Examine all journal bearings and renew any bearings that have excessive clearances.
2. Examine the thrust bearing. Renew the thrust bearing if the clearance is excessive.
3. Inspect the turbine rotor for signs of damage, if inspection ports are provided.

4. Check the shaft packing rings for heating colors. If the clearance is too small, the vibration will become worse and the shaft will overheat. Stop and renew packing rings.

5. Check the shaft coupling bolts.

6. Check the coupling alignment.

7. Look for loose bolts in the unit. Replace or tighten bolts as necessary.

8. After completing steps 1 through 7, reassemble the unit and operate it at normal speed to see if the excessive vibration has been eliminated.

If the turbine continues to vibrate excessively, it is probably out of balance. In this event, a balance test must be made. Portable vibrational test equipment, available on tenders and repair ships, may be used to make a balance test with the turbine in place; or the unit may be tested at a shipyard. Only experienced personnel should be permitted to balance a turbogenerator, and the instructions of the manufacturer must be followed carefully. Details of the balancing must be recorded.

TURBINE MAINTENANCE

Steam turbine construction is relatively simple, and its basic reliability comes from this fact. The turbine contains few moving parts and practically no wearing types of parts. If the various linkages are kept greased, lubricating oil and steam are kept clean, and proper warming and securing procedures are followed, the turbine should operate for many years without any parts replacement. Primary shipboard maintenance objectives include a continuing awareness of changes in performance. Therefore, it is necessary to keep systems clean and to periodically check internal clearances.

Generator turbine maintenance requires regular inspections or checks of the maintenance items. Maintenance requirement cards (MRCs) for turbines are required for each preventive maintenance task. Where the PMS coverage applies, preventive maintenance should be conducted in accordance with the MRCs.

Gland Packing Maintenance

Packing is fitted around the shafts of generator turbines. This packing prevents leakage of steam from an ingress of air into the turbines under all conditions of operation. The staff packing must function properly to ensure efficient operation of a turbine. The shaft packing used on most turbogenerators is labyrinth-type rings or seals. This design simplifies the removal, repair, or replacement of packing.

Replace packing rings that show excessive wear. When new packing cannot be procured nor manufactured in the time frame available for turbine repairs, the existing rings can usually be machined to restore design clearances. In some cases you may have to replace the amount of metal removed by building up the outside diameter of the ring.

To obtain maximum effective sealing, maintain the tip width of packing teeth at 0.010 inch. Resharpen blunted teeth by scraping their sides. You can use either a bearing scraper or a cutting tool slotted to the shape of the tooth. Take care to avoid reduction of tooth height. For more information concerning repair of labyrinth packing, see NSTM, chapter 231.

Turbine Casing Joints

Take extreme care in cleaning turbine casing joints. Carefully scrape and clean joint surfaces, then polish them with crocus cloth. Carefully inspect the joint faces for burrs and bruises. Never use sheet gasket material to remake a steam casing joint.

To seal the joint of a turbine, coat the surfaces with a thin layer of linseed oil and graphite or copalite. Set up opposite bolts fairly tightly and then follow around until all bolts are firmly secured.

The horizontal joint of some generator turbines is grooved in the lower half to provide a means for pressure pumping the groove with a sealing compound. Do not fill these grooves except in an emergency. Do not fill them during routine overhaul unless the flange surfaces are in poor condition and time and facilities do not permit resurfacing. Use only approved compounds to fill these grooves.

To fill the grooves, remove one end plug and the adjacent plug. Using the gun provided, start at the end hole and pump in the sealing compound until it flows out of the adjacent hole. Now, plug the first hole and place the gun in the adjacent hole. Remove the plug from the next hole and fill the next section of the groove in the same manner. Continue until the entire groove is filled. With the gun in the next to the last hole and with the sealing compound flowing from the last hole, plug the end hole and put pressure

on the entire groove. Then remove the gun, and plug the next to the last hole.

Once this operation has been started, carry it out rapidly and continuously to finish filling the groove before the sealing compound hardens.

Rotor Clearances

Axial flow turbines are usually provided with an opening in the casing to check blade clearance. As with main propulsion turbines, insert a tapered gauge between the nozzle diaphragm and the adjacent row of blades to measure blade clearance. If the blade clearance is outside the limits prescribed by the manufacturer, adjust the position of the rotor by changing the thickness of the filler piece in the thrust bearing before the unit is operated again. After each rotor adjustment, rotate the unit by hand to make sure there is no rubbing, binding, or undue friction. Also, check the gear tooth contact of the reduction gear.

Nozzle Diaphragm Maintenance

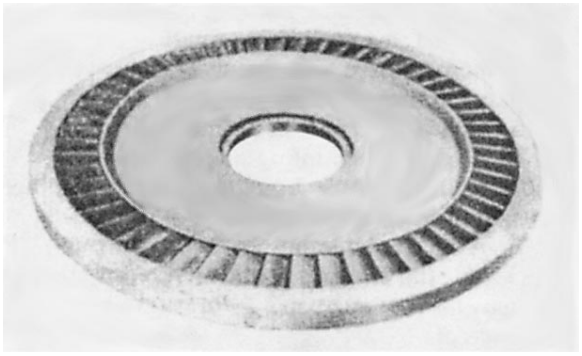
Repairs of labyrinth packing in nozzle diaphragms are normally done by shipyard, tender, or repair ship personnel. However, you should be familiar with the procedures. See the manufacturer's technical manual for more detailed information.

Nozzle diaphragms (fig. 4-1) are part of each stage of a pressure-compounded impulse turbine. Labyrinth packing and, in a few cases, carbon seals are used between the inner bore of the nozzle diaphragm and the rotor to seal against steam leakage.

To inspect or renew the labyrinth packing in a nozzle diaphragm, you must remove the upper half of the turbine casing. When the casing is lifted, the upper half of the diaphragms and the labyrinth packing will remain in the upper half of the turbine casing. When the casing has been moved to a convenient location, the segments of labyrinth packing can be removed by pushing them around in their grooves, away from the stop pin.

Corrosion

Inspect the turbine casing, especially near glands and in locations where water may collect in pockets or in lagging. Experience has shown that where water or dampness remains in contact with the casing, corrosion



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Figure 4-1.-Nozzle diaphragm with labyrinth packing.

can seriously weaken the casing. Be sure that drain holes provided in pockets are kept open and of sufficient size. When corrosion is evident, remove the lagging and scrape down the surface of the casing to good metal. Next, dry and paint the surface with two coats of approved paint. Then replace the lagging and take steps to prevent recurrence of corrosion.

You can prevent most internal corrosion and rusting that impairs reliability and economy of turbine operation. Do this by continuing operation of air ejectors for a short time to dry the machine after it has been shut down and while it is still hot. The blade path of the turbine is provided with passages to drain any condensate in interblade row cavities.

In some cases, serious corrosion has been caused by chemical action. Inspect interiors as frequently as possible. If corrosion has begun, determine its cause and eliminate it. You can use a mirror to help inspect the interior of a turbine. Be careful that you do not drop it inside the turbine. Refer to PMS or NSTM, chapter 231, for required inspection intervals.

REDUCTION GEAR MAINTENANCE

Turbogenerator reduction gears are generally of the single-reduction, single-helical type, with a reduction of about 8 to 1. In three-bearing designs, the pinion is forged and cut integral with its shaft. One end of the pinion shaft has a flange that bolts rigidly to the turbine shaft, and one end of the turbine rotor is supported by the pinion bearing. The other end of the pinion shaft has an extension on which the high-speed thrust bearing is assembled. In four-bearing designs, the pinion shaft is flexibly coupled to the turbine shaft, with two bearings supporting each shaft.

A flexible coupling of the double-ended dental type is usually used in these four-bearing designs.

The gear wheel is forged, shrunk, and keyed to the shaft. One end of the shaft is coupled to the generator shaft; part of the weight of the generator rotor is carried by the gear bearing at that end. The turbine end of the gear shaft is extended to carry the worm gear; the worm gear drives the oil pump and the governor.

The gear casing is of fabricated construction and is split at the horizontal center line of the rotor. The bearing seats are welded integral with the lower half of the gear casing. In most installations, cross members and ribs are welded into the casing to form a rigid structure for supporting the rotating elements, the oil pump, and the thrust bearing.

A reduction gear is carefully assembled and aligned for even tooth and bearing loadings to ensure that it will operate with a minimum of maintenance. However, the following paragraphs cover problems that may occur.

Do not allow the gear bearings to wear enough to cause incorrect tooth contact. For proper operation of gears, the total tooth pressure should be uniformly distributed over the total length of the tooth faces. This can only be done by accurate alignment and strict adherence to the designed clearances.

Gear misalignment after prolonged operation is usually traceable to a sudden wearing or wiping of the bearings. This misalignment can be corrected by bearing replacement. However, the installation of new bearings requires a thorough check on the alignment of the gear mesh to assure at least 90-percent contact. The replacement of bearings that exceed tolerances because of normal wear can be detrimental to the operation of the turbogenerator. The gears essentially wear to a conjugate tooth form after prolonged operation. Therefore, replacement of the bearings may cause the gears to operate at different center distances. This may cause a noisy operation. Whenever bearings are replaced, the gear alignment must be checked, and any corrective action should be taken by competent naval repair personnel.

There may be initial pitting of gear tooth faces during the early operation of the unit in service. This may be caused from poor alignment or machining errors in gear tooth profile and helices. The pitting will be localized and will indicate the tooth areas with excessive load concentrations. Such conditions should be corrected, or progressive pitting will continue and can cause general deterioration. Minute high spots in the gear tooth produced by gear bobbing or finishing techniques will also cause initial pitting. However, in this case, the pitting will be distributed over the active face, and the pitting should stop with continued service operation.

You should keep complete and adequate records to properly evaluate the cause of pitting and decide whether or not it is progressive.

Where there is pitting of the elements, metal particles from the pitted areas may be entrapped in the mesh and form raised and depressed areas. To remove the high spots, use a fine grade of Carborundum stone. Do not use files or coarse stoning that can damage the tooth contour.

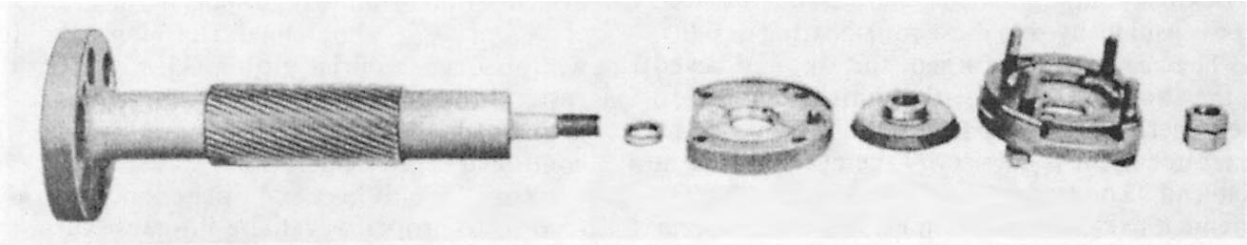
Another source of damage to the gears is foreign particles in the lubricating oil. The continued passage of these particles will destroy the original involute tooth profile. Noisy operation will be caused by the dynamic forces produced by tooth tips contacting the wear shoulder in the flanks of the mating gear teeth. Such noise is most pronounced under lightly loaded conditions when the oil film thickness of the bearing causes the gear elements to operate at minimum center distance. Under heavy loads, the bearing oil film thickness diminishes, and the gears operate under maximum center distance. Under the heavy load conditions, the mating elements withdraw from each other causing the tooth tips of one element to interfere with the wear shoulder of the mating tooth. This will reduce the tooth surface. This type of wear results in the gears having to be replaced or recut.

Foreign particles will also cause high spots, which have a highly polished appearance after prolonged operation. Such areas of heavy contact can eventually cause fatigue failure of the highly loaded portion of the tooth. Only experienced personnel should make corrections to the tooth profile to alleviate these conditions.

Almost all tests, inspections, and maintenance and repair procedures for main reduction gears also apply to turbogenerator reduction gears. Make a visual inspection of the tooth contact of the pinion gear and the main gear periodically and keep a record of the condition of the teeth.

BEARING MAINTENANCE

Chapter 2 of this manual covered propulsion turbines. You will find many similarities between the repairs of bearings in propulsion turbines and those in ship's service turbogenerators. At the same time, you will find that some bearings



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Figure 4-2.—Collar and plate type thrust bearing.

differ radically between these two kinds of turbines. Therefore, use the following information as a guide, but be sure you go to the manufacturer's technical manual before you begin actual repairs.

At regular intervals, make checks and take clearance readings of turbogenerator journal bearings and thrust bearings, including thrust collars and thrust plates, to help you anticipate the need for repairs.

Most journal bearings are cylindrical and of the steel-backed, babbitt-lined type. They are split on the horizontal center line to help in their installation and removal. Some newer turbo-generators have the pivoted segmental journal bearing. Most journal bearings are prevented from rotating by setscrews or by dowel pins. Journal bearings that are installed and operated properly and receive sufficient preventive maintenance will give many years of satisfactory service. The manufacturer's technical manual and and NSTM, chapter 244, contain information on the operation and maintenance of these bearings.

On most turbogenerators, the reduction gear casing must be removed before you can reach the pinion gear bearings, the main gear bearings, and the slow-speed thrust bearing. You can remove the forward turbine bearing, the generator pedestal bearing, and the high-speed thrust bearing by lifting the bearing caps and removing the bearings.

On many installations, the thrust bearing (fig. 4-2) consists of a thrust collar and two thrust plates. The thrust collar is locked to the pinion shaft, and the thrust plates are bolted to the casing. The axial position of the thrust collar is determined by the spacer or shim, which is ground to the desired thickness at assembly. The total running clearance between the stationary plates and the rotating element of the thrust bearing should be obtained from the manufacturer's equipment manual. Adjust this clearance by removing or adding shims to the two stationary thrust plates.

The axial position of the generator rotor is maintained by the thrust faces on the gear bearings, which bear against the thrust surfaces machined on the ends of the gear hub. Clearance is adjusted by means of a filler piece between the thrust shoulders of the gear bearings and the gear casing. The low-speed thrust bearing will show little wear under normal operating conditions. The original clearance will change very little in service. If the thrust surfaces do wear, as the result of faulty operation or improper lubrication, they should be replaced or rebabbitted when the total running clearance exceeds the manufacturer's recommendations. Instructions for adjusting the thrust clearance or renewing the thrust bearings are given in the manufacturer's technical manual. Check the applicable blueprints and technical manuals before you attempt any adjustments or repairs to these bearings.

In most installations, to remove the high-speed thrust bearing for inspection or repair, follow these steps:

1. Remove the upper and lower halves of the thrust bearing cover.
2. Remove the four bolts from the outer thrust plate.
3. Remove the outer thrust plate.
4. Remove the locknut and the securing nut from the pinion shaft.
5. Remove the thrust collar and the inner thrust plate.

If the high-speed thrust bearing needs adjustment, follow these steps:

1. Remove the thrust bearing cover.
2. Remove the four bolts from the outer thrust plate.

3. Remove the outer thrust plate.

4. Move the turbine rotor axially in the direction of the generator until the first-stage turbine wheel hits against the nozzles.

5. Set the distance between the face of the thrust collar and the land of the inner thrust plate to the clearance desired between the first-stage turbine wheel and the nozzle) plus the running clearance of the thrust bearing. Machine the locating spacer to the proper thickness to obtain this clearance.

6. Replace the locating spacer and lock the thrust collar in position on the shaft.

7. Replace the outer thrust plate.

8. Take a thrust clearance reading to determine total clearance of the thrust bearing.

9. If the thrust reading is satisfactory, replace the bearing cover and rotate the unit by hand. If there is no undue friction or binding, the unit may be turned by steam.

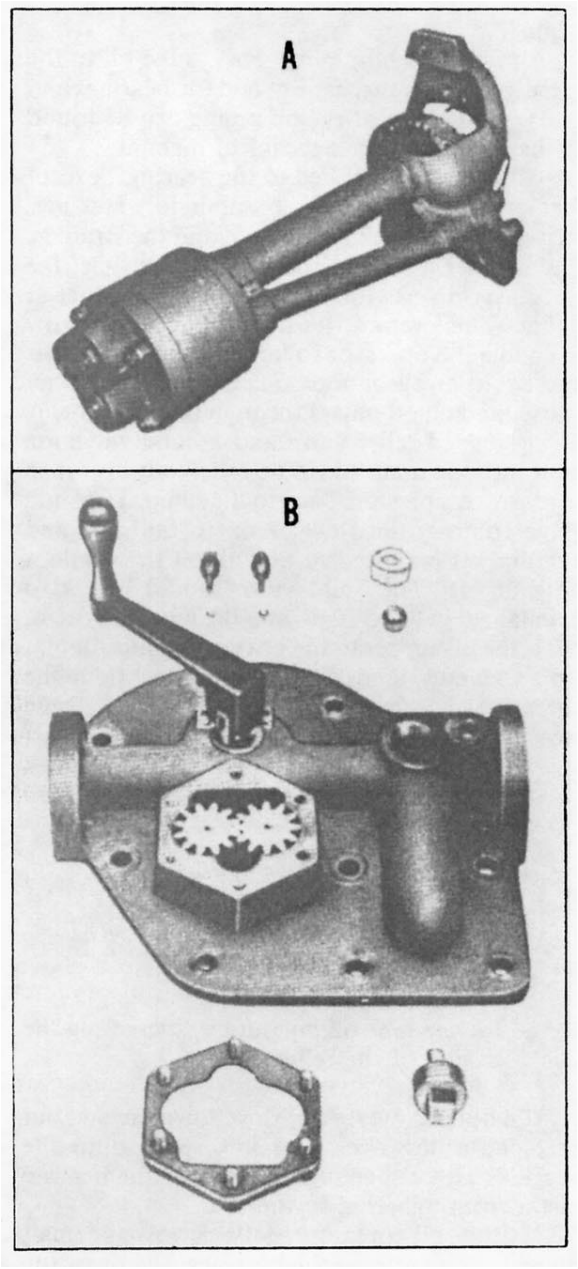
After setting the high-speed thrust bearing, set the position of the generator rotor so that the face of the gear is centered with the face of the pinion when both are in a loaded position. Move the turbine rotor in the direction of the generator, and move the generator rotor in the direction of the turbine as far as the thrust bearings will permit; set the gear rotor in this position and obtain the proper clearance by using the proper thickness of shims behind the thrust shoulder of the gear bearings.

On turbogenerator installations that use a Kingsbury thrust bearing, carry out the tests, inspections, maintenance, and repairs in the same manner as those for main propulsion turbines. The procedure is described in the manufacturers' technical manuals and in NSTM, chapter 244.

LUBE-OIL SYSTEM MAINTENANCE

Oil pressure to operate the constant-speed governor and lubricate the bearings and gears is supplied by a gear type of pump (view A, fig. 4-3). This pump is located in the base of the gear casings and driven from the low-speed gear shaft.

The separate hand-operated oil pump (view B, fig. 4-3) used to supply oil to the bearings and to the valve gear for starting is located on the gear casing.



96.21

Figure 4-3.-A. Main oil pump. B. Hand-operated oil pump.

Some ships include a third oil pump driven by an electric motor. This pump, mounted on the generator foundation, supplies lube oil to the generator while it is being started or secured. It is normally started and stopped manually. The pump may also be used as an emergency pump. Once the generator is running, the electric pump may be set so that if the oil pressure falls to a predetermined point (below normal), a pressure-sensing device

located in the oil system will start the electric pump.

A system of oil piping conveys the oil to the speed-governing mechanism and the bearings and gears. A diagram of the oil piping can be found in the manufacturer's technical manual.

All of the oil supplied to the bearings, except that supplied by the hand pump before starting, passes through the oil manifold and the strainer. The strainer assembly is of the duplex type; the shift lever diverts the oil to only one strainer at a time. The lever carries a notation or an arrow to enable the operator to know which strainer is in use. The arrow or notation points to the strainer in use, and all oil passes through this element. A spring-loaded relief valve and a hand valve are built into the manifold. The relief valve is set to relieve excess pressure back to the sump. The hand valve controls the flow of oil to the gear and bearings. It is slotted so that all oil flow cannot be shut off. The hand valve should be set to maintain about 8 to 10 psig on the lube-oil system.

If the oil supply to the bearings is interrupted, stop the unit immediately and then take the necessary steps to restart the oil circulation. These steps may include any one, or a combination of, the following:

- Clean the strainers.
- Repair any broken line.
- Remove any obstructions from the line.
- Add oil to the sump tank.
- Increase the oil pressure by increasing the setting of the relief valve.

If a bearing overheats, slow down the unit but keep it turning over at a low speed until the bearings are cool enough to prevent the bearing metal from adhering to the shaft.

If the oil pressure falls below normal, immediately examine the bearings, the lines, the strainers, and the oil level in the sump tank. If temporary repairs cannot be made satisfactorily with the unit operating, the unit must be secured.

There are several causes for oil leakage from a turbogenerator. The majority of these causes can be corrected by operating personnel. The following list shows causes of leakage with corrective measures to be taken:

1. If oil leakage occurs where a shaft emerges from a casing, the oil seals or deflectors may be excessively worn or damaged and must be replaced to stop the oil leakage.

2. The oil return holes may become clogged with residue from the oil. As the bearings wear and the holes become clogged with dirt, a greater quantity of oil than the holes can accommodate will pass through the bearings. If the bearings are badly worn, the only remedy is to fit new bearings. When the bearings are disassembled for inspection or overhaul, clear the oil passages and oil return holes of all sediment.

3. If the relief valve setting is too high, the oil pressure will be excessive and may cause oil leaks at the bearing ends. You can slightly reduce the relief valve setting to allow some of the oil to be bypassed back to the sump tank.

4. Oil leakage frequently occurs at flanges in the discharge piping. In some instances, you can tighten the flange to stop the leak. In others, you must renew the gasket. In extreme instances, you must take apart the flanges and machine the surfaces true.

When the turbogenerator is operating, clean the lube-oil strainers at least once each watch. Excessive pressure drop across the strainer indicates the need for cleaning. Two strainers are installed for each unit, but only one strainer is in the operating position. The idle strainer can be removed and cleaned. When cleaning a strainer, take care to remove any metal particles adhering to the magnets in the strainer basket. When replacing a strainer, ensure that the inner circular face is against its proper shoulder. If the strainer does not readily fit in the manifold body, do not try to tighten the cover plate; fit the strainer properly against its shoulder.

After putting the cover plate in place, fill the idle strainer with oil. To do this, open the vent and turn the transfer valve slightly toward the idle strainer until oil comes out of the vent. After you have closed the vent valve, the strainer is ready to be put in service.

Any change in the oil temperature drop through the oil cooler when all other conditions remain the same indicates that the water or oil side of the cooler requires cleaning. Even without this indication, the oil cooler tube bundle should be cleaned at regular intervals. To clean the cooler, follow these steps:

1. Turn the cooler bypass valve to the full bypass position. Shut off the water to the cooler. Drain the water side and then the oil side of the cooler.

2. Remove the main head and the floating (lower) head.

3. Remove the gland and the packing.

4. Press upward on the floating (lower) tube sheet. Grasp the main tube sheet when it passes out of the shell and draw the tube bundle straight up, taking care not to let it get out of direct line with the cooler bore and thus damage the baffles.

5. Clean the external surfaces of the oil cooler with a jet of hot water. Clean the internal surfaces of the tubes with a round bristle brush (never use a wire brush for this purpose). Clean the internal surfaces while they are still wet. If the surfaces are allowed to dry, the saltwater deposits will be difficult to remove.

6. In replacing the tube bundle, take care that the baffles do not catch on the shell, as this will cause them to carry the entire weight of the tube bundle.

7. Vent the air from the water and oil circuits after circulation has been started.

8. When the cooler is put in use (after reassembly), carefully check the gaskets and packing for leaks. If there are no leaks, the cooler is ready for routine use.

All turbine-driven generators have a lube-oil low-pressure alarm. The alarm contactor is located in the lube-oil line leading to the bearings. The contactor is connected to an audible alarm and to a signal light. The contact or will close an electrical circuit to the alarm when excessively low lube-oil pressure occurs. The circuit is closed when the unit is not in operation. Therefore, a manual switch must be opened to keep the alarm from sounding. When the unit is brought up to speed, the manual switch must be closed to make the alarm operative.

The contactor is set at the factory to operate when the oil pressure drops to 4 psig, and this setting should be maintained. Follow the instructions contained in the manufacturer's technical manual when making any adjustment to the contactor.

There are at least two pressure gauges to indicate oil pressures throughout the system.

The high-pressure gauge indicates the oil pressure delivered by the pump. This is the pressure that is applied to the governor and to the oil strainers. This gauge is labeled OIL PUMP PRESSURE; and the normal reading is from 50 to 100 psig, depending on the type of governor used.

The low-pressure gauge indicates the oil pressure in the lube-oil lines to the bearings and the reduction gears. This gauge is labeled BEARING OIL PRESSURE, and the normal reading for this gauge is about 8 to 10 psig.

ALIGNMENT

Successful operation of the turbogenerator set requires accurate alignment of the entire unit. This requires accurate setting of the gear casing, turbine casing, and adjustment of bearings. This is essential to obtain satisfactory tooth contact and proper load distribution on the bearings. It is also necessary that when the pinion and turbine shafts are coupled together that they run true with one another. Incorrect alignment may cause vibration, unsatisfactory contact of the gear and pinion teeth, unsatisfactory operation, and, finally, complete failure of the unit.

Under normal circumstances, turbogenerators will be aligned by shipyard, tender, or repair ship personnel. If the services of a shipyard, tender, or repair ship are not available, the following checks may be made by the ship's force, using these steps:

1. Check all foundation bolts to see that they are tight.

2. Check tooth contact by applying very thin layers of prussian blue to several gear teeth and applying red lead to several pinion teeth. Next rotate the pinion in a clockwise direction (when looking at the unit from the turbine end). The contact markings should cover at least 90 percent of the length of the tooth and be equally heavy at both ends of the helix.

3. If the tooth contact is unsatisfactory, you can determine the extent of bearing wear by measuring the crown thickness of the bearings. Measure the clearances of the high-speed and the low-speed thrust bearings.

4. If it is found that one of the pinion bearings or one of the main gear bearings is worn more than 0.002 inch more than the other bearing, replace or restore the bearings to design clearance. If the crown thicknesses of these bearings are satisfactory and misalignment is suspected, the units will have to be realigned by shipyard, tender, or repair ship personnel. The designed and maximum clearances of bearings are shown on applicable blueprints and given in the manufacturer's technical manuals. If blueprints and technical manuals are not available, it is recommended that the limits given in NSTM, chapter 244, be followed. These limits are to be used as a guide; bearing should be renewed, or other

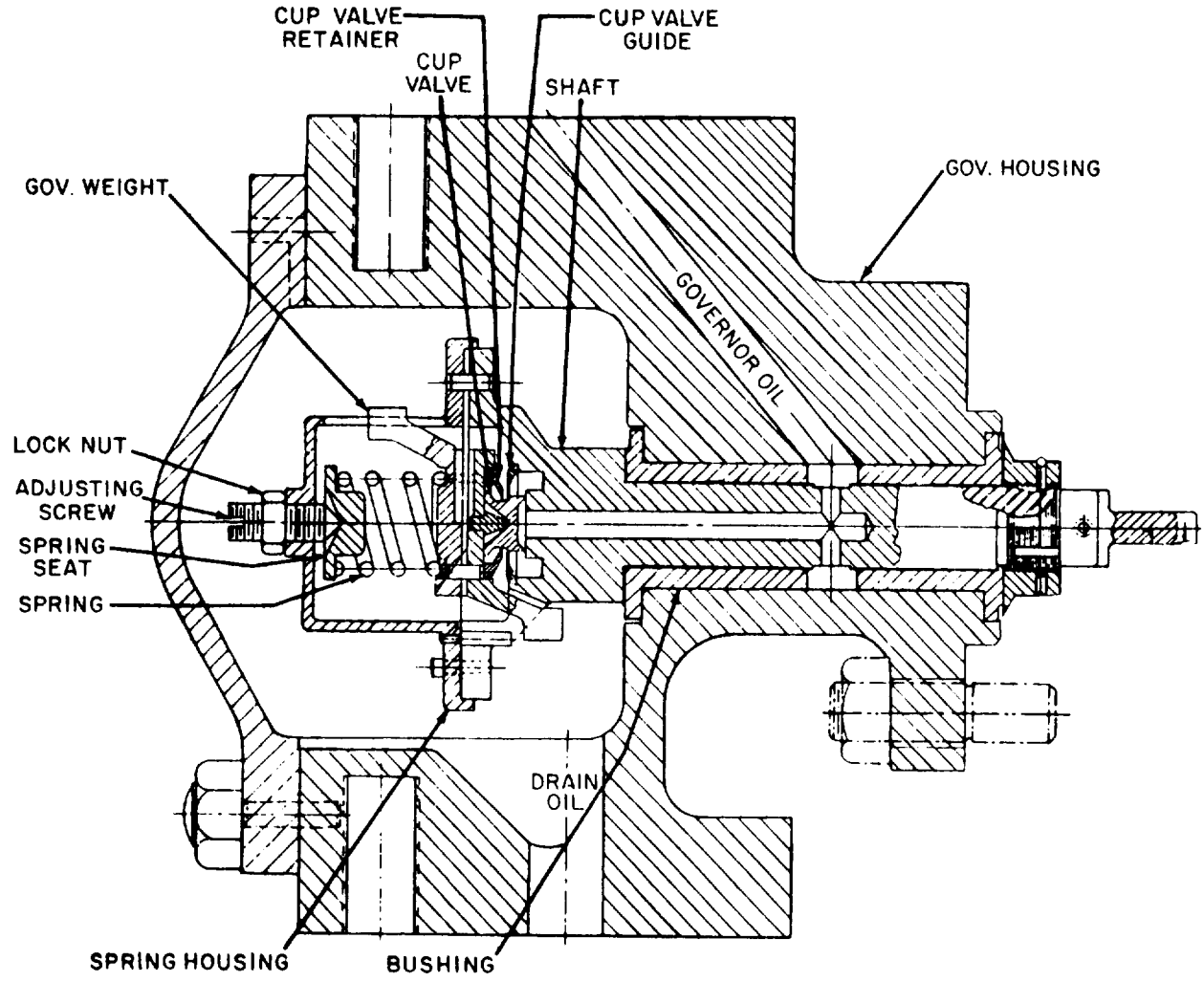


Figure 4-4.–Governor.

applicable repairs should be made, if a smaller amount of bearing wear causes vibration, misalignment, or other abnormal operating conditions.

CONTROL AND SAFETY DEVICES

Turbine-driven generators are equipped with the following control and safety devices:

- A constant-speed governor
- An overspeed trip
- A manual trip
- A lube-oil low-pressure alarm
- A relief valve
- A sentinel valve
- A back-pressure trip
- A gland seal steam regulator

Maintenance consists mainly of keeping all moving parts free of paint, rust, and dirt so that there will be no undue binding or friction. The governor is set at the factory, and the setting should not be changed. Damaged governors should be sent to the factory for repair and adjustment.

Any change in speed range or regulation should be made by adjusting the governor spring

tension. The tension is set properly at the factory and should not be changed unless absolutely necessary. *Regulation* is a term used to express the change in speed that occurs with a change in load. Regulation is usually stated as a percent change in speed that occurs when passing from no load to full load and is based on full-load speed.

Figure 4-4 shows one type of governor used on Navy ships. A constant-speed (speed-regulating) governor is defined as a governor which controls and regulates the admission of the steam to a turbine. In doing so, it automatically maintains the speed of the turbine at a predetermined rate under all conditions of load and exhaust pressure within the limits of design of the turbine. The governor shaft is located horizontally and is driven directly from the turbine rotor shaft through the overspeed trip body. Governors of this class are of the hydraulic relay type. They are centrifugally controlled, and lubricating oil is used as the relaying medium for the actuating force.

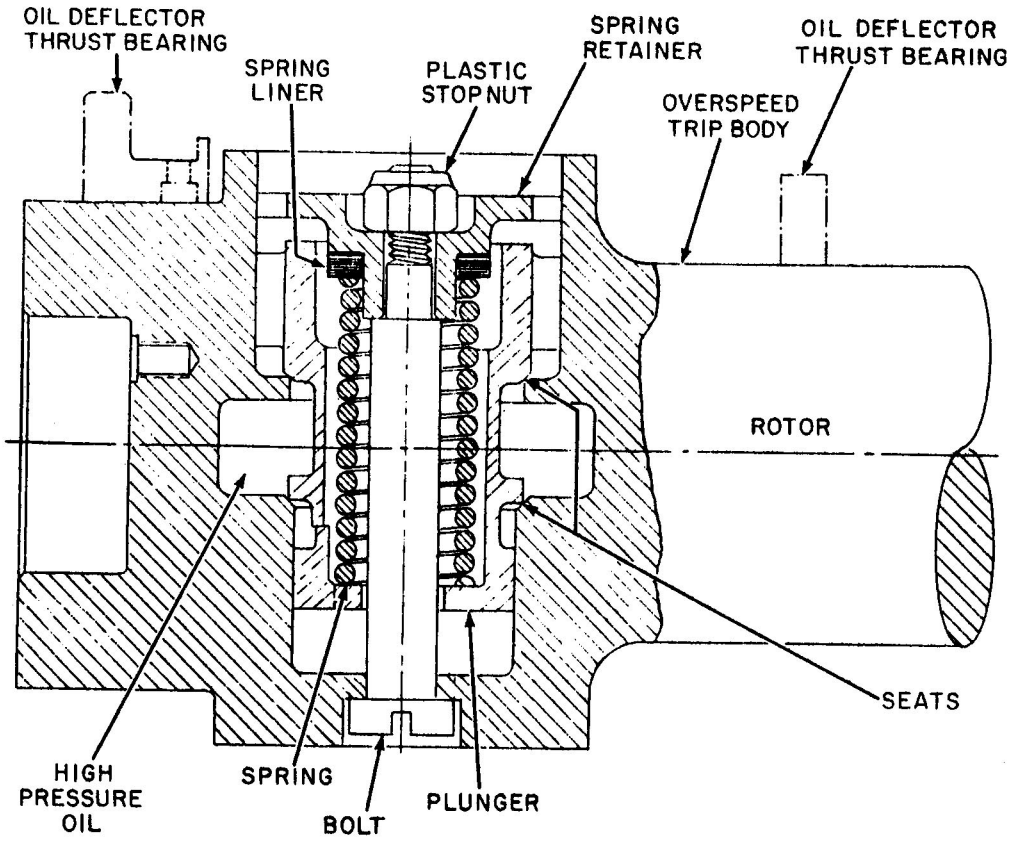
The turbine governor is set at the factory to operate at a predetermined rate with tolerance.

Do not make adjustments or repairs on a constant-speed governor without first carefully checking the manufacturer's technical manual for details on maintenance.

The overspeed trip is a device that automatically releases the operating oil pressure under the throttle valve operating piston. This allows the piston spring to close the valve. The mechanism includes a trip of the eccentric weight shaft type that functions as an oil release valve and is mounted on the thrust end of the turbine rotor. One type of overspeed trip for turbo-generators is shown in figure 4-5.

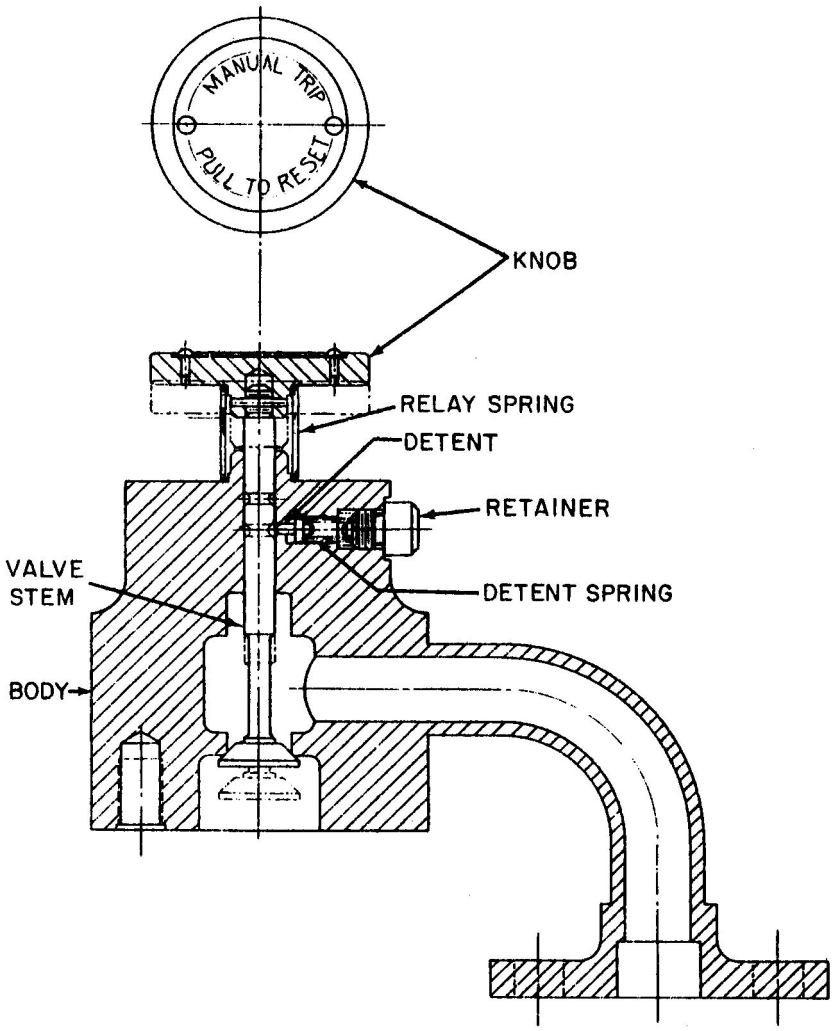
At the predetermined speed for which the device is set, the centrifugal force overcomes the spring resistance. The plunger moves outward, opening to drain the throttle valve operating oil from the cavity formed under the plunger. This mechanism opens to drain the operating oil line leading to the throttle valve operating cylinder, and loss of oil pressure causes the turbine throttle valve to be closed by the loading spring.

Once the turbine unit has been tripped through the overspeed trip mechanism, normal turbine



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Figure 4-5.—Overspeed trip.



96.48

Figure 4-6.-Manual trip.

operation cannot be resumed until the throttle valve handwheel has been fully closed. The manual trip mechanism should be in the reset position.

Overspeed trips are set at the factory and should be trouble free. If for any reason the plunger should hang up or the tripping speed should change so that an adjustment is required, disassembly will be necessary.

The manual trip (fig. 4-6) is used to stop the flow of steam to the turbine in an emergency. It is also used to secure the unit in a normal manner.

Under normal operating conditions, the parts are held in the latched position by the spring-loaded detent that fits into circumferential grooves machined in the valve stem. The detent is ready to operate by depressing the knob. The oil supply to the throttle valve is metered so that the oil can be drained faster than it can be supplied. Whenever any of the protective devices are activated, the resulting oil pressure drop permits the spring to close the throttle valve.

To reset the manual trip after if has tripped and closed the throttle valve, proceed as follows: Turn the throttle valve handwheel to the CLOSED position. Manually place the tripping mechanism in the CLOSED or RESET position. This closes the oil drain and allows oil pressure to build up, thus permitting the throttle valve to open when the handwheel is turned in the open direction.

The trip mechanism is designed and built to give trouble-free service, under normal operation, for the life of the unit, However, if foreign matter gets into the lubricating oil, it may score

the valve or become lodged under the valve and interfere with its operation. If the valve will not close tightly, try to free it with ordinary flushing by tripping the unit several times. If the valve cannot be freed in this manner or the valve becomes scored, the mechanism will have to be removed from the unit, taken apart, and manually cleaned and inspected. To do this, consult the manufacturer's technical manual for details.

The lube-oil low-pressure alarm is a safety device installed to warn the operator when the lube-oil pressure drops to a dangerously low point. The operation of this device is described earlier in this chapter under the heading Lube-Oil System Maintenance.

Three devices are used to protect the turbine against excessive exhaust pressure: a sentinel valve, a back-pressure tripping device, and a relief valve.

The small (usually one-half inch) sentinel valve is mounted on the upper half of the exhaust casing to warn the operator of excessive exhaust pressure. The valve is spring-loaded and set to function at 2 psig. This setting should be maintained.

The back-pressure trip (fig. 4-7) is set at the factory to function at 5 psig. This setting should not be changed. The relief valve is spring-loaded and mounted on the exhaust end of the turbine, which permits the turbine to exhaust through it.

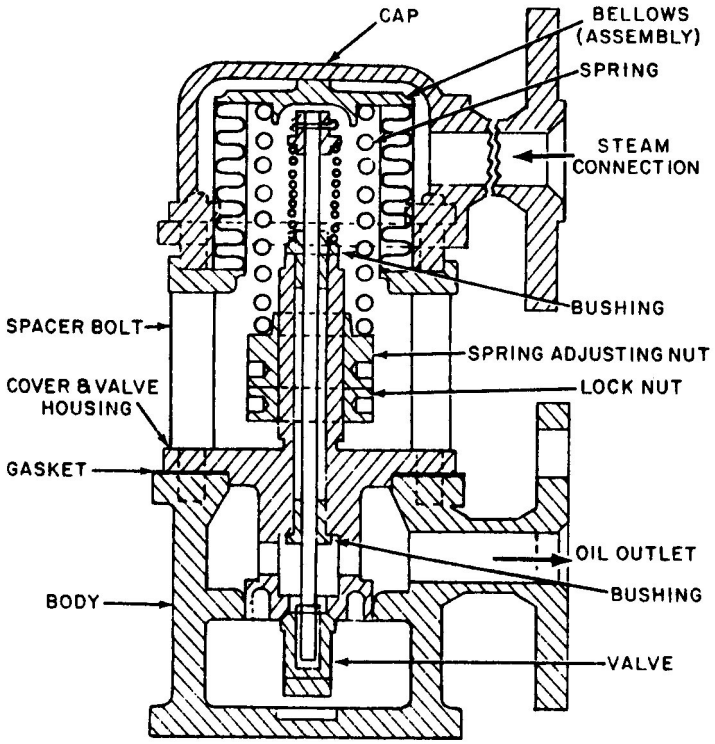
The relief valve is normally set to open at 10 to 15 psig (5 psig above the setting of the back-pressure trip). Most relief valves are fitted with a water gauge. The presence of water in the gauge indicates that the valve is closed and properly sealed with water.

When a loss of vacuum in the auxiliary condenser occurs, the sentinel valve will lift when the pressure reaches 2 psig. If the deficiency is not corrected and the pressure continues to increase, the back-pressure trip will function to shut down the unit.

Steam exhaust pressure above 5 psig opens the trip valve. Oil then flows through the trip assembly to drain, and the throttle valve closes. The throttle cannot be reopened until the exhaust pressure falls to less than 5 psig. At that time the trip valve closes and the oil pressure is built up under the throttle valve.

In the event that the back-pressure trip fails to function, the relief valve will function at a pressure of 5 psig above the setting of the back-pressure trip.

Loss of vacuum in the auxiliary condenser is the most frequent casualty to turbogenerators. Insufficient gland sealing steam (or complete loss



96.49

Figure 4-7.—Back-pressure trip.

of gland sealing steam) is a major cause of this casualty. Some ships have automatic gland sealing steam regulators on turbogenerators (and also on main propulsion turbines) to automatically control gland sealing steam and thus help to prevent loss of vacuum in the condensers.

The two regulator valves, shown in figure 4-8, make up the main component of one type of gland sealing steam system. The self-operated make-up valve (view A, fig. 4-8) is a spring-loaded, diaphragm-operated valve and actuator, requiring steam pressure to close. A handwheel is mounted in the top diaphragm casing for manual operation. The self-operated, unloading valve (view B, fig. 4-8) is a spring-loaded, diaphragm operated valve and actuator, requiring steam pressure to open it. A handwheel is mounted in the top diaphragm casing for manual operation.

Steam of sufficient quantity to seal the glands is taken from the ship's supply line at a variable pressure. It is then reduced to 2 psig, and the supply is automatically controlled by the diaphragm-operated make-up valve. Excess steam, above the amount required by the existing operating conditions for gland sealing, is automatically discharged through the diaphragm-operated unloading valve onto the condenser. The gland sealing steam requirements will vary over a wide range of turbine operating conditions, from light to heavy loads. The sealing steam demands will be greatest while the turbine is being started or operating at light loads. Conversely, the sealing steam demand will be at a minimum while the turbine operates at heavy loads. With the regulating valves properly adjusted, the sequence of their operation is as follows:

With auxiliary steam being supplied to the actuator portion of the valves, the steam enters and flows to one side of the spring-loaded diaphragms. The pressure of the sealing steam flowing through the make-up valve into the header and then to the turbine glands is reflected upon the upper surface of the diaphragm in the make-up valve and the lower surface of the diaphragm in the unloading valve. The diaphragm spring-loadings are adjusted to a predetermined value. When the gland sealing steam pressure in the header becomes high enough to overcome the individual spring-loading, the make-up valve diaphragm and its connected stem and valve plug move downward, which closes the valve. At the same time, the unloading valve diaphragm, stem, and valve move upward to the open position. Then, should the gland sealing steam pressure fall below the operational requirements, this decrease in pressure is reflected upon the upper surface of the diaphragm in the make-up valve and the lower surface of the diaphragm in the unloading valve. Since the counterbalancing steam force has been decreased, the individual valve springs will move the valve stem and plug upward in the make-up valve to open it and downward in the unloading valve to close it.

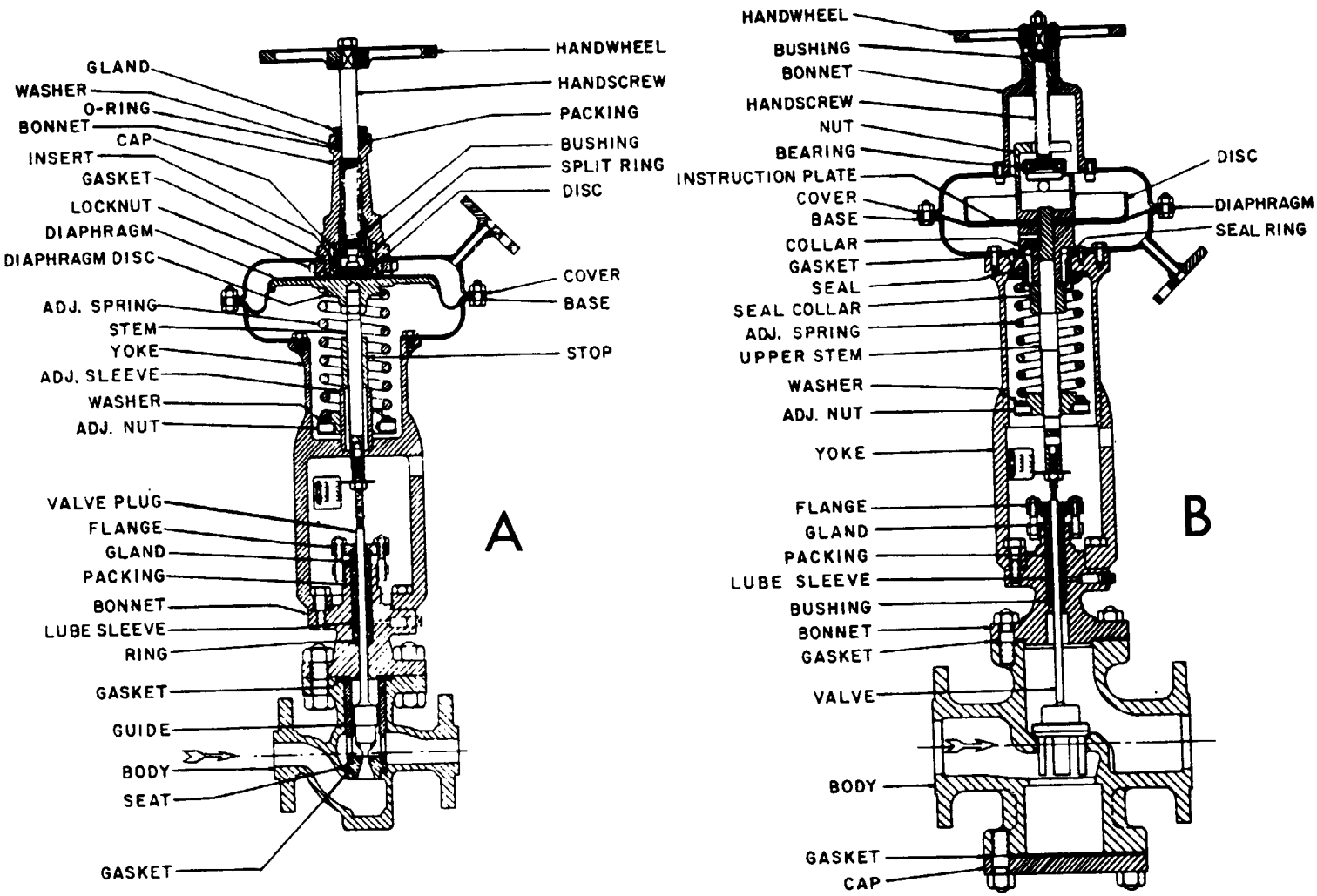
The regulator valve glands should be kept just tight enough to prevent leakage. Periodically remove the pipe plug in the side of the bonnets and pack the reservoir with graphite bearing lubricant to maintain smooth operation of the main valve rods. The valve is simple, positive, and does not require recalibration during service. For additional information consult the manufacturer's technical manual.

LIFTING TURBINE CASING AND GEAR CASING

The procedure to be followed in dismantling the turbine may be determined by studying the manufacturer's technical manual and the applicable blueprints. The instructions listed here are general. However, most generator turbine casings may be lifted by following these steps:

1. Remove all piping to the throttle valve.
2. Remove the throttle valve.
3. Disconnect the restoring lever from the pilot valve and synchronizing devices.
4. Remove the insulation from the upper turbine casing.
5. Remove the bolts from the horizontal joint of the turbine casing. The bolts in the circumferential joint need not be removed.
6. Remove the upper halves of the high--pressure and low-pressure packing boxes. Remove the packing from the high- and the low-pressure packing boxes.
7. Attach the proper lifting gear, using the pad eyes welded in the overhead and the eyebolts in the casing, and lift the casing. You may use jackscrews to help break the horizontal joint. In most installations, the upper halves of the diaphragms and the diaphragm packing are fastened to the upper half of the casing and will be lifted with it.
8. Use guide pins—a minimum of two, but preferably three.

If the turbine rotor is to be removed, the upper half of the reduction gear casing



96.50

Figure 4-8.—Gland sealing steam regulators. A. Gland sealing steam make-up valve with actuator. B. Gland sealing steam unloading valve with actuator.

must be removed first. This can be accomplished as follows:

1. Remove the pilot valve body and the synchronizing device.
2. Remove the cover from the high-speed thrust bearing and the two studs that hold the thrust bearing to the upper half of the casing (if applicable).
3. Remove all gauges and thermometers from the upper half of the casing.
4. Remove all parting flange bolts. Remove any end plates that may be bolted to the upper and lower halves of the gear casing.
5. Remove the bolts holding the oil deflector halves together (if applicable).
6. Remove all bolts that connect the upper and lower casing flanges. Then use the jacking bolts to break the joint. If you do not break the joint in this manner, you may distort the casing.
7. Lift the casing by means of the pad eyes, eyebolts, and chain hoists provided for this purpose. Lift the casing straight up to avoid striking the gear.
8. Since the pilot valve remains connected to the governor, be sure to lift the casing high enough to clear the pilot valve.
9. Remove the upper halves of the journal bearings that support the turbine pinion rotor.
10. Remove the high-speed thrust bearing.
11. Lift the turbine rotor and the pinion shaft as a single element.

PREVENTIVE MAINTENANCE

Maintain the turbogenerators and hold systematic inspections and tests at periodic intervals to ensure safe and reliable operation. At the required intervals, run idle turbines with steam (if available) or turn them by hand. Circulate oil through the system by means of the hand pump, Lubricate the trip mechanism and other working parts. Sample the lubricating oil and test it for the presence of water. Check the oil to determine its general condition and purify it when necessary. Operate all relief valves at the required intervals to make sure they will operate when necessary.

Make tests and inspections in accordance with the PMS. The PMS states the minimum number of tests and inspections necessary to assure safe and reliable operation of the equipment. Perform additional or more frequent tests at the discretion of the engineer officer.

SAFETY PRECAUTIONS

Safety precautions are extremely important and must be strictly adhered to for the safety of operating personnel and to prevent damage to the machine.

Operating instructions and safety precautions for turbogenerators should be posted in the vicinity of the units. You can get more complete information on safety precautions from NSTM, chapter 231, and the manufacturer's technical manual furnished with each unit. The following safety precautions are the MINIMUM required:

- Do not operate a turbogenerator that has an inoperative overspeed trip, back-pressure trip, or constant-speed governor.
- Keep all relief valves and the sentinel valve in good operating condition, and keep them set at the pressures specified by the manufacturers.
- Test the exhaust casing relief valve by hand before admitting steam to the turbine.
- Keep the oil sump filled with clean oil at all times.
- Avoid water hammer and damage to turbine blading and thrust bearings by properly draining steam lines and opening steam valves slowly.
- Before putting a turbogenerator in service, test the overspeed trip.
- Before starting a turbogenerator, check to see that it is clear of all foreign matter.
- Do not pass steam through a turbine at rest; admit only enough steam to immediately start the unit rolling.
- Do not allow air to be drawn through the turbine glands when the rotor is at rest.
- Keep the governor operating mechanism, valve stems, and other moving parts clean and free of corrosion.
- Keep oil pressures at the values specified by the manufacturer.

- Examine and clean the lube-oil strainers at least once each 4 hours of operation, and more often if operating conditions indicate the need for more frequent cleaning. Always ensure that the strainer caps are properly secured before use.

- Do not admit any steam (exhaust or drains) to the auxiliary condenser before an adequate flow of cooling water is passing through the condenser tubes.

- Do not admit steam to the auxiliary air ejectors before the auxiliary condensate pump is started.

- Never operate a turbogenerator that is known to have defective safety devices, defective control devices, or excessive journal or thrust bearing clearances.

- Frequently inspect all fire-main and cooling water lines in the vicinity of the generator for leaks.

SUMMARY

In this chapter, we discussed the operation and maintenance of generator turbines, reduction gears, bearings, and control and safety devices.

Keep in mind that you must follow all safety precautions to prevent injury to personnel and damage to the units.

CHAPTER 5

HEAT EXCHANGERS AND AIR EJECTORS

As a Machinist's Mate 1 & C, you must know how to maintain the heat exchangers and air ejectors on Navy ships. This chapter covers the general maintenance and repair of main and auxiliary condensers, deaerating feed tanks (DFT), and lube-oil and air coolers. Although smaller heat exchangers are not specifically discussed, the basic information in this chapter will be useful in the maintenance and repair of these other heat exchangers.

This chapter also has information on the operation and maintenance of air ejectors.

Before studying this chapter, you may find it helpful to review heat transfer and classification of heat exchangers. This information can be found in *Machinist's Mate 3 & 2* and NSTM, chapter 254.

MAINTENANCE OF MAIN AND AUXILIARY CONDENSERS

Shipyard, repair ship, or tender personnel are usually responsible for such repair work as retubing condensers and overhauling injection and overboard valves. However, you should have a good understanding of the procedures involved. You should also be qualified to act as a ship's inspector to see that all work is being performed satisfactorily. Machinist's Mates will inspect and clean main and auxiliary condensers, check for leaks and plugged tubes, and operate the units.

INSPECTING AND CLEANING CONDENSERS

Under normal operating conditions, the saltwater side of a main condenser should be inspected in accordance with the planned maintenance system. The steam side should be inspected whenever the inspection covers are removed from the low-pressure turbines.

Conditions may arise that call for more frequent inspections of main condensers. The ship may operate in shallow water or in waters where there are large amounts of seaweed, schools of small fish, or large amounts of oil. When any of these conditions occur, open the condenser for inspection and cleaning.

Carefully maintain the saltwater sides of condensers. This prevents failures caused by deposits on tubes and prevents loss of heat transfer caused by accumulations of these deposits. Inspect and clean the saltwater sides of condensers at the following times:

- Whenever zinc anodes are checked
- Immediately after grounding of the ship
- Whenever the condensers' performance indicates a possibility of tube fouling
- As soon as practical after operating in shallow or polluted water

Before opening the saltwater side of a condenser, read and observe all precautions listed in this chapter and in NSTM, chapter 254.

Saltwater Side

Lay-up requirements for the saltwater side of the condensers are divided into the following three conditions:

1. Short-term lay-ups up to 1 week
2. Midterm lay-ups of more than 1 week and less than 4 months
3. Long term lay-ups of 4 months or longer

For short-term lay-ups, the saltwater side should be kept full. Circulate the water once a day for at least 10 minutes by running the circulating pump. If you are unable to circulate

the water for 3 or more days in succession, drain the water and refill with freshwater of potable or feedwater quality. For midterm lay-up, drain the saltwater side and immediately fill it with freshwater of potable or feedwater quality. After the first 2 to 3 weeks, drain the condenser and refill with freshwater again. Thereafter, keep the saltwater side filled with freshwater until the ship returns to operation or until the saltwater side is cleaned. For long-term lay-ups, open the saltwater side and clean it. After cleaning, keep the saltwater side drained.

The general procedures for cleaning the saltwater side condensers are as follows:

1. Clean the tube sheet and the inside of the water box using freshwater and either a stiff nonmetallic brush or plastic scraper.
2. Remove material lodged in tubes with air, a water lance, water gun, high-pressure water jet, or nonmetallic rod or scraper. Do not use abrasive tools capable of scratching or marring the tube surface. Use air and water lances and any other cleaning equipment carefully to avoid damaging the protective film and causing subsequent tube failure. For further information concerning saltwater side cleaning, refer to NSTM, chapter 254.

Steam Side

The lay-up requirements for the steam side of the condensers are divided into the following two conditions:

1. Idle periods up to 1 month
2. Extended idle conditions in excess of 1 month

For idle periods, empty the hot wells of the condensers and keep them drained.

For extended shutdowns on all condensers, drain and dry out the steam side as soon as possible after the condenser has been secured. This minimizes condenser shell corrosion. The condenser shell can be dried out with an electrically heated air blower discharging into a hot well opening. After drying, close the condenser openings. Check the condenser shell weekly and repeat the drying process if moisture is found inside.

Whenever the manhole plates are removed from the low-pressure turbine for inspection or maintenance, the steam side of the tubes should be inspected. Check the entire steam side for grease and dirt. If grease and dirt are found, remove them by boiling out the condenser with a solution of trisodium phosphate. Normally, condensers that serve turbines should not require boiling out more frequently than every shipyard overhaul period. Instructions for the boiling-out process may be found in NSTM, chapter 254.

TUBE LEAKAGE

Any tube leakage, however slight, will cause serious damage if neglected. The condensate system will become contaminated and cause serious damage to the boiler tubes. It is not unusual for a newly tubed condenser to develop leaks caused by defective tubes or tube sheets or by improper installation. However, if the defects are corrected, the condenser will give years of satisfactory service.

The most common cause of tube leakage is deterioration, which starts at the saltwater side of the tube and proceeds through the tube wall of the steam side. However, leakage may also be caused by deterioration starting at the freshwater side of the tube wall, by a defective joint between the tube and tube sheet, or by cracking of the tube wall or tube sheet.

Impingement Erosion

Seawater flowing into the condenser tubes at high velocity tends to remove the thin protective film of corrosion products adhering to the tube walls. This protective film is replaced at the expense of further corrosion of the tube wall. As the protective film is continually removed and replaced by corrosion products, the tube wall is gradually thinned, and the joint between the tube and the tube sheet is weakened. A saltwater leak ultimately occurs, because of the failure of the tube joint or perforation of the tube wall beyond the tube sheet. This type of attack is generally confined to the region of the tube at or near the inlet end. It is known as impingement erosion, inlet end attack, or bubble attack. The frequency and speed of the attack are influenced mainly by water velocity through the tubes. They are also influenced by the amount of air entrained with the circulating water and by the design of water chests and injection piping.

Tube deterioration caused by impingement erosion of the tube ends can be minimized by proper regulation of circulating water through condensers and by proper venting of water chests.



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Figure 5-1.—Tubes damaged by impingement erosion.

Figure 5-1 shows a tube that has been badly damaged at the inlet end by impingement erosion.

If wet steam impinges on condenser tubes at high velocity, the surface of the tubes will rapidly erode. This erosion will eventually perforate the tube wall, and seawater will leak into the condensate. Baffles or distribution pipes installed within the condenser shell prevents direct impingement of water and steam from the auxiliary exhaust line, the recirculating line, and the makeup feed line.

These baffles must be installed in such a way that they do not touch the tubes, since vibration will cause tube failure. If frequent tube leaks occur in the vicinity of a steam or water connection to the condenser shell, it is evidence that the baffling system is defective or that the plant is not being operated properly.

To prevent tube erosion from auxiliary exhaust lines, continuously and thoroughly drain the line. Before you shift the auxiliary exhaust to a condenser, open all drain valves on the exhaust line and take every precaution to ensure that the exhaust line is drained properly. If there is a pocket in the exhaust line that will allow condensate to collect, install a drain to ensure complete drainage of the auxiliary exhaust line.

Testing for Leaks

Seawater leaks cannot always be detected by salinity indicators in the condensate system. The first indication of seawater leaks maybe a chloride buildup in the boiler or, when the plant has been secured, in the hot well of the idle condenser.

Ensure that the source of chloride contamination is not in the piping connected to the condensers, rather than the condenser tubes. Pay special attention to sections of the condensate, drain, and makeup feed piping normally under vacuum and located in the bilge area.

A change in circulating water or condenser temperature may cause a slight seawater leak to disappear temporarily, only to recur with a further change in operating conditions.

Several test methods that may be used to detect the source of circulating water leaking into condensers are described in NSTM, chapter 254. Use the simplest suitable test first. The procedure for this test is as follows:

1. Drain circulating water from the waterside of the condenser and remove the water box inspection plates.
2. Apply air pressure not exceeding 15 psig to the steam side of the condenser.
3. Slowly fill the saltwater side of the condenser with circulating water.
4. Replace the lower inspection plates as the water level nears the openings.
5. Watch the surface of the water adjacent to both tube sheets for air bubbles indicating leakage.

You will notice a large leak immediately. Detecting smaller leaks will require more time and closer observation. Consider the trim and list of the ship, as well as bowed tubes, when you inspect for leaks.

RETUBING CONDENSERS

Under normal conditions, an MM1 or MMC will not be expected to retube a condenser. Because of modern materials and manufacturing methods, condensers seldom need retubing. When they do, special tools and equipment are necessary; and the work is performed by tenders, repair ships, or a shipyard. However, you are responsible for inspecting the job to see that it has been properly completed and tested.

In general, specimen tubes should not be drawn from a condenser or heat exchanger for examination purposes except when removal is specifically directed by NAVSEA or by a Board of Inspection and Survey. However, under the following conditions, tubes may be drawn without NAVSEA authorization:

- When frequent leaks have been caused by tube failures, specimen tubes should be drawn from widely separated parts of the unit in order to establish the general condition of the tubes.

- When several tubes have failed in the vicinity of a steam or water inlet to the condenser shell, specimen tubes should be drawn unless the cause of the failure can be determined by visual inspection of the steam side of the unit.

Carefully mark samples from the most badly deteriorated tubes to show the top and the bottom of each sample and the location from which the sample was drawn. Cut the samples into lengths of about 12 inches, and identify them as to position along the length of the tube. Split them lengthwise, and open them to permit ready examination. Send these samples to NAVSEA together with a complete report of the conditions found.

Retubing Request

Before any work is begun in retubing a main condenser, authorization must be obtained from NAVSEA. When a retubing request is submitted, the following information must accompany the request:

- The condenser involved and the date when the condenser was last tubed or retubed.

- Whether or not any of the tube leaks were caused by improperly expanded or packed tube joints.

- The date when each leak occurred, the type of tube failure (usually determined when the failed tube is drawn and split for inspection), the conditions of operation, and any known or suspected contributory causes.

- The source of supply of the tube, if known.

- The position in the tube bundle of each failed tube and of each specimen tube drawn for inspection.

- The part(s) of each specimen tube where defects were found (external, internal, top, bottom, ends, and so forth); to meet this requirement, tube ends must be marked before removal so that the top can be located.

- The tube, tube sheet, and water box materials, and the type of tube joints employed.

- The condition of the zincs; the frequency of renewal, the frequency of scaling, and the method of cleaning the zincs (when installed).

- The method and frequency of cleaning the tubes.

- Whether or not the unit was kept thoroughly vented during its operation.

- Whether or not the tubes were cleaned and blown out whenever seawater was drained from the unit.

- If severe deterioration of tube ends and tube sheets is visible and photographic equipment is available, photographs of the tube sheets should be taken and sent to NAVSEA for information purposes.

- The extent of work considered necessary. Partial retubing of a condenser is not considered economical, except that authorization is sometimes given for retubing one pass of a two-pass condenser.

- A list of materials required, specifying length, outside diameter, wall thickness, and type of tube joints at both inlet and outlet ends.

- Recommendations and comments by authority endorsing the request.

Forces afloat or a shipyard may retube auxiliary condensers and other small heat exchangers

without obtaining authorization from NAVSEA. Only the type commander need approve this type of retubing. Forward complete reports of such retubing to NAVSEA. Include the same information that is required for requests for retubing main condensers.

Removing Tubes

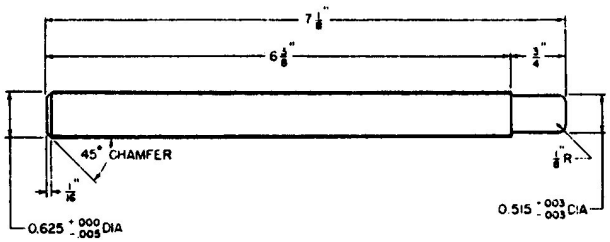
When a main condenser is to be retubed, the following procedure is the most efficient one for removing the old tubes. Cut them inside the shell with a power-driven saw or other suitable cutting tool. Then drive the ends of the tubes out of the tube sheets with a drift. Figure 5-2 shows a drift suitable for tubes that have a 5/8-inch outside diameter and a wall thickness of 0.049 inch. If you have problems in removing expanded tubes, you may have to ream the expanded ends so that only a thin shell remains at the outer surface of the tube.

If you use a reamer, it should have a pilot that closely fits the inside bore of the tube. Ensure that the reamer does not touch or mar the surfaces of the tube holes in the tube sheet. Figure 5-3 shows a reamer suitable for this type of work.

Regardless of the method used to remove the tubes, do not damage the tube holes in the tube sheets in any way.

Renewing Tubes

Before installing replacement tubes, make a very careful examination of the interior parts of the condenser shell. If there is any reason to believe that the joints between the tube sheets and the condenser shell are not in perfect condition, remove the tube sheets. True the flanges and install new gaskets. Remake joints between the stay-rods and the tube sheets and repack the stay-rods. Should any defects be found after the new tubes are installed, you may



98.34

Figure 5-2.—Drift for driving tube ends from tube sheets.



98.35

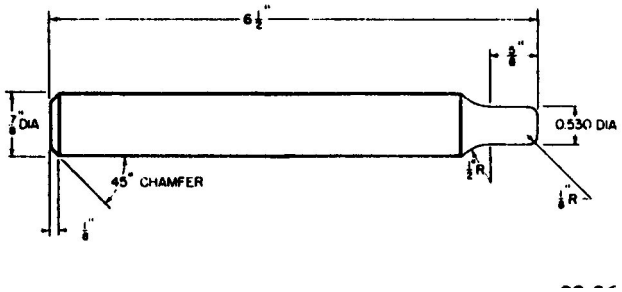
Figure 5-3.—Reamer for removing expanded tube ends.

need to cut out the newly installed tubes to correct the defect(s).

Only copper-nickel tubes conforming to NAVSEA specifications may be used in condensers that are saltwater cooled. These tubes are furnished in stock lengths and must be cut to proper length by the installing activity. The usual practice is to cut the tubes in lengths about one-eighth inch longer than the distance between the outside faces of the tube sheets. After installation, finish the tubes to the exact length by using an air-driven end mill or surface grinder.

EXPANDING TUBES.— Nearly all condensers installed aboard naval ships have the inlet tube ends expanded in the tube sheet, forming a metal-to-metal joint. In many installations, the outlet tube ends are also expanded. If the condenser tubes are expanded at both ends, it is common practice to provide one or more grooves, or serrations, in the tube holes. This increases the holding power of the expanded tube joint. Thoroughly clean out these grooves and remove any burrs before installing new tubes.

Tube expanders used in retubing condensers and other heat exchangers must meet Navy specifications. Forces afloat or shipyards should not use any type of tube expander except those furnished to the ship by the manufacturer and approved by NAVSEA. The tube expander rolls should be tapered to correspond with the taper of the expander mandrel to ensure parallel expansion of the tube walls. The inner ends of the rolls should be suitably rounded off to form a torpedo-shaped end. This prevents ridging and cutting of the tubes at the inner end of the expanded joint. A tube expander must be properly set for a given job. To do this, you must ensure that the overall length of the rolls are not less than three-sixteenths inch nor more than five-eighths inch greater than the thickness of the tube sheet into which the tube is expanded. Adjust the expander so that the expanded portion of the tube does not extend completely through the cylindrical



98.36

Figure 5-4.–Tool for flaring main condenser tubes.

portion of the tube sheet hole; leave about one-eighth inch of the tube at the inner end of the tube hole unexpanded. If the tubes are expanded completely through the tube sheet, the part of the expanded joint that extends into the condenser and beyond the support of the tube hole will bulge, and it will be extremely difficult to remove the tubes later.

After the tubes are expanded, bell or flare the inlet ends of the tubes to an outside diameter (OD) of not more than 3/4 inch for 5/8-inch OD tubes and not more than 7/8 inch for 3/4-inch OD tubes.

Drive flaring tools into the tube end so hard that the wall of the tube is appreciably thinned or cut. Figure 5-4 shows a flaring tool that is suitable for 5/8-inch OD tubes that have a wall thickness of 0.049 inch. It is good practice to mill or grind the projecting flared ends of the newly installed tubes flush with the tube sheet surface. This provides a smooth entrance for the circulating water flowing into the inlet ends of the tubes. It is not necessary to flare the outlet ends of the tubes; the tube outlet ends may be allowed to project one-sixteenth inch from the face of the tube sheet surface.

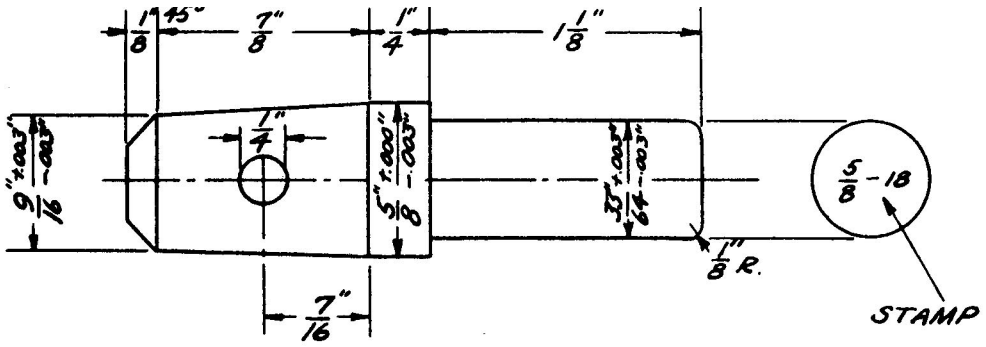
PACKING TUBES.– Use flexible metallic packing, in accordance with Navy specifications, to pack the outlet ends of packed condenser tubes. Expand the inlet ends of the tubes into the tube sheets before packing the outlet ends. Completely remove the old packing and thoroughly clean the threads and serrations of the glands of all foreign matter.

When stuffing box glands are three-fourths inch deep, the proper packing consists of two fiber rings and two metallic rings. To assist in the installation of packing, insert a loading pin (fig. 5-5) into the outlet ends of the tubes.

After the loading pin is inserted, place a fiber packing ring on the pin and drive it to the bottom of the stuffing box. Next, place a metallic packing ring on the loading pin and caulk into the packing box with three or four light hammer blows to cause the metal to flow into the threads of the gland. Then repeat these operations; i.e., insert another fiber ring and another metallic ring in the same manner. Caulk each ring in place separately. If the depth of the stuffing box is greater than three-fourths inch, install an additional metallic ring. Caulk it into place to completely fill the stuffing box with packing.

If the stuffing box is five-eighths inch deep instead of three-fourths inch deep, only three rings of packing can be used. Caulk one metallic ring in place, followed by a fiber ring and a second metallic ring. Never flare or expand or bell the outlet ends of packed condenser tubes.

When a condenser is retubed, test the tubes for leaks. The test is made by filling the shell with warm water. (Warm water must be used to avoid



96.27

Figure 5-5.–Loading pin for packing main condenser tubes.

condensate forming on tubes and tube sheets and giving a false indication of leaking.) If any leaky tubes are found, recaulk them with light hammer blows applied to the caulking tool.

The amount of force used in striking the caulking tool with the hammer is extremely important. If too little force is used, the joint will leak. If too much force is used, it will "neck" the tube end. The tube end will then be held too tightly in the packing gland to allow proper movement during normal expansion. When the necked tube does move through the packing, the joint will leak.

CARE OF IDLE CONDENSERS

The condensers on most naval ships are either expanded at both ends or expanded at the inlet end and packed at the outlet end. These units should normally be drained and kept empty when they are secured. The lay-up procedures were covered earlier in this chapter.

Whenever the saltwater side of a condenser is drained, take special care to ensure the tubes do not have water anywhere along their lengths. Tubes frequently become sagged. Water trapped in these pockets at one or more points along the tube length, if allowed to remain in a drained condenser, will gradually evaporate. The impurities left behind will corrode the tubes at these points. In time, this will cause a tube failure. This corrosive action is particularly acute when condensers are drained of highly polluted water. The best way to avoid this type of tube deterioration is with an ample supply of freshwater available from a pier. Water-lance each tube with freshwater to wash out the polluted water and remove foreign matter from the tubes. Following the water-lancing operation, kit-lance the tubes and leave them dry until the condenser is again put in service.

If sufficient freshwater is not available for water-lancing, air-lance each condenser tube and leave it completely dry; then inspect the condenser daily. If any water tends to collect in the tubes, through condensation from the atmosphere, repeat the air-lancing operation as necessary to avoid the formation of water pockets at low points along the tubes.

When a condenser is secured, keep the steam side empty.

SAFETY PRECAUTIONS FOR CONDENSERS

When opening a main condenser for cleaning or inspection or when testing a main condenser, you must use the following safety precautions, When carried out properly, they will help prevent casualties to personnel and machinery.

1. Before the saltwater side of a condenser is opened, close all sea connections tightly, including the main injection valve, circulating pump suction valve, and main overboard valve. Tag them to prevent accidental opening.
2. On condensers with electrically operated injection and overboard valves, open the electrical circuits serving these motors and tag them to prevent these circuits from being accidentally energized.
3. Before a manhole or handhold plate is removed, drain the Saltwater side of the condenser by using the drain valve provided in the inlet water box. This ensures that all sea connections are tightly closed.
4. If practical, replace inspection plates and secure them before you stop work each day.
5. Never subject condensers to a test pressure in excess of 15 psig.
6. When testing for leaks, do not stop because one leak is found. Check the entire surface of both tube sheets, as there maybe other leaks. Determine whether each leak is in the tube joint or in the tube wall so that the proper repairs can be made.
7. It is possible that hydrogen or other gases may be present in the steam side or the saltwater side of a condenser. Do not bring an open flame or tool that might cause a spark close to a newly opened condenser. Do not allow personnel to enter a newly opened condenser until it has been thoroughly ventilated and the space declared safe by a gas-free engineer.
8. Drain the saltwater side of a condenser before flooding the steam side, and keep it drained until the steam side is emptied.
9. The relief valve (set at 15 psig) is mounted on the inlet water chest. Lift it by hand whenever condensers are secured.
10. If a loss of vacuum is accompanied by a hot or flooded condenser, slow or stop the units exhausting into the condenser until the casualty is corrected, Do not allow condensate to collect in condensers and overflow into the turbine or engines.
11. Lift condenser shell relief valves by hand before a condenser is put into service.
12. Do not retain any permanent connection between any condenser and water system that could subject the saltwater side to a pressure in excess of 15 psig.

13. Do not retain any permanent connection that could allow salt water to enter the steam side of the condenser.

14. Test the main circulating pump bilge suction when so directed by the engineer officer. To conduct this test, you generally need only to start the main circulating pump, open the bilge suction line stop or check valve, and then close the sea suction line valve until it is about three-quarters closed or until the maximum bilge suction capacity is obtained.

OPERATION OF CONDENSERS

Relatively few casualties occur to main condensers compared with the number of casualties that occur to some units of naval machinery. The most frequent casualty to a main condenser is a reduction in vacuum. Inadequate vacuum or any other casualty to a main condenser will cause failure of the propulsion turbines to produce full power or cause complete failure of the main engines. Operate condensers to obtain a vacuum in accordance with design requirements and to obtain maximum service life and reliability of the equipment.

CIRCULATING-WATER CONTROL

When the gate valve in the circulating-water overboard piping is used to regulate the water flow through the condenser, this valve should be kept at least one-quarter open. If a gate valve used for throttling is closed more than three-quarters, the gate is likely to pound against the seat rings and damage the valve so that it will not be watertight when closed. There may be some erosion of the valve gate and seating rings if the valve is continually used for throttling. Whenever a ship is drydocked, inspect the injection and overboard valves to be sure they are in good working condition and watertight.

While an overboard valve is throttled, a sudden increase in power will cause a slight loss in vacuum. The loss will not usually be serious and can be corrected by opening the overboard valve. In the event of an unexpected demand for full power astern, open wide the overboard valve as quickly as possible.

VACUUM CONTROL

Under normal operating conditions, you should operate condensers fitted with scoop injection to maintain the maximum vacuum obtainable and with the main injection and overboard valves wide open, except under the following conditions of operation under full power and cruising speeds.

When making FULL POWER or speeds closely approaching full power, under cold injection conditions, the condenser can usually obtain a higher vacuum than the low-pressure turbine can use effectively in the average installation, as the full-power vacuum becomes higher than about 1 inch of mercury above the vacuum for which the low-pressure turbine was designed, the extra steam required to heat the condensate will outweigh the added economy of turbine operation that is gained by the higher vacuum. The designed full-power vacuum for any turbine installation may be found in the manufacturer's technical manual.

When operating at cruising speeds, the turbines can generally make effective use of the maximum vacuum of which the condensing plant is capable. However, with cold injection at low power, the condenser can produce a vacuum higher than that at which the air-removal equipment will handle the normal air leakage into the system. Under standby conditions, very little steam is discharged to the condenser. During standby most installations fitted with properly functioning air ejectors will produce a maximum vacuum of about 29 1/2 inches of mercury with cold injection temperature. Under these conditions, the average installation fitted with air pumps operated at normal speed will produce a maximum vacuum of 28 to 29 inches of mercury, depending on whether or not augmenters are fitted. When the ship is cruising at low and medium powers with cold injection, the condenser vacuum tends to approach the maximum of which the system is capable under standby conditions with that injection temperature. The air-removal equipment then tends to become unable to free the condenser of normal air leakage. The air collects in the condenser, tending to insulate the tubes from the condensating steam and to settle into the hot well. At that time, there is usually a noticeable increase in the condensate depression. You should try to avoid loss of economy and absorption of air into the condensate under these conditions. To do so, throttle the flow of circulating water as necessary to limit the vacuum to about 0.2 inch of mercury less than the maximum obtainable with full flow of circulating water or as necessary to reduce the condensate depression to normal. If the condensate depression remains between 0 and 2 degrees

under low-power operation at medium injection temperature, the air-removal equipment is ridding the condenser of air leakage, and throttling of circulating water is unnecessary.

When there is a loss of vacuum in a condenser, it means that the units of machinery exhausting into the condenser are out of commission. Air leakage into a condenser decreases the vacuum obtainable and increases the condensate depression. If air leakage becomes excessive, the units of machinery exhausting into the condensers will have to be secured.

Maintaining proper vacuum is one of the more important duties of engine-room watch standers. This training manual cannot cover all of the reasons for loss of vacuum. However, since air leakage into the vacuum system is the most common cause of vacuum loss, we will cover some of the methods of conducting air tests.

There are many ways in which air can leak into a system under vacuum. Every flange, gasket, connection, packing gland, and valve bonnet that connects to the vacuum system can be a source of air leakage. Air leaks can be very difficult to locate. Some of the most common methods used to find and stop leaks are covered here:

- Fill the condenser and the connected piping, which is normally under vacuum, with freshwater. Then using compressed air to build up a pressure of 5 to 10 psig in the turbine casing, check the condenser and piping for water leaks. A water leak indicates an air leak.

- Use the candle flame test. With the system under vacuum, hold a lighted candle to all areas where leaks are suspected. If the candle flame is held close to a leak, the vacuum will draw the flame toward the leak.

- Apply soapsuds to areas where leaks are suspected. The soapsuds solution should be prepared so that it has the consistency of liquid hand soap and will work into a lather on a brush. With the condenser shell subjected to a 5-pound air pressure, apply the lather all the way around the joints. Check the joints for bubbles. Lather doubtful spots a second time. If you are still in doubt about the existence of leaks, lather the doubtful spots several times.

- Use the air test. If the test is to be conducted on a main condenser, the procedure is as follows:

Start a lube-oil service pump; engage and start the turning gear. Cut in gland sealing steam to the main turbines. Next, build up a pressure of 5 to 10 psig throughout the vacuum system. Listen carefully for air leaking out of the system. This method is more effective if all the vents and machinery in the engine room, except the lube-oil pump and turning gear, can be secured. This will reduce noise, which is important since this method depends entirely on detecting the sound of air escaping.

- When testing for air leaks, investigate all places where an air leak is possible. Condensers have many fittings and joints that should be examined as far back in the lines as vacuum exists under any operating conditions.

- Leaks at flanged joints and in porous castings can usually be stopped with an application of shellac when the condenser is under vacuum. If shellac is used, consider it a temporary repair. Make permanent repairs as soon as time and the ship's operation permit.

- In installations where the condenser supports the turbine, main exhaust trunk flanges are generally fitted with a flange grooving system. This provides for pressure pumping with a suitable sealing compound. If the shell relief valve (or its connection to the condenser shell) is suspected of leaking, it can, in most installations, be tested in place. Most shell relief valves are fitted with a small-gauge glass to permit introduction of water above the disk as a test for tightness.

OTHER HEAT EXCHANGERS

Condensers are but one type of heat exchanger found in engine rooms. Lube-oil coolers, air coolers, and deaerating feed tanks (DFT) are other heat exchangers that Machinist's Mates maintain. The following sections have information on maintaining these units.

DEAERATING FEED TANKS

Additional information on the principles and operation of DFTs may be found in NSTM, chapter 9562.

General interaction on operation and maintenance of the units are discussed in this chapter. For more detailed information in any specific unit, refer to the manufacturer's technical manual.

Operation of a Deaerating Feed Tank

DFTs remove gases from the feedwater by using the principle that the volubility of gases in feedwater approaches zero when the water temperature approaches the boiling point. During operation, steam and water are mixed by spraying the water so that it comes in contact with steam from the auxiliary exhaust line. The quantity of steam must always be proportional to the quantity of water; otherwise, faulty operation or a casualty will result.

During normal operation, the only control necessary is to maintain the proper water level. This is done with automatic water level control valves. (Some of the older ships have manual water level control valves.) If the water level is too high, the tank cannot properly remove the air and noncondensable gases from the feedwater. A low water level may endanger the main feed booster pumps, the main feed pumps, and the boilers.

Overfilling the DFT may upset the steam-water balance and cool the water to such an extent that deaeration will be ineffective. Overfilling the DFT also wastes heat and fuel. The excess water, which will have to run down to the condenser, will be cooled. When it reenters the DFT, more steam will be required to reheat it. If an excessive amount of cold water enters the DFT, the temperature drop in the tank will cause a corresponding drop in pressure. As the DFT pressure drops, more auxiliary exhaust steam enters the tank. This reduces the auxiliary exhaust line pressure, which causes the augmenting valve (150-psi line to auxiliary exhaust line) to open and bleed live steam into the DFT.

When an excessive amount of cold water suddenly enters the DFT, it may cause a serious casualty. The large amount of cold water will cool (quench) the upper area of the DFT and condense the steam so fast that pressure is reduced throughout the DFT. This permits the hot condensate in the lower portion of the DFT and feed booster pump to boil or flash into vapor. The booster pump then loses suction until pressure is restored and the condensate stops boiling. With a loss of feed booster pump pressure, the main feed pump suction is reduced or lost entirely. This causes serious damage to the feed pump and loss of feedwater supply to the boiler(s). Some ships have safety devices installed on the main feed pumps to stop them when a partial or total loss of main feed booster pressure occurs.

The mixture of condensate, drains, and makeup feedwater, constituting the inlet water to the DFT, enters through the tubes of the vent condenser. The condensate pump discharge pressure forces the water through the spray valves of the spray head and discharges it in a fine spray throughout the steam-filled top or preheated section of the DFT.

If a spray nozzle sticks open or if a spray nozzle spring is broken, the flow from the nozzle will not be in the form of a spray, and the result will be ineffective deaeration. This condition cannot be discovered except by analysis of the feedwater leaving the DFT or by inspecting the spray nozzles.

Maintenance of a Deaerating Feed Tank

DFT maintenance can usually be limited to scheduled planned maintenance checks. They include, but are not limited to, the following checks:

1. Lift the shell relief and vacuum breaker valves by hand to ensure freedom of movement.
2. Test the DFT remote water level indicators.
3. Test the operation of the air-pilot-operated control valves for makeup and excess feedwater control.
4. Inspect the internal components for presence of oil and foreign matter; clean as necessary.
5. Inspect and clean the DFT check valve.
6. Test DFT spray valves.

If the DFT is not operating satisfactorily, insofar as proper temperature and deaeration is concerned, the failure can usually be traced to one of the following problems:

- You maybe using improper sampling and analyzing techniques. Ensure that a representative sampling of the feedwater is being obtained for the dissolved oxygen test.

- Excessive fluctuations in auxiliary exhaust pressure will cause unstable conditions in the DFT. The auxiliary exhaust system augmenting steam valves and dump valves should be maintained in proper condition to automatically control the exhaust pressure under all plant conditions.

- Excessive HP drain pressure can close the internal check valve, thereby starving the

deaerating section of necessary steam required for vigorous scrubbing action and final oxygen removal.

- Faulty operation of the spray valves will critically affect deaeration.

For further information concerning maintenance and repair, consult the applicable chapters of the manufacturer's technical manual.

OIL COOLERS

Oil coolers should be operated as required to maintain the oil (inlet) temperature to the bearings at the designed value. With the bearing orifices properly adjusted and the bearings in proper operating condition, a temperature of 120°F to 130°F on the discharge side of the cooler should satisfactorily meet all normal operating conditions.

When the system has more than one cooler, they should be used alternately and for approximately the same number of hours.

Maintenance of Lube-Oil Coolers

With reasonable care, lube-oil coolers on Navy ships will remain in service for several years. When salt water is used as the cooling medium, failure is usually caused by erosion, because of high water velocity, or by corrosion, because of electrolytic action.

All coolers are built in accordance with NAVSEA specifications. These specifications are designed to give adequate cooling with seawater velocities well below that which will cause appreciable erosion.

Reports of failure of this type of equipment are rare in comparison with the number of coolers installed in naval ships. Most cooler failures have occurred to units that are supplied with cooling water from a service main. In these cases, the supply of seawater available to the cooler is limited only by a valve or an orifice in the cooler supply line. Under these conditions, too wide an opening of the valve, too large an orifice, or too high a pressure in the service main will cause excessive velocity through the cooler and consequent failure because of erosion. At the same time the oil temperature is usually not appreciably lower than that obtained with proper seawater flow.

Of the two causes of cooler failure, the more likely one is erosion from high-velocity seawater. To get satisfactory service from these units, use the following precautions:

- Limit the seawater flow to the minimum that is consistent with maintaining the oil temperature within limits specified by NAVSEA or as given in the manufacturer's technical manual.

- When securing a cooler for any extended period, drain the saltwater side and flush with freshwater, when practical. At all other times keep the cooler flooded and flush it periodically with salt water.

- Clean in a manner prescribed by NAVSEA.

All of the above precautions also apply to other heat transfer equipment, such as refrigeration condensers, air compressor intercoolers and aftercoolers, and other coolers that use seawater as a cooling medium.

Cleaning Lube-Oil Coolers

If a lubricating system becomes contaminated with salt water, thoroughly clean the system before it is put back into service. Disassemble and remove all traces of rust, scale, and other foreign matter; otherwise, serious damage will result.

All foreign matter in shell and tube coolers must be removed from the inside of the shell and baffles before reassembly. Remove the material with scrapers and/or wire brushes.

With proper use of lubricating-oil purifiers, filters, and strainers, it will usually be necessary to clean only the saltwater sides of the shell and tube-type coolers. This cleaning should be done with an air lance or water lance, and if necessary, with a round bristle brush. Never use a wire brush for this purpose.

Removed tube bundles can be cleaned, when necessary, by flushing them with hot water. However, do not clean shell and tube-type coolers with chemicals without the specific approval of NAVSEA.

AIR COOLERS

Air coolers are used for closed-circuit cooling of machinery. In this type of cooler, the air is circulated over and over again. Closed-circuit

cooling has the following advantages over open-circuit cooling, in which the atmospheric air is passed through the machine:

- The machine is cleaner and is protected from any harmful gases or moisture that maybe present in the outside air.

- There is a low fire risk since not enough oxygen is in the enclosed air to sustain combustion.

- The cooling of the machine is independent of outside air.

Maintenance of Air Coolers

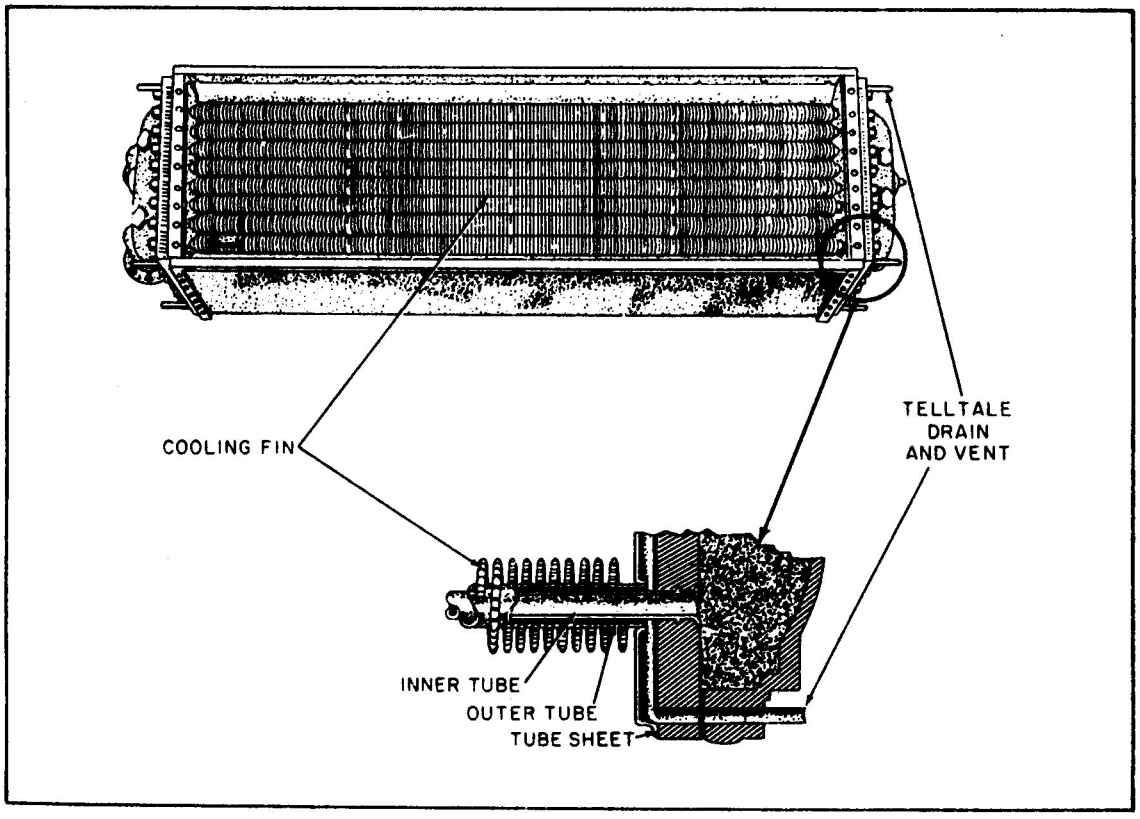
The air cooler (fig. 5-6) is a double-tube type of cooler. The double-tube construction makes it easier to find leaks in the water tubes before serious tube failure occurs.

Each double tube consists of a water-carrying tube surrounded by a close-fitting outer tube. Axial grooves in the inside surface of the outer tube extend the full length of the cooler. The grooves in the tubes all open into telltale chambers at each end of the cooler. If a leak occurs in one of the main water-carrying tubes, the leaking water runs into the grooves in the surrounding tube. and from there it runs into one of the telltale chambers. This arrangement prevents water leakage into the air ducts of the machine. You know you have a leak when you see a discharge from the open ends of the telltale drain tubes.

Proper operation and maintenance is necessary for continuous satisfactory service from the air coolers. Inspections and preventive maintenance help you locate and prevent trouble before serious damage results.

Cleaning of Air Coolers

The air cooler must be cleaned whenever foreign matter interferes with the flow of air across the tubes, whenever water deposits impair the flow of water through the tubes, or whenever such accumulations either inside or



96.51

Figure 5-6.-Air cooler.

outside the tubes, prevent proper heat transfer. Clean the cooler at least every 6 months using the following procedures:

CAUTION

Never use abrasive tools that might scratch or mar the tube surface. Any local scratch in the thin film of corrosion products on the surface of the tubes is likely to form the nucleus of a pit of corrosion, that may widen, deepen and cause tube failure.

1. Close valves in water lines to and from the air cooler. Drain water from the cooler.
2. Disconnect water, vent, drain, and telltale connections.
3. Clean the water passages as follows:

a. For ordinary cleaning, push an air lance through each tube; then wash the tube sheets and remove all foreign matter from the water chests.

b. In case of more severe fouling, push a water lance instead of an air lance through each tube.

c. In cases of extreme fouling of tubes resulting from oil or grounding of a vessel, run a rotating bristle brush through each tube. You may also drive soft rubber plugs through the tubes with an air or water gun. Follow the brush with a water lance.

4. Clean the outside of the tubes with compressed air.
5. Reassemble, using new gaskets.

AIR EJECTORS

In most ships, the first and second stages of the air ejectors and their condensers have been combined into one complete assembly. In many ships, the gland exhaust condenser has been incorporated within the shell of the after condenser. The shell is rectangular and is divided by a longitudinal plate into the intercondenser and the aftercondenser sections. A baffle at the gland vapor inlet deflects the air and vapor downward over the lower bank of tubes in the aftercondenser section.

Two sets of nozzles and diffusers are furnished for each stage of the air ejectors to provide continuous operation. Only one set is necessary for operation of the plant; the other set is kept ready for use in case of damage or unsatisfactory operation of the set in use. The two sets can be used simultaneously when excessive air leakage into the condenser calls for additional pumping capacity.

An interstage valve is provided between the discharge of each first-stage ejector and the intercondenser. This ensures that the pressure built up by the first-stage jet, in operation, will not be lost back to the condenser through the idle first stage. For a similar reason, a cutout valve is located between each second-stage suction chamber and the intercondenser. By means of diaphragm plates in the inlet and outlet heads, the cooling water (condensate) is forced to make several passes through the unit before being discharged.

The atmospheric vent is usually connected to the suction of a small motor-driven fan (gland exhausted). This fan provides a positive discharge through piping to the atmosphere above decks. This is necessary to avoid filling the engine room with steam should the air ejector cooling water supply fail. Such a failure allows the steam to pass through the intercondenser and aftercondenser without being condensed.

OPERATION OF AIR EJECTORS

With each air ejector assembly installed, the manufacturer furnishes technical manuals on operation and maintenance. General information on starting, shifting, and securing air ejectors is given in each ship's engineering operational sequencing system (EOSS). Some additional operating procedures are listed below:

- Before starting a steam air ejector, drain the steam line of all moisture. Moisture in the steam line will cut the nozzles, and slugs of water will cause unstable operation.

- Before cutting steam into the air ejectors, make sure that enough cooling water is flowing through the condenser and the condenser has been properly vented.

- Keep the loop seal line airtight; an air leak may cause all water to drain out of the seal.

- If operating both sets of air ejectors is necessary to maintain proper condenser vacuum, you probably have an air leak. It is better to eliminate the air leak than to operate two sets of air ejectors.

Unstable operation of an air ejector may be caused by any of the following: The steam

pressure may be lower than the designed amount. The steam temperature and quality may be different than design condition. There may be scale on the nozzle surface. The position of the steam nozzle may not be right in relation to the diffuser. The condenser drains may not be right in relation to the diffuser, or the condenser drains may be stopped up.

Low pressure problems are generally caused by improper functioning or improper adjustment of the steam-reducing valve supplying motive steam to the air ejector assembly. Dry steam at full operating pressure must be supplied to the air ejector nozzles.

Erosion or fouling of air ejector nozzles is evidence that wet steam is being admitted to the unit. Faulty nozzles make it impossible to operate the ejector under high vacuum. In some instances, the nozzles may be clogged with grease or some other deposit, which will decrease the jet efficiency.

MAINTENANCE OF AIR EJECTORS

In general, air ejector nozzles maybe cleaned with reamers. Use the proper size reamer for each size of nozzle, to avoid damage to the nozzle. If you must remove the nozzle for cleaning or replacement, the internal surfaces must not be damaged. Dents or deformations of the downstream end of the nozzle and rough or scratchy surfaces in the throat or diffuser passages will cause improper operation of the unit. Remove foreign deposits from the internal surface of the nozzle or diffuser with a nozzle reamer, soft copper wire, or piece of wood.

Before you disassemble or reassemble nozzles or diffusers, refer to the manufacturer's technical manual. If replacement of a nozzle or diffuser is required, use gaskets of proper thickness for reassembly. The nozzle and the diffuser tube must be concentric and in proper alignment, and the correct distance must be maintained between the ends of the nozzle and the diffuser.

Steam strainers, nozzles, or diffusers of an air ejector assembly may be cleaned or replaced while the rest of the unit is in operation. The unit that is to be opened must be isolated from the rest of the assembly to avoid burns on personnel. You can do this by closing the steam supply valve and the interstate valves of this unit.

Flooded Condenser

Improper drainage or leaking condenser tubes will cause flooding of the intercondensers and aftercondensers. If flooding occurs, the effective condensing surface is decreased, and there is a loss of vacuum. Flooding may also cause condensate to be drawn into the second-stage element, which will cause erratic operation of the unit.

If flooding is suspected, clear out drain lines and do a hydrostatic test on the unit to check for leaks at tube joints and tube walls. Tubes rarely need replacing, as most installations use condensate as a cooling medium.

If tubes do leak, the packed ends can be repacked by use of copper-asbestos packing rings supplied by the manufacturer. You can remove old packing rings and install new ones in the same manner as described in this chapter for packing of main condenser tubes. The exception is that copper-asbestos rings should be set up with several very light hammer blows on the caulking tool. Copper does not flow into the threads of the packing box as readily as does the lead packing used in main condensers.

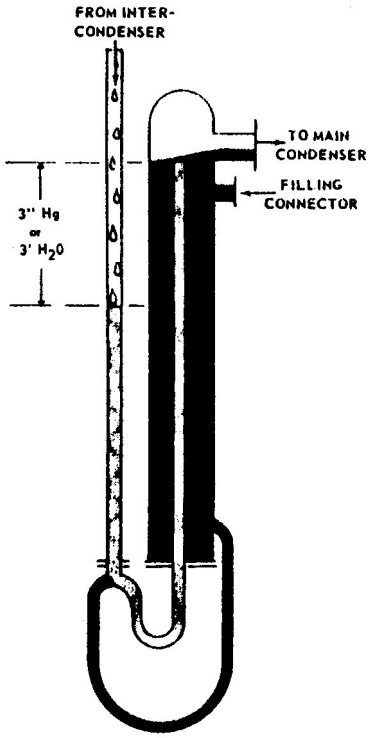
To make an emergency repair of a tube, plug both ends. Should retubing or other major repairs be necessary, conduct a hydrostatic test on all parts of the assembly to the test pressure specified by the manufacturer. Determine that all internal parts of the assembly are in proper working order before the new tubes are installed. Make a positive test to establish the tightness of the gaskets between the intercondensers and aftercondensers both before and after installing new tubes.

Maintaining the Loop Seal

An air leak in the U-shaped loop seal line (fig. 5-7) provided for draining the intercondenser makes it impossible to maintain a seal between the intercondenser and the main condenser. Water from the intercondenser passes down through the small 1-inch pipe, then through the short loop, and up through the internal pipe. The larger pipe surrounding the internal pipe is 3 inches in diameter and is connected to the main condenser. Water overflowing the internal pipe fills the external pipe and the larger loop.

If no vacuum existed in either condenser and if water from the intercondenser entered the internal pipe, it would maintain the same height in each leg.

When a vacuum is formed in both condensers, the difference between the vacuum maintained in the main condenser and that maintained in the intercondenser will be about 3 inches. The vacuum in the main condenser will be about 29 inches and that in the intercondenser about 26 inches.



96.29

Figure 5-7.—Loop seal.

If you express vacuum in terms of absolute pressure, a pressure of 112-psi will be acting down on the internal and external pipes, and a pressure of 2 psi will work down against the water level in the primary 1-inch pipe. This means that the pressure of 2 psi from the primary pipe will push water through the pipe and cause it to overflow from the external pipe into the main condenser.

When the water level in the primary leg is approximately 3 feet below that of the secondary leg, the additional weight of the water present in the secondary leg will provide the extra 1 1/2 psi necessary to counteract the 2-psi absolute pressure against the primary leg. Thus, a static condition will be obtained. If water from the intercondenser is added to the primary leg, the level on that side will rise. The additional weight of the water will cause water to be pushed into the main condenser from the secondary leg. This will restore the loop to its original static condition.

To drain water from the intercondenser to the main condenser, add water to one side of the loop and remove it from the other side. A solid body of water is maintained in the base of the loop and prevents air from passing through, which would cause an equalization of vacuum.

The purpose of the filling connection is to allow condensate to be pumped from the condensate pump discharge line to the loop seal so that the loop may be filled before placing it in operation. A cutout valve is installed in the line from the loop seal to the main condenser.

If the vacuum gauges on both the main condensers and intercondensers show the same reading, this indicates that the seal is broken. Opening the filling valve will correct this condition if it is caused by a sudden surge in vacuum or a violent roll of the ship. If the condition is caused by an air leak, the leak will have to be corrected before the loop will remain properly sealed.

SUMMARY

In this chapter, we have discussed the operation, maintenance, and repair of heat exchangers and air-ejectors. As a Machinist's Mate, you will inspect, clean, and operate these units.

The information given in this chapter is general in nature. Further information on main and auxiliary condensers, DFTs, lube-oil and air coolers, and air ejectors can be found in NSTM, chapters 254 and 9562 and in the applicable manufacturer's technical manual.

CHAPTER 6

PUMPS

As an MMI or MMC, you will be responsible for the operation and maintenance of pumps and pump governors in the engine room and other machinery spaces. This chapter covers the inspection and repair of reciprocating and centrifugal pumps and the operation and repair of pressure-regulating and speed-limiting governors.

Before studying this chapter, you may find it helpful to review chapter 5 of Machinist's Mate 3 & 2, and NSTM, chapter 503.

RECIPROCATING PUMPS

Reciprocating pumps were once widely used on board Navy ships for a variety of services. However, centrifugal and rotary pumps are now far more common in modem ships of all classes. Reciprocating pumps are generally restricted to use as emergency feed pumps, fuel-oil pumps, and lube-oil tank stripping pumps. On some of the older ships, fuel-oil-transfer, bilge, and ballast pumps may be of the reciprocating type. A reciprocating pump may be either a high- or low-pressure or single- or double-acting pump, depending on how it is used. For instance, an emergency feed pump is normally a high-pressure pump, which means the steam piston is larger than the water piston, and is a double-acting pump, which means it discharges on both strokes. This type of pump is used when your major concern is getting water into the boiler. On the other hand, a bilge and stripping pump has a higher volume output at a lower pressure. Many emergency feed pumps can use LP air; however, the air and steam should never be interfaced.

OPERATION OF RECIPROCATING PUMPS

You will sometimes have operating problems with reciprocating pumps. Some of the most common causes of trouble and their remedies are covered in the following material.

Failure to Start

There may be times, after you have lined up the pump and cracked open the throttle valve, that the pump will not start. You may repeat the starting procedure and determine that everything seems to be all right, but still the pump will not start. At this point, proceed as follows: Secure the pump. Check the suction discharge, and auxiliary steam exhaust lines. Look for a closed valve or for a valve disk that has come off its stem. If no valves are closed, the water piston or the steam piston maybe frozen, especially if the pump has been idle for some time. This may be determined by jacking the pump with a bar.

CAUTION

Never attempt to jack a reciprocating pump unless you are certain that the throttle valve and the exhaust valve are closed tightly and the steam-cylinder and steam-chest drains are wide open.

If there is no excessive friction, disconnect the auxiliary valve stem from the operating gear. Do not disturb the adjustment of the tappet collars. Open the exhaust, suction, and discharge valves and then crack the throttle. Work the auxiliary piston valve by hand (it should slide freely). Should the pump still not start, secure steam and water end valves. Remove the steam valve chest to determine whether the main piston valve has overridden or stuck. An erratic operating pump may indicate excessive dirt or contamination in the pilot valve. This may cause the valve to be jammed in the valve body.

If the pump still cannot be started, you may need to overhaul the working parts of the steam end. Excessive force (such as using a hammer) on the pilot valve drive rod will only result in further operating difficulties to the pump.

Loss of Suction

If a reciprocating pump LOSES SUCTION, it will operate irregularly or race with a decrease in discharge pressure. Obstructions in the suction line, loss of suction head, the presence of air in the system, and other conditions may cause loss of suction.

Obstructions in the suction line often cause operating problems in fire and bilge pumps. Be sure that the suction lines are clear and that all valves in the line are open. Clean the suction line strainer and the bilge strainer.

Hot liquid will often vaporize and cause reciprocating pumps to become vapor bound. The emergency feed pump is particularly subject to this problem when taking a hot suction from the DFT. To shift to cold suction (reserve feed tank), open the vents on the liquid-end valve chest. Cool the pump by applying cold water. You can use a hose or pour buckets of cold water over it. Continue the cooling measures until you see a steady flow of water coming from the vents. Use cold suction for feeding the boiler only long enough to prevent a low water casualty while securing the boiler.

Occasionally, the presence of air in the system will cause a reciprocating pump to become air-bound and lose suction. If this happens, open the vents on the liquid-end valve chest and leave them open until all air is expelled and water flows out. Then, secure the vents.

Reciprocating pumps are generally self-priming. However, pumps having a high suction lift may require priming before they will take a suction. The fire and bilge pump can usually be primed from the sea if you open the sea suction valve for short time.

Loss of Discharge Pressure

There are several reasons for a reciprocating pump to lose discharge pressure; some of the major reasons are listed here:

- Low steam pressure. Loss of steam pressure will cause the pump to slow down and lose pump capacity and discharge pressure.

- High back pressure. If the auxiliary exhaust pressure becomes abnormally high, the pump will slow down, and the discharge pressure will drop.

- Worn piston rings. Leakage of steam by worn piston rings will cause the pump to operate erratically or stop. When worn rings are suspected, disassemble the steam end and take the ring and piston measurements. If measurements are below the designed allowances, renew the rings.

- Defective valves. If a pump is operating normally and suddenly loses discharge pressure, look first for a defective valve that will cause a large loss in efficiency. If a pump races without increasing the discharge pressure, the cause is probably defective valves or air leaking into the suction line.

- Worn plunger packing. The packing on the water end plunger will wear, over a period of time; and the maximum discharge pressure from the pump will decrease accordingly. The only remedy is to renew the packing. When packing a pump with tucks, flax, or other soft packing, soak the packing in hot water for 12 hours before fitting and installing. Follow the procedures in the manufacturer's technical manual.

When you are trying to locate and correct troubles in a reciprocating pump, previous experience with a particular pump is always helpful. First, check all accessible parts. If you cannot find the trouble without disassembling the pump, check the water end before you remove any parts from the steam end. Most pump troubles are caused by fouled water cylinders, worn valves, or conditions in the pipe connections external to the pump.

MAINTENANCE OF RECIPROCATING PUMPS

Repairs must be done in accordance with the manufacturer's technical manual. The system ensures that every part of the pump that requires attention or contributes to poor performance is put into proper condition. When you do a partial overhaul, check NOT DONE on the repair data list for items that are not repaired. This will show that every part was inspected and that corrective maintenance was done where necessary. Upon completion of a pump overhaul, keep the repair data list as a permanent record of all measurements taken and all work done.

When you disassemble a pump for repair or inspection, be sure you have all applicable blueprints, the manufacturer's technical manual, and available dimensional data. Take micrometer measurements of the steam and water cylinders and the steam valve chest. Take these measurements on the fore-and-aft and athwartship diameters at the top, middle, and bottom. Record the results with a sketch showing measurements taken.

Improper alignment is a frequent source of trouble with pumps. Pumps with mountings secured to a bulkhead become misaligned more often than those with independent bases. A pump may have been properly aligned in the shop and then pulled out of line when bolted to the bulkhead mounting. After the pump mounting was secured, the ship may have changed shape enough to warp the bulkhead and cause misalignment.

The operation of an improperly aligned pump usually scores the rods and cylinders and breaks the followers. Test the alignment of pumps occasionally by removing the piston and plunger and running a line through the steam and water cylinders. Make this a routine test within the first year after a ship is commissioned and for a pump that is scoring rods or cylinders or breaking followers.

Before you run a line through the cylinder or make any adjustments, line up the foundation and determine the center line. The center line must divide each cylinder equally (fig. 6-1). Fasten one end of the line on a finger piece secured to the bottom of the water cylinder and the other on a temporary beam rigged above the steam cylinder. Then center the line at the bottom and top of the water cylinder so that it becomes the axis of this cylinder, as shown in figure 6-1. You can then move the steam cylinder about and center it on the line without disturbing the centering of the line on the water cylinder.

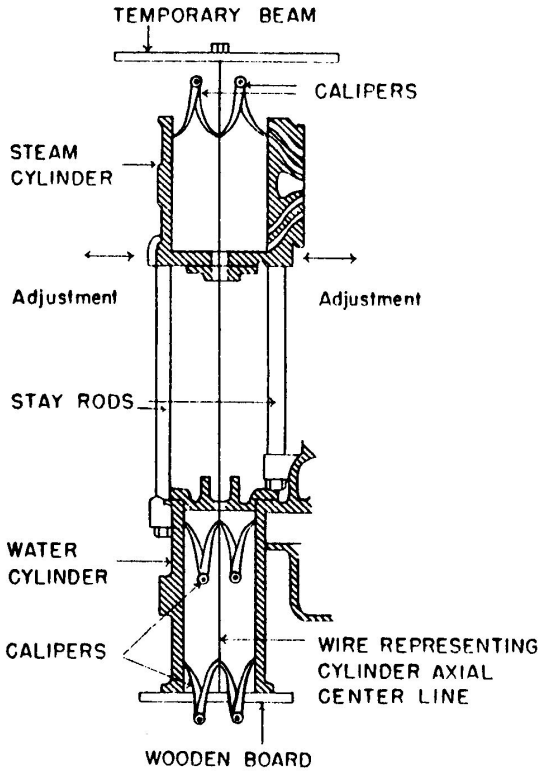


Figure 6-1.—Centering a line through two cylinders

To make a rough check of the alignment of a pump, pull the steam and liquid end rod packing and check the clearances between the piston rods and the cylinder throat bushings. Make this check with the pistons in each of three positions-top, center, and bottom of the stroke. If clearance is not uniform but the throat bushings are not worn out of round, realign the pump as soon as possible.

In some cases, when steam cylinder foundation pad bolts are slacked off, the cylinder pads pull away from the foundation as much as one-half inch. This indicates settling of foundations and bulkheads. Correct this by fitting shims between the foundation and the pump.

Piping stress is a frequent cause of misalignment. The piping should line up naturally with the pump connections and should not be forced into position. Always allow for expansion in steam and exhaust lines. Support all piping independently of the pump. Improperly installed piping puts a strain on the pump inlet and outlet connections and may force it out of alignment. Take special care to avoid vapor pockets when you install suction piping.

CENTRIFUGAL PUMPS

Centrifugal pumps are widely used on board ship to pump water and other nonviscous liquids. They have several advantages over reciprocating pumps: They are simpler, more compact, lighter, and easily adapted to a high-speed prime mover.

Centrifugal pumps also have disadvantages: They have poor suction lift characteristics, and they are sensitive to variations in head and speed.

Centrifugal pumps are usually designed for specific operating conditions and will not give satisfactory results when their rated operating conditions are altered. Before installing any centrifugal pump, be sure you understand the principle of operation and the design limitations of the specific pump.

OPERATION OF CENTRIFUGAL PUMPS

The details of operation for a centrifugal pump may vary from pump to pump. Pumps may look alike, but this does not necessarily mean that they are operated in the same manner. Post detailed instructions for operating a specific pump near the pump. Before operating the pump read the instructions carefully. Follow the step-by-step instructions in the engineering operational sequencing system (EOSS).

Many pump casualties affect the speed of the ship. Those caused by improper operation could be prevented by attentive watch standing. Always follow the engineering operating procedures and manufacturer's instructions for starting, operating, and securing pumps. This will help prevent casualties.

Starting a Centrifugal Pump

The instructions contained in this chapter for the operation of pumps are general. All pumps cannot be covered because of the many makes and types of pumps installed aboard naval ships. Manufacturers' technical manuals are furnished with all but the simplest of pumps. Those manuals contain detailed instructions on specific pumps. Study them carefully before you operate the pumps.

Before starting a centrifugal pump for the first time or after an overhaul, you should check several items. Carefully check the coupling alignment. Flexible couplings will take care of only very slight misalignment, usually about 0.002 to 0.004 inch. The exact figure can be found in the manufacturer's instructions. Excessive misalignment will cause the coupling to fail. This may cause failure of the pump shaft or bearings.

If the pump is motor driven, check the rotation of the unit. Most pumps have an arrow on the pump casing that indicates the proper direction of rotation.

Check all piping that pertains to the pump. During overhaul, most valves in the piping will have been closed. The lube-oil system and the suction, discharge, vent, recirculating, and bypass valves must be linedup properly. Be sure an adequate supply of water is available for the lube-oil cooler; and check the inlet, outlet, and root valves.

The following checks and actions are not necessarily listed in any proper order, and all items do not apply to all steam-driven pumps. Operate the pump in accordance with the ship's EOSS. Use these checks and actions to start a steam-driven centrifugal pump.

1. Check the level of oil in the sump tank or bearing housing. Fill any oil cups or reservoirs. If the pump is lubricated by a detached pump, open and adjust all valves in the discharge and suction lines.

2. Rotate the handle of the lube-oil filter. Lubricate the linkage on the speed-limiting governor.

3. Open the suction valve, the vent, and the recirculating valves. Open any valves in gland water seal lines. (The discharge valve should be closed when you start centrifugal pumps.)

4. Open the steam and exhaust root valves.

5. Check the suction pressure (if applicable).

6. Open all steam drains.

7. Open the turbine exhaust valve.

8. Open the bypass around the governor (if fitted).

9. Crack the turbine throttle valve.

10. Increase the steam-chest pressure until the pump is turning fast enough to ensure adequate lube-oil pressure.

11. Check the packing glands for proper leak-off.

12. When the pump vent blows a solid stream of water, close the vent.

13. Close the pump governor bypass and test the constant-pressure governor.

14. When lube-oil temperature reaches 90°F, open the valve to allow cooling water to flow into the lube-oil cooler.

15. When ordered to put the pump (not fitted with a pressure governor) on the line, increase the pump discharge to the required amount by opening the throttle valve to the necessary speed. If the pump is fitted with a constant-pressure governor, set the governor to give the required discharge pressure.

16. When the pump is delivering the required discharge pressure, open the pump discharge valve.

Operating a Centrifugal Pump

When a pump has been started, do not leave it unattended. Have an experienced person on hand to check for abnormal operation. Make frequent checks on the temperature of the lube oil leaving the cooler and each bearing. The suction and discharge pressures

may become too high or too low. Packing glands may overheat and burn out.

The principal troubles that may occur with centrifugal pumps are as follows:

- Low discharge pressure. There are several reasons why a pump will not discharge at maximum capacity or pressure. The pump may be improperly primed, thus the proper quantity of liquid does not reach the pump casing. The speed of the pump may be too slow. On a turbine driven pump, the speed-limiting governor may be set too low, or the constant-pressure governor may need adjusting. The pump may have mechanical defects such as worn wearing rings, worn bearings, a bent shaft, or a damaged impeller.

- Loss of suction. If a pump has been operating satisfactorily and loses suction, air may be entering the auction line or packing glands. The suction strainer may have become clogged, or dirt or other foreign matter may have entered the impeller opening. In a main feed pump, the main feed booster pump may not be operating at its normal discharge pressure.

- Excessive vibration. In a pump, excessive vibration may be caused by one of the following: misalignment of the unit, a sprung foundation, worn impeller rings, worn bearings, a bent shaft, an improperly balanced impeller, or a broken impeller.

When putting a main feed pump on the line, make sure the main feed booster pump is maintaining the requited pressure. Boiler feedwater is discharged under pressure from the main feed booster pump to the suction side of the main feed pump. This in turn discharges the feedwater through the feed line to the boiler at a high pressure.

There are two sets of wearing rings in each stage. These wearing rings have a minimum of clearance, as do the rings in a main feed booster pump. However, the rotation of a main feed pump can be five times as great as that of a main feed booster pump. Therefore, the possibility of seizure of the main feed pump wearing rings is much greater.

Water entering the suction of the main feed pump has its pressure reduced while passing through the entrance ports. Since this water is at a temperature of about 240°F, this reduction in pressure might easily cause the water to flash into steam. If this occurs, the pump will become vapor bound. The water cannot then flow through the pump and remove heat from the pump casing. A vapor-bound feed pump will require about 15 seconds to overheat, causing the wearing rings to seize.

The main feed booster pump discharge should be maintained as near the designed value as possible. For an installation designed to operate at 50 psi of booster pressure, the main feed pump should not be turned over when there is less than 40 psi of booster pressure.

When main feed pumps are running, ensure the oil temperature and pressure at the bearings are in accordance with the manufacturer's operating instructions. If a detached lube-oil pump is provided, it will automatically cut in if the lube-oil pressure falls below a predetermined amount. If low lube-oil pressure develops after the detached lube-oil pump starts, shift to the standby unit. Secure the faulty unit and determine and correct the cause of low lube-oil pressure. On installations without a detached lube-oil pump, if low lube-oil pressure occurs, shift immediately to the standby unit. Do not operate the faulty pump until the proper lube-oil pressure has been restored.

There is a common tendency to tighten packing glands too tightly. This causes the packing to burn and leads to scoring of the shaft sleeves. The packing glands should be adjusted so that a small amount of water is leaking out of the stuffing boxes. This water lubricates and cools the packing and packing gland. The packing gland should always be parallel to the face of the stuffing box and not cocked at an angle. If a stuffing box leaks excessively and it becomes necessary to tighten the gland, take up evenly on the gland bolts by a slight turn. Wait a reasonable time. Then, if the leakage is still excessive, tighten the gland bolts by another slight turn. Continue this procedure until there is only a trickle of water from the stuffing box.

When a main feed pump is running, do not change from hot to cold suction or vice versa, unless there is an extreme emergency. Make periodic checks for vibration of the pump and driving unit. If vibration becomes excessive, stop the pump and investigate.

When a main circulating pump is used to pump the engine-room bilges, start the pump in the same way you would for main condenser circulating service. Then gradually close the main injection valve and open the bilge suction valve. When the pump is operating on a high-suction lift, as when pumping bilges, reduce the speed to about two-thirds of rated speed. Even then, the pump will be noisy. This cannot be avoided but can be minimized by slowing the pump.

Securing a Centrifugal Pump

To secure a steam-driven centrifugal pump, proceed as follows:

> **NOTE**
>
> These procedures are not necessarily listed in any proper order and mayor may not apply to all centrifugal pumps. Secure the pumps in accordance with the ship's EOSS.

- Close the pump discharge valve.
- Close the throttle valve.
- Close the exhaust valve.
- Close the suction valve.
- Close the vent, recirculating, and gland-sealing valves. (On some units, recirculating and vent valves are locked open.)
- Open the turbine casing drain.
- Close the stem and exhaust root valves.
- Close the turbine casing drain after the turbine is completely drained.

MAINTENANCE OF CENTRIFUGAL PUMPS

This chapter contains some of the information you must have to give proper care and maintenance to centrifugal pumps. Before you try to repair any pump, study the manufacturer's technical manual and the maintenance records carefully.

Mechanical Seals

Today, mechanical seals are rapidly replacing conventional packing in most centrifugal and rotary pumps. Fitting pumps with mechanical seals eliminates excessive stuffing box leakage. They are particularly well suited for pumps that move flammable liquids, such as fuel and lube oil. A mechanical seal is shown in figure 6-2.

Mechanical seals use bleed pressure from the liquid being pumped to help seal the shaft and stuffing box. This positive pressure will ensure adequate liquid circulation at the seal faces. The positive pressure also should minimize foreign matter deposit on the seal parts.

Seawater pumps equipped with mechanical seals also should allow for the use of conventional packing should the seal fail. This feature allows you to make emergency repairs without removing the seal.

You should replace mechanical seals in nonflammable liquid systems whenever the seal is removed for any reason. You also should replace the seal when the leakage rate approaches a steady stream, reduces pump performance, or affects surrounding equipment.

Zero leakage is allowed for mechanical seals on flammable liquid pumps. In addition to replacement whenever it is removed, you will need to replace these mechanical seals when the seal shows more than a slight dampness at the seal housing after 30 minutes of operation. Because of the hazard involved, do not operate flammable liquid pumps with excessively leaking seals.

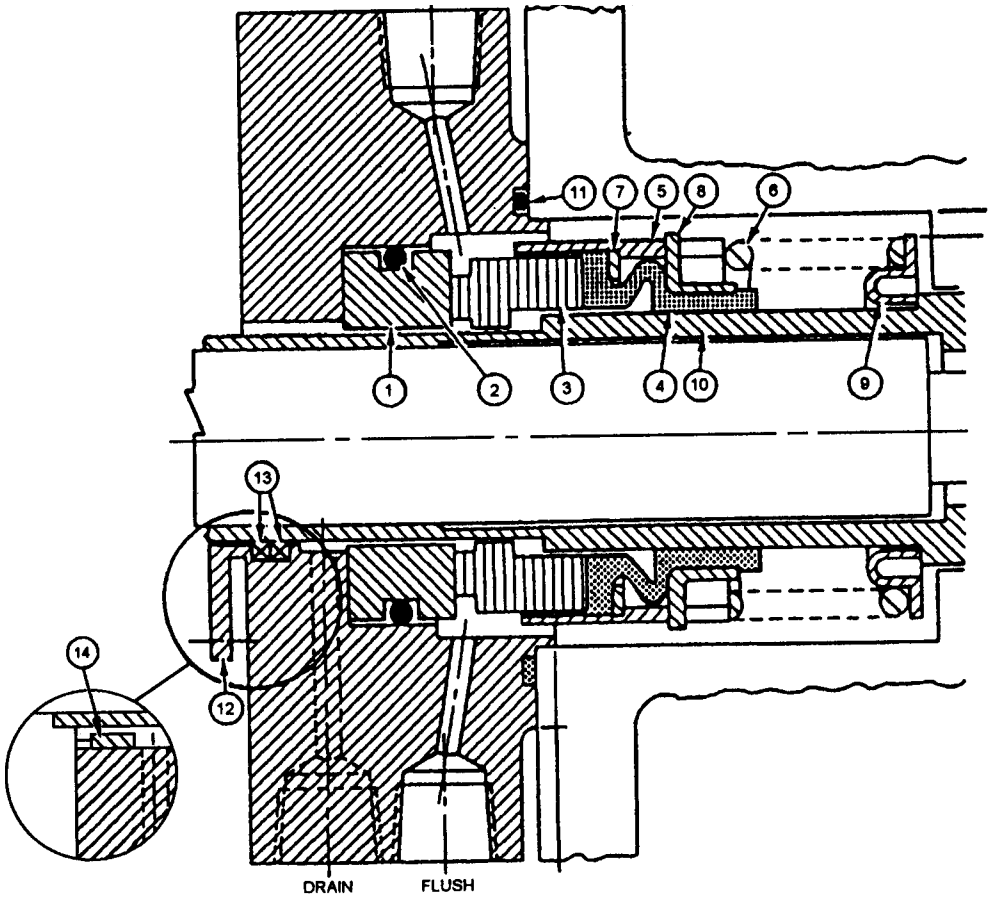
When you replace mechanical seals, you must use a stub or step sleeve to position the seal on the shaft. The shaft sleeve must be chamfered on the outboard end to ease mechanical seal mounting. Setscrews shall not be used to position mechanical seals.

Bearing Maintenance

Pump bearings must receive approximately the same tests, inspections, and maintenance as bearings installed in other units of naval machinery, pump bearings must be supplied with an adequate amount of oil at the right temperature and of the viscosity designated for that particular pump. The manufacturer's technical manual contains information on lubrication of each pump.

THRUST BEARINGS should be examined in accordance with PMS. Check the condition of the bearing and the position of the rotor. When checking the rotor position, allow for expansion of the shaft from a cold to a hot condition. There are many types of thrust bearings installed in pumps. Study the manufacturer's technical manual before you disassemble any thrust bearing.

JOURNAL BEARINGS should be systematically inspected. Check the condition of the journal and the bearing surface and correct any deficiencies. Take lead readings and maintain bearing clearances as shown in the manufacturer's plans. If the manufacturer's technical manual is not available, follow the instructions in NSTM chapter 244.



1. Mating ring
2. O-ring
3. Primary ring
4. Bellows
5. Retainer
6. Spring
7. Disc
8. Drive band
9. Spring holder
10. Sleeve
11. O-ring
12. Aux. gland
13. 3/16 sq. pkg.
14. Bushing

Figure 6-2.—Typical mechanical seal.

WATER-LUBRICATED BEARINGS are installed in main condensate pumps and main condenser circulating pumps. In main condensate pumps, the bearing is located in the casing, between the first stage and second-stage suction compartments, where it also serves as an interstage seal. Vertical movement of the bearing is prevented by shoulders in the casing; and a stop pin prevents angular movement. During normal operation of the pump, the bearing is lubricated by a constant flow of water through the bearing. This flow is maintained as a result of the pressure differential between the two suction compartments.

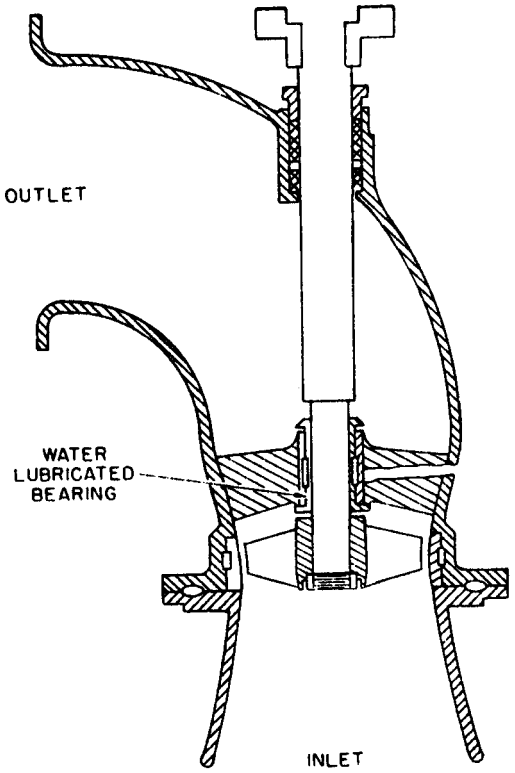
In main condenser circulating pumps (fig. 6-3), the water-lubricated bearing is located immediately above the propeller and is designed for a radial load only. The bearing is held in place by shoulders in the casing and is lubricated by the flow of water through the pump.

A number of materials have been used for water-lubricated bearings, such as leaded bronze, graphited bronze, lignum vitae, laminated phenolic material grade FBM (fabric-based Bakelite or Micarta), and barium. Most water-lubricated bearings are now made of rubber or phenolic material.

Check the condition of water-lubricated bearings frequently. Excessive wear causes shaft misalignment and possible bearing wear or shaft breakage.

BALL and ROLLER BEARINGS are used in many shipboard pumps, especially in small pumps and in main condensate, main feed booster, and lube-oil service pumps. These bearings must be handled as carefully as any other piece of precision equipment. The following precautions will aid in proper bearing maintenance:

- Do not remove the bearing from its container until you are ready to install it.



96.15

Figure 6-3.—Main condenser circulating pump, showing Internal water-lubricated bearing.

- Be certain that the journal, housing, or any other mating part is of the correct dimensions.

- Avoid damage during handling; do not drop the bearing; keep dirt and moisture away from the bearing, shaft, and housing.

- Use proper tools to remove the old bearing and install the new one.

- Use the correct lubricant and the proper amount. After assembly, rotate the journal by hand to ensure there is no undue friction.

In rolling contact bearings, the journal is supported by the races and rolling elements rather than the oil film. However, lubrication still plays an important part in the operation because it dissipates heat and prevents corrosion. The oil film also helps keep foreign matter out of the bearing. Use enough grease or oil to provide a protective film over the bearing parts. Too much lubricant will churn, and the bearing will overheat. When a roller or ball bearing fails in service, it must be renewed, because it cannot be repaired. The replacement bearing must be carefully installed if it is to give satisfactory service.

Replacing Pump Rotors

Pumps, like all machinery, in time, will need overhauling. Much of the work on pumps involves removing the rotor from the casing. To renew wearing rings, bearings, sleeves, or impellers, you must remove the casing and lift out the rotor.

Use the following procedures to disassemble a MAIN FEED PUMP

1. Wire shut and attach a danger tag to all suction, discharge, vent, and recirculating valves. Drain water from the casing.

2. Remove all suction, discharge, vent, and recirculating lines that will interfere with lifting the casing and rotor.

3. Remove the bearing caps and the bearings (journal and thrust).

4. Disconnect the coupling between the turbine and pump.

5. Remove the packing glands and the packing.

6. Remove the pump casing horizontal joint bolts.

7. Break the horizontal casing joint by tightening the jack screws.

8. Attach the lifting gear to the upper half of the casing (eyebolts are provided for this purpose).

9. Lift the upper half of the casing until it is clear of the rotor. Change the lifting gear and swing the upper casing half clear of the pump.

10. Attach cables around the shaft at both ends, making certain that you do not lift on a journal surface. Lift the rotor out of the lower half of the casing.

11. The rotor can then be moved to a location where it can be disassembled. To have access to all rotor parts, place the rotor on a workbench or two wooden sawhorses.

Remove all rotor parts in the sequence and in the manner recommended by the manufacturer.

It may be necessary to heat the impellers to remove them. If so, warm the impeller evenly all around while keeping the shaft as cool as possible.

When the rotor parts are disassembled, check the shaft carefully. Check the journal surfaces for burrs or nicks. If a lathe is available, the shaft can be swung in the lathe. You can then use a dial indicator to determine whether the shaft is bent or the journals are

out of round. The journal surfaces can be measured with an outside micrometer to determine whether there is wear. If the journals are worn or out of round, they can be built up and machined to the designed diameter at a repair activity. If the wearing rings are to be renewed, they will have to be fitted either in the ship's machine shop or at a repair activity.

Before you reassemble the rotor, make sure that all parts are clean and free of burrs (especially the faces of the impeller and the sleeves).

The following clearances should be within the limits indicated in the manufacturer's technical manual: the oil clearances of the journal and thrust bearings, the running clearance of the wearing rings, the clearance between the impeller and diaphragm bushing, and the clearance between the shaft sleeve and stuffing-box bushing.

Before lowering the rotor, roll in the lower half of the journal bearings. Clean all dirt and foreign matter from the lower half of the casing. Use a new parting flange gasket to avoid leaks; internal leaks will lower the efficiency and maximum capacity of the pump.

Attach the lifting gear and lower the rotor into the casing. Make sure that all stationary rotor parts-diaphragms, casing rings, and stuffing-box bushings- will enter their respective fits in the casing without binding. If you need to use force to get the rotor parts into the casing, remove the rotor and check all parts for dirt and burrs.

When the rotor is in place, lower the upper half of the casing. Ensure that the casing fits over the rotor easily. If it does not, remove the upper casing half and examine it for dirt and burrs. When the upper and lower casing halves contact each other properly, insert the casing dowels. Next, tighten the parting flange nuts; tighten them evenly several times. Assemble the thrust bearing; then place the upper half of the bearings in position and bolt the two halves of each together.

Adjust the flingers; they should be close to the face of the bearings but MUST not rub. Tighten the flinger setscrews and close up the bearings by placing the caps over them and tightening the bolts. Take a reading on the thrust bearing clearance.

The pump shaft and turbine shaft MUST be in correct alignment. For information on pump alignment, refer to the manufacturer's technical manual or NSTM, chapter 503.

All water lines MUST be in place and tightened before you attempt to align the unit. Otherwise, tightening the lines may cause misalignment of the unit. Pack the stuffing boxes with the proper packing; then the unit is ready to be tested.

Rotate the pump several times by hand before you cut steam into the driving unit. Ensure there is no undue binding or friction.

The procedure for replacing a MAIN CONDENSATE PUMP ROTOR or a MAIN FEED BOOSTER PUMP ROTOR is similar to the procedure described above. These pumps are usually mounted vertically. The rotor cart be disassembled without disturbing the driving unit. The procedure is as follows:

1. Obtain the manufacturer's technical manual and blueprints. Study the construction details and procedures for assembly and disassembly. Note the manufacturer's data on wearing ring clearances, bearing clearances, and other necessary dimensions. Check the maintenance records; alterations may have been made.

2. Remove the new rotor from its storage place. Clean and inspect the new rotor; take all necessary measurements.

3. Assemble all necessary lifting gear and tools, including special tools.

4. Remove the nuts at the parting flange and remove the casing half. Take off the bearing cap, unbolt the bearing housing, disconnect the coupling, and lift out the old rotor.

5. Inspect the interior of the casing. Clean all flanges and make new gaskets. Use new gaskets on all flanges. Any leakage through a main condensate pump flange will cause a loss of vacuum in the main condenser.

6. After the cleaning and inspecting are done, lower the new rotor into place.

7. Place the casing in position and tighten the parting flange nuts. If the casing binds or does not fit properly, remove the casing and correct the trouble.

8. When the casing has been secured in place, rotate the rotor by hand to ensure there is no binding or undue friction.

9. Reassemble the bearing housing and connect the coupling. If the pump still turns freely, the unit is ready to be tested by steam (or motor). If all conditions are satisfactory, bring the pump up to operating speed and pressure. When the pump is used for the first time,

keep it under close observation for several hours. Do not consider it ready for unlimited operation until it has carried the required load with the ship underway.

Prepare a work request for the necessary repairs to the defective rotor. Write up all necessary details, including balancing. Take the rotor to the appropriate repair activity. All pump and driving unit rotating parts are balanced dynamically for all speeds from at rest to 125 percent of rated speed. This is usually done on balancing machines generally available on tenders and repair ships and at all naval shipyards.

Pump rotors may be overhauled on board ships with adequate shop facilities. Take the rotor to the machine shop and dismantle it. Take the parts off the shaft in the sequence recommended by the manufacturer. When the parts have been removed, check the shaft in the same manner described in this chapter for shafts of main feed pump rotors.

If the shaft is not bent or out of round, reinstall the parts on the shaft, using new parts as needed. The best practice is to heat the bearing in an oil bath to about 200°F (but not exceeding this temperature). Slip it over the journal and position it by means of the locknut. The locknut can be tightened as the bearing cools.

Give wearing rings the clearance recommended by the manufacturer. When the rotor is reassembled, stow it properly so that it will be ready for use when needed.

Lubricating Systems

Lack of lubrication or improper lubrication is a major cause of pump failure. Before a pump is started, check the level of oil in the sump not only for the amount of oil, but also for the quality of oil it contains. If water is found in the oil pump, check for leakage from turbine glands, a leaky oil cooler, or any other possible source of water contamination. Check the oil filters or strainers frequently. In those with edge filtration (such as in the Curio type of filter), sediment will collect in the bottom of the filter. Clean it out frequently. Check the housings of grease-lubricated bearings occasionally to ensure they are free of water, dirt, and other foreign matter. If water is found in the bearing housing, trace it to its source. The frequency with which grease is added to a bearing must be determined by the type of service and the effectiveness of the grease seals.

When starting a pump, check the oil pressure and the flow of oil to all bearings. Make sure that the lube-oil pump is discharging at the designed pressure. Ensure that cooling water is flowing through the oil cooler and that all air is vented from the cooler. It may be necessary to vent the lube-oil system. To do this, open the vent on the highest point in the lube-oil system and close the vent when oil appears.

When water or other foreign matter is found in **a** lube-oil system, do not operate the unit until the system has been drained, cleaned, and filled with the proper quantity and quality of oil.

Flexible Couplings

On most turbine-driven pumps, the pump end is joined to the turbine end by a flexible coupling. Flexible couplings take care of very slight misalignment between the driven and the driving shaft. However, they cannot take care of excessive misalignment. Excessive misalignment causes rapid wear of the coupling and damage to both the pump and the turbine.

There are currently two types of flexible couplings in use. The most common type is the self-lubricated type. However, most boiler main feed pumps use the dry type of flexible coupling. Inspect and lubricate flexible couplings following the PMS. When a flexible coupling is opened, be sure you inspect all gear teeth, pins, or other parts subject to wear. Replace parts if necessary.

Rigid Couplings

Some small pumps are connected to their driving units by rigid flange-type couplings. When this type of coupling is used, frequent realignment of the shafting is necessary. Misalignment is indicated by worn bearings or bushings, abnormal operating temperatures, and abnormal noises.

Wedges or shims are placed under the base of the driven unit and under the base of the driving unit (fig. 6-4, view A). They help alignment when the machinery is installed. Jacking screws also are used to level the units. When the driving unit or the driven unit (or both) have to be shifted sideways to align couplings, side brackets are welded in convenient spots on the foundation. Large setscrews are used to shift the units sideways or endwise. After the units have been adjusted so the outside diameters and faces of the coupling flanges run true as they are manually rotated, the chocks are fastened. The units are securely bolted to the foundation. Then, the coupling flanges are bolted together.

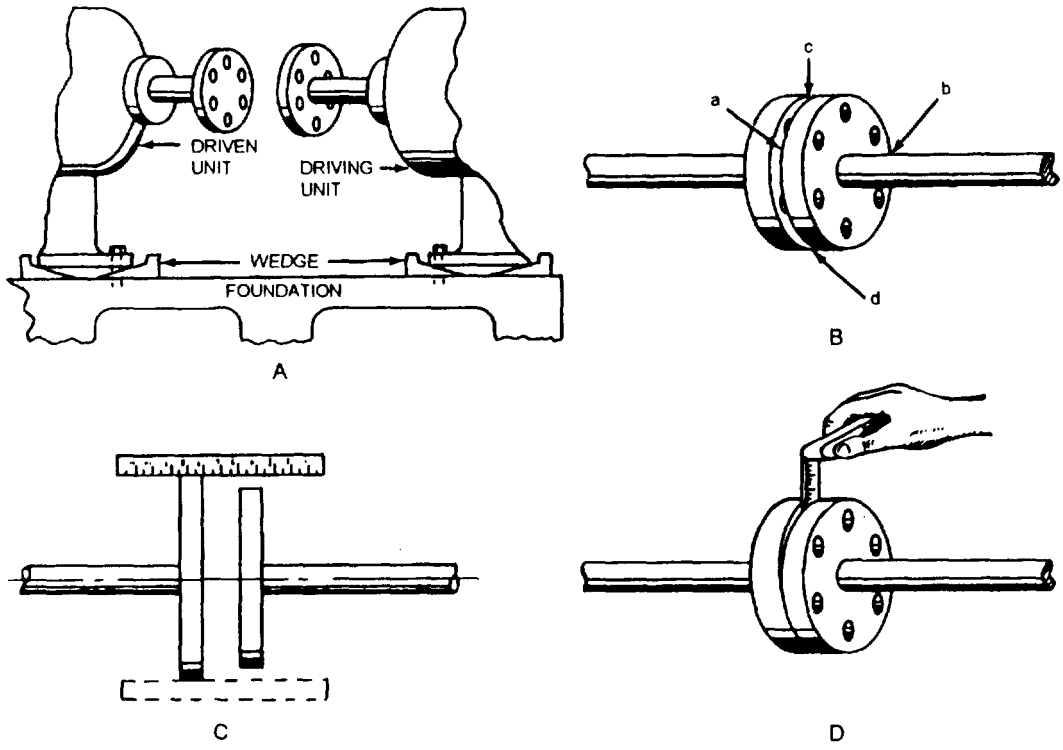


Figure 6-4.—Alignment of flange couplings. A. Leveling the unit, B. Aligning the coupling faces. C. Aligning flange diameters. D. Checking with feelers.

When rigid flange couplings are used, check the shaft alignment when the pump is opened. Also, you should check shaft alignment when unusual vibration or other signs of misalignment are noted. Three methods are used for checking alignment in shafts connected by flange-type rigid couplings.

- A 6-inch scale
- A thickness gauge
- A dial indicator

When using a 6-inch scale to check alignment, check the distance between the faces of the coupling flanges at 90-degree intervals. Find the distance between the faces at point a, point b, point c, and point d, as indicated on view B of figure 6-4. If all distances between the faces are equal at these points, the coupling faces are parallel to each other. If the faces are not parallel, adjust the driving unit or the driven unit (or both) with shims until the couplings check true. When measuring the distances, keep the outside diameters of the coupling flanges in line. To do this, place the scale across the two flanges, as shown in view C of figure 6-4. If the flanges do not lineup, raise or lower one of the units with shims. Then, if necessary, shift the units sideways using the jacks welded on the foundation. To check this kind of alignment, use the scale at 90-degree intervals. This is the same procedure you used for checking the distance between the flange faces.

When you use a thickness gauge to check alignment, the procedure is similar to the one used in checking with the scale. When the outside diameters of the coupling flanges are not the same, use a scale on the surface of the larger flange. Then, use feelers between the surface of the smaller flange and the edge of the scale. For a narrow space, check the distance between the coupling flanges with a thickness gauge (fig. 6-4, view D). Wider spaces are checked with a piece of square key-stock and a thickness gauge. Rotate the coupling flanges one at a time, and check them at 90-degree intervals. If the faces are not true, the shaft has been sprung. Many times the shafts must be removed and sent to a repair activity for reworking.

When using a dial indicator to check alignment, clamp the indicator to one coupling flange. Then, rotate both flanges together. If no variation is shown on the dial indicator, the coupling is running true. If misalignment does exist, the dial indicator will show the degree of misalignment. If you find misalignment, align the units. Then, check them again with the dial indicator. When possible, you should use dial indicators for checking the alignment of couplings. This is the most accurate method of checking alignment.

ROTARY PUMP ROTORS

Generally, it is more difficult to replace main lube-oil service pump rotors than rotors in other types of pumps. The driving unit must be removed before the liquid end can be disassembled. With the drive unit removed, the pump rotor and rotor housing can be disassembled without removing the mountings or the main lube-oil connections.

Under normal operating conditions, the rotors are completely covered with oil, which cuts rotor wear to a minimum. Therefore, the rotors may give years of satisfactory service without repairs. In some instances, rotor failure has been caused by normal wear; air trapped in the casing; or dirt, wood, or metal objects in the casing. To replace a defective rotor, proceed as follows:

On a turbine-driven unit, remove the drive unit by breaking the steam and exhaust lines. Disconnect the coupling and remove the bolts that secure the spacing frame to the pump casing. Attach the lifting gear and lift the drive unit off intact.

To disassemble the liquid end (fig. 6-5), first remove the lower coupling half, the packing gland, and the upper casing head. The rotors will then be exposed and can be withdrawn. As the rotors are lifted out of their housings, the idlers must be supported; the pump is constructed in such a manner that only the housings hold the rotors in mesh. With the rotors removed, the housings are accessible. The housings fit snugly in the bore of the casing and are separated by a spacer ring. They are positioned axially by jam screws, which bear on the casing heads, and circumferentially by guide pins, which are fitted individually to ensure alignment of the housing bores. The guide pins are secured by pipe plugs. Before the rotor housings can be removed, the housing guide pins must be removed. The outer ends of these pins are drilled and tapped for the application of a pulling tool. Because these guide pins are fitted parts, each pin must

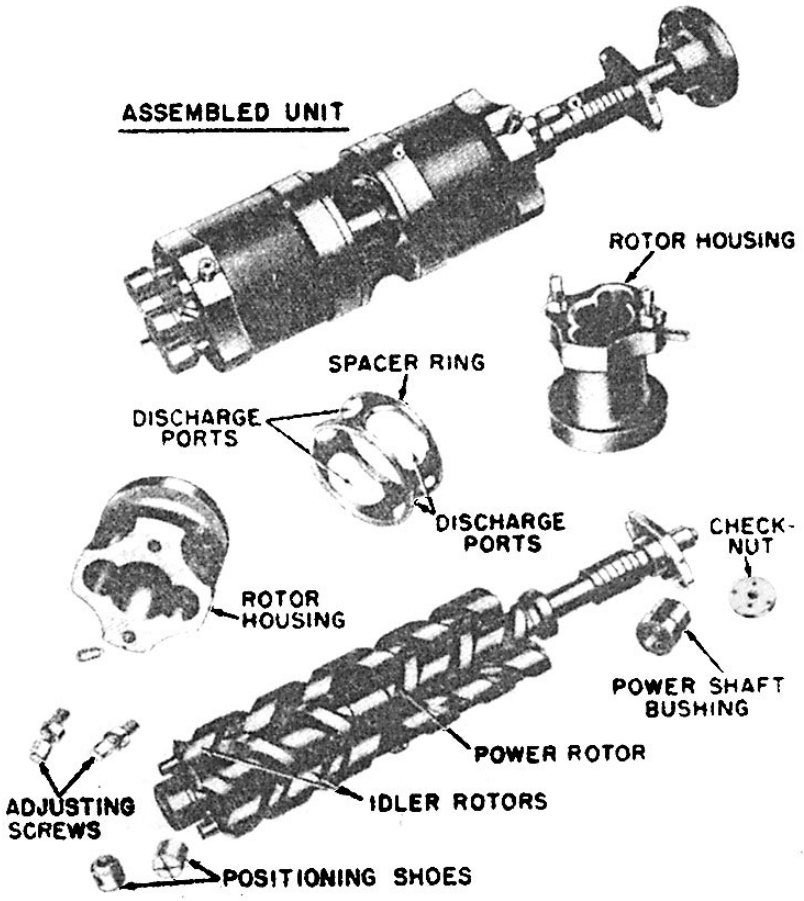


Figure 6-5.-Rotor assembly for a lube-oil service pump.

be marked as it is withdrawn so that it can be replaced properly.

Before reassembling the unit, carefully inspect and clean all parts of the pump. Be certain that the settings of the lower housing jam screws are correct (check the manufacturer's technical manual or blueprint).

When reassembling the pump, lower the bottom housing, the spacer, and the upper housing into place separately. Ensure that each part seats firmly and that the guide pin slot in each housing registers with the pin hole in the casing. The special tool used to pull the housings can also be used to assemble them. Next, install the housing guide pins and their securing plugs. If new housings are installed, carefully align the bores and fit new guide pins to maintain alignment. You can then set up the jam screws in the upper housing.

Insert the rotors and turn them by hand to see that they are free and do not bind. Binding of the rotors is an almost certain indication that the bores of the housings are not in line or that the guide pins or the housings, or both, have not been properly installed. Install the upper casing head, making sure that the thrust plate and the seal bushing are in place and that the latter is secured by the stop pin provided for that purpose.

When a pump is assembled at the factory, the locating caps on the idlers are setup to establish the proper running positions of the idlers with reference to the power rotor and are then secured by riveting. So long as a set of rotors remains intact, readjustment of the locating cap settings is rarely necessary. Even over long periods of service, wear of the hardened contact surfaces will be negligible.

Whenever new rotors are installed, you must establish the proper locating cap settings. The proper cap settings are such that the lower end surfaces of all three rotors will lie in a common plane when the rotors are properly meshed and the idlers are located centrally with respect to end play in the power rotor.

The cap settings must be established before the rotors are installed. However, the rotors should be inserted in one of the housings for the adjustments, to ensure proper meshing. A tapped hole is provided in the base of each cap. This is done so that the pulling tool, or some other suitably threaded implement, can be used to jack the cap into position. After the settings have been established, rivet the caps into place; you will have to drill the shaft ends for the rivets. Rivet holes are provided in the caps of all idlers supplied by the factory.

SHAFT-DRIVEN LUBE-OIL PUMPS are of the same size and design as the steam-driven pumps but differ in their mountings and drive details.

On ships built since World War II, the attached lube-oil pump is driven from the main reduction gear by an assembly of bevel and spur gears. The driving connection is made by a pinion, mounted on a hub, that is attached to the lower, low-pressure, low-speed pinion quill shaft coupling.

PUMP CONTROL DEVICES

Turbine-driven pumps are fitted with devices to control or limit the speed of the unit or to regulate the discharge pressure of the unit.

SPEED-LIMITING GOVERNORS

Speed-limiting governors are set to give a rated speed at rated load conditions. With the governor properly set, the turbine speed should not exceed the rated speed for any condition of load by more than 5 percent. If the governor will not function within the prescribed limit, it must be overhauled and the cause of faulty operation located and corrected. Speed-limiting governors should be inspected and tested in accordance with the 3-M Systems. They must be tested more often if ordered by NAVSEA, the type commander, or any other proper authority.

Chapter 5 of *Machinist's Mate 3 & 2,* contains information on the principles of operation of a centrifugal weight type of speed-limiting governor. Briefly review that chapter if necessary. To set this type of governor, remove the governor lever and the governor cover. The governor spring will then be accessible. If you want to increase the maximum speed of the unit, you must increase the tension of the governor spring by tightening the adjusting nut. With increased spring tension, more centrifugal force will be required to move the weights outward. This in turn moves the sleeve outward against one end of the governor lever and moves the other end of the governor lever inward. These movements close down on the poppet valve and decrease the amount of steam flow to the turbine.

If you decrease the tension on the governor spring, the governor weights will move outward with less centrifugal force. As a result, the maximum speed of the unit will decrease.

There is very little wear in a speed-limiting governor; however, preventive maintenance is required. The governor must be kept clean. Dirt or other foreign matter can foul the spring; more force is then required to move the weights, which allows the pump to overspeed. Rust on the governor lever fulcrum pin causes the lever to bind and not function properly. Keep all pins in the linkage and the valve stem free of paint, rust, and dirt so that the linkage can move freely. Occasionally, make a test to determine whether the poppet valve is leaking. You can make this test by pushing the valve onto its seat by hand. If the valve is leaking, the turbine will continue to rotate.

CONSTANT-PRESSURE PUMP GOVERNORS

Turbine-driven main feed pumps and fire pumps are fitted with constant-pressure governors. These governors control the discharge pressure of the unit by automatically controlling the amount of steam admitted to the turbine.

The following paragraphs deal with maintenance of these governors. For more complete details on operation and maintenance of constant-pressure governors, see the manufacturer's technical manual.

The most common cause of improper operation of constant-pressure governors is dirt or other foreign matter. These materials are carried with the steam into the governor and interfere with the operation of the moving parts. The only remedy is to disassemble the governor and thoroughly clean all parts.

Failure of the governor to properly regulate the pump discharge pressure may also be caused by one or more of the following reasons:

- Leakage around the seating surfaces of the control valve, the main valve, or the threads of their respective seat rings
- A main valve spring or a controlling valve spring that is broken, that is weak, or that has taken a permanent set
- A broken, cracked, or excessively deformed diaphragm
- Improper adjustment of the needle valve
- Too little or too great a clearance between the control valve and its diaphragm
- Clogged ports in the diaphragm chamber
- Binding of any moving parts

This is not a complete list of reasons for failure of constant-pressure governors, but it does cover the most common causes.

When a constant-pressure governor is sluggish or erratic because dirt or other foreign matter is interfering with the free movement of working parts, the governor must be completely disassembled and all parts cleaned. The manufacturer's technical manual gives a step-by-step procedure for disassembly. Use extreme care to remove and clean all parts. Clean the parts with an approved solvent and a soft brush. If this cleaning method fails to remove hardened deposits, use a sharpened tool; but use it with extreme caution.

Pay particular attention to cleaning the seat for the cylinder liner. This liner must fit properly to prevent it from projecting above the body flange. The bore of the main valve guide must also be carefully cleaned. As each part is cleaned, inspect it carefully for excessive wear. If parts must be renewed, use only parts finished by the manufacturer.

If there is leakage through the control valve or its bushing, steam will flow to the top of the operating piston. This action opens the main valve and holds it open, even though there is no tension on the adjusting spring. The main valve must be able to close completely, or the governor cannot operate properly. The only remedy is to disassemble the governor and stop the steam leakage. In most instances, the control valve must be renewed. If the leakage is through the bottom of the bushing and its seat, the seat must be lapped. A cast iron lapis best for this type of work.

The lap should be rotated through a small angle of rotation, lifted from the work occasionally, and moved to a new position as the work progresses. This will ensure that the lap slowly and gradually rotates around the entire seat circle. Do not bear down heavily on the handle of the lap, and take particular care not to bear sideways on the lap. Replace the compound often, using only clean compound. If the lap develops a groove or cut, redress the lap. Do not lap any longer than necessary to remove all damaged areas.

When you install the control valve and its bushing, remember that the joint between the bottom of the bushing and its seat is a metal-to-metal contact. The bushing must be installed tightly. When it is all the way down, tap the wrench lightly with a hammer to ensure a steamtight joint.

When the controlling valve is installed, check the clearance between the top of the valve stem and the diaphragm. It is absolutely mandatory that this

clearance be between 0.001 and 0.002 inch. If the clearance is less than 0.001 inch, the diaphragm will hold the control valve open, allowing steam to flow to the main valve at any time the throttle valve is open. If the clearance is more than 0.002 inch, the diaphragm will not fully open the control valve. This means that the main valve cannot open fully and the unit cannot be brought up to full speed and capacity.

When the main valve seating area is damaged, it must be lapped in by the same process. ALWAYS lap in the main valve with the piston in the cylinder liner to ensure perfect centering.

If the damage to the seating surfaces is excessive, install new parts. Use parts supplied by the manufacturer, if available.

If the top flange of the top cap becomes damaged, use extreme care to machine it. See the manufacturer's technical manual for the correct clearances. (See fig. 6-6)

All seating surfaces must be square with the axis of the control valve seat threads and must have the smoothest possible finish. Before starting the reassembly, be sure all ports in the top cap and diaphragm chamber are free of dirt or other foreign matter. Check to ensure that the piston rings are free in their grooves. Be sure the cylinder liner is smooth and free of grooves, pits, or rust.

When installing the cylinder liner, make certain that the top of the liner does not extend above the top of the valve body. The piston must work freely in the liner; if there is binding, the governor will not operate satisfactorily. Renew the controlling valve spring and the main valve spring if they are weak, broken, or corroded or if they have taken a permanent set. If necessary, renew all diaphragms. If the old diaphragms are used, install them in their original position; do not reverse them.

Follow the instructions in the manufacturer's technical manual when you reassemble the governor. All clearances must be as designed if the governor is to operate satisfactorily. Check each moving part to ensure freedom of movement.

When the governor is reassembled, test it as soon as possible so that you can make any necessary corrections.

SAFETY PRECAUTIONS FOR OPERATING PUMPS

Carefully following the list of safety precautions listed below will help prevent casualties to the pumps on your ship.

- If relief valves are fitted, ensure that they function at the designated pressure.
- Never attempt to jack a pump by hand when the steam valve to the driving unit is open.

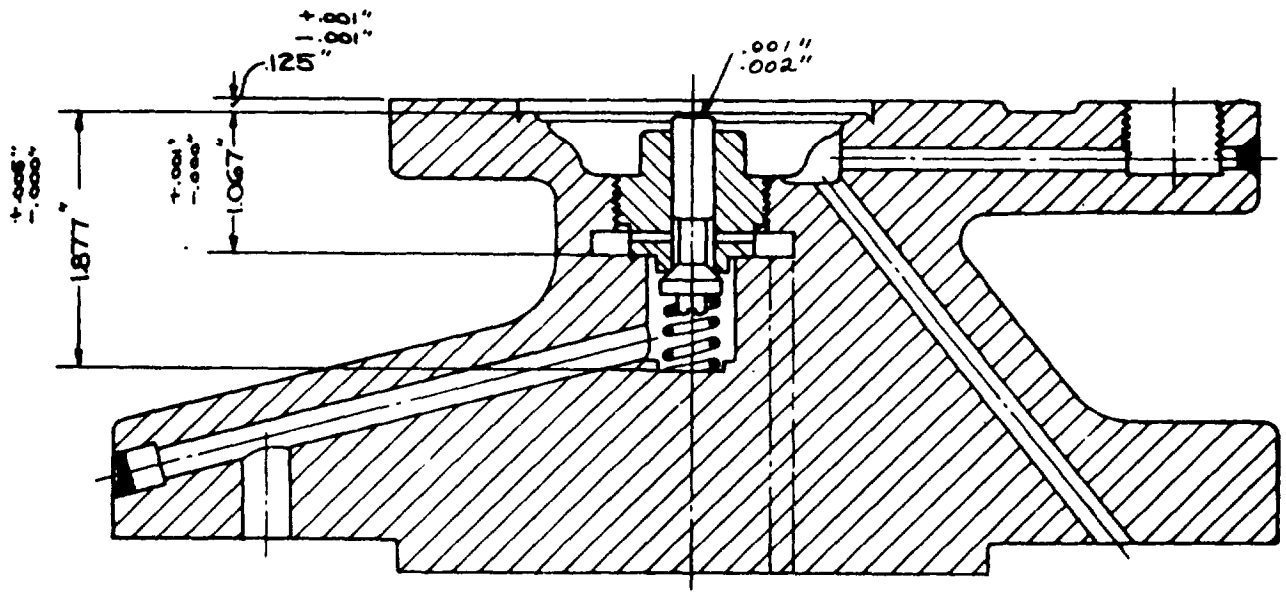


Figure 6-6.—Important points in cleaning a top cap assembly.

- Do not render inoperative the overspeed trip or the speed-limiting or speed-regulating governor.

- Ensure that overspeed trips are set to shut off steam to the unit when the rated speed is exceeded by 10 percent.

- Ensure that speed-limiting and speed-regulating governors are set to limit pump speed to rated speed under rated conditions and that rated speed is not exceeded by more than 5 percent for any loading condition.

- Ensure that drains are open and that steam and exhaust root valves are wired shut and tagged before opening the turbine-driven unit steam end.

- Never operate a positive displacement rotary pump with a discharge valve closed unless the discharge is protected by a properly set relief valve.

- Never use a jacking bar to start a reciprocating pump while the steam valve to the pump is open.

SUMMARY

In this chapter, you have been given information on the operation of several types of pumps and the problems you may encounter with pumps. The information presented in this chapter does not contain specific repair procedures. For detailed information on the maintenance and repair of pumps, you should consult NSTM, chapter 503, and the specific manufacturer's technical manuals.

CHAPTER 7

DISTILLING PLANTS

As a Machinist's Mate 1 or C, you will operate, troubleshoot, and repair the submerged tube and flash types of distilling plants used by the Navy.

The type and size of distilling plants used on each class of ship are determined by many factors. Some of these are—type of propulsion plant, number of personnel assigned, safety, and reliability. For more information than is provided in this training manual, see the manufacturer's technical manual for the type of plant on your ship.

SUBMERGED TUBE DISTILLING PLANTS

The low-pressure, submerged tube distilling plants vary considerably on different ships; but the principle in all cases is the same. The handling of abnormal operating conditions and the maintenance procedures are basically the same. In almost all instances, the personnel who stand watches on distilling plants are also responsible for their upkeep and maintenance. This allows you to detect abnormal operating conditions before they reach advanced stages. It is your responsibility to locate any operating trouble and to make the necessary adjustments or repairs.

TROUBLESHOOTING A SUBMERGED TUBE PLANT

Naval distilling plants are designed to produce distillate of very high quality. The chloride content of distillate discharged to the ship's tanks must not exceed 0.065 equivalent per million. Any distilling unit that cannot produce distillate of this quality is not operating properly.

Steady operating conditions are essential to the satisfactory operation of a distilling unit. Fluctuations in the pressure and temperature of the first-effect generating steam will cause fluctuations in the pressure and temperature throughout the entire unit. These fluctuations may cause priming, with increased salinity of the distillate. They may also cause chaotic operation of the feed and brine pump. Rapid fluctuations of pressure in the last effect also tend to cause priming.

Except under emergency conditions, no plant should be forced beyond its rated capacity. Such forcing requires higher steam pressures, which produce higher temperatures that cause more rapid scaling of the evaporator tubes. The same is true if the unit is operated at less than designed vacuum—the heat level rises throughout the unit, causing an increased tendency toward scale formation.

In operation, the elements of any plant are interdependent because of the heat and fluid balances throughout the plant. Adjustment of any one control can produce widespread effects on these balances. For example, an increase in the feeds to the first effect raises the liquid level in the first effect. More heat is required to raise the feed to the boiling point. Less heat is then available for evaporation in the first-effect shell, and a smaller amount of heat flows to the second-effect tube nest. These changes will work out to a new balanced condition, but other adjustments will be required to make the new balance satisfactory. Under such circumstances, overcontrolling can cause many readjustments. It is best to make adjustments singly and in small increments, allowing enough time between each adjustment for the conditions to become steady.

A failure to get full-rated capacity is one of the most frequent troubles in the operation of a distilling plant. The trouble may be very difficult to remedy since it may be caused by a combination of things. The following factors promote low output of the distilling plant:

1. Low steam pressure above the orifice
2. Low vacuum in the first-effect tube nest
   a. Air leaks
   b. Improper water levels in the evaporator shell

c. Scale formation on the evaporator tube nest
   (1) Improper feed treatment or lack of feed treatment
   (2) Brine density maintained above 1.5/32
3. Improper water levels
4. Improper venting of the evaporator tube nest
5. Low vacuum in the last-effect shell

Steam Pressure

A distilling plant cannot maintain its full output unless it is supplied with dry steam at the designed pressure. The orifices must pass the proper amount of steam to ensure plant output with a pressure of about 5 psig above the orifice, Inspect the orifice annually. During the inspection, measure the orifice and compare the reading with the figure stamped on the plate. Replace the orifice if necessary.

If the steam pressure above the orifice varies, locate and correct the source of trouble.

Check the diaphragm control valve to determine whether or not it is operating properly. If it is functioning properly and the pressure cannot be maintained above the orifice, the plant is not getting enough steam.

The auxiliary exhaust steam supply for the distilling plants, after passing through the regulating valve, is usually slightly superheated. This is caused by the pressure drop through the reducing valve and orifice plate. A small amount of superheat has little or no effect on operation or scale formation. However, if it is necessary to use live steam, use the installed desuperheater spray connection 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. The fluctuations may cause priming, with increased salinity of the distillate, as well as erratic water levels in the shells. Proper operation of automatic pressure regulators in the steam supply line will eliminate fluctuation of the pressure in the first-effect heat exchanger.

First-Effect Tube Nest Vacuum

The pressure in the first-effect tube must range from 14 inches of mercury, with clean tubes, to 3 inches of mercury 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, there is a great reduction in output. If the reduction in vacuum is caused by scale and not by improper operating conditions, the tubes must be cleaned.

Keep the vacuum in the first-effect tube nest as high as possible. This helps keep scale formation to a minimum, enabling the plant to operate at full capacity.

Always correct a vacuum reduction that is caused by any factor other than deposits on tube surfaces. This will reduce deposits and greatly prolong the time between cleanings. The primary factors affecting the first-effect tube nest vacuum are air leakage, low water level 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 large change of vacuum for any one day's operation. A 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 will cause losses of capacity and economy. Air leaks from the atmosphere into the generating steam line (downstream from the orifice plate), the first-effect tube nest front header, and the first-effect tube nest drain piping will cause a loss of vacuum and capacity. 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 too low a water level in any evaporator shell. On older plants, the water levels are controlled by manually regulating the feed valves. On newer ships, the water levels are automatically controlled by Weir types of feed regulators. Inability to feed the first effect is usually caused

by scale deposits in the feed lines between the effects. It is important that the gauge glass and the gauge glass fittings be kept free of scale that cause false water-level indications. Air leaks around the gauge glass will also cause false level indications in the gauge glass.

Once the distilling plant is in operation, the feeding must be maintained at a steady rate. Sudden rising of the water levels or too high a water level will cause priming, or a carry-over of small particles of brine with the vapor. The level of water in the shell must be carried at the highest level that can be held and still prevent priming, because scale will form rapidly on exposed tube surfaces.

The pressure differential between the first and second effects permits the second-effect feed to discharge into the second-effect shell. A partial or total loss of pressure differential indicates air leaks between the first- and second-effect shells in the two-effect distilling plants. Large air leaks between the first effect and second effect can be readily detected; 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. They must be located and repaired before the plant will operate properly.

Proper Venting of Various Units

Pay careful attention to the problem of air collection in various parts of the distillery unit. Air is mixed with water and steam and enters the unit at various parts of the system. Since air is heavier than water and lighter than steam, it tends to settle between the two, usually in the following points:

- The evaporator heat exchange and drain regulator
- The high points of the feed line
- The water side of the distillery condenser
- The vapor and evaporator heat exchanger drain feed heater

Air vents should be cracked open to ensure adequate venting. If an evaporator does not reach its rated capacity, it is usually caused by a failure to vent the accumulated air. An accumulation of air in any part of the system causes a loss in capacity and erratic operation. Excessive venting of an evaporator heat exchanger can mean reduced economy. The proper setting of vent valves during operation is largely a matter of experience.

Last-Effect Shell Vacuum

Most manufacturers' technical manuals call for a vacuum of approximately 24 inches of mercury in the last-effect shell when the temperature of the seawater is 85°F; the vacuum should be higher when the seawater is colder. Lower vacuum can generally be traced to one of the following problems: air leaks, improper operation of air ejectors, insufficient flow of seawater, and ineffective use of the heat transfer surface in the distilling condenser.

MAINTENANCE

The plant will operate at full output for relatively long periods of time only if every part is maintained in proper operating condition. You can ensure this by periodic inspections and tests and by cleaning or replacing parts as necessary. Some parts require more attention than others. Some of the more common plant maintenance tasks are discussed below.

Testing for Air Leaks

The importance of eliminating air leaks cannot be overemphasized. Many distilling plant problems are caused directly by air leaks in the shells of distilling plants. These leaks cause a loss of vacuum and capacity. Be very careful when you make up joints, and keep them tight. Periodically test joints under pressure for leaks.

There are several ways to test for air leaks in the tube nests, heat exchangers, shells, and the piping systems. When the plant is in operation, you can use a candle flame to test all joints and parts under vacuum. When the plant is secured, you can use an air-pressure or soapsuds test on the various component parts. The manufacturer's technical manual describes how the various parts of the plant can be isolated and placed under air pressure.

You can also detect air leaks by hydrostatic tests of the various parts of the plant. When performing air tests or hydrostatic tests, do not exceed the maximum limit of the test pressures specified by the manufacturer.

Testing for Saltwater Leaks

If you find a leak in a heat exchanger, locate the defective tube(s) by means of an air test or a hydrostatic test, in accordance with the recommended procedure in the manufacturer's instructions. Use blueprints to study the construction details of the individual heat exchanger.

As soon as a leaky tube has been located, plug it at both ends. Use special composition plugs that are provided in the allowance repair parts.

Plugging the tubes reduces the amount of heating surface; therefore, the heat exchanger will not give satisfactory performance after a number of tubes have been plugged. It will then become necessary to retube the heat exchanger. Under normal conditions, this work should be accomplished by a naval shipyard or tender. However, repair parts and a number of special tools are included in the Ship's Allowance List so that emergency repairs can be made.

To find which of the tubes within a removable tube bundle is leaking, you need to test the individual bundles hydrostatically. If the leak is in a removable bundle (vapor feed heaters when within an evaporator shell, evaporator tube nests, distilling condensers on Solo-shell end-pull plants), withdraw the bundle and apply a hydrostatic test at full pressure. Apply 50 psi on the tube side.

If a leak occurs in a nonremovable tube bundle (distillate coolers, air-ejector condenser, extenal vapor feed heaters), remove the tube nest covers and apply a full test pressure of 50 psi on the shell side of the unit.

If a nonremovable distillate condenser bundle is within an evaporator shell, remove the tube nest covers and apply a full test pressure of 30 psi to the evaporator shell.

AIR-EJECTOR OPERATION

In operation, air ejectors require little attention. However, the following points should be noted:

The steam pressure at the nozzle inlet must not be less than that for which the ejector is designed (and which is stamped on the nameplate). There may be a substantial pressure drop in the steam line, and it may be necessary to carry a higher pressure on the gauge. However, pressures at the air-ejector nozzle 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. Such problems are indicated by a lower than normal vacuum. The problem may be caused by low steam pressure or wet steam. If so, increase the steam pressure or provide suitable drainage, either by installing a trap or by manual means. If the nozzle or steam strainer is clogged, remove it and clean it. Most plants have two sets of air ejectors; this permits the use of the plant on one unit while the second is cleaned or repaired. However, some of the latest plants have only one set of air ejectors.

When it is necessary to clean air-ejector nozzles, use the special nozzle reamers furnished to each ship for this purpose. Never use sharp-edged tools to clean nozzles. You will damage the nozzle surfaces and impair the efficiency of the air ejectors.

You will find a procedure for testing air ejectors in the manufacturer's technical manual. In general, follow the same maintenance procedures for distilling plant air ejectors as for air ejectors for main condensers.

The air-ejector strainer is usually an integral part of the air-ejector inlet. It should be inspected and cleaned in accordance with the planned maintenance system. When a new plant is first put into operation, the strainer may require cleaning every day or even more frequently. A dirty strainer will cause a reduced or fluctuating vacuum. If a strainer or a nozzle becomes damaged, replace it with a new one.

INSUFFICIENT CIRCULATING WATER

An insufficient flow of circulating water is indicated if the temperature of the water rises more than 20°F in 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. If the overboard discharge temperature of the distiller condenser circulating water is too low, it will cause a loss of efficiency 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 problems occur that are not caused

by improper operating procedures, inspect the condenser circulating water system to determine the cause of faulty operation.

Carry out preventive maintenance procedures to ensure that the circulating water pump is maintained in good material condition. The maintenance and repair of this pump are similar to that for the other pumps of the plant.

Carry out routine procedures to ensure the proper setting and maintenance of the back-pressure regulating valve. If this valve is not functioning properly, disassemble it and repair or replace parts as needed before it interferes with the operation of the distilling plant.

To ensure that the condenser circulating water system is clean and free from scale and foreign matter, inspect the piping at regular intervals. Inspect and clean the strainers in accordance with the planned maintenance system. This is to prevent accumulations of foreign matter from interfering with the proper operation of the distilling plant.

IMPROPER DRAINAGE

The distilling plant may not produce designed output even when the pressure above the orifice is 5 psig and the first-effect tube nest vacuum is several inches of mercury. If so, this always indicates 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 also indicates improper draining of the condenser.

Each regulator is installed to prevent steam or vapor from being blown through the heat exchanger before it has condensed and given up its latent heat. Improper operation may result either in drains being stopped up or steam or vapor being blown through the heat exchanger. The stoppage of drains in the first effect causes condensate to back up and reduce the heating surface. The result is the same in the second effect. In addition, since the drains make up a part of the distilled-water output, the capacity is reduced. Since these regulators all operate under vacuum, be very careful that all joints are free from air leaks.

CONSTANT BRINE DENSITY

The concentration of brine in the evaporators, to a certain extent, has a direct bearing on the quality of the distillate. Since varying quantities of brine discharged overboard may affect the operating conditions, the quantity of brine discharged and the brine density must be kept as constant as possible.

If the brine concentration is too low, there will be a loss in capacity and economy. If the brine concentration is too high, there will be an increase in the rate of scaling of the evaporator heating surfaces, and the quality of the distillate will be impaired.

The brine density, which should never exceed 1.5/32, is dependent mainly on the quantity of brine pumped overboard and the amount of fresh water being produced. Check the density frequently during each watch and adjust it to the required density. On older distilling plants the brine density is adjusted by means of a hand-controlled valve located in the discharge line of the brine overboard pump.

Frequent changes of brine density tend to disrupt steady performance of the plant. Therefore, you should make only very small changes. The proper setting for a specific plant should be learned from experience and maintained as practical.

A salinometer is used to measure the degree of salinity or the concentration of brine. Check accuracy of the salinometer occasionally by placing it in distilled water. If it is accurate, it should sink to the zero mark on the scale corresponding to the temperature of the water.

FLASH TYPES OF DISTILLING UNITS

The flash type of evaporator, like all distilling plants, removes salts and other impurities from raw seawater by evaporation and condensation. The water is boiled and converted to steam, which is then condensed to form distilled water. The flash evaporator is different from other distilling plants; evaporation takes place at temperatures well below the normal boiling point of water and without the use of submerged heat transfer surfaces.

In the flash type of distilling plant, the temperature of the water is never raised beyond 175°F. It is only raised to this temperature within the last pass of tubes of the saltwater heater. Flash evaporation takes place at temperatures as low as 104°F. In addition, there is no boiling on heat transfer tube surfaces. This greatly reduces scale formation and prolongs operation at maximum efficiency.

The term *flash evaporation* means that water is converted to steam as it enters an evaporating chamber, without further addition of heat. Flashing at low temperatures is possible only when a vacuum is maintained in the chamber; the boiling point of water decreases as the pressure in the chamber is reduced. As in other methods of distillation, a portion of the water remains behind in the evaporating chamber and is taken off as brine.

PRINCIPAL COMPONENTS

The unit discussed in this section is a five-stage plant in which feedwater is flashed to vapor in five evaporator stages at successively lower pressures.

The connections, or passages, between evaporator stages are the feedwater and distillate loop seals. These Permit the flow of feedwater and distillate from stage to stage while preserving the varying degrees of vacuum in each stage.

The condensers are mounted on top of each stage between the front and rear water boxes. Feedwater flows through the tubes in six passes. It enters at the lowest tubes at the front of the condenser, reverses direction at the water boxes three times, and leaves at the top of the tubes in the condenser. Each condenser has a pet cock for venting entrained air or noncondensable gases.

The evaporator stages become larger in the direction of reduced pressure. The feedwater loop seals that extend from the bottom of evaporator stage one through stage four are visible as cylinders. An evaporator drain is located in the center of the dished bottom of each loop seal. The flanged brine outlet from the evaporator is at the bottom of the fifth stage.

The distillate loop seal between the distillate collection trough of one stage and the condensers of the following stages also protrude below the bottom of the evaporator.

If the salinity of the distillate reaches 0.065 epm per gallon, a warning device indicates the high salinity. The salinity cell shutoff valves permit withdrawal and descaling of the salinity cells without securing the unit.

Although the condenser at each stage produces an equal amount of distillate, the amount flowing from each stage is larger than the preceding, as in the distillate cooler. Therefore, the loop seal piping grows progressively larger.

The total distillate production of the five stages is withdrawn from the bottom of stage five, pumped into the shell of the distillate cooler, and passed on to the storage tanks.

The DISTILLATE COOLER is a heat exchanger of the shell and tube type. The heat of the hot distillate flowing around the tubes is transferred by conduction to the cooler feedwater flowing through the tubes.

Distillate flows into the shell space surrounding the tubes through an inlet near the feedwater outlet. The distillate is retained in the cooler long enough to transfer its heat through the tubes by vertically placed baffles as it flows from the top to the bottom of the cooler.

Thermometers are mounted on the inlet and outlet piping of the cooler. Another thermometer is mounted on the feedwater inlet piping.

As the distillate leaves the cooler, and if the salinity does not exceed 0.065 epm per gallon, it is pumped to storage tanks. If the salinity exceeds 0.065 epm per gallon, a solenoid trip valve, operated by a salinity indicating cell, dumps the distillate to the bilges or waste tank. This process continues until the salinity is at or below 0.065 epm per gallon. At that time, the operator should manually engage the dump valve so the distillate will go to the storage tank.

Pet cocks are located on each end of the cooler to bleed off any accumulation of air or noncondensable gases.

The FEEDWATER PREHEATER is a gas or liquid heat exchanger of the shell and tube type, similar in design to the distillate cooler. The preheater is located in the feedwater line between the condenser of the first evaporator stage and the saltwater heater.

High-pressure ship's steam, first used by the air ejectors to evacuate the stage evaporators, is piped into the preheater shell. A series of five baffles, spaced close together in the top steam outlet, reduces the velocity of the steam that condenses on the outside of the heat transfer tubes.

Feedwater that has already been partially heated in the tubes of the distillate cooler and the five-stage condensers flows through the tubes of the preheater via the front water box in a single pass. There it acquires the heat of condensation of the air-ejector steam before leaving the preheater at the rear water-box outlet.

A salinity cell, set to energize at 0.10 epm, operates a shutoff valve in the piping below the condensate outlet. The valve dumps high-salinity water to the bilge or a drain tank. A 6-inch loop seal in the condensate line ensures that the salinity cell is submerged at all times.

A thermometer is located on the front of the preheater. A pet cock for venting is also located on the water box.

The SALTWATER HEATER is a gas or liquid heat exchanger that raises the feedwater temperature before it enters the flash chamber of the first evaporator stage. The saltwater heater is mounted on the operating end of the evaporator and extends the full width of the unit. Feedwater enters and leaves the heater from the front water box after making four passes through the heater.

Four thermometers are installed on the heater. Two measure the feedwater inlet and outlet temperature. A third, mounted on the heater shell, measures the steam temperature surrounding the tubes. A fourth, mounted on top of the heater shell, measures the temperature of the desuperheating temperature in the steam side.

Low-pressure steam in the heater passes through an orifice that provides, within limits, a uniform flow of steam. It then flows past the desuperheater nozzle, which reduces steam temperature in the shell of the heater. Steam pressure is indicated by a pressure gauge on the operating panel.

The entering steam is directed along the length of the tubes by impingement baffles, which prevent erosion of the tubes. Steam condenses on the tubes and falls to a condensate well at the bottom of the heater shell. (A drain regulator of the float type controls the level of the condensate in the well. A salinity cell, set to energize at 0.10 epm, controls a shutoff valve located in the ship's piping between the drain pump and regulating valve.) The desuperheater atomizes the heater condensate in the low-pressure steam side of the heater.

The saltwater heater provides feedwater to the inlet of the first evaporator stage flash chamber, and the amount of heat from the steam is constant; therefore, the feedwater flow through the heater must be adjusted according to the inlet temperature. The feedwater flow is controlled by a valve on the outlet side of the heater.

The air-ejector PRECOOLER is a gas or liquid heat exchanger. It cools noncondensables and condenses steam drawn from the first three evaporator stages and the saltwater heater by a two-stage vacuum-producing air ejector.

The precooler uses feedwater pumped into the distilling unit as a coolant. The water makes six passes through heat transfer tubes, entering and leaving at the front end of the cooler.

Steam and noncondensables are drawn into the cooler at the top near the rear of the cooler. The flow of hot gases is directed around the transfer tubes for efficient heat transfer by impingement baffles at the inlet and seven vertical baffles through which the tubes run.

Condensate collects on the tubes and drops to the bottom of the shell. A salinity cell operates a shutoff valve in the precooler condensate line. The valve dumps the condensate to the bilge or drain tank when the salinity is greater than 0.065 epm.

The outlet for noncondensables is mounted on the top of the shell. It is flanged to the suction chamber of the first ejector of the two-stage air-ejector system. The two air ejectors produce a vacuum in the precooler that results in the flow of steam and noncondensables from the evaporator. A thermometer is mounted on the feedwater inlet of the cooler.

Cooling water from the air-ejector precooler flows into the AFTER-CONDENSER, the fifth of the heat exchangers mounted on the evaporator. The after-condenser completes the condensation of any air-ejector steam not condensed in the precooler and cools noncondensable gases before venting them to the atmosphere. It enables the unit to operate without emission of steam from the evaporator.

Cooling water enters and leaves the after-condenser through an inlet in the front and an outlet pipe in the rear of the condenser.

Air-ejector steam and noncondensable gases enter the shell side through an inlet in the front of the unit. Noncondensable gases are vented through a valve on the rear of the unit. A series of vertical baffles directs the steam around the tubes on which it condenses. Condensate is removed through bottom outlets on both ends of the condenser.

A salinity cell set to operate at 0.10 epm controls a shutoff valve below the condenser.

Three high-pressure, steam-operated, vacuum-producing AIR EJECTORS are mounted on the precooler side of the evaporator unit. The ejector system consists of a single-stage (booster) air-ejector and a two-stage air-ejector arrangement in which the steam outlet from one air ejector is flanged to the suction side of the other.

The single-stage ejector uses ship's steam to draw vapor and noncondensables from evaporator stages four and five. Gases are drawn from the evaporator through a vapor duct in each distillate collection trough so that a minimum of steam is withdrawn. Pipes from stages four and five lead to a bronze tee flanged to the ejector.

The single-stage ejector steam and entrained gases leave the ejector outlet tubing, flow through a check valve, and reenter the evaporator shell through the top of stage three. From there, they are piped into the bottom of the stage three condenser section.

This arrangement allows the single-stage ejector to produce the high degree of vacuum required in stages four and five. An ejector discharging into a vacuum is able to achieve a higher degree of vacuum than one discharging to atmosphere. A vacuum of 28 inches of mercury is required in stage five.

The two-stage ejector draws noncondensables from the saltwater heater and the first three evaporator stages. The noncondensables from stages four and five are directed back into stage three. Therefore, the two-stage ejector actually handles all noncondensables within the unit.

The suction chamber of the second ejector is flanged to the noncondensables outlet of the precooler. The gases pass through the precooler before they are entrained in the air-ejector steam. The two-stage ejectors use ship's steam and produce a vacuum in the precooler slightly greater than in the first evaporator stage.

Orifice plates of varying sizes are flanged into the piping from the evaporator stages and saltwater heater leading to the air ejectors. These plates prevent the air ejectors from withdrawing an undue amount of steam from the evaporator along with the noncondensables.

The discharge of the second ejector is flanged to the suction chamber of the third ejector. The discharge of the third ejector is flanged to piping that contains a check valve and runs diagonally across the top of the evaporator shell to the air-ejector steam inlet of the preheater shell near the front water box.

The pressure of ship's steam piped to the ejectors is indicated on the independently mounted pressure gauge panel. Line pressure to the air ejectors must be maintained at or above 135 psig; **a** lower pressure will cause unstable operation of the ejector and will affect the vacuum in the evaporator.

A DUPLEX STRAINER, located in the ship's feedwater inlet piping, removes solid matter from seawater by filtering through one of the two perforated and screened bronze baskets. Basket wells are located in the body or housing of the strainer on either side of the centrally located flanged inlet and outlet.

A lever handle between the wells directs the feedwater into the left-or right-hand well. When one basket becomes clogged, flow is switched to the other. The clogged basket should be removed and cleaned.

An inlet and outlet angle type of RELIEF VALVE is flanged into the feedwater inlet between the feedwater pump and the air-ejector precooler. The valve is set to open at 75 psig. This prevents pressure buildup from an obstruction in the feedwater lines or accidental operation of the feedwater pump with the feedwater control valve closed.

MAINTENANCE OF FLASH TYPES OF UNITS

Many of the maintenance procedures for a flash type of distilling plant are similar to those for a submerged tube plant. Both types of plants are subject to air leaks, saltwater leaks, and malfunctioning pumps and other auxiliary equipment. Some of the more important maintenance problems are covered in the following paragraphs.

Air Leaks

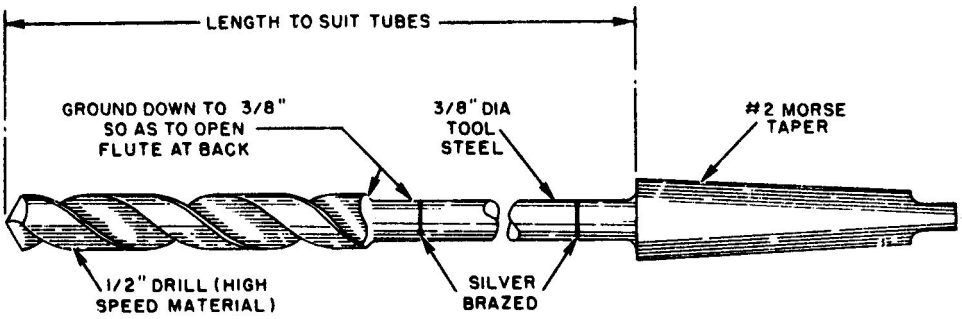
All parts of the distilling plant, except the circulating, feedwater and freshwater lines, operate under a vacuum. Be very careful to prevent air leaks that may seriously interfere with the proper operation of the plant.

The brine overboard and distillate pumps take their suction from points of relatively high vacuum. Air leaks in the piping to these pumps are particularly objectionable and must be eliminated. A small amount of air entering these lines, even though it is insufficient to affect the distilling plant vacuum, may cause the pump to lose suction. Do not overlook leaks in the lines to the pump suction gauges.

Apply an 8- to 10-psig low-pressure hydrostatic test to the entire system. Do this according to the planned maintenance system and at any other time when you suspect an air leak. The saltwater circulating pump can be used to apply the pressure.

Pumps

Proper operation of all pumps is essential for the successful operation of the distilling plant. The effect of air leaks into the suction line of the pumps has been discussed in the preceding paragraph. Proper operation of the water-sealed gland lines and proper maintenance of the glands themselves are necessary for dependable operation



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Figure 7-1.–Tool for removing scale inside tubes.

of the pumps. General information on operation and maintenance of pumps may be found in *Machinist's Mate 3 & 2,* and in this training manual. However, consult the manufacturer's technical manual for details of any specific pump.

Saltwater Leakage

You may find salt-water-to distillate or salt-water- to condensate leaks at any of the various tube bundles. These will be immediately indicated by an alarm bell and a red light that shows which cell has a conductivity increase. The cells are located downstream from each tube bundle. Tube leaks are usually caused by damaged or corroded tubes or by improper expansion of tubes into tube sheets.

Faulty tubes may be sealed with plastic tube plugs or removed and replaced. Follow standard Navy procedures.

Cleaning Heat Exchangers

The tubes of the distillate cooler, air-ejector condenser, and the stage condensers operate with comparatively cool salt water inside them and will seldom require cleaning. However, the seawater in the saltwater heater is at a higher temperature. These tubes will occasionally require cleaning to remove the hard scale on the inside of the tubes. A special tool (fig. 7-1) is furnished for this purpose.

The procedure for cleaning saltwater heaters is as follows: Remove the waterheads. Insert the special cleaning tool in the tube and drive it with a 250- to 300-rpm motor. The motor should be of the reversible type. Feed a light stream of water into the opposite end of the tube to wash the scale from the cutting tool and out of the tube. A light stream of compressed air may be substituted in place of the water. Take care not to drive the tool too fast and be certain that the tool is straight when you insert it into the tube.

Perform an 8- to 110-psig hydrostatic test on the shell of the saltwater heater before replacing the heads. If a greater test pressure is used, the relief valve will have to be plugged or removed.

Cleaning Feed Boxes

If feed flow is below normal and the distiller feed pump discharge is normal, the first-stage flash orifices may be plugged. If water backs up into the first stage, the second-stage orifices may be plugged. However, the second-stage orifices are larger and will not be as readily plugged. Water backing into the first stage may also be caused by insufficient pressure difference between the stages.

The temperatures in the feed boxes are well below the range in which saltwater scale forms. Therefore, the only plugging or fouling at the orifices should come from the foreign matter in the system. Should the orifices in either stage become plugged, remove the access plate at the front of the unit, remove the perforated plates from the feed box, and remove the obstructing material from the orifices. The feed boxes are constructed so that the front can be readily removed for access to the orifices.

SUMMARY

This chapter gave you information on the operation, troubleshooting, and repair of distilling plants. As a Machinist's Mate, you are also responsible for the upkeep and maintenance of distilling plants. Remember to consult the manufacturer's technical manual for the type of plants on your ship.

CHAPTER 8

REFRIGERATION AND AIR CONDITIONING

As an MM 3 & 2, you learned the principles of refrigeration and air conditioning and the components and accessories that make up the system. You learned how to start, operate, and secure refrigeration plants. In addition, you performed routine maintenance jobs such as checking for noncondensable gases, pumping down the system, using the halide torch to test for leaks, and changing the lubricating oil in refrigeration compressors. As you advance in rate, you will be expected to have a greater knowledge of the construction and operating principles of refrigerating equipment. You will perform more complicated maintenance jobs, make repairs as required, determine the causes of inefficient plant operation, and accomplish the necessary corrective procedures.

This chapter provides information that supplements related information in other training manuals that apply to your rating and that is related to the qualifications for advancement. Information is included 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.

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 modern 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.

CAPACITY CONTROL

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,

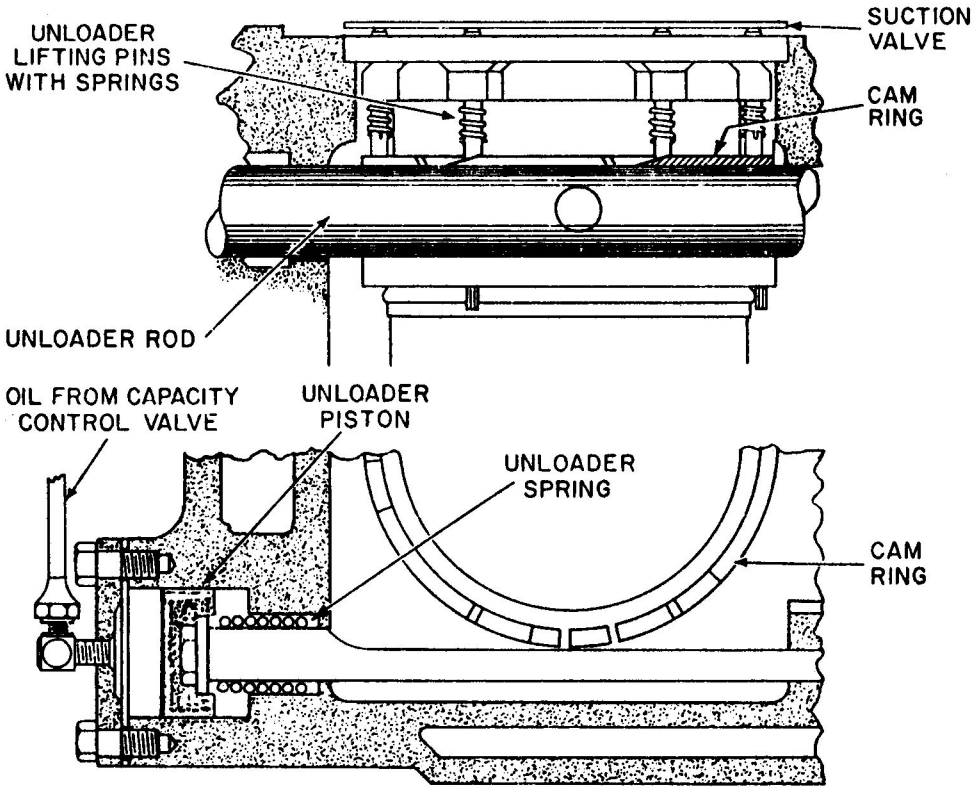
Unloading of the cylinders in the compressor is accomplished by lifting the suction valves off their seats and holding them open. This method of capacity control unloads the cylinders completely and still allows the compressor to work at as much as 25 percent of its rated capacity.

Unloader Mechanism

When the compressor is not in operation, the unloader mechanism is in the unloaded position. (Fig. 8-1 is an example of one type of system.) 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 suet ion 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 push rod 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. 8-2]. On most compressors the unloader is connected to the cylinders in pairs.

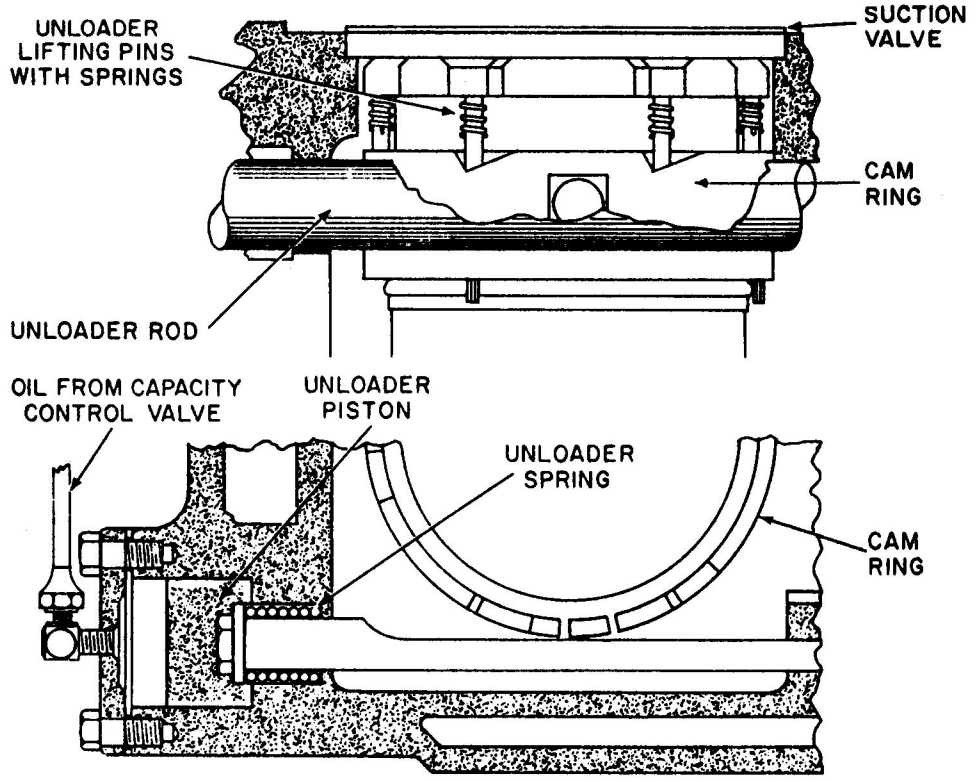
Capacity Control Valve

The capacity control valve (fig. 8-3) is located in the compressor crankcase cover. The valve is



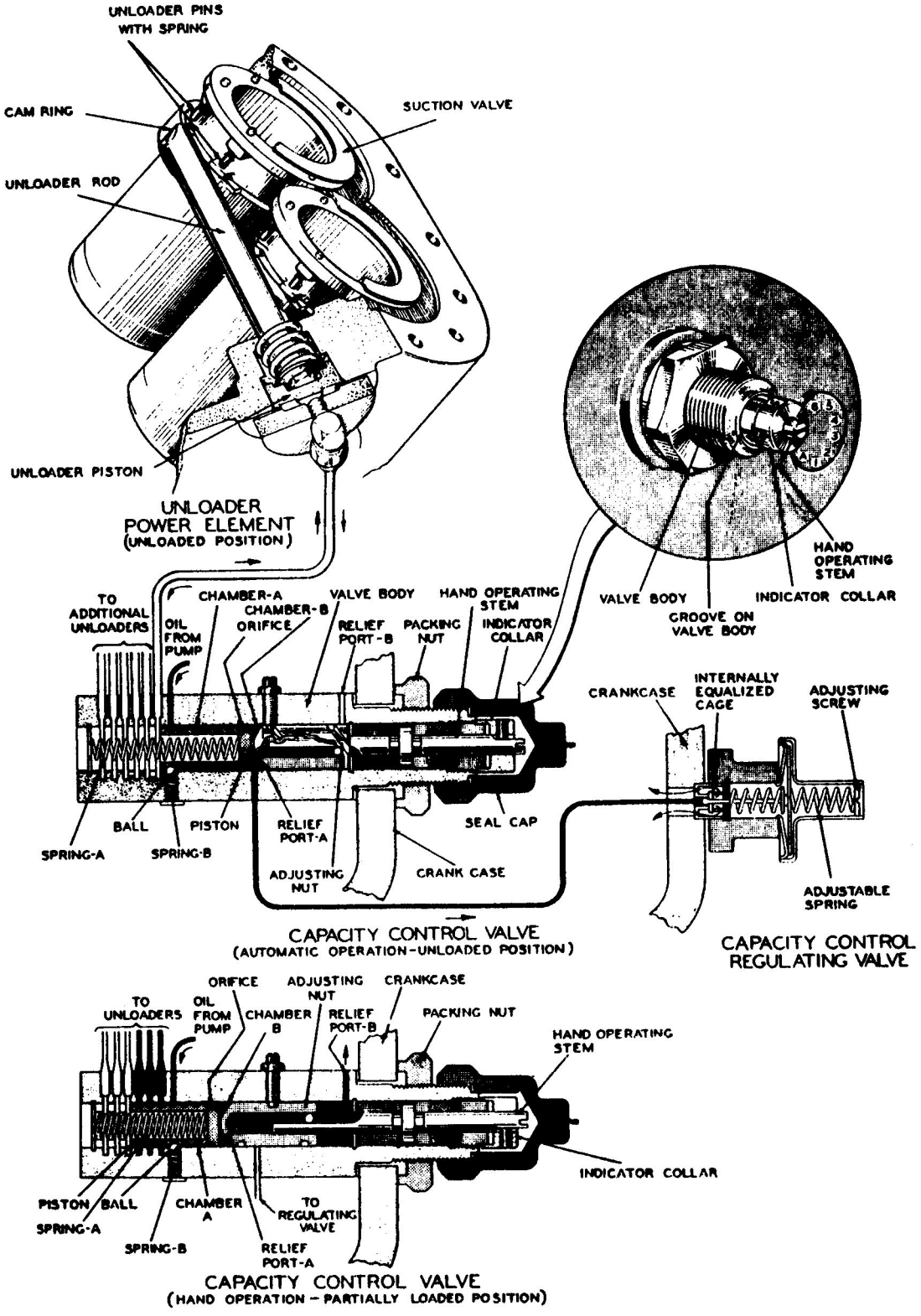
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Figure 8-1.—Unloader mechanism in unloaded position.



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Figure 8-2.—Unloader mechanism in loaded position.



121.64

Figure 8-3.—Capacity control system.

actuated by oil pressure from the main oil pump. It admits or relieves oil to or from the individual unloader power elements, depending on suction or crankcase pressure. Referring to figure 8-3, when the compressor is at rest, the two cylinders equipped with the unloader element will be unloaded and 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 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 MM1 or MMC, 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 satisfactorily, 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.

The compressor internal suction valves may be checked for leakage as follows:

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 inches 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

new units until after the compressor has been in operation for at least 3 days. It maybe necessary for the valves to wear in.

However, if any of the compressor suction valves are defective, 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 crankshaft 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. At this point, 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:

1. 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 always 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.
2. Moisture is frequently the cause of an acid condition of the lubricating oil. Oil in this condition will not provide satisfactory lubrication and will promote failure of the compressor parts. If moisture is suspected, use a refrigerant dehydrator when the compressor is put into operation. Anytime foreign material is found in the lubricating oil, thoroughly clean the entire system (piping, valves, and strainers).

REMOVING 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 open the oil drain valve or plug 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 and take the necessary precautions to support the seal to prevent it from being blown from the compressor and damaged.

INSTALLING SHAFT SEAL.— Clean and replace the entire seal assembly in accordance with the manufacturer's instructions.

Wipe the shaft clean with a linen or silk cloth; do not use a dirty or lint-bearing cloth. Unwrap the seal, being careful not to touch the bearing surfaces with your hands. 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. Test the unit for leaks by opening the suction and discharge valves and using a halide leak detector.

Evacuating the Compressor

Whenever repairs to a compressor are of such a nature that any appreciable amount of air enters 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. 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. To clean the strainer screen, dip it 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 and 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, noting the correct relative position so that errors will not be made when reassembling.
2. Inspect all those parts that become accessible because of the removal of other parts requiring repair or replacement.
3. Make certain that ail parts and surfaces are free of dirt and moisture.
4. Apply clean compressor oil freely 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. Renew all gaskets,
9. Clean the crankcase and renew 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, take care not to destroy the thin protective coating on the inner surfaces of the tubes. If the tubes become badly corroded, replace them. This 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 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 will prove very useful in removing dirt from condensers in hard-to-reach places. When installations are exposed to salt spray and rain through open doors or hatches, care should be taken 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 as follows:

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 the 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 ap propriate repairs or mark and plug all leaky tubes for later repairs.

RETUBING CONDENSERS

The general procedures for retubing condensers are in chapter 5 of this training manual. You can find further information in NSTM, chapter 516. When 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

By means of a gear and screw arrangement, the thermostatic expansion valves used in most shipboard systems can be adjusted to maintain a superheat ranging approximately from 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 and decreased pressure has the opposite effect.

Some thermostatic expansion valves have a fixed (nonadjustable) superheat. These valves are used in equipment or systems where the piping configuration and evaporating conditions are constant, primarily in self-contained equipment.

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 to the compressor. Should the liquid refrigerant collect at a low point in the suction line or coil and be 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. Normally you should first 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 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 and with the low-pressure gauge loosely connected to the expansion valve out let. The low-pressure gauge is connected loosely to provide 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 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. With the valve in good condition, the pressure will increase a few pounds and then either stop or build up very slowly. 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 showing on both gauges as outlined above, 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. 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 described above, other parts of the system will need periodic maintenance to keep the plant operating properly.

Vibration may cause leakage in the piping system, allowing air and moisture to be drawn in or a loss of the 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 maybe found in NSTM, chapter 516. 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 reason to believe the system has a leak. The leaks must be found and corrected. Immediately following—or during—the process of charging, the system should be carefully checked 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 valves in their normal position. 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 it 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 effect 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, using an approved solvent and a small brush. Reassemble 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 are provided with 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 may be accomplished in much the same manner as described for cleaning suction strainers.

When cleaning is necessary, the lubricating oil in the crankcase should be drained from the compressor. A new charge of oil, equal to the amount drained, should be added before restarting the unit. When the compressor is put back into operation, the lube-oil pressure should be adjusted to the proper setting by adjustment of the oil pressure regulator.

MAINTAINING COOLING COILS

Cooling coils should be inspected regularly and cleaned as required. The cooling coils should be defrosted 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 defrosting depends on many factors. Some of these are refrigerant evaporating temperature, condition of door gaskets, moisture content of supplies placed in boxes, frequency of opening, doors, and atmospheric humidity.

You should always defrost the cooling coils before the frost thickness reaches three-sixteenths of an inch. When defrosting, ensure that the frost is not scraped or broken off. This may cause damage to the coils.

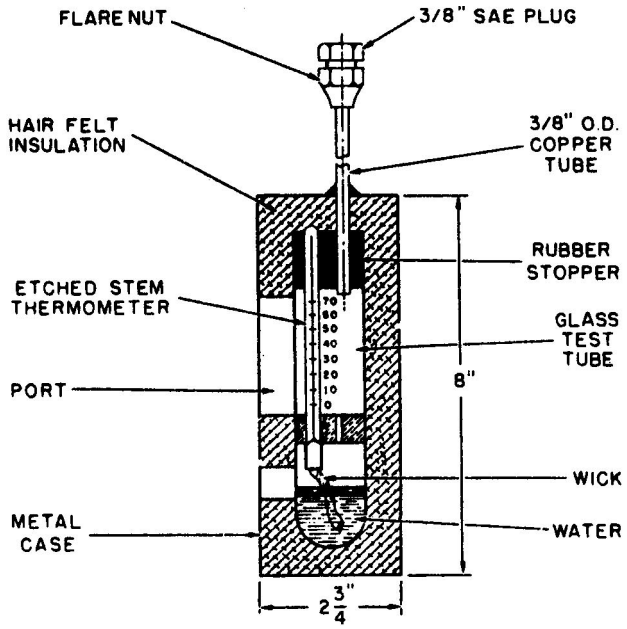
EVACUATING AND DEHYDRATING THE SYSTEM

Where moisture accumulation must be corrected, the system should first be cleared of refrigerant and air. The time required for these processes will depend upon the size of the system and the amount of moisture present. It is 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 8-4 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



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

96.32

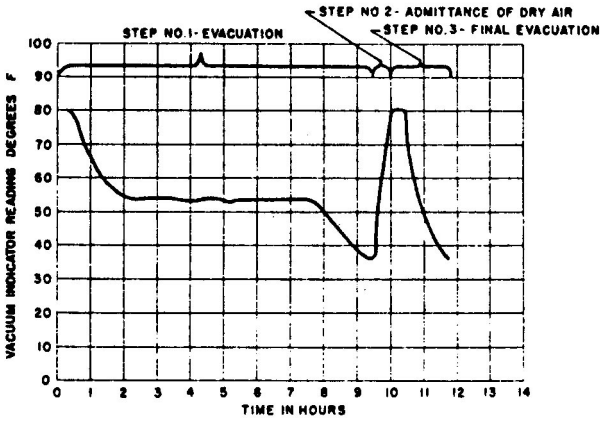
Figure 8-4.-Dehydrator vacuum indicator.

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 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 inch 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 be reflected in the temperature drop of the vacuum indicator as shown in figure 8-5, 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 decrease in temperature. When the temperature reaches 35°F (0.2 inch 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; 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. At this time, 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,



96.33

Figure 8-5.—Vacuum indicator readings plotted during dehydration.

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 pump 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, the drying agent in the dehydrator should be replaced. If a replacement cartridge is not available, the drying agent can be reactivated and used until a replacement is available.

Reactivation is accomplished by removing the drying agent and heating it for 12 hours at a temperature of 300°F to bake out the moisture. The drying agent may be placed in an oven, or a stream of hot air maybe circulated through the cartridge. These methods are satisfactory for reactivating commonly used dehydrating agents such as activated alumina and silica gel. Where special drying agents are employed, the specific instructions furnished by the manufacturer should be followed to reactivate the agents.

After reactivation, the drying agent should be replaced in the dehydrator shell and sealed as quickly as possible. This prevents absorption of atmospheric moisture. When the drying agent becomes fouled or saturated with lubricating oil, it must be replaced by 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 in the system. Extreme care must be taken 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. Where such a cleaner is not available, a hard, wool felt fiber about five-sixteenths inch thick, should be inserted into the suction strainer screen. The plant should be operated, with an operator in attendance, for at least 36 hours or until the system is cleaned, depending upon the size and condition of the plant.

AIR-CONDITIONING CONTROL

Most of the information presented to this point 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 may be used on three types of systems:

1. Systems employing a simple thermostatically controlled single-pole switch to control flow of refrigerant to the cooling coil.
2. Systems using reheaters, employing a thermostatic element actuating two interlocked switches.
3. Systems using reheaters in the same manner as those in item 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 thermostatic control for the refrigeration plant. Although the type 1 system requires single-pole thermostats, the 2PD used in types 2 and 3 systems can be used. The cooling switch would then be connected in the normal manner with the heating switch inoperative.

The type 2 system is most commonly used because of past experiences and present efforts to make living and working spaces more habitable, also because of the rapid development of various types of weapons systems that require cooling. These systems often use a common cooling coil serving several different spaces. Assume three spaces are being cooled by a common coil. Since the 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 may open the cooling coil valve.

Suppose space B in figure 8-6 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.

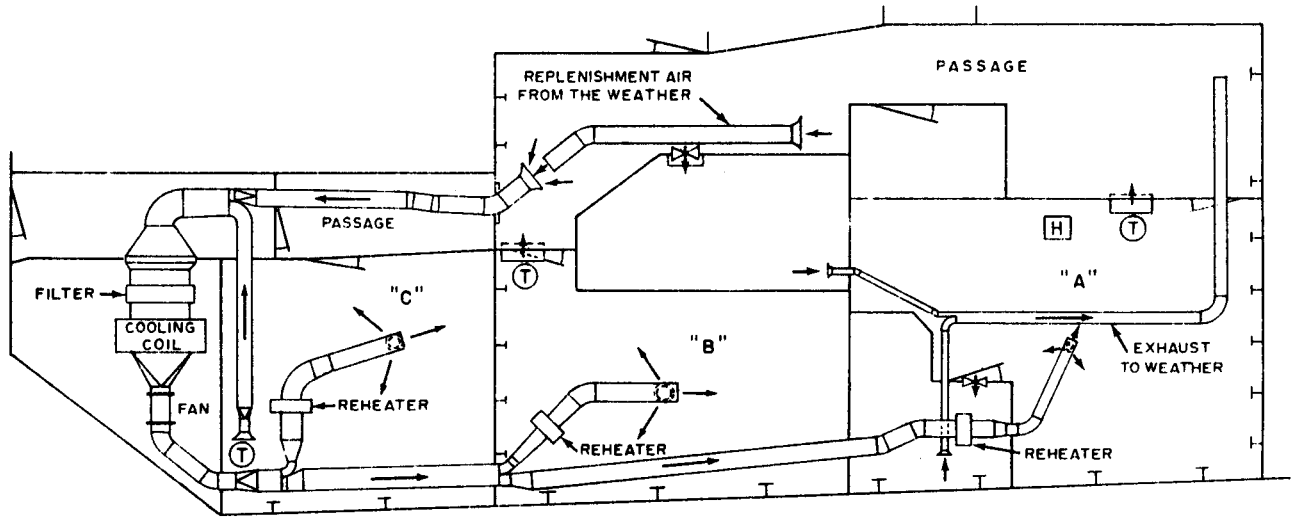
The type 3 system is identical to the type 2 system, except that a humidistat is wired in parallel with the thermostatic heating switch. The type of system is used mostly in weapons and electronic spaces. The humidistat is set for the relative humidity condition desired. In most installations, it is 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 prove to be worthwhile to avoid malfunctions.

The two-position 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. Inspection and checks should be made at the beginning of, and midway through, the cooling season, and at the same times during the heating season.

Sensing elements should be inspected and any dust accumulations removed. Thermostatic sensing elements may have dust and dirt removed



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Figure 8-6.–Typical air conditioning system.

with a soft brush. Sensing elements in humidistats must be blown off gently with air so as not to damage the element.

Magnetic valves should be checked for operation. Be sure that they open and close completely.

Set points of the thermostats and 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

- 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. Figure 8-7 lists some of the problems along with possible causes and corrective measures. Figure 8-8 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 shall 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 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. If you are entering, or you are in, a space when refrigerant may be present in the atmosphere, leave the space immediately if:

- You smell something that is unusual.

- You feel light-headed.

Trouble	Possible Cause	Corrective Measure
High condensing pressure.	Air of non-condensable gas in system.	Purge air from condenser.
	Inlet water warm.	Increase quality 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 valve, 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.	Pump 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.

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Figure 8-7.—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.	Adjust, repair, or replace thermal expansion valve.
	(a) Dirty strainers. (b) Moisture frozen in orifice or orifice plugged with dirt. (c) Power element dead or weak.	(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 valve.	Replace discharge valves. check bulb attachment.
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 LP 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 HP control switch. 1. Repair or replace switch. 2. Check power supply. 3. Close switches.

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Figure 8-7.—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.
Sudden loss of oil from crankcase.	Liquid refrigerant slugging back to compressor crank case.	Adjust or replace expansion valve.
Capacity reduction system fails 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.

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Figure 8-7.—Trouble diagnosis chart—Continued

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 representative of average space temperature
	Thermostat out of adjustment or sticking	Calibrate with good thermometer	Clean, adjust, or replace the thermostat
	Cooling coil magnetic valve not opening.	Solenoid Valve Valve sticking	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 thermometer at location	Move 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.

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Figure 8-8.—Trouble diagnosis chart.

- Your feel giddy.
- You experience shortness of breath.
- Your 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 WITHOUTTESTING THE AIR FOR REFRIGERANT.

11. Establish and document emergency rescue procedures to ensure all personnel can be safely removed from potentially hazardous exposures.

SUMMARY

In this chapter, we discussed the construction and maintenance of refrigeration and air-conditioning equipment. Periodic maintenance is required to keep plants and systems operating properly.

For additional information on refrigeration and air conditioning, refer to NSTM, chapter 516.

CHAPTER 9

AUXILIARY EQUIPMENT

This chapter provides general information on a variety of equipment that is not directly related to the propulsion plant. Some of the equipment that will be discussed includes the steering gear, cargo or weight-handling equipment, hydraulic systems, and landing and galley equipment.

Although the Machinist Mates are not usually the operators of the above mentioned equipment, you, as the MM1 or MMC will be responsible for the repairs, replacements, or adjustments with the exception of the electrical work.

For any additional information on auxiliary equipment, refer to the manufacturer's technical manual or the *Naval Ships' Technical Manual.*

STEERING GEAR

Most modern naval vessels have electro-hydraulic steering gear. This type of steering gear was developed because of the heavy power requirements for steering gear on large high-speed ships.

You will be responsible for the maintenance and repair of the pumps and components of the hydraulic system. Therefore, you should familiarize yourself with this type of equipment. Your best source of information is the manufacturer's instruction book.

GENERAL DESCRIPTION

In electrohydraulic steering gear, the rudder is usually moved by hydraulic rams operating in cylinders connected hydraulically to variable delivery pumps. The pumps are driven by continuously running electric motors. The direction and rate of rudder travel are controlled by changing the position of the tilting block in the hydraulic pump.

On most large naval ships, two complete power units are provided for each ram. In such dual installations both motors and pumps may be operated at once. However, only one pump is normally connected to the ram at any given time. Dual power units provide an added safety factor; however, both power units should be run at the same time only long enough to check out and warm up the system.

CONTROL SYSTEMS

The remote control of steering gears on most Navy ships is done electrically by means of an alternating-current synchronous transmission system. The power-type system consists of interchangeable receiving and transmitting units. When the transmitter rotor is turned, the receiver rotor turns in synch; that is, at the same speed and in the same direction. The transmitters are located in the steering room and in the pilot house. They are mechanically connected through gearing to the steering wheels. The transmitters at each of the control stations are electrically connected to the receivers in the steering room. Generally, the circuits connecting the transmitters to the receivers are run in duplicate cables—one running along the port side of the ship and one running along the starboard side. Indicator lights show the cable, transmitter-receiver, and power sources in use.

Any apparent deficiencies in the electrical steering control system should be investigated and reported immediately. Some examples are sluggishness during operation and incorrect setting at rudder limit stops or control linkage.

EMERGENCY STEERING GEAR

Emergency hand-driven steering gear is provided on all combatant and auxiliary ships that have electrohydraulic steering gear. This steering gear consists of a small hydraulic pump, associate shuttle valves, piping, relief valves, and fittings. This equipment is located in the steering room. The piping from the hand pump is connected to the drainlines to eliminate the need for an additional high-pressure cutout valve. Manual positioning of the transfer valve isolates the rams

from the main pumps to prevent motoring of the main power units. The pump is hand cranked and usually set at a reduced stroke for hand steering. The pump operates in either direction of rotation, allowing for rudder positioning,

Some large combatant ships have separate emergency hydraulic units for each steering gear that are driven by electric motors. These units can operate the ram cylinders when the steering units are submerged. A single hand wheel controls the flow of oil for the rams and operates the rudder at a greatly reduced rate.

ANCHOR WINDLASSES

A windlass is used intermittently and for relatively short periods of time. It must handle the required load under extremely severe conditions. To prevent deterioration and to provide dependable operation whenever required, maintenance and adjustment must be continued during the periods when the machinery is not in use.

Windlass brakes (electric and hand brake) must be maintained in satisfactory condition if they are to perform their function properly. Because of wear and compression of brake linings, the clearance between the brake drum and band will increase after a windlass has been in operation. Means of adjustment are provided on all windlass brakes. Maladjustment of a windlass brake could result in the loss of the anchor and chain. Therefore, you should become familiar with maintenance procedures.

Lubrication instructions should be carefully followed. If a windlass has been idle for some time, lubrication of the equipment should be accomplished before operation is attempted. After a windlass has been used, the equipment should be lubricated to protect finished surfaces from corrosion.

The hydraulic transmissions of electrohydraulic windlasses and other auxiliaries are manufactured with close tolerances between moving and stationary parts. These tolerances are to be maintained and unnecessary wear prevented. Every precaution possible must be taken to prevent the entry of dirt and other abrasive material. When the system is replenished or refilled, only clean oil should be used and the oil should be strained as it is poured into the tank. If a hydraulic transmission has been disassembled, all parts should be thoroughly cleaned before reassembly. Before piping or valves are installed, their interiors should be cleaned to remove any scale, sand, or other foreign matter.

WINCHES AND CRANES

In several respects, the maintenance of a winch is similar to that of a windlass. The drum brake on winches and cranes will normally see very little wear since it is normally applied when the load has stopped moving. The electric or hydraulic brake mounted on the input shaft of the gear box of the winch or crane receives essentially all the wear. It should be inspected regularly and repaired when necessary. Steps should be taken to prevent oil or grease from accumulating on the brakes. The operation of brake-actuating mechanisms, latches, and pawls should be checked periodically.

The sliding parts of positive clutches must be properly lubricated, and the locking device on the shifting gear should be checked to determine if it will hold under load. The oil of gear reduction units should be checked for proper amount and purity. Periodic inspections should be made of the pressure lubrication fittings normally installed on slow-moving parts. On installations that use hydraulic transmission, the pumps and lines are maintained in the same way as those of any other hydraulic system.

As with many other auxiliary units, winches and cranes may be driven by hydraulic transmissions, by electric motors, by diesel engines, or by hand. Maintenance should be accomplished in accordance with the planned maintenance system (PMS). In general, the maintenance of electrohydraulic cranes requires that the oil in the replenishing tanks be kept at the prescribed levels, and that the system be kept clean and free of air. The limit stop and other mechanical safety devices must be checked regularly for proper operation. When cranes are not in use, they should be secured in their stowed positions. All electric power to the crane controllers should be disconnected at the power distribution panel.

ELEVATORS

Carriers have two or more electrohydraulic elevators capable of handling airplanes between the flight and hangar decks at relatively high speed. You may not be called upon too frequently to maintain this type of machinery. If you are, you will find maintenance procedures similar to those of other auxiliaries that use fluid to transmit power.

Elevator cables and fittings should be inspected frequently, and the tension of the cables in each group kept equal. Frequent inspections ensure that (1) there is proper oil level in the pressure and exhaust tanks, (2) there is no excessive leakage in the sump leak-off connections, (3) the pistons seal properly in the hydraulic cylinders, and (4) the entire system is clean.

CONVEYORS

Two types of conveyors are used for shipboard handling; gravity and powered. Gravity-type conveyors should require little or no maintenance. The powered vertical conveyors, tray type, will require PMS.

Vertical conveyors consist of a drive system that includes a drive motor, clutch, speed reducer, motor brake, drive shafts with chain sprockets, and connecting roller chain. The conveying system consists of a chain sprocket and an endless roller chain connected to guide tracks that carry the trays. Each conveyor has operating controls and various safety devices.

Periodic tests and inspections are required to ensure accident-free conveyor operation. For further information, consult your manufacturer's technical manual and applicable NSTM.

HYDRAULIC SYSTEMS

The overall efficiency of hydraulic installations used to control or drive auxiliary machinery is basically dependent upon size of installation, oil pressure, speed, and condition of the equipment. The care given the hydraulic components of the system is an important factor. Major repair of hydraulic gear, except for piping and fittings, is generally performed at a naval shipyard or by the manufacturer. Routine maintenance, keeping the oil clean, and maintaining proper fluid levels is the responsibility of the operator.

Hydraulic transmissions are sturdy, proven machines, inspected and tested with such care that casualties seldom occur except as a result of faulty assembly, installations, or maintenance. If a properly installed hydraulic system is operated regularly and maintained with proper care, it will retain its design characteristics of power, speed, and control, and the need for costly repair and replacement will seldom occur.

PIPING AND FITTINGS

Properly installed hydraulic piping and valves are seldom a source of trouble, except for leakage. Some leaks may become serious enough to cause a reduction in the efficiency of the unit. Frequent inspections should be made and necessary steps taken to eliminate leakage.

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 standby unit, if available. If not, secure the equipment while the gasket of the leaking flange is being replaced. Make certain that the flange surfaces are cleaned carefully before the gasket is applied. (NOTE: Fittings should not be tightened while the system is pressurized.)

Relief valves or shuttle valves of a hydraulic system may be sources of trouble. Loss of power may indicate a leaking relief valve. Shuttle valves may stick and fail to cut off. This condition is indicated when oil escapes from the high-pressure side of the line into the expansion tank or when the pressure control fails. When a shuttle valve fails to operate, the stop valves should be closed and the defective valve removed for repair. The seats of leaking relief valves should be reground.

FLUID SYSTEM

An inspection of an oil sample drawn from a hydraulic system may reveal the presence of metal particles, water, sludge, acidity, or other contaminants. If so, the system must be drained, flushed, and refilled in accordance with current applicable Navy procedures for the particular system. The presence of foreign particles in the hydraulic system indicates a possible component malfunction, which should be corrected prior to flushing the system.

Hydraulic fluid may be contaminated by use as the working fluid or as a flushing medium. It must not be used again, but should be disposed of according to prevailing instructions.

PUMPS AND MOTORS

An electric motor rotates the hydraulic pump. Oil under pressure is delivered from the pump to the hydraulic motor of the variable speed transmission through piping. The hydraulic motor rotates the individual unit or equipment through suitable reduction gearing. Whether the pumps and motors of hydraulic transmissions are of the axial or radial piston type, maintenance

procedures and operating principles are relatively the same. In general, maintenance information on other types of pumps also app;lies to hydraulic pumps and motors.

On modern hydraulic transmissions, shaft packing materials are of five general classifications: synthetic rubber, fluorinated compounds, silicones, fabric and rubber combinations, and leather. The hydraulic fluid to be sealed determines the type of packing material to be used. Packings for use in hydraulic systems containing petroleum-base fluid cannot be used in systems using phosphate ester fluids and vice versa. Water-glycol fire-resistant fluids and water-petroleum oil-emulsion fluids are generally compatible with any packings designed for petroleum oil.

The success or failure of any packing material depends upon more than compatibility of the fluid and the packing material. Other considerations are pressures, shock loads, clearances, surface finishes, temperatures, frequency and duration of work cycles. Packings should be installed in the sequence and direction given in applicable instruction manuals, or as the old ones are removed. Packing glands should only be tightened to the degree that leakage is kept to acceptable levels. Overtightening increases friction and shortens packing life.

There is less likelihood of *poor alignment between the driving and driven members* of a hydraulic transmission if the wedges, shims, jacking screws, or adjusting setscrews are properly set and secured when connected units are installed. However, because of a casualty, misalignment may cause severe stress and strain on the coupling and connected parts. Misalignment should be eliminated as soon as possible by replacing any defective parts and readjusting the installed aligning devices. If this is not done, pins, bushings, and bearings will have to be replaced frequently.

Since there is no end play to either the pump or 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.

MAINTENANCE

Regular operation, proper lubrication, proper maintenance of all the units, and cleanliness of the fluid are principal requirements for keeping a hydraulic transmission in satisfactory operating condition. Regular operation of hydraulic equipment prevents corrosion, sludge accumulation, and freezing of adjacent parts. The need for proper lubrication and cleanliness cannot be too strongly emphasized.

Detailed instructions on the maintenance of a specific unit may be obtained from the PMS and the appropriate instruction book. However, the general information that follows will also be helpful.

In attempting to locate the source of any problem in an electrohydraulic system, remember that all problems will be in one of three categories—hydraulic, electric, or mechanical. Isolating a problem into one of these categories is one of the primary steps in locating the source of trouble.

Hydraulic Casualties

These casualties are generally the result of low oil levels, external or internal leakage, clogged lines or fittings, or improperly adjusted valves and other working parts. Do not disassemble a unit unless you are certain that the trouble exists within that unit. Unnecessary disassembly can lead to additional trouble, because of the dirt that may enter an open system.

Leaks are a frequent cause of trouble in hydraulic equipment. Leaks are generally caused by excessively worn parts, by abnormal and continuous vibration, by excessively high operating pressures, or by faulty or careless assembly. External leaks usually have little effect on the operation of equipment other than a steady draining of the oil supply. Still, even a small leak wastes oil, and the resulting unsightly appearance of a machine is indicative of poor maintenance.

External leaks may result from any of the following causes: 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 sealing squarely.

Internal leaks, however, generally result in unsatisfactory operation of the equipment. Large internal leaks are indicated by loss of pressure and failure of equipment. Large internal leaks can usually be located by installing a pressure gauge 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 from improperly fitted or damaged gaskets.

The symptoms of trouble in a hydraulic system are frequently in the form of unusual noises. Some noises are characteristic of normal operation and can be disregarded, while others are evidence of serious trouble. Even though the exact sound indicating trouble can be learned only through practical experience, the following descriptive terms will give a general idea of the noises that are trouble warnings.

POPPING and SPUTTERING noises indicate that 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 the use of improper oil.

If air becomes trapped in a hydraulic system, HAMMERING will occur in the equipment or in the transmission lines. If hammering occurs, check for improper venting. In some cases, a POUNDING or RATTLING noise occurs as a 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 overlooked if it stops when speed or load is reduced. If the noise continues at low speeds or light loads, the system should be vented of air. Air in a hydraulic system can also cause uneven motion of the hydraulic motor.

The cause of a GRINDING noise is most likely to be dry bearings, foreign matter in the oil, worn or scored parts, or overtightness of some adjustment.

HYDRAULIC CHATTER is a term sometimes used to identify noises caused by a vibrating spring-actuated valve, by long pipes improperly secured, by air in the lines, or by binding of some part of the equipment.

If the packing is too tight around some moving part, SQUEALS or SQUEAKS may occur. This type of noise might also indicate that a high-frquency vibration is occurring in a relief valve.

Electrical Casualties

Although the EM is responsible for checking electrical equipment troubles, you can help by making a few simple tests when electrical troubles occur. Such an oversight as not having a switch in the ON position may be the reason for equipment failing to operate. If the circuit is closed and the equipment still fails to operate, check for blown fuses and tripped circuit breakers. These troubles generally result from an overload on the equipment. If a circuit breaker continues to open, the problem may be damaged equipment, excessive binding in the electric motor, obstruction in the hydraulic transmission lines, or faulty operation of the circuit breaker. Another source of electrical problems maybe in the circuit; check for open or shorted leads, faulty switches, and loose connections.

Mechanical Casualties

An electrohydraulically driven auxiliary may become inoperative because of a mechanical failure. If so, check for improper adjustment or misalignment of parts, shearing of pins or keys, or breakage of gearing, shafting, or linkage. Elimination of troubles resulting from any of these causes should be accomplished in accordance with the manufacturer's instructions for the specific equipment.

COMPRESSED AIR SYSTEMS

In working with any of the three types of compressed air systems (low-, medium-, and high--pressure), you probably found that the compressor caused most of the problems. The design and capacity of compressors vary, but the maintenance procedures are essentially the same. However, remember that the care and maintenance of high-pressure compressors requires additional safety precautions. Always follow the procedures recommended by the manufacturer.

While modern compressed air systems are rugged and dependable, they are not designed to withstand abusive treatment. Gasketed joints, pipe joints, and bolts will safely withstand the strain required for a tight connection when the specified torque is applied with the correct tool. The application of greater force usually results in breakage. If a joint or bolt cannot be tightened without using an oversized wrench or wrench handle extension, there is probably something wrong with the assembly.

CARE AND MAINTENANCE OF AIR COMPRESSORS

The overall goal in maintaining compressed air systems is to prevent a reduction in compressor capacity. You need to keep a ship's air compressor operating efficiently at all times and prevent as many troubles as possible. To do that, you must know how to care for air intakes and filters; how

to maintain and replace air valves; how to take care of air cylinders, pistons, and wrist pins; how to adjust bearings, couplings, and so forth; and how to maintain the lubrication, cooling, control, and air systems.

Air Intakes and Intake Filters

Satisfactory operation of any compressor requires a supply of clean, cool, dry air. To help keep the air supply clean, filters are fitted to compressor intakes. Unless these filters are inspected and cleaned regularly they will become clogged and cause a loss of capacity.

To clean filter elements, remove them from the intake and wash them with a jet of hot water or steam, or immerse them in a strong solution of washing soda. The filter body should be drained and replaced. Filter elements of the oil-wetted type should be dipped in clean oil after cleaning. Before replacing the element in the intake, let excess oil drain from it. The use of gasoline or kerosene is prohibited for cleaning air filters, because of explosive fumes that may collect in the compressor or air receiver.

Air Valves

The inlet and discharge valves of compressors require special attention. When valves leak, compressor capacity is reduced and pressure is affected. Deviation from normal intercooler pressure may indicate a leaking or broken valve, rise in pressure indicates a defective inlet valve, and a decrease in pressure indicates a defective discharge valve. Another sign of valve trouble is an unusually hot valve cover.

Dirt is generally the cause of leaking valves. When valves become dirty, the source of trouble can usually be traced to dirty intake air; use of an excessive amount, or of an improper grade, of cylinder oil; or excessively high air temperature, resulting from faulty cooling. Periodic inspection and cleaning of valves and valve passages minimizes the number of air valve troubles.

When air valves are removed for inspection, mark each valve to ensure that it will be replaced in the same opening from which it was removed. Inspect valves carefully and do not disassemble them for cleaning unless their condition necessitates such action. Dirt or carbon can usually be removed from valve parts without disassembling the valve. 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. To remove carbon from valve parts, soak the individual part in a suitable solvent and then brush or scrape it lightly. After drying and reassembling the valve parts, test the operation of the valve to see if it opens and closes freely.

Before replacing air valves in a cylinder, inspect the gaskets. If other than copper, replace any gaskets that are damaged. Copper gaskets should always be replaced. Since it may be difficult to distinguish between suction and discharge valves, extreme care must be taken when the valves are being inserted in the cylinder. Make certain that suction valves open TOWARD and discharge valves AWAY FROM the center of the cylinder; otherwise, serious damage or loss of capacity will result. In most instances, special lock nuts are provided to seal against leakage at the threads of the valve setscrew.

Cylinders, Pistons, and Related Parts

You should be familiar with the procedures for cleaning cylinders, removing pistons, fitting new piston rings, replacing cylinders, checking piston end clearances, adjusting bearings, replacing wrist pins, packing stuffing boxes, and caring for couplings and V-belts. Follow the maintenance procedures recommended by the manufacturer and observe all safety precautions as you do the work.

Control Devices

Because of the great variety of controls regulating the unloading devices used with compressors, detailed instructions on their adjustment and maintenance must be obtained from manufacturers' instruction books,

If a control valve fails to operate properly, disassembly and a thorough cleaning will usually be necessary. Some control valves are fitted with filters filled with sponge or woolen yarn to prevent dust and grit from being carried into the valve chamber. These filters also remove the gummy deposit that comes from the oil used in the compressor cylinders. The filter element should be replaced with the specified material each time a valve is cleaned. Do not use cotton, because it will pack down and stop the air flow.

Since relief valves ensure safe operation of a compressed air system, they must be maintained in satisfactory operating conditions at all times. Relief valves should be set as specified by the manufacturer. They should be tested in accordance with the PMS.

ROTARY-CENTRIFUGAL AIR COMPRESSORS

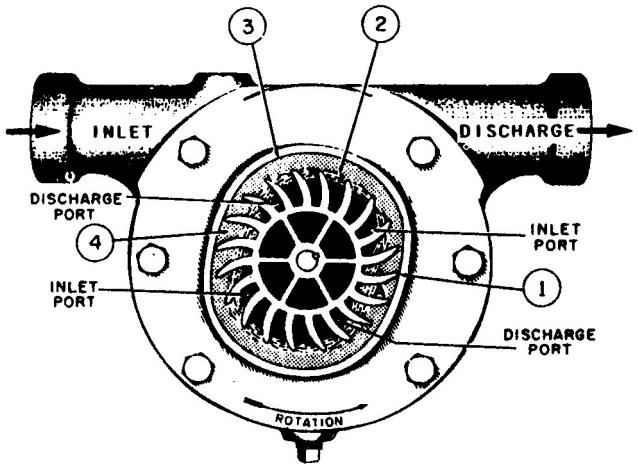
The one nonreciprocating type of air compressor that is found aboard ship is referred to as a rotary compressor, a centrifugal compressor, or a "liquid piston" compressor. Actually, the unit is something of a mixture, operating partly on rotary principles and partly on centrifugal principles. It might be called a rotary-centrifugal compressor, and we will use that term here.

The rotary-centrifugal compressor is used to supply low-pressure compressed air. Because this compressor is capable of supply air that is completely free of oil, it is often used as the compressor for pneumatic control systems and for other applications where oil-free air is required.

The rotary-centrifugal compressor, shown in figure 9-1, consists of a round, multibladed rotor that revolves freely in an elliptical casing. The elliptical casing is partially filled with high-purity water. The curved rotor blades project radially from the hub. The blades, together with the side shrouds, form a series of pockets or buckets around the periphery. The rotor is keyed to the shaft of an electric motor. It revolves at a speed high enough to throw the liquid out from the center by centrifugal force. This results in a solid ring of liquid revolving in the casing at the same speed as the rotor but following the elliptical shape of the casing. This action alternately forces the liquid to enter and recede from the buckets in the rotor at high velocity.

To follow through a complete cycle of operation, let us start at point A. The chamber (1) is full of liquid. The liquid, because of centrifugal force, follows the casing, withdraws from the rotor, and pulls air in through the inlet port. At (2) the liquid has been thrown outward from the chamber in the rotor and has been replaced with atmospheric air. As the rotation continues, the converging wall (3) of the casing forces the liquid back into the rotor chamber, compressing the trapped air and forcing it out through the discharge port. The rotor chamber (4) is now full of liquid and ready to repeat the cycle, which takes place twice in each revolution.

A small amount of seal water must be constantly supplied to the compressor. This makes up for the water that is carried over with the compressed air and removed in a refrigeration-type dehydrator.



147.119

Figure 9-1.—Rotary-centrifugal compressor.

CARE AND MAINTENANCE OF AIR SYSTEM EQUIPMENT

The care and maintenance of air system equipment includes inspections, cleaning, testing, and repairing. These activities should be done in accordance with the PMS.

Surface Inspections and Maintenance

The air flasks, high-pressure piping, and separators are inspected in accordance with the PMS. These inspections are made to determine if there is any external corrosion or damage to flasks or piping. Air flasks must be blown down weekly. Moisture separators installed downstream of the compressor must be blown down hourly during operation of the compressor. Filter elements must be changed in accordance with existing instructions. The drainage of air system equipment must be sufficiently frequent to prevent excessive accumulations of moisture and oil. Such accumulations not only cause internal corrosion and fouling of moving parts, but also create a serious hazard in that excessive oil accumulation may cause an explosion.

Inspection, Cleaning, and Testing By Repair Activities

In addition to shipboard inspection and maintenance of high-pressure air flasks and separators, there must be inspections, cleaning, testing, and repainting performed at prescribed intervals by a repair activity.

INSPECTIONS AND MAINTENANCE

Minimum requirements for the performance of inspections and maintenance on high-pressure air plants are listed in the PMS.

It is the responsibility of the engineering officer to determine if the condition of the equipment, hours of service, or operating conditions necessitate more frequent inspections and tests. Details for outline tests and inspections may be obtained from the appropriate manufacturer's instruction book or from the *Naval Ships' Technical Manual.*

SAFETY PRECAUTIONS

There are many hazards associated with the process of air compression. Serious explosions have occured in high-pressure air systems because of a diesel effect. Ignition temperatures may result from rapid pressurization of a low-pressure deadend portion of the piping system, malfunctioning of compressor aftercoolers, leaky or dirty valves, and many other causes. Every precaution must be taken to have only clean, dry air at the compressor inlet.

Air compressor accidents have also been caused by improper maintenance procedures. Some examples are disconnecting parts while they are under pressure, replacing puts with units designed for lower pressures, and installing stop valves or check valves in improper locations. Improper operating procedures have also caused air compressor accidents with resulting serious injury to personnel and damage to equipment.

In order to minimize the hazards of compression and the use of compressed air, all safety precautions outlined in the manufacturers' technical manuals and in the *Naval Ships' Technical Manual* must be strictly observed

FORCED DRAFT BLOWERS

Forced draft blowers require very little maintenance and repair under normal conditions. However, you should make sure they are adequately lubricated. Most of the maintenance work with blowers is related to keeping the lubrication system and the steam seals in proper condition.

Keep the lubricating oil in the reservoirs clean. You should always fill the reservoir to the correct level with oil of the specified weight and grade. Take an oil sample as required by the lube oil quality management program. Then, take appropriate action if needed. The lube oil quality management program was discussed in chapter 1 of this TRAMAN.

Check the steam seals (particularly on vertical forced draft blowers) frequently for leakage. Excessively leaking steam seals contribute to water losses, heat stress and high humidity, and lube oil contamination. Most forced draft blowers have gland leakoff piped to to auxiliary gland exhaust condenser. The auxiliary gland exhaust fan will pull a slight vacuum on the seals to recover some of the losses.

Automatic shutters are not subject to much wear under normal operating conditions. However, you should be sure they are kept well lubricated. Some shutters have Zerk grease fittings, others have oil holes. Be sure you use the correct lubricant. If the automatic shutters are not properly lubricated they may stick. Sticking shutters can slam shut with enough force to cause damage to the shutters and the toggle gear. A stuck shutter can cause an idle forced draft blower to rotate backwards. Replace broken or sprung parts to assure smooth operation of the shutters. You should inspect shutters often to make sure they operate freely and seal tightly when closed

Do not operate forced draft blowers if they are vibrating excessively or making any unusual noises. Vibration may be caused by worn or loose bearings, a bent shaft, loose or broken foundation bolts, an unbalanced or broken fan, a broken turbine blade, or other defects. You must correct all defects as soon as possible to prevent a complete breakdown of the blower.

In case of an emergency, you can make minor repairs to fan blades aboard ship; but, you must not make major repairs without specific instructions from NAVSEA. Wipe blower fans frequently to remove dirt and dust. You should never paint a blower fan or any other rotating part of the unit.

SUMMARY

In this chapter, you were provided information on auxiliary equipment, such as steering gear, anchor windlasses, elevators, conveyers, hydraulic and compressed air systems, and forced draft blowers. The information in this chapter does not contain specific repair procedures. For detailed information on the maintenance and repair of auxiliary machinery, you need to consult the specific manufacturer's technical manual.

CHAPTER 10

PROPULSION PLANT EFFICIENCY

The military value of a naval ship depends to a large extent on its cruising radius, which in turn depends upon the efficiency with which a propulsion plant is operated. Economical operation involves making fuel, lubricating oil, boiler feed water, potable water, and consumable supplies last as long as possible. A ship is not ready for wartime steaming unless the engineering department can and does operate reliably and efficiently. it is, therefore, important that engineering personnel maintain propulsion equipment in a reliable condition and that the equipment be operated at maximum efficiency.

The primary purpose of the peacetime Navy is to train and prepare personnel for wartime conditions. However, in peacetime, maximum economy must be practiced to keep operating and maintenance costs at a minimum.

The operation of an engineering plant cannot be considered reliable when machinery casualties occur frequently. Some of the more common causes of machinery casualties are

1. changing the setup of the plant at high speeds;
2. radical maneuvering of the ship;
3. inexperienced or improperly trained personnel;
4. inattentive watch standing;
5. poor supervision; and
6. inadequate repairs, maintenance, and preventive maintenance.

Accurate knowledge and continuous effort are required to keep propulsion plants operating reliably and efficiently. It is necessary for the personnel concerned to be familiar with the chapters of the *Naval Ships' Technical Manual* that deal with main propulsion plants and associated auxiliary equipment. It is also necessary for personnel to have an accurate knowledge of the appropriate manufacturer's technical manuals, official publications, and directives on operational procedures and material upkeep.

When a ship is underway, the MMC or MM1 will normally stand watch as the engineering officer of the watch (EOOW). The engine-room supervisor must be capable of supervising all the operations of the propulsion and auxiliary machinery and of preparing systems applicable to the engine room assigned. The EOOW must be capable of supervising the entire propulsion plant, which includes the other engine room(s) and the firerooms.

On ships having more than one main propulsion plant, the associated engine room and fireroom are usually operated together as one unit. On some auxiliary ships this one unit constitutes the entire propulsion plant; on combatant ships, this unit may be one of two or four separate propulsion plants. The physical characteristics of compartments and bulkheads, or the location and arrangement of machinery and equipment, do not change the operating principles of a main propulsion plant. On older ships, it was necessary to operate two separate spaces as one basic unit; however, on most new large combatant ships, NAVSEA has changed this arrangement. The present machinery arrangement has the basic propulsion plant, consisting of boilers, main engines, turbogenerators, and auxiliary machinery of the associated engine room and fireroom, in one compartment. This compartment is called a main machinery room.

In operating the associated engine room and fireroom as one complete propulsion plant, maximum reliability and efficiency cannot be obtained unless there is cooperation, understanding, and teamwork between engine-room and fireroom personnel. A great deal depends upon the knowledge and supervisory ability of the senior watch stander in each main machinery space. The MM in charge of the engine room should have a practical knowledge of fireroom operation, of safety precautions, and of the casualties that may occur during operation of the engineering plant.

The EOOW must see that the officer of the deck (OOD) and the engineer officer are immediately informed of all important facts concerning the operation of the main engines. The EOOW is responsible for reporting to the engineer officer and the OOD such items as casualties to machinery, boilers available, generators available, and maximum speed at which the ship is capable. The EOOW must also report such operations as placing a major unit of machinery in or out of commission and starting or securing a piece of machinery. He/she must be capable of carrying out appropriate engineering casualty control procedures for the overall operation of the propulsion plant in order to minimize the effect of the casualty on the the overall operation of the plant.

ENGINEERING PERFORMANCE

During peacetime, the objective of engineering department training in the fleet is to create and maintain readiness to deliver the designed performance of the engineering plant at all times. Such readiness includes the ability to operate free of breakdowns, to control engineering damage, to make prompt and effective emergency repairs, and to operate the engineering plant safely and economically. Administrative instructions are provided each ship for the purpose of furnishing a general and uniform guide by which type commanders or their subordinates may estimate or evaluate the engineering performance and readiness of the ships assigned to their command.

ENGINEERING RELIABILITY

A ship must be capable of performing any duty for which it was designed. A ship is considered reliable when it meets all scheduled operations and is in a position to accept unscheduled tasks. In order to do this, the ship's machinery must be kept in good condition so that the various units will operate as designed. Some of the steps to promote reliability areas follows:

1. A good preventive maintenance program must be carried out at all times. This involves regular tests, inspections, and repairs.
2. Machinery and piping systems must be operated in accordance with good engineering practices. Operating instructions and safety precautions should be posted for each unit of machinery.
3. Supervisory personnel must have a thorough knowledge of the ship's machinery and piping systems. Information on construction, operation, maintenance, and repair of machinery can be obtained from the manufacturer's technical manuals and blueprints.
4. A good engineering department administrative organization will ensure proper assignment of duties and responsibilities and proper training and supervision of personnel. The MMC and MM1 will have administrative and supervisory duties. As a supervisor, the MMC or MM1 must see that all pertinent instructions and procedures are carried out in regard to the proper operation, maintenance, and repair of machinery.
5. Personnel must be thoroughly trained. This can best be accomplished by a combination of methods. An effective method of training is to have the students learn by doing; a good example of this is watch standing. Another method of training is carrying out regularly scheduled and well-planned instruction periods. These instruction periods are not limited to classroom instruction—they may be conducted by holding engineering casualty control drills while underway.

The Personnel Qualification Standards provide the minimum requirements necessary to qualify on a watch station.

ENGINEERING PLANT ECONOMY

In order to obtain economy, the engineering plant, while meeting prescribed requirements, must be operated so as to use a minimum amount of fuel. THE FUEL PERFORMANCE RATIOS ARE GOOD OVERALL INDICATIONS OF THE CONDITION OF THE ENGINEERING PLANT AND THE EFFICIENCY OF THE OPERATING PERSONNEL. The fuel performance ratio is the ratio of the amount of fuel oil used to the amount of fuel oil allowed for a certain speed or steaming condition. The fuel performance ratio is a general indication of the ship's readiness to operate economically and within established standards. In determining the economy of a ship's engineering plant, the same consideration is given to the amount of water used on board ship. Water consumption is computed in (1) gallons of makeup feed per engine mile, (2) gallons of makeup feed per hour at anchor, and (3) gallons of potable water per person per day.

The increase or decrease in a ship's fuel economy depends largely on the operation of each unit of machinery; economical operation further depends on personnel understanding the function of each unit and knowing how units are used in combination with other units and with the plant as a whole.

Good engineering practices and safe operation of the plant should never be violated in the interest of economy—furthermore, factors affecting the health and comfort of the crew should meet the standards set by the Navy.

Indoctrination of the ship's crew in methods of conserving water is of the utmost importance, and it should be given constant consideration.

Economy Versus Safety

Aboard naval ships, economy measures cannot be carried to extremes because there are several safety factors that must be considered. Unless proper safety precautions are taken, reliability may be sacrificed; and in the operation of naval ships, reliability is one of the more important factors. In operating an engineering plant as economically as possible, safety factors and good engineering practice must not be overlooked.

Notes on Efficient Operation

There are several factors that, if given proper consideration, will promote efficient and economical operation of the engineering plant. Some of these factors are (1) maintaining the designed steam pressure, (2) proper acceleration of the main engines, (3) maintaining designed condenser vacuum, (4) guarding against excessive recirculation of condensate, (5) maintenance of proper insulation and lagging, (6) keeping the consumption of feed water and potable water within reasonable limits, (7) conserving electrical power, (8) using the correct number of boilers for best efficiency at the required load levels, and (9) maintaining minimum excess combustion air to the boilers.

MAINTAINING A CONSTANT STEAM PRESSURE is important to the overall efficiency of the engineering plant. Wide or frequent fluctuations in the steam pressure or degree of superheat above or below that for which the machinery is designed will result in a considerable loss of economy. Excessively high temperatures will result in severe damage to superheaters, piping, and machinery.

PROPER ACCELERATION AND DECELERATION OF THE MAIN ENGINES is an important factor in the economical operation of the engineering plant. A fast acceleration will not only interfere with the safe operation of the boilers but will also result in a large waste of fuel oil. The Machinist's Mate in charge of an engine-room watch, or standing throttle watch, can contribute a great deal to the economical and safe operation of the boilers.

A HIGH CONDENSER VACUUM can be obtained only by the proper operation and proper maintenance of the condenser. A low exhaust pressure (high vacuum) is an important factor in obtaining maximum engineering efficiency. Steam exhausting into a low-pressure area has a greater range of expansion and therefore is capable of accomplishing more useful work. The total available energy in the steam is much higher per pound of pressure difference in the lower range of pressures than in the upper range. This is the most important reason why the condenser vacuum should be maintained as high as possible.

EXCESSIVE RECIRCULATION OF CONDENSATE should be avoided as it cools the condensate, which then has to be reheated as it enters the deaerating feed tank. This reheating process causes an excessive amount of steam to be used to maintain the proper temperature in the deaerating feed tank.

MAINTENANCE OF PROPER INSULATION AND LAGGING not only increases the overall economy of the engineering plant but also is a safety measure and increases the comfort of personnel. In every power plant there is a heat loss as heat flows from heated surfaces, such as piping and machinery, to the surrounding air and cooler objects. This heat loss can be kept to a minimum by proper insulation.

While increasing the economy of the plant, insulation also reduces the quantity of air necessary for ventilating and cooling the space. Proper insulation also reduces the danger of personnel receiving burns from contact with the hot parts of the piping, valves, and machinery. Good insulation, elimination of steam leaks, and a clean ventilation system contribute to good economy and to the comfort and safety of personnel.

CONSERVATION OF FEED WATER AND POTABLE WATER has a direct bearing on the overall efficiency and economy of the ship. Feed water and potable water consumption rates are entered on the fuel and water report. Type

commanders use these consumption rates as a factor for judging the efficiency of ships operating under their command. Ships having excessive feed water consumption rates should take immediate steps to eliminate all steam and water leaks, which contribute to the uneconomical operation of the plant. Improving feed water consumption rates will also improve the fuel oil performance ratio.

The consumption of potable water by the ship's crew bears a direct relationship to the efficient operation of the engineering plant; the greater the amount of fresh water distilled, the greater the amount of steam used. Conservation of fresh water requires the close cooperation of all personnel aboard ship, since large amounts may be wasted by improper use of the laundry, scullery, galley, and showers.

FAILURE TO CONSERVE ELECTRICAL POWER is a very common source of waste aboard ship. Lights are frequently left on when not needed, and bulbs of greater wattage than required are often used.

If the ship's ventilation system is improperly operated or improperly maintained, the result is a waste of electrical power. Vent sets are often operated on high speed when low-speed operation would provide adequate ventilation and cooling. Dirty and partially clogged ventilation screens, heaters, cooling units, and ducts will result in inefficient operation and power loss.

In checking the operation of the engineering plant for efficiency, consider the proper operation and maintenance of all units of auxiliary machinery. Economical operation of the distilling plants and of the air compressors will contribute a great deal to the overall efficiency of the plant. Because of the large number and various types of pumps aboard ship, their operation and maintenance are important factors. Units of machinery that operate continuously (or most of the time) must be given careful attention with respect to efficient operation and maintenance.

The following are specific recommendations for the efficient operation of engineering plants:

- Maintain superheated steam temperature as close to the designed temperature as operating conditions permit.

- Boiler casings should always be tight. Leaky casings result in excessive fuel consumption because additional steam is required to increase blower capacity and heat is conducted away from the boiler by leaking air.

- High feed water consumption indicates an uneconomical plant. No feed water leak is too small to be neglected.

- Keep the steam pressure temperature as steady as is feasible at all times.

- Throttlemen must carefully follow the acceleration and deceleration table posted on the throttle board.

- Check the condensing system frequently for proper operation and tightness.

- Check the operation of the deaerating feed tank frequently.

- Keep all drain valves, drain lines, and steam traps in good working condition.

- Check all orifice plates in piping systems for good material condition, proper size, and proper operation.

- Keep the steam pressure to the air ejectors steady and at the designed pressure.

- Keep the auxiliary exhaust pressure at the designated value by maintaining the automatic dumping valves in good working condition.

- Maintain all insulation and lagging in good condition.

- Keep the bilges dry. Water in the bilges will add to the humidity of the air, necessitating more ventilation and causing bilge piping to corrode.

- Keep ventilation systems clean at all times.

- Run ventilation motors on low speed unless high speeds are necessary.

- Whenever the ship's electrical load will permit, operate one generator, rather than two. It is more economical to operate one generator at nearly full load than to operate two generators at light loads.

- Maintain proper lubricating oil temperatures. Cold lube oil can be an indirect cause of excess fuel oil consumption and improper bearing lubrication.

- Use the proper number of boilers for best efficiency at the required load condition.

- Use the proper setup of pumps and other auxiliaries at all times.

- Keep heat exchangers, such as lube oil coolers, operating efficiently.

- Never sacrifice safety for economy. Personnel may be injured and machinery may be damaged.

Trail Performances

Trial performances, such as full power and economy trials, are conducted to furnish evidence of the ship's engineering plant readiness for peacetime or wartime steaming conditions. By studying the trial performance reports, the type commander and NAVSEA can evaluate the ship's readiness to make required speeds and economy of operation. Information on conducting trial performances will be given in a later chapter of this training manual.

CONTROL OF ENGINEERING CASUALTIES

The ability of engineering department personnel to control engineering damage and make emergency repairs is measured by PERFORMANCE OBSERVED during training exercises and actual emergencies. The first consideration in judging the effectiveness of engineering casualty control lies in evaluating the ability of the ship's force to maintain and repair the ship's machinery and equipment. For complete evaluation, allowances must be made for the age, service, and character of the installed machinery, for time and facilities allotted for maintenance and repair, and for experience and training of engineering personnel.

Another means of judging the readiness and ability of a ship and the ship's crew to perform the operations that might be required of them in time of war is by conducting an OPERATIONAL READINESS INSPECTION (ORI). The ORI consists of conducting battle problems and other operational exercises that involve all divisions aboard ship. The results of the engineering casualty control exercises greatly reflect the condition of the machinery and the effectiveness of the personnel. During such an exercise, too much dependence should not be placed on a few key personnel. All personnel should be trained so that smooth teamwork and reliable performante may be obtained.

Careful and continuous efforts by the MM1 and MMC must be carried out to train personnel on steaming watch. In peacetime, almost all of the engineering casualties occur during a steaming watch, at which time the key personnel may not be present. These casualties must be handled by the personnel on watch at the time when they occur. The senior watch standers should check the training of their watch standers and have a thorough knowledge of both their ability to stand watch and to handle casualties. The senior watch standers should take all practical steps to instruct and train personnel on watch.

GETTING READY TO GET UNDERWAY

Getting a ship underway, especially a large ship, in a smooth and efficient manner depends to a great extent upon the administrative procedures and organization of the engineering department. Posting the steaming watch, providing advanced information to supervisory personnel, disseminating instructions to watch standers, mustering and checking watch standers on stations, and warming up the main plant and standing by to get underway, require certain procedures, coordination, and instructions by supervisory personnel.

To prevent misunderstanding and confusion, forms and check-off lists are used in getting the engineering plant ready to get underway. The purpose of check-off sheets for warming up or securing a main plant is to provide a convenient and simple procedure for checking the required steps in proper sequence. Check-off sheets will ensure that no important step is overlooked or forgotten.

STEAMING ORDERS

Steaming orders are usually written by the engineer officer or the main propulsion assistant. Steaming orders are necessary, especially on large ships, to supply advance information to supervisory personnel and to enable administrative personnel to make necessary preparations.

Steaming orders list the various units of machinery and the readiness requirements of the engineering department. This form usually includes the major machinery to be used, the

lighting-off times, the cutting in of boilers, spinning of main engines, the times of warming up and putting ship's service generators on the line, standard speed, the name of the engineer officer of the watch, the name of the leading petty officer of the watch, and any additional information that the engineer officer thinks necessary. The steaming orders are generally written the night before the ship is to get underway and left in a convenient location, such as the log room or central control, for the duty officers and duty petty officers to sign. When a petty officer signs the steaming orders, it means that he/she has read and understood the orders and therefore is fully responsible for carrying out any and all applicable orders. The early posting of such orders is essential in getting a large propulsion plant underway with a minimum of confusion.

On smaller ships, such as destroyers, steaming orders are usually brief and simplified. The first part of the engine-room lighting-off sheet is generally used as the steaming orders. Key personnel, such as MMC arid EMC, are notified by the engineer officer or by the assistant engineer officer as to the time the ship will get underway. The duty MMC, who has received all the necessary information and instructions, is responsible for making preparations for getting underway.

WARMING UP THE PROPULSION PLANT

When all watch standers have been mustered in the engine room or machinery room, the petty officer in charge of the watch should inform main engine control that his/her space is manned and ready to light off. The officer of the watch or the senior petty officer in main engine control must check to see that all spaces are manned and ready to warm up the main propulsion plant. The officer of the watch or the petty officer who is assuming the duties of the officer of the watch must also see that all other required reports are made to main engine control.

At the time specified by the steaming orders, the senior watch stander will direct the spaces to start warming up the plant in accordance with the engineering operational sequencing system (EOSS).

Many casualties that have occurred during warming up the plant can be traced directly to lack of cooperation between engine-room and fireroom personnel, misunderstanding of orders, lack of coordination by the senior watch stander, starting or securing machinery without orders, and opening or closing valves without orders to do so.

It is very important to hold the boiler load to a minimum until the main feed pump can be warmed up and is ready to feed the boiler. On ships using an emergency feed pump for feeding the in-port boiler, it is very important to warm up the main feed pump as soon as possible. As additional machinery is started, the load on the emergency feed pump increases. Emergency feed pumps are designed to feed a boiler at low loads only; a main feed pump should take the load as soon as one is warmed up and ready to be put on the line.

When an additional boiler is ready to be brought on line, the officer of the watch must carefully coordinate the efforts of the engine-room and fireroom watch standers to prevent casualties. Putting another boiler into service involves starting additional feed booster pumps, main feed pumps, another deaerating feed tank, and splitting the plant. At this point in the warming up process, a lack of cooperation or a misunderstood order can cause several different kinds of casualties; an empty deaerating feed tank, loss of main feed pressure, or loss of electrical power are but a few of the casualties that have occurred. Split-plant valves should never be opened or closed without orders from the officer of the watch in main engine control, and when such orders are received the valves should be opened (or closed) as soon as possible.

REPORTING READY TO ANSWER BELLS

During the last few minutes before the ship is scheduled to get underway, the officer of the watch has many duties and responsibtities to carry out. The officer of the watch must

1. be certain that the items listed on the steaming orders are carried out or will be carried out according to the engineer officer's orders;
2. know that all required machinery has been warmed up properly, put on the line, and is running normally;
3. be sure that the required boilers are on the line, that all main steam lines have been properly drained and lined up as specified by the lighting-off sheets;
4. ensure that the required number of ship's service generators are on the line, and that the electrical load is split;

5. be sure that the Electrician's Mates and IC Electricians have tested the engine order telegraph, the shaft revolution indicator, the steering engines, and the anchor windlass; and

6. know that the plant is split and that all standby machinery has been tested and is ready for use, if needed.

The main engines must be tested before the engineering plant is ready to get underway. On a small ship, such as a destroyer, the EOOW will request permission from the OOD to test main engines, usually about 15 minutes before the ship is scheduled to get underway. On a large ship, such as a CVA, this request maybe made 1 hour or more before the scheduled departure time.

When the OOD is certain that the area around the screws is clear of boats, lines, or other objects that may foul the screws, he/she will grant permission to test the main engines. When this permission has been granted, the EOOW must notify all engineering spaces. When all main engines have been tested satisfactory, the EOOW will report to the OOD that the engineering department is ready to get underway.

After the main engines have been tested, and while you are waiting to answer bells, the main engines must be turned by steam. The engines are spun, astern and then ahead, to prevent putting way on the ship. Spinning the engines not only heats the casings but also prevents the rotors from bowing. The interval of time between testing main engines and getting underway may be prolonged by weather, traffic, casualties, or other conditions; during this time the main engines must be turned by steam at least once every 3 to 5 minutes. However, if the getting underway time is unduly delayed, the commanding officer may grant permission to engage and start turning gear to keep the engines turning.

FIREROOM OPERATION

In order for an MMC or MM1 to carry out his/her duties properly, he/she must possess some knowledge of basic fireroom procedures. This is especially true of those installations where an MMC is in charge of the control engine room while underway. The efficient and safe operation of the engineering plant depends to a large degree on close cooperation between the engine-room and fireroom personnel. By the time personnel in either space have become first class or chief petty officers, they should have a good knowledge of the entire engineering plant. This does not mean that they should be able to switch watch standing jobs, but they should have a good understanding of what is occurring on the other side of the bulkhead or, in some ships, on the other side of the space.

Close cooperation of personnel in both spaces is always important, and is especially important when warming up or securing the plant because this is the time when many casualties occur. As additional machinery is started in the fireroom, the engine room should be notified. In many instances, the fireroom should be notified as machinery is started or secured in the engine room. NEVER take for granted that personnel in other spaces know which machinery is in operation.

Most ships have single-furnace boilers; however, some of the older ships such as BBs have double-furnace boilers. The present discussion is limited to pointing out certain operational differences between double-furnace (controlled superheat) and single-furnace (non-controlled superheat) boilers, since these are currently the two most commonly used types.

The double-furnace boiler with controlled superheat is installed on many combatant ships built up to the end of World War II. The operating pressure of this type of boiler is approximately 615 psig with a maximum superheater outlet temperature of 850°F. The superheaters of these boilers cannot be fired safely unless there is a safe minimum flow of steam passing through the superheaters.

On huge combatant ships, there is usually sufficient steam flow (even when steaming for auxiliary purposes) to maintain fires under the superheater side. However, in most installations, it is usually necessary to be underway and making about 12 knots before the fires can be lighted under the superheater side of the boiler. When the superheater is operating and the steam flow drops below a safe minimum, the superheater fires must be secured immediately.

From the standpoint of maintenance and repairs to the steam piping, turbine casings, and superheater handhole plates, it is not feasible to put superheaters into operation until it is expected that the ship's speed will be more than 10 knots for a considerable period of time. Furthermore, continually lighting off and securing the superheater fires will cause extensive steam leaks throughout the system subjected to fast changing temperature conditions. These steam leaks will

waste more fuel than could be saved by a few minutes of superheat operation.

The single-furnace boiler without controlled superheat creates a different type of problem. After the boiler is on the line and furnishing steam, there will be sufficient flow because all steam passes through the superheater. When this type of boiler is lighted off or secured, there is no normal flow of steam through the superheater and some means of flow must be established. This means that before a boiler is cut in and after it is removed from the line cooling steam must pass through the superheater.

The following brief discussion on the construction and operation of the single-furnace boiler with uncontrolled superheat will help you understand the need for protection steam during lighting-off and securing operations.

The superheater is installed within the banks of the generating tubes and receives heat from the same fire as the generating tubes. In operation, the steam is generated; but before any of it is used, it is routed through the superheater.

The steam used for auxiliary purposes must be desuperheated by passing it through a desuperheater that is submerged below the water level in the steam drum or water drum. When the boiler is steaming for auxiliary or underway purposes, there is a constant flow of steam through the superheater, sufficient to cool the superheater tubes. During the time when the boiler is lighted off, before the stops are opened-and also when the boiler is secured, after the stops are closed-there is no normal flow through the superheater. During this time there is heat in the furnace and the superheater tubes are subjected to this heat. If there is no steam flow through the superheater tubes during this period, the superheater will become overheated and damaged. This problem is overcome by piping steam from the auxiliary steam line (150-psi line), through the superheater tubes, and into the auxiliary exhaust line.

When the boiler pressure exceeds the 150 psi of the auxiliary steam line, steam flow must be provided through the superheater by the use of high-pressure drains, auxiliary machinery, and throttling the steam in the auxiliary exhaust line. The amount of oil fired in the boilers during light-off should be very carefully controlled to prevent overheating superheater tubes.

It is sometimes necessary to light off and put additional boilers on the line when a ship is underway. With noncontrol superheat boilers, the steps are much the same as for putting the first boiler or boilers on the line. With superheat control boilers, additional precautions must be taken.

When the steam lines are carrying superheated steam, it would be dangerous to admit saturated steam to the lines. It is not usually possible to establish enough steam flow to light off the superheaters of the incoming boilers, until the boilers are on the line. It is permissible to bring in the incoming boilers without their superheaters in operation, if the superheater outlet temperature of the steam boilers is lowered to 600°F. Lowering of the superheat temperature on the steaming boilers should be started in time so that the cutting-in temperature can be reached before the incoming boilers are up to operating pressure. Except in an emergency, the temperature of the superheaters should NOT be lowered or raised at a faster rate than 50°F every 5 minutes.

If the ship is operating at a speed that requires maximum or nearly maximum superheat temperature and the saturated side is being fired at maximum or near maximum, the officer of the watch must know and inform the bridge that the speed of the ship will have to be reduced in order to cut in additional boilers.

OPERATING THE PLANT UNDERWAY

After the ship is clear of the harbor, the commanding officer will order the special sea detail secured. With the ship underway, a considerable amount of attention must be given to the plant. Some of the important factors to be considered are pointed out in the following paragraphs.

OPERATING INSTRUCTIONS

In order to be a good operator, the MM must become acquainted with all standing orders and operating. instructions for the ship. These are made up for each ship and show the various plant arrangements (split plant, cross-connected steaming, cruising arrangement, etc.) for the different speeds. Each watch stander must read and understand the steaming orders and any additional orders issued by the engineering officer.

MAIN CONDENSER VACUUM

Maintaining a designed vacuum in the main condenser makes available more useful work from

each pound of steam. This increases the maximum speed of the ship. The vacuum for which the turbine was designed must be maintained. Watch standers must give careful attention to detect and prevent air leaks into the main condensing system. In order to maintain a designed vacuum, the following precautions must be taken:

1. Keep gland packing in good condition.

2. Maintain gland seal steam at the required pressure (usually 1/2 to 2 psig).

3. Eliminate all air leaks into the condensing system.

4. Maintain adequate water in the reserve feed tank which is in use for makeup feed.

5. Ensure that throttles not in use do not leak. Any leakage of steam past a closed throttle will tend to raised the temperature and pressure within turbines not in use.

If the condenser vacuum is not as high as it should be in relation to the condenser load and the cooling water overboard temperature, some part of the condensing system is not functioning properly. The operator should check for malfunctioning of a condensate pump or air ejectors, and for an air leak in some part of the system under vacuum.

PREPARING TO ENTER PORT

When the ship is still out in the open sea, main engine control should request permission to pump bilges. The EOOW must keep in mind the guidelines set forth in the Environmental Protection Manual, OPNAVINST 6240.3, which governs the discharge of oily waste overboard. Both soil and waste drains of the CHT systems must be shifted from overboard into the holding tanks.

Permission to blow tubes on all steaming boilers must be requested from the officer of the deck and carried out accordingly. When the bilges have been pumped and tubes blown on all steaming boilers, a report must be made to the bridge.

On ships with controllable superheat boilers, it is necessary to lower the temperature of the superheated steam before entering port. Lowering the temperature and securing the superheaters require close cooperation between the bridge, the engine room, and the fireroom. The fireroom must receive word in sufficient time so that the burnerman can lower the superheat temperature at the proper rate. (Remember, superheat should NOT be raised or lowered at a rate greater than 50°F every 5 minutes.)

SECURING THE MAIN PLANT

After main engine control has been notified of the time the ship is expected to enter port, advance preparations can be made for entering port, securing the main plant, and setting the auxiliary watch. Personnel must be informed and given specific instructions. On most ships, especially on small ships, the MMC in charge of the watch will supervise the preparations for entering port and the oprations that take place. The MMC and MM1 will also be concerned with the administrative procedures involved in bringing a ship into port, securing the main engines, and setting the auxiliary watch.

AUXILIARY MACHINERY

On installations where the turbogenerators exhaust to either the auxiliary or main condensers, the following procedure should be used:

1. Put the required auxiliary condensers in operation, and start the required number of ship's service turbogenerators. After sea detail is set, ensure that all turbogenerators are exhausting into their respective auxiliary condensers.

2. Warmup auxiliary machinery that is to be used in anchoring or mooring the ship.

3. Shift the low-pressure drains to the auxiliary condenser. It is usually not good practice to shift the auxiliary exhaust to the auxiliary condenser until the main plant is at least partially secured. In most installations, the auxiliary exhaust will overload the auxiliary condenser, cause a loss of vacuum, and probably result in loss of one or more ship's service turbogenerators. The auxiliary exhaust should be dumped to the main condensers until the auxiliary condenser is safe from overheating.

SETTING THE AUXILIARY WATCH

Each ship or class of ships will have its own detailed forms for securing procedures. A procedures used for destroyers is described in *Machinist's Mate 3 & 2.*

The officer of the watch must coordinate the securing operations. Although securing sheets are provided for each space, the petty officer in charge of the space must secure in accordance with the

orders of the officer of the watch. No split-plant valves should be opened or closed without specific orders from the officer of the watch. No machinery, especially ship's service turbogenerators, should be started or stopped without orders from the officer of the watch. No watch stander should take for granted that he/she knows what is going on in another space. Usually, only the officer of the watch knows what is going on in all spaces.

When the auxiliary watch is set, the officer of the watch or the MMC in charge of the watch will make a final inspection before reporting to the OOD. The officer of the watch must know the status of all machinery. He/she must be able to report to the engineering officer and the OOD that the auxiliary watch is set, which boiler(s) and ship's service generator(s) are in use; and the time of securing boiler, generators, and engines. The officer of the watch should also inform the OOD that the turning gears are engaged and turning, and approximately when they will be secured. The OOD enters this information in the deck log.

The officer of the watch or MMC in charge of the watch must also know what units of machinery, if any, will require repairs, the extent of the repairs, approximately how long the unit(s) will be out of commission, and the length of time that would be required to get the ship underway. All persons concerned, from the personnel actually doing the work to the commanding officer of the ship should know this information. The commanding officer must know at all times how long it will take to get the ship underway and the maximum speed of which the ship is capable. Transmittal of this information starts with the senior petty officer in each space and goes through the chain of command to the commanding officer.

SUMMARY

The chapter has covered the general operation of the engineering plant. Major areas of discussion were efficient operation of the plant; engineering casualty control; and lighting off, operating, and securing the plant. Proper operation and maintenance of the engineering plant cannot be overemphasized. Unless the engineering plant is kept in top operating condition by a well-trained crew, the ship may not be able to respond adequately to operational requirements.

CHAPTER 11

QUALITY ASSURANCE

INTRODUCTION

As you progress towards MM1 or MMC, your responsibilities become more involved in quality assurance (QA). You will be responsible for ensuring that the work performed by your technicians and by outside help is completed with the highest quality possible. Most of the personnel in the MM rating take pride in the performance of their jobs and they normally strive for excellence.

As the work group or work center supervisor, one of your many responsibilities will be to ensure that all corrective action performed is done correctly and meets prescribed standards. Improper performance of repairs or installations could endanger the lives of personnel or an expensive piece of equipment or cause another piece of equipment to fail prematurely. A well-organized QA and inspection program will minimize the impact of a moment of carelessness or inattention. This chapter will familiarize you with the purpose, basic organization, and mechanics of the QA program.

You may be assigned as a QA representative or collateral duty inspector from time to time. As a work center supervisor, you will be responsible for the quality control (QC) program in your workspaces. It is important that you become quality conscious. To make any program successful, you will have to know and understand the QA program and obtain the cooperation and participation of all your personnel. This requires you to ensure that all tests and repairs conform to their prescribed standards. In addition, you as a supervisor must train all your personnel in QC.

QUALITY ASSURANCE PROGRAM

The 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 impart discipline into the repair of equipment, safety of personnel, and configuration control, thereby enhancing ship's 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 conflicts exist between the QA manual and previously issued letters and transmittals by the appropriate force commanders, the QA manual takes precedence. 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 intermediate maintenance activities (IMAs), they also apply to maintenance done aboard ship by ship's force. In all cases, when 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 general in nature. Each activity must implement a 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 ensure that you comply with technical specifications during all work on ships of both the surface fleet and the 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.

CONCEPTS OF QUALITY ASSURANCE

The ever-increasing technical complexity of present-day surface ships and submarines has spawned the need for special administrative and technical procedures known collectively as the QA program. The QA concept is fundamentally the prevention of debts. This encompasses all events from the start of maintenance operations until their completion. It is the responsibility of all maintenance personnel. Achievement of QA depends on prevention of maintenance problems through your knowledge and special skills. As a supervisor, you must consider QA requirements whenever you plan maintenance. The fundamental rule for you to follow for all maintenance is that TECHNICAL SPECIFICATIONS MUST BE MET AT ALL TIMES.

Prevention is concerned with regulating events rather than being regulated by them. It relies on eliminating maintenance failures before they happen. This extends to safety of personnel, maintenance of equipment, and virtually every aspect of the total maintenance effort.

Knowledge is obtained from factual information, This knowledge is acquired through the proper use of data collection and analysis programs. The maintenance data collection system provides maintenance managers unlimited quantities of factual information. The experienced maintenance manager provides management with a pool of knowledge. Correct use of this knowledge provides the chain of command with the tools necessary to achieve maximum shipboard readiness.

Special skills, normally not possessed by production personnel, are provided by a staff of trained personnel for analyzing data and supervising QA programs.

The QA program provides an efficient method for gathering and maintaining information on the quality characteristics of products and on the source and nature of defects and their impact on current operations. It permits decisions to be based on facts rather than intuition or memory. It provides comparative data that will be useful long after details of particular times or events have been forgotten. QA requires both authority and assumption of responsibility for action.

A properly functioning QA program points out problem areas to maintenance managers so they can take appropriate action to accomplish the following:

- Improve the quality, uniformity, and reliability of the total maintenance effort.
- Improve the work environment, tools, and equipment used in the performance of maintenance.
- Eliminate unnecessary man-hour and dollar expenses.
- Improve the training, work habits, and procedures of maintenance personnel.
- Increase the excellence and value of reports and correspondence originated by the maintenance activity.
- Distribute required technical information more effectively.
- Establish realistic material and equipment requirements in support of the maintenance effort.

To obtain full benefits from a QA program, teamwork must be achieved first. Blend QA functions in with the interest of the total organization and you produce a more effective program. Allow each worker and supervisor to use an optimum degree of judgment in the course of the assigned daily work a person's judgment plays an important part in the quality of the work. QA techniques supply each person with the information on actual quality. This information provides a challenge to the person to improve the quality of the work. The resulting knowledge encourages the best efforts of all your maintenance personnel.

QA is designed to serve both management and production equally. Management is served when QA monitors the complete maintenance effort of the department, furnishes factual feedback of discrepancies and deficiencies, and provides the action necessary to improve the quality, reliability, and safety of maintenance. Production is served by having the benefit of collateral duty inspectors formally trained in inspection procedures; it is also served in receiving technical assistance in resolving production problems. Production personnel are not relieved of their basic responsibility for quality work when you introduce QA to the maintenance function. Instead, you increase their responsibility by adding accountability. This accountability is the essence of QA.

GOALS

The goals of the QA program are to protect personnel from hazardous conditions, increase the time between equipment failure, and ensure proper repair of failed equipment. The goals of the QA program are intended to improve equipment reliability, safety of personnel, and configuration control. Achievement of these goals will ultimately enhance the readiness of ship and shore installations. There is a wide range of ship types and classes in the fleet, and there are equipment differences within ship classes. This complicates maintenance support and increases the need for a formalized program that will provide a high degree of confidence that overhaul, installations, repairs, and material consistently meet conformance standards.

THE QUALITY ASSURANCE LINK TO MAINTENANCE

Accomplishment of repairs and alterations according to technical specifications has been a long-standing requirement for U.S. Navy ships. Ultimate responsibility to ensure that this requirement is met rests with the person performing the maintenance. To do the job properly, a worker must be

- properly trained
- provided with correct tools and parts,
- familiar with the applicable technical manuals and plans, and
- adequately supervised

These elements continue to be the primary means of assuring that maintenance is performed correctly. As a supervisor, you can readily see where you fit in.

Once the need for maintenance is identified you must consider QA requirements concurrently with the planning and performing of that maintenance. Technical specifications will come from a variety of sources. The determination of which sources are applicable to the particular job will be the most difficult part of your planning effort. Once you make that determination, the maintenance objective becomes two-fold

1. Ensure the maintenance effort meets all specifications.
2. Ensure the documentation is complete, accurate, and auditable.

It is vital that you approach maintenance planning from the standpoint of first-time quality.

THE QUALITY ASSURANCE ORGANIZATION

The QA program for naval forces is organized into different levels of responsibility. For example, the QA program for the Naval Surface Force for the Pacific Fleet 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 form ships.

The QA program organization (Navy) begins with the commanders in chief of the fleets, who provide 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 QA 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 pertinent technical requirements.

The CO ensures that all work requests requiring special controls are properly identified and that applicable supporting documentation is provided to the maintenance or repair activity using the applicable QA form.

The CO also ensures that departures from specifications are reported, required audits are conducted, and adequate maintenance is performed for the material condition necessary to support continued unrestricted operations.

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. On most surface ships other than IMAs, the QAO is the chief engineer, with a senior chief petty officer assigned as the QA coordinator. The QAO is responsible for the following:

- Coordinating the ship's QA training program
- Maintaining ship's QA records and inspection reports according to the QA manual
- Maintaining auditable departure from specification records
- Reviewing procedure and controlled work packages prepared by the ship before submission to the engineer
- Conducting QA audits as required by the QA manual and following up on corrective actions to ensure compliance with the QA program
- Maintaining liaison with the lMA office for all work requiring QA czmtrols
- Providing QA guidance to the supply department when required
- Preparing QA/QC reports (as required) by higher authority
- Maintaining liaison with the ship engineer in all matters pertaining to QA to ensure compliance with the QA manual

The **quality control inspectors (QCIs),** 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 QCI will have are as follows:

- Maintain ship records to support the QA program.
- Inspect all work for conformance to specifications.
- Ensure that only calibrated equipment is used in acceptance testing and inspection of work.
- Witness and document all tests.
- Ensure that all materials or test results that fail to meet specifications are recorded and reported.
- Train personnel in QC.
- Initiate departure from specification reports (discussed later) when required.
- Ensure that all inspections beyond the capabilities of the ship's QA inspector are performed and accepted by IMA before final acceptance and installation of the product by the ship.
- Report all deficiencies and discrepancies to the ship's QA coordinator (keeping the division officer informed).
- Develop controlled work packages for all ship repair work requiring QA controls.

More on QCI duties will be discussed later in this chapter, because this will more than likely be the area you will be associated with.

RESPONSIBILITIES FOR QUALITY OF MAINTENANCE

Although the CO is responsible for the inspection and quality of material within a command, he or she depends on the full cooperation of all hands to meet this responsibility. The responsibility for establishing a successful program to attain high standards of quality workmanship cannot be discharged by merely creating a QA division within a maintenance organization. To operate effectively, this division requires the full support of everyone within the organization. It is not the instruments, instructions, and other facilities for making inspections that determine the successor failure in achieving high standards of quality, it is the frame of mind of all personnel.

Quality maintenance is vital to the effective operation of any maintenance organization. To achieve this high quality of work each of your personnel must know not only a set of specification limits, but also the purpose for these limits.

The person with the most direct concern for quality workmanship is you-the production supervisor. This stems from your responsibility for the professional performance of your assigned personnel. You must establish procedures within the work center to ensure that all QA inspection requirements are complied with during all maintenance evolutions. In developing procedures for your work center, keep in mind that inspections normally fall into one of the three following inspection areas:

- RECEIVING OR SCREENING INSPECTIONS. These inspections apply to material, components, parts, equipment, logs, records, and documents. These inspections determine the

condition of material, proper identification, maintenance requirements, disposition, and correctness of accompanying records and documents.

- IN-PROCESSING INSPECTIONS. These inspection are specific QA actions that are required during maintenance or actions in cases where satisfactory task performance cannot be determined after maintenance has been completed. These inspections include witnessing, application of torque, functional testing, adjusting, assembling, servicing, and installation.

- FINAL INSPECTION. These inspections comprise specific QA actions performed following the completion of a task or series of tasks. QA inspection of work areas following task completion by several different personnel is an example of a final inspection.

You have the direct responsibility as production supervisor to assign a collateral duty inspector at the time you assign work. This allows your inspector to make the progressive inspection(s) required; the inspector is not then confronted with a job already completed, functionally tested, and buttoned up. Remember, production personnel to which you have assigned the dual role of inspector cannot inspect or certify their own work.

QUALITY CONTROL INSPECTOR

The QCI is the frontline guardian of adherence to quality standards. In the shops and on the deck plates, the QCIs must constantly remind themselves that they can make a difference in the quality of a product. They must be able to see and be recognized for their contributions in obtaining quality results.

As a work center supervisor, you will be responsible for the QA program in your work spaces. You must realize that QA inspections are essential elements of an effective QA program. You are responsible to your division officer and the QAO for coordinating and administering the QA program within your work center. You are responsible for ensuring that all repaired units are ready for issue. This doesn't mean you have to inspect each item repaired in your shop personally; you should have two reliable, well-trained technicians to assist you in QA inspections. To avoid the many problems caused by poor maintenance repair practices or by the replacement of material with faulty or incorrect material, you must take your position as QCI very seriously. When you inspect a certain step of installation, ensure to the utmost of your knowledge and ability that the performance and product meet specifications and that installations are correct.

Most commands that have a QA program will issue you a special card that will identify you as a qualified QCI for your command. Each of your shop QCIs also will be assigned a personal serial number by the QAO as proof of certification to use on all forms and tags that require initials as proof that certified tests and inspections were completed. This will provide documented proof and traceability that each item or lot of items meets the material and workmanship for that stage of workmanship. Also, you will be given a QCI stamp so that you can stamp the QCI certification on the forms or tags as a checkoff of a particular progressive step of inspection or final job completion. The stamp will also serve as proof of inspection and acceptance of each satisfactory shop end product. This stamp may have your command identification and a QCI number that is assigned and traceable to you.

As QCI, you should be thoroughly familiar with all aspects of the QA program and the QC procedures and requirements of your specialty.

You will be trained and qualified by the QAO according to the requirements set forth by your applicable QA manual and the QC requirements applicable to your installation. The QAO will interview you to determine your general knowledge of records, report completion, and filing requirements.

You will report to the appropriate QA supervisors while keeping your division officer informed of matters pertaining to QA work done in the shop. You and your work center QCIs will be responsible for the following:

- Developing a thorough understanding of the QA program.

- Ensuring that all shop work peformed by your work center personnel meets the minimum requirements set forth in the latest plans, directives, and specifications of higher authority and that controlled work packages (CWPs) are properly used on repair work.

- Ensuring that all work center personnel are familiar with applicable QA manuals by conducting work center/division training.

- Maintaining records and files to support the QA program, following the QA manual.

- Assuring that your work center and, when applicable, division personnel do not use measuring devices, instruments, inspection tools, gauges, or fixtures for production acceptance and testing that do not have current calibration stickers or records attached or available.
- Performing quality control inspections of each product manufactured or repaired by your work center.
- Assisting your division officer and QAO in conducting internal audits as required and taking corrective action on noted discrepancies.

Alternate QCIs are usually assigned as backups to the regular QCIs. Their qualifications and responsibilities will be the same as those of the regularly assigned QCI.

WORK CENTER CONTROLLED MATERIAL PETTY OFFICERS

As a supervisor, you must also ensure that procedures governing controlled material are followed. You can do this by having one or more of your work center personnel trained in the procedures for inspecting, segregating, stowing, and issuing controlled material. When they have completed their training, designate them as controlled material petty officers (CMPOs).

SHOP CRAFTSMAN

As stated earlier, the person doing the work, whether it be manufacturing or repairing, is responsible to you when questions arise about the work being performed, whether the work is incorrect, incomplete, or unclear. Make sure your workers know to stop and seek work instructions or clarification from you when questions or conditions arise which may present an impediment to the successful completion of the task at hand.

A good lesson to teach over and over to all workers is to strive to achieve first-time quality on every task assigned. This not only will instill pride and professionalism in their work, but also will ensure a quality product.

QUALITY ASSURANCE REQUIREMENTS, TRAINING, AND QUALIFICATION

A comprehensive personnel training program is the next step in an effective QA program. For inspectors to make a difference, they must be both trained and certified. They must have formal or informal training in inspection methods, maintenance and repair, and certification of QA requirements. Costly mistakes, made either from a lack of knowledge or improper training, can be entirely eliminated with a good QA training program at all levels of shop or work group organization. Before personnel can assume the responsibility of coordinating, administering, and executing the QA program, they must meet certain requirements. Personnel assigned to the QA division or QC personnel you have assigned in your work center, such as QCIs, CMPOs, or their alternates, should be highly motivated towards the QA program. It is imperative that a qualification and requalification program be established for those personnel participating in the program. Where military standards and NAVSEA technical documents require formal technical training or equivalent, those requirements must be met and personnel qualification vigorously and effectively monitored to ensure that qualifications are updated and maintained. When formal training for a specific skill is not a requirement, the guidelines of the QA manual maybe used as a basis for training to ensure that personnel are provided with the necessary expertise to perform a required skill. Personnel who obtain a QA qualification must undergo periodic QA training and examinations, both oral and written, to maintain the qualification. We will discuss this procedure in the following paragraphs.

QUALITY ASSURANCE OFFICER

The QAO's primary duty, assigned by the CO in writing, is to oversee the QA program. The QAO ensures that personnel assigned to perform QA functions receive continuous training in inspecting, testing, and QC methods specifically applicable to their area of assignment. The QAO also ensures that QCIs receive cross training to perform QA functions not in their assigned area. This training includes local training courses, on-the-job training (OJT), rotation of assignments, personnel qualification standards (PQS), and formal schools.

Whenever possible, the QAO receives formal training according to the QA manual. He or she is responsible to the repair officer for planning and

executing a QA training program for the various qualifications required for QA. The QAO personally interviews each perspective QCI to ensure that the person has a thorough understanding of the QA mission.

REPAIR OFFICER

The repair officer (RO) maintains qualified personnel in all required ratings for the QA program in his or her department. He or she also ensures that personnel assigned to the repair department are indoctrinated and trained in QA practices and requirements.

DIVISION OFFICERS

Division officers ensure that their divisional personnel receive training and are qualified in the QA process and maintain those qualifications. They make sure that all repairs, inspections, and production work requiring a witness are witnessed by division work center QC inspectors and that all test records are completed and signed. Division officers ensure that all test personnel observe all safety precautions pertaining to the specific equipment and wear personal safety equipment at all times while conducting these evolutions. They also make sure that test equipment, if required, is properly calibrated and that adequate overpressure protection is provided during tests in division spaces.

QUALITY ASSURANCE SUPERVISORS

QA supervisors are senior petty officers who have been properly qualified according to the QA manual. They have a thorough understanding of the QA function and are indoctrinated in all aspects of the coordinating, administering, and auditing processes of the QA program. QA supervisors train all QCIs and CMPOs and ensure their recertification upon expiration of qualifications. QA supervisors also administer written examinations to all perspective QCIs and those QCIs who require recertification to ensure a thorough understanding of the QA program.

QUALITY CONTROL INSPECTORS

QCIs are trained by the QA supervisors in applicable matters pertaining to the QA program. An inspector must be equally as skilled as the craftsman whose work he or she is required to inspect. Not only should the inspector know the fabrication or repair operation and what workers are required to do, but also how to go about doing it.

To recognize a product quality characteristic, QCIs must be given certain tools and training. Tools of their trade should include measuring devices and documentation. Their training is both formal (documented course of instruction) and informal (OJT). They must pass a written test given by the QA supervisor, as well as an oral examination given by the QAO. The written exam includes general requirements of the QA program and specific requirements relative to their particular specialty. Successful completion of the shop qualification program course for QCIs will fulfill this requirement. The QA supervisor may also administer a practical examination to perspective QCIs in which they will have to demonstrate knowledge of records and report completion, and filing requirements. This will ensure that the QCIs have a general knowledge of and proper attitude toward the QA program.

CONTROLLED MATERIAL PETTY OFFICERS

CMPOs are normally petty officers, E-4 or E-5, who are thoroughly familiar with controlled material requirements as outlined in the QA manual. They, too, are trained and qualified by a QA supervisor. The QAO will interview them, as he or she did for the QCIs, to see if they have a general knowledge of controlled material requirements.

The QA supervisor will give them a written test to ensure that they have sufficient knowledge of controlled material requirements and procedures to carry out their responsibilities effectively.

OPERATION OF A QUALITY ASSURANCE PROGRAM

Initiating an effective, ongoing QA program is an all-hands effort. It takes the cooperation of all shop personnel to make the program work. As the shop or work group supervisor, you will be responsible for getting the program rolling.

The key elements are a good personnel orientation program, a comprehensive personnel training program, use of the proper repair procedures, and uniform inspection procedures. When you have organized the shop or work center and have placed all these elements in practice, your QA program will be underway. These elements are discussed in the following paragraphs.

PERSONNEL ORIENTATION

The best way to get the support of your personnel is to show them how an effective QA program will benefit them personally. Eliminating or reducing premature failures in repaired units and introducing high-reliability repairs will appreciably reduce their workload, saving them frustration and enhancing the shop or work group reputation. This program, as any new program or change to an existing program, will probably meet with opposition from some shop personnel. By showing your shop personnel to benefits of a QA program, you greatly reduce opposition to the change.

REPAIR PROCEDURES

Repair procedures may be defined as all of the action required to return an equipment to its proper operating condition after a defect has been discovered. Repair procedures include parts handling, disassembly, component removal or replacement, and reassembly. Strictly adhering to the proper repair procedures will almost entirely eliminate premature failures. You, as shop supervisor or work group supervisor, and subordinate work center supervisors are responsible for ensuring that the proper procedures are used in handling all repairable units.

QUALITY ASSURANCE TERMS AND DEFINITIONS

As a supervisor, you need to be able to talk to your personnel about QA and have them be able to carry out your instructions properly and promptly. You need to promote the use of words and phrases pertaining to quality and related programs, thus improving the clarity in your communication with them about QA. To do this, you need to understand the terms frequently used throughout the QA program. Each TYCOM's QA manual and MIL-STD-109 has a complete list of these terms, but the most frequently used terms are listed here:

QUALITY ASSURANCE. Quality assursnce (QA) is a system that ensures that materials, data, supplies, and services conform to technical requirements and that repaired equipment performs satisfactory.

QUALITY CONTROL. Quality control (QC) is a management function that attempts to eliminate defective products, whether they are produced or procured.

ACCEPTANCE. Acceptance is when an authorized representative approves specific services rendered (such as a repair or manufactured part).

CALIBRATION. This is the comparison of two instruments or measuring devices, one of which is a standard of known accuracy traceable to national standards, to detect, correlate, report, or eliminate by adjustment any discrepancy in accuracy of the instrument or measuring device being compared with the standard

INSPECTION. This is the examination and testing of components and services to determine whether they conform to specified requirements.

IN-PROCESS INSPECTION. This type of inspection is performed during the manufacture and repair cycle to prevent production defects. It is also performed to identify production problems or material defects that are not detectable when the job is complete.

INSPECTION RECORD. Inspection records contain data resulting from inspection actions.

SPECIFICATIONS. A specification is any technical or administrative directive, such as an instruction, a technical manual, a drawing, a plan, or publication, that defines repair criteria.

AUDIT. An audit, as it applies to the QA program, is a periodic or special evaluation of details, plans, policies, procedures, products, directives, and records necessary to determine compliance with existing requirements.

CERTIFIED (LEVEL 1) MATERIAL. This is material that has been certified (as to its material and physical properties as well as traceability to the manufacturer) by a qualified certification activity. This material has a material and identification control (MIC) number assigned along with a certification document.

CONTROLLED MATERIAL. This is any material that must be accounted for and identified throughout the manufacting or repair process. (See level of essentiality.)

CONTROLLED WORK PACKAGE. A controlled work package (CWP) is an assemblage of documents identified by a unique serial number that may contain detailed work procedures, purchase documents, receipt inspection reports, objective quality evidence, local test results, and any tags, papers, prints, plans, and so on that bear on the work performed This will be discussed later in the chapter.

DEPARTURE FROM SPECIFICATION. This is a lack of compliance with any authoritative document, plan, procedure, or instruction. A detailed discussion will follow later in the chapter.

DOCUMENTATION. This is the record of objective evidence establishing the requisite quality of the material, component or work done.

LEVEL OF ESSENTIALITY. A level of essentiality is a certain level of confidence required in the reliability of repairs made. The different levels of essentiality will be discussed later in the chapter.

PROCEDURE. A procedure is a written instruction designed for use in production and repair, delineating all essential elements and guidance necessary to produce acceptable and reliable products.

PROCESS. This is a set of actions written in a special sequential order by which a repair or maintenance action, a test, or an inspection is done using specific guidelines, tools, and equipment.

RELIABILITY. Reliability means the probability that an item will perform its intended function for a specified interval understated conditions.

SUBSAFE. The acronym SUBSAFE is a short reference to the Submarine Safety Program, which provides a high level of confidence in the material conditions of the hull integrity boundary. SUBSAFE will be discussed later in this chapter.

THE CONTROLLED WORK PACKAGE

To provide additional assurance that a quality product will result from the in-process fabrication or repair, the CWP was developed. It provides QC techniques (requirements or procedures) and shows objective quality evidence (documentation) of adherence to specified quality standards. These requirements or procedures include both external (TYCOM) and internal (command-generated) information fix work package processing and sign-off. The typical CWP that will arrive at your desk will have QA forms, departure from specifications forms, material deficiency forms, production task control forms, and QC personnel sign-off requirements. You, and all the other work centers involved in the performance of the task, must review the contents of each package as well. When you review the package, check that the requirements specified for their accomplishment are correct, in a correct sequence, and so on. Each CWP covers the entire scope of the work process and is able to stand on its own. Traceability from the work package to other certification documentation is provided by the job control number (JCN).

You must ensure that the CWP is at the job site during the performance of the task. If the work procedure requires the simultaneous performance of procedure steps and these steps are done in different locations, use the locally developed practices to ensure you maintain positive control for each step.

Immediately after a job is completed, but before the ship gets underway, each assigned work center and the QAO will review the work package documentation for completeness and correctness. If you and your workers have been doing the assigned steps as stated this should not be a problem. Ensure that all the verification signature blocks are signed. Make sure all references, such as technical manuals or drawings, are returned to the appropriate place.

ENCLOSURES

You will find a lot of documentation inside the CWP when it arrives at your desk. Inside will reprocess instructions, plans, technical drawings, and instructions pertinent to the production job at hand. Documents listed as references are not intended to be included in the CWP, but they must be available when required. You will also find a copy of applicable portions of references included in the CWP. In addition to 4790/2R, Automated Work Request, is included within the CWP to provide for complete documentation and references back to the originating tended unit. You will use all of the documentation to perform the maintenance action, production task, or process assigned to your work center.

REVISIONS

You can make minor corrections to the work procedure (as directed by local instructions) as long as they do not change the scope of the work being performed However, you must initiate a revision when it becomes necessary to change the original scope of the job, such as a part not originally intended to be worked on. The revision cover sheet gives exact instructions on adding, deleting, or changing steps in the work sequence.

ADDENDUM

Depending on the complexity of the task, it may be desirable to have two or more work centers working

portions of the task concurrently. Planning and estimating (P & E) will initiate an addendum to the original CWP. The addendum will include all the headings of the CWP-references material list, safety requirements, work sequence, and so forth. When you complete the work steps, include the addendum with the CWP.

LEVELS OF ESSENTIALITY, ASSURANCE, AND CONTROL

To provide your customers both repair quality and QA, you as a supervisor of a work center or a work group in an IMA and your maintenance personnel must understand and appreciate your customers and their operational environment. This will require that you and your personnel give serious thought and consideration to how a system's nonperformance may endanger personnel safety and threaten the ship's mission capability. For example, you are not going to be aboard the submarine as it does its deep dive to test hull integrity (and your hull packing work). You must stress to your workers how system essentiality, in an operational environment, equates with mission capability and personnel safety. In other words, workers must understand how the work they perform in a maintenance or repair environment can seriously affect the operational capabilities of the tended unit as well as the safety of the personnel aboard the unit. This is where the assigned levels of essentiality, assurance, and control come into play. What do we mean by these terms? We will discuss each in the following paragraphs.

LEVELS OF ESSENTIALITY

A number of early failures in certain submarine and surface ship systems were due to the use of the wrong material. This led to a system for prevention involving levels of essentiality. A level of essentiality is simply 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 tests 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 or indispensable in the performance of the ship's mission. Levels of essentiality also indicate the impact that catastrophic failure of the associated part or equipment would have on ship's mission capability and personnel safety.

LEVELS OF ASSURANCE

QA is divided into two levels: A and C. Each level reflects certain quality verification requirements of individual fabrication in processor repair items. Here, verification refire to the total of quality of controls, tests, and/or inspections. The levels of assurance areas follows:

Level A:	Provides for the most stringent or restrictive verification techniques. This normally will require both QC and test or inspection methods.
Level C:	Provides for minimum or "as necessary" verification techniques. This normally will require very little QC or tests and inspections.

LEVELS OF CONTROL

QC may also be assigned generally to one of the two levels–A or C. Levels of control are the degrees of control measures required to assure reliability of repairs made to a system, subsystem, or component. Furthermore, levels of control (QC techniques) are the means by which we achieve levels of assurance.

An additional category that you will see is level I. This is reserved for systems that require maximum confidence that the composition of installed material is correct.

CONTROLLED MATERIAL

Some material, as part of a product destined for fleet use, has to be systematically controlled from procurement, receipt, stowage, issue, fabrication repair, and installation to ensure both quality and material traceability. Controlled material is any material you use that must be accounted for (controlled) and identified throughout the manufacturing and repair process, including installation, to meet the specifications required of the end product. Controlled material must be inspected by your CMPO for required attributes before you can use it in a system or component and must have inspection documentation maintained on record. You must retain traceability through the repair and installation process. These records of traceability must be maintained for 7 years (3 years aboard ship and 4

years in record storage). Controlled material requires special marking and tagging for identification and separate storage to preclude. loss of control. The RO may designate as controlled material any material that requites material traceability.

Under this definition, controlled material has two meanings. The first meaning applies to items considered critical enough to warrant the label of controlled material. Your CMPOs will be responsible for inspecting the material when it is received, stowing it separately from other material, providing custody, and seeing that controlled assembly procedures are used during its installation.

The term *controlled material* is used in reference to material either labeled SUBSAFE or classed in one of three levels of essentiality. (Strictly speaking, SUBSAFE is not a level of essentiality.)

SUBSAFE

To help you understand SUBSAFE, we will discuss a little of the background of the program. The Submarine Safety Program (hence the name SUBSAFE) was established in 1963 as a direct result of the loss of USS *Thresher.* The program is two-fold, consisting of both material and operability requirements. It provides a high level of confidence in the material condition of the hull integrity boundary and in the ability of a submarine to recover from control surface casualties and flooding.

SUBSAFE requirements are split into five categories, which are devoted to

- piping systems,
- flooding control and recovery,
- documentation,
- pressure hull boundary, and
- government-furnished material.

There are three SUBSAFE definitions you need to consider: SUBSAFE system, SUBSAFE boundary, and SUBSAFE material.

SUBSAFE System

A SUBSAFE system is any submarine system determined by NAVSEA to require the special material or operability requirements of the SUBSAFE program. How does it concern you? After you have installed and maintained a system, it must prevent flooding of the submarine, enhance recovery in the event of flooding, and ensure reliable ship control.

SUBSAFE Boundary

A SUBSAFE boundary marks the specific portion of a SUBSAFE system within which the stringent material or operability requirements of SUBSAFE apply.

SUBSAFE Material

Within the SUBSAFE boundary, two different sets of requirements apply-SUBSAFE and level I. What is the difference between the two? The difference is expressed by two words, *certification* and *verification.* Material certification pertains to the SUBSAFE program. his means that an item certified as SUBSAFE meets a certain testing or fabrication requirement and can be used as intended in a critical hull integrity or pressure-containing role. On the other hand, material verification pertains to the level I program. An item specified as level I has had its material composition tested and verified. This testing and verification ensures traceability from the material back to a lot or batch to ensure that material composition complies with procurement specifications. This traceability from material back to lot or batch is done through the assigned controlled material number, either a locally assigned number or one assigned by the vendor.

DEPARTURE FROM SPECIFICATIONS

Specifications are engineering requirements, such as type of material, dimensional clearances, and physical arrangements, by which ship components are installed, tested, and maintained. All ships, surface and submarine, are designed and constructed to specific technical and physical requirements. As a supervisor, you must ensure your personnel make every effort to maintain all ship systems and components according to their required specifications. There are, on occasion, situations in which specifications cannot be met. In such cases, the system or component is controlled with a deviation from specification. To maintain a precise control of any ship's technical configuration, any deviation you make must be recorded and approved as a departure from specification.

DEFINING A DEPARTURE FROM SPECIFICATION

Plainly put, a departure from specification is a lack of compliance with an authoritative document, plan,

procedure,orinstrucdon. As a minimum, departures are required when the following situations occur:

- There is a lack of compliance with cognizant technical documents, drawings, or work procedures during a maintenance action that will not be corrected before the ship gets underway.
- There is a lack of compliance with specifications for "as found" conditions during a maintenance action for which no prior action is held (such as a shipyard waiver) that will not be connected before the ship gets underway.
- There is a lack of compliance with a specification discovered and no corrective action is planned.
- A departure from specifications not required for nonconforming conditions discovered and not caused by maintenance or a maintenance attempt. Specifically, for items that routinely fail and for which corrective action is planned, only a CSMP entry is made.

SUPERVISOR'S REPORTING PROCEDURES

You and your workers who perform maintenance have an obligation to perform every repair according to specifications. When a departure is discovered, it is the responsibility of the person(s) finding it to report it.

There are several causes for workers failing to report departures from specifications. You must stress to all of your workers that any deviation from specifications must be recorded, reviewed, and approved by the proper authority. This is sometimes caused by the lack of adequate inspection, QC, and management of the process for determining compliance with specifications. Sometimes workers simply do not understand the specification requirements. Another cause is a lack of training in the skills necessary to meet specif cations. The lack of time for adequate planning and parts procurement, thereby requiring an emergency temporary repair instead of a permanent repair, is another cause for workers failing to comply with specifications. From this discussion, you can see the role you as a supervisor play during this all-important process.

DEPARTURES FROM SPECIFICATION TYPES AND CLASSIFICATION

There are two types of departures that affect you and the reporting procedure—major and minor. We will briefly discuss each of them in the following paragraphs.

Major Departure from Specifications

A major departure from specifications is any departure from specifications that affects the reliability of the ship's control systems, watertight integrity, or personnel safety. Major departures from specifications require approval from higher authority. If you have a departure from specifications that falls into any of the following categories, consider it a major departure:

- Any departure that directly involves the safety of the ship or personnel
- Any departure that reduces the integrity or operability of equipment essential to the ship's mission (for example, installation of parts that do not meet all applicable material certification requirements)
- Failure to complete any required retest of a component or subsystem that, if defective, could cause flooding
- Any nonconformance to plan specifications resulting in a change of configuration considered to be a permanent repair
- Failure to meet all applicable standards for major repairs unless other alternatives are authorized by the QA manual (in other words, failed strength test)

Minor Departure from Specifications

This includes all departures that are not determined to be major. Minor departures may be permanent or temporary and are approved by the TYCOM.

PERMANENT CLASSIFICATION.—Departures are classified as permanent where the nonconformance does not present a risk of failure. Permanent departures are approved by the TYCOM with NAVSEA concurrence.

TEMPORARY CLASSIFICATION.—Departures classified as temporary are departures where nonconformance does present an unreasonable risk and the TYCOM is willing to accept that risk for some period of time. Temporary departures are normally approved by TYCOM with technical community concurrence.

REPORTING PROCEDURES

Who reports a departure from specification? Do you as the supervisor? Only if you are the one finding or causing the departure. As stated in the QA manual, the person discovering or causing the departure must initiate the departure from specification. However, does this mean that each time we cause a departure we immediately start the paper work? No! The originator must ensure that the departure is identified during fabrication testing, or inspection of the completed work He or she must make every effort to correct each deficiency before initiating the departure request. Work must not continue until the deficiency is corrected or the departure request is approved.

Now that we have identified a departure, what do we do with it? We go back to the originator. He or she must ensure that QA Form 12 (fig. 11-1) is properly filled out and forwarded via the chain of command to the QAO.

The originator must also retain a copy of the prepared departure request until he or she receives the returned copy from the QAO indicating that all actions concerning the departure have been completed (approved or disapproved).

Make sure that the originator has an approved copy of the departure request accompanying the completed work and that the original copy is retained in the CWP.

QUALITY ASSURANCE FORMS AND RECORDS

The following are the titles and descriptions of the forms and records you will use the most. A rule to remember when using these forms is that ail QA forms must be completed and signed in the proper sequence.

QA FORM 1, CONTROLLED MATERIAL RECEIPT INSPECTION REPORT

This record (fig. 11-2) is used by the CMPO to document the proper receipt and inspection of items that have been designated as controlled materials.

QA FORM 2, CONTROLLED MATERIAL IN-PROCESS CONTROL TAG

This tag (fig. 11-3) is attached by supply, QA, or shop personnel to provide traceability of accepted controlled material from receipt inspection through final acceptance.

QA FORM 3, CONTROLLED MATERIAL REJECT TAG

Shop personnel, supply, or QA personnel will attach this tag (fig. 11-4) to rejected items. The individual finding or causing the unacceptable condition attaches the tag to the rejected item. The tag indicates that material is unacceptable for production work and must be replaced or reinspected before use.

QA FORM 4, CONTROLLED MATERIAL SHIP-TO-SHOP TAG

This tag (fig. 11-5) is used to identify and control material to be repaired. You attach the tag to the item to be repaired. It is a good idea to stamp the three sections of the tag with a control number and log it in your shop log.

QA FORM 4A, SHIP-TO-SHOP TAG (GENERAL USE)

This tag is used to identify and control material and equipment in a positive manner from ship to repair shop. This tag does not require a material control number. Instead it uses an equipment serial number, a job sequence number, and, if possible, a Navy standard stock number for maintaining positive control.

QA FORM 7, CONTROLLED MATERIAL INVENTORY/RECORD

This form (fig. 11-6) is used by your CMPO to provide a standard inventory record of controlled material received and issued

QA FORM 8, PRODUCTION TASK APPROVAL AND ROUTING (SF USE ONLY)

This form (fig. 11-7) is used to identify and list the scope and purpose of the task. It also lists the contents of the work procedure and documents the approval authority for the start and completion of the task.

QA FORM 8A, PRODUCTION TASK CONTROL FORM

This form (fig. 11-8) is used to allow detailed development of a step-by-step work procedure.

QA FORM 10, RE-ENTRY CONTROL LOG

The re-entry control log (fig. 11-9) is used to provide a chronological record of re-entry into SUBSAFE boundaries. Each time a QA Form 9 is used, the IMA, QAO, or ship's engineer must log the time issued and serial number assigned on QA Form 10.

DEPARTURE FROM SPECIFICATION REPORT
SURFLANT 9090/12

FROM: _____ DEPARTURE SERIAL NO. _____
(ORIGINATOR) DATE _____

TO: REPAIR OFFICER/ENGINEER OFFICER

VIA: QUALITY ASSURANCE OFFICER/COORDINATOR

UIC W/C JSN

SHIP & HULL NO. _____

1. TYPE DEPARTURE _____ CATEGORY _____ LEVEL CONTROL _____
2. SYSTEM/COMPONENT _____
3. LOCATION _____
4. NAVSHIPS DRAWING/PLAN NO./PIECE NO. _____
5. TAB/SIB/REFERENCE _____
6. APPLICABLE SPECIFICATIONS _____
7. SITUATION/DEGREE OF NON-COMPLIANCE _____
8. COMMENTS/RECOMMENDATIONS (TESTS CONDUCTED) _____
9. ANSWER REQUESTED BY _____ _____
10. PASS TO CO _____ SQD _____ TYCOM _____ QA OFFICER/COORDINATOR
11. DEPARTURE REQUEST MSG DTG _____ _____
12. COMNAVSURFLANT DEPARTURE ANSWER/MSG DTG _____ REPAIR OFFICER/ENGINEER OFFICER
13. FINAL DISPOSITION: CLEARED _____ CANCELLED _____ OTHER _____ MSG DTG _____
14. REMARKS _____

Figure 11-1.—QA Form 12, Departure from Specification Report.

CONTROLLED MATERIAL
RECEIPT INSPECTION REPORT
SURFLANT 9090/1

1. NOMENCLATURE	2. LEVEL / MIL-SPEC	3. MIC OR I.D. NUMBER
4. REQ. NUMBER	5. JULIAN DATE	6. NUMBER RECEIVED
7. NSN	8. VENDOR'S MARK	
9. ACCEPTABLE DOCUMENTATION FURNISHED ☐ YES ☐ NO	SIGNATURE	DATE

10. INSPECTION REQUIRED X - RECORDS REQUIRED 0 - RECORDS NOT REQUIRED

☐ MT ☐ PT ☐ RT ☐ UT ☐ VIS ☐ CHEM ☐ PHYS ☐ SPOT CHECK ☐ DIMEN ☐ HARD NESS

11. INSPECTION RESULTS / REMARKS AND SIGNATURE

12. DISPOSITION ☐ ACCEPT ☐ REJECT		13. ☐ UPGRADE ☐ MIL-SPEC	☐ LI
14. DOWNGRADE ☐ MIL-SPEC ☐ GENERAL STOCK	REJECT TO ☐ SOURCE	15. SIGNATURE	15A. DATE

Figure 11-2.–QA Form 1, Controlled Material Receipt Inspection Report.

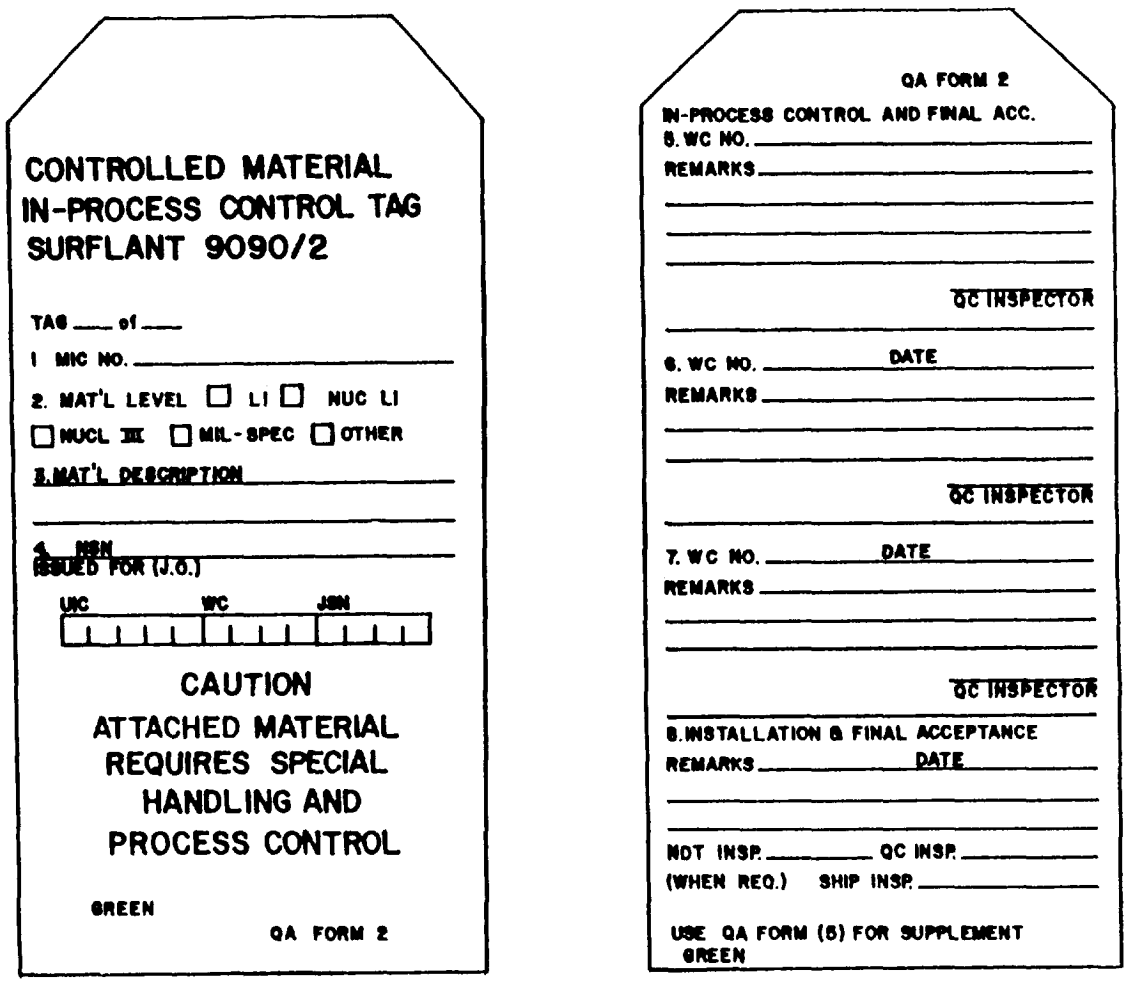


Figure 11-3.-QA Form 2, Controlled Material In-Process Control Tag.

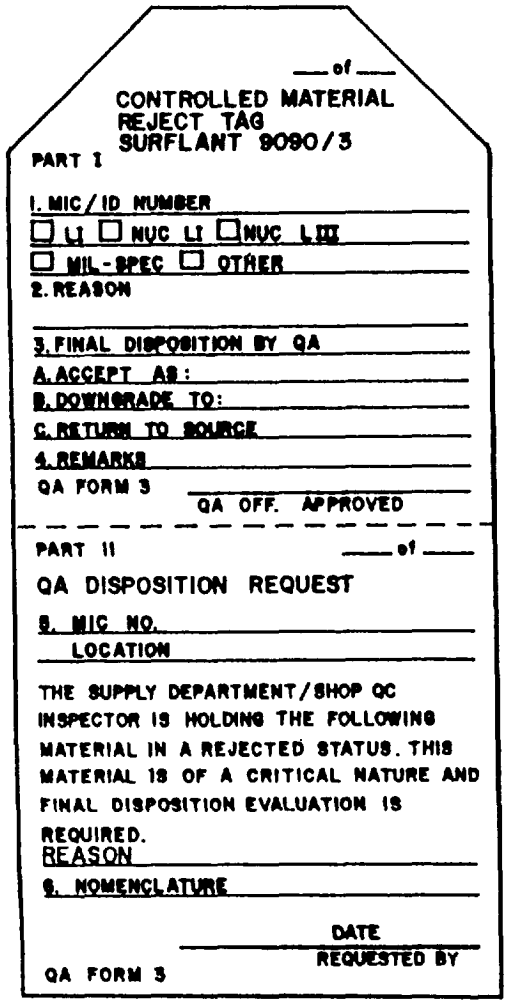


Figure 11-4.–QA Form 3, Controlled Material Reject Tag.

QA FORM 13, QUALITY ASSURANCE PLANNING INFORMATION SHEET

This form (fig. 11- 10) provides the IMA with the necessary information to develop a CWP before the start of work. When filled out, this sheet will be attached to the 4790/2K and delivered to the IMA. For CSMP entries, this form is delivered to the IMA at the pre-arrival conference.

QA FORM 15, REQUEST FOR RELEASE OF REJECTED MATERIAL OR WORKMANSHIP

Should there be an urgent and overriding requirement for the use of material or workmanship, the division office production officer may request that the repair officer and squadron material officer release rejected material or workmanship. For example, a shaft has been machined undersize, but it is determined that this condition will have little or no effect on the equipment operation. If the release is authorized the reject tag and

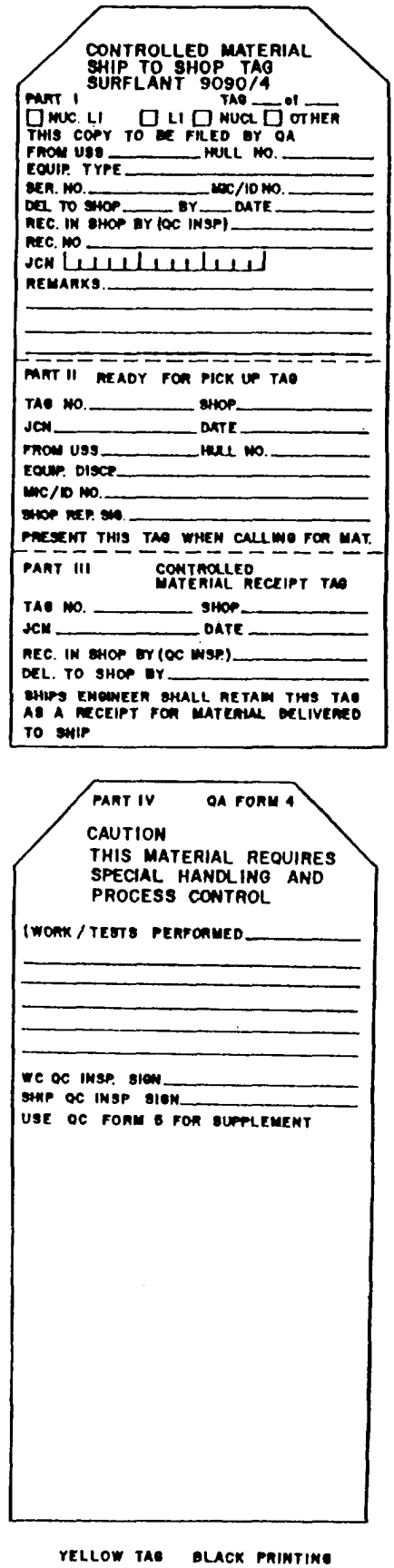
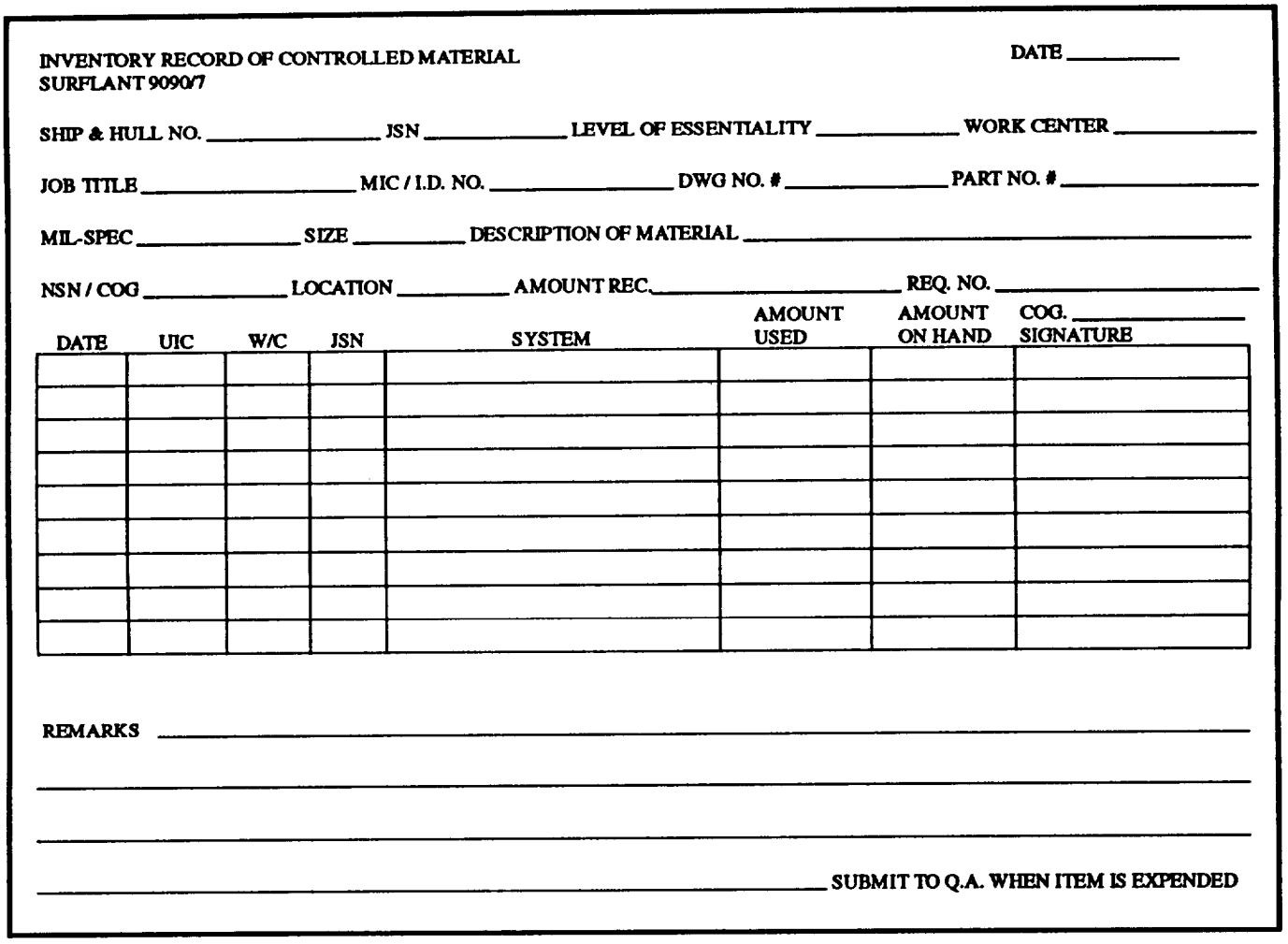


Figure 11-5.-QA Form 4, Controlled Material Ship-to-Shop Tag.



INVENTORY RECORD OF CONTROLLED MATERIAL
SURFLANT 9090/7

DATE _____

SHIP & HULL NO. _____ JSN _____ LEVEL OF ESSENTIALITY _____ WORK CENTER _____

JOB TITLE _____ MIC / I.D. NO. _____ DWG NO. # _____ PART NO. # _____

MIL-SPEC _____ SIZE _____ DESCRIPTION OF MATERIAL _____

NSN / COG _____ LOCATION _____ AMOUNT REC. _____ REQ. NO. _____

COG. _____

DATE	UIC	W/C	JSN	SYSTEM	AMOUNT USED	AMOUNT ON HAND	SIGNATURE

REMARKS _____

_____

_____

_____ SUBMIT TO Q.A. WHEN ITEM IS EXPENDED

Figure 11-6.-QA Form 7, Controlled Material Inventory/Record.

the Material Deficiency Report (QA Form 16) must be filed in the QA office files, along with the completely filled out QA form 15. Then the released material may be used but one of the following three actions must be completed before the certification files are completed

- Material released for use and action complete
- Material released for use but must be re-worked at a later date
- Material released for use but must be replaced at a later date

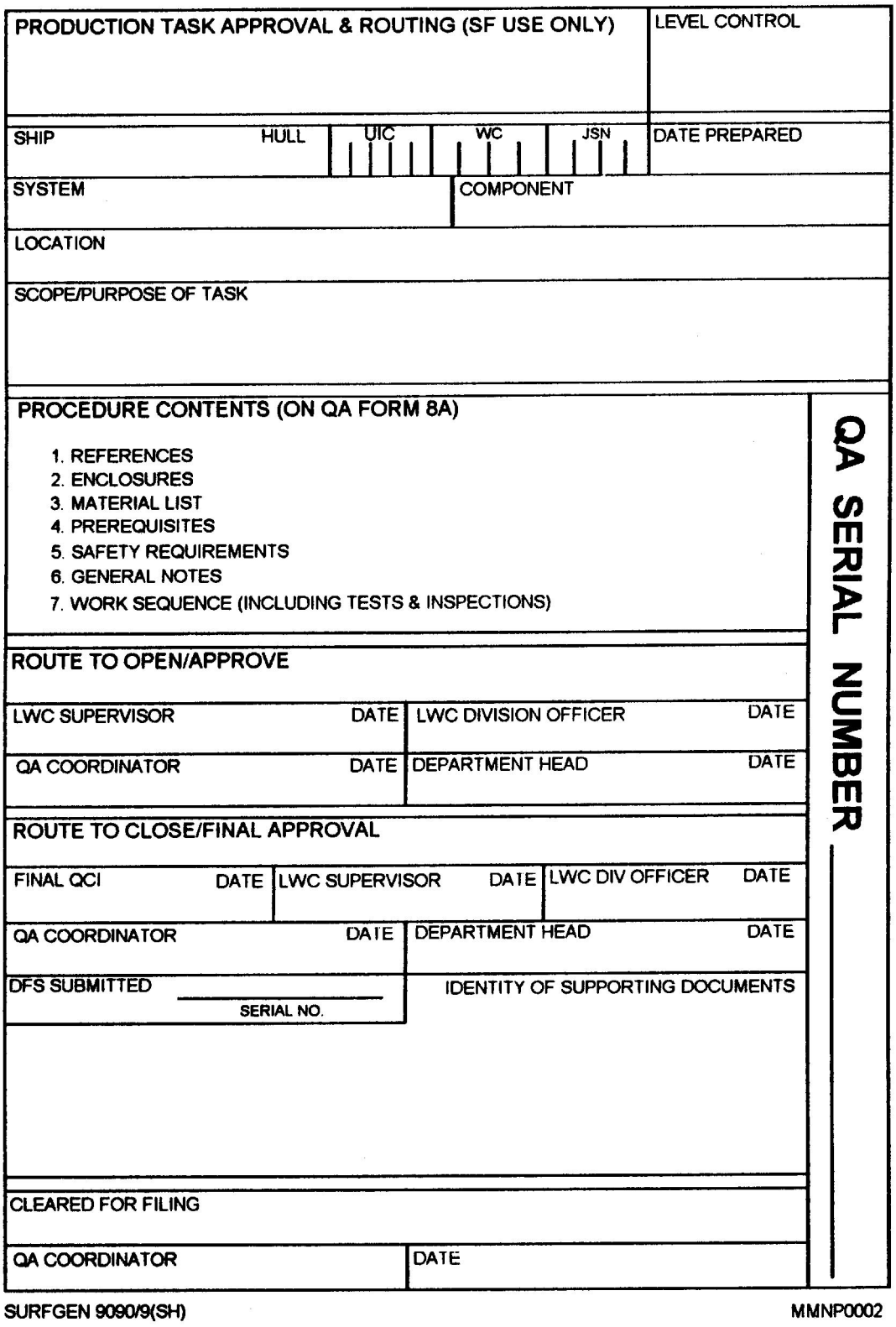
The use of QA Form 15 (fig. 11-11) requires the initiation of QA Form 12, Departure from Specifications Request.

QA FORM 16, MATERIAL DEFICIENCY REPORT

This form (fig. 11-12) is used to provide a uniform method of reporting and recommending disposition of rejected material to the supply department. It is used where required to supplement QA Form 3 and instead of QA Form 15. The report contains a descriptive statement of material for a job order within the scope of this program and includes necessary sketches, photographs, samples, and blueprints. This report recommends a course of action.

QA FORM 17, MISCELLANEOUS INSPECTION REPORT—OTHER THAN NDT OR HYDRO

This form (fig. 11-13) lists all the tests and inspections that must be peformed at each step. A QA Form 17 must be completed and signed off before any step can be signed off on the QA Form 10.



PRODUCTION TASK APPROVAL & ROUTING (SF USE ONLY)

LEVEL CONTROL

SHIP HULL UIC WC JSN DATE PREPARED

SYSTEM COMPONENT

LOCATION

SCOPE/PURPOSE OF TASK

PROCEDURE CONTENTS (ON QA FORM 8A)

1. REFERENCES
2. ENCLOSURES
3. MATERIAL LIST
4. PREREQUISITES
5. SAFETY REQUIREMENTS
6. GENERAL NOTES
7. WORK SEQUENCE (INCLUDING TESTS & INSPECTIONS)

QA SERIAL NUMBER

ROUTE TO OPEN/APPROVE

LWC SUPERVISOR DATE | LWC DIVISION OFFICER DATE

QA COORDINATOR DATE | DEPARTMENT HEAD DATE

ROUTE TO CLOSE/FINAL APPROVAL

FINAL QCI DATE | LWC SUPERVISOR DATE | LWC DIV OFFICER DATE

QA COORDINATOR DATE | DEPARTMENT HEAD DATE

DFS SUBMITTED _____ SERIAL NO. | IDENTITY OF SUPPORTING DOCUMENTS

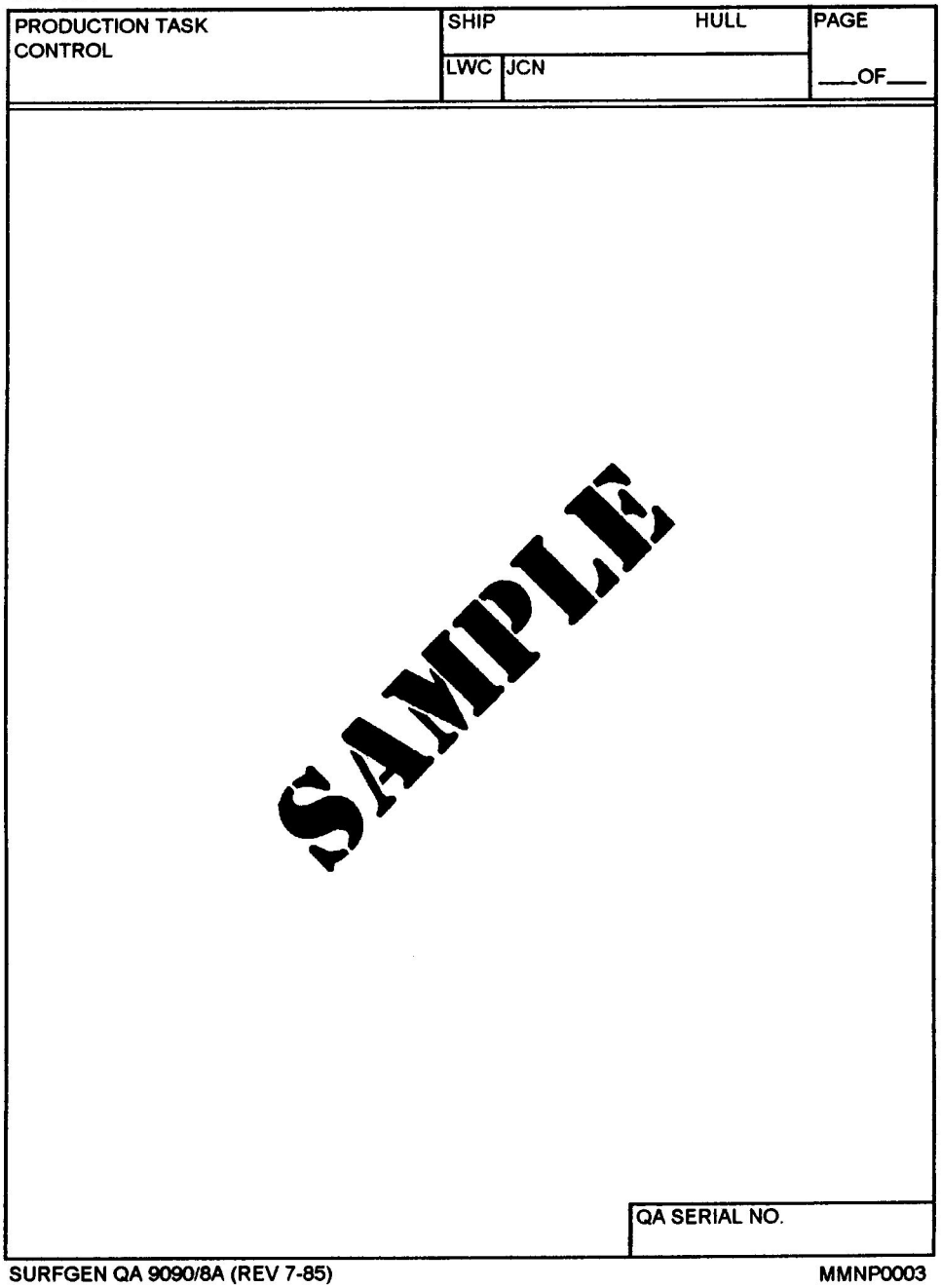
CLEARED FOR FILING

QA COORDINATOR | DATE

SURFGEN 9090/9(SH) MMNP0002

Figure 11-7.—QA Form 8, Production Task Approval and Routing (SF USE ONLY).

COMNAVSURFLANTINST 9090.1A/COMNAVSURFPACINST 4855.22



SURFGEN QA 9090/8A (REV 7-85) MMNP0003

S/N 0116-LF-890-9051

Figure 11-8.—QA Form 8A, Production Task Form.

RE-ENTRY CONTROL LOG
SURFLANT 9090/10

PAGE NO. _____

REC. NO.	REV	ASSOCIATED REC'S	SYSTEM RE-ENTERED	PRIME RESPONSIBILITY GROUP	DATE OF			REMARKS
					ISSUE	START	COMPLETION	

Figure 11-9.—QA Form, Re-entry Control Log.

COMNAVSURFLANTINST 9090 1A/COMNAVSURFPACINST 4855.22

QUALITY ASSURANCE
PLANNING INFORMATION SHEET

SHIP	JCN	DATE
SYSTEM	COMPONENT	
JOB DESCRIPTION		

TECHNICAL DATA

PIPING	OPERATING PRESSURE	OPERATING TEMP	SIZE
DRAWING NO.	ON BD ☐	MATERIAL	
ISOLATION REQUIREMENTS			

MECHANICAL	TYPE EQUIPMENT		
DRAWING NO.	ON BD ☐	TECH M...	ON BD ☐
APL NO.		...CTURER	
SYSTEM OPERATING PRESSURE	OPERATING TE...	SIZE	SYSTEM FLUID

ELECTRIC MOTOR	APL NO.	TECH MANUAL NO.	ON BD ☐
MANUFACTURER	I.D. NO.	MFR DRAWING NO.	ON BD ☐

FRAME	HORSEPOWER	SPEE...	...OLTAGE	FREQ.	PHASE	AMPS	DUTY

HULL (WELDING)	TYPE STRUCTURE		
COMP. NO.	FITTING NO. OR FRAME	EXACT LOCATION	
DRAWING NO.	ON BD ☐	MATERIAL	

REMARKS

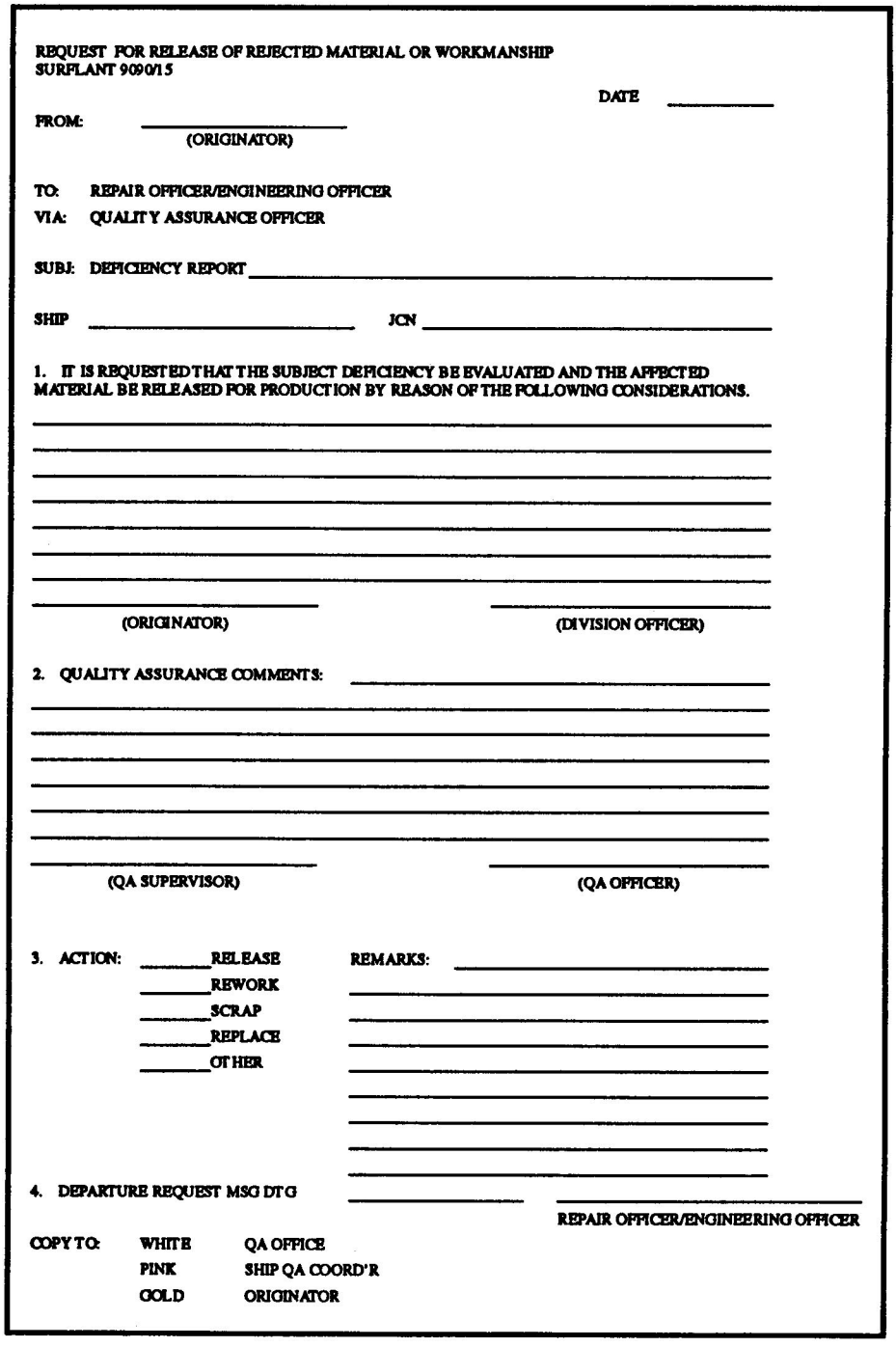
PREPARED BY.	APPROVED BY (DIVISION OFFICER OR HIGHER)

SURFGEN QA 9090/13 (REV 11-85)
S/N 011-LF

MMNP0001

SAMPLE

Figure 11-10.—QA Form 13, Quality Assurance Planning Information Sheet.



REQUEST FOR RELEASE OF REJECTED MATERIAL OR WORKMANSHIP
SURFLANT 9090/15

DATE _____

FROM: _____
(ORIGINATOR)

TO: REPAIR OFFICER/ENGINEERING OFFICER
VIA: QUALITY ASSURANCE OFFICER

SUBJ: DEFICIENCY REPORT _____

SHIP _____ JCN _____

1. IT IS REQUESTED THAT THE SUBJECT DEFICIENCY BE EVALUATED AND THE AFFECTED MATERIAL BE RELEASED FOR PRODUCTION BY REASON OF THE FOLLOWING CONSIDERATIONS.

_____
_____
_____
_____
_____
_____
_____
_____

(ORIGINATOR) (DIVISION OFFICER)

2. QUALITY ASSURANCE COMMENTS: _____
_____
_____
_____
_____
_____
_____
_____

(QA SUPERVISOR) (QA OFFICER)

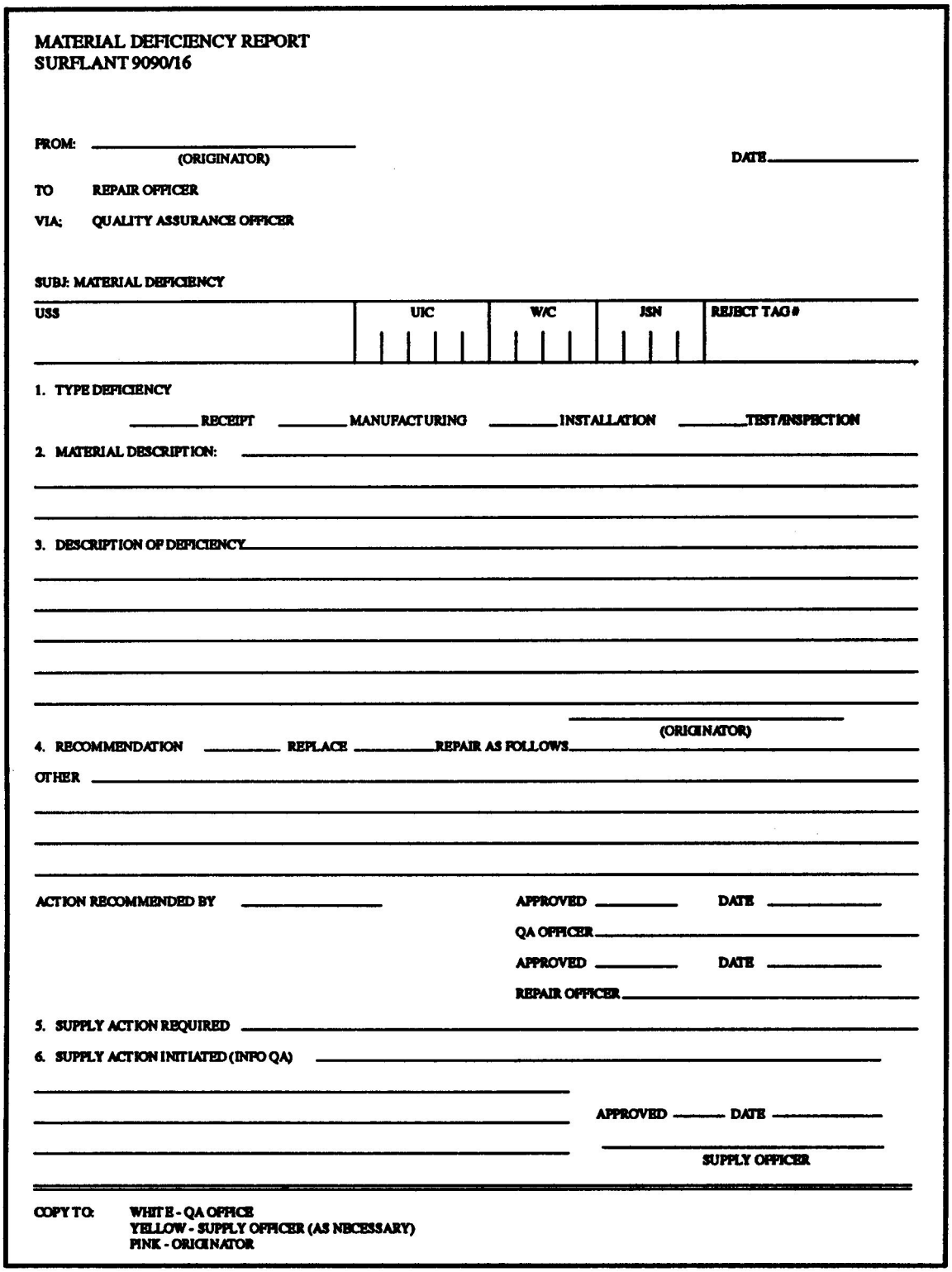
3. ACTION: _____RELEASE
_____REWORK
_____SCRAP
_____REPLACE
_____OTHER

REMARKS: _____
_____
_____
_____
_____
_____
_____
_____
_____

4. DEPARTURE REQUEST MSG DTG _____ _____
REPAIR OFFICER/ENGINEERING OFFICER

COPY TO: WHITE QA OFFICE
PINK SHIP QA COORD'R
GOLD ORIGINATOR

Figure 11-11.—QA Form 15, Request for Release of Rejected Material or Workmanship.



MATERIAL DEFICIENCY REPORT
SURFLANT 9090/16

FROM: _____ DATE _____
(ORIGINATOR)

TO REPAIR OFFICER

VIA; QUALITY ASSURANCE OFFICER

SUBJ: MATERIAL DEFICIENCY

USS	UIC	W/C	JSN	REJECT TAG #

1. TYPE DEFICIENCY

_____ RECEIPT _____ MANUFACTURING _____ INSTALLATION _____ TEST/INSPECTION

2. MATERIAL DESCRIPTION: _____

3. DESCRIPTION OF DEFICIENCY _____

_____
(ORIGINATOR)

4. RECOMMENDATION _____ REPLACE _____ REPAIR AS FOLLOWS _____

OTHER _____

ACTION RECOMMENDED BY _____ APPROVED _____ DATE _____

QA OFFICER _____

APPROVED _____ DATE _____

REPAIR OFFICER _____

5. SUPPLY ACTION REQUIRED _____

6. SUPPLY ACTION INITIATED (INFO QA) _____

APPROVED _____ DATE _____

_____
SUPPLY OFFICER

COPY TO: WHITE - QA OFFICE
YELLOW - SUPPLY OFFICER (AS NECESSARY)
PINK - ORIGINATOR

Figure 11-12.—QA Form 16, Material Deficiency Report.

COMNAVSURFLANTINST 9090.1A/COMNSVSURFPACINST 4855.22

MISCELLANEOUS INSPECTION REPORT
OTHER THAN NDT OR HYDRO

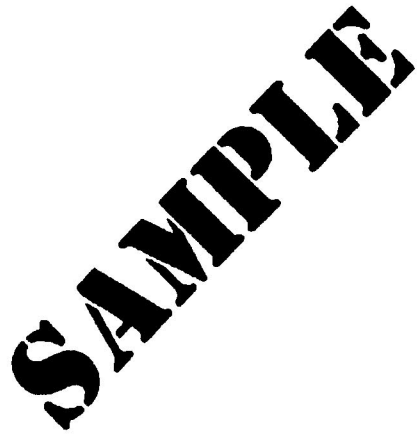
QA LOG NO.	JCN	WORK CENTER	DATE

SHIP	SYSTEM	COMPONENT

JOB DESCRIPTION

TYPE OF INSPECTION	DWG NO.

SKETCH



REMARKS

FINAL DISPOSITION ACC./REJ.	WORK CENTER QCI	DATE

SURFGEN QA 9090/17 (REV 7-85)
S/N 0116-LF-990-9128

MMNP0004

Figure 11-13.—QA Form 17, Miscellaneous Inspection Report—Other than NDT or HYDRO.

CHAPTER 12

RECORD SYSTEMS

Accurate, legible, and up-to-date engineering records plus timely, accurate, and legible reports reflect efficient administration. Records maintained by the engineering department and reports submitted to the engineering officer provide the data for engineering reports to higher authority. The engineer officer uses reliable records and reports to keep up with the state of material and performance in the department.

There is no simple way to assure the accuracy of records and reports. The first step is to establish the responsibility for keeping the records and preparing the reports within the department. The next step is to assign the duty of checking and verifying the data contained in the reports. The engineering department and division organization manuals provide excellent means of fixing departmental record-keeping responsibilities. The department training program should train personnel to obtain data and maintain records.

Some engineering records are mandatory (required by law) while others are necessary for efficient operation of the engineering plant. This chapter covers the records and reports that are basic to a well-administered engineering department of any ship.

LEGAL RECORDS

The Engineering Log, NAVSEA 3120/2, and the Engineer's Bell Book, NAVSEA 3120/1, are legal records of the engineering department. Completed Engineering Log and Engineer's Bell Book sheets are kept on board as permanent records. However, they may be released when requested by a Navy court or board, or the Department of the Navy. If it is necessary for any part of these records to be removed from the ship, a photostatic copy of the material to be removed is prepared for the ship's files and certified as a true copy by the engineer officer. Completed Engineering Log and Engineer's Bell Book sheets may be destroyed 3 years after the date of the last entries. When a ship is stricken from the list of naval ships, its current Engineering Log and Engineer's Bell Book sheets are forwarded to the newest naval records management center. Sheets less than 3 years old are kept on board when a ship is placed in an inactive status.

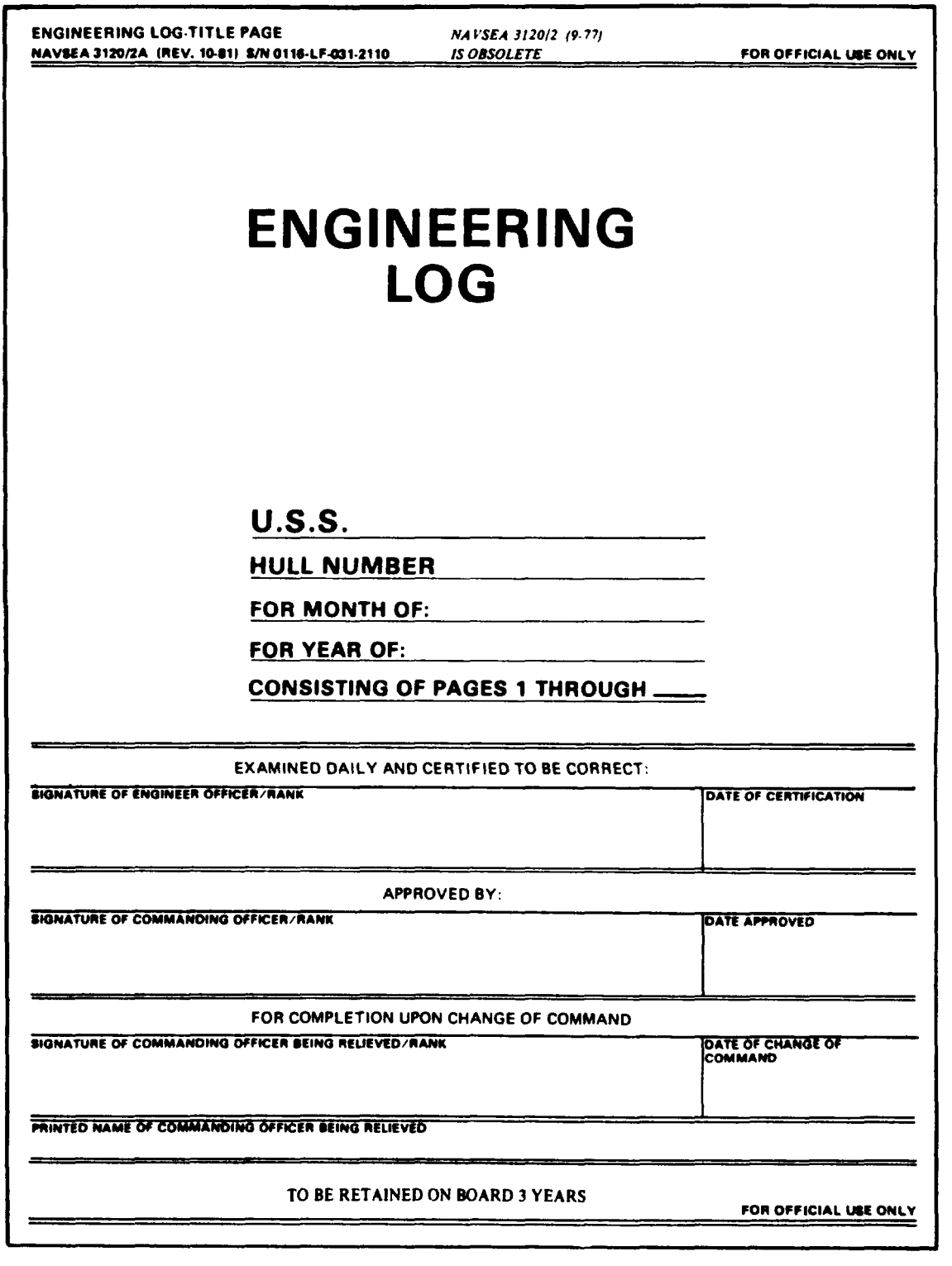
ENGINEERING LOG

The Engineering Log, NAVSEA 3120/2 (fig. 12-1), together with the log continuation sheet, is a complete daily record by watches. It is a record of important events and data pertaining to the engineering department and the ship's propulsion plant. The log must show the average hourly rpm (to the nearest tenth) for all shafts; the speed in knots; the total engine miles steamed for the day; all major speed changes; draft and displacement upon getting underway and anchoring; fuel, water, and lubricating oil on hand, received, and expended; the disposition of the engines, boilers, and principal auxiliaries and any changes in their disposition; any injuries to engineering department personnel; any casualties to machinery, equipment, or material; and such other matters specified by competent authority.

Entries in the Engineering Log are made according to instructions (1) on the log sheet, (2) in NSTM, chapter 090, and (3) in directives issued by the type commander. Each entry must be a complete statement and employ standard phraseology. The type commander's directives contain other requirements pertaining to the Remarks section of Engineering Logs for ships of the type; the engineer officer must ensure compliance with these directives.

The original Engineering Log, prepared neatly and legibly in ink or pencil, is the legal record. The remarks should by prepared and must be signed by the engineering officer of the watch (EOOW) underway or the engineering duty officer in-port, whichever applies. The log may NOT contain erasures. When a correction is necessary, a single line is drawn through the original entry so the entry remains legible. The correct entry is inserted in a manner as to ensure clarity and legibility. Only the person required to sign the log for the watch may make corrections, additions, or changes. That person must then initial the change in the margin of the page.

The engineer officer verifies the accuracy and completeness of all entries and signs the log daily. The commanding officer approves the log and signs it on the last calendar day of each month and on the date he/she relinquishes command. The engineer officer should require that the log sheets be submitted in time to be



ENGINEERING LOG-TITLE PAGE
NAVSEA 3120/2A (REV. 10-81) S/N 0116-LF-031-2110

NAVSEA 3120/2 (9-77)
IS OBSOLETE

FOR OFFICIAL USE ONLY

ENGINEERING LOG

U.S.S. _____

HULL NUMBER _____

FOR MONTH OF: _____

FOR YEAR OF: _____

CONSISTING OF PAGES 1 THROUGH ____

EXAMINED DAILY AND CERTIFIED TO BE CORRECT:

SIGNATURE OF ENGINEER OFFICER/RANK	DATE OF CERTIFICATION

APPROVED BY:

SIGNATURE OF COMMANDING OFFICER/RANK	DATE APPROVED

FOR COMPLETION UPON CHANGE OF COMMAND

SIGNATURE OF COMMANDING OFFICER BEING RELIEVED/RANK	DATE OF CHANGE OF COMMAND

PRINTED NAME OF COMMANDING OFFICER BEING RELIEVED

TO BE RETAINED ON BOARD 3 YEARS

FOR OFFICIAL USE ONLY

Figure 12-1.—The Engineering Log.

ENGINEERING LOG

NAVSEA 3120/2B (REV. 10-81) S/N 0116-LF-031-2116 (9-77 EDITION IS OBSOLETE) CLASSIFICATION

U.S.S.					HULL NUMBER
DAY	MONTH	YEAR	TIME ZONE	TIME ZONE CHANGE TO	TIME ZONE CHANGE FROM
AT/PASSAGE FROM				PASSAGE TO	TOTAL MILES TRAVELED TODAY

EQUIPMENT STATUS *(Need not be completed for continuing pages)*

MAIN ENGINES	PLANT STATUS	BOILERS
GENERATORS	STEERING ENGINES COMBINATION	
DAYS OUT OF DRY DOCK	CATAPULT STATUS *(CV's Only)*	DAYS SINCE LAST HULL CLEANING

DRAFT FWD	DRAFT AFT	DRAFT MEAN	TONS
LIQUID LOAD		PERCENT OF FULL LOAD (%)	

MAJOR EQUIPMENT OUT OF COMMISSION

EXAMINED DAILY AND CERTIFIED TO BE CORRECT

SIGNATURE OF ENGINEER OFFICER/RANK	DATE OF SIGNATURE

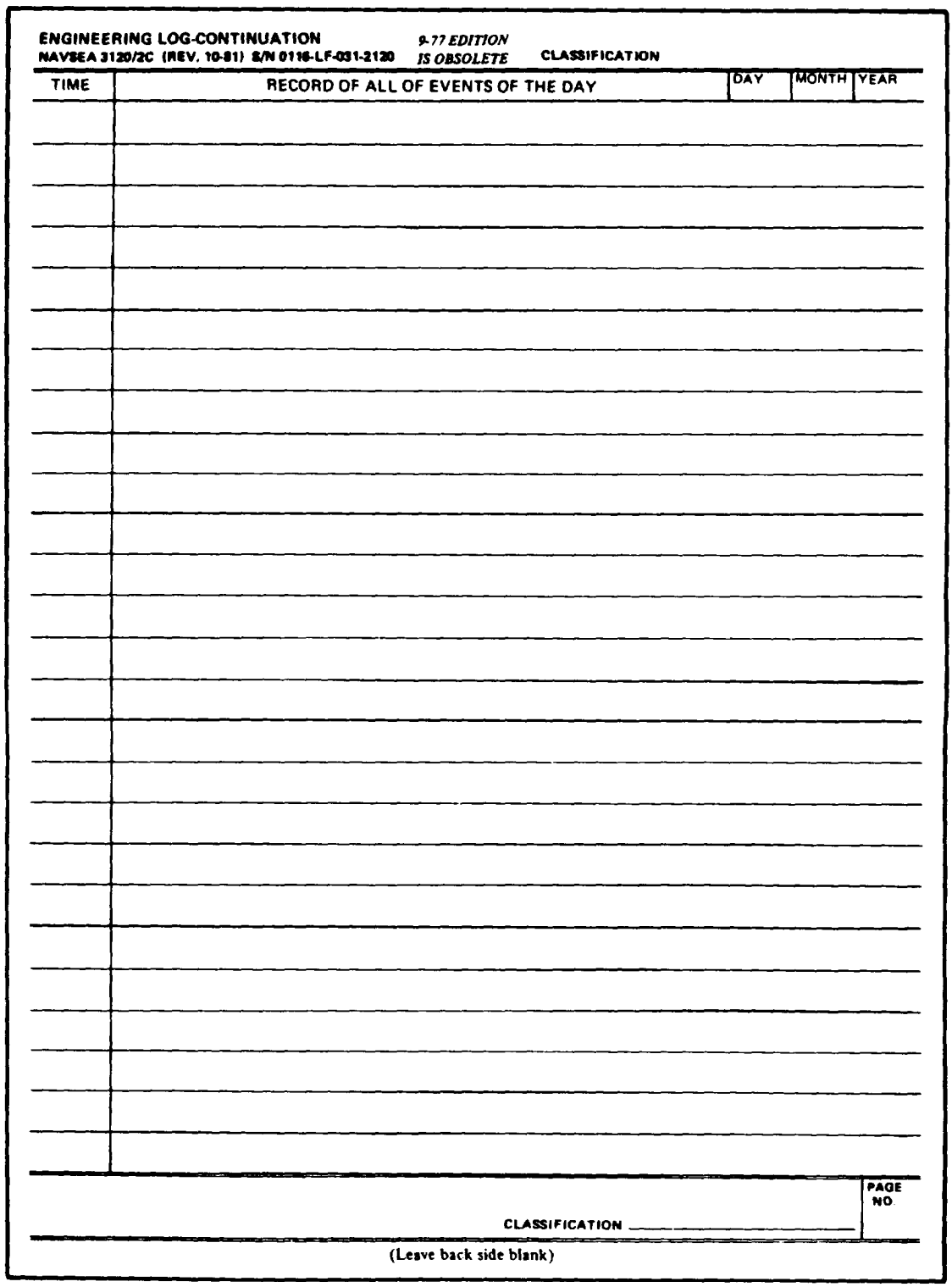
TIME	RECORD OF ALL EVENTS OF THE DAY	DAY	MONTH	YEAR

PAGE NO.

CLASSIFICATION

(Leave back side blank)

Figure 12-1.-The Engineering Log–Continued.



ENGINEERING LOG-CONTINUATION
NAVSEA 3120/2C (REV. 10-81) S/N 0116-LF-031-2120

9-77 EDITION IS OBSOLETE

CLASSIFICATION

TIME	RECORD OF ALL OF EVENTS OF THE DAY	DAY	MONTH	YEAR

CLASSIFICATION

PAGE NO

(Leave back side blank)

Figure 12-1.–The Engineering Log–Continued.

ENGINEERING LOG INSTRUCTIONS FOR ALL SURFACE SHIPS

Instructions For Keeping The Engineering Log - Title Page, Form NAVSEA 3120/2A (Rev. 10-81); Engineering Log, Form NAVSEA 3120/2B (Rev. 10-81); Engineering Log - Continuation, Form NAVSEA 3120/2C (Rev. 10-81); Engineering Log - Instructions, Form NAVSEA 3120/2D (Rev. 10-81)

(For All Surface Ships)

1. The Engineering Log shall be maintained in accordance with Art. 0724 of Navy Regulations, and Section 423 of OPNAVINST 3120.32A. It shall be neatly written in pen or pencil. The original writing is the legal record and must be preserved. It is not desired that the log be recopied except when one or more pages are sent away from the ship. A reproduced copy will then be used.

2. If the information in the sheet is classified, fill in the classification of the log sheet at the top and bottom in the spaces provided. (For example: Classified by: OPNAVINST 3063, Review By: 1 Mar 1992).

3. Fill out the data cover sheet, form NAVSEA 3120/2A.

a. Page numbering shall be completed with the number on the last page of the last day of the month.

b. Examined and approved signatures are completed at the end of the month.

4. Complete the log. All unused blanks shall be crossed out. Do not erase. All errors shall be lined out, initialed, and dated by the person making the original entry.

a. Fill in the heading. Fill in the total miles traveled at the end of the day.

b. Fill in the equipment status section. This section must be completed on the first page of each day only. Continuation sheets will be used when required.

(1) Main engines - Enter engines which are in use. (If a single engine ship, enter number one.)

(2) Plant status - Enter split/cross-connected/cold iron/auxiliary/modified main, etc.

(3) Boilers - Enter boilers which are on the line.

(4) Generators - Enter SSTG/SSDG which are on the line and in parallel operation, e.g., 1 and 2, 4 and 6, --- , ---- .

(5) Steering engines combination - Enter both unit (motor) and cable.

(6) Enter the number of days out of dry dock.

(7) Enter catapults which are operating and from which spaces each is being provided with steam, e.g., 1/2, 2/4, 3/2, 4/3.

(8) Enter the number of days since the last hull cleaning.

(9) Enter the draft readings when in port. When underway, enter the percentage of liquid load (in gallons), fuel (including aircraft if applicable) and water (including ballast and list control if applicable). Then, calculate the draft from the percent of full load, which shall include ammunition and food.

(10) Major equipment out of commision (OOC)- Enter engines, boilers, SSTG/SSDG, emergency generators, steering gear and combinations of major auxiliary equipment which cause main machinery to be OOC, e.g., # 1A and B lube oil service pumps, or # 2A and B FDB, etc. The intent of this section is to list only those components which affect the overall operation of the ship by placing a limitation on the performance or flexibility of the ship. If space is not sufficient to make all entries, they shall be continued in the section "RECORD OF EVENTS OF THE DAY".

c. Examined daily and certified to be correct: This section shall be examined, verified as correct and signed by the Engineering Officer at the end of each day.

d. Page numbers-Pages shall be numbered consecutively with the first day of each month numbered page one. The back of each page shall be left blank.

e. Record the events of the day.

(1) Remarks shall be entered by watch or days as applicable.

(2) The remarks shall be a chronological listing of the day's events, each of which shall be written at the time of occurrence. The following is a complete listing of all requirements generated by the chain of command above the Type Commander level. If Type Commanders desire to increase the recording requirements, an instruction shall be published in the 3100 series including all additional requirements

(a) Personal casualties

(b) Equipment casualties

(c) Shifting of major equipment

(d) Changing to and from maneuvering combinations

(e) Beginning and ending major evolutions-General Quarters, refueling, entering port, etc.

(f) Change in catapult status (CV only)

(g) Shifting lube oil strainers

(h) Opening and inspecting main engines, generators and boilers, and any changes made therein

(i) Setting safeties on boilers

(j) Disposition and changes in principal auxiliaries which affect main machinery operation

5. The Engineering Log may be destroyed 3 years after the date of the last entry. When a ship is stricken, current logs must be forwarded to the nearest Records Management Center.

Figure 12-1.-The Engineering Log–Continued.

checked and signed before noon of the first day following the date of the log sheet(s). The completed pages are filed in a post-type binder and are numbered consecutively. They begin with the first day of each calendar year and go through the last day of the calendar year.

When the commanding officer (or engineer officer) directs a change or addition to the Engineering Log, the person concerned must comply unless he/she believes the proposed change or addition is incorrect. In that event the commanding officer (or engineer officer) enters such remarks over his/her signature as appropriate. After the log has been signed by the commanding officer, it may not be changed without the CO's permission or direction.

ENGINEER'S BELL BOOK

The Engineer's Bell Book, NAVSEA 3120/1 (fig. 12-2), is a record of all bells signals and other orders received by the throttleman regarding movement of the ship's propellers. Entries are made in the Bell Book by the throttleman as soon as an order is received. The assistant usually makes the entries when the ship is entering or leaving port, or engaging in any maneuver that may involve frequent speed changes. This allows the throttleman to devote his/her 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 1 (fig. 12-2).

3. The order received is recorded in column 2, Minor speed changes are recorded by entering the number of rpm ordered. Major speed changes are recorded using the following symbols:

1/3-ahead 1/3 speed
2/3-head 2/3 speed
I-ahead standard speed
II-ahead full speed
III-ahead flank speed
Z-stop
B1/3-back 1/3
B2/3-back 2/3
BF-back full speed
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 record as rpm in column 2 (minor speed changes), do not make an entry in column 3.

5. The shaft revolution counter reading at the time of the speed change is recorded in column 4. The shaft revolution counter reading is taken hourly on the hour while underway and entered in column 4.

Ships and craft with controllable reversible pitch propellers also use column 4 to record responses to speed change orders. However, they record changes in the propeller pitch in feet and fractions of feet. Entries for astern pitch are preceded by the letter B. Entries are made of counter readings each hour on the hour. This information helps in the calculation of miles steamed during those hours when the propeller pitch remains constant.

On ships with gas turbine propulsion plants, a bell logger provides an automatic printout each hour. It shows when propeller rpm or pitch change by more than 5 percent when the engine order telegraph is changed, or when the controlling station is shifted

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

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

In ships or crafts with controllable pitch propellers, bridge personnel control the engines and maintain the Bell Book.

Some smaller ships with controllable pitch propellers sometimes need to switch control of the engines between the engine room and the bridge. For that purpose they maintain two Bell Books, and the personnel in control of the engines at any one time make entries in the Bell Book. When control shifts from one to the other, say from the bridge to the engine room, bridge personnel enter the time they gave control to the engine room. At the same time, engine-room personnel enter the time they assumed control. When the Bell Book is maintained by bridge personnel, the officer of the deck (OOD) signs it. When it is maintained by engine-room personnel, the EOOW signs it. At the end

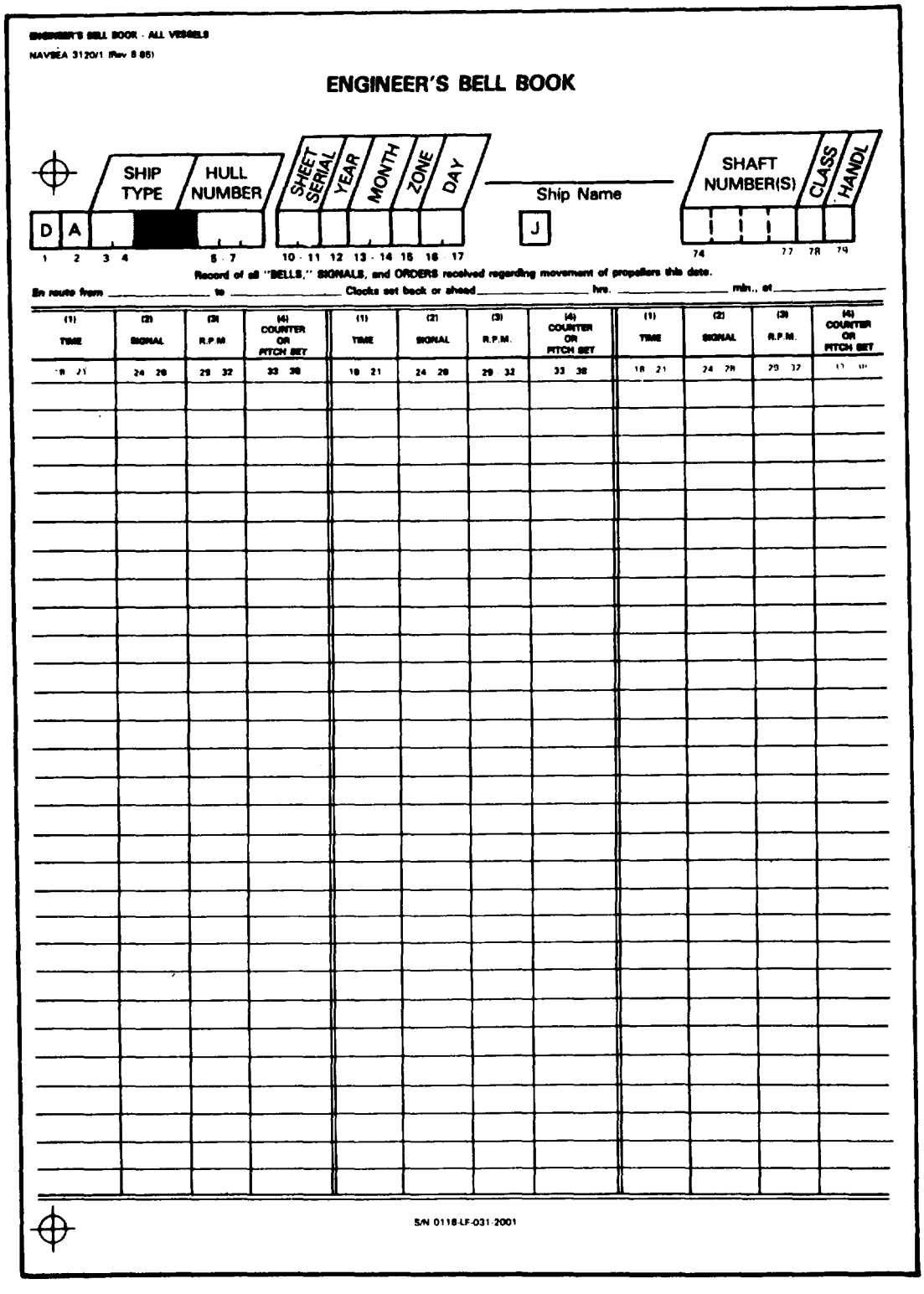


Figure 12-2.-Engineer's Bell Book.

of the day, the two sets of Bell Sheets are consolidated and approved so there is only one official set for the day.

There can be no alterations or erasures in the Bell Book. An incorrect entry should be corrected by drawing a single line through the entry and recording the correct entry on the following line. The EOOW, the OOD, or the watch supervisor should initial changes.

OPERATING RECORDS

Engineering operating records help ensure regular inspection of operating machinery and provide data for performance analysis. They should be reviewed daily at the level specified by appropriate directives. Operating records are not intended to replace frequent inspections of operating machinery by supervisory personnel. Also, they are not to be trusted to warn of impending casualties. Personnel who maintain operating records must be properly indoctrinated. They must be trained to correctly obtain, interpret, and record data and to report any abnormal conditions. Acceptable high and low readings and abnormal readings must be permanently recorded on operating logs for each machinery type. Abnormal readings should be circled in red and reported to the watch supervisor.

The type commander's directives specify which engineering operating records will be maintained and prescribe the forms to be used when no standard record forms are provided. The engineer officer may require additional operating records if he/she finds them necessary.

The operating records discussed in this chapter are generally retained on board for 2 years. They may then be destroyed according to current disposal regulations. Complete records must be stowed where they will be properly preserved and easily located in case of need.

PROPULSION STEAM TURBINE AND REDUCTION GEAR OPERATING RECORD

The Propulsion Steam Turbine and Reduction Gear Operating Record, NAVSEA 9231/1 (fig. 12-3), is a daily record maintained for each main engine in operation. In ships with more than one main engine in the same engine room, a separate sheet is maintained for each engine, but common entries are omitted from the record for the port engine.

The watch supervisor enters the remarks and signs the record for his/her watch. The petty officer in charge of the engine room checks the accuracy of the record and signs it in the space provided on the back of the record. The main propulsion assistant notes the contents and signs the record. Any unusual conditions noted in the record should be reported to the engineer Officer immediately.

DIESEL ENGINE OPERATING RECORD

The Diesel Engine Operating Record, NAVSEA 9231/2, is a complete daily record for each operating propulsion and auxiliary diesel engine in the ship. The watch supervisor writes and signs the remarks for his/her watch. The petty officer in charge of the ship's diesel engines checks the accuracy of the entries and signs the record in the space provided. The engineer officer notes the contents and approves the record daily by signing it.

AC/DC ELECTRIC PROPULSION OPERATING RECORD

The AC/DC Electric Propulsion Operating Record, NAVSEA 9235/1, is daily record for each operating propulsion generator and motor in ships (except submarines) equipped with ac or dc electric propulsion machinery. A separate record sheet is used for each shaft. Exceptions are ships with more than two generators or two motors per shaft, where as many sheets as required are used.

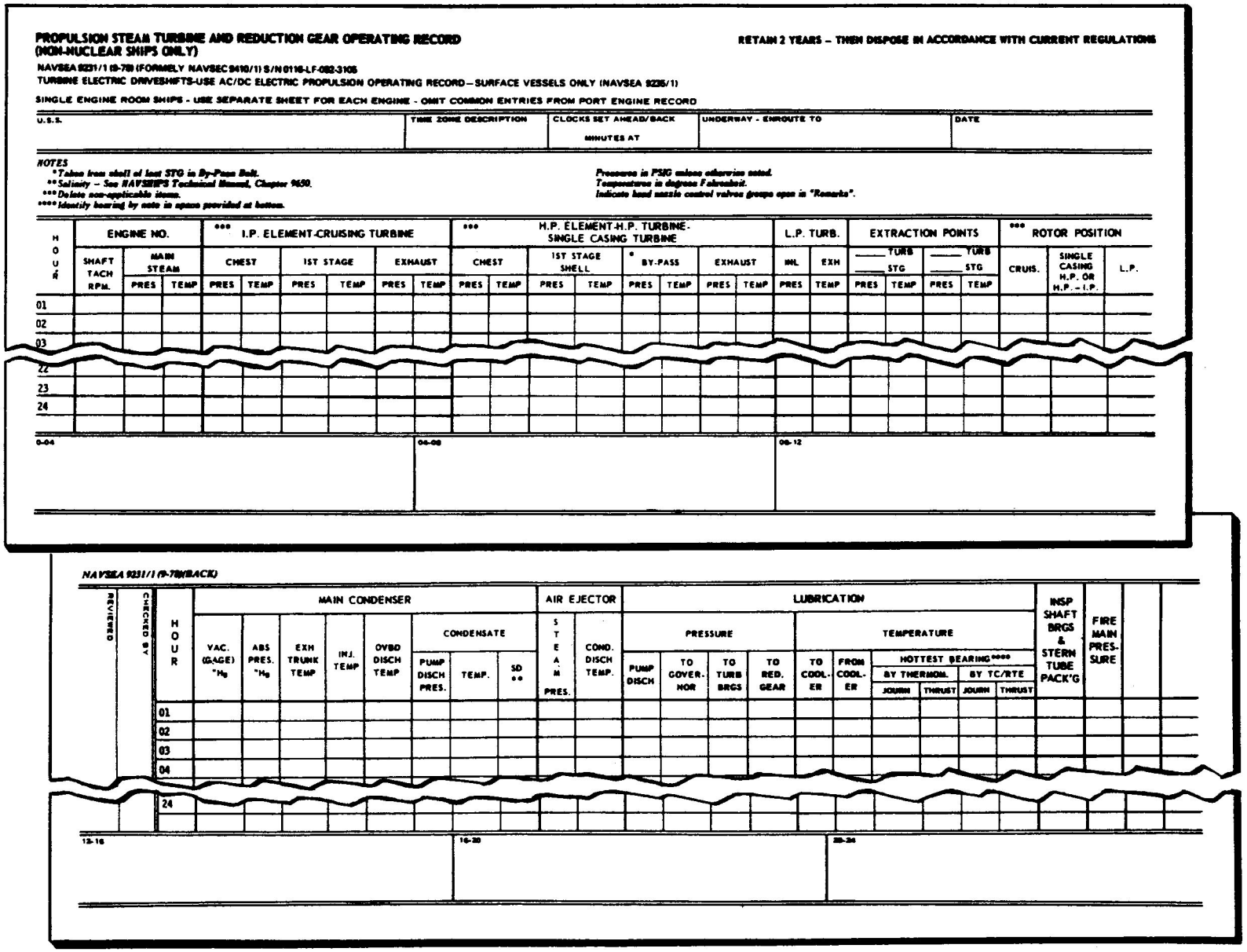
Data is entered on the record and the remarks are written and signed by the Electrician's Mate (EM) of the watch. The accuracy of the entries is checked by the EM in charge of the electric propulsion equipment and the electrical officer. Space is provided on the record for the daily approval and signature of the engineer officer.

BOILER ROOM OPERATING RECORD

The Boiler Room Operating Record, NAVSEA 9221/6 (fig. 12-4), is a complete record for each steaming fireroom. Space is provided on the back of the record for the operating data of all fireroom auxiliary machinery. Entries are checked for accuracy by the fireroom supervisor. The division officer also checks and initials the record. The engineer officer checks the entries and approves the record daily by signing it in the appropriate space.

ELECTRICAL LOG

The Electrical Log, NAVSEA 9600/1 (fig. 12-5), is a complete daily record for each operating ship's service generator. Entries for the prime movers are generally recorded by the generator watch (MM).



PROPULSION STEAM TURBINE AND REDUCTION GEAR OPERATING RECORD
(NON-NUCLEAR SHIPS ONLY)

RETAIN 2 YEARS – THEN DISPOSE IN ACCORDANCE WITH CURRENT REGULATIONS

NAVSEA 9231/1 (9-78) (FORMERLY NAVSEC 9410/1) S/N 0116-LF-092-3105

TURBINE ELECTRIC DRIVESHIFTS-USE AC/DC ELECTRIC PROPULSION OPERATING RECORD – SURFACE VESSELS ONLY (NAVSEA 9235/1)

SINGLE ENGINE ROOM SHIPS - USE SEPARATE SHEET FOR EACH ENGINE - OMIT COMMON ENTRIES FROM PORT ENGINE RECORD

U.S.S.	TIME ZONE DESCRIPTION	CLOCKS SET AHEAD/BACK MINUTES AT	UNDERWAY - ENROUTE TO	DATE

NOTES
**Taken from shell of last STG in By-Pass Bolt.*
***Salinity – See NAVSHIPS Technical Manual, Chapter 9650.*
****Delete non-applicable items.*
*****Identify bearing by note in space provided at bottom.*

Pressures in PSIG unless otherwise noted.
Temperatures in degrees Fahrenheit.
Indicate load nozzle control valves groups open in "Remarks".

HOUR	ENGINE NO.			*** I.P. ELEMENT-CRUISING TURBINE						*** H.P. ELEMENT-H.P. TURBINE-SINGLE CASING TURBINE								L.P. TURB.		EXTRACTION POINTS				*** ROTOR POSITION		
	SHAFT TACH RPM.	MAIN STEAM		CHEST		1ST STAGE		EXHAUST		CHEST		1ST STAGE SHELL		* BY-PASS		EXHAUST		INL	EXH	___ TURB ___ STG		___ TURB ___ STG		CRUIS.	SINGLE CASING H.P. OR H.P. – I.P.	L.P.
		PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP	PRES	TEMP			
01																										
02																										
03																										
22																										
23																										
24																										
0-04										04-08								08-12								

NAVSEA 9231/1 (9-78)(BACK)

REVERSO	CHECKED BY	HOUR	MAIN CONDENSER								AIR EJECTOR		LUBRICATION										INSP SHAFT BRGS & STERN TUBE PACK'G	FIRE MAIN PRESSURE			
			VAC. (GAGE) "Hg	ABS PRES. "Hg	EXH TRUNK TEMP	INJ. TEMP	OVBD DISCH TEMP	CONDENSATE			STEAM PRES.	COND. DISCH TEMP.	PRESSURE				TEMPERATURE										
								PUMP DISCH PRES.	TEMP.	SD **			PUMP DISCH	TO GOVER-NOR	TO TURB BRGS	TO RED. GEAR	TO COOL-ER	FROM COOL-ER	HOTTEST BEARING **** BY THERMOM. JOURN	HOTTEST BEARING **** BY THERMOM. THRUST	HOTTEST BEARING **** BY TC/RTE JOURN	HOTTEST BEARING **** BY TC/RTE THRUST					
		01																									
		02																									
		03																									
		04																									
		24																									
12-16										16-20													20-24				

Figure 12-3.—Propulsion Steam Turbine and Reduction Gear Operating Record.

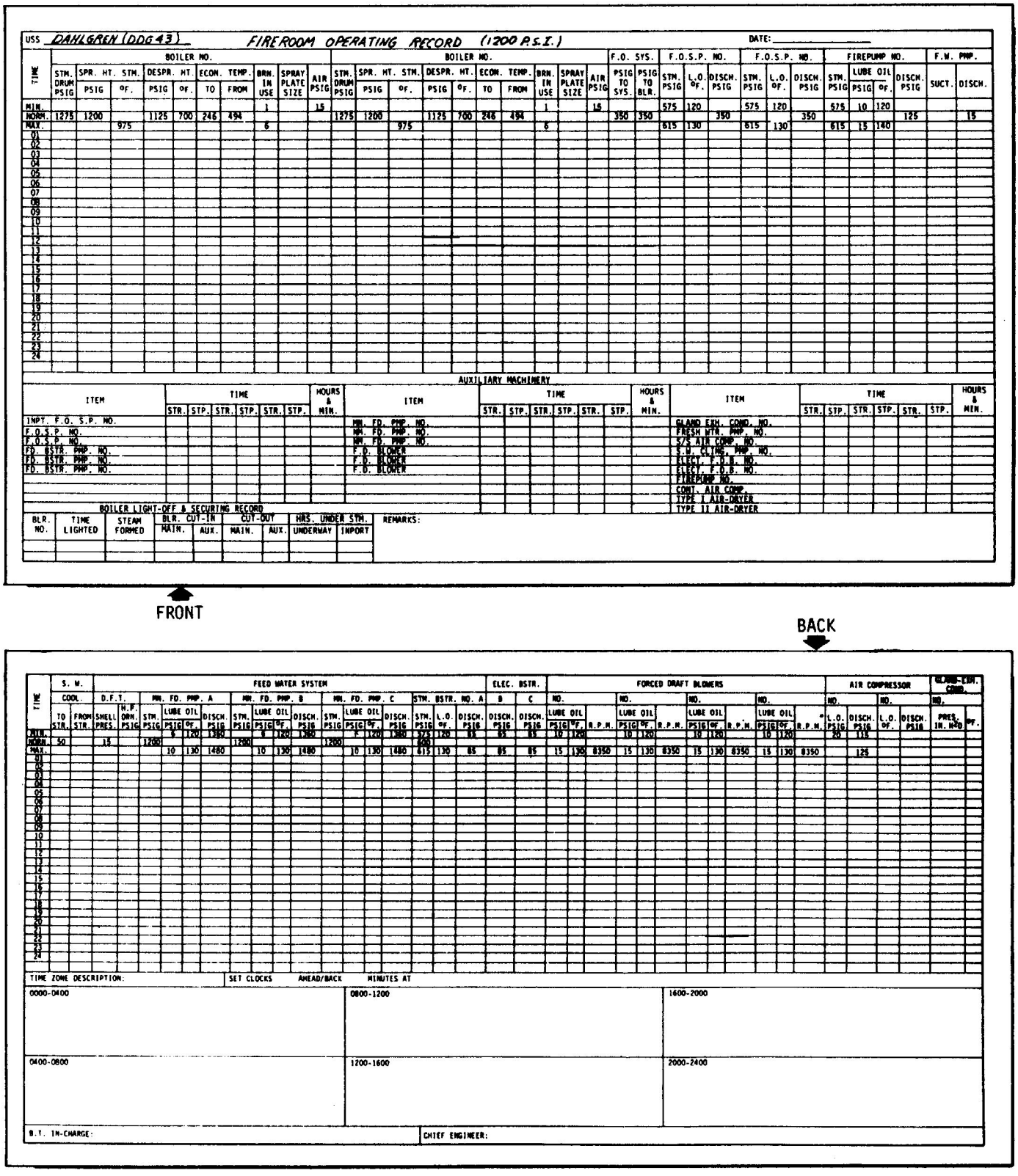
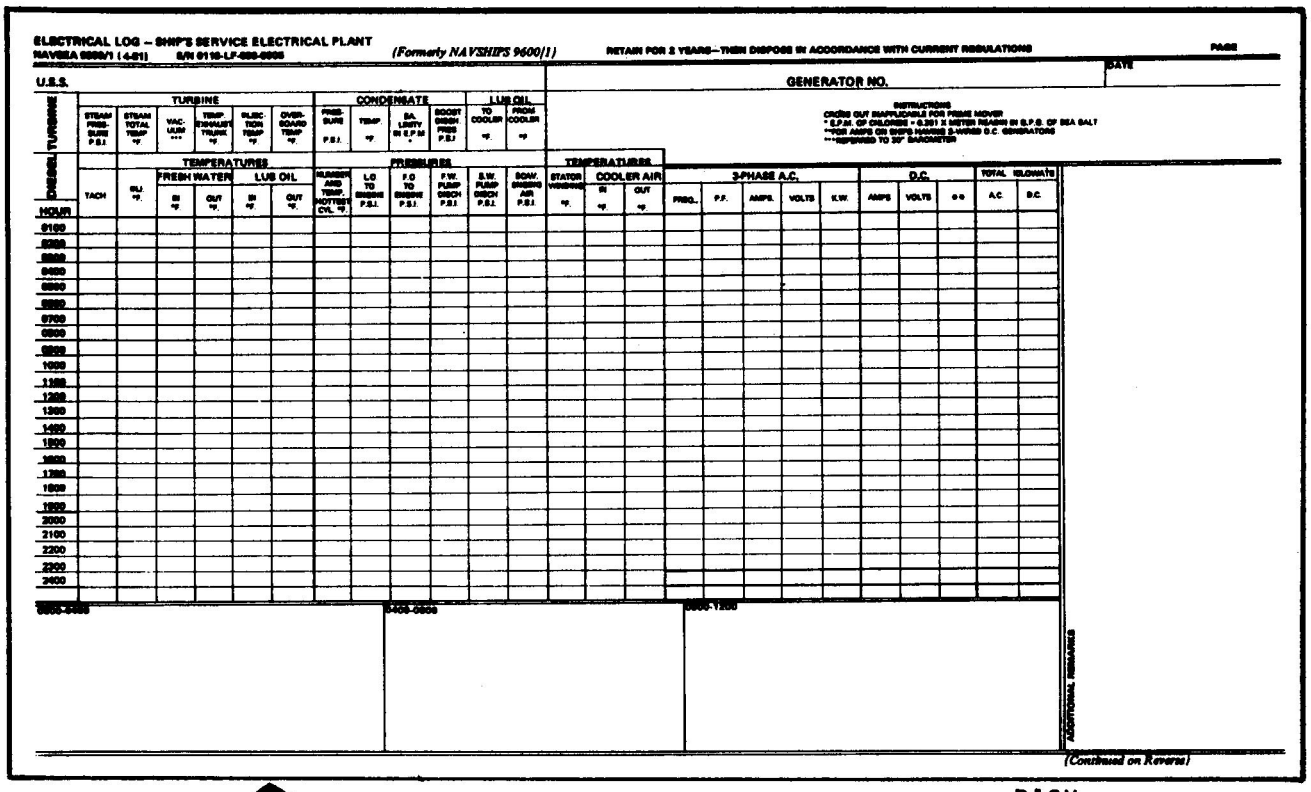


Figure 12-4.—Boiler Room Operating Record.



FRONT

BACK

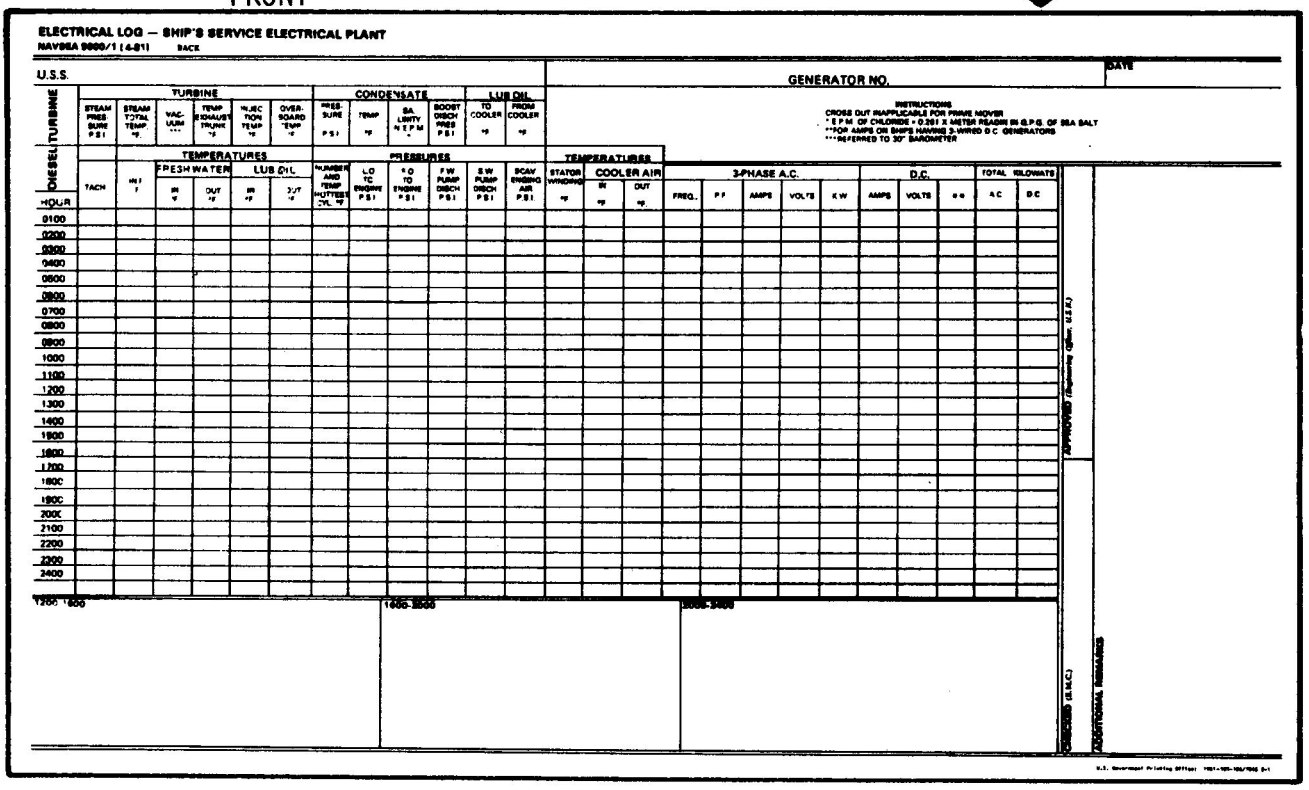


Figure 12-5.—Electrical Log–Ship's Electric Plant.

Electrical data are recorded by the switchboard watch (EM). Each signs the remarks made for his/her watch.

The accuracy of the entries is checked by the EM in charge of the ship's service generators. Both the M and E division officers check the record for accuracy and any evidence of impending casualties. Each officer initials the record to indicate it has been checked. The engineer officer notes the content and signs the record daily in the space provided.

DISTILLING PLANT OPERATING RECORD

There is a distilling plant operating record for each of the three principal types of distilling plants in use aboard naval ships. The records are (1) the Low Pressure Distilling Plant Operating Record, NAVSEA 9530/3, (2) the Flash Type Distilling Plant Operating Record, NAVSEA 9530/1 (fig. 12-6), and (3) the Vapor Compression Distilling Plant Operating Record, NAVSEA 9530/2. Each is a complete daily record maintained for each distilling plant in operation. Personnel of the watch record data and remarks in the record. The watch supervisor signs the remarks for his/her watch, and the petty officer in charge of the ship's distilling plants checks all entries for accuracy and signs the record. The division officer (M or A, as applicable) reviews and initials the record. Space is provided on the back of the record for the daily signature of the engineer officer.

REFRIGERATION/AIR CONDITIONING EQUIPMENT RECORD

The Refrigeration/Air Conditioning Equipment Operating Record, NAVSEA 9516/1 (fig. 12-7), is a complete daily record fix each operating refrigeration plant and air conditioning plant (except package units). Spaces on the front of the record are for entries applicable to both refrigeration and air conditioning plants (view A of fig. 12-7). The entries made on the back of the record are illustrated in view B of figure 12-7 (air conditioning). Note that data are recorded at 2-hour intervals in this record. The A division officer reviews the contents and initials the record daily.

GYROCOMPASS OPERATING RECORD

The Gyrocompass Operating Record is a locally prepared, complete daily record for each operating master gyrocompass. The form for the log is prepared according to the type commander's directives. Columns in the log should provide space for recording the times of starting and stopping the gyrocompass, total hours of operation since delivery of the gyrocompass, and important operating data pertaining to the gyrocompass installation. The petty officer in charge of the interior communications (IC) equipment checks the accuracy of the log and the electrical officer notes its contents daily.

IC ROOM OPERATING RECORD

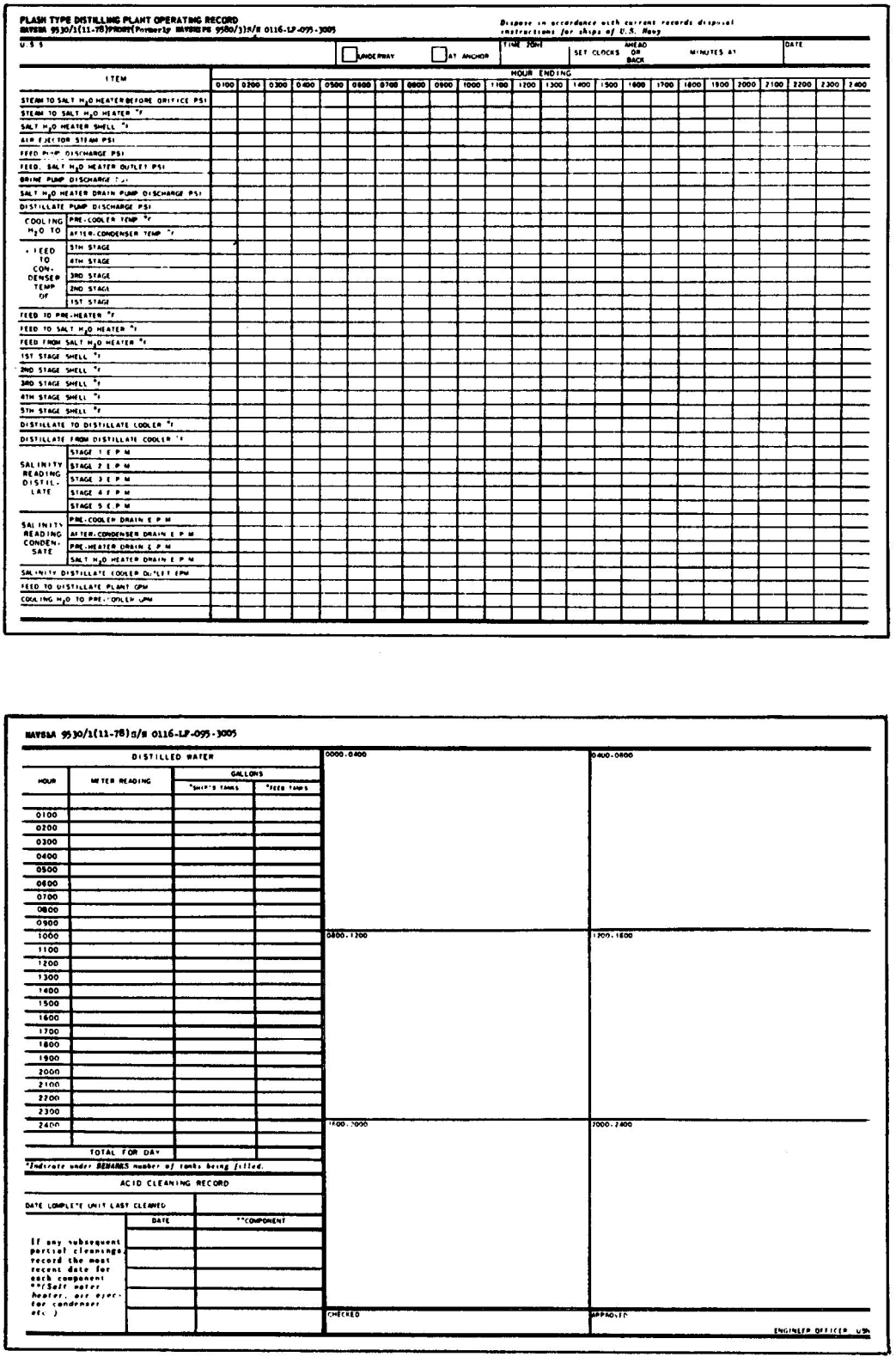
The IC Room Operating Record is a daily record of major electrical equipment in operation in the IC room and is maintained by the IC watch. The form for the record is prepared locally according to the type commander's directives. On small ships the gyrocompass log and the IC room record may be maintained on the same form. Important data such as voltages and currents of major units of IC equipment (IC switchboard, telephone switchboard, and motor generator sets) should be recorded on the form. The IC Room Operating Record is checked and approved in the manner described for the Gyrocompass Operating Record.

AIR COMPRESSOR OPERATING RECORD

Some large ships maintain an Air Compressor Operating Record that contains important data such as temperatures and pressures pertaining to air compressors in operation. When required by the type commander, the Air Compressor Operating Record is prepared locally according to his/her directives. Contents of the record should be checked by the petty officer in charge of the air compressors and the appropriate division officer.

FUEL AND WATER ACCOUNTS

The maintenance of daily fuel oil, lubricating oil, water, and diesel oil accounts is vital to the efficient operation of the engineering department. The type commander generally prescribes forms and procedures necessary to account for and preserve a limited supply of fresh water and fuel. Chapter 090 of the NSTM lists the fuel and water accounts that the Naval Sea Systems Command (NAVSEASYSCOM) considers indispensable to the engineering department. Principally, these accounts inform the engineer officer of the status of the ship's liquid load. They also form the basis for several important reports submitted to higher authority by the engineer officer. One of the most important of these is the report of the amount of burnable fuel on hand.



PLASH TYPE DISTILLING PLANT OPERATING RECORD
NAVSEA 9530/1(11-78)PREVIOUS(Formerly NAVSHIPS 9580/3)S/N 0116-LP-095-3005

Dispose in accordance with current records disposal instructions for ships of U.S. Navy

U.S.S. | ☐ UNDERWAY ☐ AT ANCHOR | TIME ZONE | SET CLOCKS AHEAD OR BACK MINUTES AT | DATE

ITEM		HOUR ENDING 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
STEAM TO SALT H_2O HEATER BEFORE ORIFICE PSI																									
STEAM TO SALT H_2O HEATER °F																									
SALT H_2O HEATER SHELL °F																									
AIR EJECTOR STEAM PSI																									
FEED PUMP DISCHARGE PSI																									
FEED, SALT H_2O HEATER OUTLET PSI																									
BRINE PUMP DISCHARGE °F																									
SALT H_2O HEATER DRAIN PUMP DISCHARGE PSI																									
DISTILLATE PUMP DISCHARGE PSI																									
COOLING H_2O TO	PRE-COOLER TEMP °F																								
	AFTER-CONDENSER TEMP °F																								
FEED TO CONDENSER TEMP OF	5TH STAGE																								
	4TH STAGE																								
	3RD STAGE																								
	2ND STAGE																								
	1ST STAGE																								
FEED TO PRE-HEATER °F																									
FEED TO SALT H_2O HEATER °F																									
FEED FROM SALT H_2O HEATER °F																									
1ST STAGE SHELL °F																									
2ND STAGE SHELL °F																									
3RD STAGE SHELL °F																									
4TH STAGE SHELL °F																									
5TH STAGE SHELL °F																									
DISTILLATE TO DISTILLATE COOLER °F																									
DISTILLATE FROM DISTILLATE COOLER °F																									
SALINITY READING DISTILLATE	STAGE 1 E P M																								
	STAGE 2 E P M																								
	STAGE 3 E P M																								
	STAGE 4 E P M																								
	STAGE 5 E P M																								
SALINITY READING CONDENSATE	PRE-COOLER DRAIN E P M																								
	AFTER-CONDENSER DRAIN E P M																								
	PRE-HEATER DRAIN E P M																								
	SALT H_2O HEATER DRAIN E P M																								
SALINITY DISTILLATE COOLER OUTLET EPM																									
FEED TO DISTILLATE PLANT GPM																									
COOLING H_2O TO PRE-COOLER GPM																									

NAVSEA 9530/1(11-78)S/N 0116-LP-095-3005

DISTILLED WATER

HOUR	METER READING	GALLONS *SHIP'S TANKS	GALLONS *FEED TANKS
0100			
0200			
0300			
0400			
0500			
0600			
0700			
0800			
0900			
1000			
1100			
1200			
1300			
1400			
1500			
1600			
1700			
1800			
1900			
2000			
2100			
2200			
2300			
2400			
TOTAL FOR DAY			

*Indicate under REMARKS number of tanks being filled.

ACID CLEANING RECORD

DATE COMPLETE UNIT LAST CLEANED

If any subsequent partial cleanings, record the most recent date for each component **/Salt water heater, air ejector condenser etc.)

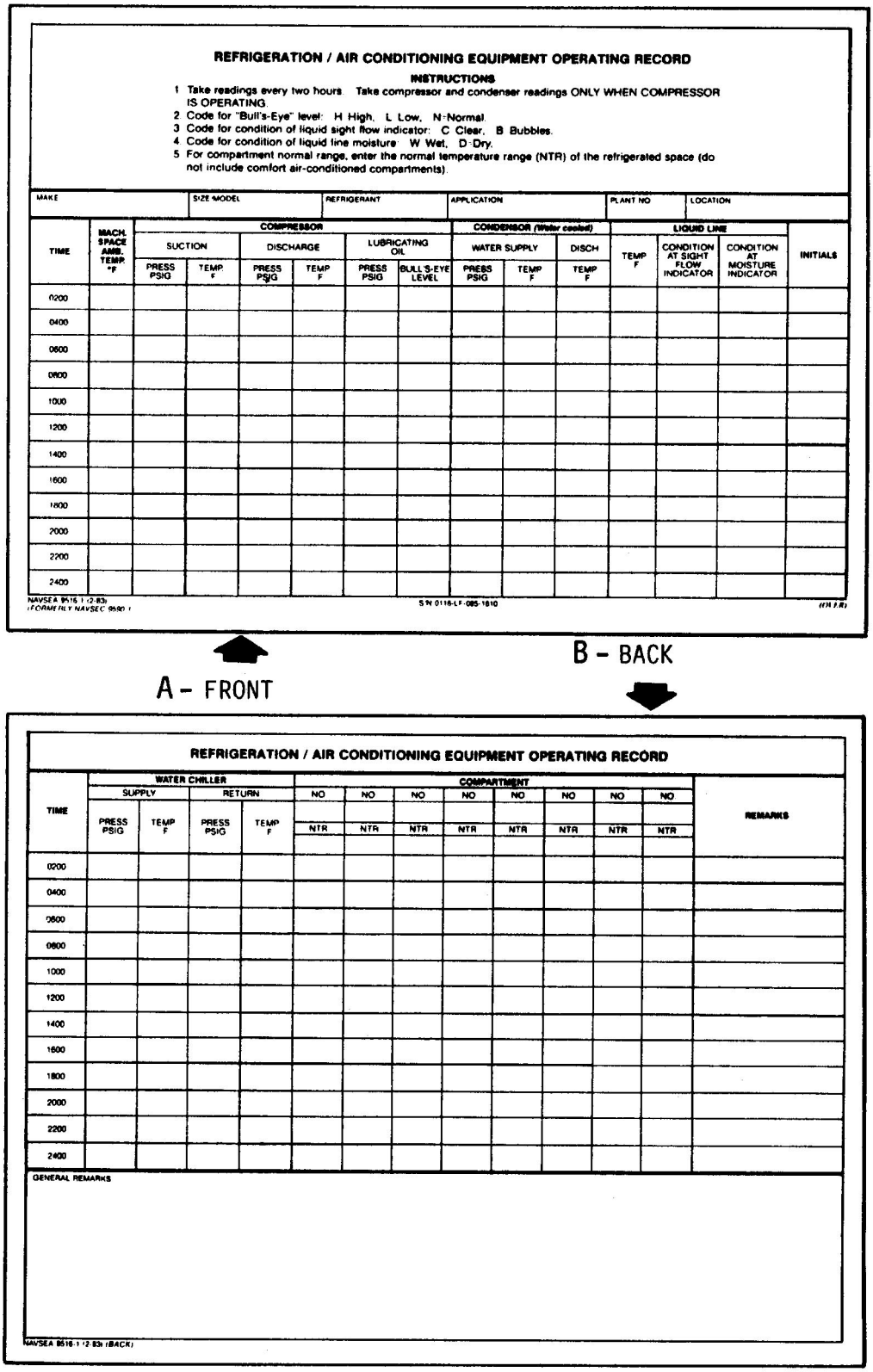
DATE	**COMPONENT

0000-0400 | 0400-0800 | 0800-1200 | 1200-1600 | 1600-2000 | 2000-2400

CHECKED | APPROVED

ENGINEER OFFICER USN

Figure 12-6.—Flash Type Distilling Plant Operating Record.



REFRIGERATION / AIR CONDITIONING EQUIPMENT OPERATING RECORD

INSTRUCTIONS

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

MAKE	SIZE/MODEL	REFRIGERANT	APPLICATION	PLANT NO	LOCATION

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

NAVSEA 9516-1 (2-83) (FORMERLY NAVSEC 9580-1) S/N 0116-LF-095-1810 (REAR)

A - FRONT

B - BACK

REFRIGERATION / AIR CONDITIONING EQUIPMENT OPERATING RECORD

TIME	WATER CHILLER				COMPARTMENT								REMARKS
	SUPPLY		RETURN		NO	NO	NO	NO	NO	NO	NO	NO	
	PRESS PSIG	TEMP F	PRESS PSIG	TEMP F	NTR	NTR	NTR	NTR	NTR	NTR	NTR	NTR	
0200													
0400													
0600													
0800													
1000													
1200													
1400													
1600													
1800													
2000													
2200													
2400													

GENERAL REMARKS

NAVSEA 9516-1 (2-83) (BACK)

Figure 12-7.—Refrigeration/Air Conditioning Equipment Operation Record. A. Front. B. Back.

It is fundamental to all naval operations that all ship and unit commanders know the exact amount of burnable fuel on hand. It is sound engineering practice to fill all fuel oil tanks to 95 percent of volumetric capacity to allow for expansion and to prevent spillage. When submitting fuel reports, the 95 percent volumetric capacity of the tank is assumed to be 100 percent of the burnable fuel. It is possible, however, to fuel above the 95 percent volumetric capacity. When fueled to 100 percent volumetric capacity, the burnable fuel percentage figure will exceed 100 percent. The engineer officer should not hesitate to report burnable fuel in excess of 100 percent when this amount is actually on board.

When computing the amount of burnable fuel on board, only the fuel oil in storage tanks and service tanks is considered and only if it is above the service suction and transfer suction tailpipes. Fuel below those pipes is not considered burnable. The design height of suction tailpipes is shown on ship's plans. The fuel oil in contaminated tanks (settling or separating tanks), also is not considered burnable.

FUEL AND WATER REPORTS

The engineer officer submits the Fuel and Water Report, NAVSEA 9255/9, daily to the commanding officer (fig. 12-8). The report indicates the amount of fuel (fuel oil and diesel oil) and water on hand as of midnight the previous day. The report also includes the previous day's feed and potable water performance, results of water tests, and the steaming hours on boiler firesides and waterside.

The Fuel and Water Report is compiled from data obtained from the Daily Fuel and Lube Oil Account and the Daily Water Account. The original and one copy of the report is delivered to the OOD early enough to

NAVSEA 9255/9 (REV. 2-80) (FRONT)
(Formerly NAVSEA 9518/1)
S/N 0116-LF-062-5548

FUEL AND WATER REPORT

DATE _____

TO: COMMANDING OFFICER, USS _____

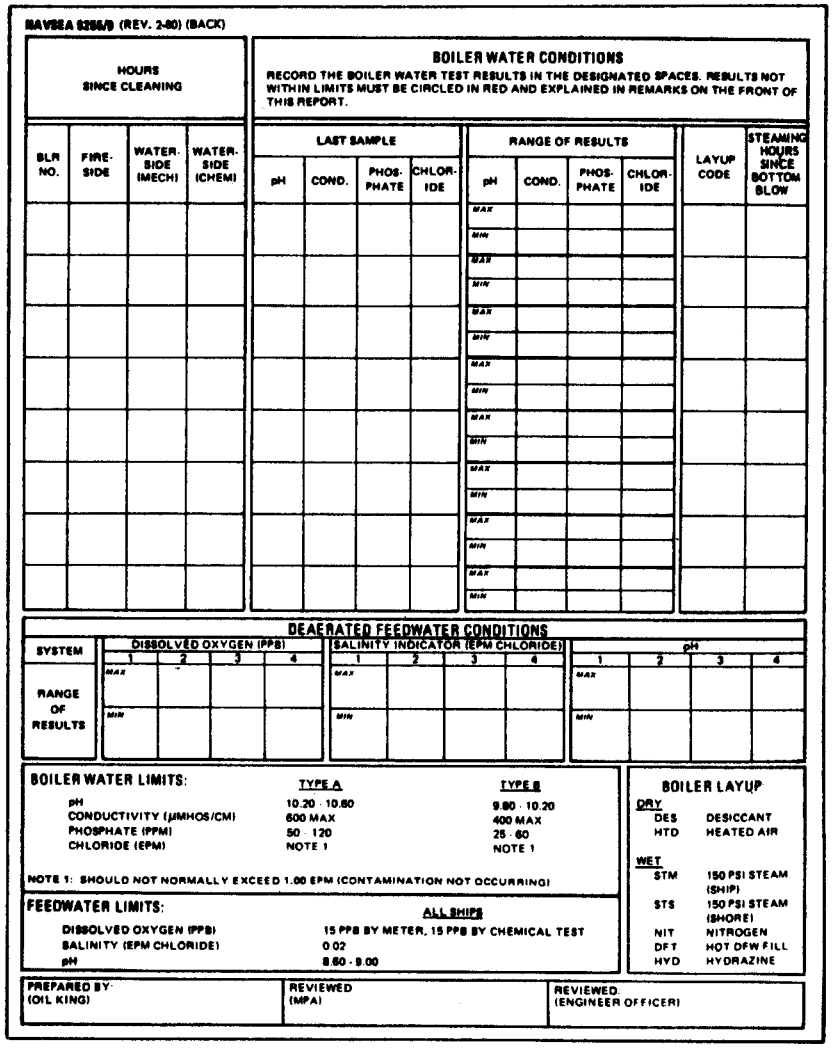
	FUEL (GALLONS)		LUBE OIL (GALLONS)	WATER (GALLONS)	
	BOILER FUEL	DIESEL FUEL	STORAGE TANKS	POTABLE	RESERVE FEED
ON HAND LAST REPORT					
RECEIVED (+)					
DISTILLED (+)					
EXPENDED (-)					
GAIN (+) LOSS (-) BY INVENTORY					
ON HAND THIS REPORT					
ON HAND %					

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			FEEDWATER CONSUMPTION	
PERSONNEL ON BOARD	GALLONS USED PER PERSON	STANDARD	NOT UNDERWAY (GALLONS PER HOUR)	UNDERWAY (GALLONS PER HOUR)

REMARKS:

Figure 12-8.—Fuel and Water Report (front).



NAVSEA 9355/9 (REV. 2-80) (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.

BLR NO.	FIRE-SIDE	WATER-SIDE (MECH)	WATER-SIDE (CHEM)	LAST SAMPLE pH	LAST SAMPLE COND.	LAST SAMPLE PHOS-PHATE	LAST SAMPLE CHLOR-IDE	RANGE OF RESULTS	pH	COND.	PHOS-PHATE	CHLOR-IDE	LAYUP CODE	STEAMING HOURS SINCE BOTTOM BLOW
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						

DEAERATED FEEDWATER CONDITIONS

SYSTEM	DISSOLVED OXYGEN (PPB) 1	2	3	4	SALINITY INDICATOR (EPM CHLORIDE) 1	2	3	4	pH 1	2	3	4
RANGE OF RESULTS MAX												
RANGE OF RESULTS 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 12-8.—Fuel and Water Report (back).

submit to the commanding officer with the 1200 reports.

DAILY FUEL AND LUBE OIL ACCOUNT

The Daily Fuel and Lube Oil Account is generally a single daily record sheet showing the receipt, use, expenditure, transfer, and changes by inventory or apparent meter error of the contents of each fuel oil, diesel oil, and lubricating oil tank throughout the ship.

Forms and procedures are prescribed by the type commanders. An account form is submitted before and after receiving or delivering fuel oil. The form is prepared by the oil king and checked for accuracy by his/her leading petty officer and division officer. It is then submitted to the engineer officer for approval and signature. The information in the record is the basis of reports submitted to higher authority (commanding officer and force or unit commander) by the engineer officer.

DAILY WATER ACCOUNT

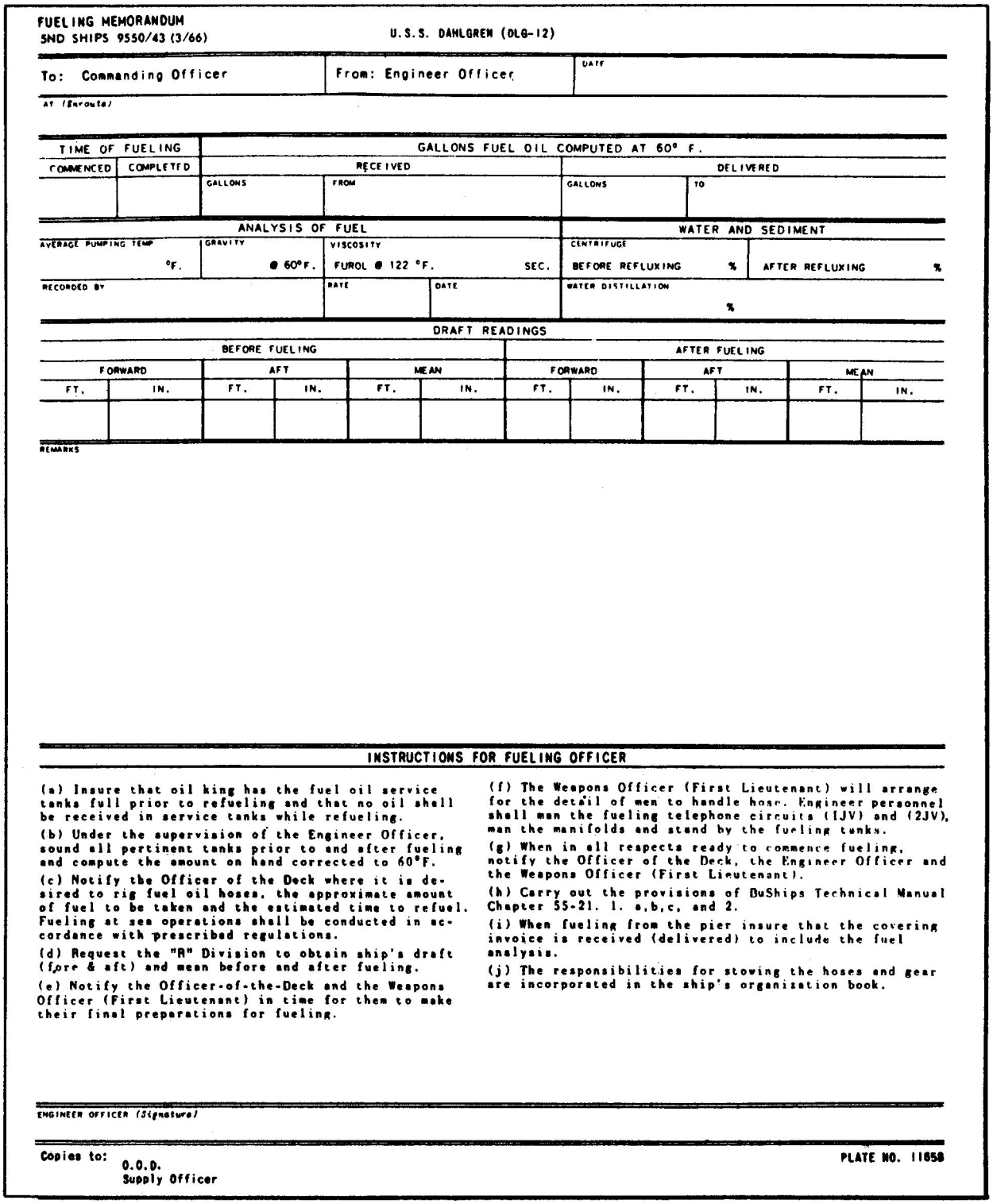
The Daily Water Account is a daily record of the feedwater for boilers and potable fresh water in reserve feed tanks, deaerating feed tanks, boilers, and potable water tanks throughout the ship. The oil king records the data, which is then checked by his/her leading petty officer and division officer. The record is then submitted to the engineer officer for approval and signature. The daily water account is also a source if information that is included in reports to higher authority.

FUELING MEMORANDUM

The engineer officer uses a Fueling Memorandum (fig. 12-9) to inform interested parties whenever fuel oil or diesel oil is received or delivered. Those interested parties include the commanding officer, the OOD, the supply officer, and any others concerned, including the ship being refueled when that is the case.

LIQUID LOAD PLAN

The Liquid Load Plan of the ship is a printed or locally prepared diagrammatic layout of all the ship's tanks, with each colored to show graphically the approximate status of fuel, ballast water, reserve feedwater, and potable water. The oil king prepares and distributes the plan daily. Copies serve as important



FUELING MEMORANDUM
SND SHIPS 9550/43 (3/66)

U.S.S. DAHLGREN (DLG-12)

To: Commanding Officer | From: Engineer Officer | DATE

AT (Enroute)

TIME OF FUELING		GALLONS FUEL OIL COMPUTED AT 60° F.			
COMMENCED	COMPLETED	RECEIVED		DELIVERED	
		GALLONS	FROM	GALLONS	TO

ANALYSIS OF FUEL				WATER AND SEDIMENT	
AVERAGE PUMPING TEMP	GRAVITY	VISCOSITY		CENTRIFUGE	
°F.	@ 60°F.	FUROL @ 122 °F.	SEC.	BEFORE REFLUXING %	AFTER REFLUXING %
RECORDED BY		RATE	DATE	WATER DISTILLATION %	

DRAFT READINGS

BEFORE FUELING						AFTER FUELING					
FORWARD		AFT		MEAN		FORWARD		AFT		MEAN	
FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.

REMARKS

INSTRUCTIONS FOR FUELING OFFICER

(a) Insure that oil king has the fuel oil service tanks full prior to refueling and that no oil shall be received in service tanks while refueling.

(b) Under the supervision of the Engineer Officer, sound all pertinent tanks prior to and after fueling and compute the amount on hand corrected to 60°F.

(c) Notify the Officer of the Deck where it is desired to rig fuel oil hoses, the approximate amount of fuel to be taken and the estimated time to refuel. Fueling at sea operations shall be conducted in accordance with prescribed regulations.

(d) Request the "R" Division to obtain ship's draft (fore & aft) and mean before and after fueling.

(e) Notify the Officer-of-the-Deck and the Weapons Officer (First Lieutenant) in time for them to make their final preparations for fueling.

(f) The Weapons Officer (First Lieutenant) will arrange for the detail of men to handle hose. Engineer personnel shall man the fueling telephone circuits (1JV) and (2JV), man the manifolds and stand by the fueling tanks.

(g) When in all respects ready to commence fueling, notify the Officer of the Deck, the Engineer Officer and the Weapons Officer (First Lieutenant).

(h) Carry out the provisions of BuShips Technical Manual Chapter 55-21. 1. a,b,c, and 2.

(i) When fueling from the pier insure that the covering invoice is received (delivered) to include the fuel analysis.

(j) The responsibilities for stowing the hoses and gear are incorporated in the ship's organization book.

ENGINEER OFFICER (Signature)

Copies to:
O.O.D.
Supply Officer

PLATE NO. 11858

Figure 12-9.—Fueling Memorandum.

aids to the damage control watch officer, engineer officer, and EOOW. In large ships, a copy of the plan may be posted at each repair party control station to provide information to the repair party officers.

BOAT FUELING RECORD

The Boat Fueling Record is a locally prepared, daily record of the boat fueling. It is indispensable for ships carrying or maintaining a large number of boats. All operating boats should be fueled daily before 0800 to prevent fueling at unusual hours and to ensure readiness for unscheduled calls. The record for each boat should indicate (1) the boat number, (2) the fuel capacity in gallons, (3) the fuel on hand, (4) the approximate fuel consumption in gallons per hour, and (5) whether or not the boat was fueled to capacity.

OIL KING'S MEMORANDUM

The Oil King's Memorandum is a locally prepared report that includes soundings of all reserve feedwater tanks, fuel oil tanks, feedwater suction, and standby tanks. It is submitted twice daily to the EOOW and engineer officer.

BOILER WATER TREATMENT LOG

The forms in the following list are used to record data that helps maintain proper water conditions in a steam propulsion plant:

1. Cover Sheet and Monthly Boiler Data, NAVSEA 9255/6 (fig. 12-10).
2. Feedwater Chemistry Worksheet/Log, NAVSEA 9255/4 (fig. 12-11).
3. Boiler Water Chemistry Worksheet/Log, NAVSEA 9255/8 (fig. 12-12).
4. Trend Analysis Graphs, NAVSEA 9255/13 (Type A Boilers), NAVSEA 9255/12 (Type B Boilers).
5. Reserve/Makeup Feedwater Test Log, NAVSEA 9255/10 (fig. 12-13).

The Reserve/Makeup Feedwater Test Log, is used for feedwater tests on all ships with propulsion and auxiliary boilers. The Feedwater Log, with one of the previous logs listed, will be used on each ship to record the test of feedwater and test and treatment of boiler water.

Specific instructions for the maintenance of these logs are given in the NSTM, chapter 220, volume 2, and the Boiler/Feedwater Test and Treatment Course (certification course).

3-M SYSTEMS

The primary objective of the Navy Ship's Maintenance and Material Management (3-M) Systems is to manage maintenance and maintenance support in a manner that will ensure maximum equipment operational readiness. OPNAVINST 4790.4B, volumes I, II, and III, contain all of the detailed procedures and instructions for the effective operation of the 3-M Systems. That includes examples of the forms discussed in this chapter. Other instructions on the 3-M Systems are found in the type commander's maintenance manuals.

The following sections will discuss the most common records of the 3-M Systems that must be kept current in the engineering department.

PLANNED MAINTENANCE SCHEDULES

In an effective Planned Maintenance System (PMS), PMS schedules must be accurately filled out and posted in a timely manner. PMS schedules are categorized as cycle, quarterly, and weekly.

Cycle Schedule

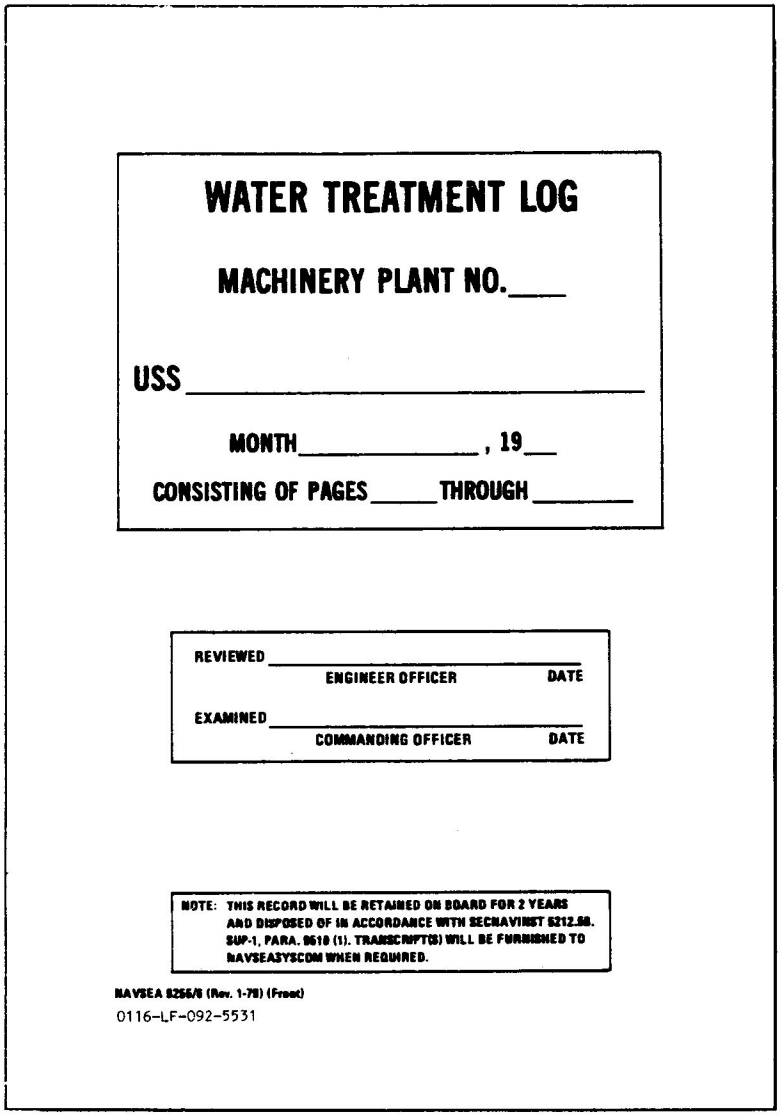
The Cycle PMS Schedule displays the planned maintenance requirements to be performed between major overhauls of the ship. The following information must be filled in on the cycle schedules ship's name and hull number, work center designator code, maintenance index page (MIP) number, component's or system's name, and maintenance scheduled in each quarter after overhaul.

The engineer officer must supervise all cycle scheduling of engineering department maintenance, and then sign and date the Cycle PMS Schedule before it is posted.

If there is a need to rewrite the Cycle PMS Schedule, the old schedules should be filed with the last quarterly schedule with which it was used.

Quarterly Schedule

The Quarterly PMS Schedule is a visual display of the work center's PMS requirements to be performed during a specific 3-month period. Spares are provided to enter the work center, quarter after overhaul, department head's signature, date prepared, and the



WATER TREATMENT LOG

MACHINERY PLANT NO.____

USS _____

MONTH _____, 19__

CONSISTING OF PAGES_____THROUGH _____

REVIEWED _____
ENGINEER OFFICER DATE

EXAMINED _____
COMMANDING OFFICER DATE

NOTE: THIS RECORD WILL BE RETAINED ON BOARD FOR 2 YEARS AND DISPOSED OF IN ACCORDANCE WITH SECNAVINST 5212.5B. SUP-1, PARA. 0510 (1). TRANSCRIPT(S) WILL BE FURNISHED TO NAVSEASYSCOM WHEN REQUIRED.

NAVSEA 9256/6 (Rev. 1-79) (Front)
0116-LF-092-5531

NAVSEA 9256/6 (Rev. 1-79) (Back)

MONTHLY BOILER DATA

TOTAL STEAMING HOURS

BOILER NUMBER			
DATE LAST INSPECTED			
INSPECTED BY			
HRS. BROUGHT FWD.			
HRS. THIS MONTH			
TOTAL HRS. TO DATE			

BOILER HOURS STEAMED SINCE LAST MECHANICAL WATERSIDE CLEANING

BOILER NUMBER			
DATE LAST CLEANED			
HRS. BROUGHT FWD			
HRS. THIS MONTH			
TOTAL HRS. TO DATE			

BOILER HOURS STEAMED SINCE LAST CHEMICAL WATERSIDE CLEANING

BOILER NUMBER			
DATE LAST CLEANED			
HRS. BROUGHT FWD			
HRS. THIS MONTH			
TOTAL HRS. TO DATE			

BOILER HOURS STEAMED SINCE LAST FIRESIDE CLEANING

BOILER NUMBER			
DATE LAST CLEANED			
HRS. BROUGHT FWD			
HRS. THIS MONTH			
TOTAL HRS. TO DATE			

BOILER SAFETY VALVES SET

	DATE	PRESSURE LIFT	PRESSURE RESEAT
BOILER NUMBER			
#1 DRUM			
#2 DRUM			
#3 DRUM			
PILOT			
SUPERHEATER			
BOILER NUMBER			
#1 DRUM			
#2 DRUM			
#3 DRUM			
PILOT			
SUPERHEATER			
BOILER NUMBER			
#1 DRUM			
#2 DRUM			
#3 DRUM			
PILOT			
SUPERHEATER			

WATER CHEMISTRY STANDARDS RUN

TEST	DATE	RESULT
CONDUCTIVITY (BOILER)		
CHLORIDE (BOILER)		
PHOSPHATE (BOILER)		
HARDNESS (FEEDWATER)		
CHLORIDE (FEEDWATER)		

HYDROSTATIC TEST DATES

BOILER NUMBER			
LAST 150% HYDRO			
LAST 125% HYDRO			

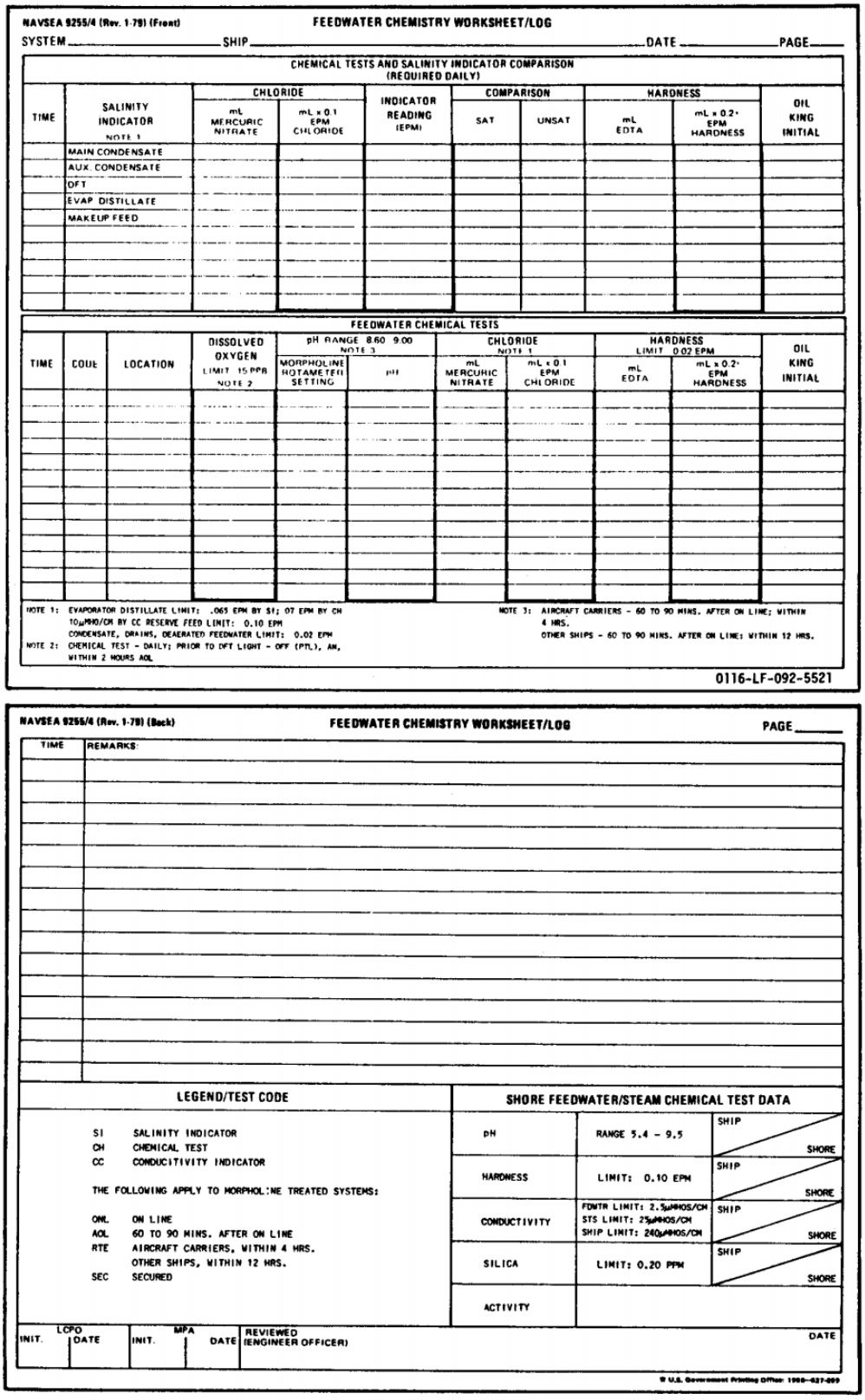
DATES OF IMPORTANT EVOLUTIONS

BOILER NUMBER								
SOOT BLOWER HOT								
BOTTOM BLOWDOWN PIPING HOT								
AIR CASING TEST								
SATISFACTORY BOILER FLEXIBILITY TEST								
SATISFACTORY FULL POWER								
SATISFACTORY ECONOMY TRIAL								

GOVERNOR SETTINGS

NUMBER										
FORCED DRAFT BLOWERS	Cone / Governing									
NUMBER										
FUEL OIL SERVICE PUMPS	Cone / Governing									
NUMBER										
MAIN FEED PUMPS	Cone / Governing									
NUMBER										
MAIN FEED BOOSTER PUMPS	Cone / Governing									

Figure 12-10.—Cover Sheet and Monthly Boiler Data.



NAVSEA 9255/4 (Rev. 1-79) (Front) FEEDWATER CHEMISTRY WORKSHEET/LOG

SYSTEM _____ SHIP _____ DATE _____ PAGE _____

CHEMICAL TESTS AND SALINITY INDICATOR COMPARISON (REQUIRED DAILY)

TIME	SALINITY INDICATOR NOTE 1	CHLORIDE: mL MERCURIC NITRATE	CHLORIDE: mL x 0.1 EPM CHLORIDE	INDICATOR READING (EPM)	COMPARISON: SAT	COMPARISON: UNSAT	HARDNESS: mL EDTA	HARDNESS: mL x 0.2 EPM HARDNESS	OIL KING INITIAL
	MAIN CONDENSATE								
	AUX. CONDENSATE								
	DFT								
	EVAP DISTILLATE								
	MAKEUP FEED								

FEEDWATER CHEMICAL TESTS

TIME	CODE	LOCATION	DISSOLVED OXYGEN LIMIT .15 PPB NOTE 2	pH RANGE 8.60 9.00 NOTE 3: MORPHOLINE ROTAMETER SETTING	pH	CHLORIDE NOTE 1: mL MERCURIC NITRATE	CHLORIDE NOTE 1: mL x 0.1 EPM CHLORIDE	HARDNESS LIMIT .02 EPM: mL EDTA	HARDNESS LIMIT .02 EPM: mL x 0.2 EPM HARDNESS	OIL KING INITIAL

NOTE 1: EVAPORATOR DISTILLATE LIMIT: .065 EPM BY SI; 07 EPM BY CH
10μMHO/CH BY CC RESERVE FEED LIMIT: 0.10 EPM
CONDENSATE, DRAINS, DEAERATED FEEDWATER LIMIT: 0.02 EPM

NOTE 2: CHEMICAL TEST - DAILY; PRIOR TO DFT LIGHT - OFF (PTL), AM, WITHIN 2 HOURS AOL

NOTE 3: AIRCRAFT CARRIERS - 60 TO 90 MINS. AFTER ON LINE; WITHIN 4 HRS.
OTHER SHIPS - 60 TO 90 MINS. AFTER ON LINE: WITHIN 12 HRS.

0116-LF-092-5521

NAVSEA 9255/4 (Rev. 1-79) (Back) FEEDWATER CHEMISTRY WORKSHEET/LOG PAGE _____

TIME	REMARKS:

LEGEND/TEST CODE

SI SALINITY INDICATOR
CH CHEMICAL TEST
CC CONDUCITIVITY INDICATOR

THE FOLLOWING APPLY TO MORPHOLINE TREATED SYSTEMS:

ONL ON LINE
AOL 60 TO 90 MINS. AFTER ON LINE
RTE AIRCRAFT CARRIERS, WITHIN 4 HRS.
OTHER SHIPS, WITHIN 12 HRS.
SEC SECURED

SHORE FEEDWATER/STEAM CHEMICAL TEST DATA

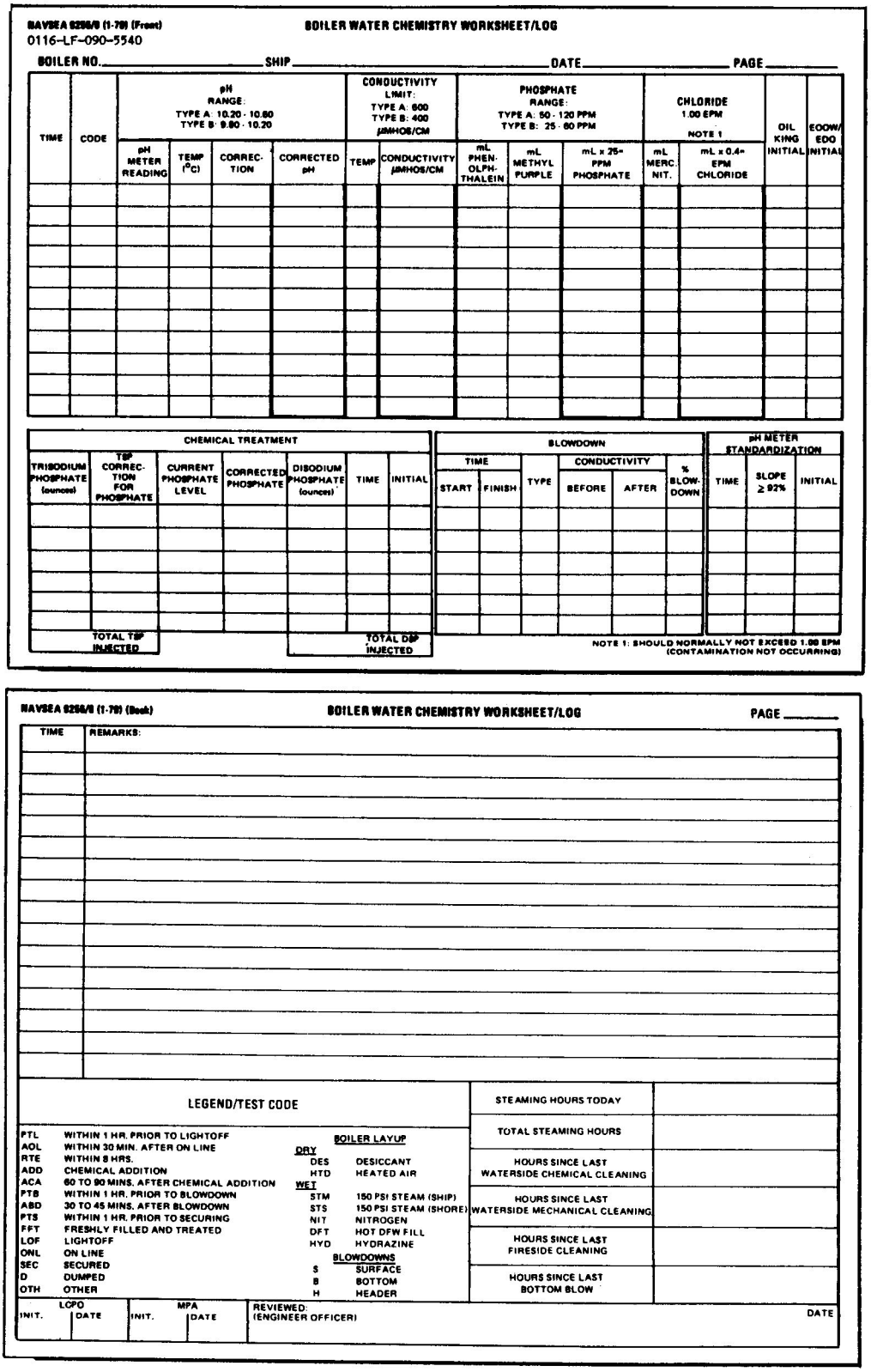
		SHIP / SHORE
pH	RANGE 5.4 - 9.5	SHIP / SHORE
HARDNESS	LIMIT: 0.10 EPM	SHIP / SHORE
CONDUCTIVITY	FDNTR LIMIT: 2.5μMHOS/CM STS LIMIT: 25μMHOS/CM SHIP LIMIT: 240μMHOS/CM	SHIP / SHORE
SILICA	LIMIT: 0.20 PPM	SHIP / SHORE
ACTIVITY		

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

U.S. Government Printing Office: 1980-627-099

Figure 12-11-Feedwater Chemistry Worksheet/Log.

months covered. The schedule has 13 columns, one for each week in the quarter. These permit scheduling of maintenance requirements on a weekly basis throughout the quarter. There are also columns to enter the MIP number and PMS requirements require rescheduling. There are “tic” marks across the top of the scheduling columns for use in showing the in-port/underway time of the ship for the quarter.



NAVSEA 9256/8 (1-79) (Front) — BOILER WATER CHEMISTRY WORKSHEET/LOG

0116-LF-090-5540

BOILER NO. _____ SHIP _____ DATE _____ PAGE _____

TIME	CODE	pH RANGE: TYPE A: 10.20 - 10.60 TYPE B: 9.80 - 10.20				CONDUCTIVITY LIMIT: TYPE A: 600 TYPE B: 400 µMHOS/CM		PHOSPHATE RANGE: TYPE A: 50 - 120 PPM TYPE B: 25 - 60 PPM			CHLORIDE 1.00 EPM NOTE 1		OIL KING INITIAL	EOOW/ EDO INITIAL
		pH METER READING	TEMP (°C)	CORRECTION	CORRECTED pH	TEMP	CONDUCTIVITY µMHOS/CM	mL PHENOLPHTHALEIN	mL METHYL PURPLE	mL x 25= PPM PHOSPHATE	mL MERC. NIT.	mL x 0.4= EPM CHLORIDE		

CHEMICAL TREATMENT						
TRISODIUM PHOSPHATE (ounces)	TSP CORRECTION FOR PHOSPHATE	CURRENT PHOSPHATE LEVEL	CORRECTED PHOSPHATE	DISODIUM PHOSPHATE (ounces)	TIME	INITIAL
TOTAL TSP INJECTED				TOTAL DSP INJECTED		

BLOWDOWN					
TIME			CONDUCTIVITY		
START	FINISH	TYPE	BEFORE	AFTER	% BLOWDOWN

pH METER STANDARDIZATION		
TIME	SLOPE ≥ 92%	INITIAL

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

NAVSEA 9256/8 (1-79) (Back) — BOILER WATER CHEMISTRY WORKSHEET/LOG — PAGE _____

TIME	REMARKS:

LEGEND/TEST CODE

PTL	WITHIN 1 HR. PRIOR TO LIGHTOFF
AOL	WITHIN 30 MIN. AFTER ON LINE
RTE	WITHIN 8 HRS.
ADD	CHEMICAL ADDITION
ACA	60 TO 90 MINS. AFTER CHEMICAL ADDITION
PTB	WITHIN 1 HR. PRIOR TO BLOWDOWN
ABD	30 TO 45 MINS. AFTER BLOWDOWN
PTS	WITHIN 1 HR. PRIOR TO SECURING
FFT	FRESHLY FILLED AND TREATED
LOF	LIGHTOFF
ONL	ON LINE
SEC	SECURED
D	DUMPED
OTH	OTHER

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

BLOWDOWNS

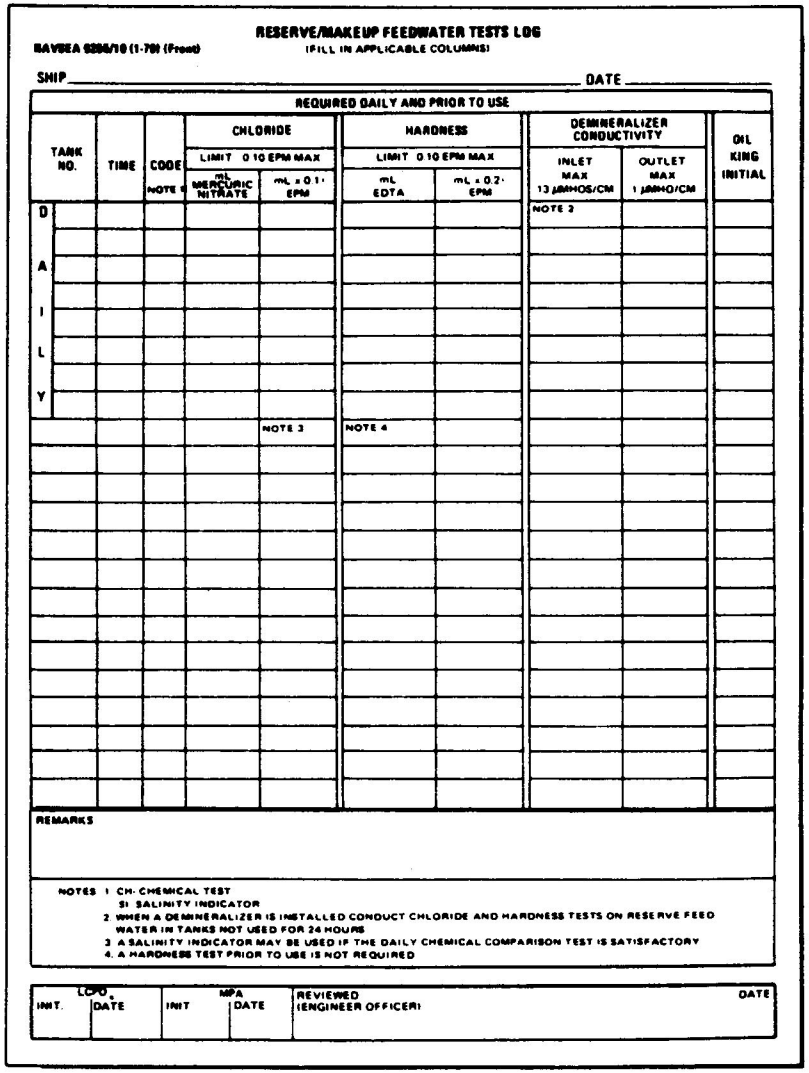
S	SURFACE
B	BOTTOM
H	HEADER

STEAMING HOURS TODAY	
TOTAL STEAMING HOURS	
HOURS SINCE LAST WATERSIDE CHEMICAL CLEANING	
HOURS SINCE LAST WATERSIDE MECHANICAL CLEANING	
HOURS SINCE LAST FIRESIDE CLEANING	
HOURS SINCE LAST BOTTOM BLOW	

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

Figure 12-12.—Boiler Water Chemistry Worksheet/Log.

The engineer officer must supervise scheduling of PMS on the quarterly schedule for his department. The engineer officer must then sign and date the schedule before it is posted. At the end of each quarter, the engineer officer must review the quarterly schedule, check the reasons for PMS actions not accomplished, and sign the form in the space provided on its reverse side. The division officer is responsible for updating the



RESERVE/MAKEUP FEEDWATER TESTS LOG

NAVSEA 9355/10 (1-79) (Front) (FILL IN APPLICABLE COLUMNS)

SHIP _____ DATE _____

REQUIRED DAILY AND PRIOR TO USE

TANK NO.	TIME	CODE (NOTE 1)	CHLORIDE LIMIT 0.10 EPM MAX: mL MERCURIC NITRATE	CHLORIDE: mL x 0.1 = EPM	HARDNESS LIMIT 0.10 EPM MAX: mL EDTA	HARDNESS: mL x 0.2 = EPM	DEMINERALIZER CONDUCTIVITY: INLET MAX 13 µMHOS/CM (NOTE 2)	DEMINERALIZER CONDUCTIVITY: OUTLET MAX 1 µMHO/CM	OIL KING INITIAL
DAILY									
				NOTE 3	NOTE 4				

REMARKS

NOTES 1. CH- CHEMICAL TEST
SI SALINITY INDICATOR
2. WHEN A DEMINERALIZER IS INSTALLED CONDUCT CHLORIDE AND HARDNESS TESTS ON RESERVE FEED WATER IN TANKS NOT USED FOR 24 HOURS
3. A SALINITY INDICATOR MAY BE USED IF THE DAILY CHEMICAL COMPARISON TEST IS SATISFACTORY
4. A HARDNESS TEST PRIOR TO USE IS NOT REQUIRED

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

FEEDWATER TANK SOUNDINGS

NAVSEA 9355/10 (1-79) (Back)

TIME	TANK NO. _____	_____	_____	_____	_____	_____	_____	_____	TOTAL FEED-WATER (GALLONS)	%
0000										
0100										
0200										
0300										
0400										
0500										
0600										
0700										
0800										
0900										
1000										
1100										
1200										
1300										
1400										
1500										
1600										
1700										
1800										
1900										
2000										
2100										
2200										
2300										
2400										

Figure 12-13.—Reserve/Makeup Feedwater Tests Log.

quarterly schedule every week. Completed quarterly schedules should be kept on file for 1 year.

Weekly Schedule

The Weekly PMS Schedule is a visual display of the planned maintenance scheduled for a given work center during a specific week. The work center supervisor uses weekly schedules to assign and monitor work on the PMS tasks by work center personnel.

The Weekly PMS Schedule contains blank spaces to be filled in for work center code, date of current week division officer's signature, MIP number minus the date code, component names, names of personnel responsible for specific maintenance requirements, outstanding major repairs, and situation requirements.

The work center supervisor is responsible for completing the Weekly PMS Schedule and for updating it every day.

FEEDBACK FORM

The PMS Feedback Report Form, OPNAV Form 4790/7B, provides maintenance personnel with the means to report discrepancies and problems and to request PMS coverage. All PMS Feedback Reports are sent to NAVSEACANs or TYCOMs, based on the category of the feedback report.

Feedback reports are originated in the work center and must be signed by the originator. They are then screened and signed by the division officer and the engineer officer before being forwarded to the 3-M coordinator. The 3-M coordinator will date and sign the feedback report, serialize it, and return the green copy to the originating work center. The originating work center will file the green copy until an answer to the feedback report is received.

SHIP'S MAINTENANCE ACTION FORM

The Ship's Maintenance Action Form, OPNAV 4790/2K, is used by maintenance personnel to report deferred maintenance and completed maintenance. This form also allows the entry of screening and planning information for management and control of intermediate maintenance activity (IMA) workloads.

The OPNAV 4790/2K is originated in the work center. It is screened for accuracy and legibility, and initialed by the division officer and engineer officer before being forwarded to the 3-M coordinator. When the form is used to defer maintenance, the 3-M coordinator will send two copies back to the originating work center to hold on file. When the deferred maintenance is completed, one of the copies is used to document the completion of the maintenance.

CURRENT SHIP'S MAINTENANCE PROJECT

The standard Current Ship's Maintenance Project (CSMP) is a computer-produced report listing deferred maintenance and alterations that have been identified through Maintenance Data Collection System (MDCS) reporting. Copies of the CSMP should be received monthly. The engineer officer is provided with a copy for each of the engineering department work centers, and each work center is provided a copy that shows only its own deferred maintenance.

The purpose of the CSMP is to give shipboard maintenance managers a consolidated list of deferred corrective maintenance. They can use the list to manage and control maintenance in the deferred items. The work center supervisor is responsible for ensuring the CSMP accurately describes the material condition of his work center.

Each month when a new CSMP is received, verified, and updated, the old CSMP maybe destroyed.

OPNAVINST 4790.4B, contains the instructions and procedures needed to complete and route all 3-M Systems forms.

ADDITIONAL RECORDS

The engineering department records and reports discussed in this section inform responsible personnel of coming events (including impending casualties). They supply data for the analysis of equipment performance, provide a basis for design comparison and improvement, or provide information for the improvement of maintenance techniques and the development of new work methods. The records are those papers that must be compiled and retained on board (in original or duplicate form) for prescribed periods. They are primarily used for reference in administrative and operational matters. The reports are of either a one-time or recurring nature. Recurring reports are required at prescribed or set intervals, while one-time reports need to be made on the occurrence of a given situation.

ENGINEER OFFICER'S NIGHT ORDER BOOK

The engineer officer keeps a Night Order Book as part of the engineering records. In it the engineer officer enters orders with respect to (1) operation of the engineering plant (2) any special orders or precautions concerning the speed and operation of the main engines, and (3) all other orders for the night for the EOOW. The Night Order Book is prepared and maintained according to instructions issued by the type commander. Some type commanders require that the Night Order Book have a specific format that is standard for ships of the type. Others allow use of a locally prepared form but specify certain contents of the book.

The Night Order Book must contain orders covering routine recurring situations (engineering department standing orders) as well as orders for the night for the EOOW. Standing orders are issued by the engineer officer as a letter-type directive (instruction), according to the ship's directives systems. A copy of the instruction is posted in the front of the Night Order Book. Orders for the night for the EOOW generally specify the boilers and other major items of machinery to be used during the night watches. A form similar to the one illustrated in figure 12-14 is in use in some ships for the issuance of the engineer officer's night orders.

The Night Order Book is maintained in port and at sea. In the temporary absence of the engineer officer in port, the engineering department duty officer maintains it. Underway, the Night Order Book is delivered to the EOOW before 2000 and is returned to the log room before 0800 of the following day. In addition to the EOOW, principal engineering watch supervisors and the oil king should read and initial the night orders for the watch. In port, the leading duty petty officer of each engineering division and the principal watch supervisors should read and initial the night orders.

STEAMING ORDERS

Steaming Orders are written orders issued by the engineer officer. They list the major machinery units and readiness requirements of the engineering department based upon the time set to get the ship underway. Generally, a locally prepared form similar to the one illustrated in figure 12-15 is used to issue the Steaming Orders. The orders normally specify the (1) engine combinations to be used, (2) times to light fires and cut in boilers, (3) times to warm up and test main engines, (4) times to start and parallel ship's service generators, (5) standard speed, and (6) EOOW and principal watch supervisors. Early posting of Steaming Orders is essential to get a ship with a large engineering plant under way.

GYROCOMPASS SERVICE RECORD

A Gyrocompass Service Record Book is furnished to the ship for each gyrocompass installed The book is a complete record of inspections, tests, and repairs to the gyrocompass and must always remain with its associated gyrocompass. The front of the book contains complete instructions for maintaining the record-they must be followed carefully. If the Gyrocompass Service Record Book is lost or damaged, use the *Navy Stock List of Publications and Form*, NAVSUP 2002, to get a replacement. Include the mark, modification, and serial number of the gyrocompass for which the book is intended.

DEGAUSSING FOLDER

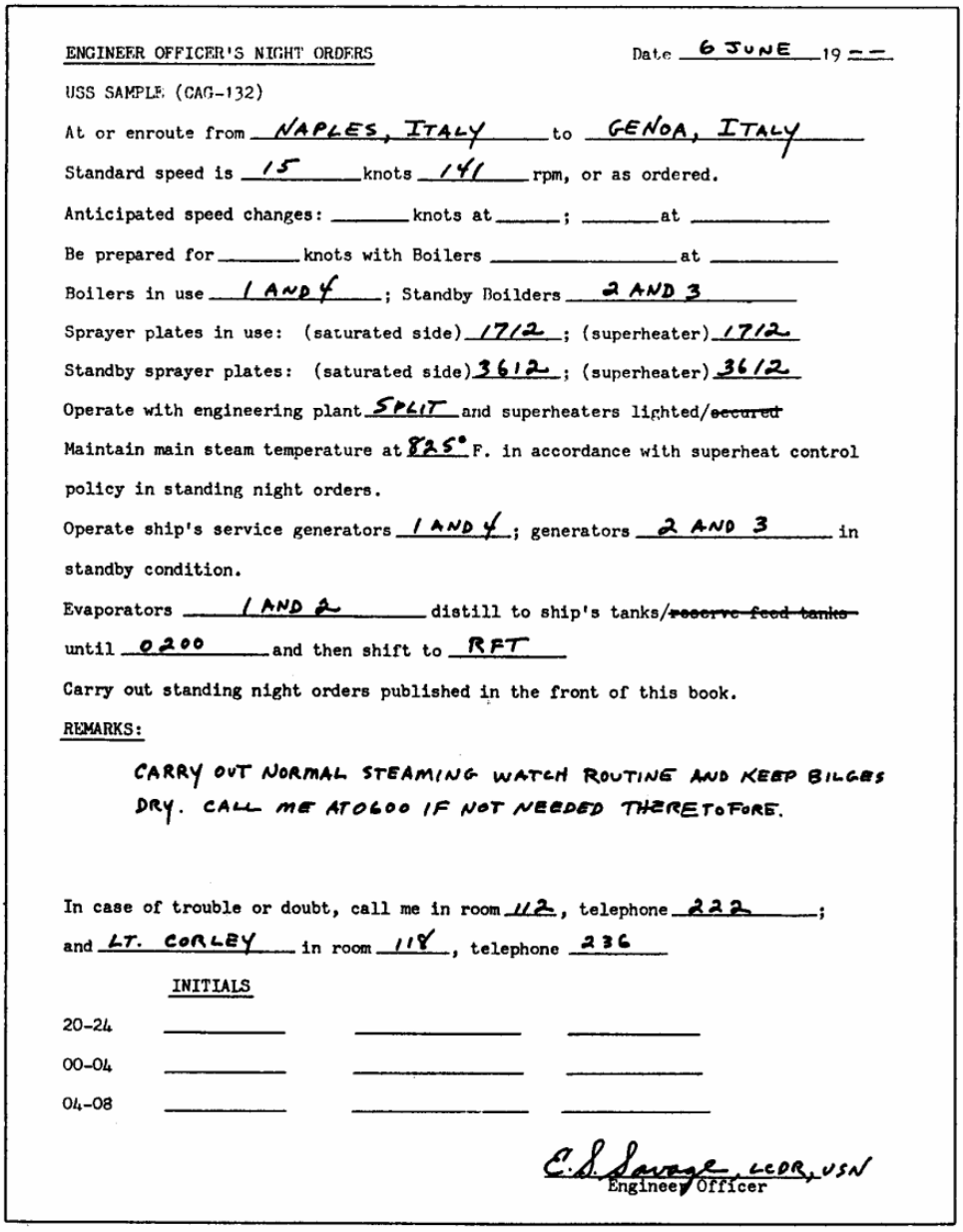
The ship's Degaussing Folder is a record of the degaussing installation in the ship. The folder contains (1) a description of the degaussing installation; (2) a record of inspections, tests, and repairs performed by repair activities; (3) the values of all coil currents for the ship's position and headings; and (4) a record of the degaussing range runs. The Degaussing Folder is necessary to the operation of the degaussing system and must be safeguarded against loss. Generally, the navigator keeps the Degaussing Folder with the names of engineering personnel who will use it.

The Ship's Degaussing Action Log, NAVSEA 8950/19, is provided for recording maintenance of the degaussing system performed by the ship's force. When complete, the forms are inserted in the degaussing folder.

BOILER TUBE FAILURE REPORTS

The form shown in figure 12-16 is a standard form to be used when reporting failed or replaced boiler pressure parts. The form (NAVSEA 95 10/2), together with any required samples of deposits, tubes, and boiler water, should be forwarded to the nearest shipyard or repair facility for analysis and report.

If the tube failure is unusual and there is doubt of the cause, send the tubes and report to the Naval Ships Engineering Center, Philadelphia Division (formerly Naval Boiler and Turbine Laboratory). Send them



ENGINEER OFFICER'S NIGHT ORDERS Date 6 JUNE 19--

USS SAMPLE (CAG-132)

At or enroute from NAPLES, ITALY to GENOA, ITALY

Standard speed is 15 knots 141 rpm, or as ordered.

Anticipated speed changes: _____ knots at _____; _____ at _____

Be prepared for _____ knots with Boilers _____ at _____

Boilers in use 1 AND 4; Standby Boilders 2 AND 3

Sprayer plates in use: (saturated side) 1712; (superheater) 1712

Standby sprayer plates: (saturated side) 3612; (superheater) 3612

Operate with engineering plant SPLIT and superheaters lighted/~~secured~~

Maintain main steam temperature at 825° F. in accordance with superheat control policy in standing night orders.

Operate ship's service generators 1 AND 4; generators 2 AND 3 in standby condition.

Evaporators 1 AND 2 distill to ship's tanks/~~reserve feed tanks~~ until 0200 and then shift to RFT

Carry out standing night orders published in the front of this book.

REMARKS:

CARRY OUT NORMAL STEAMING WATCH ROUTINE AND KEEP BILGES DRY. CALL ME AT 0600 IF NOT NEEDED THERETOFORE.

In case of trouble or doubt, call me in room 112, telephone 222;
and LT. CORLEY in room 118, telephone 236

	INITIALS		
20-24	_____	_____	_____
00-04	_____	_____	_____
04-08	_____	_____	_____

C. L. Savage, LCDR, USN
Engineer Officer

Figure 12-14.-Engineer Officer's Night Orders (sample).

according to current instructions issued by NAVSEASYSCOM.

When filling out the Boiler Tube Casualty Report, always use standard terminology to provide meaningful
information on the nature and causes of the damage. If you cannot determine the exact type of damage, remember and use the following terms to help you.

- **RUPTURE** describes all openings associated with tube enlargement;

- **PERFORATION** describes openings other than cracks that are not associated with tube enlargement;

- **CRACK** describes a longitudinal or circumferential separation where there is no appreciable tube enlargement.

If it is necessary to submit samples in connection with boiler pressure part damage, follow current instructions issued by NAVSEASYSCOM. Here are a few tips on how to prepare and submit samples:

U.S.S. SPEEDWELL CV-3333
ENGINEERING DEPARTMENT
STEAMING ORDERS

Date 17 August, 19__

The ship is scheduled to get underway at 1400, 18 August, 19__

1. The Engineering Department shall report ready to get underway at 1345 (zero time)

2. Boilers Nos. 1,2,3,4,6,8 shall be used.

3. Steaming watches (3rd steaming section) below as follows:

SPACE	BOILERS	MACHINERY
No. 1 Machinery Space		
No. 2 Machinery Space		
No. 3 Machinery Space		
No. 4 Machinery Space		

4. Light Boiler Nos. 1, 2 at 0800; Cut-in 1030
Boiler Nos. 3, 4 at 1000; Cut-in 1230
Boiler Nos. _____ at _____; Cut-in _____

5. Commence warming-up main engines at 1130, and follow warming-up schedule.

6. Warm up Nos. 2 1250-K.W. generators at 0800; cut in (idle) 0900.
Nos. 4 1250-K.W. generators at 1200; cut in (idle) 1245.
Nos. _____ 1250-K.W. generators at ____; cut in (idle) _____.

7. Test main engines at 1330. Report the Engineering Department ready to get underway to Engineer Officer.

8. Have all burners made up with 3208 sprayer plates and in use by _____.
Standby 2508 sprayer plates.

9. Operate 2 set(s) evaporators, and distill as directed by E.O.O.W.

10. Calls

Engineer Officer	0700
Assistant Engineer Officer	0630
Main Propulsion Assistant	0600

On Station:

Duty Officer	R.E. Caldwell
Junior Duty Officer	G.E. Holt
Duty MMC	Miller, MMC
Duty MMC	Smith, MMC
Duty BTC	Walters, BTC
Duty EMC	Land, EMC

11.

Watch	E.O.O.W.	J.O.O.W.
0000-0400	D. D. Harper, Lt(jg)	R. S. Smith, Ensign
0400-0800	R. C. Johnson, Lt.	E. E. Robertson, Ensign
0800-1200	C. C. Smart, Ch. Mach.	D. F. Edwards, Ensign
1200-1600	R. E. Caldwell, Lt(jg)	G. E. Holt, Mach.
1600-1800	D. D. Harper	R. S. Smith
1800-2000	R. C. Johnson	E. E. Robertson
2000-2400	C. C. Smart	D. F. Edwards

Unless notified otherwise, standard speed will be 15 knots, 115 rpm.

Glenn Eyler, LCDR, U.S.N.
(Engineer Officer)

Copies: Duty Officer and C.P.O.'s, Steaming M.S.,
Div. B.B.'s, File.

Figure 12-15.-Steaming Orders (sample).

- Samples of damaged pressure parts must be obtained as nearly as possible in their original form. A complete tube section containing an example of the metal damage makes a good sample.

- Cut sample tubes into convenient lengths for shipping, but mark them **CLEARLY** for reassembly. Do **NOT** use oil for cutting a tube that is to be submitted as a sample. Cut sample tubes so the damaged area will not be cut, burned, or otherwise disfigured.

- A poorly labeled sample is nearly worthless. Mark tube sections with paint to show the side toward the furnace, the top and bottom orientation of the tube, the distance of the rupture, crack, or fault from the furnace floor or roof (if the complete tube is not forwarded), and the steam drum end. Also, use paint to show the relationship of each section to the other sections of the tube, the boiler number, the name of the ship, and any other necessary information. The marking must not cover or contaminate the damaged area. Do **NOT**

BOILER TUBE FAILURE REPORT
NAVSEA 9510/2

INSTRUCTIONS – Check or fill in as applicable. A separate report should be filled out for each circuit, for each type of failure noted. Derangements of a particular circuit (warpage, sagging, marrings, blisters, etc.) which accompany but do not constitute a complete failure (rupture, perforation, crack, etc.) may be described under REMARKS on last page. Forward report to Naval Ship Systems Engineering Station, Philadelphia, PA 19112. When failed tube is forwarded for analysis, forward adjacent tube.

A. SHIP: USS_____ BOILER NO._____ DATE_____

DATE OF FAILURE_____ CIRCUIT_____

TYPE OF FAILURE
RUPTURE_____: THIN-LIPPED_____ THICK-LIPPED_____
CRACK_____: LONGITUDINAL_____ TRANSVERSE_____
PERFORATION_____.
PITTING_____: FIRESIDE CORROSION_____ WATERSIDE CORROSION_____
OTHER_____:_____(Describe under COMMENTS)

FAILED TUBE NO.(S)_____

TUBE IDENTIFICATION ACCORDING TO:
TUBE PLAN IN MFRS. INSTRUCTION BOOK:_____ TUBE IDENTIFICATION SHEET_____

B. WATERSIDE DEPOSITS_____ FIRESIDE DEPOSITS_____

THICKNESS OF DEPOSITS: W/S_____ F/S_____

INDICATIONS ON WATERSIDES: OIL_____ FOREIGN OBJECTS_____

C. APPROXIMATE LOCATION OF FAILURE FROM:

FURNACE FLOOR (Water Wall Tubes)_____ FT
WATER DRUM (Generating Bank Tubes)_____ FT
SUPERHEATER HEADER:_____ FT FROM INLET OF_____ OR OUTLET OF_____
PASS NO._____.
ECONOMIZER HEADER:_____ FT FROM INLET_____ OR OUTLET_____ HEADER
DESUPERHEATER HEADER:_____ FT FROM INLET_____ OR OUTLET_____ HEADER
ORIENTATION OF FAILURE:_____ TOWARD FURNACE _____ AWAY FROM FURNACE _____

D. OPERATING CONDITIONS AT TIME OF DISCOVERY OF FAILURE:

I STEAM RATE_____ (% FULL POWER)
BOILER LOAD: INCREASING_____ DECREASING _____ STEADY _____
SPRAYER PLATE SIZE(S) IN USE _____
NUMBER AND LOCATION OF BURNER(S) IN USE_____

II LIGHTING OFF_____ SECURING_____ LAY-UP_____

III UNDER HYDROSTATIC TEST. . . .AT_____PSIG

SHEET 1 OF 2

E. IF RUPTURE OCCURRED: ACTION TAKEN IMMEDIATELY AFTER DISCOVERY (DESCRIBE)_____

TOTAL STEAM HOURS ON FAILED TUBE(S): SINCE INSTALLATION_____
ON WATERSIDES: SINCE LAST CHEMICAL CLEANING_____
SINCE LAST MECHANICAL CLEANING_____
ON FIRESIDES SINCE LAST CLEANING_____

FAILED TUBE(S): PLUGGED_____ RENEWED_____ DATE_____
IF RENEWED: INSTALLING ACTIVITY: SHIP'S FORCE_____
SHIPYARD (NAME)_____
TENDER/REPAIR ACTIVITY (NAME)_____

SAMPLES FORWARDED FOR ANALYSIS: DATE_____ TUBE NO.(S)_____

F. COMMENTS: (ADDITIONAL INFORMATION, SUSPECTED CAUSE OF FAILURE.)

SHEET 2 OF 2

Figure 12-16.—Boiler Tube Failure Report.

submit tube samples with paper tags tied onto them; when paper tags are used, they generally become lost or disfigured long before the sample arrives at its destination.

- The best way to submit a sample of a tube deposit is usually to submit a section of the tube with the deposit still in place. If for some reason this cannot be done, separate the deposit sample from the metal. Use a sharp instrument that can take the entire thickness of the deposit down to the sound metal. As a last resort, you can take deposit samples by scraping or brushing. However, samples taken in this way are broken up and frequently contaminated with other material. They provide limited useful information.

- Forward deposit samples in clean bottles or cans. Permanently mark the container with all the required identifying information.

- Take a 1-gallon sample of boiler water while the boiler is being emptied or just before it is emptied and submit it with samples of waterside deposits. Be sure the bottle is clean before the sample is collected. Fill the bottle almost to the top; stopper it tightly; and label it clearly with all identifying information, including information on recent water tests and water treatment.

- When you submit samples for analysis, send an explanatory letter with them. Include information on the circumstances under which the failure ocurred, the cause of the failure (if known), the firing rate at the time, the number of steaming hours since the last waterside cleaning, and any other pertinent formation.

BOILER TUBE RENEWAL SHEETS

Boiler Tube Renewal Sheets, often called Boiler Tube Data Sheets, should be used to keep a record of defective tubes and of renewed tubes. Boiler Tube Renewal Sheets are available for most boilers now in naval use. Figure 12-17 illustrates this form for a Babcock & Wilson double-furnace boiler; figure 12-18, A and B, shows the form for a Foster Wheeler single-furnace boiler. If Boiler Tube Renewal Sheets are not available for a particular boiler, similar forms can be prepared from the boiler plans.

SHIP CHARACTERISTICS CARDS

The Ship Characteristics Card, OPNAV 9010/2, is a report of comprehensive information essential to an understanding of the characteristics and capabilities of surface ships and service craft. A similar report, the Submarine Characteristics Card, OPNAV 9010/1, applies to submarines. Current OPNAV and fleet commanders directives prescribe the distribution and frequency of submission of the ship and submarine characteristics cards. The current revision of OPNAVINST 9010.8 applies. The report includes instructions for completing the forms.

The data in the Ship Characteristics Card must be accurate and complete because CNO uses it for planning. Where accurate data are not available, make an estimate and mark it with the letter *E*, and then follow up with exact data as soon as practical.

CNO requires that all ships submit the Ship Characteristics Card (1) upon commissioning or being placed in service, (2) within 30 days after completion of regular overhaul, and (3) whenever a change in military characteristics (including any change in weapons installations) is made. The engineer officer must make certain that the current revision of the Ship Characteristics Card is used to submit the reort. When filled in, the Ship Characteristics Card is classified Confidential.

MAIN PROPULSION TURBINE CONDITION REPORT

The Main Propulsion Turbine Condition Report is a letter report of the condition of each propulsion turbine and is submitted to NAVSEASYSCOM via the type commander 3 months before each regular overhaul. The report includes data and information on the turbines according to NAVSEASYSCOM requirements pertaining to main propelling machinery. The report includes recommendations by the commanding officer and type commander that the turbine should or should not be disassembled for inspection and overhaul during the regular period.

When the type commander's endorsement on a turbine condition report recommends disassembly of the turbine casing, NAVSEASYSCOM reviews and normally approves the recommendation. However, the type commander may ask for additional information or alternate or additional tests and inspections before approving disassembly of the casing. When the turbine report shows the condition of the tubine is satisfactory and no urgent alterations are necessary, NAVSEASYSCOM does not answer the report. Any answer from NAVSEASYSCOM that approves disassembly or asks for additional tests or inspections

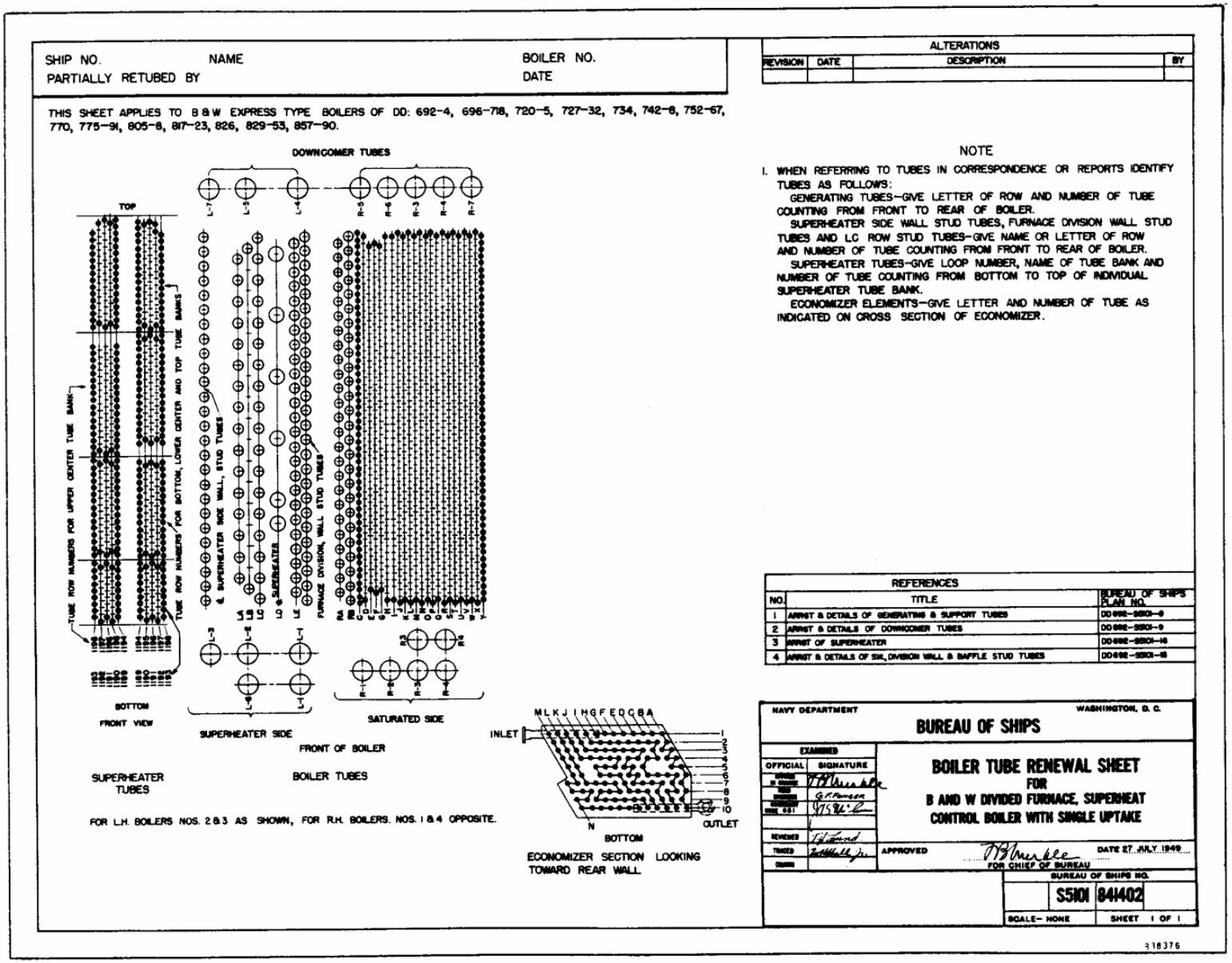


Figure 12-17.—Boiler Tube Renewal Sheet for a Babcock & Wilcox Double-furnace Boiler.

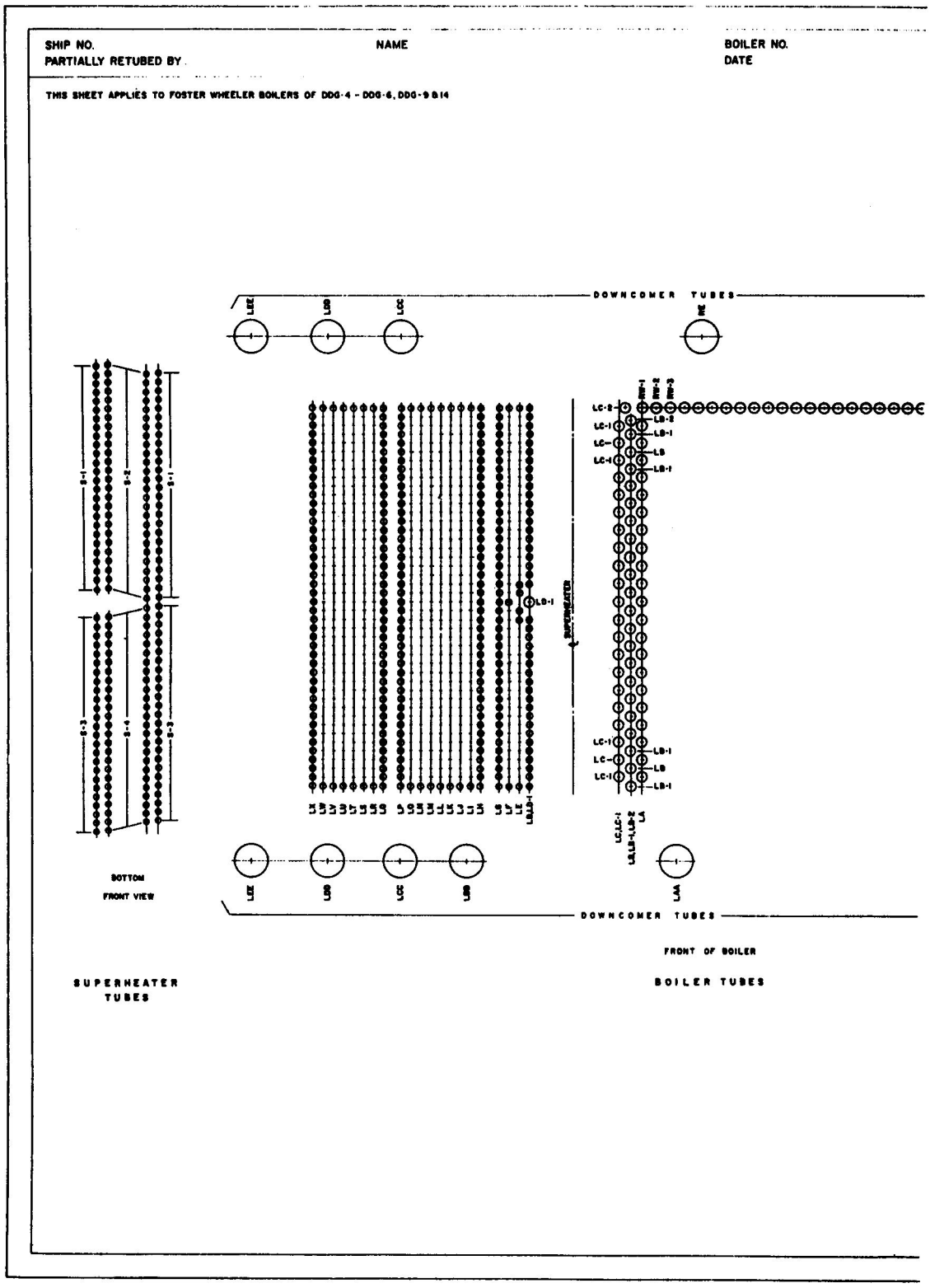


Figure 12-18.—Boiler Tube Renewal Sheet for a Foster-Wheel Single Furnace Boiler.

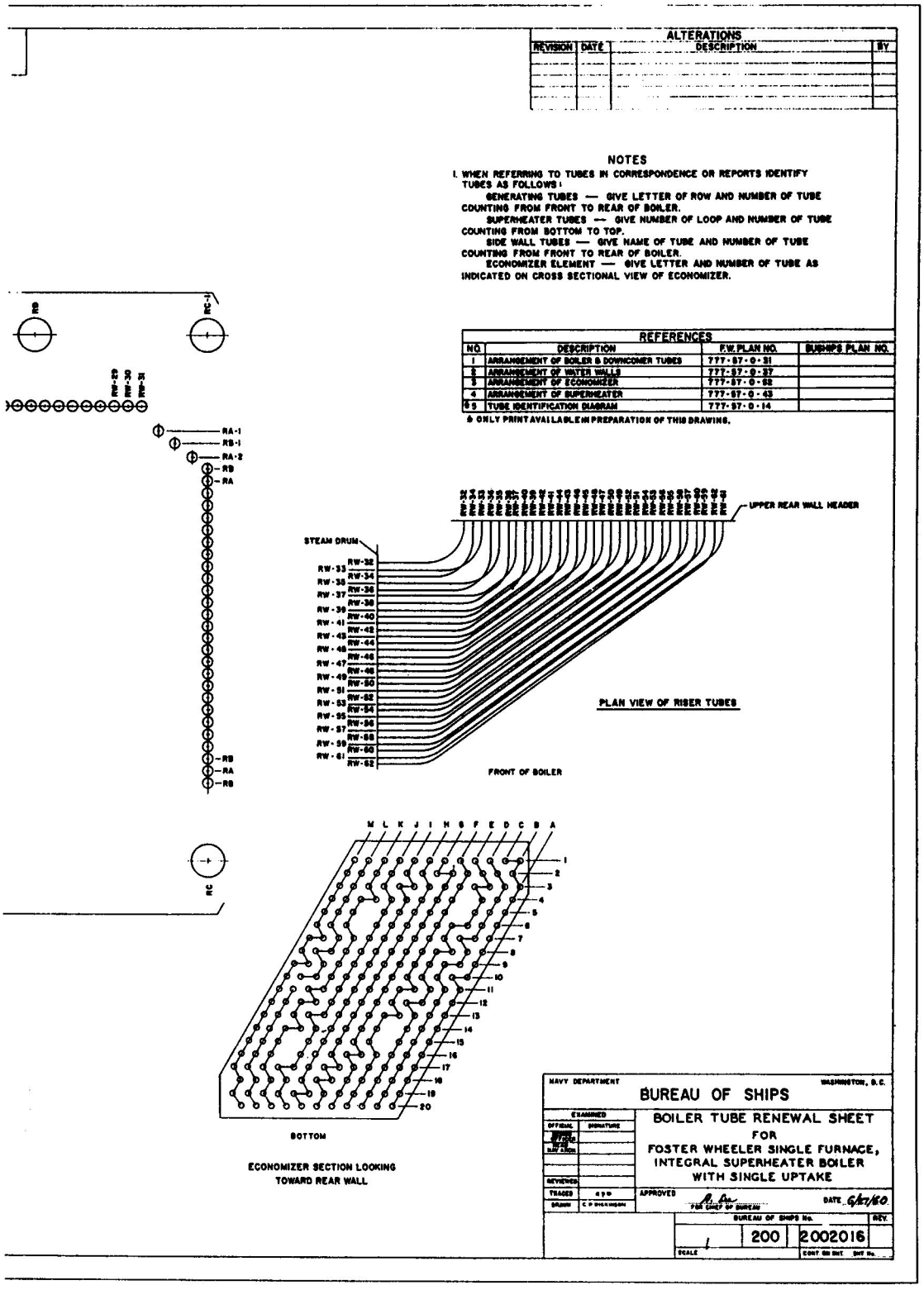


Figure 12-18.—Boiler Tube Renewal Sheet for a Foster-Wheel Single Furnace Boiler—Continued.

REPORT NUMBER NAVSEA	TITLE	FORMAT	CODE	REFERENCE NTSM CHAPTER
9070-2	docking report	NAVSEA 9070/1 9070/2 9070/3 9070/4 9070/5	S	Chap. 997 (9070) 094 (9080)
9000-1	Delivery Report upon Delivery of any Ship to any Government	Letter	S	094 (9080)
9880-2	Storm Damage to Ships— report of	Letter	S	100 (9110)
4710-2	Examination of Structure by Shipyards; report of	Letter or message	S	100 (9110)
4730-1	Periodic Cargo Tank Inspections & Tests (AO, AOR & AOG)	Letter	S	100 (9110)
9080-1	Report of Deep Div	Letter	S	100 (9110)
3530-2	Magnetic Compass Table	NAVSEA 3120/4	S or every 12 mo.	252 (9240)
9291-2	Report of Solid Ballast Installations or Changes	Letter, Drawing or Sketch	S	096 (9290)
9290-1	Report of Excessive Rolling, Heeling or Pounding or Inadequate Propeller Immersion	Letter & 2 Data Sheets		096 (9290) 096 (9290)
9410-1	Main Propulsion Turbines; condition of	Letter	S	231 (9411)
9410-2	Turbine Lifting and Repair Report	NAVSEA 9410/4 9410/5 9410/6 9410/7 9410/8 9410/9	S	231 (9411)
9430-1	Bent or Cracked Shafts	Letter	S	243 (9430) 100 (9110)
9440-1	Report of Propeller Measurements	NAVSEA 420	S	245 (9440)
3960-1	Fuels & Lubricants, Testing of, by Naval Shipyards Laboratories	Letter	S	262 (9450)
9510-1	Boiler Settings on Safety Valve	Letter		221 (9510)
9500-1	Auxiliary Steam Turbines; Protection Against Excessive pressure, relief valves	Letter	S	551 (9490)
9510-6	Boiler Maintenance of Brickwork; Refractory Lining, Provision for Vibration	Letter	S	221 (9510)
9610-1	Submarine Battery Quarterly Report	NAVSEA 149	Q	223 (9623)
9620-6	Battery Water Analysis	Letter	S	223 (9623)
9620-1	Inspection of Submarine Battery Elements: report of	Letter	S	223 (9623)
9620-3	Battery Deficiency Report	Letter	S	223 (9623)
9720-5	Ammunition Handling & Stowage	Letter	S	700 (9780)
4440-4	Report of Change on Boats Status	NAVSEA 215	S	583 (9820)

*LEGEND: Frequency code letters:

D–Daily	BM–Bi-Monthly
W–Weekly	Q–Quarterly
BW–Bi-Weekly	SA–Semi-Annually
SM–Semi-Monthly	A–Annually
M–Monthly	S–Situation

Figure 12-19.—Summary of Situation Reports.

will be directed to the type commander with copies to the reporting ship, the overhaul activity, and any other activities concerned. The activity (usually the type commander) controlling the operating schedule and overhaul funds of the ship, has final authority for disassembling the casing.

SITUATION REPORTS

Situation Reports are one-time reports required when certain situations arise. Figure 12-19 is a summary of one-time reports (not previously described) pertaining to the engineering department. The situations that call for the reports listed in the summary are explained in the references given.

SUMMARY

In this chapter, we discussed some of the records and logs that you, as a MM1 or MMC, should be familiar with. Make sure that you check the accuracy and legibility of all records and logs. For information on requirement frequency, format, and submission requirements, refer to the directives of appropriate fleet and other operational commanders.

CHAPTER 13

BOILER FIRESIDES AND WATERSIDES

You will need to develop technical skills to perform and evaluate boiler tests and inspections. By studying this chapter, you can obtain some of the knowledge needed to perform your job. Reviewing the manuals referenced in this text will help you to understand the required tests and inspections.

Boiler tests and inspections provide you with valuable information on the state of the boilers. Tests and inspections must be performed and evaluated correctly to be of any real use. Careless performance of tests and inspections could lead to real problems. The problems that you ignore, or cover up, can become serious or even fatal. Poorly performed tests and inspections, particularly in the fireroom, will always come back to haunt you.

GENERAL INSPECTION REQUIREMENTS

Whenever a boiler is opened for cleaning and maintenance, carefully inspect all parts of the boiler.

Enter the results of the inspections in the boiler water treatment log and in the engineering log. You must report any unusual cases of damage or deterioration to the type commander (TYCOM). Such reports must contain a detailed description of the damage and a description of the remedies that have been applied. They also must have a statement about the cause of the damage. Send a copy of the report to Naval Sea Systems Command (NAVSEA).

The cycle and minimum requirements for boiler tests and inspections are found in the Planned Maintenance System (PMS) and the TYCOM's maintenance manual.

INSPECTION OF FIRESIDES

Boiler firesides should be inspected for signs of damage to the refractory lining, tubes, drums and headers, baffle plates, seal plates, support plates, and other metal parts. This type of inspection is usually conducted when the boiler is secured for fireside cleaning. However, it should be conducted each time the boiler is secured.

REFRACTORY INSPECTION

Frequent inspection of refractories, together with early repairs, can postpone the need for complete renewal. It is good engineering practice to inspect the refractories every time the boiler is opened. Such inspections should be very detailed if the boiler has been operated under severe service conditions. Severe service conditions are steaming at high rates, burning low-grade or contaminated fuel, or undergoing rapid fluctuations of temperature. Severe conditions cause rapid deterioration of refractories and, therefore, increase the need for frequent inspections.

To make a proper inspection of boiler refractories, you need to know the causes of refractory deterioration. You also should know how to tell the difference between serious damage and less serious damage. Serious damage may require a complete renewal of brickwork. Less serious damage may require only patching.

General Causes of Deterioration

SHRINKAGE is an important cause of furnace deterioration. Shrinkage is indicated by cracks in the refractory that do not close. True shrinkage (permanent shrinkage) is rare in firebrick approved for naval use. However, this defect can occur in castable and plastic refractory. Normally, cracks in refractory are caused by insufficient expansion rather than shrinkage. In castable refractory, shrinkage is caused by excessive water added during mixing. Renew the castable if this is the case.

Also during your inspection, look for signs of UNEQUAL STRESSES. They are caused by rapid raising or lowering of the furnace temperature. Emergencies may arise that require the rapid raising or lowering of the furnace temperature. You should remember that the refractories cannot stand this treatment too often. You will find that raising the furnace temperature too rapidly will cause the firebrick to break at the anchor bolts. Lowering the temperature too rapidly will cause deep fractures in the firebrick.

Look for signs of MECHANICAL STRAIN caused by poor operation, such as panting, of the

boiler. The most common cause of boiler panting and vibration is improper fuel-air ratio. Panting can weaken the firebrick. Continued panting or vibration of the boiler will cause a weakened section of the wall to be dislocated.

Inspect for REDUCED FIREBRICK THICKNESS, Firebrick can be reduced in thickness without reducing the insulating value. The guideline for renewal of firebrick is thickness reduced by 1 inch for 2 1/2-inch firebrick; thickness reduced by 2 1/2 inches for 4 1/2-inch firebrick. Spalling, flame impingement, and slag are the causes of reduced firebrick thickness. You will need to correct the cause of the damage or repairs will be wasted.

Inspect the casings for any SIGNS OF OVERHEATING. These indicate a loss of insulation and excessive heat penetration. Under normal conditions, the brickwork in a boiler should last for several years without complete renewal.

You should inspect expansion joints often for signs of INCOMPLETE CLOSURE. Keep the joints free of motiar, refractory particles, and debris. The joints should close properly when the boiler is fired, You can tell if an expansion joint is closing completely by inspecting it when the furnace is cold. If the inside of the expansion joint is light in color, the expansion joint is closing properly. If the inside is dark and discolored, it is not closing properly. Pack expansion joints with fiberfrax or kaowool.

You can use the same method to tell whether cracks in refractory materials are closing properly. If the cracks are dark, showing that they do not close, fill them with mortar or fiberfrax.

Burner Fronts

The first firing of a castable burner front does more damage than any other single firing. Therefore, the first inspection after installation is very important. The unfired burner front may appear in perfect condition. Actually, it can contain defects of material or workmanship that show up in the first firing.

RADIAL CRACKS in the burner fronts may be found on the first inspection. These cracks are not normally harmful. They are caused by stresses resulting from the normal expansion and contraction of the refractory. After the radial cracks occur, the stresses are relieved and there should be no further cracking of this type.

The cracks that result in extensive damage run almost parallel to the surface of the burner front. These are called PARALLEL CRACKS. Parallel cracks usually appear at or slightly behind the leading edge of the bladed cone. They are not dangerous until they actually loosen pieces of the burner front. Improper installation and improper boiler operation are the usual causes of parallel cracking. Burner cones with parallel cracks found during a ship's overhaul period shall be renewed.

A slanting crack in the narrow section between the burners sometimes joins a radial crack. When this occurs, pieces of castable tend to break off. This type of damage can usually be repaired by a castable patch.

During your inspection, you may find that a castable burner front is breaking after very little service. This is usually caused by using too much water in mixing the material during installation. Sometimes it is caused by the material partially setting before installation. This happens during storage when the castable material reacts with moisture in the air. When castable material sets before use, it will never reach full strength.

Castable is also subject to spalling after several hours of service. The peeling material is usually in 1/8-inch strips. Do not remove the strips unless they are in the burner cone and are interfering with combustion.

If a castable front is chalky or crumbly, find out how deep the condition goes. If you can rub off only the surface, the burner front is not seriously damaged. Do not remove the crumbly material. The condition is serious only if it affects the burner cone or if the casing shows signs of overheating.

When repairs are made to castable or plastic refractory, you should replace the entire thickness. Layer-to-layer bonding is unreliable.

You should inspect burner tile for loose segments or broken pieces that might cause improper cone angles. Repair broken or damaged segments by patching them with castable refractory. In some cases, a new segment of tile can be installed.

When fitting burner tile, you should fit individual burner tiles to the metal throat ring and to each other.

Refractory Summary

When inspecting boiler refractories, keep in mind that refractory is designed to be functional, not pretty.

As long as it is performing and is structurally sound, complete replacement is not usually warranted.

Most refractory damage occurs because of operational procedures. Boilers must occasionally be operated under very severe and damaging conditions. A lot of damage to refractories is caused by poor operating procedures that are really not necessary under the circumstances. You should show operating personnel any refractory damage that is related to poor operation of the boiler. Make them aware of the damage caused by poor operation and how they can help prevent a reoccurrence.

FIRESIDE TUBE INSPECTION

When inspecting the exterior of boiler tubes, look for signs of warping, bulging, sagging, cracking, pitting, scaling, and acid corrosion. Inspect all tube sheets for signs of leakage, especially the superheater tube sheet.

Sometimes adjacent boiler tubes are warped so they touch each other. This condition is called TUBE MARRIAGE. Tube marriages can result from overheating of the tubes or from stresses developed in the tubes during installation. After the initial period of steaming, always inspect newly erected boilers and retubed boilers for tube alignment.

When inspection reveals one or more tube marriages, consider renewal of the married tubes. Base your decision on the following considerations:

1. If the tube marriage occurs in screen tubes 1 1/2 inches or larger, or if the furnace side wall, rear wall, or water screen tubes are bowed, tube replacement should be based on the following:
    a. Gas laning from the tube marriages is sufficient to cause overheating of the superheater and superheater supports, the inner casing, or the bottom rows of the economizer.
    b. Hard scale exists on the waterside of the tube.
    c. The tubes are blistered or show other signs of overheating.
    d. The tubes cannot be mechanically repositioned cold.
    e. A high degree of refractory exposure has resulted from the tube marriages, and the tubes cannot be readjusted by using small metal spacers.
2. If 1-inch or 1 1/4-inch tubes in the main bank of generating tubes are married, replacement is usually not required if the tube joints are tight under hydrostatic test.

Also, you should check the condition of the firesides of the finned tubes. A few cases of warping and cracking of the tinned tubes have been reported. The tubes, the fins, and the welds that join the fins to the tubes should all be checked. Report any warping, cracking, or other damage found on finned tubes.

To identify the cause of tube failure by visual inspection, you need to know something about the various ways that tubes rupture, warp, blister, and otherwise show damage. You must report tube failures to Naval Sea Systems Engineering Station (NAVSSES) on a Boiler Tube Failure Report. Record all tube failures on the Boiler Tube Renewal Record and have it entered in the Boiler Inspection and Repair Information System (BIRMIS) by a certified steam generating plant inspector (SGPI).

The next section of this chapter deals with the inspection techniques required for determining the causes of tube failure. After discussing inspection techniques, we will cover the various ways in which boiler tube damage is classified and identified.

Inspection Techniques

The inspection techniques required for determining the cause of tube failure will vary with the type of problem. For example, you can usually describe a rupture in a fire row tube adequately from visual observation; but, the cause of damage to a tube deep in the tube bank is more difficult to determine. It is difficult to determine this type of damage without removing the intervening tubes. When a blistered tube suggests a waterside deposit, you can determine the nature and extent of the deposit only by removing and splitting the tube.

Relatively simple equipment is required for the field inspection of damaged or fouled pressure parts. Equipment for this purpose includes the following:

1. Devices for measuring tube diameters, depth of pits, and thickness of deposits
2. Instruments for separating deposits and corrosion products
3. An approved type of portable light
4. A supply of clean bottles for collecting samples of deposits

5. A mirror for viewing inaccessible places

You can improvise many of these items of equipment. For example, you can make a simple gauge for measuring the depth of waterside pits by pushing a paper clip through a 3 x 5 inch card. The point of the clip should project beyond the card, at right angles to the card. Such an improvised depth gauge is shown in figure 13-1. To measure tube enlargement or tube thinning, you can wrap a section of string around a deformed tube, and then lay it along a ruler. Of course, special tools such as calipers, depth gauges, and scale thickness indicators are more accurate. Use them if they are available. However, the improvised tools also can give good results.

Classification of Boiler Tube Damage

Boiler tube damage is grouped here under four major classifications:

1. Fireside cavities and scars
2. Waterside cavities and scars
3. Tube deformities and fractures
4. Tube deposits

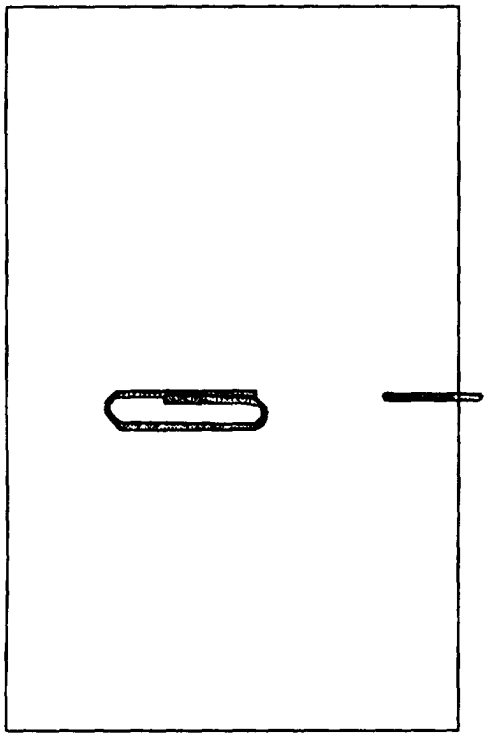


Figure 13-1.—Improvised depth gauge.

We will cover waterside cavities and scars and waterside tube deposits later in this chapter under Inspection of Watersides.

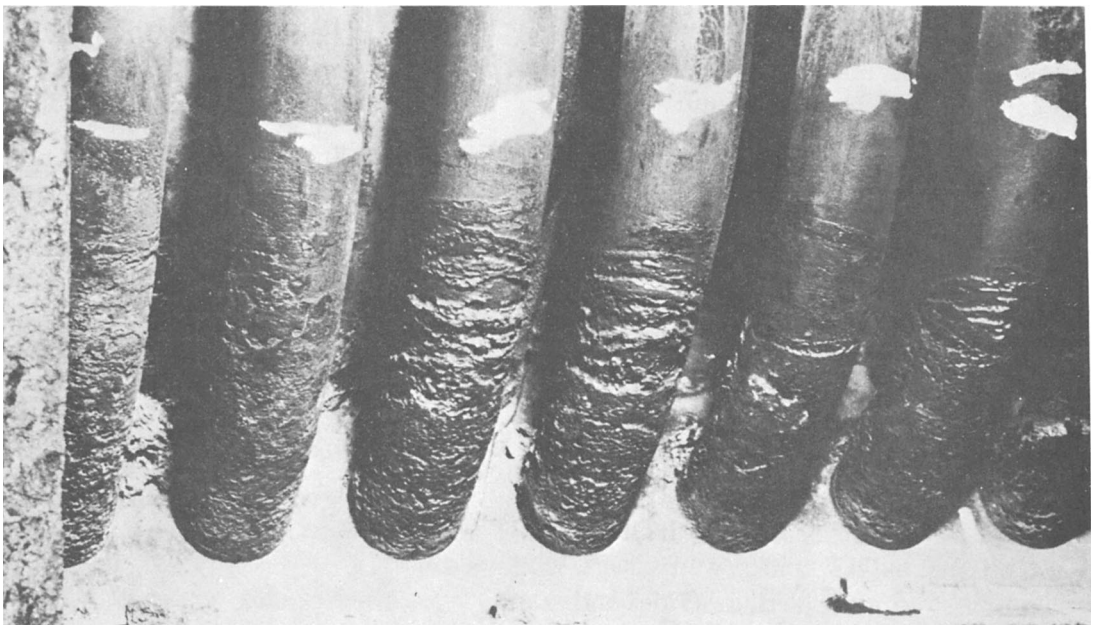
FIRESIDE CAVITIES AND SCARS.— Fireside cavities and scars on the tube firesides often indicate the reasons for tube failure. The first type of boiler tube damage we will cover is CIRCUMFERENTIAL GROOVE. It describes the metal loss that occurs in bands or stripes around the circumference of a tube. Fireside grooving of this type often occurs at the header ends of horizontal tubes, such as superheater tubes. The most common cause of this damage is leakage from tube seats higher up in the tube bank. The grooving occurs as the water runs down the header and onto the tube ends. Grooving also can occur from water dripping directly onto the tubes. This kind of damage is greater on the top of the tube than on the underside. But, the groove may extend around the entire circumference.

Fireside circumferential grooving also can occur on vertical generating tubes. This type of damage results from thin, damp deposits of soot on horizontal drums or headers. Circumferential grooving can occur in any part of the boiler where leakage provides a sufficient supply of water. Large quantities of water trapped between the water drum and the boiler casing can produce general fireside grooving. The grooving occurs around the bottom of the rear generating tubes. An example of this general fireside grooving is shown in figure 13-2.

CRATERS are deep, irregular, straight-walled cavities in the tube metal. WATER TRACKS resemble craters. Water tracks consist of wandering, straight-walled, canyonlike cavities in the tube metal. Both cratering and water tracking usually occur at the header ends of water wall tubes and division wall tubes. They start when water becomes trapped between the tube metal and the surrounding refractory. Water washing of boiler firesides, without proper drying out, is a frequent cause of cratering and water tracking.

NOTE: Approval by NAVSEA is required before water washing.

However, any leak higher up in the boiler also can cause this type of damage. The size of the leak and the angle of the tube leaked upon greatly determine the type of damage. Both cratering and water tracking are shown in figure 13-3.

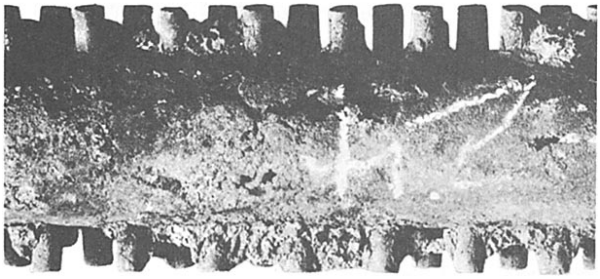


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Figure 13-2.-General fireside grooving.

GENERAL FIRESIDE THINNING consists of a uniform loss of metal over a large area on the outside of the tube. Soot corrosion is by far the most common cause of general fireside thinning. Three areas are more susceptible to this kind of damage. They are the superheater tube ends (between the headers and the seal plates), water drum ends of generating tubes, and return bends in economizer tubes. General fireside thinning of a generating tube is shown in figure 13-4.

FIRESIDE BURNING occurs when the rate of heat transfer through the tube wall is reduced. This causes the metal to overheat. Waterside deposits can cause fireside burning. But, most serious fireside burning occurs when a tube becomes steam bound or



98.138

Figure 13-3.—Fireside cratering and water tracking.



104.97

Figure 13-4.-General Fireside thinning of a generating tube.

dry. Figure 13-5 shows the coarse, brittle appearance of tube metal that has suffered fireside burning.

STEAM GOUGING occurs when steam jets out of a hole in an adjacent tube. You can identify steam gouging by the extremely smooth surface of the cavity and the irregular shape of the cavity. As shown in figure 13-6, a steam gouge looks as though the metal has been blasted away and the cavity polished.

TOOL MARKS, such as chisel cuts or hammer scars, are usually easy to identify. As shown in figure 13-7, tool marks do not resemble corrosion effects in any way.

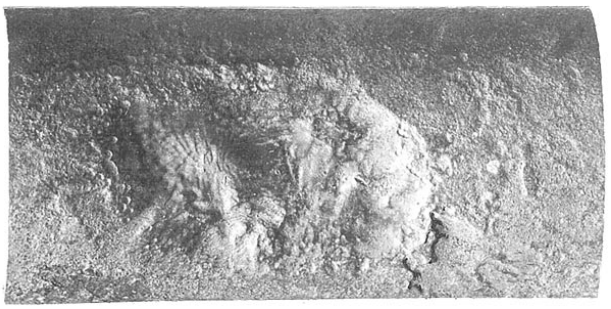
TUBE DEFORMITIES AND FRACTURES.—Tube deformities and fractures are another type of boiler tube damage. This type of damage includes abnormal bends, blisters, bulges, cracks, warps, sags, and other breaks or distortions. Like the cavities and scars previously discussed, tube deformities and fractures are easy to distinguish by visual observation.

The THIN-LIPPED RUPTURE, shown in figure 13-8, is a fairly common tube deformity. The rupture resembles a burst bubble. The open lips of the break uniformly taper to sharp edges, and there is no evidence of cracking or irregular tearing of the metal. True thin-lipped ruptures occur in economizer tubes, generating tubes, and, to a lesser extent, superheater tubes.



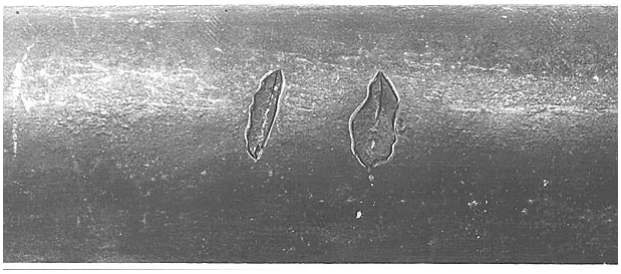
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Figure 13-5.-Fireside burning.



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Figure 13-6.-Fireside steam gouge.



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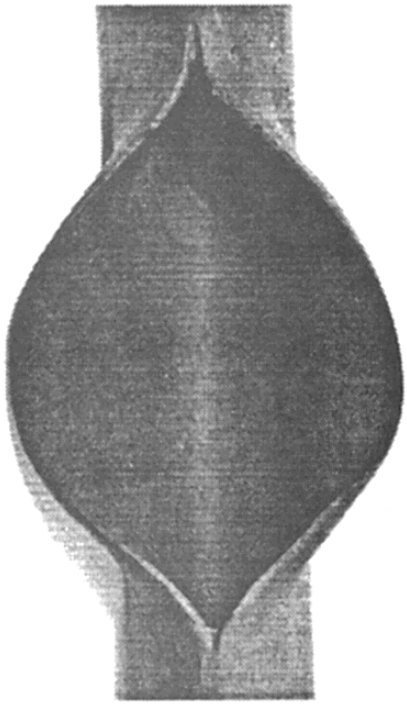
Figure 13-7.—Fireside tool marks.

Ruptures of this type indicate that the flow of steam or water was not adequate to absorb the heat to which the tube was exposed. Consequently, the tube metal softened and flowed and then burst. Thin-lipped ruptures can be caused by a sudden drop in water level. They also can be caused by tube stoppage from plugs, tools, and debris left in the boiler.

Serious THICK-LIPPED RUPTURES resemble the thin-lipped ruptures. However, their edges are thick and ragged rather than tapered and knifelike. In mild steel generating tubes, thick-lipped ruptures indicate milder and more prolonged overheat. Abnormal firing rates, momentary low water, flame impingement, gas laning, and many other causes can produce mild but prolonged overheat.

Thick-lipped ruptures are the most common type of rupture in superheater tubes. Sudden intense over-heat or mild and prolonged overheat can produce this type of rupture in alloy steels. The superheater tube shown in figure 13-9 blew to pieces when the thermally stressed metal yielded under superheater pressure.

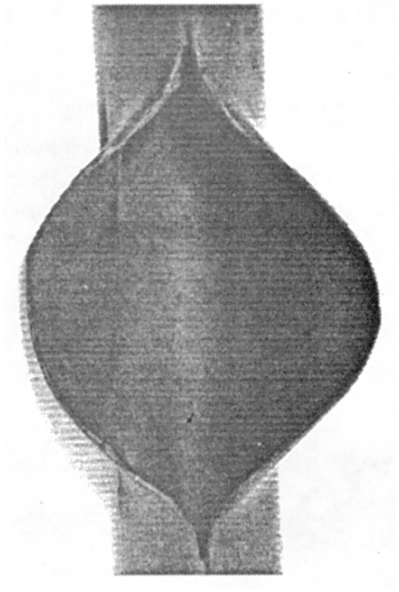
PERFORATION is the term used to describe openings in a tube NOT associated with tube enlargement. The most common kind of perforation is probably the pinhole leak. Often, the first evidence of tube failure is a pinhole leak.



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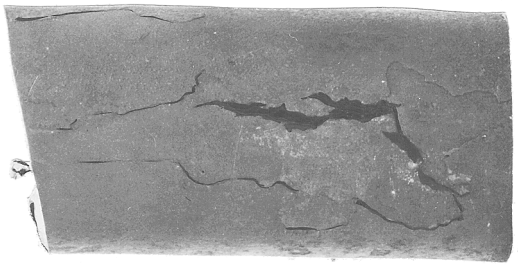
Figure 13-8.—Thin-lipped rupture.

THERMAL CRACKS result from prolonged, mild overheat or repeated short-time overheat. Cracks of this type are found most often in alloy superheater tubes. However, they can occur in mild steel tubes as well. The cracked tube wall has normal thickness, and the break has a dark crystalline appearance. A typical example is shown in figure 13-10.



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Figure 13-9.—Thick-lipped rupture.



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Figure 13-10.—Thermal crack of a superheater tube.

Certain chromium superheater tubes with molybdenum and titanium alloys sometimes develop very long, straight, seamlike longitudinal cracks. Such failures can occur in service because of original defects. Failures can occur even though the boiler has been operating under normal conditions and has not been overheated.

TUBE ENLARGEMENT, of the type shown in figure 13-11, is common in superheater tubes but rare in generating tubes. This uniform enlargement of a portion of the tube is caused by milder overheat than that which produces cracks or ruptures. If an enlarged tube is continued in service, it will probably crack or break.



104.101

Figure 13-11.—Enlarged tube.

HEAT BLISTERS differ from tube enlargements because they affect only one side of the tube. The side is usually the side toward the heat. Blisters appear as egg-shaped lumps on the fireside. They indicate that the tube has been heated to the softening point and has blown out under boiler pressure. Heat blisters always indicate the presence of waterside deposits. If the deposit is brittle, such as scale or baked sludge, blistering breaks the deposit. This can allow the boiler water to quench the hot metal before the tube bursts. You can most commonly find heat blisters on the fire row generating tubes. They are rarely found on super-heater tubes or economizer tubes. A typical heat blister is shown in figure 13-12.



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Figure 13-12.-Heat blister.

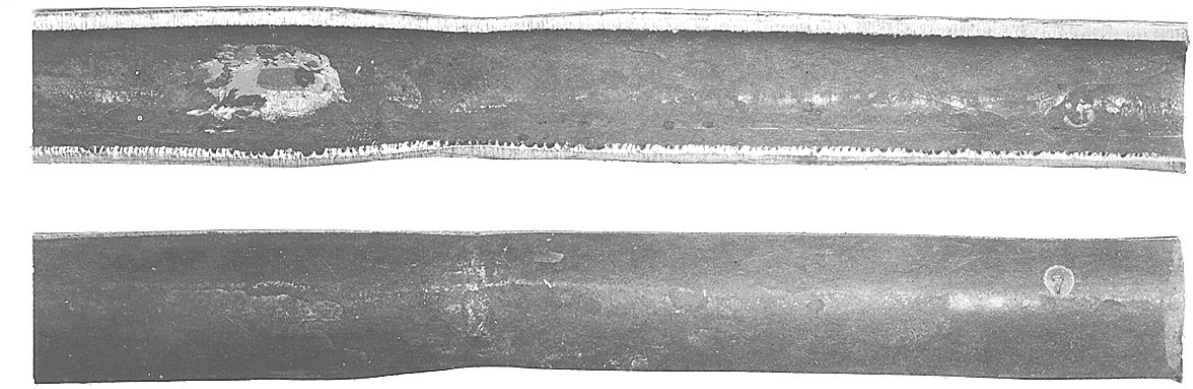
SAGGING is the term applied to tubes that appear to have dropped downward toward the furnace under their own weight. This type of deformation results from semiplastic flow of the tube metal, caused by mild overheat. A momentary condition of low water is probably the most common cause of sagging. Under certain conditions, sagged tubes may still be continued in service. You can use sagged tubes if the distortion is not severe enough to prevent the flow of combustion gases. You also can use them when the boiler has been cooled slowly.

WARPING is similar to sagging except that the distortion is haphazard rather than in one direction. Warping usually occurs as a result of sudden cooling of the tubes after they have been overheated. Cooling a boiler too rapidly after a low water casualty causes warping.

SWAGING is the term that identifies the reduction of tube diameter by mechanical deformation. The effect is a recessed band or circumferential indentation around all or part of the tube circumference. Swaging is most likely to occur when a tube passes through a support plate or seal plate. Therefore, it is more commonly found in superheater tubes. A swaged tube is shown in figure 13-13.

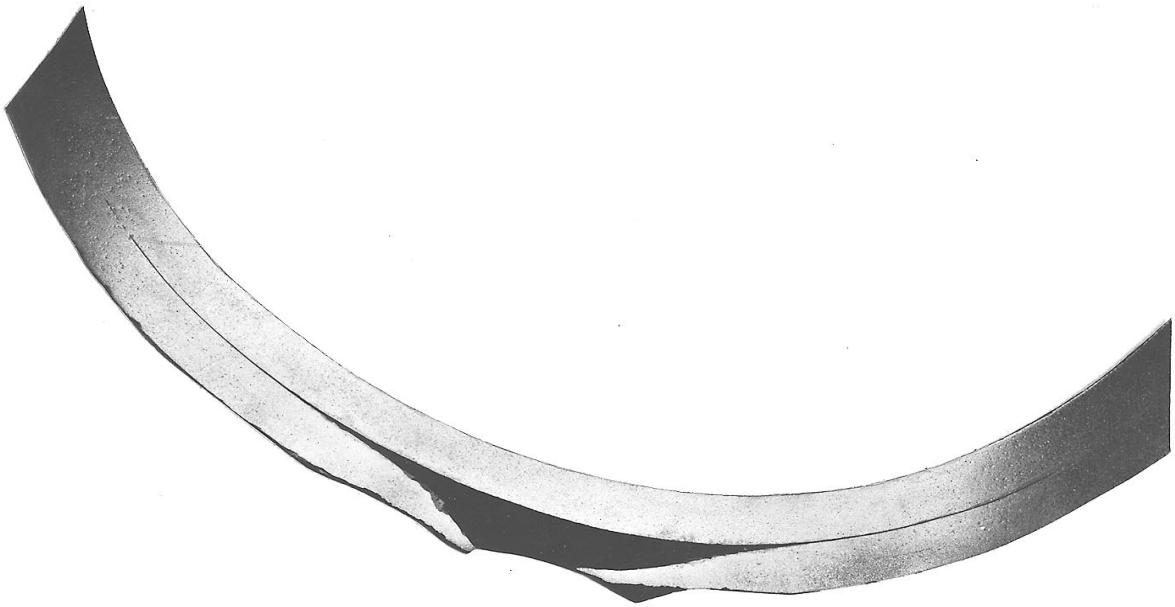
MECHANICAL FATIGUE CRACKS occasionally occur in boiler tubes. These cracks are caused by mechanical processes such as flexing. You can identify cracks of this type by a clean, bright break through most of the metal thickness. Fatigue cracks begin on the outside circumference of the tube bends and can extend around the outer half of the tube,

TUBE WALL LAMINATION is shown in figure 13-14. This lamination or layering occurs during the fabrication of the tube. Tube lamination shows up after



98.156

Figure 13-13.–Swaged superheater tube.



98.157

Figure 13-14.-Tube wall lamination.

the tube has been in service. It is not a common material defect found in boiler tubes.

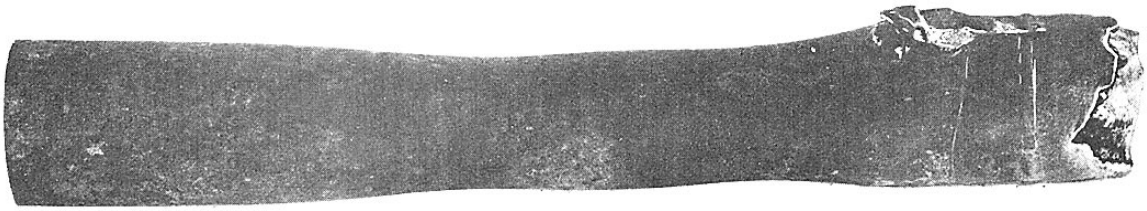
FOLDED TUBES are also the result of defective fabrication. This defect is usually found on the tighter bends of a tube and is caused by improper bending. A folded tube is shown in figure 13-15. This defect resembles a heat blister in appearance, but the folded tube shows no wall thinning. It also has a depression on the side of the tube opposite to the bulge.

STRETCHED or NECKED TUBES are also the result of defective fabrication. In some ways, this defect resembles a swaged tube, except that the defect is over a longer section of the boiler tube. A stretched or necked tube is shown in figure 13-16.



98.158

Figure 13-15.—Tube fold (fabrication defect).



98.159

Figure 13-16.-Stretched (necked) tube.

FIRESIDE TUBE DEPOSITS.— Tube deposits can produce many of the scars and deformities just described. Fireside tube deposits include soot, corrosion products, and high-temperature oxide. Tube deposits can cause tube failure because they lead to localized corrosion of the tube metal. The accurate identification of tube deposits is a necessary part of determining the cause of tube failure.

SOOT is a broad term used to cover all of the ash products that result from combustion. These ash products include carbon, sand, salts such as sodium sulfate, and other materials. Soot deposits are usually powdery or ashy on the tube surfaces near the top of the boiler. They usually pack solid on drums, headers, and the lower ends of the tubes.

CORROSION PRODUCTS seldom form major fireside deposits. Occasionally, however, bulky deposits of ferrous sulfate can form. These deposits are the result of the combination of soot and large amounts of water. These deposits sometimes travel away from their original location and adhere to remote rows of generating tubes. You can remove corrosion deposits by mechanical cleaning. You will need to find the source of the water leakage and correct the problem. You also should locate the site of the original deposit and carefully inspect the area for signs of corrosion.

HIGH-TEMPERATURE OXIDE is the term applied to heavy fireside layers of mixed iron oxides formed by overheating the tube metal. Low water is a frequent cause of high-temperature oxide on the tube firesides. The high-temperature oxide has a rather layered appearance. It resembles corrosion products and is often wrongly called mill scale.

EXTERIOR INSPECTION OF DRUMS AND HEADERS

The exteriors of all boiler drums and headers should be inspected for signs of corrosion under the insulation. Corrosion of the drum is indicated by rusty streaks on the tubes or drum pads. Signs of corrosion on or around the edges of the covering also can indicate possible corrosion. You should investigate any of these indicators immediately. Water from machinery or piping installed over the boiler can drip down on the boiler. The water can work its way under the insulation. In such installations, the boiler drum coverings must be removed, and the exteriors of the drums must be inspected. This should be done at intervals specified by NAVSEA.

INSPECTION OF BAFFLE, SEAL, AND SUPPORT PLATES

You should inspect all corrosion-resisting steel plates whenever firesides are opened. These include steam drum protection plates, baffle plates, seal plates, and superheater support plates. Baffle plates are subject to damage from overheating when clogged gas passages interfere with the designed flow of combustion gases. This situation allows extremely hot gases to flow over the plates. Failure of these parts interferes with design heat transfer. The plates should be inspected at every opportunity. They should be renewed when necessary.

INSPECTION OF UPTAKES AND SMOKEPIPES

The uptakes and smokepipes must be examined following the PMS. You should inspect the following items carefully:

1. The uptake expansion joints to be sure they are not clogged with soot
2. The reinforcing ribs or Z-bar stiffeners for looseness or breaks
3. The rain gutters to see that they are not plugged with soot
4. The top of the economizer for cleanliness

INSPECTION OF WATERSIDES

You need to inspect boiler watersides before and after watersides cleaning. An inspection also should take place at any other time that the chief engineer considers it advisable. If you suspect hard scale or serious corrosion, have some tubes removed for a detailed examination. Enter the results of watersides inspections on the boiler water treatment logs and on the engineering log.

When watersides are inspected, at least one handhole plate must be opened on each pass of the superheater.

NOTE: An exception is that at each alternate cleaning period the entire superheater must be opened.

Open the drums and headers completely and remove the internal fittings. Permanently mark the internal fittings to indicate their position in the steam drum. Marking the internals will help you to reinstall them in their proper place. Since boiler internals are not assembled with gaskets, installing them in their

proper place assures that the fittings will seal properly to prevent carryover.

You should dry out the boiler very thoroughly before a watersides inspection is begun. A wet boiler gives a false indication of its true condition. Note and record the general appearance of all visible areas of the boiler watersides. In particular, look for accumulations of sludge and for indications of scale, rust, general corrosion, and oil or grease marks. You should try to determine the extent of all defects and their nature.

When oil contamination is suspected, examine the watersides while the boiler is still wet. Before the boiler is drained, take water samples from the steam drum and the economizer headers. Another test for suspected oil is to rub a piece of paper on the wet surfaces of the economizer. If oil is present, the paper will be translucent when it dries.

WATERSIDE BOILER TUBE INSPECTION

Regular and careful waterside inspection of boiler tubes provides the information required to determine the need for tube renewal. Inspection is necessary to evaluate the effectiveness of boiler water treatment and other maintenance procedures. The information reported after an inspection allows you to diagnose boiler operating troubles and to analyze boiler casualties. In general, regular inspection of boiler tubes gives you an overall picture of the condition of the ship's boilers. Refer to the *Steam Generating Plant Inspections (Non-Nuclear), NAVSEA S9221-02-MMA-010* Manual, for more detailed information about boiler waterside inspections.

Inspection Techniques for Tube Water side Inspection

At each regularly scheduled shipyard overhaul, certain tubes are removed and examined. Removals include two generating tubes, one superheater, and one screen tube about two-thirds furnace depth. You are not required to have a superheater tube removed on boilers that have a walk-in superheater. You also are not required to remove superheater tubes on boilers in which the individual superheater tubes cannot be removed or replaced without cutting bulkheads. However, if problems with tube failures have occurred or unusual conditions are noted, then tube removal is required. Economizer tubes are not ordinarily removed for inspection. However, if you think the economizer is not in good condition, then have sample tubes removed.

Each tube removed must be cut into sections and split. Before you section and split the tube, mark the tube so it may be reassembled in the laboratory the same as it was in the boiler. You must identify each section with the tube number, hot side, top, any defects found in the tube, and the boiler number. Proper marking will assure that the information gathered will be useful.

The tubes are examined by the activity that removes them. The activity must provide a report of findings and recommended corrective actions to the ship. Copies must be sent to the TYCOM, NAVSEA, and NAVSSES Philadelphia. The ship must retain the reports on file and be prepared to provide copies to the Board of Inspection and Survey.

Superheater tubes removed for inspection must be replaced. Generating tubes removed for inspection need not be replaced under certain conditions. The first condition is that there are not more than 10 tubes plugged as a result of inspection requirements. The second condition is that the tubes were removed from the last two rows of the tube bank. Tubes removed from furnace walls or from fireside rows must be replaced.

The need for cutting an exploring block has been virtually eliminated by new technology. The British Tube Inspection Unit (BTIU) is an inspection device used primarily for ships preparing for overhaul. It can be used to inspect visually the inside of boiler tubes and to measure the depth of pits in boiler tubes. You also can ultrasonically measure the remaining tube wall thickness.

The visual inspection is accomplished by using an endoprobe inserted into the tube from the steam drum end. The endoprobe has a light source that can transmit light either forward or laterally depending on the type of probe used. The pit depth gauge is a micrometer used with the endoprobe, It can be operated from the upper end of the endoprobe.

The BTIU is only used by a specially trained team. The leader of the team must hold current certification as a Navy steam generator plant inspector and should be familiar with BTIU equipment.

Another piece of equipment that has helped eliminate the need for exploring blocks is the Laser Optic Tube Inspection System (LOTIS). LOTIS is used by specially trained teams under the direction of

NAVSSES Philadelphia. The LOTIS can map, measure, and record tube waterside deformities along the entire tube length. LOTIS uses a laser to measure and a video camera to map and record.

Waterside Cavities and Scars

To make a detailed inspection of watersides of boilers, you should know some of the terms. This section will help you to identify visually the various waterside cavities and scars.

Localized pitting is the term used to describe scattered pitting on the watersides. Pitting is caused by exposure to oxygen or boiler water that contains dissolved oxygen. Localized pitting of a generating tube is shown in figure 13-17. Localized pitting of a superheater tube is shown in figure 13-18.

Pitting is most likely to occur in tubes that receive the most heat. Pitting occurs in superheaters and at the steam drum ends of generating tubes. Active oxygen pits are pits that are still scabbed over, rather than clean. When you find this type of scab, break the scab and check for the presence of black oxide dust. Cleaning out the pits will stop the active oxygen attack.



104.103
Figure 13-17.–Localized pitting (generating tube).



104.104
Figure 13-18.-Localized pitting (superheater tube).

When you observe pitting, examine the tubes to see whether the pitting is moderately heavy and general throughout the boiler. To determine this, you must measure pits for size and depth. The pitting is considered general throughout the boiler and moderately heavy when numerous pits are deeper than 50 percent of the wall thickness and a few pits are deeper than 65 percent.

Tubes with pit depths of 50 to 65 percent of the minimum designed wall thickness must be plugged. However, if pitting to this depth is found throughout the boiler, consideration must be given to complete tube renewal.

Rolled tube end defects are some of the more commonly seen problems. Most tube end defects are minor, but they can appear serious. Some of the defects with rolled tube ends are covered in the following paragraphs.

Honeycombing appears as if the end of the tube was pricked with a pin. Honeycombing is only important if it occurs in new tubes after chemical cleaning.

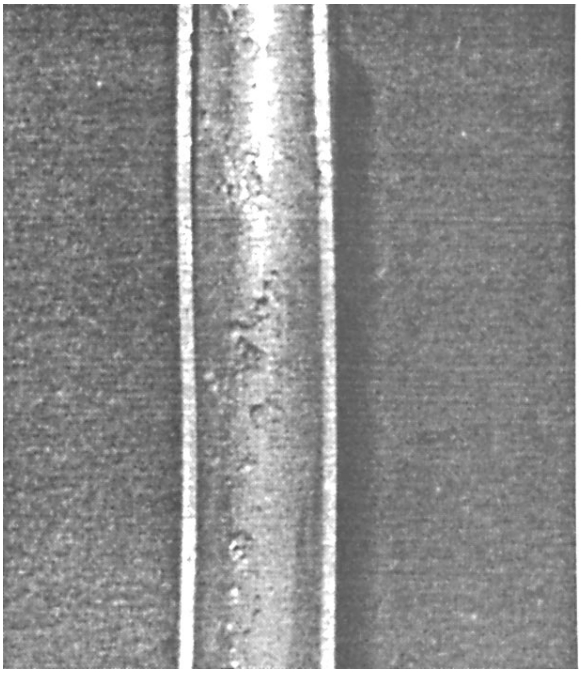
Hairline indications appear as if a hair had been placed across the tube end and may run down the tube bore. This condition only becomes important when the indication starts to widen and become a crack.

Bell cracking is the most serious defect. You cannot defer this repair. The crack is an actual separation of the tube metal. To repair this you will need to grind the crack completely out of the tube end and round the edges (fair). Perform a dye penetrant test to ensure that the crack is completely removed. If the crack runs down the tube bore beyond the tube sheet, remove the tube. You may need to replace the tube with a blind nipple if it is in the middle of the tube nest.

Bell flaking occurs inside the tube bore and appears as if tiny flakes of metal had fallen away.

Bell thinning is simply general corrosion of the tube bell. This condition looks more serious than it is, because it looks as if the tube bell was wasting away. It can, however, warn you that there may be serious problems in the tubes themselves. Examples of rolled tube end defects are shown in figure 13-19.

General waterside corrosion occurs when the boiler water is not alkaline enough over long periods. This type of corrosion resembles many small pits grouped together. General waterside corrosion can cover a large area of drums or be only on generating tubes. General waterside corrosion is shown if figure 13-20.



104.105

Figure 13-20.-General waterside corrosion of a boiler tube.

Waterside grooves are similar to localized pits in some ways, but they are longer and broader than the pits. Waterside grooves usually occur in the relatively hot bends of the tubes near the water drum. They also may occur on the external surfaces of desuperheater tubes. Some waterside grooves are clean, but most contain islands of heavy corrosion scabs. A typical

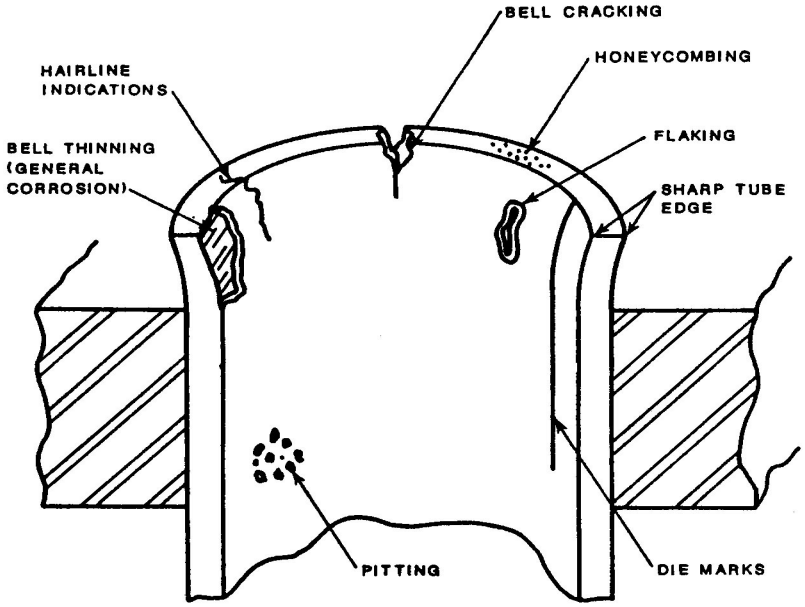


Figure 13-19.—Rolled tube end defects.

example of waterside grooving is shown in figure 13-21.

Corrosion fatigue fissures are deep-walled, canyonlike voids. They have the appearance of being corroded rather than fractured. You may find them filled with corrosion products. These fissures occur in metal that has been fatigued by repeated stressing. Therefore, the metal is more subject to corrosion than it would otherwise be.



104.106

Figure 13-21.—Waterside grooving.

General waterside thinning can occur if the boiler water pH is too low or too high for a long time. If acid residues are not completely removed from a chemically cleaned boiler, then general waterside thinning also can occur. The greatest loss of metal tends to occur along the side of the tube that is toward the flame. The entire length of the tube from steam drum to water drum may be affected Figure 13-22 shows general waterside thinning.

Waterside burning may occur if the temperature exceeds about 750°F in plain carbon steel tubes. It may occur if the temperature exceeds 1000°F in most alloy superheater tubes. The effect of waterside burning is the oxidation of the tube metal to a shiny, black, magnetic iron oxide. This is known as high-temperature oxide.

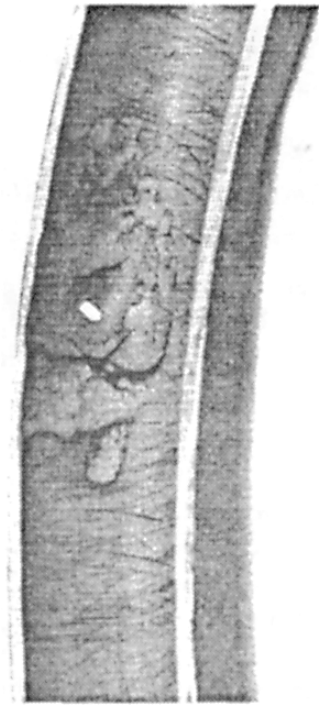
Waterside abrasion is the term used to describe waterside cavities that result from purely mechanical causes rather than from corrosion. For example, tube brushes or cutters can cause abrasion spots at sharp bends in economizer, superheater, and generating tubes. The surface markings of waterside abrasions, such as those in figure 13-23, clearly indicate that they result from mechanical abrasion rather than from corrosion.

Die marks appear as straight and uniform longitudinal scratches or folds on the watersides of the tube.



98.145

Figure 13-22.—General waterside thinning.

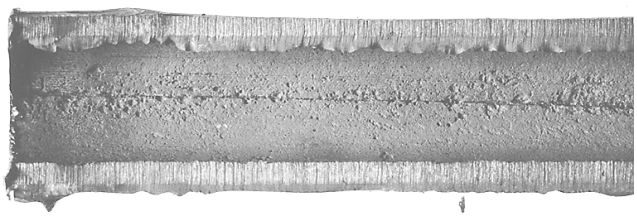


104.107

Figure 13-23.—Waterside abrasion.

They are the result of faulty fabrication. Die marks, shown in figure 13-24, may extend for the full length of the tube. Localized corrosion occurs quite often along the die mark.

Stress corrosion cracks are often invisible to the naked eye, but they may lead to a visible crack or break in the pressure part. Metallurgical examination is usually necessary to determine if cracking has occurred. Stress corrosion cracking may occur in stainless steel tubes in the superheater. It is caused by small amounts of oxygen and chloride contamination being present in the superheater. This type of contamination normally happens when the boiler is laid up improperly or carryover is occurring.



98.146

Figure 13-24.—Die mark.

WATERSIDE INSPECTION OF DRUMS AND HEADERS

Whenever a boiler is opened for cleaning and maintenance, inspect the internal surfaces of the drums and headers carefully for evidence of cracking. You should pay particular attention to steam drum manhole knuckles and the knuckles at the drum heads. Corners of cross boxes and headers, superheater header vent nozzles, and handhole openings are important places to inspect also. Record any defect found in the boiler water treatment log and in the engineering log. Also, report these defects to the engineer officer so appropriate repair action can be taken.

HYDROSTATIC TESTS

Boilers are tested hydrostatically for several different purposes. You must understand, in each case, why a test is being made. It also is important to use, but NOT exceed, the test pressure specified for that particular purpose.

Test pressures higher than that required to prove the test objective will only reduce the long-term life of the boiler. You should avoid subjecting an already tested boiler to hydrostatic test pressures when testing adjacent boiler systems.

You must hold the hydrostatic test pressure for 15 minutes before beginning the inspection. This is to prevent exposing personnel to the boiler under test pressure during this initial period.

The following is a list of the four hydrostatic test pressures used and the purpose of each:

1. 100 percent of boiler maximum steady-state drum operating pressure (120 percent steaming rate). This test is used to determine the tightness of gaskets, valves, fittings, and all tube seats of rolled, rerolled, or welded tubes, including downcomers, risers, and support tubes. Simply put, this means that a boiler that operates at 1275 psig will have test pressure of 1275 psig for this hydrostatic test.

2. 125 percent of boiler maximum steady-state drum operating pressure (120 percent steaming rate). This test is used for replacements, including rolled or welded economizer and super-heater tubes except downcomers, risers, and superheater support tubes. It is used after chemical cleaning, minor weld repairs to handhole and manhole seats, and replacement of handhole and manhole plates furnished through the stock

system. This test is also used after repairs to drums and nozzles involving defects of one-half or less of original wall thickness.

3. 135 percent of boiler design pressure. This test is used after replacement of drains, vents, blowdown piping, boiler piping, and welded valves. You will need the design pressure for the boiler, NOT the operating pressure, to determine this test pressure.

4. 150 percent of boiler design pressure. This test is used for testing major weld repairs to headers, drums, and nozzles involving defects of more than one-half of original wall thickness; renewal or rewelding of downcomers, risers, and superheater support tubes; and unsatisfactory strength inspection at the 5-year period. For this test you need to know the design pressure to determine the test pressure. You must contact NAVSEA for approval **BEFORE the 150 percent hydrostatic test is applied.**

FIVE-YEAR INSPECTION AND TEST

At 5-year intervals, each boiler should be inspected for integrity of welds and nozzle connections. This inspection is performed under the supervision of NAVSSES Philadelphia. Sufficient lagging and refractory must be removed from drums and headers to expose the welded joints and the nozzle connections. The welds and nozzle connections must be inspected visually from inside and outside.

Occasionally, the visual inspection will indicate that the 150 percent hydrostatic test is warranted. Should the area prove tight under test pressure, further investigation of the suspected area may still be warranted. If there is any doubt about the welds, you should have a nondestructive test (NDT) lab inspect them. Again, you must contact NAVSEA **BEFORE** you subject the boiler to the 150 percent hydrostatic test pressure.

INSPECTION OF SLIDING FEET

Each time a boiler is lit off you should check the installed movement indicators on the sliding feet to ensure that the sliding feet are moving. If the sliding feet do not move, the boiler could suffer damage. The damage could be to the casings, saddles, or even to the boiler tubes.

You should inspect the boiler saddles and sliding feet at each fireside cleaning period. The sliding feet must be thoroughly cleaned and greased following PMS using the approved grease. Using the wrong grease will only contribute to the freezing of sliding feet movement.

TESTS AND INSPECTIONS OF BOILER AIR CASINGS

Inspect visible portions of the boiler air casings as often as possible. You need to look for open seams, sheared bolts, buckling, sheared welds, heat damage, and other signs of damage.

Carefully examine the inner casing whenever refractories are removed. Also, a detailed inspection of the inner casing should be made at every other shipyard overhaul. Note any signs of burning, warping, or leakage. It is very important to check the inner casing in the areas around the soot blowers. Misalignment of a soot blower may result in a poor seal between the flanges of the stuffing box and the inner casing. Check for air leaks or a defective gasket between these flanges also.

Inspect the economizer front and rear vestibules for soot accumulation. You need to repair any leaking soot seals. Check the holes provided for pressurizing the economizer vestibules to make sure they are open. This helps prevent soot and combustion gases from leaking into the vestibules and the fireroom. Repair any defects in the inner casing as soon as possible.

You need to inspect the outer casing completely and test it for tightness. This should usually be accomplished at every shipyard overhaul. Inspect more often if conditions indicate the need. Test the outer casing for tightness by putting the space between the casings under an air pressure. You should then spread soapsuds along all seams, joints, access doors, and other openings. Leaks in the outer casing will be indicated by soap bubbles. Mark the casing to show exactly where the leaks are located.

You need to inspect blower flaps for proper operation. Any frozen or broken flaps should be repaired or renewed as soon as possible.

TESTS AND INSPECTIONS OF BOILER APPURTENANCES

Inspect boiler appurtenances, external fittings, to determine their operating condition. Boiler appurtenances in poor condition can lead to serious damage or personnel casualties. The inspection of boiler

appurtenances should be conducted at the required intervals specified by NAVSEA.

BOILER PRESSURE GAUGES

All boiler pressure gauges are inspected and calibrated following PMS and the meter calibration (METCAL) schedules. Malfunctions can cause repair or calibration to be needed more frequently. You should be sure that boiler steam drum pressure gauges are recalibrated just before setting boiler safety valves. Check the gauge line connections for leaks. A leaking connection will cause the condensate seal to bleed off. This will allow live steam to enter the boiler steam pressure gauge. The steam will cause the gauge to malfunction.

BOILER THERMOMETERS

Distant-reading thermometers of the quick-reading, bare-bulb type (bulb installed at superheater outlet) should be checked at regular intervals against the glass stem thermometer at the superheater outlet. Be sure the distant-reading thermometer is accurate. The accuracy should be checked by comparing the readings of the two thermometers during steady steaming conditions. The distant-reading thermometer should be calibrated and adjusted if necessary. The thermal alarm, if installed, should be checked by slowly raising the superheater temperature until the alarm sounds. If the thermal alarm is out of adjustment, you should correct it as soon as possible. Refer to the manufacturer's technical manual for the proper settings and the adjustment procedures for the superheater thermal alarm.

AIR REGISTERS AND ATOMIZERS

Burner impeller plates, air doors, drip pans, and burner cone openings should be inspected and cleaned after every steaming period at sea or in port. The position of the atomizer assembly in relationship to the diffuser should be checked and adjusted at specified intervals.

BOILER VALVES

For safe and efficient plant operation, it is vital that all important valves at or near the boiler be inspected frequently. You need to maintain these valves in the best possible operating condition. Important valves include the main steam stop valve and the auxiliary steam stop valve. The feed system valves, surface and bottom blow valves, and fuel oil valves are also very important. High-pressure drain, guardian, and root valves are all important.

At least yearly, each piping system should be pressurized. This should be done one section at a time so you can detect leaking or malfunctioning valves. Between such tests, inspect the valves frequently for signs of leakage. Leakage can occur through stuffing boxes or through flanged joints. A buildup of corrosion products around the stuffing box is an indication of excessive leakage through a stuffing box. Scoring or discoloration of the valve stem at the entrance to the stuffing box is also an indicator of leakage. Leakage may be caused by various defects. These defects include worn packing in the stuffing box, improperly made-up joints, and a bent or scored valve stem.

You need to inspect valves frequently to see that they open and close freely. They should not bind or stick. They should be moved often enough to keep them from becoming frozen or otherwise inoperable. Valve sticking, binding, and malfunctioning can have a variety of causes. The cause could be a bent valve stem, burred threads on the stem or on the yoke, or paint or rust on the threads. Scale, cuts, or dirt on the seating surfaces, a detached disk, or other defects also can cause malfunctioning. Check these problems by isolating the valve so it can be dismantled and inspected.

TESTS AND INSPECTIONS OF PIPING

You must ensure that all piping connected with boiler operation is maintained in a condition of complete reliability. The early detection and correction of leakage or other defects are of vital importance. Any sign of an unsound condition of piping should be investigated and remedied without delay.

The nature and frequency of piping system tests and inspections vary depending upon the system involved, the condition of the piping, and other factors. Visual inspections, tests to determine wall thickness, hydrostatic tests, and other tests or inspections maybe required. All shipboard piping in operating status will be tested following PMS.

All repaired boiler piping, piping subassemblies, and valves must be hydrostatically tested at a pressure 35 percent above the maximum system pressure before being reinstalled. Do not allow them to be tested at less than 50 psig. This pressure should be held while a complete inspection is made of the pipe assembly. Give special attention to the renewed parts. Hold the

test pressure for at least 15 minutes. This will allow any slow leaks to become evident. Hold the pressure until the inspector is satisfied that no slow leaks exist.

For complete details on tests and inspections of piping refer to NSTM, chapter 505, "Piping Systems," S9086-RK-STM-010.

ON-LINE ALIGNMENT VERIFICATION (OLV) PROCEDURES

The objective in aligning and maintaining the automatic boiler control (ABC) system is to achieve satisfactory overall control system performance. Overall system performance is measured by using the boiler flexibility (flex) test. Failure of the flex test by itself does not provide all the information needed to determine why the test failed. Malfunction or misalignment of almost any component in any of the control loops could cause poor system performance. This, in turn, would cause failure of the flex test.

The OLV procedures provide you with a set of checks to help test the system. These checks will verify proper performance of each of the subsystems and control loops within the ABC system. You should conduct the OLV checks before attempting the boiler flex test. OLV checks accomplish the following:

1. They provide a means for quantitatively checking control system Performance.
2. They help determine which components need adjustment or repair during poor system performance.

The controls should pass the boiler flexibility test if all the OLV checks are satisfactory. If they do not pass, the fault lies outside the control systems or the flex test was not conducted properly.

NOTE: The OLV should only be attempted by qualified ABC repair personnel.

BOILER FLEX TEST

The boiler flex testis used on propulsion boilers that have ABC systems installed. The flex test determines if the controls are adjusted properly.

The flex test is conducted by changing the boiler load by 70 percent in 45 seconds. Each load change (ramp) is then monitored for a specified period. The steam drum pressure, water level, and combustion must remain within specified limits, as stated by COMNAVSEASYSCOM PMS 301 letter. After completion of the 70 percent ramp, all systems must stabilize within 4 minutes from the start of the test. Observe the stability for 2 minutes. The boiler is then subject to a 70 percent ramp in the opposite direction with the same requirements being met again.

The flex test is conducted between 15 and 95 percent of boiler full power depending on operating requirements.

If you are involved in the flex test, you should be familiar with all the requirements listed in NSTM, chapter 225.

CARE OF BOILER FIRESIDES

You will find that keeping the boiler firesides clean will actually save work, as well as save the boiler. Clean tubes do not collect deposits as readily as dirty tubes. Firesides are easier to clean when they are slightly dirty than when they are heavily coated with soot or carbon.

The burning of any petroleum product tends to be incomplete. This causes carbon deposits on the boiler firesides. These deposits seriously reduce the efficiency of a boiler. Slag contributes greatly to the failure of many parts. Superheater support plates, baffles, protection plates, and soot blowers are parts that could be affected. Deposits act as insulation and prevent the transfer of heat to the water or steam in the tubes. This reduces boiler efficiency.

Accumulations that block gas passages through the tube banks require the use of higher forced draft blower air pressures to force combustion gases through the boiler. This reduces boiler efficiency. Accumulations that block the gas passages also interfere with the designed flow of gases over protection plates, baffles, seal plates, and other parts. This condition contributes to early failure of these parts.

If soot is allowed to remain on the boiler firesides, the sulfur in the soot combines with moisture to form sulfuric acid. his acid attacks tubes, drums, and headers. The extent of the damage caused by acid attack depends upon two factors. They are the amount of time the soot remains on the tubes and the amount of moisture present during this interval. Moisture may be present because of high atmospheric humidity, rain or snow coming down the stack, or leaky boiler tubes. Steam or water leakage through the boiler casing joints also could produce moisture. Pinhole leaks at the point where the tubes enter the water drums and headers may indicate soot corrosion. Soot corrosion also may develop at other points where it is difficult

to clean the tubes properly. If you allow soot corrosion to proceed unchecked, the result will be extensive deterioration of the boiler metals. You can find detailed procedures for cleaning boiler tire sides in NSTM, chapter 221.

CARE OF BOILER WATERSIDES

Failure to keep boiler waatersides clean reduces the efficiency of the boiler and contributes to overheating. This may lead to serious damage. Tube failures resulting from defective materials or poor fabrication are rare. Most tube failures, except those associated with water-level casualties and fireside corrosion, are caused by waterside deposits or accumulations. Some tube failures are caused by waterside deposits of hard scale. More frequently, however, tube failures occur as the result of an accumulation of relatively soft materials. The following items are considered soft materials:

1., Metal oxides
2. Residue of chemicals used for boiler water treatment
3. Solids formed from the reactions between scale-forming salts or other impurities
4. Chemicals used for boiler water treatment

CLEANING AND INSPECTION FREQUENCY

Boilers using the coordinated phosphate (COPHOS) treatment system without demineralizers installed will NOT be steamed more than 2,000 hours between waterside inspection periods. Boilers using COPHOS treatment with demineralizes installed may steam up to 4,000 hours, provided the demineralize is on line and no serious contamination has occurred. Boilers using CHELANT treatment have their watersides inspected at regularly scheduled boiler inspections, every 18 to 24 months. Using the CHELANT treatment system, boilers have been steamed 40,000 hours with no need for cleaning.

Boiler water treatments are discussed further in chapter 1 of this TRAMAN and in NSTM, chapter 220, volume 2. Detailed instructions for boiler waterside care is contained in NSTM, chapter 221.

MECHANICAL CLEANING

The three methods of mechanically cleaning a boiler are tetrasodium ethylene diamine tetraacetate (EDTA), high-pressure water-jet, and power-driven wire brushing.

EDTA Boiler Cleaning

This method consists of injecting EDTA into the boiler prior to the 1,800-to 2,000-hour inspection. The boiler is then steamed at 240 psi, plus or minus 10 psig, for 4 hours. The boiler is then dumped while still hot, and then flushed. As with any chemical, you must ensure that all proper environmental and safety procedures are followed when boilers are dumped. After the boiler has been dumped and flushed, inspect the boiler watersides. For this procedure, only one girth plate has to be removed. The tubes should appear black without soft deposits. A light dustlike powder may be present. If the inspection reveals that cleaning was not successful, the boiler must be recleaned. The method used for recleaning is determined by conditions present in the boiler.

The Naval Sea Systems Command (NAVSEA) gives complete details on cleaning with EDTA, including the neutralization procedures. These instructions are incorporated into NSTM, chapter 221.

High-Pressure Water-jet

This is the preferred method of mechanically cleaning watersides. The cleaning is done by passing a hose with a nozzle through the tube. The hose has a nozzle that sprays water combined with sodium nitrite under high pressure (approximately 10,000 psi) around the inside of the tube. The water-jet blasts away the soft deposits on the tube surface. Water-jet cleaning will not remove hard scale deposits. Superheaters are not normally cleaned using this method. If unusual conditions indicate the need, contact NAVSEA for approval.

The water-jet cleaning is done only by qualified personnel as outlined in NTP-S-30-7602. Team training in the operation of the water-jet machine is conducted before working with the machine. Team training is conducted by a certified instructor at shore intermediate maintenance activities (SIMAs). Detailed instructions for the operation, maintenance, and safety precautions associated with this machinery may be found in *High-Pressure Water-Jet Cleaning Equipment,* NAVSEA S6300-AE-MMA-010.

Power-Driven Wire Brush

The power-driven wire brush is the oldest method of cleaning boiler watersides. The wire brush is driven by one of three methods: (1) electric motor, (2) pneumatic turbine, or (3) a pneumatic or hydraulic turbine driven with steel (serrated-edge) cutting wheels. The latter method is furnished only to tender and repair ships. A pneumatic turbine with a flexible holder and expanding wire brush is the most commonly used equipment. Cleaning is done by passing the brush through the tube until the tube is properly cleaned. You will find complete details for cleaning watersides in NSTM, chapter 221.

BOILING OUT BOILERS

Boilers are boiled out to remove rust preventive and oil. The conversion to distillate fuel has made fuel oil contamination rare. A new ship or one that has had major tube renewal requires boiling out to remove rust preventive. Refer to NSTM, chapter 221, for detailed instructions for boiling out.

ACID CLEANING BOILERS

Boilers are acid cleaned to remove hard scale or baked-on sludge that cannot be removed by mechanical cleaning. There are two methods of acid cleaning, MIL-STD 796 and MIL-STD 1607.

The MIL-STD 796 provides for a 10-percent solution of hydrochloric acid (HCL). This method is used only by qualified contractors or at naval shipyards under the supervision of a shipyard chemist. This method is hazardous because of the chemical involved. Stainless steel superheaters are NOT to be cleaned using this method.

The MIL-STD 1607 is a sulfamic acid cleaning procedure. It is approved for use by ship's force, military repair facilities, and private contractors. This method may be used for stainless steel superheaters.

Before acid cleaning a boiler, contact NAVSEA for approval. Be prepared to give deposit analysis data, including thickness and composition.

The applicable procedure should be specified when contracting for acid cleaning. For detailed instructions and safety precautions, refer to the applicable MIL-STD and NSTM, chapter 221.

LAYING UP IDLE BOILERS

Boiler watersides begin to corrode as soon as they are exposed to the atmosphere. This occurs after the boiler is secured. For this reason, a secured boiler that is not going to be lit off within 24 hours should be laid up as soon as possible after securing. The method of lay-up you use depends on the following conditions:

1. The length of time the boiler is to be secured
2. The maintenance that is planned while the boiler is secured
3. The effectiveness of the lay-up method
4. The availability of support items for the lay-up method used

Wet Lay-ups

The authorized wet lay-ups are steam blanket, nitrogen blanket, hot deareated fill, hydrazine/ morpholine, and sodium nitrite methods. The sodium nitrite and hydrazine/morpholine methods require that all water be drained from the boiler before injection of chemicals. The hydrazine/morpholine method is authorized for use by industrial activities only

Dry Lay-ups

The authorized dry lay-ups are hot air and desiccant methods. Before placing a boiler on dry lay-up, you must ensure the boiler is empty. Draining a warm boiler will help with dry-out. Blow low-pressure air through all horizontal tubes to remove all water from the boiler.

You can find detailed step-by-step procedures for boiler lay-up methods in NSTM, chapter 221.

MANHOLE AND HANDHOLE FITTINGS AND OPENINGS

At each regular boiler overhaul, you should inspect all manhole and handhole fittings. If necessary, get them repaired. This includes fittings on all drums, headers, and economizers.

The manhole and handhole fittings should be removed carefully. Ensure that the seating surfaces and the threads on the fittings are protected. Take out one fitting at a time and leave the gasket on the fitting temporarily. The gasket will protect the seating surface. After removing each fitting, put the yoke back on the stud. Screw the nut on so it is flush with the end

of the stud. This will help to protect the threads. Next, find a safe place to keep the fitting until you are ready to work on it. A good deal of damage to handhole and manhole plates results from careless handling.

MAINTENANCE AND CLEANING

The seating surface on the fitting and the drum or header must be clean and true and free from defects. Ensuring that they are clean will help make a satisfactory seal. A power-driven cup brush, such as the one shown in figure 13-25, should be used for cleaning the handhole seating surfaces. A circular wire brush is usually best for cleaning the manhole seating surfaces.

REPAIRS TO HANDHOLE AND MANHOLE SEATING SURFACES

After cleaning, use a template made of flat stock to check the header seats. Header seats must be flat and they must be square with the opening. The maximum allowable taper for a handhole seat is 0.008 inch. The maximum allowable taper for manhole seats is 0.012 inch. Seats exceeding these dimensions must be refaced using approved seat grinding equipment. **Seat refacing is done only by personnel qualified to operate seat grinding equipment.** Typical handhole seat grinding equipment is shown in figure 13-26. After grinding, check that the header wait thickness is not below the minimums listed in NSTM, chapter 221. **Headers that fall below the minimum wall thickness must be weld repaired. Personnel performing weld repairs will be qualified as specified in MIL-STD-248.**

A problem may occur when the clearance between the shoulder of a manhole plate and the manhole is greater than 3/32 inch. If the clearance is greater than 3/32 inch, the plate may have to be built up by electric welding at the inner edge of the shoulder. Except in emergencies, this welding should be done at a naval shipyard. At a naval shipyard, the plate may be stress relieved after the welding. If the plate is not stress relieved, serious distortion may occur.



Figure 13-25.-Cup brush for cleaning handhole seating surfaces.

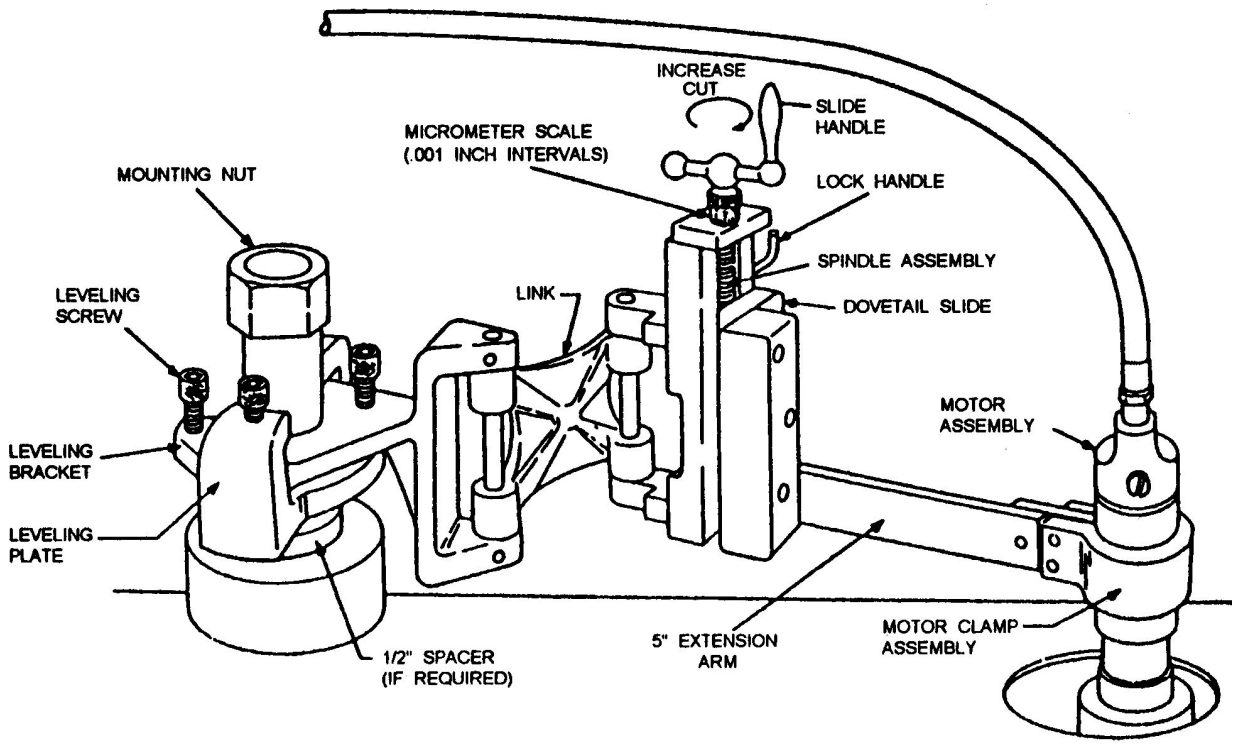


Figure 13-26.—Handhole seat grinding equipment.

SUPERHEATER SUPPORT AND SEAL PLATES

You should be sure that the superheater support and seal plates are maintained in good condition at all times. Make sure they are completely renewed whenever necessary. Serious damage to superheater tubes can result from failure to keep the support and seal plates in good condition. Burning is perhaps the most common cause of damage to these plates. Support plates are subject to burning on the edge nearest the furnace. Seal plates are usually burned when the fiberfrax protection falls away.

On most boilers, the complete renewal of superheater support and seal plates requires the renewal of superheater tubes. Sometimes the leading edge of a support plate is burned back past the first row of superheater tubes. If the plate is otherwise in good condition, you may use a reinforcing strip. The reinforcing strip, scalloped on the INSIDE, is used to support the first row of superheater tubes. This type of reinforcing strip is shown in figure 13-27. The burned edge of the old support plate is also shown in this figure.

AIR CASINGS, UPTAKES, AND SMOKE PIPES

The air register is the only opening where you should allow air to enter an operating boiler furnace. You should make every effort to keep the inner casing airtight at all times. Air leaking into the furnace through the inner casing does not become intimately mixed with the fuel oil. These air leaks have a chilling effect on the heating surfaces and gases of combustion, which reduces boiler efficiency.

Air leakage throughout the inner casing into the furnace is actually a common occurrence that should be corrected immediately. Fuel oil waste (10 percent or more) has been directly traced to air leakage through the inner casing.

The tightness of outer casings is also important for boiler efficiency. Leaky outer casings can greatly reduce the efficiency of the forced draft blowers. Sometimes, the reduced efficiency makes it impossible to achieve the combustion rates required for full power. Even at lower firing rates, air leakage through the outer casing wastes auxiliary steam because the forced draft blowers are run at a higher speed to maintain the necessary air pressure.

Uptakes and smoke pipes must be kept in good condition and free of leaks. Water running onto the boiler can cause damage in the following ways:

1. The boiler inner casings may corrode and rust.
2. The economizer elements and boiler tubes are subject to acid attack.
3. Expansion joints in the stack may deteriorate.

The most frequent cause of air leakage through the boiler casings is improper sealing of the casings. You may find this trouble on newly installed boilers or, more commonly, on recently overhauled boilers. Improper sealing may be caused by using the wrong sealing compound on joints and seams. It also may result from using defective or nonconforming gaskets. You can keep a boiler airtight if the seams are properly made up and the gaskets are properly installed.

Corrosion of the casings is another common cause of air leakage. Water may drip onto the casing from piping and valve leaks. It also may run out of the vents and onto the casing when the boiler is being filled. To prevent this, be sure that a drain funnel is installed from the air vents. Insulation around safety valves should be sealed with epoxy to prevent insulation from becoming waterlogged and to prevent rusting of the casing.

Overhauling boiler casings is tedious and difficult work. Every joint and every opening—no matter how small-must be checked for proper sealing. Since the work is tiresome, small leaks are often ignored. Burned or corroded sections of casing are also not repaired. If the work is done carefully, however, most boilers will show a marked reduction in fuel oil consumption. The following paragraphs describe areas or sections of casings to check for leakage.

Whenever the refractories are removed, check the inner casing around the brick bolt retaining strips. Sometimes these pull out, making holes in the inner casing. If a hole is found, braze or weld a patch over the hole. Be sure the patch is of the same material as the casing.

When floor refractories are removed, check the inner casing around the furnace drain. Corrosion can cause cracks or breaks in the casing in this area. If this happens, clean the metal thoroughly and then patch by brazing or welding.

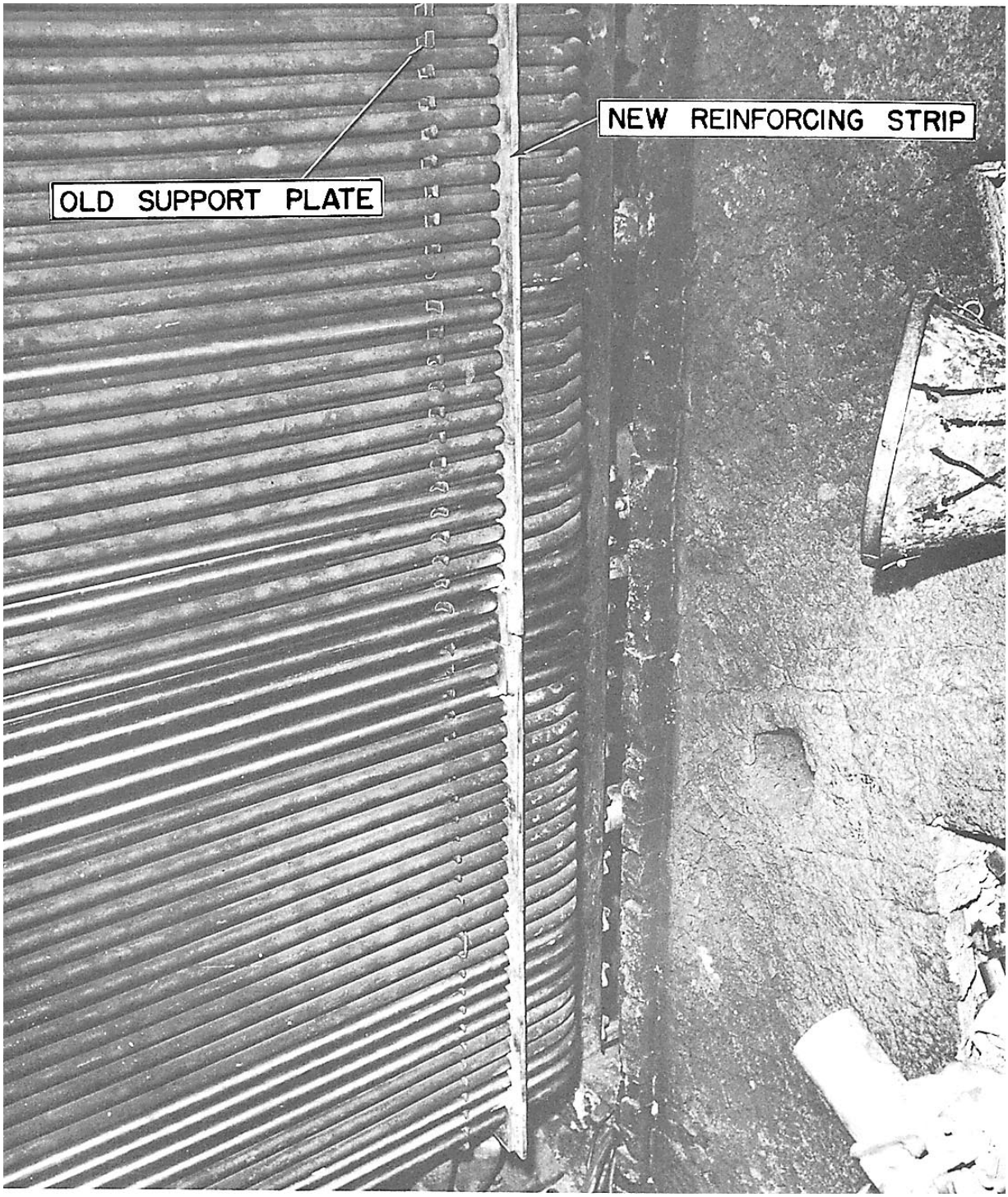


Figure 13-27.—Reinforcing strip for superheater tubes.

The inner casing around peepholes may become burned if the castable refractory falls out. If you find burned spots on the inner casing near the peepholes, replace or patch the area.

The gaskets and studs on the superheater access doors should be kept in good condition and replaced whenever necessary. Imperfect closure of these access doors is a major cause of air leakage.

Air leakage through the outer casing may occur as a result of bad gaskets or loose seams or joints. In particular, the bolted flanges that cover the ends of drums and headers may become loose. Corrosion or vibration could cause this. Thus, air could leak out of the outer casing. If one of these flanges becomes corroded, you will have to remove the flange section and replace it.

Access doors or panels in the outer casing sometimes require repair. You must ensure that the insulation on these doors or panels is kept in good condition. This will keep the outer casing from overheating.

The uptakes and smoke pipes must be kept in good condition and free of leaks. Leaks around the base of the stack may allow water to seep down inside the boiler casing and stack gas to enter the space.

Where smokestack rain gutters are installed, inspect them frequently. Remove all soot accumulations and make sure the drains are not plugged. If the drains plug repeatedly, consider increasing the drain piping size and reducing any sharp bends that may cause plugging.

The expansion joints in the uptakes require special maintenance. To prolong the life of expansion joints, make sure all soot is removed when firesides are cleaned.

MAINTENANCE OF FUEL OIL BURNERS

Fireroom fuel oil equipment must be clean, properly installed, and properly maintained at all times. You will be responsible for the cleanliness, proper installation, and maintenance of fireroom fuel oil equipment. The NSTM, chapter 221, and the manufacturers' technical manuals are the basic references for technical information on fuel oil equipment.

You must ensure that fuel oil burners are correctly installed, maintained, and kept clean and free of defects. The following sections of this chapter describe aspects of burner installation and maintenance of particular importance to you.

MAINTENANCE AND CARE OF AIR REGISTERS

You should check all parts of the air register often to make sure they are operating properly. This includes checking the air foils, the diffuser plate, and the air doors. In particular, check new or newly assembled installations before they are put into operation.

Make sure air surfaces of the register are clean and free of oil, carbon deposits, and dirt. Air doors, foils, scoops, and diffusers should be wiped off at frequent intervals. Be sure slots in the diffuser plates are free of material that would impede airflow.

POSITIONING THE ATOMIZER BARREL

The position of the atomizer barrel in the distance piece must be checked and adjusted periodically. You make this adjustment by screwing the distance piece in or out as necessary. To make the final adjustment, you need to align the cooling slots in the distance piece. On most applications this will make the screws in the diffuser vertical. You are looking for the proper relationship between the face of the atomizer and the diffuser plate. Check the manufacturer's technical manual for the correct setting. This setting may not be changed from specifications without approval of NAVSEA.

POSITIONING THE BURNER ASSEMBLY

After setting the atomizer barrel, check the withdrawal setting. This is checked by measuring the distance from the stationary air foils, often called *shark's teeth*, to the diffuser. Be sure that the diffuser is centered with the air foils. Adjust the withdrawal by moving the burner head assembly in or out. Lock the setting with the thumbscrew. A distance piece may then be made for each burner and attached to the burner head. This will give you an indication if the burner setting has been inadvertently moved.

INSPECTION OF SPRAYER PLATES

Periodically inspect the sprayer plates and vented plunger assemblies, if installed, with a GO-NO-GO gauge. These gauges are provided by the sprayer plate manufacturer. Never use home-made versions of the GO-NO-GO gauge. If any sprayer plate fails this test, discard it. The sprayer plate fails if the NO-GO end of the gauge enters the orifice far enough to cover the end of the gauge. Do NOT use excessive force during this test. Reject any sprayer plate that the GO end of the gauge will not enter the orifice.

Atomizers are frequently ruined because personnel don't understand the fineness of atomization. Atomizers can easily be ruined by careless handling. Atomizers should be cleaned with wooden utensils after each use. Sprayer plates must be protected with a coat of light oil and stored in a wooden box. If an atomizer fails to give a finely atomized spray after cleaning, discard it.

There should be three sprayer plates per burner for full power size sprayer plates. There should be two light-off sprayer plates per boiler. Overload sprayer plates should be in the custody of the chief engineer.

BURNER SAFETY SHUTOFF DEVICE

Most burners are equipped with burner safety shutoff devices. This device prevents fuel from spilling into the fireroom if the burner root valve is accidentally opened with no atomizer assembly installed. You can find detailed information on burner safety shutoff devices in NSTM, chapter 221.

BURNER LEAKAGE

Burner leakage rates should be checked before each steaming period while the fireroom is cold-iron. Use the applicable PMS MRCs. The burner front should be tagged out using caution tags. Check the leakage rate for the fuel oil root valves, safety shutoff devices, and ball check valves (if installed). The maximum allowed leakage rates are ZERO leakage from root valves and no spray or constant stream from safety shutoff devices. Leakage from safety shutoff valves should be less that 8 ounces per hour at system pressure.

USE OF GASKETS

Fuel oil burner assembly gaskets must be of the proper dimensions and material. They must be installed exactly as specified in the manufacturer's technical manual. Failure to do this may cause fuel oil leakage and poor atomization.

Before installing burner gaskets, clean the seating surfaces carefully. Be sure the seating surfaces are smooth and true, without nicks or other irregularities. If the seating surfaces are not perfectly true, the seating surfaces should be trued up.

On burners with safety shutoff valves or other automatic safety devices, the thickness of the gaskets is very important. Using a gasket that is too thick may prevent full opening of the safety check valve. This may reduce the pressure available for atomization of the oil.

SUMMARY

The information you have studied in this chapter is not designed to make you an inspector or a technician. This chapter should help make you aware of the many tests and inspections conducted on boilers and their associated equipment. You will find that you are the quality assurance inspector when these tests are performed on your ship. Always have the proper NSTM available when conducting these tests. Use it to guide you and to make sure that you do not overlook anything.

CHAPTER 14

BOILER FITTINGS AND INSTRUMENTS

This chapter presents information on boiler fittings and instruments other than those relating to automatic control systems. You will need a thorough knowledge of maintenance and repair of boiler fittings and instruments for advancement to MM1 or MMC.

SAFETY VALVES

Navy boilers are fitted with safety valves on the steam drum and the superheater outlet. Several different types of safety valves are in use. All are designed to open completely (pop) at a specified pressure. They remain open until a specified pressure drop (blowdown) occurs. Safety valves must close tightly, without chattering, and remain tightly closed after reseating.

Safety valves used on 1200 psig boilers are subjected to more severe service than those on 600 psig boilers. The higher boiler operating pressure and temperature of 1200 psig boiler degrades valves quicker than those with lower pressures and temperatures. The superheater safety valve usually suffers damage the quickest. To ease this situation the Navy introduced, and is in the process of installing, the Greno Industrial Supply (GIS) safety valve system (fig 14-1) on the superheater outlet. The GIS safety valve system replaces the pilot safety valve as well as the superheater outlet safety valve. This system uses boiler pressure to keep the safety valve seated. When the boiler pressure exceeds the set point of the safety valve controls, the pressure on top of the safety valve is released. This allows the safety valve to lift. The lift pressure is set by the operator. However, the blowdown is designed in and cannot be adjusted

MAINTENANCE AND REPAIR

Safety valves must be maintained in the best possible operating condition at all times. All tests, inspections, and adjustments must be made as required. However, you should **never** make unnecessary repairs or adjustments. You should leave safety valves alone

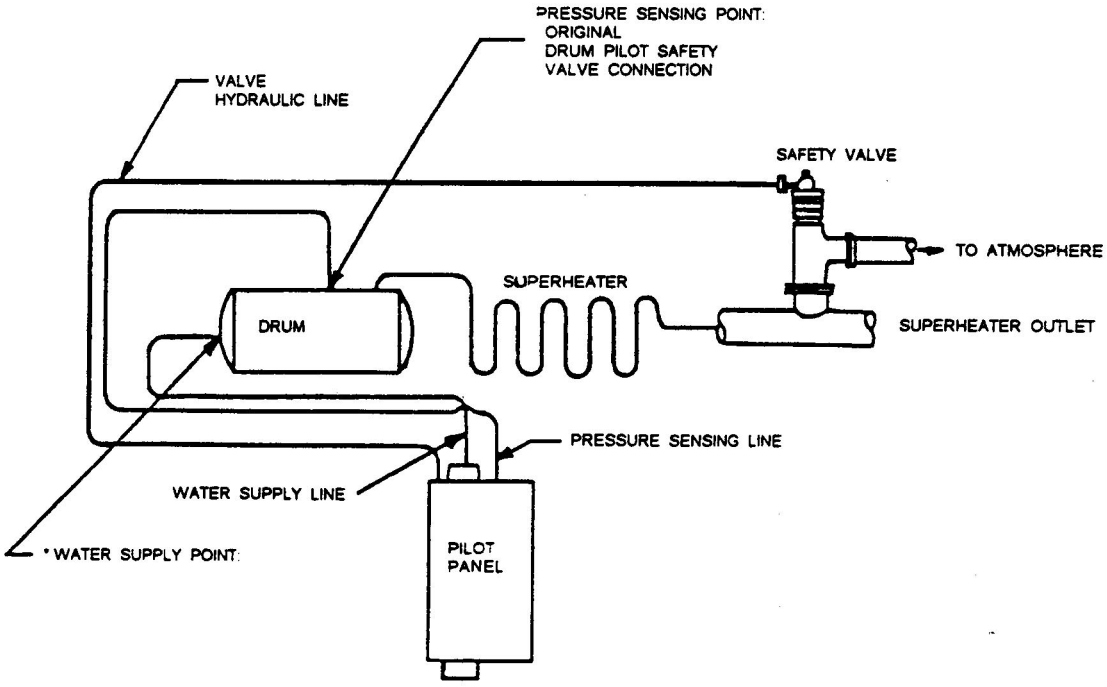


Figure 14-1.–GIS safety valve system.

(except for the required tests and inspections) as long as their operation is proper. Disturbing or altering the internal parts of safety valves often causes unsatisfactory operation in valves that were previously working all right. This is particularly true if work is done by someone not thoroughly familiar with proper repair methods.

After a period of service, safety valves may simmer when they are within 1 percent of their popping pressure. Such simmering does not require corrective action, provided the valve does not simmer at the boiler operating pressure.

For continued satisfactory operation of safety valves, all original dimensions must be maintained very closely. You should replace worn parts when necessary. Keep grinding in of valve parts to a minimum. Any grinding involves the removal of metal and changes the original dimensions. A safety valve may be ground in lightly once or twice without any substantial effect on the clearances. However, heavy or repeated grinding changes the dimensions and causes unsatisfactory operation of the valve.

In many cases, neither the equipment nor the technical skill required for a complete overhaul of safety valves is available. Safety valves that need repair should be overhauled by a naval shipyard or by some other repair activity whenever possible. Emergency repairs must sometimes be made. You should keep boiler safety valve repair parts and tools on hand. An understanding of the correct procedures for repairing safety. valves is needed **before** you attempt any repairs. Learning by your mistakes is not a good idea when dealing with safety valve repairs. You can learn a great deal by watching the experts when your ship's safety valves are being overhauled.

Sometimes it is necessary for you to grind in a safety valve or to make other repairs to it. Be sure to consult the manufacturer's technical manual and drawings. The information here gives some of the more important aspects of safety valve repairs.

The Navy uses several different kinds of safety valves. There are the huddling chamber, the nozzle reaction, and the newer GIS safety valves in the fleet. Therefore, no single discussion can apply equally well to all types. Be sure you have a thorough understanding of the particular valve you are working on before you attempt to repair it. Also, be sure you have assembled all pertinent information, such as PMS, blueprints, and technical manuals.

For satisfactory operation of safety valves, essential original dimensions must be retained. Grinding in and subsequent adjustment of valve parts should be kept to a minimum. If you must repair a safety valve, you should carefully verify all measurements against the blueprints **before** you start the work. Should you find worn out parts, replace them. Continued unsatisfactory operation usually indicates that essential dimensions have changed. Clearances may have been modified by repeated grindings. As a result, correction to other parts has been omitted.

The grinding in of a safety valve involves a departure from design dimensions. This is true even where the amount of metal removed is small. Success in eliminating leaks often follows first grinding. However, it is not safe to assume that further grinding will effectively remedy subsequent leaks. Small metal templates made by the valve manufacturer should be carried on board for each set of safety valves. You should use these in gauging the correct dimensions or clearances of the valves and valve seats during grinding in.

Although various brands of safety valves differ in detail, the valve shown in figure 14-2 illustrates the principles common to all spring-loaded safety valves. You can use figure 14-2 as you read about safety valve seat and disk surfaces. The letters refer to various components and dimensions of figure 14-2.

When a cut is taken on the valve disk or valve seat, metal is removed from the seating surface (W) of either the valve disk or the valve seat. Also, when a safety valve is repeatedly ground in, metal is removed from W. This procedure changes the vertical position of the disk, and it changes important dimensions. To prevent this, you must take steps to counteract the effects of the cut on the valve seat or disk. For example, if you remove 0.005 inch (vertically) from W of the disk, then remove an equal amount of material from the surfaces at B and C. In this way, there is no change in the original dimensions of X. Likewise, if the cut is taken from W of the seat, take a cut off the horizontal shoulder (D). This keeps the dimensions on F as originally designed. This is an important feature of some types of valves. Restore any existing chamfer on E after taking the cut from W.

Safety valve springs, spindles (stems), and adjusting screws will not be painted. The external surfaces of safety valve bodies, bonnets, caps, yokes, and flanges will be painted to provide adequate protection against corrosion formation. Use two coats of heat-resistant, aluminum paint.

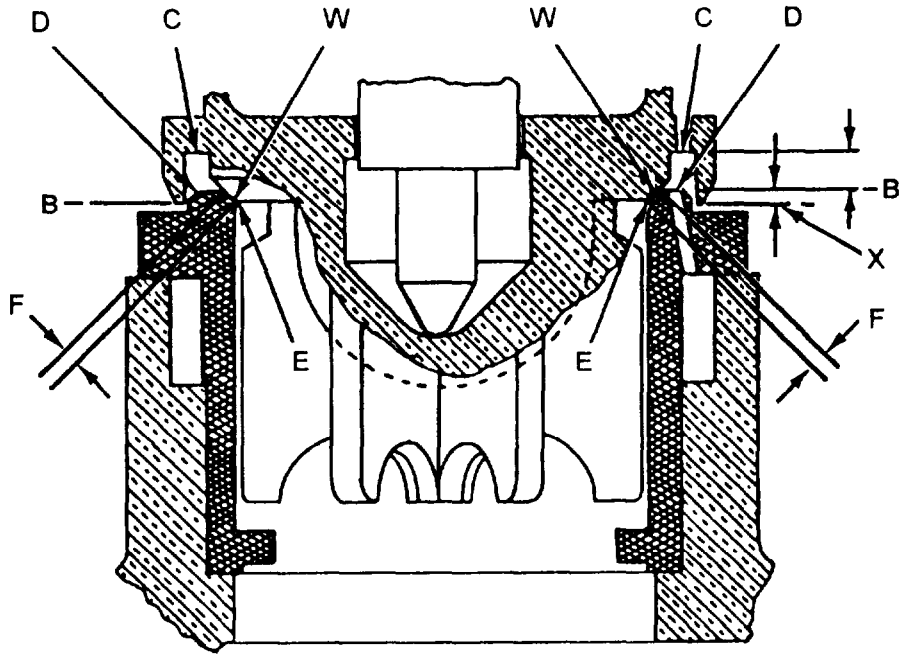


Figure 14-2.-Safety valve seat and disk details.

SAFETY VALVE SETTINGS

Developments in boiler design require use of different types of safety valves, with different procedures for setting these valves. One set of rules for setting valves is impractical. Therefore, settings for safety valves of all ships are issued by NAVSEA. All safety valves installed on a boiler are set using the pressure gauge installed on that boiler. The pressure gauge should be calibrated before testing, setting, or resetting any safety valve(s). Pressure gauges on all boilers should be calibrated to agree as closely as possible. Special attention should be given to their accuracy in the working pressure range. In calibrating pressure gauges on boilers, the hydrostatic leg in the gauge piping should be compensated for in setting the gauge hands. This compensation may be based on 2 feet of water being equivalent to 1 psi pressure. For example, if the vertical distance from the highest point of the gauge line to the center of the gauge is 10 feet, you need to set the pressure gauge hand at 5 psi less than the actual pressure at the gauge to show the actual pressure. Safety valve tests are not required when a new or recalibrated boiler pressure gauge is installed.

The differential pressure between the valve set point and the drum operating pressure is restricted by design considerations to minimal values. You must maintain steam pressure gauges and the automatic boiler control system in optimum condition. This will help you take full advantage of the allowable differential.

The popping and reseating pressure ranges are specified by NAVSEA. They are stamped on the valve nameplate and given in the PMS. The following popping pressure tolerances are correct as long as all valves on the boiler still pop and reseat in proper sequence:

1. On boilers with a drum pressure of 325 psi or below (300 psi nominal standard safety valves or less), the maximum tolerance is plus or minus 3 psi.
2. On boilers with a steam drum pressure of 326 to 710 psi (600 psi nominal standard safety valves), the maximum tolerance is plus or minus 5 psi.
3. On boilers with a steam drum pressure of 711 to 1410 psi (1500 psi nominal standard safety valves), the maximum tolerance is plus or minus 10 psi. Blowdown range between 3 to 6 percent of individual safety valve lift (popping) pressure is acceptable, if the boiler valves reseat in proper sequential order. For example, on pilot action, drum valves reseat before superheater valves. Attempting to achieve too fine a blowdown setting in an individual safety valve can lead to repeated lift tests. This breaks down the finely honed surfaces of valve disks and nozzles

(seats). Excessive changes to the blowdown setting may also affect the lift (popping) setting of the valve.

Safety valve settings must **NEVER** be increased or decreased, outside the allowed range, without authorization from NAVSEA. Before authorization is given to change safety valve settings, the boiler must be inspected and hydrostatically tested. It is tested for strength at 150 percent of designed boiler pressure.

SAFETY VALVE PROBLEMS

One common problem with spring-loaded safety valves is leakage past the valve's seating surfaces. Because of the hard metallic seating surfaces and the low setting forces, some leakage may be present at full boiler pressure. As valves are degraded by time and numerous pops, the leakage rate of the valve increases. When wear has degraded the valve and leakage has become excessive, you should examine the seating surfaces when availability permits. Take remedial action as necessary. Repair procedures are outlined in the boiler manufacturer's technical manual.

Safety valve leakage, although a nuisance, is not grounds for curtailing boiler operation. At present, there is only one criterion available for determining whether safety valve leakage has reached a point requiring repair action. The criteria is evidence of a steady plume of steam (3 feet long in calm air) emitting from the exhaust line at the stack. For most types of safety valves, you can identify which safety valve on a steaming boiler is leaking excessively by using the following method: Carefully place a cool, flat knife blade between the lowest coils of the spring of each valve. The leaking valve will leave excessive moisture beads on the knife. A mirror may be used instead of a knife. You should wear insulated gloves to avoid skin contact with possible nonvisible superheated steam vapor at spring-loaded superheater valves.

To maintain good seating surfaces and optimize valve performance, you should keep popping of the valves to a minimum. When valves are set, the tolerances given earlier in this chapter should be used. Sometimes, the valves do not respond to adjustment of the rings or the spring nut as described in the manufacturer's technical manual. If this happens, you should notify NAVSEA and, if required, request their assistance.

BOILER OPERATION DURING SAFETY VALVE TESTING

During continuous testing and steam setting of installed safety valves, avoid complete securing of the boiler and all burners. Whenever possible, put the boiler on line to supply steam to auxiliary machinery. Such machinery should be limited to blowers, feed pumps, and a turbo generator during a safety valve test. Placing the boiler on line also helps to maintain good steam flow through the superheater. Avoid continuous safety valve tests with closed main and auxiliary stops for the boiler. You should use one burner to bring boiler to line pressure and to maintain it for steam supply. Use a second burner to assist in raising the boiler pressure to lift safety valves. Secure the second burner and reduce fuel oil pressure to the first burner immediately following lift. If you can, complete the operation by raising and lowering steam pressure using only one burner **without securing boiler fires.** The main concern is to avoid several cycles of completely securing fires and lighting off a hot boiler. Such cycling can result in flareback or furnace explosions.

DUPLICATE SAFETY VALVE SETTINGS

On some boilers the pilot assist spring-loaded superheater safety valve and the lower drum safety valve have the same lift settings. When they are tested independently, confusion in gagging valves and the lift required following gag removal can occur. To eliminate confusion, use the following procedure:

1. Gag all valves except the superheater safety valve.
2. Set the superheater valve to minus tolerance.
3. Gag the superheater valve carefully and remove the gag from the number 2 drum valve.
4. Set the number 2 drum valve (higher setting).
5. Remove the gag from the number 1 drum valve.
6. Set the number 1 drum valve (lower setting) to plus tolerance.
7. Remove the gag from the drum pilot valve.
8. Set the pilot valve.
9. Remove the gag from the superheater valve.
10. Test pop the pilot-superheater valves in combination.

By using this procedure, you avoid subsequent tests of the superheater valve on its own spring action following gag removal. In actual operation, the superheater valve operates on pilot-assist. Notice that spring-loaded superheater safety valves are not lift-tested separately, except when they are initially installed, reworked, removed from and reinstalled on a boiler, or lifted accidently by hydrostatic pressure.

GAGGING SAFETY VALVES

When the boiler is cold (except prior to hydrostatic test), don't place gags on safety valves. Thermal expansion of safety valve spindles will cause severe stress on the spindle. The prefered procedure is to lay the gags on the steam drum by the safety valves while the boiler is warming up. Don't place gags on the safety valves of a steaming boiler until the boiler pressure is 100 to 200 psi below the lowest safety valve setting. This includes the pilot valve on the boiler.

HAND EASING GEAR

The safety valve hand easing gear has a dual purpose. It is used to lift the safety valves during emergency conditions and also to check that safety valve internals are free without overpressurizing the boiler. Some hand easing gear consists of cam operated gears and cables to lift the safety valves in proper order. Other types of gear consist of levers attached to cables to lift the safety valves. No matter which type you have, you should maintain hand easing gear in good condition.

You need to check the hand easing gear operation every 1,800 to 2,000 operating hours. Check the operation without actually opening the safety valves. Disconnect the cables from the valves and operate the hand easing gear through the entire cycle. Observe the operation of the lever arms for sequence of lift and snap back action. Also, check the clearance on the lifting fork of the safety valve. The fork must not touch the lifting collar of the safety valve stem when the hand easing gear is in the normal position. Set this clearance while the boiler is at normal operating temperature. This will help prevent safety valve simmer when different rates of thermal expansion cause the gap to close.

The hand easing gear is not designed to support the compression of the safety valves as the boiler pressure decreases. The cam operated gear opens each safety valve in sequence and holds them open until the highest set valve is opened. This operation takes so much time that boiler water level cannot be maintained if firing is stopped. Therefore, use hand easing gear only during emergency conditions that justify the damage that will occur to the safety valves and the gear.

In-depth information on hand easing gear operation, adjustment, and maintenance is found in *NSTM,* chapter 221, and the manufacturers' technical manuals.

SOOT BLOWERS

Soot blowers are installed to remove soot from the boiler firesides while the boilers are steaming. Soot blowers should be operated in all steaming boilers:

1. At least once each week while underway, in port, or at anchor.
2. After leaving or just before entering port.
3. As soon as practical after making heavy smoke from any cause (such as lighting off or casualty).
4. When periodic fireside inspection reveals excessive soot deposits in boilers, especially in the economizer area, increase the soot blowing frequency to once daily at sea and in port (subject to local port regulations). Increase the frequency only if fuel oil burner settings and equipment are satisfactory, automatic combustion controls are working properly, and the boiler has not had extended periods of dark smoke. If the next inspection reveals excessive deposits, increase soot blowing frequency to twice a day at sea. Do not increase the inport cycle. Inspect the soot blowing elements and check soot blowing pressures when any of these conditions exists.

Prolonged low firing rates from inport steaming produces increased soot deposits in the economizer area. The lower fuel pressures result in less efficient atomization and combustion of the fuel. You can reduce, but not eliminate, these soot deposits by using fewer burners at a higher fuel pressure.

Blowing tubes has an effect on the upper decks. Note that frequent use of soot blowers results in less smoke and soot topside.

Soot blower elements should be rotated at a rate of 10 to 15 seconds for each 90 degrees of rotation. Each element must be rotated one to three complete turns, depending on the condition of boiler firesides.

Soot blowers must be used in the proper sequence. This ensures that the soot is swept progressively toward the uptakes. Normally, the uppermost soot blowers are

used at the beginning and end of each soot blowing cycle. Refer to the manufacturer's technical manual for each boiler to obtain the exact sequence for blowing tubes. Consult the manufacturer's technical manual for details on the construction, operation, and maintenance of soot blowers on any particular boiler.

Some soot blowers are operated by endless chains, others by hand cranks. On some soot blowers, the admission and cutoff of steam is controlled so that the tubes are swept only during a part of each rotation of the element. The part of each rotation when steam is admitted and tubes are swept is called the BLOWING ARC. Blowing arcs are controlled by cams or by stops.

Soot blowers are useful, but they can also be very dangerous. A soot blower casualty usually allows large quantities of steam to escape very rapidly into the fireroom or machinery space. You can prevent most soot blower casualties by

1. observing all required operational precautions and

2. carrying out all necessary inspection and maintenance procedures.

A practice that is extremely dangerous is using the soot blowers without warming the steam line gradually and thoroughly. When steam is admitted suddenly to the cool piping, the piping is subjected to thermal shock. This shock could be severe enough to cause piping failure.

Another dangerous practice is using excessively high steam pressures to blow tubes. Sometimes the high steam pressure results from a combination of operational and mechanical defects.

Operate soot blowers at their proper blowing pressure. Most rotary soot blowers operate at 300 psi. How-ever, some rotary soot blowers are set to operate at a lower pressure. Stationary soot blowers operate at 150 psi. You should always check the manufacturer's technical manual for the correct soot blower operating pressure. If no pressure limit is given, then 300 psi (plus or minus the allowable tolerance) applies. The steam pressure is reduced from line pressure by a reducing orifice, pressure control disks, or valves. You should check the steam pressure by temporarily installing an accurate pressure gauge at the connection provided for this purpose on the soot blower head, This is shown in figure 14-3. If the pressure gauge shows the operating steam pressure is higher than the required setting, the pressure control disks may need to be reset or the defective orifice, disk, or valve may have to be replaced. Report the results of the tests to the engineer officer before starting any repair action.

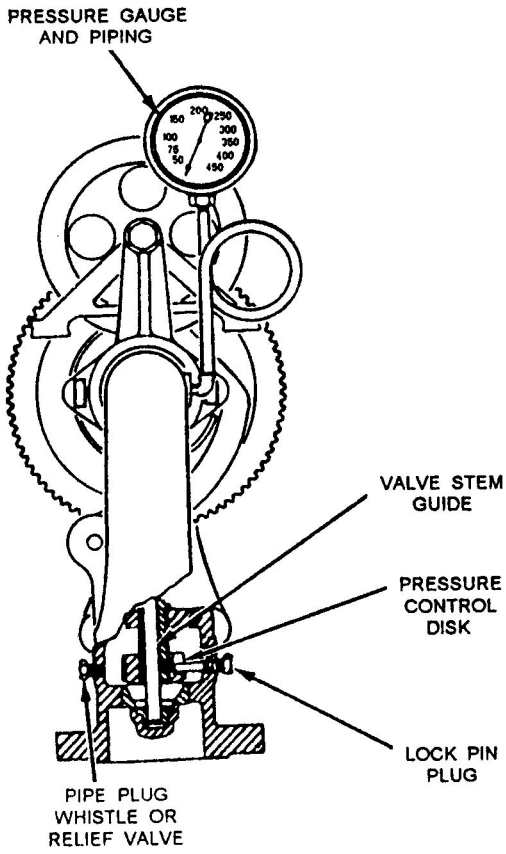


Figure 14-3.—Pressure gauge installation.

Soot blower casualties have occurred because of steam lines rusting out, bearings coming loose, worn-out parts giving way, and similar troubles. Casualties from these troubles are usually related to improper inspection and maintenance.

Some of the important aspects of soot blower inspection and repair that you may perform or be responsible for are covered in the following sections.

SOOT BLOWER PIPING

All soot blower piping and connections should be examined at each major overhaul. Examine the piping and joints whenever there is reason to suspect unsatisfactory conditions. The wall thickness of soot blower piping should be determined by ultrasonic measurements taken at various points. Refer to *NSTM*, chapter 505, for the requirements for remaining wall thickness.

When the supply piping is being inspected, you should verify that the piping is installed according to the latest applicable NAVSEA drawing. If the supply piping is not properly installed, it should be altered when repair or renewal of piping becomes necessary, Soot blower piping is inspected according to PMS.

Renewal is determined by the results of the ultrasonic tests.

Before soot blower piping can be inspected visually, some of the lagging must be removed. The lagging must be replaced correctly after the inspection. The insulation must be sealed with epoxy at the termination point below each soot blower head. This epoxy seal prevents moisture from seeping under the insulation and causing corrosion.

Insulation and lagging should **NOT** be used on soot blower steam piping located underneath the floor plates. If such lines were insulated and lagged, corrosion would be likely to proceed unnoticed and unchecked. There could be consequent danger of the lines giving way. Portions of the soot blower steam piping that are underneath the floor plates should be left bare. These parts should be painted with two coats of heat-resistant paint.

Drain nipples and drain valves are provided at low points in the supply piping. The drain valve must have either a hole drilled in the valve disk or a notch cut in the valve seat. Regularly check all drain openings with a probe to make sure they are open to prevent water from accumulating in the soot blower piping.

Soot blower piping should be installed so it slopes downward from the element to the drain nipple or the drain valve. The piping should be free of pockets and should have no horizontal sections. The drains should be located so the discharge does not drain onto drums, casings, piping, or machinery. Also, you must ensure that the discharge is not a hazard to personnel. The drains should be arranged to discharge below the floor plates, about 6 inches above the bilges.

SOOT BLOWER HEADS

All moving parts in the soot blower heads must be inspected regularly. Ensure that they operate freely and that they are not excessively worn or corroded. During each major overhaul, soot blower heads must be very carefully checked for suitability for service. Each head must first be cleaned of all corrosion products. Then, the thickness of the head must be measured by an approved ultrasonic measuring device. Any head must be discarded immediately if it

1. has a thickness of 50 percent less than the original thickness specified on the applicable drawings or
2. is shown to be structurally unsound by examination.

When soot blowers are being installed, attach the head to the end of the element so the element nozzles will line up correctly with the tubes. The correct alignment is shown on the boiler plans. The correct lineup of the element nozzle is also necessary during reassembly of the soot blower heads after they have been repaired. Most soot blowers have an arrow on the outside of the large gear wheel. This arrow shows the direction the nozzles are pointing. When assembling or reassembling soot blowers, install the elements so the nozzles point in the direction indicated by the arrow.

You must ensure that the soot blower elements are firmly attached to the heads. In some soot blowers a threaded coupling attachment is used. In others, the element and a head extension piece are each screwed into a flange. Then, the flanges are bolted together. In either type, there must be a thread engagement of at least 1/2 inch. All threads must be firmly set, and the screwed connections must be tack welded in at least three locations around the outside. Figure 14-4 shows a soot blower coupling connection.

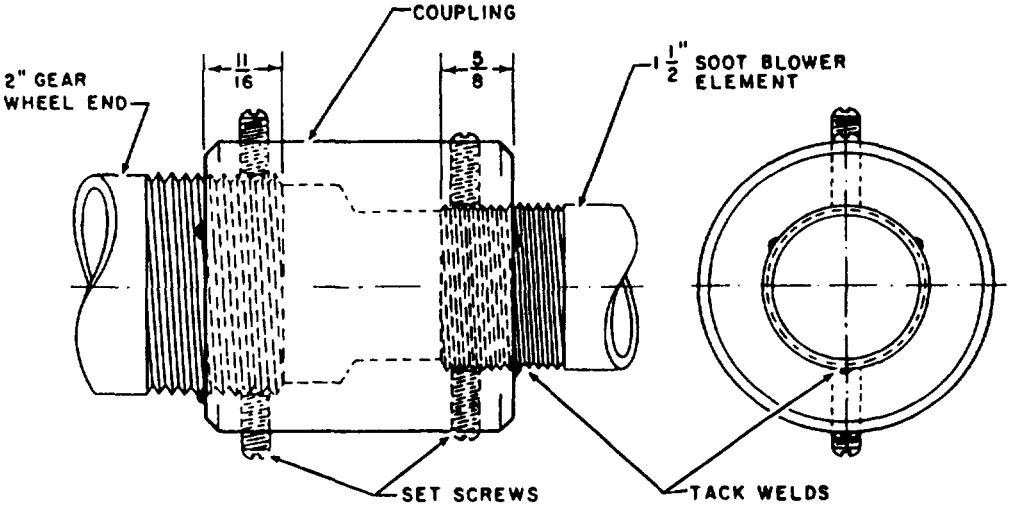


Figure 14-4.-Soot blower coupling connection.

SOOT BLOWER PACKING

Most soot blowers require the occasional addition or renewal of packing. Split-ring packing is usually used on soot blowers. However, consult the manufacturer's technical manual and the drawings for specific information on the packing requirements for your boiler.

Sometimes leaks cannot be stopped by taking up on the packing glands. The addition of one or two packing rings to each gland may solve this problem. The old packing should be removed and replaced if leakage is severe or the packing has been used for a long time.

SOOT BLOWER VALVES

The soot blower head steam valves must be kept in good condition. They must seat properly, and they must not leak. The existence of leaks may be detected by the presence of furnace gases at the drain connections.

Oil should not be used on the valve stems. Oil may form a gummy deposit that could cause the valve stem to stick in the guide. If a valve stem does stick, remove it from the valve and clean it.

You can grind in the steam valve without removing the soot blower head from the boiler. Remove the gooseneck flange bolts and the nuts on the end of the bracket stud. The entire unit may then be pulled out. The gooseneck can be turned to any position convenient for grinding in the valve.

If you can remove the soot blower head from the boiler, the operation of grinding in the steam valve may be easier. First, break the gooseneck flange joint. Then, remove the cap screws that hold the bottom of the bracket to the gooseneck. Next, remove the nut on the inner end of the sheave wheel shaft. Now, the gooseneck can be drawn off the swivel tube without disturbing the packing. The gooseneck can be taken to the shop so that the valve can be ground in.

Both the valve disk and the valve seat are renewable. They should be replaced rather than reground if they are badly worn, damaged, or have previously been overground.

SOOT BLOWER ELEMENTS

Soot blower elements are made of 1 1/2-inch or 2-inch tubing. The tubing has nozzles placed at equal distances along one side. Specifications for the spacing of the nozzles are as follows:

1. Not greater than every third tube if the axis of the element is at right angles to the axis of the tubes
2. Not greater than 3 inches if the axis of the element is parallel to the tubes

For right angle arrangements, position the nozzles to prevent steam from impinging directly on the boiler tubes.

The type of metal used in soot blower elements depends on the gas temperatures to which the elements will be exposed. Therefore, the elements are **NOT** interchangeable even if the nozzles are identical in size and spacing. If the soot blowers must be disassembled, identify the elements so they can be reinstalled in their correct locations.

If an element does not rotate freely, the most likely cause is warping of the element. Sometimes you can straighten an element without removing it from the boiler. Turn the element to the point where it binds hard in the bearings, then leave it in this position for a few hours. You can do this if the bearings are properly aligned and firmly attached.

If this procedure does not straighten the element so it rotates freely, remove the element from the boiler. Then, lay the element on a level surface, heat it, and tap it with a wooden block until it is straight. Most elements should be heated to about 1500°F. They may or may not require quenching after they have been straightened. Other alloy elements must be heated to a higher temperature (about 1600°F) and quenched. Always consult the manufacturer's technical manual for the exact temperatures and quenching procedures. The various alloys used for soot blower elements react quite differently to heating and quenching. The differences in procedures are really more important than they might seem.

SOOT BLOWER BEARINGS

Bearings for the soot blower elements are made of 25 percent chrome, 20 percent nickel or 20 percent chrome, 12 percent nickel. The bearings are not tight fitting and the soot blower elements do not actually ride in them. They are more for a guide than actual support.

When tightening or renewing bearings, be sure the boiler tubes are clean where they touch the bearings. After tightening the bearing bolt nut, tap the bearing

lightly with a hammer. Make sure the bearing fits close against the tube. Then, pull up on the nut one or two more turns to ensure an absolutely tight fit. Then, spot weld the nuts to the bolts or bearing plate.

SOOT BLOWER CAMS

On many soot blowers, the blowing arcs are controlled by cams. The cam settings are checked according to PMS. This check ensures that steam is being admitted to the soot blower elements only when the elements are rotated through their proper blowing arcs. The correct blowing arc of each soot blower is shown in the manufacturer's technical manual for the boiler. The cams must be set so the nozzles will not blow directly onto headers, drums, or baffles at close range.

To set the cam on a soot blower with a blowing arc of less than 360°, remove the cam from the gear wheel. Then, set the element nozzles in the position they should be in when the valve in the soot blower head starts to open. With the head in position, attach the cam to the gear wheel. Use two cam bolts made up hand tight so the cam opening touches the trigger end. Turn the head until the nozzles are in the position they should be in when the valve has just closed. Now, bolt the cam securely to the gear wheel. Make sure the opening end of the cam is in the correct position. Check the blowing arc carefully. Observe the position of the nozzles when the valve starts to open and when it has just closed. Make sure the steam jets will not strike any headers, drums, or baffles at close range.

SCAVENGING AIR SYSTEM

The scavenging air system provides a means to prevent combustion gases from backing up into the soot blower head. This system allows combustion air from the boiler outer air casing to blow into the soot blower head. If you allow combustion gas to accumulate in the soot blower head, the mixture of moisture and sulphur creates sulfuric acid. This acid could cause serious corrosion.

A check valve is installed in the scavenging air piping near the soot blower head. The valve is normally in the open position. When tubes are being blown, steam enters the check valve and pushes the valve into the closed position. When tubes are not being blown, the combustion air pressure in the scavenging air line keeps the check valve open.

You should inspect the check valve often. Keep the valve clean and free of corrosion products or debris that would hinder the operation of the valve.

The scavenging air piping between the check valve and the soot blower head is made of the same material as the soot blower steam piping. It is insulated and lagged in the same manner. The scavenging air line, between the check valve and the boiler casing, is copper tubing. Route the copper tubing to help in the event of check valve failure. The bend of the copper tubing will serve to deflect the steam downward. The direction should be away from the boiler casing and away from the registers.

The scavenging air piping between the check valve and the soot blower head should be treated like the soot blower steam piping. It should be checked and tested in the same way and at the same intervals as the soot blower steam piping. The copper tubing should be checked often for holes or cracks.

BOILER INSPECTION DEVICE (BID)

Most boiler explosions occur during boiler light off. These explosions happen because of unburned fuel collecting in the furnace from leaking burners, unsuccessful light off attempts, and from failure to remove burners after securing the boiler.

The BID was designed specifically for inspecting the furnace for unburned fuel. The BID is basically a periscope that has its own lighting and power source. Equipped with mirrors and prisms, the BID allows you to inspect the furnace deck quickly and effectively.

There are two sizes of BIDs. One is for main propulsion boilers and a new, smaller size has been designed for auxiliary boilers. You are required to have one operational BID for each fireroom.

You can <u>never</u> assume that the boiler purge has removed all the unburned fuel, especially in a hot boiler. Before you light fires in a boiler, you must inspect the furnace for unburned fuel. You also need to inspect the furnace after each unsuccessful light off attempt. You must remove all signs of unburned fuel before you continue with the boiler light off.

Checking the furnace for unburned fuel is a simple operation. Check the operation of the BID before you insert it into the firebox. Ensure that the light off atomizer is inserted into the light off burner, the fuel system is pressurized, and the purge is completed. Insert the BID into the furnace using the lighting off port. After insertion, check the furnace floor for signs

of unburned fuel. Be sure you check the entire floor area of the furnace. Unburned fuel may appear as shiny spots on the brickwork. Unburned fuel vapors will cause the BID mirrors to fog. Occasionally, you can smell fuel vapors coming from the light off port; but, this is not a good indication of unburned fuel. Always inspect the furnace using the BID

REMOTE WATER LEVEL INDICATORS (RWLIs)

RWLIs are used to observe the water level from various locations in the fireroom. The two types of RWLIs commonly used in the Navy are the Barton and the Yarway water level indicators, RWLIs are installed to give the operator and machinist's mate of the watch (MMOW) a secondary means of monitoring steam drum water level. The MMOW can monitor the RWLI at an operating station away from the upper level in front of the boiler.

The primary RWLI sends a signal to another RWLI located in main engine control. This setup allows the engineering officer of the watch (EOOW) to observe the boiler water level. The primary RWLI also actuates the boiler high and low water alarms. These alarms activate at preset levels and sound in the fireroom and main engine control.

Refer to the manufacturers' technical manual for detailed information on remote water level indicator operation, maintenance, and repair.

SUMMARY

In this chapter, you have learned about some of the boiler fittings and instruments you will be responsible for operating and maintaining. The material in this chapter introduced you to the complexity of the maintenance and repair of various boiler fittings and instruments.

CHAPTER 15

ENVIRONMENTAL POLICIES AND PROCEDURES

The federal government continues to emphasize how important it is that federal agencies do everything possible to prevent environmental pollution. Presidential executive orders and congressional legislation support this emphasis. All facilities owned by, or leased to, the federal government must be designed, operated, maintained, and monitored to conform to air, water, and noise standards established by federal, state, and local authorities.

The Navy will work to protect and improve the quality of the environment. We will follow all regulatory standards that apply to us, and we will initiate actions to conserve natural resources, protect historical and cultural properties, and prevent or control pollution. This chapter covers the policies and instructions under which we work to protect and improve the environment and it provides an overview of the procedures we use to do so.

POLLUTION CONTROL LAWS AND REGULATIONS

The following paragraphs offer a brief overview of the more important laws and regulations we use to protect the environment.

In 1899, Congress passed a law prohibiting the discharge of refuse in navigable waters of the United States. The Oil Pollution Act of 1924 prohibits the discharge of oil of any kind (fuel oil, sludge, oily waste, and so forth) into navigable waters. The Oil Pollution Act of 1961 prohibits the discharge of oil or oily mixtures, such as ballast, within the prohibited zones established by any nation, and those zones range from 50 to 150 miles seaward from the nearest land. The 1961 act ratified a 1954 international agreement known as the Convention for the Prevention of Pollution of the Sea by Oil. Proposed amendments would abolish prohibited zones and extend oil dumping prohibitions to all ocean areas.

The Oil Pollution Act of 1924 was repealed by the Water Quality Improvement Act of 1979. This act prohibits the noncasually discharge of any type of oil from any vessel, onshore facility, or offshore facility into or upon navigable waters of the United States, adjoining shorelines, or waters of the contiguous 12-mile zone. Other features of the act provide for the control of hazardous substances other than oil and for the control of sewage discharges from vessels.

The Clean Air Amendments of 1970 set goals for the reduction of pollutant emissions from stationary sources and vehicles. New stationary sources that bum fossil fuels must conform to emission standards determined by the Environmental Protection Agency (EPA).

In 1970, Congress also passed two acts that declared a national policy to improve the environment. They were the National Environmental Policy Act of 1969 and the Environmental Quality Improvement Act of 1970. These acts require federal, state, and local governments to create and maintain conditions where man and nature can exist together.

The Navy's environmental quality program is the *Environmental and Natural Resources Program Manual,* OPNAVINST 5090.1. It contains guidelines to prevent, control, and abate air and water pollution. In general, we must ensure that all facilities, including ships, aircraft, shore activities, and vehicles, are designed, operated, and maintained to conform with standards set forth in the 1970 and 1979 acts. The following paragraphs cover the most important requirements of the instruction.

Shore activities will use municipal and regional waste collection and disposal systems whenever possible. We will handle all materials such as solid fuels, petroleum products, and chemicals in ways that prevent or minimize pollution of the air and water. We will reprocess, reclaim, and reuse waste material whenever feasible. Ships will use port disposal facilities for all waste before they get underway and when they return to port. We will not discharge oil products within any prohibited zone, and we will not discharge trash and garbage within 12 miles of shorn. We will normally burn waste material in open fires. We will not use sinking agents and dispersants to fight oil spills except when there is a substantial fire hazard or danger to human life.

To meet the requirements of the Clean Air and Water Quality Improvement Acts, the Navy has instituted several ongoing programs. Some of them are

in operation and others are being tested and evaluated For example, we now operate completely enclosed firefighting training facilities from which no smoke escapes. Aboard ship, we have shifted from Navy standard fuel oil to distillate, which reduces air pollution because it has a low sulfur content and burns more cleanly than standard fuel oil. We are now evaluating several models of self-contained shipboard sanitary treatment systems that eliminate the discharge of polluted sewage.

You can see that the Navy is using time, money, and effort to reduce environmental pollution. To support that policy, you should closely supervise all operations that involve fuel handling, waste disposal, and the use and disposal of toxic materials. Indoctrinate personnel on the causes of pollution and the necessity to reduce it. Be sure personnel under your supervision comply with regulations and operating procedures for pollution control devices.

In the rest of this chapter, we'll cover the procedures and facilities we use to help improve the environment.

PREVENTING OIL SPILLS

The preferred method to reduce and control environmental pollution is to prevent the pollution. We must integrate prevention measures into any planned industial proms, operation, or product as part of the cost of daily operations. The following paragraphs discuss ways to prevent pollution caused by oil spills.

Before you start any fueling, defueling, or internal transfer operation, check all machinery and piping systems for tightness and for signs of leaking glands, seals, and gaskets. When you change oil or add oil to machinery, take care not to spill the oil into the bilge. Keep a drip pan and rags ready for use if needed. Keep a close watch on centrifugal purifiers when they are in operation to make sure they do not lose the water seal and dump the oil into the bilge or contaminated oil tank

When you deballast, keep a careful watch on the overboard discharge to make sure that no oil is pumped overboard with the water from the ballast tanks.

Pump all oily waste from tank cleaning operations into a sludge barge.

Control of shipboard oil pollution is complicated by the many and varied sources of oily waste. The Navy is incorporating oil pollution control systems and components into its ships that will reduce oil pollution by the following means:

1. Reduce the generation of oily waste.
2. Store waste oil and oily waste.
3. Monitor oil and oily waste.
4. Transfer or offload waste oil and oily waste to shore facilities.
5. Process oily waste.

The training officer must ensure that formal training is provided to key personnel who maintain and operate pollution control equipment. The training officer is responsible for training that achieves an acceptable level of expertise.

Figure 15-1 shows a schematic diagram of a typical shipboard oil pollution control system.

As a supervisor, you should be sure that all engineering personnel are familiar with the sources of oil spills and oil waste that may cause pollution. The following lists show common sources of oil and oily waste that find their way into the water.

1. Lubricating oil

a. Leakage and drainage from equipment and systems

b. Contaminated oil from centrifugal purifiers

c. Used oil removed from equipment during an oil change

2. Fuel oil

a. Spillage during fueling, defueling, and internal transfer operations

b. Leakage through hull structures into bilges

c. Stripping from the contaminated oil settling tank

d. Ballast water from fuel tanks of noncompensated fuel systems or bulk carriers

e. Ballast water from compensated fuel tank systems during refueling, defueling, and internal transfer operations

f. Tank cleaning operations

3. Hydraulic fluids

a. Leakage of hydraulic fluid from glands and seals into hydraulic pump room bilges

b. Spillage during system filling replenishment

c. Spillage caused by hydraulic system casualties

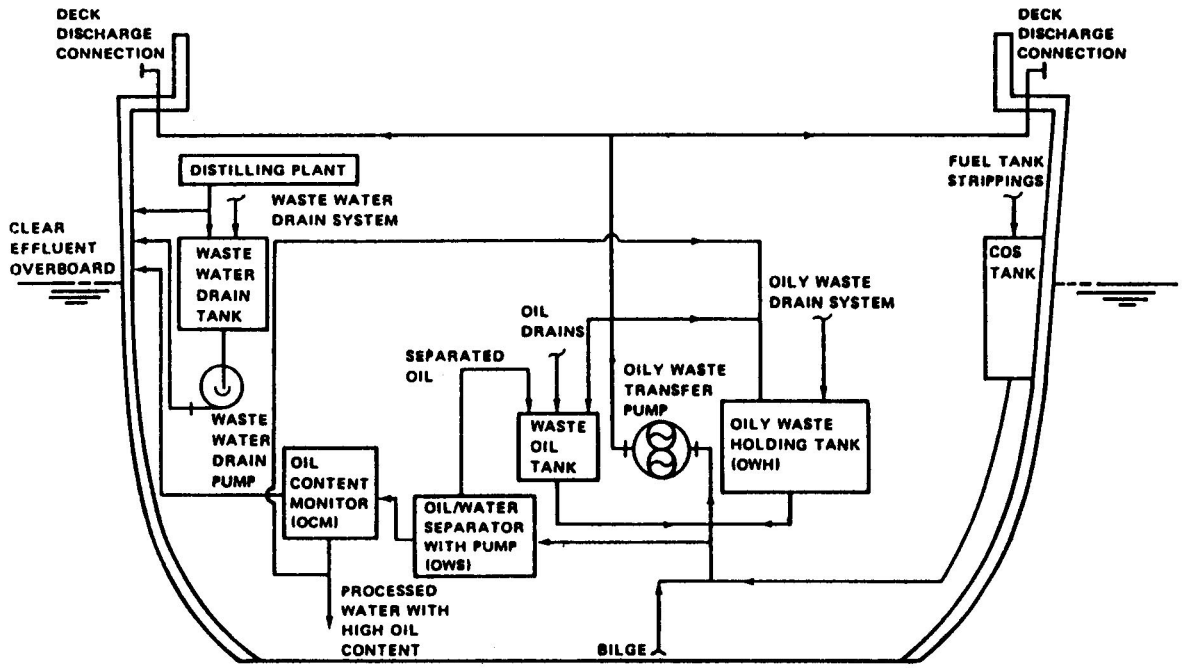


Figure 15-1.–Typical shipboard oil pollution control system.

HANDLING OIL SPILLS

All oil spills and slicks or sheens within the 50-mile prohibited zone of the United States shall be reported immediately according to the *Environmental and Natural Resources Program Manual,* OPNAVINST 5090.1. Navy ships can now provide immediate remedial action on oil spills until they are relieved by shore-based response units. Since U.S. shorebased units are seldom available in non-Navy or foreign ports, a ship may have to clean up the entire spill.

A cleanup kit has been developed for use by the ship's crew. The *U.S. Navy Oil Spill Containment and Cleanup Kit,* NAVSEA 0994-LP-013-6010, contains a description of the kit and instructions for its use. The manual describes safety precautions for use of the kit as well as the recommended shipboard allowance. A trained crew that acts quickly can contain a spill, and it can often collect the entire spill without help from shore-based personnel.

SHIPBOARD SEWAGE AND WASTE DISPOSAL

The environmental harm caused by sewage discharges into rivers, harbors, and coastal waters by naval ships is of great concern. Secretary of Defense regulations require the Navy to control sewage discharges. Navy policies and responsibilities are defined in *the Environmental and Natural Resources Program Manual,* OPNAVINST 5090.1.

The Navy intends that all naval ships will be equipped with marine sanitation devices (MSD) that will allow them to comply with the sewage discharge standards without compromising mission capability. However, sewage discharge regulations do not forbid overboard discharge during an emergency when there is danger to the health and safety of personnel. In the past, shipboard sewage has been discharged overboard routinely. We changed that practice when evidence showed that concentrations of sewage in inland waters, ports, harbors, and coastal waters of the United States were bad for the environment.

In 1972 the Chief of Naval Operations decided that the Navy would install the sewage collection holding, and transfer (CHT) system (a type of MSD) aboard naval ships that could use that method of sewage pollution control without serious reduction in military capabilities. The CHT system represented the least cost and risk solution to the problem. Most operational fleet ships of sufficient size have CHT systems.

Navy ships have two types of CHT systems. The type for a particular ship depends on the holding tank capacity. Systems with tanks with a capacity of more than 2000 gallons use a comminutor and aeration system. Smaller systems with capacities of less than

2000 gallons use strainers. Figures 15-2 and 15-3 show the comminutor-type and the strainer-type systems.

The goal for the CHT system is to provide the capacity to hold shipboard sewage generated over a 12-hour period. Large ships can usually reach the goal, but smaller ships often reach their capacity in about 3 hours; probably not enough time to get outside the 3-mile restricted zone. Ships can get a waiver if they cannot reach the 12-hour holding time because of serious impact on military or operational characteristics. These ships are identified in DOD Directive 6050-4 of April 1976. NSTM, chapter 997 discusses sewage discharge procedures for ships in drydock.

The CHT system accepts soil drains from water closets and urinals, and waste drains from showers, laundries, and galleys. The three functional elements of sewage collection, holding, and transfer make up the CHT system.

The collection element consists of soil and waste drains with diverter valves. Depending on the position of the diverter valves, the soil or waste can be diverted overboard or into the CHT tank.

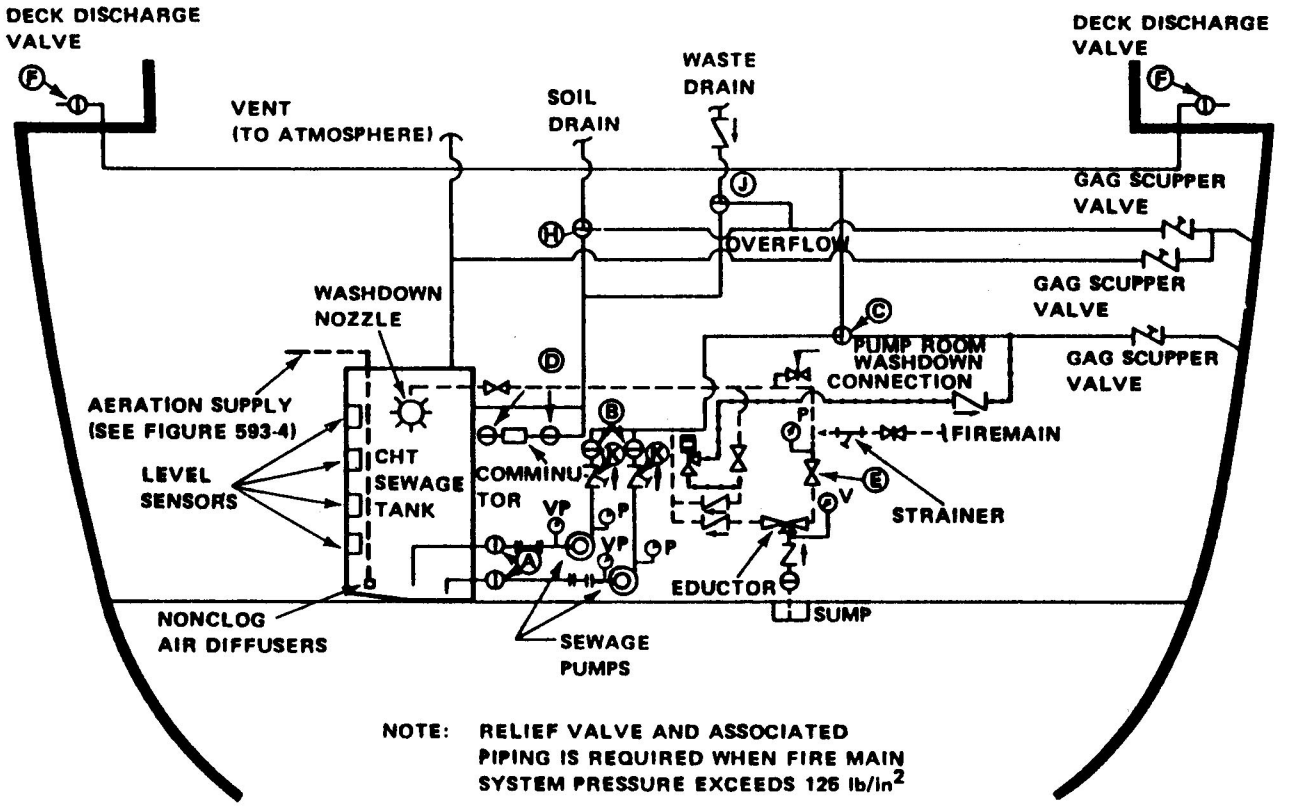


Figure 15-2.-Comminutor-type CHT system.

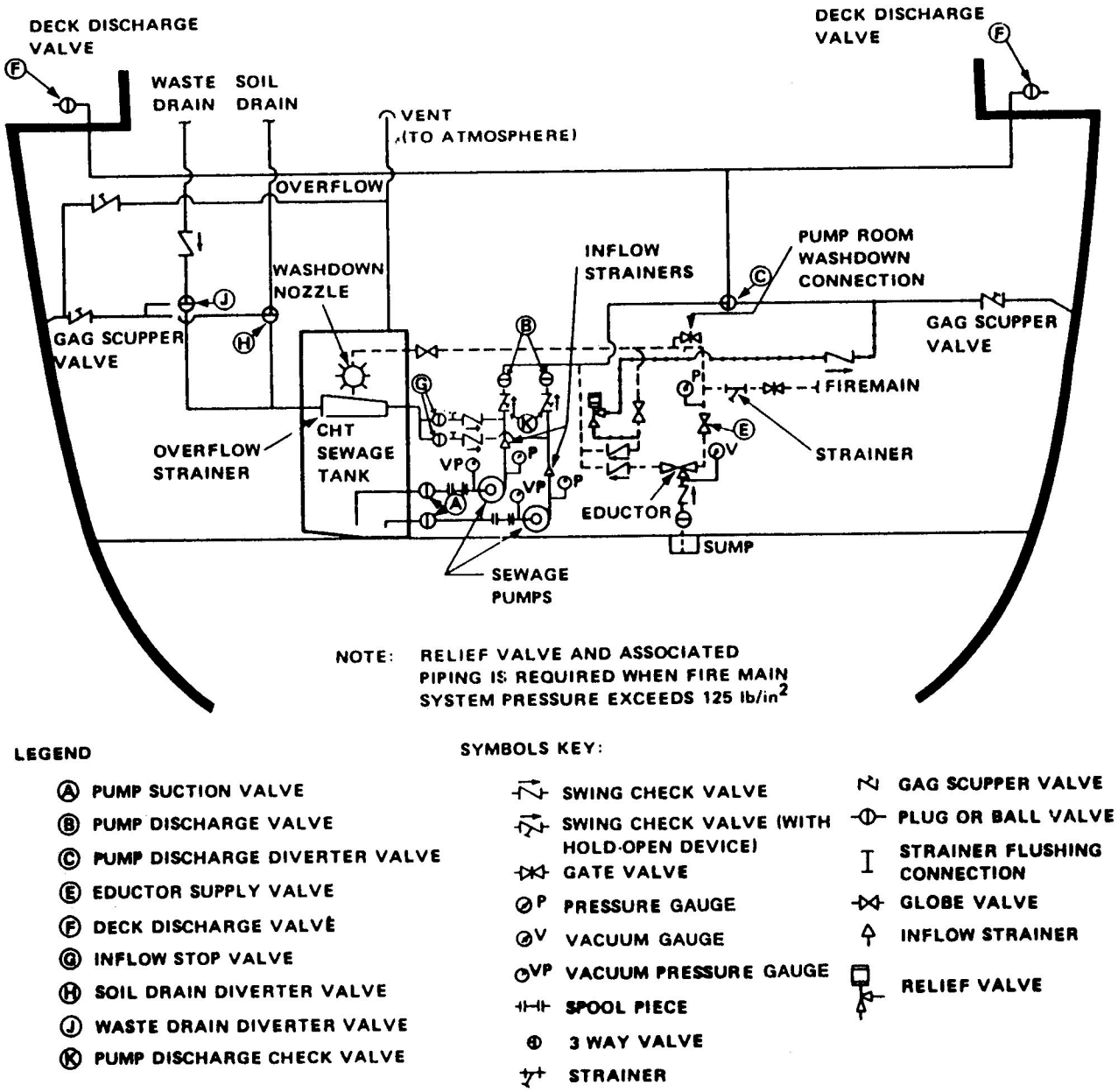


Figure 15-3.–Strainer-type CHT system.

The holding element consists of a holding tank. The transfer element includes sewage pumps, overboard and deck discharge piping, and deck discharge fittings.

The CHT system can be used in any of three distinct modes of operation, depending on the situation.

1. When the ship passes through restricted zones, the CHT system is set up to collect and hold discharges from the soil drains only.

2. During in-port periods, the CHT system will collect, hold, and transfer to a shore sewage facility all discharges from the soil and waste drains.

3. When the ship operates at sea outside restricted areas, the CHT system will be set up to divert discharges from soil and waste drains overboard.

NSTM, chapter 593, has more information on the operation and maintenance of CHT systems.

FUEL OIL STORAGE AND HANDLING

Fuel oil systems aboard ship include fuel oil tanks, fuel oil piping, fuel oil pumps, and the equipment we use to strain, measure, and burn the fuel oil.

FUEL OIL TANKS

Navy ships use four kinds of tanks that are part of the ship's system to receive, hold, and distribute fuel oil. They are (1) storage tanks, (2) overtlow tanks, (3) service tanks, and (4) contaminated oil settling tanks. We'll explain their functions in the following pages.

Fuel oil tanks are vented to the atmosphere through pipes leading from the top of each tank to a location abovedecks. The vent pipes allow air to leave or enter the tank as fuel is added or removed. Most fuel oil tanks are equipped with manholes, overflow lines, sounding tubes, liquid level indicators, and lines by which you may fill, empty, and cross-connect the tanks.

Fuel Oil Storage Tanks

The main fuel oil storage tanks are part of the ship's structure. They may be located forward and aft of the machinery spaces or abreast of these spaces. They may be in double-bottom compartments as long as those compartments are not directly under boilers. Some tanks have connections that allow them to be filed with fuel oil or with seawater from the ballasting system.

Fuel Oil Overflow Tanks

Fuel oil overthrow tanks receive the overflow from fuel oil storage tanks that are not fitted with independent overboard overflows. Overflow tanks also serve as ballast tanks because they can be filled with seawater from the ballasting system.

Fuel Oil Service Tanks

Fuel oil is taken aboard by fueling trunks or special connections leading to the fuel oil storage tanks. The fuel oil is then pumped to the fuel oil service tanks. All fuel for immediate use is drawn from the service tanks. The fuel oil service tanks are considered part of the fuel oil service system described later in this section.

Contaminated Oil Settling Tanks

The contaminated oil settling tanks hold oil that is contaminated with water or other impurities. After the oil has settled, the unburnable material, such as water and sludge, is pumped out through low suction connections. The burnable oil remaining in the tanks is transferred to a storage tank or a service tank.

The contaminated oil tanks also can receive and store oil, or oily water, until it can be discharged overboard without violation of environmental regulations. See OPNAVINST 5090.1 to learn when you may empty the contaminated oil settling tanks either overboard or to barges.

FUEL OIL PIPING SYSTEM

The fuel oil piping system includes the piping and pumps for three systems, each of which is connected at different levels of the storage or service tanks for (1) the fuel oil falling and transfer system, (2) the fuel oil service system, and (3) the fuel oil tank stripping system. The pipes are connected to the storage and service tanks at different levels so the pumps can take suction from any of these levels. The service system is connected at the highest level, the filing and transfer system is connected at the next lower level, and the tank stripping system is connected at the lowest level. We'll explain the function of each in the following paragraphs.

Fuel Oil Filling and Transfer System

The fuel oil filling and transfer system receives fuel oil aboard and (1) fills the fuel oil storage tanks, (2) fills the fuel oil service tanks, (3) changes the list of the ship by transferring oil between port tanks and starboard tanks, (4) changes the trim of the ship by transferring oil between forward and after tanks, (5) discharges oil for fueling other ships, and (6) in emergencies transfers fuel oil directly to the suction side of the fuel oil service pumps.

The fuel oil filling system of some ships consists of a trunk-filling and tank-sluicing arrangement. Other ships have pressure filling systems that are connected to the transfer mains so the filling lines and deck connections can be used both to receive and discharge fuel oil. The pressure filling systems operate with a minimum pressure of approximately 40 psi at the deck connections.

In general, the filling and transfer system consists of large mains running fore and aft. These are transfer mains, cross-connections, mains to fuel oil booster and transfer pumps, and risers to take on or discharge fuel oil. Other lines and manifolds are arranged so the&l oil booster and transfer pumps can transfer oil from one tank to another and, when necessary, deliver fuel oil to the suction side of the fuel oil service pumps.

Fuel oil Tank Stripping System

The fuel oil tank stripping system can clear the tanks of sludge and water before oil is pumped from these tanks by the fuel oil booster and transfer pumps or by the fuel oil service pumps. The stripping system is connected through manifolds to the bilge pump or, in some ships, to special stripping system pumps. The stripping system discharges the contaminated oil, sludge, and water overboard or to the contaminated oil settling tanks.

Fuel Oil Service System

The fuel oil service system used aboard any ship depends partly on the type of fuel oil burners installed on the boilers. The fuel oil service system includes the fuel oil service tanks, a service main, manifolds, piping, and fuel oil service pumps.

Fuel oil service pumps take suction from the service tanks through independent tailpipes, cutout valves or manifolds, suction mains, and pump connections. The suction arrangements for fuel oil service pumps allow rapid changes in pump suction from one service tank to another. The pump suction piping is arranged to keep to a minimum any contamination that might result if one service pump takes suction from a service tank that is contaminated with water. The tank stripping system is connected through stop-check valves to the service suction mains so these mains can be cleared of oil that is contaminated with water. The service suction main is common to all pumps in one particular space. It has connections to the fuel oil transfer main through stop-check valves that are normally locked in the closed position.

Aboard some ships, JP-5 can be used as boiler fuel in emergencies. The JP-5 systems are arranged so they can discharge to the fuel oil service system.

Two classes of fuel oil service pumps are commonly used (1) main fuel oil service pumps, and (2) port and cruising fuel oil service pumps. Both are usually screw-type rotary pumps that may be either motor- or turbine-driven the difference is in size and in gallons delivered.

The fuel oil service system also needs fuel oil strainers, burner lines, and other such items to deliver fuel oil to the boiler fronts at the required pressures.

PRECAUTIONS IN HANDLING FUEL OIL

All petroleum products, including fuel oil, are potentially dangerous. Heated fuel oil may generate vapors that are flammable, explosive, and dangerous if you inhale them. The oil king must have thorough knowledge of these hazards. Thee oil king also must make certain that all personnel in fuel oil details take the necessary precautions. The following list covers the most important precautions:

1. Do **NOT** allow anyone to smoke or to carry matches or lighters while handling fuel oil.

2. Use only approved types of protected lights when working near fuel oil.

3. Do **NOT** allow oil to accumulate in bilges, voids, and so forth. The vapor from even a small pool of heated fuel oil can cause an explosion.

4. **NEVER** raise the temperature of fuel oil above 120°F in fuel oil tanks. If the tanks are next to a magazine, **NEVER** allow the oil to become hot enough to raise the magazine's temperature above 100°F, nor to maintain the magazine's temperature at more than 90°F.

5. **NEVER** raise the temperature of the fuel oil above the flashpoint in any part of the system before it enters the boiler.

6. **NEVER** exceed the designed pressure in any part of a fuel oil system.

7. Do **NOT** allow smoking, open flame, or any spark-producing object near fuel oil tank vent pipes.

8. Be sure the wire screen protectors in the vent pipes are intact. Do **NOT** allow the wire screen protectors to be painted.

9. **REMEMBER THAT FUEL OIL FUMES ARE DANGEROUS IF INHALED.** If your eyes sting or burn, you probably also are inhaling the fumes. The symptoms range from headache and dizziness to unconsciousness and suffocation. Give first aid to any person suffering from inhalation of fuel oil fumes; see chapter 3, *Standard First Aid Training Course*, NAVEDTRA 12081. Remember, also, that a person who is suffering only mild effects from inhaling fuel oil fumes may be confused or drowsy enough to cause a serious accident.

10. **NEVER** enter and do **NOT** allow anyone else to enter any fuel oil compartment until the gas free engineer declares it **SAFE FOR PERSONNEL.** Always get permission from the gas free engineer before any person enters a fuel oil tank.

11. Observe all safety precautions for closed or poorly ventilated compartments. These are listed in NSTM, chapter 074.

12. When the ship is in drydock, be sure oil does **NOT** drain from the ship onto the dock.

13. Do **NOT** heat distillate fuel by using the ship's fuel oil heaters. In general, you will not need to heat tanks, but severe cold weather may create a need to do so. If the transfer pump is having difficulty moving the fuel, and the fuel in the tank is below 50°F, you may heat fuel oil to approximately 75°F to dissolve the waxy constituents.

14. Use only the sprayer plates recommended for use with the distillate fuel.

15. When burning a distillate fuel, do **NOT** allow a smoky, hazy stack. Improper combustion causes excessive fuel consumption and a dangerous stack condition, and it adds to air pollution.

16. When ships are refueled where the ambient temperature is below 40°F, do not fill storage tanks above 95 percent of capacity. If a tank exceeds that amount, pump the oil down to 95 percent of capacity as soon as possible.

17. Be sure all personnel under your supervision know the provisions of the Oil Pollution Act and the Federal Water Pollution Control Act.

FUELING RESPONSIBILITIES AND PROCEDURES

There are many preparations to be made before the ship actually takes on fuel. The deck force or other personnel are responsible for some of these, but the oil king is responsible for others. For simplicity, this section will be addressed to you, the oil king, though some others will supervise or perform some of the procedures.

Deballast and strip oil tanks as soon as possible after you get word that the ship will take on fuel. If sea conditions make it impossible to deballast before the ship enters port, get permission from port authorities to deballast into a barge after the ship enters port. Be sure the ballasted tanks are pumped out according to the recommended sequence tables so the ship will retain as much stability and maneuverability as possible. We will include more information on ballasting later in this chapter.

Before receiving fuel, order soundings or readings on all fuel oil storage tanks and all fuel oil service tanks. Then, submit a statement to the officer in charge of fueling showing the amount and location of all fuel oil aboard You always should know how much fuel is aboard, where it is located, how much more can be taken on, and the order in which the tanks should be filled.

Before taking on fuel, see that all service tanks and as many storage tanks as possible are topped off to the 95 percent level. This will reduce the number of tanks that must be filled. This requirement maybe modified if it will reduce the time required for fueling; it may be faster to distribute the oil in the receiving ship so approximately the same amount of time will be required to fill at each receiving station. A tank-loading schedule based on previous experience is useful to meet this last requirement.

In some ships, such as destroyers, fuel oil is delivered directly into a fuel oil service tank. When you refuel this type of ship, take fuel oil service suction from the receiving service tank until just before the approach alongside the delivering ship, then shift suction to a fuel standby service tank. Never take fuel oil service suction from the service tank that is receiving fuel oil.

Post a fueling watch list well in advance of fueling time, and be sure all personnel involved in the operation know their stations and duties. A fueling detail includes messengers, pneumercator personnel and tank sounders, personnel at the forward and after hose connections, personnel at the manifolds, and telephone talkers. Be sure all fueling detail personnel are experienced and capable.

As a rule, man fueling stations one-half hour before fueling time. Assign only the number of personnel required to handle the fueling. Additional personnel may get in each other's way.

After the fueling stations are manned, but before fueling is started, test the phone circuits, connect the air hoses to the fueling connections, and screw thermometers and pressure gauges into the fueling connections if they are required.

Before starting fueling, check equipment at all stations. Equipment required for fuel tank sounding stations includes graduated sounding rods or tapes of used), rags, and tee wrenches. Equipment required for topside fueling stations (depending on the type of refueling rig used) includes sledge hammers, axes, ball peen hammers, bolt cutters, hose coupling spanner wrenches, rags, and end fittings.

When fuel oil is received from a naval source of supply such as a naval ship, a naval storage tank, or a naval fuel barge, the activity supplying the oil must furnish the commanding officer of the receiving ship with an analysis of the oil. If possible, you and an officer of the receiving ship should witness soundings and the drawing of samples from the tanks of the supplying activity. The samples must be taken from the suction level of the tank from which the oil is to be drawn. One sample should be taken before the unloading is started, and another after the loading is completed. Both samples must be centrifuged to determine the percentage of sediment and water.

When fueling is done at sea, it may be impossible for the delivery ship to furnish a complete analysis of the oil and for the receiving ship to send representatives to witness the soundings and samplings. In this case, the supplying vessel furnishes a statement of the American Petroleum Institute (API) gravity and water and sediment content of the oil. The receiving ship must then take samples during delivery and make tests to determine the percentage of water and sediment. Take the samples with a dipper from the tank that is being filled, or draw them through connections in the delivery pipeline. Take enough small samples to make a total sample of at least 5 gallons. Then, take smaller samples from the total sample for the test. Before you take the samples, clean all the containers you will use for that purpose.

When fuel is coming aboard, keep a constant check on all tanks that are receiving fuel. In large ships, in particular, you must follow a systematic procedure to get all tanks properly filled without unnecessary loss of time. You also must be sure the stability of the ship is not impaired.

When there are several tanks in each overflow group, initially open one or two tanks in each group. When these have been filled to approximately 85 percent capacity, start filling the others in the group and closing down the valves to the tanks that are almost full, topping them off slowly. Fill the overflow tank in each group last.

Each tank has a sounding rod or a tank-capacity indicator of the pneumercator type. There may be other systems in use, which will not be covered, but you can get information about them from the manufacturer's technical manual. As oil is being received, assign someone to each tank that is receiving fuel. If you are using a sounding rod, sound the tank every 3 or 4 minutes until it is nearly three-fourths full. From this point on, take continuous soundings. Fill tanks to the 95 percent level. You can fill to slightly above this mark to allow the oil to foam, but be sure the FINAL level of oil in any tank is at the 95 percent mark.

As each succeeding tank is filled, be sure personnel at the remaining tank sounding stations are even more alert than before. As the last tank is being filled, notify the delivery ship to drop the pump pressure or to slow down the pump, as appropriate.

After you have determined the amount of fuel oil being received per minute, you can give the delivery ship a “stop pumping” time. If your calculations are correct, all tanks will be full when the pump is stopped.

You must keep the fueling officer informed as to the amount of oil received as a percentage of the total to be received and the probable time required to complete the fueling. The fueling officer keeps the commanding officer posted on the progress of the fueling.

When all tanks are full, empty the fuel hose by one of two methods: (1) blow back the oil in the hose to the delivery ship by opening the compressed air valve to the fueling connection, or (2) have the supplying ship take a back suction, which also requires that the air valve be opened. As soon as the fuel hose has been cleared, **IMMEDIATELY** uncouple the hose and return it to the delivery ship.

You also must be familiar with the procedures used to discharge fuel. The following list shows some of the steps typically used to discharge fuel oil:

1. Be sure the tanks from which fuel is to be discharged are filled and topped off to the 95 percent level.

2. If necessary, heat the oil to the temperature required to produce a viscosity of 450 SSU. This procedure is not usually required with distillate fuel.

3. Sound all tanks that will be used.

4. Couple the fuel hose and rig it according to prescribed procedures.

5. Lineup the fuel oil system to discharge fuel, and test the operation of the fuel oil pumps.

6. Place red flags over the side of the ship at the fueling stations.

7. Be sure the officer of the deck has draft readings taken forward and aft before and after fueling.

8. Set the fueling detail, setup the fueling board, and fill in available data on the fueling sheet for the fueling officer.

9. Man fueling stations about one-half hour before the expected time of approach of the ship to be fueled. Be sure personnel at the fueling stations test sound-powered phone circuits, connect air hoses to the fueling connections, screw in thermometers and pressure gauges, warm up the fuel pumps, and open valves to the fuel tanks. When the fueling detail is ready and has made all required checks and preparations, report to the fueling officer. The fueling officer wilt inform the bridge and request that the smoking lamp be out.

10. When you get word to start discharging fuel, start the pumps and operate them slowly at first, then bring them up to full-rated capacity. Buildup a pressure of approximately 40 psi at the fueling connections.

11. Continue pumping at the rated pump capacity until a tank is down to approximately 35 percent of its capacity; then shift pump suction to another tank. Slow the pumps and stop them upon a request from the receiving ship.

12. Remove fuel oil from the fuel hose by blowing air through it, or the delivery ship may take a back suction. Disconnect the hose and rig and handle them according to prescribed procedures.

13. Sound the tanks and compute the amount of fuel discharged.

BALLASTING SYSTEM

Whenever a liquid is shifted from one place to another aboard ship, there is an effect on the ship's list, trim, or stability. One of your routine jobs is to reduce any instability. To do that, you should keep as many fuel oil tanks as possible filled with fuel oil to the 95 percent level. There may be other times when you may have to use the ballasting system to move seawater to or from empty tanks. Normally, you will need to do that only in case of damage or when the ship has an unusually small store of fuel oil that brings on instability.

To keep the fuel oil tanks at 95 percent capacity, you should accumulate leftover fuel oil from partly used tanks so only those tanks actually in use are less than 95 percent full. This prevents free surface effect that occurs when a liquid only partly fills a tank and moves freely back and forth as the ship moves. There is some free surface effect when a tank is filled to the 95 percent level, but the effect is limited because the overhead interferes with the free movement of the liquid beyond a certain point. There is more danger of serious loss of stability from tanks that are half-full than from tanks that are 95 percent full.

The ballasting system allows controlled flooding of certain designated tanks to control the ship's stability. You can use the ballasting system to flood all tanks that are designated as fuel oil and ballast tanks and to flood certain voids. The ballasting and deballasting systems are arranged so all designated compartments and tanks can be ballasted either separately or together and drained either separately or together. Seawater is used as ballast, and it may be taken from the firemain or directly from sea chests. Use drainage pumps or eductors to remove the ballast water. Handle all ballasting and deballasting according to the sequence tables furnished for each ship or class of ship.

Ballasting empty fuel oil tanks helps control stability by maintaining a low center of gravity in the ship and by keeping off-center tanks full to prevent off-center flooding. Ballasting also contributes to torpedo protection—it provides a layer of nonflammable liquid at the shell of the ship to absorb fragments and otherwise minimim torpedo damage.

Admit ballast water only to those tanks that are designated for ballasting. Be sure the tanks are empty of fuel oil before you add ballast. After you have used water ballast in any tank, remove as much water as possible before you fill it with fuel oil. Use the lower level suction lines for that purpose.

If your ship suffers collision or battle damage, the damage control aspects of the your job may suddenly become vital. To make stability calculations, damage control central must have accurate information on the distribution of all liquids carried on board. To maintain or improve stability, they may order the immediate transfer of fuel oil, feedwater, or other liquids. If you are the oil king during such an emergency, you will not have time to learn your job or to catch up on details you may have forgotten or overlooked. You must **ALWAYS** know how much liquid is in all tanks and exactly how the fuel oil or feedwater transfer systems must be lined up to shift liquids from tank to tank.

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Assignment Questions

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

ASSIGNMENT 1

Textbook Assignment: "Management Programs," Chapter 1, and "Propulsion Turbines," Chapter 2, pages 1-1 through 2-14.

1-1. Why is the control of contamination entering a modern boiler critical?

1. To prevent environmental contamination
2. Because of the high rate of steam generation
3. To reduce the formation of dissolved gases
4. Because contaminants always form scale

1-2. What property of feedwater contributes to scale buildup?

1. Hardness
2. Chloride ion
3. Dissolved oxygen
4. Dissolved ammonia

1-3. What indicator of active oxygen will be present in a boiler?

1. Scabs
2. Stress corrosion cracks
3. Scale buildup on tubes
4. Open pits

1-4. How does the Cophos system of boiler water treatment prevent contaminants from damaging the boiler?

1. It removes contaminants before entry into the boiler
2. It adds excess phosphate to the boiler water
3. It precipitates contaminants into sludge
4. It removes dissolved solids by surface blowdown

1-5. By what means does the Cophos program prevent caustic corrosion in the boiler?

1. By maintaining a high pH level
2. By maintaining a low pH level
3. By maintaining the proper relationship between pH and phosphate
4. By keeping phosphates low

1-6. What method removes sludge from the boiler?

1. Surface blowdown
2. Bottom blowdown
3. Wipe out after securing
4. Chemical treatment

1-7. Which, if any, of the following treatment chemicals add only the needed phosphates?

1. DSP
2. TSP
3. Caustic soda
4. None of the above

1-8. What person must approve the use of caustic soda as a treatment for the boiler?

1. The oil king
2. The EOOW
3. The petty officer of the watch
4. The chief engineer

1-9. What factor determines whether a boiler is classified as type A or B under the Cophos system?

1. Water volume
2. Heat transfer rate
3. Treatment chemicals used
4. Steam drum pressure

1-10. The CHELANT treatment system keeps contaminants from damaging the boiler by what action?

1. Removing contaminants before entry into the boiler
2. Removing contaminants after entry into the boiler
3. Bonding the treatment chemicals to contaminants
4. Coating the boiler metal with a magnetic layer

1-11. The CHELANT treatment chemicals are injected into what component of the steam cycle?

1. Directly into the boiler
2. Into the DFT
3. Gravity fed into the freshwater drain tank
4. Into the economizer

1-12. Which of the following signal pressures determines the rate of injection of CHELANT treatment chemicals?

1. Feed flow signal
2. Steam drum pressure
3. Steam flow signal
4. Boiler water level

1-13. Along with EDTA and hydrazine, what treatment chemical(s) is/are used on 600-psi boilers?

1. TSP only
2. DSP only
3. TSP and DSP
4. Caustic soda

1-14. Which of the following CHELANT treatment chemicals participates in the formation of the boiler's magnetite layer?

1. TSP
2. EDTA
3. Hydrazine
4. DSP

1-15. At a minimum, how often does the boiler require testing using the complete CHELANT system when no contamination is occurring?

1. Every 24 hours
2. Every 12 hours
3. Every 8 hours
4. Every 4 hours

1-16. What person(s) is/are responsible for maintaining the boiler water chemistry logs and ensuring their accuracy?

1. The oil lab personnel
2. The oil king
3. The leading chief
4. The division officer

1-17. The CO should review the boiler water treatment logs a minimum of how often?

1. Daily
2. Weekly
3. Monthly
4. Quarterly

1-18. What person makes the data entries in the boiler water treatment log?

1. The oil king performing the analysis
2. The oil king in charge
3. The leading chief
4. The MPA

1-19. What are the most common fuel tests performed?

1. Visual and flash point
2. BS&W and flash point
3. Visual and BS&W
4. Flash point and visual

1-20. Visual tests for lube oil must meet clear and bright criteria. To what does bright criteria refer?

1. Lack of free water in the sample
2. Lack of sediment in the sample
3. Particulate matter in the sample that covers less than one-quarter of the bottom of the bottle
4. Entrained water present in the sample

1-21. At a minimum, how often should the oil king check the refueling equipment?

1. Daily
2. Weekly
3. Monthly
4. Before each refueling

1-22. What person assigns personnel to refueling stations?

1. The MPA
2. The chief engineer
3. The oil king
4. The EOOW

1-23. Tracking the progress of tank filling during refueling allows you to accomplish which of the following actions?

1. Compute the per minute receiving rate
2. Fill all tanks without loss of time
3. Give good standbys for stopping pumping
4. Each of the above

1-24. You are preparing to transfer fuel from storage to service tanks. What authority determines the effect of this transfer on the stability of the ship?

1. The EOOW
2. The DCC
3. The oil king
4. The chief engineer

1-25. What is the purpose of ballasting fuel tanks?

1. To prevent rusting of the metal
2. To keep tanks filled
3. To maintain stability
4. To prevent water entry into the tank

1-26. What is the maximum allowable lengthh of an extension cord?

1. 15 feet
2. 25 feet
3. 50 feet
4. 75 feet

1-27. When repairs to a ship's system are being made by a repair activity, what group is responsible for tagging the system out?

1. The tended ship
2. The repair shop personnel
3. The repair activity QA personnel
4. The repair activity

1-28. After the need to perform repairs to your equipment is identified, what person initiates the tag-Out?

1. The petty officer in charge
2. The chief in charge
3. The person who will do the repairs
4. The EOOW

1-29. When you are unsure of the position of a tagged valve, what verifying the position of the valve?

1. Turn it towards the open position only
2. Turn it towards the closed position
3. Clear the tag, then turn it towards the open position
4. Clear the tag-out sheet before checking the valve position

1-30. Which of the following dry-bulb readings requires heat stress monitoring?

1. 80°F
2. 90°F
3. 95°F
4. 100°F

1-31. As an engineering space supervisor, what can you do to improve heat stress conditions within the spaces?

1. Train personnel to properly preventive maintenance
2. Perform quality assurance checks during maintenance actions
3. Train assigned personnel to report heat stress deficiencies identified during operation or while on watch
4. Each of the above

1-32. What method best determines the effectiveness of training lectures?

1. Tests
2. Question the lecturer
3. Observe the lecture
4. Proofread the lecture before it is presented

1-33. For what period of time are training schedules prepared?

1. 3 months
2. 6 months
3. 12 months
4. 18 months

1-34. Where should you maintain the record of each individual's completed training?

1. In the master training catalog
2. In the individual's service record
3. With the training schedule
4. In the individual's training folder

1-35. Which statement distinguishes a type I propulsion unit from other major types?

1. It has internal bypasses in the high-pressure chamber
2. It is equipped with internal and external bypasses
3. It has a single casing for each ahead element
4. There are six ahead elements in each casing

1-36. What arrangements do all types of turbines have in common?

1. Two ahead-cruising elements
2. External steam bypass units
3. Internal steam bypass units
4. Astern elements for backing

1-37. Which valve is most likely leaking if the main shaft of the turbine continues to rotate after the throttle valve has been closed?

1. In-line steam valve
2. Main steam bypass valve
3. Main steam guarding valve
4. Nozzle control valve

1-38. Nozzle valves on modern naval ships are operated by which of the following methods?

1. Cams
2. Hand
3. Plungers
4. Steam pressure and springs

1-39. During the warm-up period of the turbine, inspection should show that all EXCEPT which of the following conditions are true?

1. There is freedom of operation without rubbing
2. Oil flow and temperature are
3. A reduced vacuum is maintained
4. Rotors are turning rapidly

1-40. What is the normal operating inlet oil temperature for most main turbines?

1. Between 90° and 120°F
2. Between 120° and 130°F
3. Between 130° and 140°F
4. Between 140° and 150°F

1-41. What is the maximum permissible temperature rise in the bearing?

1. 25°F
2. 50°F
3. 75°F
4. 100°F

1-42. What is the minimum oil temperature at which a turbine may be rotated?

1. 50°F
2. 70°F
3. 90°F
4. 110°F

1-43. While standing the engine-room watch, you hear a rumbling sound from one of the turbines when it begins to vibrate. What action should you immediately take'?

1. Stop the turbine
2. Slow the turbine
3. Check the oil pressure
4. Check the bearing temperature

1-44. Which of the following conditions is most apt to cause a turbine in operation to vibrate and rumble?

1. Bent propeller blades
2. Overheated bearings
3. Water in the turbine casing
4. Leaking oil seal

1-45. Inspection of a turbine reveals a shaft with heat discoloration. If the bearings are in good condition, which of the following is probably the cause of the discoloration?

1. Bent or broken propeller blades
2. Rubbing of oil seal rings
3. Rubbing of shaft packing
4. Both 2 and 3 above

1-46. When the main shaft of a turbine vibrates excessively with lesser vibration in the main reduction gear, what is the most likely cause?

1. An overheated bearing
2. A distorted rotor
3. Excessive differential expansion of the rotor casing
4. Bent or broken propeller blades

1-47. In accordance with the planned maintenance system, inspections are made of interiors of main turbines. Appropriate entries should be made in which of the following documents?

1. The engineering log
2. The bell book
3. The main turbine operating log
4. The night order book

1-48. Depth micrometer readings should be taken at each bearing when a turbine is first installed. These readings are used for which of the following purposes?

1. To determine actual oil clearance
2. To determine minimum oil clearance
3. To determine axial position at the rotor
4. To determine references when taking future readings

1-49. Which of the following is a quick and constant means of checking the axial position of the rotor shaft?

1. A depth micrometer
2. An installed rotor position indicator
3. The crown thickness reading
4. A feeler gauge

1-50. What instrument is used to check the clearance between the rotating and stationary blocks of the HP and LP turbines?

1. Taper gauge
2. Feeler gauge
3. Dial indicator
4. Depth micrometer

1-51. A turbine bearing that is only slightly wiped can be restored to service after which of the following actions?

1. Machine polishing
2. Tapping with a fine oilstone
3. Filing to a good bearing surface
4. Scraping to a good bearing surface

1-52. What method should be used to remove slight rust pits from a turbine thrust bearing collar?

1. File with a jeweler's file
2. Rub with fine crocus cloth
3. Scrape with a bearing scraper
4. Machine cut

1-53. What method should be used to remove the marks left by grinding or machining a bearing thrust collar?

1. Scraping
2. Filing
3. Lapping
4. Burnishing

1-54. Assume that a thrust bearing has a design clearance of 0.012 inch, a maximum clearance of 0.023 inch, and a minimum clearance of 0.009 inch. What size shim should be used to adjust the rotor end play if the clearance reading is 0.024 inch?

1. 0.001 in.
2. 0.012 in.
3. 0.015 in.
4. 0.240 in.

1-55. A properly installed journal bearing that has been in service for some time will usually display a worn or polished area centered in which, if any, of the following locations?

1. In the upper half of the bearing only
2. In the upper and lower half of the bearing
3. In the lower half of the bearing only
4. None of the above

1-56. Which of the following operations should you perform first when installing a new journal bearing?

1. Carefully clean the bearing
2. Bolt the bearing halves together
3. Measure the bearing bore
4. Lubricate the bearing

1-57. To prevent damage to the shaft packing when the lower half of a turbine journal bearing is being removed, excessive lifting of the rotor must be avoided. What amount of lift is recommended by the textbook?

1. 0.0001 in. or less
2. About 0.005 in.
3. Between 0.005 in. and 0.01 in.
4. About 0.1 in.

1-58. You should check the contact area of a nozzle control valve with its seat by using which of the following methods?

1. Measuring with a thickness gauge
2. Inserting a thin piece of paper between the seat and the disk
3. Measuring with a dial indicator
4. Bluing the valve

1-59. YOU should not, under any condition, use the nozzle control valve to lap its seat for which of the following reasons?

1. It could destroy the hardness of the valve
2. It could destroy the spherical surface of the valve
3. It could leave flat spots on the valve and seat
4. Both 2 and 3 above

1-60. To resurface a nozzle control valve seat, it is recommended that you use which of the following materials?

1. The valve and grinding compound
2. A cast-iron cone and grinding compound
3. An emery cloth and oil
4. A fine oilstone

1-61. You are repairing worn labyrinth packing. Which of the following is,/are the best tool(s) to use to increase the height of the tooth?

1. Jeweler's files
2. Bearing scraper
3. Chisel bar and hand chisel
4. Machinist's hammer and wire gauge

1-62. When a turbine casing is lifted with suspicion of internal damage, you should get technical determination of the necessity to disassemble the casing directly from which of the following persons/commands?

1. The Naval Sea Systems Command
2. The naval shipyard
3. The commanding officer
4. The fleet commander

1-63. What authority grants final authorization to lift turbine casings?

1. NAVSEA
2. NAVSSES
3. The type commander
4. The fleet commander

1-64. You are asked to compile information on the condition of each propulsion turbine for the CO's report, which must be submitted to Naval Sea Systems Command 3 months before the next regular overhaul. The type of information required in the report is specified in which of the following publications?

1. The manufacturer's technical manual
2. The Naval Ships' Technical Manual
3. The Coordinated Shipboard Allowance List
4. Each of the above

1-65. In preparation for lifting a turbine, you must remove which of the following parts?

1. The flexible coupling covers between the turbine and the reduction gears
2. The bearing and thrust oil drain
3. The bearing oil drain
4. The gland leak-off vent

1-66. When lifting a propulsion turbine upper casing, which of the following bolts should you NOT remove?

1. Vertical joint bolts
2. Horizontal joint bolts
3. Inspection cover bolts
4. Internal bolts

1-67. What means should you use to loosen the cast joint of a turbine that is being disassembled?

1. Crowbar
2. Chain fall and wire slings
3. Jacking bolts
4. Chain fall and shackles

1-68. When lifting the upper casing of a turbine, you should use guide pins to prevent possible damage to which of the following internal parts?

1. The nozzle valves
2. The turbine blading
3. The shaft packing
4. Both 2 and 3 above

1-69. You are supervising the lifting of a turbine casing and have ten people to help you do the job. What tasks should you assign to them?

1. One person at each corner to read measurements from the guide pins; one person at each side to help you observe the operation; four persons to operate the chain falls
2. One person at each corner to steady the casing as it is being raised; four persons to operate the chain falls; one person on each end to read measurements from the guide pins
3. One person at each corner to steady the casing as it is being raised; one person to help you observe the operation; five persons to operate the chain falls
4. One person at each corner to steady the casing and read the measurements from the guide pins; six persons to operate the chain falls

1-70. How should a turbine casing be lifted?

1. Gradually and in successive rises of 1 inch
2. Rapidly about 5 inches at a time
3. Quickly 2 to 3 inches, then slowly an inch at a time
4. Slowly in successive rises of 5 inches at a time

1-71. When the lifting yoke is used to lift a turbine rotor, the lifting yoke is attached to what component ?

1. The after end of the rotor
2. The forward end of the rotor
3. The after face of the shaft coupling flange
4. The forward face of the shaft coupling flange

1-72. When the rotor is being lifted, it is prevented from moving forward or aft by which of the following means?

1. Rotor guide brackets
2. Rotor guide saddles
3. Rotor guide pieces
4. Rotor guide supporting bars

1-73. Which of the following securing devices are used to plate a rotor in its raised position after lifting?

1. Rotor guide spacer bolts
2. Rotor guide saddles
3. Rotor guide tie brackets
4. Each of the above

1-74. Under which of the following conditions should you initiate arrangements to have a turbine rotor balanced?

1. When new blades are installed
2. When the turbine upper casing is removed
3. When the carbon packing is renewed
4. When the nozzle valve seats are resurfaced

1-75. If solvent fails to clean the horizontal flange joints of a turbine casing, what should you use?

1. An emery cloth
2. A file
3. A crocus cloth
4. A belt sander

ASSIGNMENT 2

Textbook Assignment: "Propulsion Turbines (continued)," chapter 2, and "Reduction Gears," chapter 3, pages 2-14 through 3-13.

2-1. What action should you take if you discover high spots on the turbine casing joint during reassembly?

1. Remove the high spots by filing
2. Remove the high spots by stoning or scraping
3. Fill in the low spots by welding
4. Fill in the low spots by welding or brazing

2-2. When reassembling a turbine casing, which of the following compounds should you use between the casing joints?

1. White lead
2. Graphite grease
3. Varnish
4. Only those permitted by the Naval Ship's Technical Manual

2-3. Turbine flanges may have a system of grooves for which of the following purposes?

1. To seal the joints in an emergency
2. To seal the joints at an overhaul period
3. To save time when the casing is being replaced
4. Each of the above

2-4. In preparing an overhauled propulsion plant for the dock trial, you circulate lube oil through the system after the lube-oil strainers are fitted with muslin bags, which are changed at specified intervals. When the bags no longer show evidence of dirt or foreign matter, operating conditions permit you to take which of the following actions?

1. Turn the engine by steam
2. Test the main engines
3. Engage the turning gear
4. Reverse the engines

2-5. At what speed are engines usually permitted to turn during a dock trial?

1. One-half speed
2. Full speed
3. At a speed determined by the engineer officer
4. At a speed determined by the commanding officer

2-6. On a ship with two engines, which of the following procedures is during a dock trial?

1. Turn both engines in the ahead direction
2. Turn both engines in the astern direction
3. Turn one engine ahead and the other astern and then reverse them
4. Turn only one engine at a time

2-7. When testing main engines during a dock trial, what should be the approximate rpm for each change?

1. 5 rpm
2. 10 rpm
3. 15 rpm
4. 20 rpm

2-8. Overhauled main engines are considered ready for post repair trial under which of the following conditions?

1. When they are tested and found satisfactory and ready for dock trial
2. When they are operated by steam, tested at various speeds up to and including the maximum allowable for dock trials and found satisfactory
3. When muslin bags no longer show dirt or foreign material, and no abnormal conditions are detected with the jacking gear turning the engines
4. When the special sea detail has been stationed

2-9. Which of the following is a general safety rule that applies to the operation of all turbines?

1. Make sure that all steam lines are drained before a ship gets under way
2. When a turbine begins to vibrate, increase its speed
3. When the throttle valve sticks, open the guarding valve and use it as a throttle
4. Keep the rotors locked while the main engines are being warmed up

2-10. When removing inspection plates, connections, or covers that permit access to the turbines, you must obtain authorization from which of the following persons?

1. MM1 or MMC
2. Engineer officer
3. Commanding officer
4. Type commander

2-11. In order for lubrication to be suitable for reduction gears, which of the following conditions must be true?

1. The oil must be at the proper temperature
2. The oil must be clean
3. The required amount of oil must be supplied to the gear
4. Each of the above

2-12. On late model ships, which of the following devices control(s) the quantity of oil delivered to the reduction gear bearings?

1. The pressure regulator
2. The relief valve
3. The orifices in the supply line
4. The pressure-operated pump

2-13. Which of the following is a likely result of delivering too little or too much oil to a bearing?

1. An overheated bearing
2. An underheated bearing
3. A sharp rise in oil pressure followed by a drop in pressure
4. A drop in oil pressure followed by a sharp rise in pressure

2-14. Oil is supplied to a bearing at 125°F. If the bearing is operating properly, what should be the maximum allowable temperature of the oil leaving the bearing?

1. 130°F
2. 145°F
3. 160°F
4. 175°F

2-15. If it becomes necessary to alter a spray nozzle, who must give the authorization?

1. The main propulsion assistant
2. The engineer officer
3. The commanding officer
4. The Naval Sea Systems Command

2-16. What is likely to happen if the bull gear is allowed to dip into the oil?

1. The oil will foam excessively
2. The oil will become aerated
3. The temperature of the oil will increase
4. Each of the above

2-17. Why is there an increase in temperature when too much oil is in the oil sump?

1. The oil circulates faster and hence becomes hotter
2. Greater quantity bypasses strainers and is apt to pick up metal bits
3. The gear will churn and aerate the oil, making it a poor lubricant
4. Greater quantity tends to hold the heat

2-18. What must be done if the bull gear dips into the oil?

1. The engine must be slowed or stopped until normal conditions are restored
2. Some of the oil must be removed without changing the engine speed
3. The engine must be stopped and the oil drained and replaced
4. The engine must be stopped and some fresh oil added

2-19. When salt water leaks into the lube oil, you must seal off the source of the salt water and remove the oil from the system. What else should you do?

1. Operate the lube-oil purifier continuously until all evidence of water disappears
2. Flush the system thoroughly with clean oil
3. Stop all oil circulation, and permit the water to settle to the bottom of the sump; then drain it off
4. Increase the circulation of the oil to heat it and cause the water to evaporate

2-20. Lube oil should be replaced when the neutralization number exceeds what minimum, value?

1. 0.40
2. 0.50
3. 0.60
4. 0.75

2-21. What substances cause turbine and gear lubricating oil to emulsify?

1. Fresh water and sea water
2. Air bubbles
3. Fatty acids
4. Insoluble minerals

2-22. Operating reduction gear with emulsified oil can cause which of the following kinds of damage?

1. Wiped bearings
2. Worn gear teeth
3. Both 1 and 2 above
4. Frozen bearings

2-23. If a ship maneuvering in shallow water produces a rumbling and thumping noise in the reduction gears, which of the following is the most probable cause of the noise?

1. Vibrations initiated by the propeller
2. A fouled propeller
3. High speed
4. A bowed rotor

2-24. In interpreting abnormal noises produced by reduction gears, which of the following is the most important factor?

1. Lubricating oil pressure reading
2. Lubricating oil temperature reading
3. Power status of the ship
4. Experience of the Machinist's Mate in charge

2-25. Effective control of a casualty that produces abnormal reduction gear noises will primarily depend on which of the following factors?

1. Maintaining lube-oil pressure
2. Immediately securing the plant
3. Quickly lowering the temperature of the lube-oil
4. Speedy and accurate interpretation by the operator of the noises and other symptoms

2-26. In addition to faulty alignment, which of the following conditions is a common cause of vibration?

1. Bent shafting
2. Damaged propeller
3. Improper balance
4. Each of the above

2-27. If a reduction gear has been operating smoothly for a long time, a gradual increase in vibration is probably caused by which of the following factors?

1. Misaligned gears
2. An unbalanced turbine rotor
3. Improperly meshed gear teeth
4. Burned out bearings

2-28. After a ship has been damaged, vibration of the main reduction gear installation may come from misalignment of which of the following parts?

1. Turbine or main reduction gear foundation
2. Main shafting
3. Main shaft bearings
4. Each of the above

2-29. When vibration occurs within the main reduction gears, where should you look first for possible damage?

1. Propeller
2. Main reduction gear
3. Main shaft bearings
4. Main turbines

2-30. What is the maximum period of time that the shaft should be locked during a drill?

1. 5 min
2. 2 min
3. 3 min
4. 10 min

2-31. When unlocking a shaft, which of the following steps should you perform first?

1. Disengage the turning gear
2. Open the ahead throttle of the locked shaft
3. Stop the ship
4. Open the astern throttle of the locked shaft

2-32. Replacement bearings are carried on board in the event bearings need replacing. What percentage of bearings installed in the main reduction gear are carried as spares?

1. 25
2. 50
3. 60
4. 75

2-33. How is the pressure half of a reduction gear bearing marked?

1. By one scribe line
2. By the word “pressure”
3. By the letter “P”
4. By three radial scribe lines

2-34. How far from the end of the bearing shell should bearing wear measurements on the main reduction gears be taken?

1. 1/4 in.
2. 1 1/4 in.
3. 2 1/2 in.
4. 5 in.

2-35. Of the following measurements, which one is used to check the amount of bearing wear in the main reduction gears?

1. Crown thickness
2. Lead thickness
3. Radial clearance
4. Axial clearance

2-36. To determine the maximum allowable main reduction gear bearing clearances, you should consult which of the following documents?

1. Naval Ship’s Technical Manual
2. Manufacturer’s technical manual
3. Gear blueprints
4. Each of the above

2-37. When a casualty occurs, which of the following main reduction gear bearings is most likely to be wiped?

1. Main thrust bearing
2. Line shaft journal bearing
3. Low-speed pinion bearing
4. High-speed pinion bearing

2-38. Which of the following steps should you perform first if repairs are to be made on the main reduction gear bearings?

1. Remove the main reduction gear cover
2. Lock the main shaft
3. Pump out the reduction gear sump
4. Remove the bearing pumps

2-39. When the bottom half of a main reduction gear bearing is removed, the weight of the shaft should be supported with which of the following devices?

1. A sling
2. A block of wood
3. A dummy bearing
4. Any device that will not damage the housing

2-40. To maintain shaft parallelism, what is the maximum allowable difference in the crown thickness of the bearing on the ends of gear or pinion shafts?

1. 0.001 in.
2. 0.002 in.
3. 0.003 in.
4. 0.004 in.

2-41. What should you do to slightly scored journals?

1. Remove and rebabbitt them
2. Replace them
3. Stone and polish them
4. Grind them down and plate them with chromium

2-42. After installing new reduction gear bearings, but before circulating oil through the system, you should place muslin bags in the oil strainers. How often, if ever, should you change the bags?

1. Change at 15-minute intervals until no evidence of dust
2. Change at 30-minute intervals until no evidence of dust
3. Change at 45-minute intervals
4. Never, no change is necessary

2-43. What parts of a new 6- or 8-shoe thrust bearing may have a slight displacement from the installed position after the bearing has been put into operatian?

1. Leveling plates
2. Base rings
3. Thrust shoes
4. Thrust collars

2-44. What is the simplest means of checking thrust bearing end play?

1. Use a micrometer depth gauge and a spring loaded pin gauge
2. Use a dial indicator and jacking the main shaft forward and then astern
3. Use a dial indicator on a flange on the main shaft while the engines are going slowly ahead and then astern
4. Use a thickness gauge between a main shaft flange and the bearing while the engines are going slowly ahead and then astern

2-45. If the end play of a thrust bearing is being determined by depth gauge readings of the forward and astern thrusts, to what should the end play equal?

1. The average of the readings
2. The sum of the readings
3. The difference between the readings
4. The larger of the readings

2-46. When it is not practical to measure thrust end play while the engine is running, what should be your next course of action?

1. Jack the shaft for-e and after when cooled
2. Jack the shaft fore and after while still warm
3. Jack the shaft in the forward direction only while warm
4. Jack the shaft in the reverse direction when cooled

2-47. Which of the following is a disadvantage of using the jacking method for obtaining end play of a main shaft?

1. It puts too much stress on the thrust bearing
2. Difficulty in finding suitable support where no structural damage will occur
3. It may warp the shaft
4. Each of the above

2-48. Which of the following situations requires that a main reduction gear be given a bearing run-in before being run at full power?

1. Installation of new bearings
2. Resurfacing of old bearings
3. Realignment of the gears
4. Scoring of the gear teeth

2-49. Which of the following is a method for static checking the length of tooth contact across the face of a reduction gear pinion?

1. Take leads
2. Insert wedges between the teeth
3. Take dial indicator readings of the teeth while the gears are rolled with the turning gear
4. Coat the teeth of the pinion lightly with Prussian blue and the teeth of the mating gear with red lead pigment

2-50. Although full contact across the teeth of reduction gears is desirable, such contact is not obtainable when which of the following conditions occurs?

1. The gear teeth are cut with a slight taper
2. The gear teeth have been renewed by stoning
3. Tile gear teeth are new or slightly used
4. Each of the above

2-51. When reduction gears are properly aligned and operated, scoring is usually caused by which of the following factors?

1. Excessive loading
2. Soft material in the gears
3. Inadequate lubrication
4. Insufficient running in

2-52. Roughened gear teeth may be stoned smooth if the deterioration is due to which of the following reasons?

1. Abrasion by foreign particles
2. Backlash
3. Initial pitting
4. Destructive pitting

2-53. When, if ever, are you permitted to scrape reduction gear teeth?

1. To obtain contact
2. To remove a deformation
3. To remove initial pits
4. Never

2-54. You may determine the actual root clearance of gear and pinion by which of the following methods?

1. Using a long feeler gauge
2. Using a wedge
3. Taking leads
4. Each of the above

2-55. Which condition is most apt to cause worn flexible couplings?

1. Shaft misalignment
2. Improper gear tooth contact
3. Excessive bearing clearance
4. Unbalanced turbine rotor

2-56. Two sets of readings are taken to check the alignment of a ship's propulsion shafting. When should the readings be taken?

1. When the ship is in drydock
2. One reading when the ship is in drydock, and another reading when the ship is waterborne and without load
3. When the ship is under normal waterborne load
4. One reading when the ship is in drydock and another reading when the ship is under a normal waterborne load

2-57. Prior to opening any inspection plate or fitting on the main reduction gear, you must obtain permission from which of the following persons?

1. The commanding officer
2. The executive officer
3. The engineer officer
4. The main propulsion assistant

2-58. The main reduction gears of your ship are inspected by a repair activity. After the inspection plate is replaced, an entry of the inspection is made in the engineering log. The entry must include the name(s) of which of the following persons?

1. The engineer officer of the ship
2. An officer of the engineering department and the officer of the repair activity who inspected the gear casing
3. The leading petty officer of the engineering department only
4. The leading petty officer of the engineering department and the petty officer of the repair activity who inspected the gear casing

2-59. During shipyard overhaul, certain inspections of the main reduction gears should be made. The alignment between pinions and turbines should also be checked when the inspection indicates which of the following conditions?

1. Excessive wear of the turbine
2. Excessive thrust clearances
3. Wear of the thrust collar
4. Each of the above

2-60. Which of the following maintenance actions is NOT usually carried out just before a full power trial?

1. Opening the gear casing
2. Examining reduction gears for tooth contact and condition
3. Checking the operation of oil-spray nozzles
4. Each of the above

2-61. Main reduction gear inspection covers should be secured by high-security type of locks. Who has the responsibility for custody of keys to these locks?

1. Main propulsion assistant
2. Engineer officer
3. Executive officer
4. Commanding officer

2-62. Under which, if any, of the following conditions may a reduction gear case opening be left unattended?

1. When a satisfactory temporary is installed
2. When it is an inspection opening only
3. When the maintenance work is not completed by the end of the work day
4. None of the above

2-63. Before engaging the turning gear you should ensure which of the following conditions?

1. The propellers are locked
2. The main condenser is under vacuum
3. The main shaft is locked
4. The turning gear is properly lubricated

ASSIGNMENT 3

Textbook Assignment: "Steam-Driven Generators," chapter 4, and "Heat Exchangers and Air Ejectors," chapter 5, pages 4-1 through 5-11.

3-1. Which of the following is NOT a usual cause of excessive vibration in a turbogenerator?

1. Loose foundation hold-down bolts on the turbine or reduction gear
2. Improper balancing
3. Rubbing of gland seal rings
4. Damaged blading

3-2. When vibration of a turbine is excessive, one of the first checks you should make is to examine which of the following components for what problem?

1. The governor for improper lubrication
2. The reduction gear surfaces for improper tooth contact
3. The turbine casing for contact with moisture
4. The thrust and journal bearings for excessive clearance

3-3. After performing the maintenance prescribed for a turbine when an unbalanced condition is suspected, you operate the turbine at normal speed. What action should be taken if the turbine continues to vibrate excessively?

1. All shaft packing should be renewed
2. The turbine rotor should be balance tested
3. The bearing clearances should be readjusted
4. The turbine foundation bolts should be tightened

3-4. Extreme care should be taken in making turbine casing joints. After cleaning the joints, what should be used to polish them?

1. Steel wool
2. Emery cloth
3. Crocus cloth
4. Grinding compound

3-5. What procedure should you follow to pressure-pump the horizontal groove of a generator turbine with sealing compound?

1. Start with an end hole and pump in compound until it flows from the adjacent hole; remove gun, plug hole, and pump compound in the adjacent hole; follow this procedure, one hole at a time, until you reach the other end
2. Start with the center hole and then fill the end holes; now fill one hole at a time, working from the ends towards the center
3. Fill part of the groove by pumping compound through the center hole; then fill the remainder of the groove by pumping compound through the end holes
4. Start with the center hole and work toward each end, filling one hole at a time

3-6. When checking blade clearance between the nozzle diaphragm and the adjacent row of blades, what instrument should you use?

1. Dial indicator
2. Feeler gauge
3. Calipers
4. Taper gauge

3-7. When the blade clearance between the nozzle diaphragm and the adjacent row of blades is found to be outside the specified limits, the rotor position should be adjusted by what means?

1. Renewing the diaphragm-labyrinth packing
2. Changing the nozzle diaphragm
3. Inserting a filler piece in the thrust bearing
4. Each of the above

3-8. For what reason is labyrinth packing used between the inner bore of each nozzle diaphragm and the rotor of a pressure-compound impulse turbine?

1. To seal against steam leakage
2. To seal against lube-oil leakage
3. To seal against air leakage
4. To seal against entry of foreign matter

3-9. When corrosion is found on a turbine casing, which of the following actions should be taken?

1. Lagging should be removed
2. Surface of casing should be scraped down to good metal and dried
3. Surface should be painted with two coats of approved paint
4. Each of the above

3-10. Internal corrosion can be almost entirely prevented if you take which of the following actions?

1. Inject anticorrosion chemicals into turbine orifices
2. Wash out the turbine periodically with a water lance
3. Continue operation of air ejectors for a short time to dry the machine
4. Pump oil through the turbine regularly

3-11. Which of the following construction features is characteristic of the four-bearing design turbogenerator reduction gear?

1. One end of the turbine is supported by the pinion bearing
2. The pinion shaft is flexibly coupled to the turbine shaft
3. The pinion shaft is supported by four bearings
4. The pinion shaft is splined to receive the turbine shaft

3-12. When gear misalignment occurs after prolonged operation of a turbogenerator reduction gear, what is the probable cause?

1. Shaft wear
2. Bearing wear
3. Coupling wear
4. Tooth wear

3-13. After new bearings are installed in turbogenerator reduction gears, the gear tooth contact should be at LEAST what percentage?

1. 80%
2. 85%
3. 90%
4. 95%

3-14. What should you use to remove the high spots caused by abrasion on turbogenerator gear teeth?

1. Oilstone
2. File
3. Scraper
4. Carborundum stone

3-15. High spots on turbogenerator reduction gear teeth are apt to be caused by which of the following conditions?

1. Worn bearings
2. Foreign particles in the lube oil
3. Gear misalignment
4. Lack of lubrication

3-16. Which of the following characteristics applies to most journal bearings?

1. Cylindrical
2. Steel-backed
3. Babbitt-lined
4. Each of the above

3-17. Which of the following devices can be used to prevent rotation of most turbogenerator journal bearings?

1. Metal key
2. Dowel pin
3. Setscrew
4. Both 2 and 3 above

3-18. The reduction gear casing must be removed on most turbogenerators to have access to which of the following bearings?

1. Generator pedestal
2. Main gear
3. High-speed thrust
4. Forward turbine

3-19. By what means is the axial clearance of the generator rotor of a turbogenerator adjusted?

1. By a filler piece between the stationary thrust plates
2. By a filler piece between the thrust shoulder of the gear bearings
3. By rebabbitting the thrust surfaces
4. By replacing the bearings

3-20. What is the purpose of the gear-type pump shown in part A of textbook figure 4-3?

1. To supply oil pressure for operating the constant-speed governor
2. To supply oil pressure for lubricating the bearings and gears
3. Both 1 and 2 above
4. To supply lube oil to the generator while starting or securing

3-21. Oil pressure for operating the constant speed governor is supplied by a gear type pump driven by what component?

1. The high-speed gear shaft
2. The low-speed gear shaft
3. An electric motor
4. A hydraulic motor

3-22. On some ships, the lube oil system of the turbogenerator has an electrically operated third pump that is used for what purpose?

1. For lubricating the bearings and gears during normal operation
2. For supplying oil pressure to operate the constant-speed governor during normal operation
3. For supplying lube oil to the generator while starting or securing
4. For emergency purposes only

3-23. All the oil pumped to the bearings of a turbogenerator passes through the oil manifold and strainer EXCEPT the oil supplied by which of the following pumps?

1. The hand pump before starting
2. The gear pump used during normal operation
3. The electrically driven pump during emergencies
4. Both 2 and 3 above

3-24. The hand valve used to control the flow of oil to the gear and bearings should be set to maintain what pressure?

1. 4 to 6 psig
2. 8 to 10 psig
3. 10 to 12 psig
4. 12 to 14 psig

3-25. Oil supply to the bearings is interrupted and a check shows that the lack of oil is due to insufficient pressure. You should stop the unit and increase the oil pressure by using which of the following methods?

1. Adjust the pressure-sensing device in the oil system
2. Adjust the cooler bypass valve
3. Increase the setting of the governor
4. Increase the setting of the relief valve

3-26. Of the following conditions, which one is most likely to cause oil leakage where a shaft emerges from a turbine housing?

1. Bearings are worn
2. Oil lines are clogged
3. Oil seals are worn
4. Relief valve is set too low

3-27. What is indicated by an excessive pressure drop across a lube-oil strainer?

1. Dirty strainer
2. Improperly adjusted vent valve
3. Clogged oil bypass holes in bearings
4. High relief valve setting

3-28. A rise in the temperature of oil going through the cooler, when all other conditions remain the same, is a positive indication of which of the following conditions?

1. The oil pressure is too high
2. The cooling water pressure is too low
3. The oil and/or water side needs cleaning
4. The oil is dirty or contaminated

3-29. The internal surfaces of the lube-oil cooler tubes should be cleaned by which of the following methods?

1. A round bristle brush while the surfaces are wet
2. A round wire brush while the surfaces are dry
3. An approved solvent
4. A jet of hot water

3-30. What is the correct setting of the lube-oil low-pressure alarm contactor?

1. 6 psig
2. 2 psig
3. 8 psig
4. 4 psig

3-31. What is the normal reading for the (a) bearing oil pressure gauge and (b) oil pump pressure gauge?

1. (a) 6 to 8 psig
   (b) 25 to 50 psig
2. (a) 8 to 10 psig
   (b) 50 to 100 psig
3. (a) 10 to 12 psig
   (b) 100 to 150 psig
4. (a) 12 to 14 psig
   (b) 150 to 200 psig

3-32. Incorrect alignment of the turbogenerator can cause which of the following undesirable conditions?

1. Unsatisfactory contact of the gear and pinion teeth
2. Vibration
3. Unsatisfactory operation
4. Each of the above

3-33. Bearing wear is often the cause of unsatisfactory tooth contact of the reduction gear and pinion. How can you determine the extent of bearing wear?

1. By measuring the center-to-center distance of axes of the gear and pinion
2. By measuring the amount of backlash in the gear and pinion train
3. By measuring the crown thickness of the bearings
4. Each of the above

3-34. Under which of the following conditions is the renewal of bearings in a turbogenerator justified?

1. When a small amount of wear causes vibration
2. When the wear exceeds the maximum clearance shown on applicable blueprints
3. When the wear exceeds the maximum clearance listed in the manufacturer' s technical manual
4. When the wear is equal to, or exceeds , the clearance limits set forth in Naval Ships' Technical Manual

3-35. In addition to a relief valve and a sentinel valve, the turbine-driven generator is equipped with which of the following control and safety devices?

1. Constant-speed governor and lube-oil low-pressure alarm
2. Overspeed trip and back-pressure trip
3. Manual trip and gland seal steam regulators
4. Each of the above

3-36. What does the term “regulation” denote?

1. A change in load stated as a percentage change
2. A change in load at full speed
3. A change in speed that occurs with a change in load
4. A change in speed that occurs without a change in load

3-37. What is the function of the overspeed trip device?

1. It stops the turbine by closing the throttle valve
2. It reduces the speed of the turbine in the event the governor malfunctions
3. It prevents excessive speed in the event of overregulation
4. It controls the steam flow to the turbine in the event the governor malfunctions

3-38. What is the function of the manual trip shown in textbook figure 4-6?

1. It stops the flow of steam to the turbine in an emergency
2. It stops the turbine when it is being secured normally
3. Both 1 and 2 above
4. It serves as control for gland sealing steam and lube oil

3-39. What is the main cause of loss of vacuum in the auxiliary condenser of the turbogenerator?

1. Low exhaust pressure
2. Low lube-oil pressure
3. Insufficient gland sealing steam
4. Excessive gland sealing steam

3-40. What part(s) of a turbogenerator must be moved first if the turbine rotor is to be removed?

1. Pinion shaft
2. Upper half of the reduction gear casing
3. Upper halves of the journal bearings that support the turbine pinion rotor
4. Pilot valve

3-41. Which of the following maintenance actions is required for an idle turbine of a ship at anchor?

1. Turning the turbine with steam, if available
2. Sampling and testing the lubricating oil for presence of water
3. Operating all relief valves at intervals by hand
4. Each of the above

3-42. Safety demands that to be operable a turbogenerator must have which of the following devices?

1. An operative speed-limiting governor
2. An operative back-pressure trip
3. An operative constant-speed governor
4. Each of the above

3-43. The MM1 and MMC will most likely be involved with which of the following jobs concerning condensers?

1. Retubing condensers
2. Plugging condenser tubes
3. Overhauling injection valves
4. Overhauling overboard valves

3-44. Which of the following water conditions requires that a ship's main condensers be inspected and cleaned more frequently than when conditions are normal?

1. Shallow water
2. Water containing large amounts of seaweed
3. Water containing large amounts of oil
4. Each of the above

3-45. Grease and dirt should be removed from the steam side of condenser tubes by boiling them out with what type of solution?

1. Water and soap
2. Water and salt
3. Trisodium phosphate
4. Hot water and benzine

3-46. Which of the following conditions can cause a newly tubed condenser to develop leaks?

1. Defective tubes
2. Defective tube sheets
3. Improper installation
4. Each of the above

3-47. Impingement erosion may be influenced by which of the following factors?

1. Water velocity through the tubes
2. Amount of air entrained with the circulating water
3. The design of water chest and injection piping
4. Each of the above

3-48. Continual, thorough drainage is necessary to minimize the effects of tube erosion from the

1. recirculating line
2. auxiliary exhaust line
3. makeup feed line
4. auxiliary circulating water inlet

3-49. Chloride buildup in a steaming boiler of a propulsion plant indicates what defect?

1. Seawater leakage into the condensate system
2. Air leakage into condensate system
3. Dirty condenser tubes
4. No chemicals in the steaming boiler

3-50. When testing condensers for leaks, what is the maximum allowable air pressure that can be placed on the steam side of the condensers?

1. 10 psig
2. 15 psig
3. 20 psig
4. 25 psig

3-51. Assume that a condenser needs retubing. Under normal conditions, which of the following tasks is most likely the responsibility of the MM1 or MMC?

1. Inspecting the job after retubing to make sure it has been properly completed and tested
2. Removing the old tubes from the condenser
3. Readying the necessary tools and equipment
4. Installing the new tubes in the condenser

3-52. The report that should accompany a condenser retubing request should contain which of the following information?

1. Date of last retubing
2. Type of tube failure
3. Type of tube joints employed
4. Each of the above

3-53. Which of the following tools is/are used to remove expanded tube ends?

1. Drift
2. Reamer
3. Both 1 and 2 above
4. Mandrel

3-54. What person may authorize the retubing of small heat exchange units without prior approval of the Naval Sea Systems Command?

1. The type commander only
2. The engineer officer or type commander
3. The commanding officer or type commander
4. The main propulsion assistant or engineer officer

3-55. Suppose that you are installing replacement tubes in a condenser. If you suspect that the joints between the tube sheets and the condenser shell are not in perfect condition, which of the following actions should you take?

1. Remove the tube sheets
2. True the flanges
3. Install new gaskets
4. Each of the above

3-56. Copper-nickel tubes used in condensers that are saltwater cooled must be cut to the proper length for installation. The usual practice is to cut each tube so its length exceeds the distance between the outside faces of the tube sheets by about how much?

1. 1/16 in.
2. 1/8 in.
3. 3/16 in.
4. 1/4 in.

3-57. Under what condition should tube holes be grooved or serrated?

1. When tubes are expanded at the inlet end only
2. When tubes are expanded at the outlet end only
3. When tubes are expanded at both ends
4. When tubes are expanded at one end only; either outlet or inlet

3-58. Assume that condenser tubes with an outside diameter of 3/4 inch are being expanded for installation. What maximum flare to the tube ends should be allowed?

1. 1 in.
2. 7/8 in.
3. 1 1/4 in.
4. 1 5/8 in.

3-59. What should be the condition of an idle condenser that will remain secured for several weeks?

1. Empty only
2. Filled with fresh water only
3. Either empty or filled with fresh water
4. Filled with seawater

3-60. Before the saltwater side of a condenser is opened, which of the following connections should be closed and secured tightly against accidental opening?

1. Main injection valve
2. All sea connections
3. Main overboard valve
4. Circulating pump suction valve

3-61. Before removing a manhole or handhole plate, you should drain the saltwater side of the condenser for which of the following reasons?

1. To ensure that gases are not present in the condenser
2. To ensure the release of all pressure from the saltwater side of the condenser
3. To ensure that all sea connections are tightly closed
4. To ensure that all steam that might exist will be released

3-62. What should you do if a loss of vacuum is accompanied by a hot or flooded condenser?

1. Slow down or stop the units
2. Lift the relief valve mounted on the inlet water chest
3. Start the main circulating pump
4. Lift the condenser shell relief valve

3-63. What is the most frequent casualty to a main condenser?

1. A hot condenser
2. A cold injection temperature
3. A lack of condensate depression
4. A loss of vacuum

3-64. When the gate valve in the circulating-water overboard piping is used to regulate the water flow through the condenser, what is the minimum permissible opening to prevent possible damage to the valve?

1. Valve just clear of its seat
2. 1/8 open
3. 1/3 open
4. 1/4 open

3-65. For the later turbines served by scoop-injection condensers operating under standby conditions with cold injection, the air pumps produced a maximum vacuum of how many inches of mercury?

1. 30 to 32
2. 28 to 29
3. 25 to 27
4. 22 to 24

3-66. Assume that a turbine is operating at low power and medium injection temperature . What is the range of condensate depression in which you may assume that the condenser is being freed of air?

1. 2° to 4°
2. 2° to 3°
3. 0° to 3°
4. 0° to 2°

3-67. What is the most common cause for loss of vacuum in a condenser?

1. Air leakage into the vacuum system
2. Faulty overboard valve
3. Faulty injection valve
4. Excessive flow of circulating water

3-68. Whether or not the air test for locating air leaks into a condenser succeeds depends on which of the following factors?

1. The ability to detect the sound of air escaping
2. The ability to detect the appearance of soap bubbles
3. The ability to detect the presence of moisture
4. The ability to detect the movement of a candle flame

3-69. What is the purpose of the small gauge glass on some of the shell relief valves connected to condensers?

1. To automatically indicate any increase in vacuum
2. To permit water above the disk as a test for tightness
3. To automatically indicate air leakage into the condenser
4. Each of the above

3-70. Maintaining too high an operating water level in the deaerating feed tank causes which of the following conditions?

1. Air and noncondensable gases in the feedwater
2. Possible damage to the main feed pumps
3. Loss of feed pressure
4. Possible damage to the main feed booster pumps

3-71. What would be the probable result of an excessive amount of cold water suddenly being pumped in the deaerating feed tank?

1. Shell pressure would increase due to condensate flashing into steam
2. Booster pump discharge pressure would increase
3. Better deaeration would be obtained
4. Shell pressure would reduce, allowing condensate to flash into steam

3-72. How is the inlet water to the deaerating tank forced through the spray valves of the spray head?

1. By the condensate pump discharge pressure
2. By the feed booster pump pressure
3. By the main feed pump discharge pressure
4. By the auxiliary condensate pump suction

3-73. What is the minimum satisfactory temperature on the discharge side of the oil cooler for normal operating conditions?

1. 90°F
2. 110°F
3. 120°F
4. 130°F

3-74. What is the highest permissible temperature on the discharge side of the oil cooler?

1. 110°F
2. 120°F
3. 130°F
4. 140°F

3-75. When salt water is used for coolin~ in a lube-oil cooler, failure of the cooler may be caused by which of the following conditions?

1. Scale, due to the salt content of the water
2. Erosion, due to the high water velocity
3. Corrosion, due to electrolytic action
4. Both 2 and 3 above

ASSIGNMENT 4

Textbook Assignment: "Heat Exchangers and Air Ejectors," and Chapter 5, and "Pumps," chapter 6, pages 5-11 through 6-13.

4-1. Which of the following conditions can cause excessive velocity through a cooler and erosion due to failure of the cooler?

1. Too wide an opening in the valve
2. Too large an orifice
3. To high a pressure in the service main
4. Each of the above

4-2. Tube bundles that are removed from a lube-oil cooler may be cleaned by which of the following methods?

1. Flushing them with hot water
2. Flushing them with a boiler compound solution
3. Wire brushing the tubes on the inside and scraping them on the outside
4. Working a reamer through the tubes

4-3. In which of the following situations should both sets of nozzles of an air ejector be used?

1. Under all normal operating conditions
2. only under full power conditions
3. Only when one of the nozzles is ope~-sting at less than full pressure
4. When excessive air leakage into the condenser necessitates additional pumping capacity

4-4. The interstage valve between the discharge of each first-stage ejector and the intercondenser serves which of the following purposes?

1. It prevents loss of vacuum
2. It prevents loss of pressure built up by the first-stage jet
3. It maintains a positive discharge to the atmosphere
4. It ensures a steam free engine room if the air ejector cooling water supply fails

4-5. Which of the following is a operation of air ejectors?

1. Before starting the flow of cooling water through the condenser, be sure steam is cut into the air ejector
2. Before starting a steam air ejector, be sure the steam line is drained of all moisture
3. After starting, use both sets of ejector nozzles until pressure and temperature are normal
4. Under normal conditions, be sure a steady flow of air through the loop seal is maintained

4-6. Unstable operation of an air ejector may be caused by which of the following conditions?

1. Condenser drains plugged up
2. Scale on the nozzle surface
3. Steam pressure below normal
4. Each of the above

4-7. Erosion of air ejector nozzles is most apt to be caused by what factor?

1. Wet steam
2. Seawater
3. Boiler compound
4. Galvanic electricity

4-8. When installing an air ejector nozzle, you must maintain the proper distance between the nozzle and what component(s)?

1. The steam strainer
2. The diffuser end
3. The tube banks
4. The steam inlet valve

4-9. As a safety precaution, when cleaning an air ejector steam strainer while the rest of the unit is in operation, you should isolate the strainer from the rest of the assembly by using which of the following procedures?

1. Cut out the intercondenser
2. Cut out the aftercondenser
3. only close the steam supply valve of the unit being opened
4. Close the steam supply valve and open the interstate valve of the unit being opened

4-10. Which of the following is a probable cause of flooding intercondensers and after-condensers of an air-ejector?

1. Leaking condenser tubes
2. Leaking division plates between the condensers
3. Insufficient vacuum
4. Excessively high vacuum

4-11. What material should be used to repack the packing ends of air ejector condenser tubes when leakage occurs?

1. Fiber packing rings
2. Lead packing rings
3. Capper-asbestos packing rings
4. Caulking compsund

4-12. When a vacuum is formed in both condensers, what is the approximate difference, if any, that exists between the vacuum maintained in the main condenser and that maintained in the intercondenser?

1. 1 in.
2. 2 in.
3. 3 in.
4. None

4-13. Reciprocating pumps used aboard combatant ships are most often used as what kind of pumps?

1. Main condensate and booster pumps
2. Emergency feed, fire, and bilge pumps, and fuel oil tank stripping pumps
3. Steam pumps
4. Fuel pumps

4-14. When a reciprocating pump fails to start, it may be necessary to jack the pump with a bar to determine whether it has a frozen piston. Before attempting to jack the pump, you should make sure that which of the following conditions exist (s)?

1. The throttle valve is closed tightly and the exhaust valve is open
2. Both the throttle valve and the exhaust valve are closed tightly
3. The steam cylinder and the steam chest drains are wide open
4. Both 2 and 3 above

4-15. The operation of a reciprocating pump that fails to take suction will be jerky. What is the first this malfunction?

1. Shift suction to a standby feed tank
2. Open the vent valves in the valve chest cover
3. Ensure that all stop and check valves in the suction line are open
4. Shift to the standby feed pump and clear the suction line of all obstructions

4-16 What condition can cause loss of discharge pressure in a reciprocating pump?

1. Worn piston rings
2. High exhaust pressure
3. Low steam pressure
4. Each of the above

4-17 In a reciprocating pump that has been operating normally, what is the most probable cause of a sudden loss of discharge pressure?

1. Defective valve
2. Vapor binding
3. Broken plunger
4. Frozen steam piston

4-18. When a reciprocating pump is disassembled for repair or inspection, micrometer measurements should be taken of the steam and water cylinders and the steam valve chest. These measurements should be taken at which of the following locations?

1. The top and bottom of the fore and aft diameters only
2. The top and bottom of the fore and aft, and athwarthship diameters
3. The top, middle, and bottom of the fore and aft diameters only
4. The top, middle, and bottom of the fore, aft, and athwarthship diameters

4-19. When aligning the steam and water cylinders of a reciprocating pump, (a) what is used as a reference point and (b) which alignment?

1. (a) A centering mark on the pump mounting
   (b) water cylinder
2. (a) Midpoint between the stay rods
   (b) steam cylinder
3. (a) The exact center of the steam cylinder
   (b) water cylinder
4. (a) The exact center of the water cylinder
   (b) steam cylinder

4-20. Although centrifugal pumps have several advantages over reciprocating pumps, they also have disadvantages. Which of the following is a disadvantage of centrifugal pumps?

1. They must be primed in order to operate on a suction lift
2. They are more complicated
3. They are much heavier
4. They are bulkier

4-21. Before starting a centrifugal pump for the first time after overhaul, which of the following checks should you make?

1. Alignment of the lube-oil system, suction, discharge, vent, recirculating, and bypass valves
2. Direction of rotation when the pump is motor driven
3. Coupling alignment
4. Each of the above

4-22. Flexible couplings will compensate for only slight misalignment. Normally, the misalignment should fall within what range?

1. 0.001 in. to 0.002 in.
2. 0.002 in. to 0.004 in.
3. 0.005 in. to 0.010 in.
4. 0.010 in. to 0.025 in.

4-23. Which of the following valves should be closed when you are starting a centrifugal pump?

1. Exhaust root valve
2. Discharge valve
3. Recirculating valve
4. Suction valve

4-24. Which of the following conditions may cause failure of a centrifugal pump to discharge at maximum capacity or pressure?

1. Properly primed pump
2. Excessive lube-oil pressure
3. Worn leaking rings
4. Flooded condenser

4-25. Which of the following is a cause of excessive vibration in a centrifugal water pump?

1. A clogged suction strainer
2. Air leaking into the suction line
3. A broken impeller
4. A maladjusted constant-pressure governor

4-26. If the pump is designed to operate at 50 psi of booster pressure, what is the minimum booster pressure at which a main feed pump should be turned over?

1. 30 psi
2. 35 psi
3. 40 psi
4. 45 psi

4-27. Improperly adjusted packing glands can cause serious damage to the pump. How and why should you adjust the glands?

1. Tighten the gland slowly until there is no water leakage, to keep water from corroding the shaft sleeve
2. By progressive steps, slowly tighten the gland until only a small amount of water leaks out of the stuffing box, to provide lubrication and coolant
3. Tighten the gland until all water leakage stops, but the shaft sleeve turns without binding, to keep water from scoring the shaft sleeve
4. Tighten the gland so that water leakage stops, but the packing remains moist enough to provide for proper lubrication of the shaft sleeve

4-28. When checking the rotor position of a pump, you should make allowances for which of the following conditions?

1. Expansion of the shaft due to increased temperature
2. Contraction of the shaft due to decreased temperature
3. Wear due to operating time
4. Each of the above

4-29. The bearing located between the first and second-stage suction compartment in the casing of a main condensate pump serves as an interstate seal and is lubricated by which of the following substances?

1. Water
2. Oil
3. Grease
4. Graphite

4-30. Which of the following precautions will aid you in the proper handling of ball and roller bearings?

1. Check all mating parts for installing a bearing
2. Store bearings in their containers until they are put in use
3. Rotate the journal by hand after installation to check for friction
4. Each of the above

4-31. Although the journal of rolling contact bearings is supported by the race and rolling elements rather than by the oil film, proper lubrication is important in their operation. The lubricant is used mainly for which of the following purposes?

1. To reduce friction between moving parts
2. To provide a coolant and prevent corrosion
3. To help prevent foreign matter from entering the bearing
4. Both 2 and 3 above

4-32. To remove impellers, which of the following steps should you take?

1. Chill the impeller and the impeller shaft
2. Warm the impeller and the impeller shaft
3. Chill the impeller evenly while keeping the shaft as warm as possible
4. Warm the impeller evenly while keeping the shaft as cool as possible

4-33. You are in the process of reassembling a main feed pump. Before lowering the rotor into the casing, what step should you take?

1. Roll in the lower half of the journal bearings
2. Insert the casing dowel pins
3. Adjust the flingers
4. Place the upper halves of the thrust bearings in position

4-34. You have just lowered the upper casing half during reassembly of a main feed pump. After the upper and lower casing halves contact each other properly, what step should you take immediately?

1. Adjust the flingers
2. Install a new parting flange gasket
3. Insert the casing dowels
4. Install the lower halves of the journal bearings

4-35. Before disassembling or assembling a main condensate or main feed booster pump, which of the following documents should you check?

1. Manufacturer's technical manual
2. Equipment maintenance records
3. Equipment blueprints
4. Each of the above

4-36. After the rotor is replaced in a main feed booster pump or a main condensate pump, when is the pump ready for unlimited operation?

1. As soon as the upper casing is bolted down
2. After movement of the rotor has been checked manually
3. After the driving unit has been brought up to operating speed
4. After the pump has carried the required load with the ship under way

4-37. In preparing to install a ball bearing on a shaft, which of the following procedures should you follow?

1. Soak the bearing in oil that has a temperature that is near, but does not exceed 200°F
2. Soak the bearing in oil that has a temperature that is 300°F plus or minus 10°F
3. Bathe the shaft in ice water
4. Cool the shaft with the contents of a fire extinguisher

4-38. What is the major cause of pump failure?

1. High lubricant temperature
2. Lack of, or improper, lubrication
3. Excessively tightened packing glands
4. Insufficiently tightened, or leaking, packing glands

4-39. Which of the following factors helps determine the frequency with which grease is added to a bearing?

1. Type of bearing
2. Type of grease used
3. Type of service
4. Prevailing temperature

4-40. When starting a pump, for which of the following reasons may it be necessary for you to open the vent on the high point in the lube-oil system?

1. To ensure a water-free system
2. To ensure an air-free system
3. To ensure normal oil pressure
4. To ensure normal oil temperatures

4-41. When you disassemble a main lube-oil service pump to replace the rotor, what step must you perform first?

1. Remove the mountings
2. Disconnect main lube oil lines
3. Remove the driving unit
4. Remove the motor housing

4-42. To disassemble the liquid end of the turbine-driven lube oil service pump, what part should you remove first?

1. The packing gland
2. The upper casing head
3. The lower coupling half
4. The idler

4-43. Before removing the rotor housing of a lube oil service pump, you must remove the housing guide pins by which of the following means?

1. A drift
2. A pulling tool
3. Pipe plugs
4. Jam screws

4-44. When reassembling a lube oil service pump, if you install new housings, what other new parts must you install?

1. Jam screws in the upper housing
2. Guide pins
3. Power rotors
4. Idler rotors

4-45. Assume that the new rotors you installed in a lube oil service pump are properly meshed and that the idlers are located centrally with respect to the end play in the power rotor. The locating of the fallowing conditions exists?

1. The lower end surfaces of all three rotors lie in a common plane
2. The inside surfaces of the rotor housing and motor housing lie in a common plane
3. The spacer ring is centered in the power rotor
4. The power rotor is concentric with the rotor housing

4-46. The attached lube oil pumps of ships built after World War II are driven by which of the following sources?

1. Turbines
2. Electric motors
3. An assembly of bevel and spur gears from the main reduction gear
4. Each of the above

4-47. When the speed-limiting governor of a turbine-driven pump is properly set, what should be the maximum turbine speed relative to rated speed?

1. The same or slightly less
2. Approximately 5% below
3. Not more than 5% above
4. 10 to 15% above

4-48. Which of the following conditions is apt to cause a constant pressure governor to become sluggish?

1. Dirt in the moving parts
2. A clogged needle valve
3. A broken diaphragm
4. A weak spring

4-49. What is the correct clearance between the controlling valve stem and the diaphragm of a constant-pressure governor?

1. 0.000 to 0.001 in.
2. 0.001 to 0.002 in.
3. 0.002 to 0.003 in.
4. 0.003 to 0.004 in.

4-50. What is the effect of incorrect clearance between the control valve stem and the lower diaphragm of a constant-pressure governor?

1. Excessive or insufficient clearance will cause the diaphragm to hold the control valve open and the pump cannot be stopped without closing the throttle
2. Excessive clearance will prevent the lower diaphragm from fully opening the control valve, which will cause reduced pump capacity
3. Insufficient clearance will cause the diaphragm to hold the control valve open and the pump cannot be stopped without closing the throttle
4. Both 2 and 3 above

4-51. Which of the following statements pertaining to constant-pressure governors is true?

1. When a diaphragm must be replaced, the new part should be one made by the manufacturer of the governor
2. Graphite or s similar substance should be used on new gaskets
3. New diaphragms should be installed with gaskets of the proper thickness
4. The stem of the controlling valve should pr-eject above the diaphragm seat

ASSIGNMENT 5

Textbook Assignment: "Distilling plant," and chapter 7, "Refrigeration and Air Conditioning," chapter 6, pages 7-1 through 8-18.

5-1. In the maintenance of submerged tube distilling plants, the MM1 and MMC have which of the following responsibilities?

1. They make adjustments
2. They locate troubles
3. They make repairs
4. Each of the above

5-2. What should be the maximum epm of the chloride of distillate discharge to the ship's tanks?

1. 0.010 epm
2. 9.020 epm
3. 0.065 epm
4. 0.100 epm

5-3. Which of the following may be a result of operating a distilling plant above its rated capacity?

1. An increased rate of scaling due to the higher temperatures resulting from higher steam pressure requirements
2. A reduced rate of scaling due to required use of higher steam pressure
3. Failure of evaporator tubes due to required use of higher steam pressures and temperatures
4. An increased salinity of the distillate due to fluctuating or reduced steam pressures

5-4. A failure to get full-rated capacity is one of the most frequent troubles in the operation of a distilling plant. Of the following factors, which one does NOT promote low output of the distilling plant?

1. Low vacuum in the first-effect tube nest
2. Improper water levels
3. Low steam pressure above the orifice
4. Brine density of 1.5/32

What should be the maximum overboard brine density of a distilling plant to obtain a maximum output?

1. 0.15/3.2
2. 1.5/32
3. 3.2/15
4. 0.15/32

5-6. What is the supply steam pressure required for full capacity operation of a distilling plant?

1. 5 psig above the orifice
2. 10 psig above the orifice
3. 15 psig above the orifice
4. 20 psig above the orifice

5-7. A distilling plant may fail to maintain proper steam pressure above the orifice even though the pressure reducing valve is functioning properly due to which of the following conditions?

1. Low vacuum in the first-effect tube nest
2. Excessively high vacuum in the last-effect shell
3. Insufficient steam supply to the plant
4. Improper air ejector operation

5-8. Water for desuperheating steam in a distilling plant should be taken from which of the following sources?

1. The brine pump
2. The first-effect tube nest drain pump
3. The freshwater distillate
4. The distilling condenser circulating pump

5-9. Since the vacuum in the first-effect tube nest of a submerged-tube-type distilling plant should be as high as possible to keep scale formation to a minimum and permit full capacity operation, how much vacuum will ensure the most sufficient operation of the plant?

1. 16 in. Hg
2. 20 in. Hg
3. 24 in. Hg
4. 28 in. Hg

5-10. Which of the following factors is affecting the first-effect tube nest vacuum of a submerged-tube-type distilling plant is NOT likely to cause a sudden loss of vacuum?

1. Air leakage
2. Improper venting of the evaporator
3. Scale deposits on the tubes
4. Improper draining of the evaporator tube nest

5-11. The inability to feed the first-effect shell of a distilling plant is usually caused by which of the following factors?

1. Air leakage in the feed system
2. A vapor-bound feed line
3. Scale deposits in the seawater side of the air ejector condenser
4. Excessive superheat steam at the air ejector nozzle

5-12. After a distilling plant is operating, what unfavorable condition will be caused by the sudden rise of water levels?

1. Carryover of small particles of brine with the vapor
2. Scale will form on tube surfaces
3. Partial loss or pressure will occur
4. Each of the above

5-13. Which comparison of the vacuums at the first- and second-effect shells indicates that there is a large air leak between the shells?

1. First-effect vacuum is higher
2. Second-effect vacuum, is higher
3. First- and second-effect vacuums are the same
4. First- and second-effect vacuums are alternately higher

5-14. When the temperature of the seawater is 85°F or cooler, what should be the amount of vacuum in the last-effect shell of a distilling plant?

1. 14 to 16 in. Hg
2. 16 to 26 in. Hg
3. 24 in. Hg or less
4. 26 in. Hg or more

5-15. Failure to obtain a vacuum at 26 inches or more of mercury can be caused by all EXCEPT which of the following factors?

1. Improper operation of air ejectors
2. Insufficient flow of seawater
3. Ineffective use of heat transfer surface in the distilling condenser
4. Seawater injection of 85°F

5-16. When the distilling plant is in operation, what method should be used to test for air leaks?

1. Candle flame
2. Soapsuds
3. Air pressure
4. Hydrstatic

5-17. When a saltwater leak is detected in a heat exchanger, what type of test should you perform to locate the defective tube (s)?

1. Candle flame only
2. Candle flame or hydrostatic
3. Air only
4. Air or hydrostatic

5-18. If you find two leaky tubes in a heat exchanger that has no history of leaking tubes, what action should you take?

1. Replace them
2. Plug them at both ends
3. Repair them
4. Remove them and plug the tube sheets

5-19. To locate a leak in the nonremovable tube bundle of an air ejector condenser, what should you do?

1. Test the bundle hydrostatically by applying a pressure of 50 psi on the tube side of the unit
2. Remove the tube nest covers and test the bundle hydrostatically by applying a pressure of 30 psi to the shell side of the unit
3. Test the bundle hydrostatically by applying a full test pressure of 30 psi to the condenser shell
4. Remove the tube nest covers and test the bundle hydrostatically by applying a pressure of 50 psi on the shell side of the unit

5-20. What numbers should be stamped on the nameplates of distilling plant air ejectors?

1. The designed operating pressure not to be exceeded by more than 5 psig
2. The minimum operating steam pressure to be used
3. The maximum operating pressure to be used
4. The designed operating pressure not to be raised or lowered

5-21. When the air ejector cannot maintain the required vacuum, what is the probable cause?

1. Wet steam
2. Low steam pressure
3. Obstructed nozzle or clogged steam strainer
4. Each of the above

5-22. What is a good sign of an insufficient flow of circulating water in the condenser section of the distiller condenser?

1. A temperature rise through the condenser in excess of 20°F
2. Equal temperature rise throughout the condenser
3. A temperature rise through the condenser of less than 20°F
4. Overspeeding of the circulating pump

5-23. If a distilling plant fails to produce designed output when steam pressure is 5 psig above the orifice, and the first-effect tube nest vacuum is several inches of mercury, what is the probable cause?

1. Scalp on the tubes
2. Overheating in the second effect tube nest
3. Improper venting of the first-effect tube nest
4. Improper drainage of the second-effect tubes

5-24. To obtain a maximum vacuum in the first-effect tube nest, what should be the maximum overboard brine density of a distilling plant?

1. 15/32
2. 1.5/32
3. 3 2/15
4. 1 15/32

5-25. The instrument you use to measure brine concentration should be checked occasionally for accuracy. An accurate instrument should read zero on the applicable scale when the instrument is placed in what type of water?

1. Raw seawater
2. Fresh water
3. Distilled water
4. Chemically treated water

5-26. The distilling plant is equipped with a warning device to indicate high salinity when the distillate reaches what epm per gallon?

1. 0.035
2. 0.065
3. 0.35
4. 0.65

5-27. What happens to distillate after it leaves the cooler?

1. It is pumped to the storage tanks if the salinity is over 0.065 epm per gallon; otherwise, it is pumped to the bilges
2. It is pumped to the storage tanks if the salinity is 0.065 epm or less per gallon; otherwise, it is dumped to the bilges
3. It is dumped to the bilges if the salinity is at least 0.065 epm per gallon; otherwise, it is pumped to the storage tanks
4. It is dumped to the bilges if the salinity is 0.065 epm or less per gallon; otherwise, it is pumped to the storage tanks

5-28. What is the source of heat used to heat the feedwater in the preheater?

1. High-pressure ship's steam discharged from the air ejectors
2. Heat of the distillate from the distillate cooler
3. Heat of the steam from the first-stage condenser
4. Heat of the steam from the last-stage condenser

5-29. The saltwater heater discharges feed water into what location?

1. The feedwater preheater
2. The air ejector condenser
3. The distillate cooler
4. The first-stage flash chamber

5-30. The air ejector precooler is equipped with a salinity cell that operates a shutoff valve to dump the condensate to the bilge or drain tank when the salt content exceeds what epm?

1. 0.010 epm
2. 0.065 epm
3. 0.10 epm
4. 0.65 epm

5-31. The vacuum producing equipment of the distilling plant consists of which of the following types of ejectors?

1. Single-stage ejector
2. Two-stage ejector only
3. Four-stage ejector
4. Booster ejector and a two-stage ejector

5-32. What is the required vacuum in stage five?

1. 16 in. Hg
2. 22 in. Hg
3. 28 in. Hg
4. 34 in. Hg

5-33. To ensure proper operation of air ejectors, what should be the minimum steam pressure to the air ejectors?

1. 135 psig
2. 145 psig
3. 155 psig
4. 160 psig

5-34. To locate and eliminate minor air leaks before they impair proper operation of a distilling plant, a low-pressure hydrostatic test should be applied to the plant a minimum of how often?

1. Weekly
2. Monthly
3. Quarterly
4. In accordance with PMS

5-35. You may find salt water in condensate leaks at any of the various tube bundles of a flash-type distilling unit. How are these leaks indicated?

1. By an alarm bell and a red light which shows at which cell a conductivity increase has occurred
2. By a hissing sound and a blinking red light to indicate the general location
3. By automatic shutdown of the feed pumps and a flashing red light
4. By a buzzer and flashing lights

5-36. After a saltwater heater is cleaned, a hydrostatic test of 8 to 10 psig should be performed on the shell before reassembly. What should you do if a greater test pressure is used?

1. Request permission from NAVSHIPS
2. Adjust the relief valve according to the pressure used
3. Remove or plug the relief valve
4. Request permission from the type commander

5-37. The high-speed compressor of multicylinder, reciprocating design found frequently on today's modern ships has its output controlled in which of the following ways?

1. Automatically, by loading and unloading the cylinders only
2. Manually only
3. By a combination of automatic and manual controls
4. Sometimes automatically and sometimes manually

5-38. How is the unloader mechanism of the compressor operated?

1. By refrigerator suction pressure
2. By compressor discharge pressure
3. By oil pressure from the capacity control valve
4. Mechanically from compressor operations

5-39. Although the Navy's air conditioning and refrigeration school teaches maintenance procedures, you should also refer to which of the following documents for details of the particular plants aboard your ship?

1. Applicable NAVALTs
2. Applicable SHIPALTs
3. Manufacturer's technical manual
4. Naval Ships' Technical Manual

5-40. Suppose a refrigerant compressor has been pumped down to 2 psig and the suction and discharge stop valves are closed. What is indicated by a discharge pressure drop at a rate of 3 psi per minute and a suction pressure increase?

1. Suction valve is leaking
2. Discharge valve is leaking
3. Suction stop valve is leaking
4. Discharge stop valve is leaking

5-41. If compressor discharge valves become defective, which of the following actions should you take?

1. Valve should be relapped immediately
2. Entire discharge valve assembly should be replaced
3. suction line stop valve should be opened
4. Each of the above

5-42. Which of the following conditions is an early indication of crankshaft seal failure?

1. Oil leaking at the shaft in large amounts
2. Pressure of foreign matter in the system piping
3. Formation of moisture at the pulley wheel mount
4. Overflow of refrigerant into the compressor line

5-43. Crankshaft seal failure on reciprocating compressors in a refrigeration system may be caused by which of the following factors?

1. Faulty lubrication
2. Moisture
3. Dirt or foreign material
4. Each of the above

5-44. When you are renewing a leaky crankshaft seal, for which of the following reasons should you NOT attempt to pump the refrigerant out of the compressor?

1. Air will be drawn into the compressor, causing it to rust
2. Air will be drawn into the compressor, causing the discharge valves to freeze
3. Air will be drawn into the compressor, causing the expansion valves to freeze
4. The oil in the compressor will be pumped into the system

5-45. When you are installing a shaft seal, which of the following safety precautions should you observe?

1. Do not touch the bearing surface with your hand
2. Rinse the seal in an approved cleaning solvent
3. Dip the new seal in clean refrigerant oil just prior to installation
4. Each of the above

5-46. The purge valve at the top of the condenser in a refrigeration System serves which of the following purposes?

1. It takes out unpleasant fumes from the refrigerant
2. It removes any air that may accumulate in the system
3. It vents off excess refrigerant in an emergency
4. It permits opening the refrigeration system for cleaning and inspecting

5-47. When the exterior surfaces of the tubes and fins on an air-cooled condenser become dirty and restrict air circulation, the finned surfaces should be cleaned by which of the following methods?

1. With a stiff-bristled brush
2. With jets of steam
3. With compressed air lances
4. With hot water lances

5-48. In testing condenser tubes for leakage, why should 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 detect the presence of R-12
2. To dry the tube heads
3. To draw fresh air through the tube
4. To vaproize any water left in the tube

5-49. 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. Temperature is much lower at the outlet size only
2. Temperature is lower at the inlet side only
3. Temperature is approximately the same at the outlet and the inlet sides only
4. Temperatures at both outlet and inlet can vary, making each of the above statements true at different times

5-50. Liquid refrigerant may flood from the evaporator back to the compressor if the tehemostatic expansion valve is adjusted in what manner?

1. Too high a degree of superheat
2. To equalize the pressure between the lower side of the diaphragm and the valve outlet
3. Too low a degree of superheat
4. Stuck shut

5-51. Under normal operating conditions, how full should the receiver of a properly charged refrigeration system be when the compressor compressor stops?

1. 25%
2. 50%
3. 85%
4. 100%

5-52. During plant operation, which of the following symptoms will indicate a clogged R-12 liquid line strainer?

1. Temperature of the tubing on the outlet side of the strainer will be much warmer than the tubing of the inlet side
2. Temperature of the tubing on the inlet side of the strainer will be much warmer than the tubing on the outlet side
3. Pressure on the outlet side of the strainer tubing will be much higher than on the inlet side
4. Pressure on both the inlet and outlet sides of the strainer tubing will be the same

5-53. Cooling coils should be defrosted before the frost reaches what maximum thickness?

1. 3/16 in.
2. 1/2 in.
3. 3/4 in.
4. 1 in.

5-54 What procedure is used to remove moisture remaining in a refrigeration system after preliminary dehydration?

1. The vacuum pump suction line is connected to the expansion valve, the system is open to the atmosphere, and the charging connection is closed
2. The vacuum pump suction line is connected to the expansion valve, the system is open to the atmosphere, and the charging connection is open
3. The vacuum pump suction line is connected to the charging connection, the system is closed to the atmosphere, and the charging connection is closed
4. The vacuum pump suction line is connected to the charging connection, the system is closed to the atmosphere, and the charging connection is open to the vacuum pump

5-55. When you are evacuating and dehydrating a refrigeration system, as soon as the vacuum indicator shows 0.2-inch mercury absolute, where should you admit dry air through a chemical dehydrator?

1. At a point farthest from the pump
2. At the cooling coils
3. At the compressor entrance
4. At the condenser entrance

5-56. To be properly reactivated, dehydrating agents should be heated (a) to what specific temperature and (b) for what length of time?

1. (a) 200°F (b) 24 hours
2. (a) 300°F (b) 12 hours
3. (a) 400°F (b) 6 hours
4. (a) 500°F (b) 1 hour

5-57. If you do not have a tank-type cleaner, how should you clean an R-12 system?

1. By flushing boiling water through the system 3 times
2. By inserting a hard wool felt filter in the suction strainer screen and operating the plant with an operator
3. By plowing hot air through the system with a blower for 24 hours
4. Each of the above

5-58. When refrigerant is being charged into a refrigeration system, what total number of persons must be present?

1. One
2. Two
3. Three
4. Four

5-59. In a space where refrigerant may be present in the atmosphere, for which of the following reasons should you leave the space immediately?

1. If you smell something unusual
2. If you experience shortness of breath
3. If you feel light-headed
4. Each of the above

ASSIGNMENT 6

Textbook Assignment: "Auxiliary Equipment," chapter 9, and "Propulsion Plant Efficiency," chapter 10, pages 9-1 through 10-10.

6-1. What is/are the best source(s) of information for the maintenance and repair of pumps and components of the hydraulic system?

1. Naval Ships' Technical Manuals
2. Manufacturer's instruction book
3. Ship's blueprints
4. NAVALTs and SHIPALTs

6-2. How is the steering gear on most Navy ships controlled?

1. Electrically
2. Mechanically
3. Hydraulically
4. Manually

6-3. Windlass maintenance includes which of the following procedures?

1. Adjusting the brake
2. Lubricating before operation
3. Cleaning of parts before reassembly after disassembly
4. Each of the above

6-4. Which of the following conditions is NOT required as a part of proper maintenance of electrohyclraulic cranes?

1. Frequent inspection of the drum brake
2. System clean and air free
3. Limit stop and other mechanical safety devices checked regularly for proper operation
4. Oil in replenishing tasks at prescribed levels

6-5. In addition to performing maintenance on cranes that are driven by hand, an MM1 or MMC also performs maintenance on cranes driven by which of the following means?

1. Electriic motors
2. Diesel engines
3. Hydraulic transmissions
4. Each of the above

6-6. In addition to cleanliness of the entire system, which of the following conditions must be ensured following inspections of elevator cables and fittings?

1. That there is proper oil level in the pressure and exhaust tanks
2. That there is no excessive leakage in the sump leakoff connections
3. That pistons seal properly in the hydraulic cylinders
4. Each of the above

6-7. What should you do to correct a leaking relief valve in a hydraulic system?

1. Regrind the valve seat
2. Replace the valve seat
3. Replace the valve
4. Install valve seat inserts

6-8. A hydraulic: system must be drained, flushed, and refilled if an oil sample from the system shows the presence of which of the following substances?

1. Water
2. Sludge
3. Ac id
4. Each of the above

6-9. The success or failure of packing material for modern hydraulic transmissions is governed by which of the following factors?

1. Compatibility of fluid and packing material
2. Pressures, shock loads, clearances, and surface finishes
3. Frequency and duration of work cycles
4. Each of the above

6-10. The type of shaft packing material to be used in a modern hydraulic transmission is determined by which of the following factors?

1. Hydraulic fluid to be used
2. Frequency of work cycles
3. Temperature
4. Shock load

6-11. When connecting units are installed in a hydraulic transmission, good alignment between the driving and driven parts is usually achieved by properly setting and securing all EXCEPT which of the following connectors?

1. The coupling flange bolts
2. The jacking screws
3. The wedges and shims
4. The adjusting setscrews

6-12. Regular operation of hydraulic equipment is essential to maintaining the hydraulic transmission in satisfactory operating condition because regular operation helps prevent which of the following conditions?

1. Sludge accumulation
2. Freezing together of parts
3. Corrosion
4. Each of the above

6-13. Leaks frequently cause trouble in hydraulic equipment and are generally caused by all EXCEPT which of the following conditions?

1. Worn parts
2. Faulty assembly
3. Low operating pressure
4. Continuous vibration

6-14. Which of the following conditions may cause external leaks in hydraulic equipment?

1. Improperly flared tube ends
2. Distorted or scored sealing rings
3. Crossed threaded fittings
4. Each of the above

6-15. How can you locate small internal leaks in hydraulic equipment?

1. Install a pressure gauge in various parts of the system
2. Disassemble and visually inspect parts
3. Use magnetic flux
4. Listen for identifying sounds

6-16. Which of the following noises indicate that air is entering the pump intake line and may be the result of an air leak in the suction line?

1. Grinding noises
2. Hammering noises
3. Popping and sputtering noises
4. Pounding and rattling noises

6-17. You should check the system for improper venting when the transmission lines develop which of the following types of noises?

1. Grinding noises
2. Hammering noises
3. Popping and sputtering noises
4. Pounding and rattling noises

6-18. Which term identifies noises caused by a vibrating spring-actuated valve?

1. Squealing
2. Rattling
3. Hydraulic chatter
4. Sputtering

6-19. Which of the following is a common cause of squealing or squeaking noises in a hydraulic system?

1. Excessively tightened packing around moving parts
2. Air pockets in the cylinder
3. Insufficient vacuum in the fluid line
4. Wiped bearings

6-20. The air intake filter elements of an air compressor may be cleaned by which of the following methods?

1. Washing them with kerosene or gasoline
2. Washing them with a jet of hot water or steam
3. Immersing them in a strong solution of washing soda
4. Both 2 and 3 above

6-21. What symptom indicates a defective inlet valve in the 2nd stage of a two-stage air compressor?

1. Increase in pressure in the intercooler
2. Overheating of air cylinders
3. Decrease in pressure in the first stage
4. Warm valve cover

6-22. You can reduce the frequency with which air valve troubles occur, or possibly prevent them from occuring, by taking which of the following actions?

1. Periodically blowing off the valve cover to keep it from becoming too hot
2. Inspecting and cleaning valves and valve passages regularly
3. Periodically circulating high temperature air around the valves
4. Keeping the pressure high in the intercooler

6-23. When you are replacing air valves in the cylinder of an air compressor, what should you do about gaskets?

1. If the old gasket is not damaged, use it but reverse it
2. Replace all gaskets with new cries
3. Replace all copper gaskets with new ones; non-copper gaskets need to be replaced only when damaged
4. Replace all non-copper gaskets with new ones, copper gaskets need to be replaced only when damaged

6-24. After cleaning an air compressor control valve that is fitted with a filter, you should replace the filter element by using a prescribed material. Which of tile foillowing materials should NOT be used?

1. Sponge
2. Woolen yarn
3. Cotton
4. Both 2 and 3 above

6-25. The rotary-centrifugal compressor found aboard ship is also known by which of the following designations?

1. Rotary compressor
2. Centrifugal compressor
3. Liquid piston compressor
4. Each of the above

6-26. The rotary-centrifugal compressor is often used for pneumatic control systems for which of the following reasons?

1. It is capable of providing a higher pressure than that of most other compressors
2. It is capable of supplying air that is completely free of oil
3. It supplies low-pressure air that is free of moisture
4. It is relatively maintenance free and can operate at full capacity over a long period of time

6-27. The revolving rotor of the compressor throws the liquid out from the center by what method?

1. Air pressure
2. Hydraulic pressure
3. Centrifugal force
4. The converging wall of the casing

6-28. At a minimum, how often must moisture separators, installed downstream of an operating air compressor, be blown down?

1. Daily
2. Weekly
3. Hourly
4. Monthly

6-29. What person is responsible for determining whether an air compressor needs to be inspected and tested more oft-en than prescribed by the manufacturer?

1. The executive officer
2. The engineer officer
3. The leading petty officer
4. The petty officer directly in charge of maintenance

6-30. Which of the following is NOT a common cause of machinery failure aboard ship?

1. Poor supervision
2. Radical maneuvering of the ship
3. Operating the ship at overcruising speed
4. Improper inspection procedures

6-31. On the newer naval ships, the main machinery room houses the basic propulsion plant. The basic propulsion plant consists of which of the following components?

1. Engines only
2. Engines, boilers, turbogenerators, and associated auxiliary machinery
3. Engines and emergency generators only
4. Engines, emergency generators, and associated boilers

6-32. The MM in charge of a watch on board ship must report immediately all emergency conditions that alter the operating capabilities of the main engines to which of the following persons?

1. The officer of the deck only
2. The engineer officer only
3. The engineer officer and the officer of the deck
4. The executive officer

6-33. For machinery and piping systems to be operated according to good engineering practices, what should you do?

1. Ensure that operating instructions and safety precautions are posted for each unit
2. Ensure that each person has a thorough knowledge of the machinery
3. Ensure that each watch stander has a copy of the manufacturer's technical manual
4. Ensure that regularly scheduled casualty control drills are held under way

6-34. What data furnish an accurate index of engineering plant economy while the ship is under way?

1. Fuel consumption per hour of operation
2. Fuel consumption as compared to the amount of fuel allowed for certain speed or steaming condition
3. Both 1 and 2 above
4. Consumption in gallons of makeup feed per engine mile

6-35. Economical plant operation may be sacrificed for which of the following reasons?

1. To ensure reduced preventive maintenance requirements
2. To ensure personnel safety and machinery reliability
3. To ensure higher ship speed and acceleration capabilities
4. Each of the above

6-36. How does fast acceleration of the main engine affect the economy of the propulsion plant?

1. By causing excessive temperatures
2. By wasting steam
3. By wasting fuel oil
4. Each of the above

6-37. If the ship's ventilation system is improperly operated or maintained, what is the end result?

1. Waste of steam
2. Waste of electrical power
3. Waste of fuel oil
4. Waste of feedwater

6-38. Efficient operation of the engineering plant requires that the steam pressure to the air ejectors be in what condition?

1. Fluctuating above and below the designed pressure, depending on conditions
2. Steady, below the designed pressure
3. Steady, slightly above the designed pressure
4. Steady, at the designed pressure

6-39. For efficient operation of the plant, the condensate depression should be maintained between what temperature range?

1. 0°F and 2°F
2. 1°F and 3°F
3. 2°F and 4°F
4. 3°F and 5°F

6-40. What report or record is most likely to be the basis for evaluating a ship's economy of operation and its readiness to make required speeds?

1. Machinery and maintenance history
2. Material inspection
3. Trial performance
4. Readiness inspection

6-41. The operational readiness inspection (ORI) is designed mainly for which of the following reasons?

1. To determine the ability of engineering personnel to control damage and effect emergency repairs
2. To determine the ability of a ship and its crew to carry out its wartime mission
3. To determine the readiness of an engineering plant for peacetime and wartime steaming
4. To determine the readiness of an engineering plant for full power trial

6-42. Since good organization and coordination are essential in getting a large ship under way in a smooth and orderly manner, the engineering department uses check-off lists. What is the purpose of check-off lists?

1. To provide a simple procedure for getting the engineering plant ready
2. To ensure that no important action is overlooked or forgotten
3. To prevent misunderstanding and contusion
4. Each of the above

6-43. Which of the following circumstances could result in a casualty to the engineering plant during its warming-up period?

1. A misunderstanding of orders
2. A failure of fireroom personnel to cooperate with engine-room personnel
3. The starting of machinery without permission
4. Each of the above

6-44. In preparing to get under way to test the main engines, the engineering officer of the watch must obtain permission from which of the following persons?

1. The officer of the deck
2. The executive officer
3. The commanding officer
4. The engineering department supervisor

6-45. Immediately after all the main engines have been tested satisfactorily, what action should the engineering officer of the watch take?

1. Direct all engineering spaces to stand by
2. Report to the OOD that the engineering department is ready to get under way
3. Request permission to turn the engines
4. Sign the steaming order

6-46. In working together with fireroom personnel, what should an MM1 or MMC be able to do?

1. Switch watches with the fireroom personnel
2. Delegate responsibility to the fireroom supervisor
3. Coordinate activities with those of the fireroom supervisor
4. Each of the above

6-47. Although the single-furnace boiler creates no special problem during operation, why is there a problem when the boiler is lighted off and secured?

1. Because all steam must pass through the superheater
2. Because there is no normal flow of steam through the superheater until the boiler is on the line
3. Because the temperature of the superheater tubes is excessively low during light-off
4. Because boiler pressure is at a minimum at this time

6-48. When you are lighting off or securing a single-furnace boiler, what must you do to keep the superheater from overheating?

1. Open the main steam stop bypass
2. Open the main steam line low-pressure drains
3. Cut in 150-psi auxiliary steam
4. Cut in the desuperheater

6-49. To maintain a high vacuum in the main condenser of a ship under way, which of the following is NOT a precaution you should take?

1. Maintain gland seal steam at 3 to 5 psig
2. Keep gland packing in good condition
3. Maintain adequate water in the reserve feed tank, which is in use for makeup feed
4. Eliminate all air leaks into the condensing system

6-50. The acceleration and deceleration charts posted at each main engine throttle board provide the throttleman with which of the following information?

1. The pressure and temperature relationship at the various speed levels
2. The number of rpm each shaft is doing at various speed levels
3. The exact amount of time the throttle man should use in each speed change
4. The amount of time it takes the turbines to accelerate or decelerate the ship to the new speed set by the throttleman

6-51. When must a report be made to the bridge?

1. After the main engines are secured
2. After the auxiliary watch is set
3. After the bilges are pumped and the tubes of the steaming boilers are blown
4. After all saltwater ballast is pumped overboard

ASSIGNMENT 7

Textbook Assignment: "Quality Assurance," chapter 11, pages 11-1 through 11-24.

7-1. Which of the following programs provides maintenance personnel with information and guidance necessary to administer a uniform policy of maintenance and repair?

1. 3-M
2. QA
3. IEM
4. COSAL

7-2. The QA manual for each TYCOM sets forth which of the following requirements?

1. Maximum QA requirements
2. Minimum QA requirements
3. Specific QA requirements for ships
4. Specific QA requirements for shore

7-3. The instructions contained in the QA manual apply to what organizations?

1. Shore activities only
2. Combat ships only
3. Repair ships only
4. Every ship and activity of the force

7-4. If conflicts exist between the QA manual and previously issued letters and transmittals by appropriate force commanders, the letters and transmittals take precedence .

1. True
2. False

7-5. Which of the following is considered part of job execution?

1. Completing QA forms
2. Training personnel
3. Meeting controlled material requirements
4. Auditing programs

7-6. The administrative part of the QA program consists of which of the following parts?

1. Preparing work procedures
2. Requisitioning material
3. Monitoring programs
4. Testing and recertifying

7-7. Technical specifications can be ruled out in the interest of completing the job quickly.

1. True
2. False

7-8. Which of the following factors spawned the need for the development of the QA program?

1. The ever-increasing technical complexity of present-day surface ships and submarines
2. The ever-increasing workload of the work centers aboard ship
3. The ever-increasing lack of formal training for technicians aboard ship
4. Each of the above

7-9. The achievement of an effective QA program depends on which of the following factors?

1. Speed of repair, special skills, and knowledge
2. Speed of repair, special skills, and prevention of maintenance problems
3. Knowledge, prevention of maintenance problems, and speed of repairs
4. Knowledge, prevention of maintenance problems, and special skills

7-10. Which of the following is one of the main goals of the QA program?

1. To ensure every repair of any failed equipment is documented
2. To decrease the time between equipment failures
3. To ensure the safety of personnel while working on SUBSAFE items
4. To protect personnel from hazardous conditions

7-11. What is the most difficult part of planning a job?

1. Determining which technical specification sources are applicable to a particular job
2. Determining the number of personnel required to accomplish a specific job
3. Determining what material is needed
4. Determining how much time is required to accomplish the job

7-12. The QA program (Navy) begins with which of the following personnel?

1. The type commander
2. The commanding officer of the ship
3. The quality assurance officer
4. The commander and chief of the fleet

7-13. What person is responsible to the force commander for QA in the maintenance and repair of the ship?

1. The type commander
2. The commanding officer
3. The quality assurance officer
4. The quality control inspector

7-14. What person(s) provide(s) instruction, policy, and overall direction for implementation and operation of the force QA program?

1. The commander and chief of the fleet
2. The commanding officer
3. The type commander
4. The quality assurance officer

7-15. Which of the following personnel is responsible for initiating a departure from specification report.?

1. The work center supervisor
2. The quality control inspector
3. The person finding or causing the departure
4. The quality assurance officer

7-16. The quality assurance officer is responsible to the commanding officer for which of the following tasks?

1. Coordinating the ship's 3-M training
2. Conducting the ship's QA training
3. Reviewing procedures and work packages prepared by the ship before submission to the engineer
4. Reviewing personnel records to ensure that everyone is qualified as quality assurance inspectors

7-17 The QCI is responsible for which of the following actions?

1. Planning work for the work center
2. Scheduling preventive maintenance
3. Assigning work to maintenance personnel
4. Inspecting all work for conformance to specifications

7-18. Which of the following personnel must know the specification limits of a job and the purpose of these **limits'?**

1. The executive officer only
2. The leading petty officer only
3. The chief petty officer only
4. Each person involved in the job

7-19. What person is responsible for maintaining the ship's QA records and test and inspection reports?

1. The quality assurance officer
2. The commanding officer
3. The repair officer
4. The type commander

7-20. The effective operation of a successful QA program requires the effort of which of the following personnel?

1. The commanding officer only
2. The quality assurance officer only
3. The engineer officer only
4. All hands

7-21. What person(s) should have the most direct concern for quality workmanship within a work center?

1. The production supervisor
2. The shop craftsmen
3. The division officer
4. The department head

7-22. What type of inspecticn determines the condition of material, maintenance requirements, and disposition and records and documents?

1. Final inspection
2. Midterm inspection
3. In-process inspection
4. Receiving or screening inspection

7-23. Which of the following is an example of a QA action performed following the completion of a series of tasks?

1. Final inspection
2. In-process inspection
3. Receiving inspection
4. Screening inspection

7-24. What number is assigned to the QCI by the QAO for use on all forms and tags that require initials as proof that certified tests and inspections were completed?

1. Social security number
2. Stock number
3. Personal serial number
4. Personal pin number

7-25. Which of the following actions is NOT considered to be part of the in-process inspection?

1. A periodic or special evaluation of details, plans, policies, procedures, product directives, and records
2. The witnessing of task performance
3. The application of torque and functional testing
4. Adjusting, assembling, servicing, and installation

7-.26. What person is responsihle for coordination and administering the QA program within a work center?

1. The QCI
2. The QAO
3. The work center supervisor
4. The division officer

7-27. Which of the following is NOT a responsibility of the QCI?

1. Developing a thorough understanding of the QA program
2. Assigning jobs that require a work package
3. Maintaining records and files to support the QA program
4. Ensuring that all work center personnel are familiar with applicable QA manuals by conducting training

7-28. Which of the following personnel is/are responsible for conducting internal audits as required and discrepancies?

1. The division officer
2. The QAO
3. The QCI
4. All of the above

7-29. Which of the following personnel is responsible for inspecting, segregating, stowing, and issuing controlled material?

1. The CMPO
2. The QCI
3. The division officer
4. The work center supervisor

7-30. Alternate QCIs (backup personnel) do not need to have the same degree of qualifications and will not be given the same responsibilitities as normally assigned QCIs.

1. True
2. False

7-31. According to the QA manual, the commanding officer assigns the primary duty of which of the following personnel in writing?

1. The QCI
2. The QAO
3. The CMPO
4. The PAG

7-32. What person is responsible for training and qualifying the work center QCI?

1. The quality assurance officer
2. The division officer
3. The quality control inspector
4. The quality assurance supervisor

7-33. CMPOs are trained and qualified by the QA supervisor and are normally of what paygrade(s)?

1. E3 and E4
2. E4 only
3. E5 only
4. E4 and E5

7-34. Which of the following personnel is/are given a written examination as well as an interview before becoming qualified to do the assigned job?

1. The QAO
2. The CMPO only
3. The QCI only
4. The CMPO and QCI

7-35. In addition to a good personnel orientation program, which of the following elements are required for an effective QA program?

1. A comprehensive training program, use of proper repair procedures, and a uniform liberty policy
2. A comprehensive training program, use of proper repair procedures , and uniform inspection procedures
3. Use of proper repair procedures and uniform inspection procedures
4. Use of new tools and equipment, proper working environment, and uniform liberty policy

7-36. What term best describes when an authorized representative approves specific services rendered?

1. Quality control
2. Inspection
3. Acceptance
4. Inspection record

7-37. What QA function is performed to identify production standards or material characteristics during manufacture or repair cycle that may not be detectable during final inspection?

1. Quality assurance
2. Quality control
3. In-process inspection
4. Technical repair standardization

7-38. What term describes a management function that attempts to eliminate defective products?

1. Quality assurance
2. Quality control
3. Audit
4. Controlled material

7-39. The examination and testing of components and services to determine whether they conform to specified requirements is defined by what term?

1. Acceptance
2. Calibration
3. In-process inspection
4. Inspection

7-40. Any technical or administrative directive that defines repair criteria is known by what term?

1. Calibration
2. Acceptance
3. Specification
4. Inspection record

7-41. What number provides traceability from the work package to other certification documentation?

1. Job control number
2. Identification number
3. Serial number
4. Stock number

7-42. What term is defined as a written instruction designed to produce acceptable and reliable products, whether produced or repaired?

1. Inspection
2. Procedure
3. Process
4. SUBSAFE

7-43. What term is defined as a set of actions written in a special sequential order by which maintenance action, a test, or an inspection is done using specific guidelines, tools, and equipment?

1. Process
2. Procedure
3. Documentation
4. Audit

7-44. What term is defined as the record of objective evidence establishing the requisite quality of the material, component, or work done?

1. Procedure
2. Documentation
3. Controlled work package
4. Departure from specification

7-45. A certain level of confidence required in the reliability of repairs made is known as what type of level?

1. Level of assurance
2. Level of control
3. Level of essentiality
4. Level of reliability

7-46. If, during the repair process, you must change the original scope of the work to be performed, what procedure must you initiate?

1. Revision
2. Addendum
3. Automated work request
4. Controlled work package

7-47 Which of the following information is NOT provided to a supervisor in a CWP?

1. QA formInstructions
2. Departure from specifications forms
3. Technical drawings
4. Stowage location of SUBSAFE material

7-48. What procedure should you follow if, during a repair process involving simultaneous performance of procedure steps, the steps are in different locations?

1. Reject the job and send the CWP back to planning
2. Make a copy of the CWP with its documentation for each jobsite
3. Use locally developed practices
4. Have the CWP at one jobsite only

7-49. what term describes the documentation contained inside a CWP?

1. Revision
2. Enclosures
3. Addendum
4. Specifications

7-50. What term indicates the impact that catastrophic failure of the associated part or equipment would have on the ship's mission capability and personnel safety?

1. Levels of assurance
2. Levels of essentiality
3. Levels of necessity
4. Levels of controls

7-51. What level(s) of assurance normally require(s) both quality control and tests and/or inspection methods?

1. A only
2. B
3. C only
4. A or C

7-52. What level of assurance provides for "as necessary" verification techniques?

1. A
2. B
3. C
4. I

7-53. Which of the following is NOT a description of controlled material?

1. It has special markings
2. It has accountability throughout the repair or manufacturing process
3. It is stowed separately
4. It must be open purchased

7-54. What term is defined as the degree of control measures required to assure reliability of repairs made to a system, subsystem, or component?

1. In-Process inspection
2. Levels of assurance
3. Levels of control
4. Levels of essentiality

7-55. What person must inspect controlled material for required attributes before it can be used in a system or component?

1. The QAO
2. The QCI
3. The CMPO
4. Tile DCPO

7-56. SUBSAFE requirements are Split into what total number of categories?

1. Five
2. Two
3. Three
4. Four

7-57. What term is defined as any submarine system determined by NAVSEA to require the special material or operability requirements of the SUBSAFE program?

1. SUBSAFE boundary
2. SUBSAFE barrier
3. SUBSAFE material
4. SUBSAFE system

7-58. Which of the following problems may cause a worker to fail to report a departure from specification?

1. Lack of training
2. Lack of time for adequate planning
3. Lack of adequate inspection
4. Each of the above

7-59. When there is a lack of compliance with cognizant technical documents, drawings, or work procedures during a maintenance action that will not under way, what document is required?

1. OPNAV Form 4790/2
2. OPNAV Form 4790/21
3. Departure from specification
4. ACN

7-60. What are the two types of departure from specifications?

1. Major and minor
2. Major and semi-minor
3. Minor and semi-minor
4. Semi-minor and minimal

7-61. What type of departure from specification must be approved by higher authority?

1. Major only
2. Minor only
3. Semi-minor only
4. Any departure from specification

7-62. What person is responsible for reporting a departure from specification?

1. The QCI
2. The CMPO
3. The QAO
4. The person who discovered or caused the departure

7-63. What QA form is used by the CMPO to provide a standard inventory record of controlled material received and issued?

1. 7
2. 8
3. 8A
4. 9

7-64. What QA form is used to identify and control material and equipment in a positive manner from ship to repair shop?

1. 9
2. 9A
3. 4A
4. 4

7-65. What QA form is attached by supply, QA, or shop personnel to provide traceability of accepted controlled material from receipt inspection through final inspection?

1. 7
2. 2
3. 3
4. 4A

ASSIGNMENT 8

Textbook Assignment: "Record Systems," chapter 12, pages 12-1 through 12-33.

8-1. Since the Engineering Log and the Engineer's Bell Book are legal records of the engineering department, they cannot be released if requested by a Navy court.

1. True
2. False

8-2. What manual provides guidance for record handling responsibilities?

1. The department manual only
2. The division manual only
3. The 3-M manual
4. The department and divisional organization manuals

8-3. What person verifies the accuracy and completeness of all entries in the Engineering Log and signs the log daily?

1. The engineer officer
2. The officer of the deck
3. The commanding officer
4. The main propulsion assistant

8-4. When a ship is removed from the list of naval ships, what is the disposition of the Engineering Log and Engineer's Bell Book?

1. They are retained on board until the ship is reactivated
2. They are forwarded to NAVSEA
3. They are released for disposal
4. They are forwarded to the nearest records management center

8-5. When the commanding officer has signed the Engineering Log, it may be changed only under which, if any, of the following conditions?

1. With the engineer officer's permission
2. If it has been completed in pencil
3. With the CO's permission or direction
4. None of the above

8-6. The Engineering Log must be maintained on board for what minimum number of years?

1. One
2. Two
3. Three
4. Four

8-7. The throttleman's assistant may make entries in the Engineer's Bell Book under which of the following conditions?

1. While being relieved for chow in condition I
2. During special evolutions that involve frequent speed changes
3. Whenever an assistant is present
4. When conducting ECC drills

8-8. When the last entry has been made in the Engineer's Bell Book before the watch changes, it should be signed by which of the following persons?

1. The EOOW
2. The upper levelman
3. The engineer officer
4. The main propulsion assistant

8-9. General operating records are normally retained on board for what minimum period of time?

1. 1 year
2. 2 years
3. 3 years
4. 4 years

8-10. When the EOOW is NOT stationed in the engine room, which of the following persons may sign the Engineer's Bell Book?

1. The throttleman
2. The senior person assigned to the space
3. The division officer
4. The watch supervisor

A. Propulsion Steam Turbine and Reduction Gear Operating Record
B. Gas Turbine Operating Record
C. Diesel Engine Operating Record
D. AC/DC Electrical Propulsion Operating Record
E. Boiler Room Operating Record
F. Electrical Log
G. Distilling Plant Operating Record
H. Refrigeration and Air-Conditioning Equipment Record
I. Gyrocompass Operating Record
J. IC Room Operating Record
K. Air Compressor Operating Record

Figure 8A

IN ANSWERING QUESTIONS 8-11 THROUGH 8-21, CHOOSE THE RECORD FROM FIGURE 8A THAT IS USED FOR THE PURPOSE SHOWN IN THE QUESTION.

8-11. Maintained for one or more main engines in operation.

1. A
2. B
3. C
4. I

8-12. Maintained for main and auxiliary diesel-powered engines.

1. A
2. B
3. C
4. G

8-13. Maintained to record operating data of all fireroom operating machinery.

1. A
2. B
3. E
4. K

8-14. Used to monitor all water-producing equipment on board

1. D
2. G
3. H
4. K

8-15. Maintained to show voltages and major currents for motor generator sets

1. D
2. G
3. H
4. J

8-16. Bell signal automatically logged by computer.

1. A
2. B
3. E
4. H

8-17. Used to record operating propulsion generators.

1. B
2. C
3. D
4. I

8-18. Used to record operating ship's service generators.

1. D
2. F
3. H
4. I

8-19. Used to record refrigeration and air-conditioning systems and equipment operating parameters.

1. B
2. D
3. F
4. H

8-20. Locally prepared and contains operating data for the gyrocompass .

1. D
2. F
3. I
4. J

8-21. Maintained for the operation of HP/LP air-producing equipment.

1. C
2. E
3. G
4. K

8-22. Fuel tanks are filled to 95 percent of their volumetric capacity for what reason?

1. To allow for expansion and to prevent spillage
2. To ensure proper fuel atomization
3. To ensure proper suction for the fuel oil service transfer system
4. To conserve unburnable fuel

8-23. When a ship is fueled to 100 percent of its volumetric capacity how is the burnable fuel reported?

1. At 95%
2. At 100%
3. In excess of 100%
4. At 100% ± 5%

8-24. When a ship is fueled at 95 percent, it is assumed to be at what percentage of burnable fuel?

1. 90%
2. 95%
3. 100%
4. In excess of 100%

8-25. Which of the following conditions is NOT indicated on the fuel and water report?

1. The amount of fuel on hand as of midnight the previous day
2. The amount of water on hand as of midnight the previous day
3. The steaming hours on boiler firesides and watersides
4. The amount of fuel and water transferred as of midnight the previous day

A. Daily Fuel and Lube Oil Account
B. Daily Water Account
C. Fueling Memorandum
D. Liquid Lead Plan
E. Boat Fueling Record
F. Oil King's Memorandum

Figure 8B

IN ANSWERING QUESTIONS 8-26 THROUGH 8-30, CHOOSE THE RECORD IN FIGURE 8B THAT IS USED FOR THE PURPOSE SHOWN IN THE QUESTION.

8-26. Shows the fuel capacity, in gallons, the fuel on hand, and the approximate fuel consumption on boats.

1. A
2. D
3. E
4. F

8-27. Shows the receipt, use, expenditure, and transfer of each fuel oil, diesel oil, and lubricating oil tank throughout the snip.

1. A
2. C
3. D
4. F

8-28. Shows a graphical layout of the approximate status of fuel, ballast water, reserve feedwater, and potable water.

1. C
2. D
3. E
4. F

8-29. Shows the feedwater for boilers, deaerating feed tanks, and potable water tanks throughout the ship.

1. A
2. B
3. D
4. E

8-30. Shows the fluid levels in ranks containing fuel oil, ballast water, potable water, and standby feedwater.

1. B
2. D
3. E
4. F

8-31. Specific instructions concerning the care and maintenance of various boiler water/feedwater tests and treatment logs and records are found in what NSTM chapter?

1. 097
2. 220
3. 222
4. 504

A. Weekly Schedules
B. Quarterly Schedules
C. Cycle Schedules
D. Feedback forms
E. Maintenance Action forms
F. CSMP

Figure 8C

IN ANSWERING QUESTIONS 8-32 THROUGH 8-36, CHOOSE THE 3-M SYSTEM DOCUMENT FROM FIGURE 8C THAT SERVES THE PURPOSE SHOWN IN THE QUESTION.

8-32. Used to schedule PMS tasks for a given work center during a specific week.

1. A
2. C
3. D
4. E

8-33. Provides a means to report deficiencies and request PMS coverage for equipment.

1. B
2. D
3. E
4. F

8-34. Provides PMS requirements for a specific 3-month period.

1. A
2. B
3. C
4. E

8-35. Used to list deferred maintenance and alterations reported in MDCS.

1. B
2. D
3. E
4. F

8-36. Used to report deferred and completed maintenance.

1. A
2. C
2. E
4. F

8-37. The engineer's Night Order Book is prepared and maintained according to instructions issued by which of the following officers?

1. The TYCOM
2. The commanding officer
3. The MPA
4. The division officer

8-38. In the absence of the engineer officer in port, which of the following persons maintains the Night Order Book?

1. The EDO
2. The MPA
3. The EOOW
4. The duty department petty officer

A.	Steaming Orders
B.	Degaussing folder
C.	Gyrocompass Service Record Book
D.	Ship characteristics cards
E.	Main Propulsion Turbine Condition Report
F.	Boiler Tube Failure Report

Figure 8D

IN ANSWERING QUESTIONS 8-39 THROUGH 8-44, CHOOSE THE DOCUMENT IN FIGURE 8D THAT IS DESCRIBED IN THE QUESTION.

8-39. Lists the readiness of major machinery in the engineering department based upon the time the ship was under way.

1. A
2. D
3. E
4. F

8-40. Provides information on tests, repairs, and inspections of all ship's coil currents.

1. A
2. B
3. D
4. E

8-41. A record of inspections, repairs, and tests on the ship's directional equipment.

1. A
2. B
3. C
4. D

8-42. Provides information on ship's design and abilities.

1. A
2. D
3. E
4. F

8-43. Describes the condition of each propulsion turbine.

1. A
2. D
3. E
4. F

8-44. Lists failed or replaced boiler pressure parts.

1. A
2. D
3. E
4. F

8-45. Which of the following is the best description of a boiler tube rupture?

1. A separation where there is no apparent tube enlargement
2. Openings other than cracks that are not related to tube expansion
3. All openings related to tube enlargements
4. Longitudinal and circumferential openings greater than 1/16 of an inch only

8-46. When it is necessary to submit a boiler tube sample for analysis, the sample should be marked by what means?

1. Paint
2. A scribe
3. Chalk covered with clear acrylic paint
4. Tags identifying the relative position to the furnace

8-47. Which of the following is the best way to submit a sample of a tube deposit?

1. Remove the deposit with a wire brush
2. Remove the deposit with a cleaning solvent and identify the solvent used
3. Submit the tube upon request after the deposit has been identified
4. Submit a section of the tube with the deposit still in place

8-48. What form sheets should you use to document defective boiler tubes?

1. Boiler Tubew Renewal Sheets
2. Boiler Tube Failure Report
3. Steaming Orders
4. Main Propulsion Turbine Condition Report

8-49. The CNO requires that all ships submit the ship characteristics card at which of the following times?

1. Upon commissioning or being placed in service
2. Within 30 days after completion of regular overhaul
3. Whenever a change in military characteristics is made
4. Each of the above

8-50. After the type commander endorses the Turbine Condition Report that recommnds disassemly of the turbine casing, which of the following commands also reviews and normally approves the recommendation?

1. NAVSEASYSCOM
2. NAVSAFCEN
3. NAVSES
4. Intermediate Repair Activity

ASSIGNMENT 9

Textbook Assignment: "Boiler Firesides and Watersides," chapter 13; "Boiler Fittings and Instruments," chapter 14; and "Environmental Policies and Procedures," chapter 15, pages 13-1 through 15-11.

9-1. Which of the following conditions is NOT classified as severe service?

1. Extended steaming at full power
2. Rapid temperature fluctuations
3. Burning contaminated fuel
4. Cold plant light-off

9-2. When you lower the temperature of the furnace too rapidly, what is the resulting damage?

1. Firebrick breakage at the anchor bolts
2. Firebrick shrinkage
3. Deep firebrick fractures
4. Anchor bolt breakage

9-3. Panting of a boiler can ultimately result in, what type of damage?

1. Dislocated furnace wall
2. Broken anchor bolts
3. Sagging burner cones
4. A badly warped furnace deck

9-4. When 4 1/2-inch firebrick thickness has been reduced to 2 1/2 inches, replacement is recommended.

1. True
2. False

9-5. A firebrick expansion joint that is light in color indicates which of the following conditions?

1. The expansion joint is closing
2. The expansion joint should be packed with fiberfrax
3. The expansion joint is not closing
4. The firebrick needs to be replaced

9-6. When you inspect a burner front, which of the following conditions is the most severe?

1. Slagging
2. Parallel cracks
3. Radial cracks
4. Peeling of the castable

9-7. Which of the following conditions indicates that too much water was used during installation of a castable burner front?

1. Peeling and spalling
2. Slagging
3. Crumbly castable
4. Breaking after very little service

9-8. When you replace burner tiles, what is the correct procedure?

1. Fit the tiles to each other only
2. Fit the tiles to the throat ring only
3. Fit the tiles to each other and the throat ring
4. Fit the tiles to the inner casing

9-9. When a blistered tube suggests a waterside deposit, the nature and extent of the deposit can be determined by which of the following methods?

1. Clean the tube with power-driven tube cleaning equipment and inspect the loosened substance
2. Hit the blister with a hammer and inspect the loosened substance
3. Remove the tube and the adjacent tube and split both tubes' watersides
4. Remove and split the blistered tube and examine the watersides

9-10. Fireside circumferential grooving on a horizontal tube often is the result of which of the following conditions?

1. Leaking tube seats above the grooving
2. Pin hole leaks in adjacent tubes
3. Thin, damp soot deposits
4. Rain entering from the smokepipe

9-11. General fireside thinning is normally caused by reduced heat transfer through the tube.

1. True
2. False

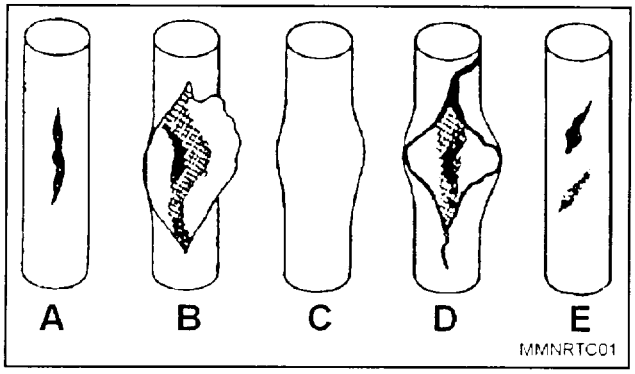


Figure 9A

IN ANSWERING QUESTIONS 9-12 THROUGH 9-15, REFER TO THE TUBE CASUALTIES SHOWN IN FIGURE 9A.

9-12. Which of these casualties are NOT caused by overheating?

1. A and C
2. B and D
3. C and E
4. A and E

9-13. Which casualty is caused by the most severe overheating?

1. A
2. B
3. D
4. E

9-14. Which casualty is caused by strictly mechanical means?

1. A
2. C
3. D
4. E

9-15. Which casualty is most common in superheater tubes but rare in generating tubes?

1. A
2. B
3. C
4. D

9-16. what tube deformity always indicates the presence of a waterside deposit?

1. Thick-lipped rupture
2. Thin-lipped rupture
3. Hea blister
4. Tube bulge

9-17. Fireside deposits lead to tube failures because of which of the following problems?

1. Localized overheating
2. Tube corrosion
3. Mechanical abrasion
4. Oxygen pitting

9-18. When hard scale is suspected during a watersides inspection, what should be your next step?

1. Remove several tubes for examination
2. Boil out the boiler with trisodium phosphate
3. Mechanically clean the boiler
4. Chemically clean the boiler

9-19. You should inspect a boiler when it is completely dry EXCEPT when you suspect which of the following problems?

1. Hard scale
2. Sludge deposits
3. General corrosion
4. Oil contamination

9-20. When tubes have been removed for inspection during overhaul, which of the following tubes may NOT need to be replaced?

1. Generating tubes
2. Furnace wall tubes
3. Superheater tubes
4. Economizer tubes

9-21. What device is used to measure and map waterside tube deformities?

1. British Tube Inspection Unit (BTIU)
2. Endoprobe
3. Pit depth micrometer
4. Laser Optic Tube Inspection System (LOTIS)

9-22. What rolled tube end defect is considered the most serious?

1. Hairline indications
2. Honeycombing
3. Bell cracking
4. Bell flaking

9-23. Which of the following conditions can lead to general waterside corrosion?

1. Extended periods of low pH
2. Short periods of low phosphate
3. Extended periods of high chloride
4. Short periods of nigh dissolved oxygen

9-24. In what area of the tube does the greatest amount of waterside thinning occur?

1. Lower tube bends
2. Flame side of the tube
3. Upper tube bells
4. Uniformly around tube

9-25. Stress corrosion cracks are caused by which of the following factors?

1. Oxygen contamination in the steam drum
2. Sludge formation in the boiler
3. High pH in the boiler
4. Oxygen and chloride contamination in the superheater

9-26. What specified period of time , should you wait prior to entering a boiler for inspection during a hydrostatic test?

1. 1 minute
2. 5 minutes
3. 10 minutes
4. 15 minutes

A. 100 percent
B. 125 percent
C. 135 percent
D. 150 percent

Figure 9B

IN ANSWERING QUESTIONS 9-27 THROUGH 9-30, HYDROSTATIC TEST FOR THE SITUATION.

9-27. Which hydrostatic test(s) is/are based on boiler designed pressure?

1. A and C
2. B and C
3. C and D
4. D only

9-28. What test is used following the rewelding of downcomers?

1. A
2. B
3. C
4. D

9-29. What test is used to determine boiler tightness?

1. A
2. B
3. C
4. D

9-30. What test is used after replacing handhole plates?

1. A
2. B
3. C
4. D

9-31. What authority must approve the use of the 150 percent hydrostatic test?

1. CO
2. TYCOM
3. NAVSEA
4. NAVSSES Philadelphia

9-32. At a minimum, how often should the sliding feet be checked for movement?

1. Each fireside cleaning
2. Each light-off
3. Quarterly
4. Annually

9-33. When is the best time to inspect the boiler inner casings?

1. During each fireside cleaning period
2. During every shipyard period
3. When refractories are removed
4. Before a major deployment

9-34. At a minimum, how often should the air casings be air tested for tightness?

1. Annually
2. Each shipyard period
3. During IMA availabilities
4. Every 5 years

9-35. Repaired boiler piping should be checked at what percent of operating pressure?

1. 100%
2. 115%
3. 125%
4. 135%

9-36. What minimum pressure should be used during hydrostatic testing of repaired piping?

1. 25 psi
2. 50 psi
3. 75 psi
4. 100 psi

9-37. What is the objective of OLV procedures?

1. To prevent equipment malfunction
2. To obtain a satisfactory boiler flex test
3. To achieve satisfactory overall system performance
4. To collect information about component alignment

9-38. What percentage of ramp load change is required for a boiler flex test?

1. 15%
2. 50%
3. 70%
4. 95%

9-39. After conducting the ramp during a boiler flex test, all systems must stabilize within what maximum period of time?

1. 2 minutes from the end of the ramp
2. 2 minutes from the start of the ramp
3. 4 minutes from the end of the ramp
4. 4 minutes from the start of the test

9-40. What is the allowable boiler load change range for conducting the boiler flex test?

1. 5 to 85%
2. 10 to 90%
3. 15 to 90%
4. 15 to 95%

9-41 What aspect of 1200-psi boilers causes accelerated degradation of safety valves?

1. Closer tolerance requirements
2. Wider range of pressure fluctuations
3. Higher usage rates
4. Higher temperatures and pressures

9-42. What pressure keeps the GIS safety valve seated?

1. Boiler pressure
2. Spring pressure
3. Gag pressure
4. Lift pressure

9-43. Safety valves may simmer when they are within what percent of their popping pressure?

1. 1%
2. 2%
3. 5%
4. 10%

9-44. Which of the following actions is/are most likely to ensure continued satisfactory operaration of safety valves?

1. Disassembling and cleaning safety valves at each boiler overhaul
2. Hydrostatic testing to determine valve condition
3. Grinding the valve parts to prevent leaks
4. Maintaining the original valve dimensions

9-45. Safety valve springs and spindles should be painted with two coats of heat-resisting aluminum paint to prevent rusting.

1. True
2. False

9-46. Which of the following procedures should be performed before testing safety valves?

1. Calibrate boiler drum gauges
2. Compare boiler pressure gauge readings to each other
3. Perform hydrostatic testing of safety valves
4. Get approval from NAVSEA

9-47. A 625-psi boiler should have what maximum tolerance popping pressure?

1. ±3 psi
2. ±3 percent
3. ±5 psi
4. ±5 percent

9-48. You should take full advantage of the given blowdown range for an individual safety valve only if which of the following provisions exists?

1. Safety valves lift in correct order
2. Safety valves reseat in correct order
3. The pilot safety valve lifts the superheater safety valve
4. Drum safety valves reseat after the superheater safety valve

9-49. What is the criteria a for determining when a safety valve requires repair?

1. A 3-foot plume of steam in calm air
2. Water beads on a cool knife blade held near the valve
3. The valve simmers upon reseating
4. The popping pressure is too low

9-50. In which of the following situations should you NOT test the superheater safety valve separately?

1. After removal and reinstallation on the boiler
2. During routine testing
3. After repairs where the safety valve was steam tested by the repair facility
4. After the safety valve was lifted by hydrostatic pressure

9-51. You are preparing to test boiler safety valves. Placing gags on cold boiler safety valves should have what result?

1. Bent spindles
2. A jammed valved disc
3. Difficulty removing the gags
4. Early lift of the safety valve

9-52. During firesides inspection excessive soot is noted. Before increasing soot blowing frequency, you should verify which of the following conditions exists?

1. Fuel burner settings are
2. Automatic combustion controls are working properly
3. Boiler has not made dark smoke
4. All of the above

9-53. How can you reduce soot buildup caused by prolonged inport steaming?

1. By increasing the number of burners used
2. By increasing combustion air flow
3. By using fewer burners with higher fuel pressures
4. By opening more air registers

9-54. If the PMS gives no pressure setting for soot blowers, at what pressure should you set rotary soot blowers?

1. 150 psi
2. 200 psi
3. 300 psi
4. 350 psi

9-55. What method is used to provide constant drainage of soot blower piping?

1. Lock open the drain valve
2. Drill a hole in the drain valve seat
3. Install a scavenging air system
4. Remove the drain valve handwheel

9-56. What is used below soot blower heads to prevent moisture from seeping under soot blower piping lagging?

1. Lagging paste
2. Metal collars
3. Epoxy sealant
4. Rubber clamps

9-57. Soot blower elements from the generating bank can be interchanged with elements from the superheater.

1. True
2. False

9-58. What is the most likely cause of soot blower binding?

1. Warped element
2. Misaligned bearings
3. Tight packing gland
4. Bowed tubes

9-59. What is the purpose of the scavenging air system on soot blowers?

1. To cool the soot blower head
2. To promote drainage of soot blower piping
3. To seal the packing gland
4. To prevent combustion gas accumulation in the element

9-60. The BID is designed for what purpose?

1. To inspect for brickwork damage
2. To inspect for unburned fuel
3. To check for burner leakage
4. To observe flame patterns

9-61. What total number of operational BID(S) is required?

1. One per boiler
2. Two per ship
3. Three per ship
4. One per fireroom

9-62. What acts require federal and local governments to create and maintain environmental improvement?

1. The Federal Anti-Pollution Acts of 1966 and 1974
2. The Water Quality Act of 1923 and the amended Environmental Protection Act of 1964
3. The National Environmental Policy Act. of 1969 and the Environmental Quality Improvement Act of 1970
4. The oil Pollution and Water Management of Navigable Waters Acts of 1987

9-63. The U.S. Navy changed from standard fuels to distillate-type fuels for what reason?

1. They are cheaper to produce
2. They are international grades of fuel
3. They are produced with higher grades of petroleum, which generate higher heat coefficient ratios and increased economy
4. They contain low sulfur content and burn cleaner

9-64. As a supervisor, it is your responsibility to reduce environmental pollution by which of the following means?

1. Strictly enforce the proper use of all tools and safety devices
2. Train personnel on the causes and prevention of environmental hazards
3. Use only your most senior personnel for any potentially hazardous environmental operation
4. File all required reports and records before beginning operations that may cause pollution

9-65. Which of the following is NOT a common source of oil contamination?

1. Misalignment of the lube oil transfer system
2. Leakage or drainage from equipment and systems
3. Contaminated oil from purifiers
4. Used oil removed from equipment during an oil change

9-66. The shipboard CHT system was designed for which of the following goals?

1. To reduce shipboard sewage discharge
2. To prevent environmental hazards at sea
3. To hold sewage generated over a 12-hour period
4. To comply with guidelines identified in DOD directives

9-67. What is the primary design difference between comminutor-type and strainer-type CHT systems?

1. Capacity
2. The number installed needed to accommodate waste disposal
3. Design features
4. Efficiency

9-68. Vent pipes are installed on fuel oil tanks for what reason?

1. To provide early detection of fuel oil spills
2. To allow air to escape or enter while filling or emptying
3. To allow proper aeration and prevent stagnation
4. To control free surface effect within the tank

9-69. The fuel oil in a tank should NEVER be allowed to exceed what maximum temperature?

1. 125°F
2. 120°F
3. 100°F
4. 90°F

9-70. Before entering a fuel oil tank or void, you should take which of the following precautions?

1. Ensure the space is certified gas free by the gas-free engineer
2. Ensure the space is free of standing fuel oil
3. Establish communications
4. Observe the two-man rule

9-71. What is the effect, if any, of a hazy smoke condition in the stack?

1. It creates a dangerous stack condition and contributes to air pollution
2. It shows that the proper fuel and air ratio is present
3. It shows that contaminated fuel oil is being sent to the boiler
4. None

9-72. When ballasting the ship, you should use the recommended sequence tables for what purpose?

1. To coordinate ballast soundings of tanks and voids being filled
2. To provide a detailed list of tanks and voids full or empty
3. To be sure the ship will retain as much stability and maneuverability as possible
4. To list all recently filled or emptied tanks and voids

9-73. When the supplying ship cannot furnish an analysis of the fuel oil it delivers, you should take samples from the tank being filled by what means?

1. From gauge cutout valves
2. With a dipper from the tank or through sample connections on the tank piping
3. Collect oil that is leaking at fuel-oil connections
4. Stop pumping, break the connection, and collect the sample

9-74. After all fuel-oil tanks are full, you should clear delivery fuel-oil hoses by what means?

1. Allow the remaining fuel to gravity feed back to the tank
2. Disconnect hoses very carefully, drain them to a large drip pan, and then cap the hose
3. Have the supplying ship take a back suction or blow back the oil with compressed air
4. Align the fuel oil transfer system and transfer the remaining fuel to a waste tank

9-75. The ballasting system on board a ship is used for which of the following purposes?

1. To reduce instability in case of damage or small store of fuel oil
2. To flush out tanks and voids
3. To move liquids to calibrate inclinometers
4. To transfer fuel from one service tank to another