



RUAYIBL T USS CHICAGO  
RUHPYHO T USS CHOSIN  
RUHPYYF T USS CIMARRON  
RHBCRLC T USS CONOLLY  
RUHPNUL T USS CONSTELLATION  
RUHPCOR T USS CORONADO  
RHOCOW T USS COWPENS  
RHOCLKC T USS CROMMELIN  
RUWNBAG T USS CURTS  
RUHPYGC T USS CUSHING  
RHWIBCC T USS DAVID R RAY  
RHWISSD T USS DOLPHIN  
RUWNBAX T USS DULUTH  
RUWNAVN T USS ELLIOT  
RUHPESX T USS ESSEX  
RHOADKP T USS FIFE  
RHOCJCN T USS FLETCHER  
RHHIPAA T USS FLORIDA  
RHWICFL T USS FLORIDA OFFCREW  
RHOCPOF T USS FORD  
RUHPYDD T USS FREDERICK  
RUWGTCZ T USS GALLANT  
RUWNAXD T USS GARY  
RHOCSGP T USS GEORGE PHILIP  
RHWISSG T USS GEORGIA  
RHWICGA T USS GEORGIA OFFCREW  
RHOCACP T USS HARPERS FERRY  
RUWNAWT T USS HARRY W HILL  
RHHMDCB T USS HAWKBILL  
RUEGJAM T USS HELENA  
RHWISSJ T USS HENRY M JACKSON  
RHWICWA T USS HENRY M JACKSON OFFCREW  
RHOCDDW T USS HEWITT  
RHHMDCJ T USS HONOLULU  
RUWNAYJ T USS HOUSTON  
RHHMDCK T USS INDIANAPOLIS  
RHRCBKW T USS INGERSOLL  
RHWIBCD T USS INGRAHAM  
RUWNAXQ T USS JARRETT  
RUWNAWB T USS JOHN A MOORE  
RHRCJYG T USS JOHN YOUNG  
RHHIPSS T USS KAMEHAMEHA  
RHHMDCN T USS KEY WEST  
RHOAJPG T USS KINKAID  
RUHPZFF T USS KITTY HAWK  
RHPWCRR T USS LA JOLLA  
RHCFMCC T USS LA MOURE COUNTY  
RHOACPN T USS LAKE CHAMPLAIN  
RUHPYDP T USS LAKE ERIE  
RUHPYFD T USS LEFTWICH  
RUWNAVY T USS LEWIS B PULLER  
RHHMDCU T USS LOS ANGELES  
RHHMDDP T USS LOUISVILLE  
RHOCMDK T USS MCCLUSKY

RUWNAUY T USS MCKEE  
RUWNAVT T USS MERRILL  
RHHIPAA T USS MICHIGAN  
RHWICMI T USS MICHIGAN OFFCREW  
RUYNZZX T USS MOBILE BAY  
RHWIBAE T USS MOUNT HOOD  
RUCORGP T USS NEVADA  
RHWICNV T USS NEVADA OFF CREW  
RUHPMTZ T USS NIMITZ  
RUYNZZJ T USS OBRIEN  
RUWNAXA T USS OGDEN  
RHHIPAA T USS OHIO  
RHWICOH T USS OHIO OFFCREW  
RUWNAWV T USS OLDENDORF  
RHPWCRR T USS OLYMPIA  
RHWISSP T USS PARCHE  
RHWISNN T USS PASADENA  
RHOCMDX T USS PAUL F FOSTER  
RHWIBCP T USS PINTADO  
RHHIPSS T USS POGY  
RHWISNN T USS PORTSMOUTH  
RUWNAWF T USS PRINCETON  
RHOCSCR T USS REID  
RUWNAWD T USS RENTZ  
RHRCNRJ T USS REUBEN JAMES  
RUYNZZG T USS RODNEY M DAVIS  
RHOAMDF T USS SACRAMENTO  
RUHPYUD T USS SAFEGUARD  
RUWNAYQ T USS SALT LAKE CITY  
RUHPYNB T USS SALVOR  
RHHIPCC T USS SAN FRANCISCO  
RHOBLSH T USS SHILOH  
RHOCJHS T USS SIDES  
RUFRBEA T USS SIMON LAKE  
RUWNAZI T USS SQUALL  
RUYNZZI T USS THACH  
RHHMDDZ T USS TOPEKA  
RHWIBCB T USS TUNNY  
RUWNAVC T USS VALLEY FORGE  
RHOCAAV T USS VANDEGRIFT  
RHODVIN T USS VINCENNES  
RUWNBBS T USS WADSWORTH  
RHOCVTS T USS WILLAMETTE  
RHHIPSS T USS WILLIAM H BATES  
RUWNAXI T USS ZEPHYR  
RHWIBAT T USS RAINIER  
RHFJFYW T COMWESTHEMGRU  
RUHPNUL T COMDESRON SEVEN  
RUHPABE T COMDESRON TWO ONE  
RUHPPEL T COMPHIBRON ONE  
RUHPBXR T COMPHIBRON SEVEN  
RUHPTAR T COMPHIBRON THREE  
RUCOBRC T AFLOATRAGRU DET SSAAC NORFOLK VA  
RUCOBRR T AFLOATRAGRULANT PATG NORFOLK VA

RULYafa T COMCARGRU EIGHT  
RUCTPHL T COMDESRON SIX  
RUFNPGJ T COMNAVSURFGRU MED  
RUCCRAX T SPECBOATU TWO TWO  
RHNVIIB T SPECBOATU TWO ZERO  
R 242000Z FEB 98 ZYB PSN 063495M27  
FM NAVSURFWARCEN SHIPSYSENGSTA PHILADELPHIA PA//9325//  
TO RUCBTFA/COMNAVSURFLANT NORFOLK VA//N4/N434A16/N431A4//  
RUWDEAA/COMNAVSURFPAC SAN DIEGO CA//N4/42E/N43114/N4342//  
RUCBKMC/COMSUBLANT NORFOLK VA//N402/4022/403/40B1/74/11//  
RHHMDBA/COMSUBPAC PEARL HARBOR HI//N402/402S/4025/74/11/403//  
RUCOSSA/COMNAVAIRLANT NORFOLK VA//N43/N434//  
RUWFEEA/COMNAVAIRPAC SAN DIEGO CA//N43/N432//  
RUWHTXG/COMINELWARCOM CORPUS CHRISTI TX//N4/N8//  
RULSSBI/PEO CLA WASHINGTON DC//PMS325/PMS312/PMS307H2/PMS377F//  
RULSDMA/PEO SC WASHINGTON DC//PMS400F2/F4/F5//  
RULSSEA/COMNAVSEASYS COM WASHINGTON DC//03Z/03N/043//  
RUWDTBV/COMSPECBOATRON ONE//N9//  
RUCOZBE/COMSPECBOATRON TWO//N9//  
RUWFAFK/COMNAVSPCWARCOM CORONADO CA//N9//  
RCCPNOA/NDOC OTTAWA//DMSS3-4//  
AIG TWO ZERO SIX  
RUWDXBA/FLETRACEN SAN DIEGO CA//JJJ//  
RUWDXCW/SOUTHWEST RMC SAN DIEGO CA//N41/80D//  
RUCOQAM/FTSCLANT NORFOLK VA//4312//  
PAGE 02 RUEOMCB1540 UNCLAS  
RUWFPBC/NAVSURFWARCENDIV PORT HUENEME CA//5B31//  
RUWDHLU/FTSCPAC SAN DIEGO CA//300/302//  
RULSAMN/NAVSEALOGCEN MECHANICSBURG PA//432//  
RULSSRG/PEO MINELWAR WASHINGTON DC//DMSS303//

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RUWHITR/COMREGSUPPGRU INGLESIDE TX//N43B//  
RUCBFAG/EWTGLANT NORFOLK VA//JJJ//  
AIG ONE ONE THREE THREE ONE  
RULSADY/NAVSURFWARCEN CARDEROCKDIV BETHESDA MD//00//  
RULSABK/NAVSURFWARCEN DET ANNAPOLIS MD//1127//  
RUWHITD/SIMA NRMF INGLESIDE TX//00//  
RUWDXBE/NAVSTA SAN DIEGO CA//84//  
RUCOFAZ/PRESINSURV NORFOLK VA//JJJ//  
RUCOHAO/INSURVLANT NORFOLK VA//JJJ//  
RUWDXCG/INSURVPAC SAN DIEGO CA//JJJ//  
RUWDXDD/PACFLT PEB SAN DIEGO CA//JJJ//  
RUCBCLF/CINCLANTFLT NORFOLK VA//N434//  
RHHMHAH/CINCPACFLT PEARL HARBOR HI//43/431//  
RHFJFMR/NAVNUPWRTAU CHARLESTON SC//03//  
RUENAAA/CNO WASHINGTON DC//N3P/4/N86P//  
RULSJGA/COMDT COGARD WASHINGTON DC//JJJ//  
PAGE 03 RUEOMCB1540 UNCLAS  
RUCOQAM/FTSCLANT NORFOLK VA//4312//

RUCOFAR/CHET NORFOLK VA//OIC//  
RULSMSC/COMSC WASHINGTON DC//N7//  
RUCOGAR/COMSCLANT NORFOLK VA//N7//  
RUWDXFH/COMSCPAC OAKLAND CA//N7//  
RUCOCGH/COGARD ENGLOGCEN BALTIMORE MD//026//  
RUCOCGT/COMCOGARD MLC LANT NORFOLK VA//VR-1//  
RUWGTCG/COMCOGARD MLC PAC ALAMEDA CA//VR-2//

BT

UNCLAS //N09233//NAVSEA 03Z FOR 03Z3B AND 03Z33//

MSGID/GENADMIN/NSWCCD-SSES 9325//

SUBJ/ACN 1A TO NSTM CHAPTER 233, DIESEL ENGINES HB STM 010 CH 233 R1

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REF/A/DOC/NAVSEA 09233/-//

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AMPN/NAVAL SHIP TECHNICAL MANUAL, S9086-HB-STM-010-CH-233R1, CHAPTER  
233 DIESEL ENGINES//

POC/D. DONAT/CIV/PRIPHN:215-897-7279/-/DSN 443-7279//

RMKS/1. THIS IS ADVANCE CHANGE NOTICE (ACN) 1A TO REFERENCE A, ACN  
CONTROL NO IS N65540-98-DD01.

2. THIS ACN DELETES PARAGRAPH 233.8.67, 233.8.69 AND 233.8.70,  
AND REPLACES THEM WITH THE FOLLOWING NEW PARAGRAPHS 233.8.67,  
233.8.69 AND 233.8.70.

3. PARAGRAPH 233.8.67 QUALIFICATION. DIESEL ENGINES AND THEIR  
LUBE OIL SYSTEMS WHICH CANNOT BE SOAKED IN ACCORDANCE WITH PARAGRAPH  
233.8.65 SHALL BE INTENSIVELY CLEANED BY FLUSHING. NAVY ENGINES  
WHICH REQUIRE HOT OIL FLUSHING ARE PROVIDED IN PARAGRAPH 233.8.70.  
FLUSHING OF THESE ENGINES ARE REQUIRED AFTER:

A. COMPLETE OVERHAUL.

B. PARTIAL OVERHAUL. ENGINES REBUILT BY OEMS, COMMERCIAL  
ENGINE REPAIR FACILITIES AND NAVAL REPAIR FACILITIES SHALL BE FLUSHED  
BY THE OVERHAULING ACTIVITY PRIOR TO DELIVERY.

C. NEW OR STORED ENGINE WHERE THE INTERNAL LUBE OIL SYSTEM HAS  
BEEN PRESERVED WITH MIL-C-16173.

FLUSHING OF THESE ENGINES AND THEIR LUBE OIL SYSTEMS ARE REQUIRED  
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AFTER:

A. CASUALTIES, IN WHICH PARTICLES FROM FAILED COMPONENTS HAVE  
BEEN CIRCULATED IN THE LUBE OIL SYSTEM AND FOUND IN THE LUBE OIL  
FILTERS AND STRAINERS AND CONTAMINATION IS VISIBLE IN THE LUBE OIL.

B. FRESH (JACKET WATER) OR SALT WATER CONTAMINATION OF THE  
LUBE OIL SYSTEM. (SEE PARAGRAPH 233.8.101.)

4. PARAGRAPH 233.8.69 ENGINES, REQUIRING REPAIR THAT HAVE NOT  
SUSTAINED A CASUALTY BUT REQUIRE REMOVAL OF INTERNAL COMPONENTS,  
DO NOT HAVE TO BE FLUSHED PROVIDED THAT PRECAUTIONS ARE TAKEN TO  
PREVENT INTERNAL LUBE OIL WETTED SURFACES FROM BECOMMING COMTAMINATED  
WITH FOREIGN OR AIR BORN DEBRIS. A CERTIFIED DIESEL ENGINE INSPECTOR  
SHALL MAKE THE FINAL DETERMINATION OF THE FLUSHING REQUIREMENT PRIOR  
TO COMPLETION OF THE REPAIR.

5. PARAGRAPH 233.8.70 ENGINES THAT REQUIRE HOT OIL FLUSHING. THE  
FOLLOWING ENGINES AND THEIR LUBE OIL SYSTEMS QUALIFIED BY PARAGRAPH  
233.8.67 REQUIRE HOT OIL FLUSHING:

A. ALL MODELS OF FAIRBANKS MORSE.

B. ALL MODELS OF EMD AND GM.

C. ALL MODELS OF COLT-PIELSTICK.

D. CATERPILLAR MODELS 3500 AND 3600 SERIES.

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E. RUSTON PAXMAN.

F. DDA (C) STEWART STEVENSON MODEL 149.

G. ALL MODELS OF ALCO.

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07 07I 09M PMS312 PMS335 03G 03G2 03K 07I 072

91K31 PMS325D PMS325G PMS340 PMS373 PMS378 PMS411

PMS325 ....ACT FOR PEO CLA

PMS312 PMS335 PMS377 PMS325D PMS325G PMS340 PMS373 PMS378

DEFAULT ....ACT FOR PEO MINE

F21 ....ACT FOR PEO SC

F4 F5 429B1 429F8 429G 429G1 429G2 429G4 500S 500TO

B3A B3B B3B1 B3B2 B3B3 B3B4 B3C1 B3D B3D1 B3D3

B3E B3E3 B3E4 B3L2 B3T2 B3T3 B42 B41 B44 B46

B4N B6VITRO B6A B63C BF D31 D32 D41 D44 D52

DCVITRO DE E1 F23 F31 F31VITRO F313 F3A1 F4B1 F4B2

F4B3 F4B4 F4BC F4C1 F4C2 F4C3 F5X F51G F51S F52M

F5BA F51H F51SESS F52 P22 F51C MDSOPR

# NAVAL SHIP'S TECHNICAL MANUAL

## CHAPTER 233

### DIESEL ENGINES



**THIS CHAPTER SUPERSEDES CHAPTER 233 DATED 1 DECEMBER 1979**

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# CHAPTER 233. DIESEL ENGINES

## SECTION 1. INTRODUCTION

### 233.1.1 FAMILIARITY WITH DETAILS

**233.1.2** Modern diesel engines cover a wide variety of makes, models and power ratings. It is essential that the applicable NAVSEA Technical Manual, Planned Maintenance System (PMS), Technical Repair Standards (TRS's), Engineering Operating Sequencing System (EOSS), Navy Maintenance Policies and courses of instruction at Naval or manufactures training schools shall be strictly adhered to during preventive maintenance and repairs. Technical documentation and training course instructions shall be followed to maintain the highest degree of Fleet readiness. All personnel involved in the operation, maintenance, minor and major repairs should be thoroughly familiar with details of the engine(s) under their care. This is the only method of ensuring reliable diesel engines in the Navy.

### 233.1.3 INSTRUCTIONS AND MANUALS TO BE CONSULTED

**233.1.4** Diesel engines used by the Navy vary to such an extent that detailed maintenance, repair and operating instructions cannot be covered in this chapter; only general principles are given. The applicable NAVSEA Technical Manual is supplied for each engine providing comprehensive information for that particular make, model and application. Personnel involved in maintenance and operation shall be familiar with the following instructions and training manuals.

- a. NAVEDTRA 10085 **Tools and Their Uses.**
- b. NAVEDTRA 12001 **Fireman**
- c. NAVEDTRA 10541 **Engineman 3 and 2**
- d. NAVEDTRA 10543 **Engineman 1 and C**
- e. NAVEDTRA 10625 **Diesel Engines**
- f. NAVEDTRA 12204 **Machinery, Repairman 3 and 2**
- g. NAVEDTRA 10531 **Machinery, Repairman 1 and C**
- h. NAVEDTRA 10883 **Fundamentals of Petroleum**
- i. NAVEDTRA 10992 **Engineering Administration**

- j. NAVEDTRA 10507 **Principles of Naval Engineering**
- k. OPNAVINST 9233.1 **U.S. Navy Diesel Engine Inspection and Inspector Training and Certification Program.**
- l. OPNAVINST 9233.2 **U.S. Navy Diesel Engine Trend Analysis Program.**
- m. NAVSEA Handbook S9233–C3–HBK–010/010 Revision 1, **Engine, Diesel, Trend Analysis Handbook.**
- n. NAVSEA Handbook S9233–CJ–HBK–010 **U.S. Navy Diesel Engine Inspector Handbook, Part 1, Inspection Procedures.**
- o. NAVSEA Handbook S9233–CJ–HBK–020 **U.S. Navy Diesel Engine Inspector Handbook Part 2, Technical Information.**
- p. NAVSEA Handbook S9233–C3–HBK–010 **Automated Diesel Engine Trend Analysis (ADETA) User Guide.**
- q. **Allowance Parts List (APL)**
- r. OPNAVINST 5100 Series **Navy Safety Precautions for Forces Afloat.**
- s. MIL–HDBK–267, **Guide for Selection of Lubricants and Hydraulic Fluids for Use in Shipboard Equipment.**
- t. OPNAVINST 5090.1 **Environmental and Natural Resources Protection Manual.**

**233.1.5** Other NSTM chapters cover related equipment and subjects, such as bearings, shafts, pumps, fire fighting, and lubrication. Consult specific chapters for the related equipment.

### 233.1.6 SAFETY PRECAUTIONS

**233.1.7** All personnel involved in diesel engine operation, maintenance and repair shall be familiar with the requirements in Section 13, the **Navy Safety Precautions for Forces Afloat** OPNAVINST 5100 series, and cautions and warnings stated in the PMS and Maintenance Requirement Cards (MRC's). These safety procedures, warnings, and cautions are mandatory for all involved personnel and may be used to augment formal safety regulations.





## SECTION 2. APPLICATION OF INSTRUCTIONS

### 233.2.1 GENERAL INFORMATION

**233.2.2** Because of the wide variations in the modern diesel engine makes, models, power ratings, applications, installations and the difference in the diesel support systems, these instructions are general in nature. These instructions apply to all ship classes with diesel engines and applications from main propulsion, electrical generation, small craft and boats.

**233.2.3** Detailed procedures for operation, maintenance, minor and major repairs are given in the applicable NAVSEA Technical Manual, Planned Maintenance System (PMS), Technical Repair Standard (TRS's) and Engineering Operating Sequencing System (EOSS).

**233.2.4** Detailed preventive maintenance actions for each diesel engine on active ships are addressed in the PMS of the Maintenance, Material, and Management System (3-M). The primary objective of the Ships 3-M System is to provide for managing maintenance and maintenance support in a manner which will ensure maximum diesel engine operational readiness. When implemented and properly used the 3-M System provides for the orderly scheduling of a preventive maintenance plan along with the required reporting and dissemination of significant maintenance related information.

**233.2.5** The (3-M) System specifies the planning, scheduling, and management of resources (men, material, and time) for those actions which contribute to

the uninterrupted functioning of equipment within its design characteristics. It defines uniform maintenance standards, based on engineering experience, and prescribes simplified procedures and management techniques for the accomplishment of maintenance. Through the (3-M) System, each ship, each department, and each supervisor is provided with the tools to plan, schedule and control shipboard planned maintenance effectively. The (3-M) System is expressly designed to:

- a. Reduce complex maintenance to simplified procedures easily identified and managed.
- b. Define the minimum planned maintenance required, schedule and control its performance, describe the methods and tools to be used, and provide for detection and prevention of impending casualties.
- c. Forecast and plan manpower and material requirements.
- d. Plan and schedule maintenance tasks.
- e. Estimate and evaluate material readiness.
- f. Detect areas requiring additional or improved personnel training or improved maintenance techniques or actions.

**233.2.6** Specifics of the 3-M System are contained in the **Ship's Maintenance and Material Management (3-M) Manual**, OPNAVINST 4790.4. When conflict and or discrepancies exist between PMS and the applicable NAVSEA Technical Manual, the PMS System prevails.



## SECTION 3. OPERATION

### 233.3.1 GENERAL

**233.3.2** It is important that careful preparation be made before a diesel engine is started after it has been overhauled, after major repairs or after long idle periods (30 day or more). Procedures to be followed are described in paragraphs 233.3.3 through 233.3.6.

### 233.3.3 PREPARATION FOR STARTING DIESEL ENGINES AFTER MAJOR REPAIRS, OVERHAUL OR LONG IDLE PERIODS

**233.3.4** Check all pipe connections for tightness and ensure that all of the diesel engine support systems are correctly installed and free of contamination. When any part of the engine or associated support systems are opened for preventive or corrective maintenance, caution shall be taken not to allow any contamination enter into the diesel engine or support systems. If major repair work was accomplished to the engine or casualties in which particles from the failed components have been circulated in the lube oil system, external and internal hot lube oil flushing shall be accomplished. The exception to this is small high speed diesel engines (i.e., Waukesha, Isotta Fraschini, some models of Caterpillar engines and, Detroit Diesel 53, 71 and 92 series.)

#### NOTE

The best procedure is to plan and conduct the work in such a way that contaminants will not enter the system.

**233.3.5** Lube oil flushing guidance for use after long idle periods (storage), major and minor repairs, overhaul, and dirty lube oil systems is given in Section 8. Detailed flushing and cleaning procedures for the closed jacket water cooling systems are given in Section 10.

**233.3.6** General procedural steps to be taken to prepare the engine for starting after major repairs, overhaul or long idle periods are:

1. Examine all piping systems, fittings, packing glands, pumps and joints for leaks in the jacket water system, lube oil system, fuel oil system and the air starting system.

2. Jacket water cooling system shall be filled and chemically treated in accordance with Planned Maintenance System (PMS) and Section 10.

3. Verify the flow of jacket water through all cooling spaces and thoroughly vent the jacket cooling water system with vent valves if provided.

4. Fill the lube oil sump to the proper level.

5. A lube oil sample shall be taken prior to starting the diesel engine following overhaul, major repairs, long idle periods and lube oil flushing. Lube oil samples shall be taken in accordance with Table 233–3–1 or Table 233–3–2 and PMS during engine run in and or break in of an overhauled engine, major repairs or replacing any power producing components (i.e., cylinder liner(s), rings, piston(s), bearing(s), main and connecting rods, piston pin(s), piston pin bushing(s) and crankshaft.

6. Oil and or grease all external working surfaces (i.e., fuel pump, fuel control linkage, governor control links, rods and etc.).

7. The diesel engine lube oil system shall be primed before starting and before the engine is turned over (by hand or by a motor driven jacking gear) prior to starting. Priming of the engine should continue only until a slight pressure is registered on the engine lube oil pressure gage or until oil is observed at each main bearing.

#### NOTE

Engines without a prelube system, the turbocharger, blower and so forth, shall be prelubed by hand before starting.

Table 233-3-1. MAIN PROPULSION RUN IN SCHEDULE

STEP	% RATED SPEED	% RATED LOAD	DURATION (MINUTES)	CHECKS
1	IDLE	0	1	B,C
2	IDLE	0	5	B
3	IDLE	0	10	B
4	20% ABOVE IDLE	0	10	B
5	30% ABOVE IDLE	0	10	B
6	40% ABOVE IDLE	0	15	B
7	50% ABOVE IDLE	0	15	B
8	75% ABOVE IDLE	0	15	B
9	85% ABOVE IDLE	0	15	B
10	FULL RATED SPEED	0	15	A,B,C
11	AS REQUIRED	25%	30	A, C
12	AS REQUIRED	37.5%	60	A, C
13	AS REQUIRED	50%	60	A, C
14	AS REQUIRED	62.5%	120	A, C
15	AS REQUIRED	75%	120	A, C
16	AS REQUIRED	87.5%	120	A, C
17	100%	100%	240	A, C
18	TREND ANALYSIS AS REQUIRED BY PMS TO ESTABLISH BASE LINE DATA FOR ADETA AND OR DETA PROGRAM			
A = CHECK PISTONS, RINGS AND CYLINDERS B = CHECK BEARINGS FOR OVERHEATING C = SAMPLE LUBE OIL  NOTE: ENGINE LOAD MAY VARY ± 5 %				

**CAUTION**

On opposed piston engines, the priming pump shall not be run for any greater time than is actually required to produce lube oil flow at the last main bearing on the upper crankshaft. Excessive lube oil priming may result in lubricating oil filling the upper pistons, allowing a certain amount of lube oil to reach the air receiver and also enter the combustion space which may cause hydraulic lock. Extreme caution shall be exercised to avoid this condition. Before the engine is started after a prolonged shutdown (30 day or more), the air receiver and blower discharge passages shall be inspected and accumulated lube oil removed.

**CAUTION**

Care should be taken to ensure that generator bearings, turbochargers, blowers and generators are not flooded by excessive priming.

**CAUTION**

During visual inspection, if it is found that lubricating oil is not reaching all parts of the system, the cause shall be located and corrected before proceeding with the starting of the engine.

**WARNING**

During visual inspection, if it is found that lubricating oil is not reaching all parts of the system, the cause shall be located and corrected before proceeding with the starting of the engine.

8. Inspection and hand hole covers should be removed and a visual check be made to ensure that lubricating oil is reaching all points of the system that are visible, main and connecting rod bearings, camshaft bearings, blowers, turbochargers, rocker arms, pistons and piston pins.

9. Ensure hydraulic governors are filled to the proper level and with the correct fluid. Set governor speed at idle or minimum speed.

10. Ensure all timing events and clearances are correct (i.e., pumps, air starting cam, camshafts, intake/exhaust valves, fuel injection nozzles, injectors etc.)

11. Clean all fuel and lube oil strainers, replace all filters in the lube oil and fuel oil system.

12. Ensure fuel oil service tank is filled and free of water and sediment.

**WARNING**

Do not bypass installed engine starting systems. Never use unauthorized starting equipment.

13. Inspect air starting system for integrity and clearances and take appropriate actions to correct any deficiencies found.

14. If the engine is equipped with an electric starter, inspect the battery and starter terminals. Inspect all the battery cable connections and battery electrolyte specific gravity. Correct any deficiencies found.

15. Bar engine 1-1/2 revolutions by hand before starting to check for binding.

**233.3.7 STARTING PROCEDURES**

**233.3.8** All engines on board Navy ships are started in accordance with local prepared starting procedures, Engineering Operating Procedures (EOP) or Engineering Operating Sequencing System (EOSS) and the applicable NAVSEA Technical Manual.

**CAUTION**

The low lube oil pressure and freshwater high temperature alarms circuit shall be operable immediately after starting the engine.

**233.3.9 RUNNING IN NEW AND OVERHAULED ENGINES**

**233.3.10** When the wearing parts of an engine have been renewed during an overhaul, or as the result of a casualty, the wearing surfaces of the engine parts shall be allowed to run in, or properly match with their mating surfaces, before full speed and load are applied to the engine. Engine parts are made to certain dimensions and are designed to be operated under specific conditions. Improper installation of a small part can put an engine out of commission just as surely as if a larger part were involved.

**233.3.11** When gears or bearings of gear trains are renewed, proper installation and adjustments are critical. If proper alignment, clearances, and lubrication are attained at installation and maintained during the initial engine operation, the new parts will run in without any rework.

**233.3.12** Proper installation and adjustment are critical for main and connecting rod bearings. If rod and main bearings are clean, properly installed, and are provided with proper lubrication, their surfaces can be run in relatively fast. An engine load is not required for run in of bearings. The first few minutes of engine operation will usually determine the success or failure of main or connecting rod bearings. Run in of piston rings and cylinder liners requires a gradual increase to 100% load. Properly seating of piston rings requires high cylinder pressures.

**Table 233-3-2. SHIP'S SERVICE AND EMERGENCY GENERATOR RUN IN SCHEDULE**

STEP	% RATED SPEED	% RATED LOAD	DURATION (MINUTES)	CHECKS
1	IDLE	0	1	B, C
2	IDLE	0	5	B
3	IDLE	0	10	B
4	20% ABOVE IDLE	0	10	B
5	30% ABOVE IDLE	0	10	B
6	40% ABOVE IDLE	0	15	B
7	50% ABOVE IDLE	0	15	B
8	75% ABOVE IDLE	0	15	B
9	100%	0	15	A, B, C
10	100%	25%	15	A, C
11	100%	37.5%	30	A, C
12	100%	50%	60	A, C
13	100%	62.5%	60	A, C
14	100%	75%	120	A, C
15	100%	87.5%	120	A, C
16	100%	100%	240	A, B, C
17	TREND ANALYSIS AS REQUIRED BY PMS TO ESTABLISH BASE LINE DATA FOR ADETA AND OR DETA PROGRAM			
A = CHECK PISTONS, RINGS AND CYLINDERS B = CHECK BEARINGS FOR OVERHEATING C = SAMPLE LUBE OIL				
NOTE: ENGINE LOADS MAY VARY ± 5 %				

**Table 233-3-3. PRESSURE CONVERSION TABLE**

PRESSURE CONVERSION DATA	
1 INCH WATER	.0735 INCHES MERCURY
1 INCH WATER	.0361 LBS PER SQ IN
1 INCH WATER	.578 OZ PER SQ IN
1 INCH MERCURY	.491 LBS PER SQ IN
1 INCH MERCURY	13.6 INCHES WATER
1 LB PER SQ IN	27.7 INCHES WATER
1 OZ PER SQ IN	1.73 INCHES WATER
1 LB PER SQ IN	2.036 INCHES MERCURY

**CAUTION**

If full load is applied too quickly to an engine having new rings or liners installed, there is a risk of galling pistons, scoring liners, or even piston seizure. On the other hand, if the engine is operated for long periods during the run in at little or no load, cylinder surfaces will glaze and the wear in action of the rings will cease before a tight seal is established.

**233.3.13** If engine is not properly run in, later application of heavy loads will result in excessive blowby, which will cause the rings to stick and clog the ring lands with carbon. The rings will never seal properly, crankcase pressure and lube oil consumption will be high and compression pressure crankcase vacuum will be low.

**233.3.14** Most engine manufacturers furnish a recommended run in schedule for their engines as used in specific applications. These schedules vary with the manufacturer, engine model, engine application and even variations of the same model when significant changes have been made in material or design.

**233.3.15** When a newly overhauled engine is run in, the manufacturer's schedule should be followed if available. If the manufacturer's schedule is not available or detailed enough, Table 233-3-1 or Table 233-3-2 and paragraphs 233.3.16 through 233.3.30 shall be used.

**233.3.16 GENERAL RUN IN PROCEDURE**

**233.3.17** A diesel engine run in schedule has two distinct phases.

a. The first phase is running in at no load, which is primarily for the purpose of mating of new main and connecting rod bearings with their journals and connecting rod bushings with their pins. No appreciable seating of piston rings will occur during this phase.

b. The second phase is running in under progressively higher loads, which gives the higher cylinder pressures and temperatures necessary for successful seating of new piston rings. Some wearing in of new main and connecting rod bearings and bushings is incidentally accomplished while running in under load, but the danger of failure of these parts decreases when the first phase is finished.

**233.3.18 METHOD OF CHECKING BEARINGS AND BUSHINGS****WARNING**

When the crankcase is opened for inspection or repairs, the starting system shall be de-energized and or deactivated and tagged out of service in accordance with current shipboard and or shore tag out instructions.

**NOTE**

Fairbanks Morse diesel engines cylinder liners are usually not honed during engine overhaul.

**233.3.19** The lubricating oil temperature shall be maintained at 48.9° C (120° F) or below during bearing checks. The running in of bearings and bushings can be checked in larger engine installations by feeling for abnormal heat. If a bearing is not properly fitted or is not getting enough lubricating oil for some reason, it will immediately heat up. The same holds true for the connecting rod bushings. After the engine is secured, overheating caused by improper wearing in of the piston pin and bushing can be felt by reaching along the connecting rod and into the piston. The checks which should be made at the end of each no load run on engines with crankcase inspections covers are:

1. Feel the edge of each connecting rod bearing and each connecting rod cap.
2. Feel the sides of each main bearing cap and saddle of each main bearing.
3. Reach along each connecting rod and feel the rod eye and bushings.

**233.3.20** As the engine continues to operate, all parts will grow warmer. The temperatures of adjacent similar parts of the engine, can be felt and compared to determine if any parts are overheating. An explosion proof light should be used in the



crankcase to provide for a good visual inspection of all areas.

**233.3.21** In the case of aluminum bearings which are overheating, serious damage to the bearing can be determined by a close inspection of the sides of the bearing shell, which are visible with the bearing installed. If the bearing has failed, beads or blisters will be visible on the sides of the bearing. If this condition is found, the bearing shall be removed and renewed, observing the crankshaft cleaning precautions normally exercised during this procedure. Consult the applicable NAVSEA Technical Manual.

**233.3.22** When an engine is checked following any run and a part is found to be overheating, the engine shall again be operated at the same speed and load previously used, with periodic inspection stops, until the temperature of the hot parts cools to approximately that of similar parts. If the affected parts fails to cool before the particular run has been repeated, the parts shall be removed and inspected to determine cause for overheating, and replaced or repaired in accordance with established procedures and the last run in shall be repeated.

**233.3.23** A slight temperature variance of similar parts are to be expected during a run in and a run should not be repeated merely because some parts are slightly hotter than others. As a part wears in, its temperature will approach that of other similar parts.

**233.3.24** Insufficient lubrication to any bearing or bushing, improper installation of bearings or bushings, or defective bearings or bushings normally will be indicated by a noticeable overheating of the affected part by the end of the 15 minute run at 40% speed, no load. A major deficiency such as a complete lack of lubrication to any part usually will be detected by a noticeable overheating of the part after the initial 1 minute run at no load.

### **233.3.25 METHOD OF CHECKING PISTON RINGS**

**233.3.26** Two methods are used to check the seating of piston rings, visual inspection and operational parameters. Both methods should be used for checking the progress of seating of piston rings where possible.

**233.3.27** In most two cycle engines, the seating of rings can be observed by visual inspection. The seating

surface of a ring which has not seated will have a dull appearance and may have areas of black carbon where blowby is occurring. When seated properly rings will have a shiny surface. Grooved face rings will have a shiny surface, except for dark circumferential lines indicating the small machined grooves.

**233.3.28** In four cycle engines, visual inspection of ring condition is not practical. Crankcase pressures, engine exhaust color, compression pressures, firing pressures and lube oil consumption shall be observed to determine progress of piston ring seating. These conditions should also be observed in the case of two cycle engines and coordinated with the results of visual inspection of the rings.

**233.3.29** As an example, if the crankcase vacuum of an engine is normally 1/2 to 1 inch of water vacuum, the vacuum immediately after an overhaul would probably be 0 or slightly on the pressure side. As the run in (under load) continues, the pressure should diminish and gradually the normal vacuum for the engine will be obtained. The engine exhaust will gradually clear and the crankcase vacuum will return to normal as the run in process is completed.

### **NOTE**

Some makes and models of diesel engines are designed to run with a crankcase pressure instead of a vacuum. Consult the applicable NAVSEA Technical Manual.

**233.3.30** Trend Analysis shall be conducted in accordance with PMS after the run in period is totally completed. A complete trend analysis is made to see if compression pressures, firing pressures and other operating parameters are within design specifications, the engine load is balanced correctly and to initiate a baseline for trend analysis.

**233.3.31** Lube oil consumption is higher than normal during the run in period. Lube oil consumption on board ship is very difficult to accurately measure, as a result lube oil consumption is estimated.



**233.3.32 PRECAUTIONS AND UNUSUAL CIRCUMSTANCES****WARNING**

When the crankcase is opened for inspection or repairs, the starting system shall be de-energized and or deactivated and tagged out of service in accordance with current shipboard and shore instructions.

**233.3.33 HELPFUL POINTS DURING RUN IN**

- a. Chrome plated rings or liners require higher cylinder pressures for successful ring seating.
- b. Engines shall be run in using MIL-L-9000, Grade MS, 9250 only. (So called break in oils shall not be used.)
- c. Introduction of abrasive elements through the air intake is not authorized.
- d. Where new rings are to be installed in old liners that are glazed, the glaze shall be broken by honing, with the exception of chrome plated liners, before installing new rings, or the rings may not seat.

**NOTE**

Fairbanks Morse diesel engines cylinder liners are usually not honed during engine overhaul.

- e. Lube oil temperatures shall be maintained at or near 48.9° C (120° F) during the no load run in to facilitate feeling of parts for heat.
- f. Lube oil and jacket water temperatures shall be maintained at their normal operating values during the run in under load.
- g. If any monitored operating temperatures go above normal during a specific step of the run in, other conditions being normal, the speed or load shall not be

increased until temperatures have returned to normal. In extreme cases, the speed or load may have to be dropped to the previous step and the run repeated before the engine can satisfactorily accept the increased speed or load required by the next step of run in.

**233.3.34** Table 233-3-1 and Table 233-3-2 provide run in schedules for main propulsion and generator sets.

**233.3.35** If unusual noises, conditions and alarms are encountered, shut engine down immediately. Throttle station shall be manned at all times for this specific purpose.

**233.3.36** After completion of steps 1 through 9 in Table 233-3-1 or Table 233-3-2, temperature should be allowed to reach normal operating values. Feel the parts in Steps 1 through 9 in Table 233-3-1 and Table 233-3-2 to determine the temperature of the parts. Do not attempt to feel parts after steps 9 through 16 in the tables; the parts will be too hot to touch. Parts should be inspected visually with an explosion proof light. Look for missing cotter pins, loose nuts, blistered aluminum bearings, purple or blue parts (previously shiny), metal particles, or anything unusual.

**233.3.37** Diesel engine log readings shall be recorded every 15 minutes during run.

**233.3.38** If a problem is encountered during any one of the steps of Table 233-3-1 or Table 233-3-2, the previous step shall be repeated until the engine can accept the next higher load and speed.

**233.3.39** Filters, strainers and temporary muslin bags, if installed, shall be cleaned or renewed after the run in.

**233.3.40** All overhaul, and break in and overhaul logs shall become a part of the repair package for future reference.

**233.3.41 CRANKCASE PRESSURE OR VACUUM****NOTE**

Some makes and models of diesel engines are designed to run with a crankcase pressure instead of a vacuum. Consult the applicable NAVSEA Technical Manual.

**233.3.42** An engine operating with a crankcase vacuum has effectively created a situation whereby the greater pressure is external to the engine and this pressure aides in holding back oil that would leak if the pressure was equal on both sides of the cover. This vacuum is maintained by various means depending on engine manufacturer. Some engine models obtain a vacuum by a motor driven centrifugal air pump and others obtain a vacuum by an air eductor arrangement from the blower or turbocharger.

**233.3.43** A crankcase vacuum system aids in reducing lube oil contamination caused by the blowby from the combustion chamber past the piston and rings into the crankcase. Since the blowby consists of products of combustion, partially burned fuel and air and some liquid or gaseous fuel, these contaminates are deposited in the oil. The vacuum system tends to remove some of the contaminates while they are airborne in the crankcase, thus aiding in the reduction of lube oil contamination.

#### NOTE

Water is used in manometers. Do not use mercury.

**233.3.44** If crankcase vacuum decreases (an increase in crankcase pressure) the engine operator should investigate the problem by first ensuring the engine crankcase vacuum U-tube manometer is working properly. The manometer should be mounted on the engine or adjacent to the engine with as short a run of tubing to the crankcase as is practical. The tubing should be examined to ensure it is not crimped or punctured which would give false crankcase readings. The manometer should be mounted higher than its crankcase connection and the tubing should be run as straight as is practical with a continuous up slope from the crankcase to the manometer. The tubing should not contain any loops, kinks or sharp bends which would trap lube oil and prevent the manometer from operating.

**233.3.45** All precautions shall be taken for the engine so that the installed system can pull a vacuum in the

crankcase. A crankcase vacuum will never be realized if air is allowed to enter the crankcase.

**233.3.46** The vacuum system should be examined to ensure it is working properly. If the system is equipped with any filters or baffles, they should be cleaned and installed correctly. Lube oil sump level should be checked to ensure it is not higher than required. If an engine is equipped with a vacuum breaker/limiter ensure it works properly before and during engine operation.

**233.3.47** If an engine has an orifice installed in the vacuum system to maintain a specified vacuum at rated load and speed, the orifice hole should be cleaned and free of any debris. Special attention shall be given to the gaskets on both sides of the orifice plate to ensure they do not obstruct the orifice opening.

**233.3.48** The orifice shall not be adjusted to increase vacuum since doing so would cover up the actual problem and indications would be that the engine and vacuum systems are working properly, when in fact a problem actually exists. When an engine has been overhauled and after the run in is completed, the orifice size should be adjusted to achieve the maximum crankcase vacuum listed in the applicable NAVSEA Technical Manual and PMS for full load and speed.

#### 233.3.49 READING THE MANOMETER

**233.3.50** The total reading is obtained by adding the readings from both tubes. For instance, if one reading is 2 inches above zero, the other 2.2 inches below zero, the reading would be 4.2 inches. The readings in both legs may be different either due to incorrect zero adjustment or due to a slight difference in the bore of the glass tube. By adding the two readings, both sources of error are eliminated. Pressure is indicated if the side that is vented to the atmosphere is higher; vacuum if it is lower than the side that is connected to the engine crankcase.

#### 233.3.51 MANOMETER CONVERSION DATA

**233.3.52** Manometer pressure conversion table see Table 233-3-3.

#### NOTE

Do not use mercury in manometers.

## SECTION 4. OPERATION AND OPERATING LIMITATIONS

### 233.4.1 RATINGS

**233.4.2** The rated power of an engine is normally the nameplate rating and is the horsepower or kilowatt output safely obtained from an engine in good operating condition at rated speed and under specified ambient conditions. For most main propulsion installations the rated horsepower of the engine corresponds to the engine horsepower at the full power trial condition

### 233.4.3 OPERATION OF DIESEL ENGINES

**233.4.4** The service life and maintenance requirements of any diesel engine are greatly influenced by the speeds and load factors imposed by the user during its operation. In some cases, the particular requirements of the installation or the mission require that the installed diesel(s) be operated much of the time at speeds and loads either higher or lower than would be desirable from the standpoint of best economy, least maintenance, and longest life.

**233.4.5** For most installations and circumstances, the user has considerable choice of the speed and load factors which can be used to accomplish the mission. When economy, maintenance requirements, and engine life are important factors, it is recommended that the user consider:

- a. An engine operated at full rated (nameplate) power output will require more maintenance and more frequent overhauls than the engine would require if the load were reduced to about 80 percent of full load and the speed reduced to about 90 percent of full rated speed. If the application does not permit a speed reduction (as in an alternating current generator), a reduction in load will still be advantageous to reduce maintenance requirements.
- b. It is not desirable to load a diesel engine to full torque output for extended periods at less than about 2/3 of full rated speed.
- c. Do not idle diesel engines unnecessarily for long periods of time. Extended operation at any speed at less than 60 percent of full load torque (or BMEP) will develop problems with carbon formation, lube oil dilution, oil carry over to the exhaust system, and other

problems relating to incomplete combustion. Operation at full rated speed and no load, or very little load, will develop these problems to the maximum degree.

d. Figure 233-4-1 illustrates some of the recommended operating limits and illustrates the area of speed load combinations which are preferred for most installations to produce the least engine maintenance and the most effective engine utilization.

### 233.4.6 DETERMINING ENGINE TORQUE AND HORSEPOWER

**233.4.7** Compliance with the recommendations of paragraph 233.4.5 requires that the operator have some reasonably accurate measure of the power being developed by the engines under various operating conditions. In most cases the operator has, or can develop, this information by using equipment and information at hand.

**233.4.8** If the engine drives an electric generator, the engine output can be accurately measured through use of the meters indicating kilowatt output of the generator, modified to reflect the efficiency of the machine.

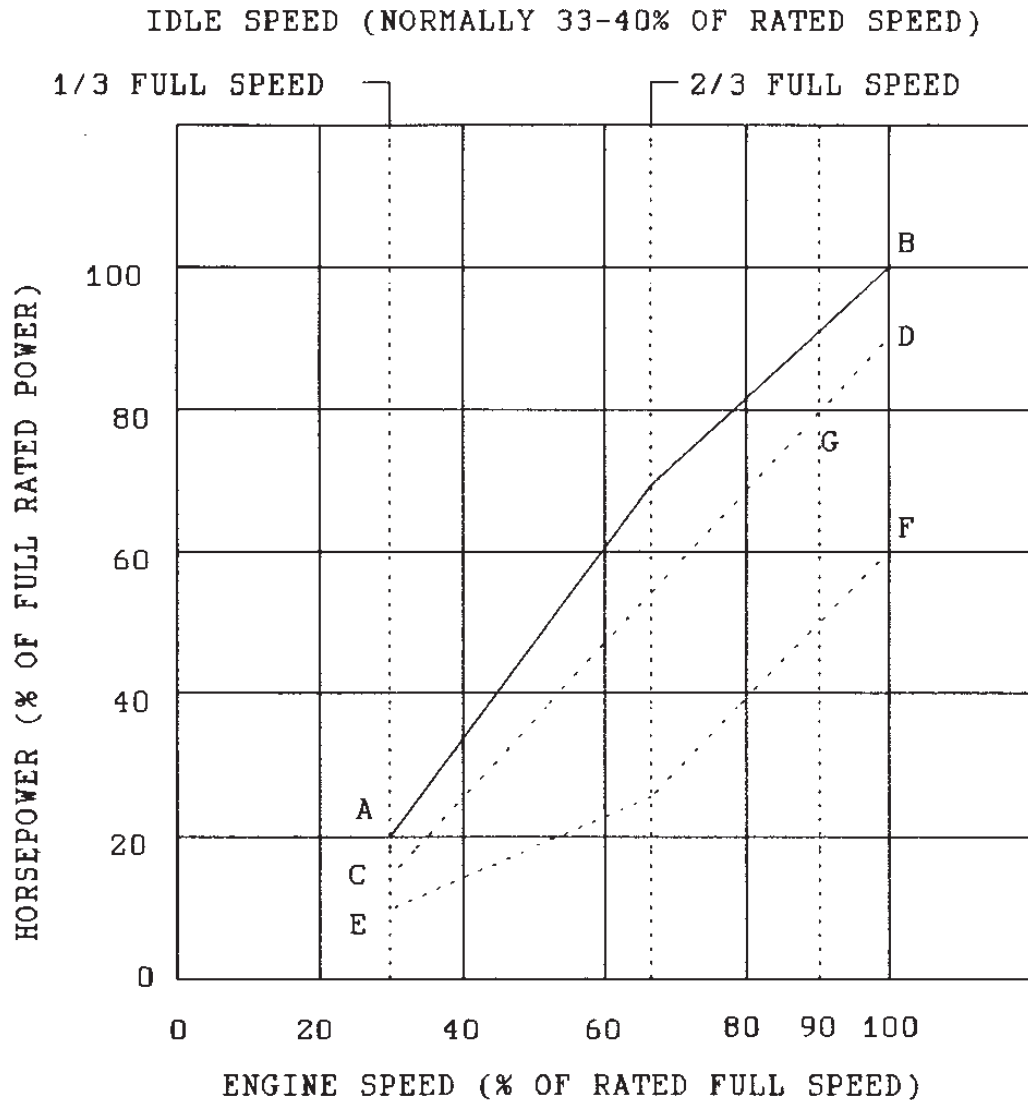
**233.4.9** If the engine drives a propeller connected through a reduction gear, the power output of the engine is obtained from curves of propeller speed versus power requirements or measured directly with torque meters and tachometers. Condition of the hull shall be a factor when determining engine power output.

### 233.4.10 EXHAUST BACK PRESSURE

**233.4.11** The results of high exhaust back pressure are detrimental and include:

- a. Higher exhaust temperatures
- b. Less air supplied for combustion
- c. Dirty exhaust
- d. Less available power

**233.4.12** The exhaust system shall be kept free of unnecessary restrictions to keep the exhaust back pressure below design limits. Precautions should be taken to prevent accumulation of excessive carbon, oil, and water in the mufflers.



- A. FULL POWER OPERATION SHOULD NOT EXCEED THE LIMITS OF CURVE A-B
- B. WHERE ENGINE WEAR AND MAINTENANCE COSTS ARE IMPORTANT CONSIDERATIONS, LIMIT ENGINE LOAD AND SPEED COMBINATIONS WITHIN AREA BOUNDED BY C-G-D AND E-F.
- C. WHERE FEASIBLE, LIMIT ENGINE SPEED TO 90 PERCENT OF FULL SPEED AND AS CLOSE AS POSSIBLE TO LINE C-G FOR OPTIMUM OPERATION. OPERATION AS MAY BE NECESSARY OUTSIDE ABOVE OPTIMUM AREA, BUT WITHIN UPPER LIMIT CURVE A-B PROVIDES SAFE OPERATION ALTHOUGH ENGINE MAINTENANCE REQUIREMENTS WILL BE INCREASED.
- D. ALTERNATING CURRENT DIESEL GENERATOR SETS SHOULD NOT BE OPERATED BELOW 60 PERCENT LOAD FOR EXTENDED PERIODS OF TIME.
- E. IF MAIN PROPULSION AND GENERATOR ENGINES ARE OPERATED BELOW CURVES E TO F PROBLEMS WITH OIL CARRYOVER, INCOMPLETE COMBUSTION AND CARBON DEPOSITS WILL INCREASE.

**Figure 233-4-1. Diesel Engine Operating Curve Main Propulsion and Generators**

**233.4.13 FIRING PRESSURES**

**233.4.14** The firing pressure in any cylinder should never be allowed to exceed the limit given by Planned Maintenance System (PMS) or the applicable NAVSEA Technical Manual. The results of allowing the firing pressure to exceed the established limits specified include:

- a. Increased thermal and tensile compressive stresses in the cylinder heads, cylinder liners, pistons and crankshaft.
- b. Higher cylinder temperatures.
- c. Dirty exhaust.
- d. A tendency to burn up the injector nozzle tips.
- e. A tendency to pound out bearing material.
- f. A tendency to cause ring failure and piston seizure.

**233.4.15 FACTORS AFFECTING SHAFT HORSEPOWER**

**233.4.16** On all types of diesel propelled ships, the percentage of engine horsepower (HP) available at the propeller depends on the type of connection between the engines and the propeller. Types of drives and the approximate relation between engine horsepower and power output to the propeller or shaft horsepower (SHP) are:

- a. Engines that are connected directly to the propeller shaft, Shaft HP = Engine HP less a loss due to thermal bearing and line shaft bearings. A loss of less than 0.75 percent.
- b. Engines that are connected to the propeller shaft by flexible couplings (sometimes part of the clutching mechanism when engaged) Shaft HP = 0.985 x Engine HP.
- c. Engines that are connected to the propeller shaft through attached reduction gears, Shaft HP = Engine HP. In this case the gears are considered to be an integral part of the engine.
- d. Engines that are connected to the propeller shaft by generator and motor, Shaft HP = Engine HP x generator efficiency x motor efficiency.
- e. Engines that are connected to the propeller shaft by generators, motors, and reduction gears, Shaft HP = generator efficiency x 0.98 x Engine HP.

**NOTE**

For generator set applications the electrical output in kilowatts is:  $Kw = 0.746 \times \text{Shaft HP}$ .

- f. Engines that drive an alternating current (AC) generator, to verify kilowatts load (kW) use the following formula:

$$kW = \frac{1.73 \times V \times A \times PF}{1000}$$

(V) = Volts

(A) = Amps

(PF) = Power Factor

(kW) = Kilowatts

**NOTE**

1.73 is the square root of 3, for 3 phase generators.

**NOTE**

If a power factor (PF) meter is not installed use 0.8.

**233.4.17 FACTORS AFFECTING SHIP SPEED**

**233.4.18** At present three general types of propellers are used on diesel propelled ships:

- a. Fixed pitch fixed diameter.
- b. Controllable reversible pitch–fixed diameter.
- c. Cycloidal propeller.

**233.4.19** At any given displacement, when the propeller pitch is fixed, the power required for propulsion varies approximately as the cube of the shaft speed.

**233.4.20** Fixed pitch propellers are designed to absorb rated horsepower at rated engine revolutions per minute (RPM) at either trial or design displacement.

**233.4.21** With controllable pitch propellers, it is possible to operate under different conditions of displacement of ship resistance at the same engine RPM and power by varying the pitch of the propeller. Operation of engines connected to controllable pitch propellers should be in accordance with the applicable NAVSEA Technical Manual and Engineering Operating Sequencing System (EOSS) if applicable.

#### **233.4.22 EFFECTS OF FOULING**

**233.4.23** Marine growth (fouling) on the propeller sides and the bottom of the ship and in the raw water piping has a very significant effect on the operation of diesel engines. The amount of fouling is dependent primarily upon three factors:

- a. The first factor is the number of days the ship has been operating after having the bottom cleaned and painted.
- b. The second factor is the temperature of the water and the locality in which the ship is operating. In tropical seas the marine growth rate is up to six times as much as in the North Atlantic.
- c. The third factor is the amount of idle time at the dock and at anchor.

#### **233.4.24 TRIM**

**233.4.25** Care should be taken to ensure that the ship will always be trimmed as close to the designed trim as possible. Because of improper trim conditions:

- a. Engines will be overloaded.
- b. The efficiency of the propulsion plant will be reduced.
- c. At any given shaft speed the ship will not attain the maximum speed when the ship is not properly trimmed.

#### **233.4.26 PROPELLER BEARINGS AND SHAFTING**

**233.4.27** NSTM Chapter 245, **Propellers**, should be consulted for detailed information concerning installation and maintenance of propeller shafts and bearings. Improperly adjusted bearings and misaligned shafting will result in increased shaft horsepower requirements at a given ship speed and may result in accelerated wear in the engine and gears.

**233.4.28** It is very important for the most efficient operation of the ship that the propellers be free of all foreign matter and nicks on the blade edges and that the

designed pitch of the propellers is maintained at all times.

#### **233.4.29 EFFECTS OF OPERATION IN SHALLOW WATER**

**233.4.30** The power required for operation in shallow water will increase. On electric-drive ships it is necessary only to limit the engine output as shown by Table 233-4-1. For extended operation in shallow water, it may be necessary to limit engine speed to 90 percent of maximum speed.

#### **233.4.31 OPERATION IN HEAVY SEAS**

**233.4.32** During operation in heavy seas, the power requirements at any given shaft RPM fluctuates considerably. The rated horsepower is intermittently exceeded when trying to maintain this rating.

#### **233.4.33 COLD WEATHER STARTING AND OPERATION**

**233.4.34** For cold weather operations the fresh water system shall be protected in accordance with Section 10 and PMS.

**233.4.35** For fuel requirements in cold weather see Section 7.

**233.4.36** For lubricating oil requirements in cold weather see Section 8.

#### **233.4.37 FUEL IGNITION AT LOW TEMPERATURES**

**233.4.38** A diesel engine depends on the heat of compression in the cylinder to ignite its fuel. In theory, this temperature in the cylinder depends only on the compression ratio and the temperature of the air entering the cylinder. When the outside air temperature drops 10 degrees, the temperature at the end of the compression stroke may drop as much as 20 degrees.

**233.4.39** Some important factors in starting engines are beyond the control of the operator, such as compression ratio, combustion chamber design, and the type of cranking system. In general, 4 stroke cycle engines can be started more easily than 2 stroke cycle engines due to better scavenging.

**233.4.40** The use of starting aids is required to start almost any diesel engine at sub zero temperatures. Starting aids authorized are listed in paragraph 233.4.42.

**233.4.41** When the ambient temperature drops, starting becomes more difficult, cranking speed is



**Table 233-4-1. TEMPERATURE LIMITS FOR  
MEDIUM AND HIGH SPEED DIESEL ENGINES**

EXHAUST TEMPERATURES:			
<p>IN NORMAL OPERATION, CYLINDER EXHAUST GAS TEMPERATURES SHALL NOT BE ALLOWED TO EXCEED THE MAXIMUM LIMIT(S) GIVEN IN PMS, EOSS OR THE APPLICABLE NAVSEA TECHNICAL MANUAL. UNLESS OTHER WISE STATED IN PMS. EOSS OR THE APPLICABLE NAVSEA TECHNICAL MANUAL, THE EXHAUST TEMPERATURE VARIATION AMONG THE CYLINDERS IN THE SAME ENGINE BANK AT FULL LOAD AND AT RATED SPEED SHALL NOT EXCEED 150 DEGREES F. THE SAME LIMIT APPLIES BETWEEN ENGINE BANKS AND ALSO FROM ENGINE TO ENGINE IN TANDEM SETS. TO MEET THIS LIMIT, FUEL RACKS, INJECTORS OR ASSOCIATED LINKAGES RE NOT TO BE ADJUSTED OUTSIDE THE APPLICABLE NAVSEA TECHNICAL MANUAL REQUIREMENTS.</p>			
	Minimum	Preferred	Maximum
FRESH WATER TEMPERATURE FROM ENGINE	68.3° C (155° F)	76.7° C (170° F)	85° C (185° F)
LUBRICATING OIL TEMPERATURE FROM ENGINE	71.1° C (160° F)	82° C (180° F)	93.3° C (200° F)
SEAWATER	N/A	N/A	N/A
NOTE: SOME HIGH SPEED DIESEL ENGINES (1800 AND HIGHER) HAVE OPERATING OIL OUTLET TEMPERATURES AS HIGH AS 107.2° C (225° F)			

reduced because of reduced battery efficiency and the increase in engine oil viscosity. Cold cylinder walls cool the incoming air, lowering the air charge temperature which further inhibits combustion.

#### 233.4.42 STARTING AIDS

**233.4.43** There are several types of starting aids for use in cold-weather operation. The majority of the starting aids assist by adding heat to the air in the combustion chamber, or by adding a volatile, easily combustible fluid, such as diethyl ether, to the intake air.

**233.4.44** Starting aids vary according to engine application, equipment installed, and harshness of the environment. Starting aids used in cold weather are in these general categories:

- a. Heating the engine coolant.
- b. Heating the engine oil.
- c. Heating the intake air.
- d. Heating the battery.
- e. Using special fuels, such as diethyl ether in minute amounts.

#### CAUTION

Use only approved starting aids.

#### WARNING

Do not use diethyl ether with air inlet preheaters.

#### WARNING

These fluids shall be handled with care since they are highly flammable, and a mixture of the vapors with air is explosive. Prolonged exposure, may cause death. Particular care shall be taken that fumes do not collect in the bilges of small craft. Exposure to the fumes should be avoided in any confined space because they will cause unconsciousness and may, under prolonged exposure, cause death.

**233.4.45** Depending of the installation, starting aids are often used in combination but diethyl ether is never used with air inlet preheaters because of the high volatility of the ether. Consult the applicable NAVSEA Technical Manual for special starting requirements for a particular engine.

**233.4.46** The most effective starting fluid is diethyl ether.

#### CAUTION

Never use bulk ether from cans.

**233.4.47** When diethyl ether is furnished for use as a starting fluid, it is usually compounded with a small amount of low pour point lubricating oil for top cylinder lubrication, and a trace of alcohol to prevent moisture freezing in the supply line.

#### CAUTION

Repeated use of ether, or an excessive application of ether on any one start, can cause damage to the engine.

#### WARNING

Explosion will occur if steel pressure primer bulbs are heated above 315.5° C (600° F).

**233.4.48** Diethyl ether starting fluid can be obtained in steel pressure primer bulbs. The introduction of a small amount of fluid into the intake before cranking the engine will facilitate starting. The use of excessive amounts should be avoided because it may backfire through the air intake, or detonate in the engine cylinder, causing mechanical damage to the engine.

**233.4.49** The steel pressure primer bulbs are pressurized with a flammable gas at approximately 250 psig and they will withstand rough handling without breaking, but will explode if heated above 315.5° C (600° F). The primer bulbs shall be used in a pressure primer discharger which pierces the



end seal on the bulb and permits the pressurizing gas to force the fluid through a connecting tube to a spray nozzle in the engine air intake system. The primer discharger is designed to prevent spillage or leakage of the fluid. Occasional difficulty will be experienced with the primer discharger because of choking of the screen in its base caused by black iron oxide which comes from inside the pressure primer bulbs. Periodic cleaning of the screen will be required.

**CAUTION**

Do not inject too much ether or the engine may be damaged because of high cylinder pressure.

**233.4.50** The amount of ether type starting fluids required for a given engine can be determined only by trial and error. It may be said that the quantity of fluid required is roughly proportional to engine displacement and increases rapidly as the temperature falls below  $-17.7^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ). Care should be exercised not to inject too much ether or the engine may be damaged because of high cylinder pressures. At sub-zero temperatures, starting is improved if a minute amount of the fluid used is sprayed into the intake manifold before starting to crank the engine.

#### **233.4.51 STARTING TECHNIQUES FOR DIESEL ENGINES**

**233.4.52** Cylinder temperature also depends on the cranking speed. Since cranking speeds for most engines are less than 200 RPM, the engines operate in a range where a small increase in cranking speed may cause a relatively large increase in combustion chamber temperature. This will make starting much easier.

**233.4.53** In general, small high speed engines start most readily with the throttle full open, although some appear to start better at part throttle. Still others start more readily if the throttle is slowly opened to the full fuel position during cranking.

**233.4.54** At low temperatures, it is usually necessary to operate an engine at a fast idle speed even though this

may cause rapid wear of bearings, piston rings, and cylinder walls. The engine speed should be reduced to normal idle as soon as possible.

#### **233.4.55 MINIMIZING EXHAUST SMOKE**

**233.4.56** The normal exhaust smoke opacity for engines in good condition operating under normal load and warmed up is well below Ringleman Number One. However, even a good engine can produce smoke during warmup. Excessive idling causes smoke from any diesel engine. Any new or overhauled engine can produce smoke until the run in procedure has been completed.

**233.4.57** In order to minimize exhaust smoke emissions the following actions are recommended:

- a. Strictly adhere to maintenance requirements as specified in the applicable NAVSEA Technical Manual and PMS requirements.
- b. Conduct trend analysis in accordance with PMS to identify potential problems which will contribute to poor combustion and engine operation.
- c. Whenever a cold engine is started, idle the engine until the lube oil temperature reaches  $35^{\circ}\text{C}$  ( $95^{\circ}\text{F}$ ). Then apply a light load (approximately 20 to 30 percent). When the lube oil temperature reaches  $48.9^{\circ}\text{C}$  ( $120^{\circ}\text{F}$ ), apply a normal operating load (60 percent or greater).

**CAUTION**

Do not operate a warm engine for any length of time at less than 60 percent load. Avoid prolonged idling (in excess of 5 minutes) of a warm engine. Combustion at low or no load is incomplete and may cause heavy carbon deposits which will foul the valves, valve stems, intake and exhaust ports, and the piston rings as well as the exhaust system.

- d. Operate a warm engine at between 60 and 80 percent of full load to the maximum extent possible.
- e. To secure a warm engine remove the load and slowly reduce RPM to the idle speed. Then run at the idle speed for three to five minutes and then shutdown.

f. When a multiple engine arrangement is provided so that various engine combinations may be used, select a combination that operates fewer engines at higher loads for low speed or low power operation. Consistent with the need for split plant operation to ensure maximum reliability, make every effort to maintain the load between 60 and 80 percent of full load. Refer to **NSTM Chapter 320, Electric Power Distribution Systems**, for information on split plant operations.

g. Never operate diesel engines at an overload except in the case of an emergency. If conditions indicate that the engine is overloaded, reduce the load immediately. Overload may be indicated by high exhaust temperatures, smoky exhaust, or high firing pressures.

#### **233.4.58 DIAGNOSING ENGINE PROBLEMS BY EXHAUST SMOKE**

**233.4.59** The major contributors to exhaust smoke emissions are:

- a. Blue smoke
  1. Worn or stuck piston rings.
  2. Worn cylinder liners.
  3. Worn valve guides.
  4. Cracked pistons.
- b. Black or gray smoke
  1. Incomplete burned fuel.
  2. Improper grade of fuel.
  3. High exhaust back pressure.
  4. Restricted air inlet.
  5. Malfunctioning turbocharger.
  6. Improperly timed injectors.
  7. Faulty injectors.
  8. Engine overload, cylinders not balanced.
  9. Low compression.

#### **233.4.60 OPTIMIZING ENGINE PARAMETERS**

**233.4.61** The diesel engine general mechanical condition shall be maintained to ensure the power output from individual cylinders are equal at rated load and speed. To obtain equal load distribution among the individual cylinders, the clearances and tolerances, and the general condition of all parts that affect the cycle

(intake, compression, power, and exhaust) shall be maintained so variations between individual cylinders are at a minimum.

**233.4.62** To obtain equal load distribution, conditions that should be as nearly equal as is possible for all cylinders are:

- a. Compression pressure.
- b. Firing pressure.
- c. Cylinder exhaust temperatures.
- d. Fuel rack/governor power position.
- e. Fuel injection timing.
- f. Quantity of fuel injected.
- g. Intake and exhaust valve timing and lift.
- h. Fuel injector popping pressures.

#### **233.4.63 OPERATING ENVELOPE**

**233.4.64** Paragraph 233.4.3 through 233.4.5, address recommended operating limits when not specifically addressed by the applicable NAVSEA Technical Manual, PMS, **Engineering Operating Sequencing System (EOSS)**. Table 233–4–1 and 233–4.2 illustrate the area of speed and load combination which are preferred for the least maintenance, the most effective and efficient engine utilization with the least amount of exhaust smoke.

#### **233.4.65 OPERATING DIESEL ENGINES WHILE IN DRYDOCK**

**233.4.66** Operating the diesel engine while in drydock may be performed but is subject to the following considerations:

- a. The diesel engine shall not be used as a primary or backup source of electrical power.

#### **NOTE**

This does not preclude using the diesel in emergency situations.

- b. Do not operate the diesel engine if there is any question concerning whether engine and driven unit is within alignment specifications.

- c. Crankshaft deflections and thrust readings shall be taken in accordance with PMS before

running the engine in drydock. These items shall be within PMS specifications.

<b>CAUTION</b>
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Do not operate the diesel engine when sandblasting, extensive grinding, or other dust producing activities are in progress.

**NOTE**

The drive end crankwebs are the most susceptible to deflections caused by misalignment of the engine. If the drive end crankweb is within specifications it is not necessary to take deflection readings on the other crankshaft webs.

d. Do not operate the diesel engine without concurrence of the repair activity.

e. The repair activity shall confirm that there are no hazards associated with the operation of the diesel engine because of the ships location on the blocks.

f. Operate the diesel engine only for the minimum amount of time needed to support current need.

g. The following special precautions shall be adhered to:

h. The atmosphere in the dry dock and inside the ship shall be monitored for carbon monoxide while the engine is operating.

i. Ensure that there is unobstructed path for inlet air and engine exhaust piping to prevent injuries or damage caused by excessive pressure or vacuum.

j. Ensure that all engine safety and monitoring devices are operational and that pressures and temperatures remain within normal operating ranges.

k. Ensure that the dry dock system which supplies cooling water to the diesel seawater system will not be overpressurized and its components damaged. The maximum allowable system pressure is 80 psi.

l. During operation of the diesel engine if any temperatures or pressures are out of specification the diesel engine shall be secured immediately.



## SECTION 5. MAINTENANCE

### 233.5.1 INTRODUCTION

**233.5.2** To keep a diesel engine in reliable operating condition, it is necessary to follow an intelligently planned procedure of periodic inspection and adjustments. With such a procedure, early failure, maladjustment, or excessive clearance of wearing parts may be detected and corrected before any serious casualty results. Planned Maintenance System (PMS), Maintenance Requirement Cards (MRC) provide intelligently planned procedures.

### 233.5.3 OVERHAUL PROCEDURES

**233.5.4** The Navy uses so many models of diesel engines, it is not possible to specify any detailed overhaul procedure in this section. Several general rules apply to all engines and shall be followed.

**233.5.5** Detailed repair procedures are listed in the applicable NAVSEA Technical Manual, Technical Repair Standards (TRS), and the PMS. Consult the applicable NAVSEA Technical Manuals, TRS's and MRC's prior to proceeding with any repair work. Particular attention should be paid to installation tolerances, wear limits, and adjustments.

**233.5.6** Observe the highest degree of cleanliness in handling engine parts. Engines have been completely destroyed by the presence of abrasive and other foreign objects which have been carelessly left in the engines after overhaul. Ensure that any engine assembled for post-repair running is free of foreign matter prior to running. Too much emphasis cannot be given to the necessity for maintaining engines that are clean both internally and externally. Dirt entering the engine during overhaul causes increased wear and poor operation. It is essential that all repair work be done under clean conditions. When overhaul or repair of precision parts and surfaces is required, the parts and the surfaces should be thoroughly cleaned and wrapped in a clean lint-free cloth or suitable paper. The parts should then be stored in a dry place until reinstalled. During installation, parts should be wiped with a lint-free cloth and coated with clean lubricating oil, where applicable. When removing or installing parts such as pistons, connecting rods, camshafts, and cylinder liners, care shall taken to ensure that the parts, new or used, are suitable for use. Precautions shall also be taken to keep dirt and other foreign material in the surrounding atmosphere from entering the engine while it is being overhauled. During

shipyard overhaul periods, the engine(s) shall be protected from grit producing work procedures (i.e., welding, sandblasting, grinding, painting, etc).

**233.5.7** Before starting repair work, ensure that all required tools and spare parts are available. Plan ahead for repair periods so everything needed is available to ensure successful and expeditious completion of the work.

### WARNING

Never attempt to bar the engine over by hand without first de-energizing and/or deactivating the starting system and tagging out of service in accordance with current shipboard and/or shore tag out instructions.

**233.5.8** Keep records of repairs, including measurements of used parts that are to be reused. Measurement of qualified new parts is not always required. All clearances and tolerances are to be in accordance with the applicable NAVSEA Technical Manual, PMS, and TRS's. All measurements shall become part of the engine overhaul or repair package for future reference.

**233.5.9** Do not test an overhauled diesel engine above name plate rating or rating listed in the applicable NAVSEA Technical Manual. Engines are normally tested to 100 percent load only. Modern generator sets have a single rating with no stated overload requirement. Overload testing is neither required nor desirable for generator applications.

### 233.5.10 FUEL INJECTORS AND PUMPS

**233.5.11** Fuel injectors, injector nozzles and high pressure fuel pumps should not be disassembled unless defective operation is indicated. The applicable NAVSEA Technical Manual, PMS, and TRS's provide instructions for servicing and adjusting fuel injection equipment and shall be strictly adhered to. Absolute cleanliness is of paramount importance. Only qualified shops and repair facilities shall overhaul and calibrate fuel injection equipment. All fuel

injection parts shall be inspected for fit, form and function prior to installation.

#### **233.5.12 EQUALIZING THE LOAD BETWEEN CYLINDERS**

##### **CAUTION**

Fuel rack settings are not to be adjusted merely to equalize exhaust temperature differences.

**233.5.13** Procedures for equalizing the load between cylinders and engines are found in the applicable NAVSEA Technical Manual and PMS. Before attempting to equalize cylinders and engines, ensure all injectors and high pressure fuel pumps are properly assembled and calibrated.

#### **233.5.14 CYLINDER HEADS**

**233.5.15** Cylinder heads shall be inspected for cracks, pitted surfaces and excessive carbon deposits at overhaul. Cylinder head repairs are to be in accordance with the applicable NAVSEA Technical Manual, PMS, and TRS's.

**233.5.16** Improper installation of cylinder head assemblies or component parts can result in permanent damage to cylinder heads, engine block, pistons, cylinder liners and turbochargers.

**233.5.17** Proper cylinder head maintenance is nothing more than the application of good work procedures guided by the applicable NAVSEA Technical Manual, PMS and TRS's.

#### **233.5.18 LINERS**

**233.5.19** Most diesel engines are designed to use replaceable cylinder liners. Some engine designs use a dry cylinder liner inserted into the bores of the cylinder block. In such designs, the cooling water does not directly contact the cylinder liner. Many engines use designs of replaceable cylinder liners where some portion (or even the entire liner's outer surface) may be in direct contact with the cooling water. These wet liner

designs shall employ a sealing system to prevent leakage of water into the engine.

**233.5.20** Wet liners are positioned in the block by a loose or light interference fit, with sealing surfaces at the top and bottom of the liner. The seals are usually O-rings. An interference fit at the bottom stabilizes the liner to reduce high frequency vibration that can induce cavitation on the water side of the liner. Liner O-ring seals and liners are installed in accordance with the applicable NAVSEA Technical Manual, PMS, and TRS's.

**233.5.21** If applicable always pressure test the engine after replacing liners and before installing pistons and heads. When a sealing surface is disturbed, always use a new O-ring or gasket.

**233.5.22** Liners will usually wear at the greatest rate in an area 90 degrees to the crankshaft and in the direction of piston thrust.

##### **CAUTION**

Engine cylinder liners shall never be stacked or stored on their sides. They will become out of round and be unserviceable.

**233.5.23** Liners shall be well coated with preservative oil or grease and stored vertically on end only.

**233.5.24** Liners should be carefully inspected and measured for wear, cracks and corrosion at each overhaul if they are to be reused. Wear limits and installation of liners shall be in accordance with the applicable NAVSEA Technical Manual, PMS, and TRS's.

#### **233.5.25 INTAKE AND EXHAUST VALVES**

**233.5.26** Intake and exhaust valves should be carefully inspected in accordance with the applicable NAVSEA Technical Manual, PMS, and TRS's. When replacing a valve in the cylinder head, extreme care shall be taken to ensure valve keepers and spring retainers are properly assembled. A valve's dropping into the cylinder may cause catastrophic engine damage.

**WARNING**

Sodium is dangerous when in contact with the atmosphere and explosive when in contact with water.

**CAUTION**

Sodium-filled exhaust and intake valves, when no longer serviceable, should be disposed of in accordance with current instructions and regulations.

**WARNING**

Do not sectionalize sodium-filled valves for training or other purposes. Personal injury may result.

**233.5.27** Sodium-filled engine poppet valves are provided with a chamber formed by the hollow stem and extending well up into the valve head. The chamber contains a sodium salt, which changes to a liquid as it is heated and provides a more rapid flow of heat from the valve head to the stem than would be possible in a solid stem valve.

**233.5.28** Sodium-filled valves may be serviced or cleaned, or the seat may be refaced in the normal manner. Extreme care shall be exercised to prevent personnel from accidentally grinding into the hollow sodium-filled portion of the valve or otherwise exposing the sodium to the atmosphere or moisture. Precautions which shall be observed when handling valves of this type are:

- a. Store valve in a dry place.
- b. Exercise care in handling and servicing, so stems are not broken.
- c. If chamber is found to be cracked, or inadvertently opened, submerge the valve in kerosene and keep it submerged until the valve can be disposed of properly.

**233.5.29** Not all sodium-filled valves are marked for identification. They can be identified by number and usually are constructed with a much larger diameter valve stem than is common for solid stem valves. If any

doubt exists in identifying sodium-filled valves, treat the valve as being sodium-filled and handle accordingly.

**233.5.30 CYLINDER RELIEF VALVES****CAUTION**

Cylinder relief valves shall never be locked closed except in cases of emergency.

**233.5.31** Cylinder relief valves shall be set in accordance with the applicable NAVSEA Technical Manual and PMS. Repeated lifting of cylinder relief valves while the engine is running indicates that the spring has become weakened, ignition or fuel injection occurs too early, or the engine is being overfueled by faulty fuel injection equipment.

**233.5.32 PYROMETERS**

**233.5.33** Pyrometers used for measuring exhaust temperatures are taken for granted and not thoroughly understood. Pyrometers are one of the most important gages on the engine. Accurate exhaust temperature readings can help identify an engine problem.

**233.5.34** The engine pyrometer exhaust temperature measuring system consists of three parts; the thermocouples, the pyrometer and the wiring that connects the thermocouples and the pyrometer together. The thermocouples, located in a protective sleeve (tubing), convert the heat that the tip of the tubing is in contact with into an electrical signal (in millivolts) that is proportional to the temperature. The pyrometer indicates the temperature by measuring this electrical signal. The wiring is made of a low resistant type and typically has a multipoint switch inline that allows one pyrometer to measure several thermocouple outputs.

**233.5.35** The engine pyrometer exhaust temperature measuring system requires little maintenance. All maintenance is in accordance with the applicable NAVSEA Technical Manual and PMS.

**233.5.36** Problems with the engine pyrometer exhaust temperature measuring system include the following:

- a. Thermocouple's protective tubing becomes coated with carbon (decreasing accuracy and



slowing response time), the tubing is installed into exhaust manifolds at different lengths, or the thermocouple has broken away from its protective tubing.

b. Pyrometer is out of calibration, is calibrated wrong, or its external resistor is not the correct resistance for the installation.

c. The wiring between the thermocouple and the pyrometers is the wrong material, the leads are not connected properly (or polarity is reversed), the lengths of the wiring are not equal between different thermocouples, the junctions in the wiring are loose or corroded, the wiring itself is brittle and broken, or the multipoint switch connections are loose or corroded.

d. For those installations whose multipoint switches include an amplifier (to boost the current over long distances), these amplifiers are adjusted wrong.

### **233.5.37 PISTONS AND RINGS**

**233.5.38** Piston ring replacement is probably the most prominent reason for engine overhaul. Piston rings are designed for three basic purposes:

- a. To seal the compression and combustion pressures within the cylinder.
- b. Transfer heat from the piston to the liner.
- c. To meter the required lubricating oil to the liner and rings.

**233.5.39** Piston rings are subjected to the adverse and varied conditions of extreme heat, pressure loading, dirt, and marginal lubrication.

**233.5.40** Piston rings function as a team. If any one ring fails on the same piston, the pressure affecting rings further from the combustion chamber will be changed. Oil rings control the oil on the cylinder liner walls but must control the amount distributed. If the oil control is too stringent, high cylinder liner and ring wear will result. If too much oil is distributed by the rings, the oil may reach the combustion space and burn causing smoky exhaust.

**233.5.41** Too much oil has an adverse effect on proper operation of compression rings and can lead to ring breakage or flutter. When it is determined that one or more rings on a piston are in need of replacement, all the rings on the affected piston shall be replaced. Replacing only the most severely worn rings will result in continued marginal performance and more frequent down time for ring servicing.

**233.5.42** With a properly functioning set of compression rings with open gaps, the pressure drop across each ring is approximately 1/2 the pressure above the ring. The pressure drop is illustrated in Figure 233-5-1.

**233.5.43** If one ring fails or is excessively worn, the additional load is transferred to the lower compression rings and may overpressurize the oil control rings.

**233.5.44** Normally all rings on one piston will be replaced when one of the rings needs replacement. Single ring replacement is not recommended except in emergencies.

**233.5.45** Piston, piston ring lands and grooves shall be cleaned before installing new rings. New rings that are installed in piston ring grooves that are stepped due to excessive wear will rapidly wear the new rings.

**233.5.46** Ring replacement shall be in accordance with the applicable NAVSEA Technical Manual, PMS or TRS.

### **233.5.47 PISTON PINS**

#### **CAUTION**

Under no circumstances are piston pins to be cleaned with sandpaper or emery cloth or filed to remove surface defects. Replacement of pin is required.

**233.5.48** Piston pins shall be rejected if they have any surface defects, nicks, burrs, etc.

### **233.5.49 BALL OR ROLLER BEARINGS**

**233.5.50** Ball or roller bearings should be renewed only when the bearings or races are definitely known to be pitted, fatigued, or worn. Frequently, fresh lubrication is all that is required after a thorough cleaning has removed gummed lubricating oil or grease. For further information see the applicable NAVSEA Technical Manual, PMS, and NSTM Chapter 243, Shafting, Bearings, and Seals.



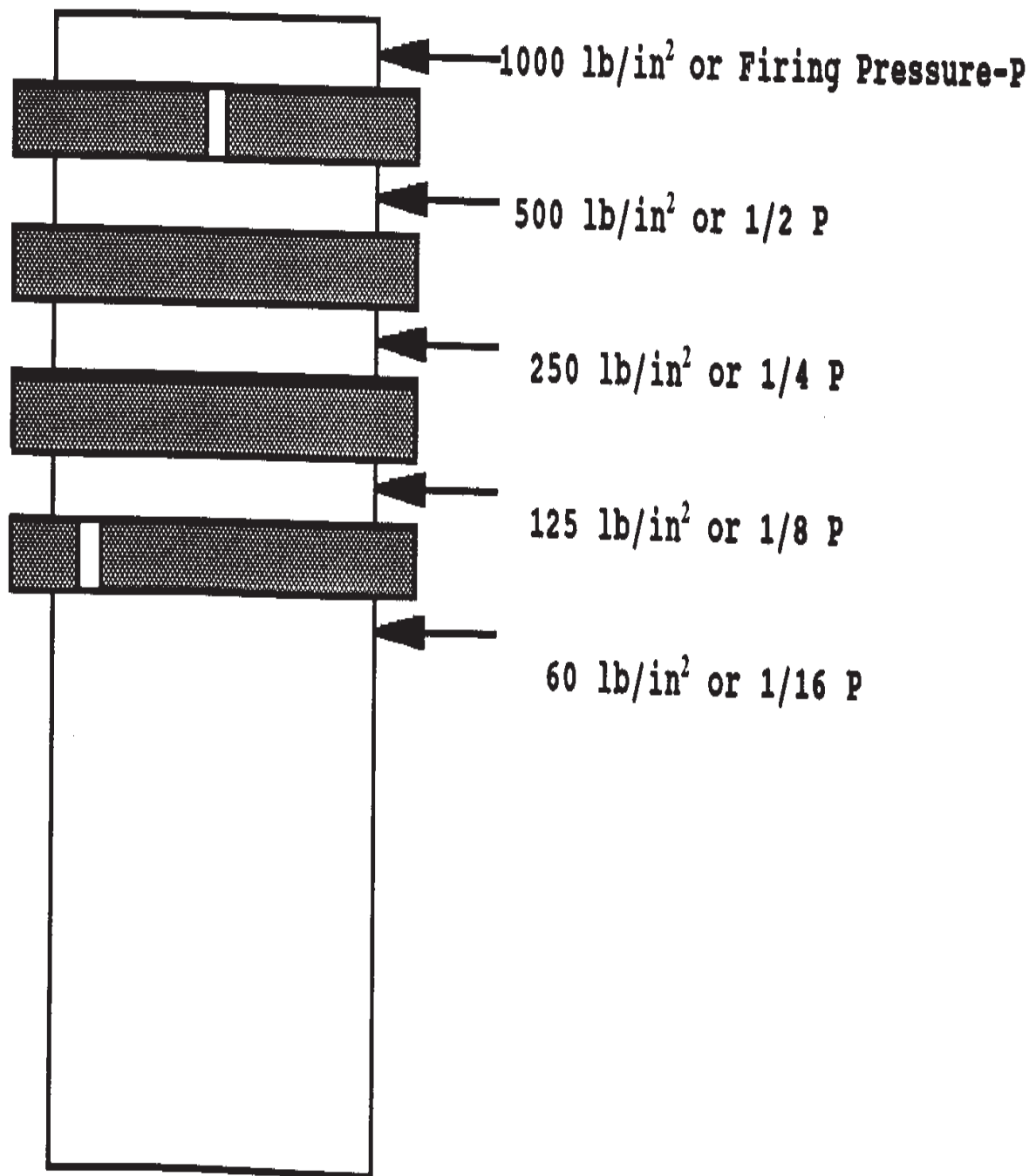


Figure 233-5-1. Normal Rate of Pressure Drop Across Compression Rings

**233.5.51 PRECISION OR BABBITT BEARINGS**

**233.5.52** Babbitt bearings should be renewed only when wiped, worn beyond allowed limits, honeycombed to such an extent that complete failure is imminent, or when sufficient bearing metal is broken loose from the shell that a serious reduction of bearing area results. Circumferential scratching and grooving, often noted during inspections, are caused by dirt in the lubricating oil. Every effort shall be made to ensure that such dirt is eliminated. Surface marks such as scratches or grooves do not affect performance, but will reduce bearing life. A worn-in operating bearing may have much greater inherent reliability than a new bearing.

**233.5.53 SHAFT JOURNAL INSPECTION**

**233.5.54** Shaft journals are machined to be round and smooth. Deviation from this original configuration will impair bearing operation. Most journal surface should be bright and shiny. Circumferential grooving caused by dirt and abrasive material reduces the area in contact with the bearing, impairs the oil film, and damages or removes the babbitt. Slight circumferential grooving is acceptable. When grooving is considerable, journal repair is required. Unacceptable conditions are considerable or heavy circumferential grooving, blackened surface, a rough, pitted, or burred surface, and babbitt deposits.

**NOTE**

Flat spots are caused by excessive use of stones, scrapers, and abrasives. Do not work journals by hand. When required, only experienced personnel should perform hand operation.

**233.5.55 SCRAPING OF JOURNAL BEARING**

**233.5.56** Hold scraping to a minimum. Never scrape bearings to alter the basic surface geometry or to change the effective bearing clearance. Bearings are manufactured to precise tolerances and, in general, should require no scraping or fitting during installation. Bearings usually show a polished area of babbitt over the bottom central 10 to 60 degrees of arc. This does not mean that the shaft does or should contact the bearing over this arc at any one time. What does happen is that, at low shaft speeds, the oil film between the journal and

bearing is thin, proportional to speed. Because the oil film is thin, the shaft tends to polish off babbitt aspirates (irregularities) at the bottom dead center and for as much as 30 degrees in the direction of journal rotation.

**233.5.57** Scraping a bearing to obtain a uniform blued contact is undesirable. It destroys the bearing arc by producing a bearing surface with the same curvature radius as the journal. When the journal and bearing have the same curvature radius, the clearance over the arc is zero, preventing the oil film from forming and causing the bearing to have no load capacity. Scraping to blend a generous clearance at the wings or parting line into the bottom 60 degree contact area is also undesirable because it shortens the active bearing arc, raises the running temperature of the bearing, and reduces the minimum oil film thickness.

**233.5.58** Since the attitude angle of the bearing (that is, the location of the point of minimum film thickness) usually exceeds 30 degrees at full power, in an area relieved by scraping, the shaft is forced to run at its worst operating point. Such operation is undesirable.

**233.5.59** Use scraping to:

- a. Blend or smooth the edges of all oil grooves as required to produce a smooth junction, but only over narrow areas, such as at a chamfer.
- b. Remove high spots anywhere on the bearing surface, but only to reduce them to match the surrounding surface profile.

**233.5.60** Modern day diesel engines use precision bearings. Consult the applicable NAVSEA Technical Manual, PMS, TRS and **NSTM Chapter 243, Shafting Bushings and Seals.**

**233.5.61 GEARS**

**233.5.62** Gears should not be renewed merely because of initial pitting of teeth. If the wearing area on the teeth show that alignment is correct, the gears can be used until wear and backlash becomes excessive for the service required, or the pitting extends to the point of possible tooth failure. In certain cases, gear tooth pitting does not continue after the wearing surfaces are well worn in following the first few hundred hours of operation. Such gears may be retained in service,

provided all operating requirements are met and the gear is inspected at regular intervals. Particular attention should be given to the tightness of a gear on its shaft because loose gears cause early failure. In addition, inspect for cracking and chipping of the teeth. For further information consult the applicable NAVSEA Technical Manual, PMS, and TRS.

### **233.5.63 TIMING**

**233.5.64** It is absolutely essential that the engine be correctly timed in accordance with the applicable NAVSEA Technical Manual and PMS. Any deviation from the timing instructions will result in loss of power and be detrimental to the engine.

### **233.5.65 GOVERNORS**

**233.5.66** When normal governor adjustments do not give the response desired, the hydraulic governor should be removed and sent to a repair activity for cleaning, overhaul, and recalibration. A spare governor should be on hand or provided so the engine can be operated during governor overhaul periods and PMS procedures.

### **233.5.67 PUMPS**

**233.5.68** The provisions of **NSTM Chapter 503, Pumps**, apply in general to engine pumps. Pumps shall be checked for wear and corrosion at time of each overhaul in accordance with the applicable NAVSEA Technical Manual and PMS. Weep holes on some pumps assist the operator to determine seal integrity. When the operating fluid drips or runs from the weep hole, seal failure is evident and replacement is required.

### **233.5.69 COUPLINGS AND UNIVERSALS**

**233.5.70** Small boat engine couplings and universals shall be visually inspected daily prior to engine operation. Ensure that no excessive run out exists and that all fasteners or locking devices are secure. When propulsion engine vibration is experienced; alignment, coupling and universals should be inspected in accordance with the applicable NAVSEA Technical Manual and PMS.

### **233.5.71 CRITICAL SPEEDS AND VIBRATION TORSIONAL DAMPERS**

#### **233.5.72 CRITICAL SPEEDS**

**233.5.73** Engines shall be operated at or too close to any destructive critical speed because the resulting vibrations will cause serious engine damage. Critical speed ranges for each specific engine design shall be passed through as quickly as possible when changing engine speed. Detailed information concerning critical

speed ranges is included in the applicable NAVSEA Technical Manual. Tachometers should be marked in red to show any critical speed ranges so the engine speed may be kept out of the critical ranges.

### **233.5.74 TORSIONAL VIBRATIONS**

**233.5.75** Every engine crankshaft has torsional vibrations which are caused by the firing pulses of the cylinders. A torsional vibration is a periodic motion twisting in alternately opposite directions of the crankshaft about its longitudinal centerline. Normally, the vibrations are damped out because vibration energy is consumed in twisting the shaft. Every particle of matter has one or more natural frequencies which will excite it. When the engine's power pulses excite a natural crankshaft frequency, it is called a resonant or critical vibration.

**233.5.76** When applying an engine to a specific application, the manufacturer should determine mathematically that the combination of crankshaft, flywheel, and driven machinery will be free of critical vibrations or provide a means to control critical vibrations. The greatest crankshaft stresses created by critical vibrations alone are normally in the crankpin or crankshaft cheek area. Each manufacturer sets the limit on the permissible stresses due to critical vibration.

### **233.5.77 REDUCING OR ELIMINATING TORSIONAL VIBRATIONS**

#### **233.5.78 FLYWHEELS**

**233.5.79** All diesel engines deliver power as series of pushes on the crankshaft that causes a twisting motion of the crankshaft. The flywheel limits instantaneous fluctuations in crankshaft speed during sudden changes of load and carries the pistons over the compression pressure.

**233.5.80** The flywheel is an energy storage device that uses the inertial effect (resistance of a weight to a change in motion) of a heavy disk (flywheel) to maintain the speed of the engine between the power pulses.

#### **233.5.81 ATTACHING FLYWHEEL TO CRANKSHAFT**

**233.5.82** One of the three following methods is usually used:

- a. Split hub flywheel.
- b. Tapered shaft and hub.

c. Flange connections.

**233.5.83** The flywheel shall be tightly and securely fastened to the crankshaft and positioned and aligned so that the runout on the flywheel is within the manufacturer's specification. An out of alignment flywheel can create a severe imbalance in the rotation of the crankshaft and seriously damage major engine components.

#### **233.5.84 FLYWHEEL MAINTENANCE**

**233.5.85** Consult the applicable NAVSEA Technical Manual and PMS for specific maintenance and repair.

#### **233.5.86 COUNTERWEIGHTS**

**233.5.87** On some crankshafts counterweights balance the off-center weight of the individual crank and thereby balance the centrifugal forces created by the rotation of the crank. On some crankshafts part of the web of the crankthrow extends beyond the main journal to form or to support the counterweights. The counterweights use inertia the same way the flywheel does; to reduce the pulsating effect of the power pulses in the engine.

**233.5.88** On some crankshafts the counterweight is integral with the crank webs. On others it is a separate piece secured to the webs with bolts or by welding. Figure 233-5-2 shows typical modern counterweight assemblies. When counterweights are fitted to the crankshaft as separate assemblies, they shall be securely fastened. If counterweights are removed from the shaft for any reason they shall always be replaced in the same position, to maintain the dynamic balance of the shaft. Match marking the shaft web and the counterweight with punch marks before disassembly is recommended.

**233.5.89** Counterweight assemblies shall be fastened to the crankshaft in accordance with the manufacturer's specification because, if improperly secured, they can loosen. As the counterweight rotates with the crankshaft, a centrifugal force pulls the counterweights away from the cranks. Gravity, also, will tend to shift them back and forth as they move from one side of the shaft to the other. Because the centrifugal force reduces the contact pressure of the counterweight and the crankshaft web, if there is any freedom (clearance) at all the counterweight will move. Although the movement may be slight at first, the clearance will gradually increase as the counterweight continues to move (possibly causing

pounding) until there is danger of breaking the hold down studs or unscrewing the nuts. If this happens, the counterweights can be thrown off, and the engine will be seriously damaged because of the weight and the severe imbalance of the crankshaft.

#### **233.5.90 VIBRATION DAMPERS**

**233.5.91** Another alternative is a system to absorb the energy of vibration and, in this way, reduce the magnitude of crankshaft vibration and stresses. Figure 233-5-3 shows a vibration damper which is attached to a free end of the crankshaft.

#### **233.5.92 VISCOUS TYPE VIBRATION DAMPER**

**CAUTION**

Do not use vibration damper as a leverage point for thrusting the crankshaft. Do not pry on the engine vibration dampener.

**233.5.93** The vibration damper consists of a hollow housing that contains a free or floating flywheel. The small clearance between flywheel and housing is filled with a viscous silicone fluid. As the crankshaft vibrates and carries the housing with it, inertia tends to cause the flywheel to turn at a more constant speed. The resulting relative motion causes high shearing action in the silicone fluid and the energy is dissipated as heat. Thus, the flywheel is connected to the crankshaft through the fluid film and any instantaneous speed change is resisted by drag of flywheel inertia acting through the fluid film. The effect is to dampen all the crankshaft torsional vibrations. This type damper would reduce the stresses created throughout the complete speed range. The viscous type damper shall be replaced at engine overhaul, or when the dampener housing is dented or warped.

#### **233.5.94 GEAR TYPE VIBRATION DAMPER**

**233.5.95** The gear type vibration damper is often called a hydraulic damper, see Figure 233-5-4. It consists of a spider gear with external teeth and an intermediate ring with internal teeth. As pressurized lube oil is supplied to the assembly, the spider gear drives the intermediate ring, which actually floats. Damping action is provided by strategically placed vent holes drilled in the system

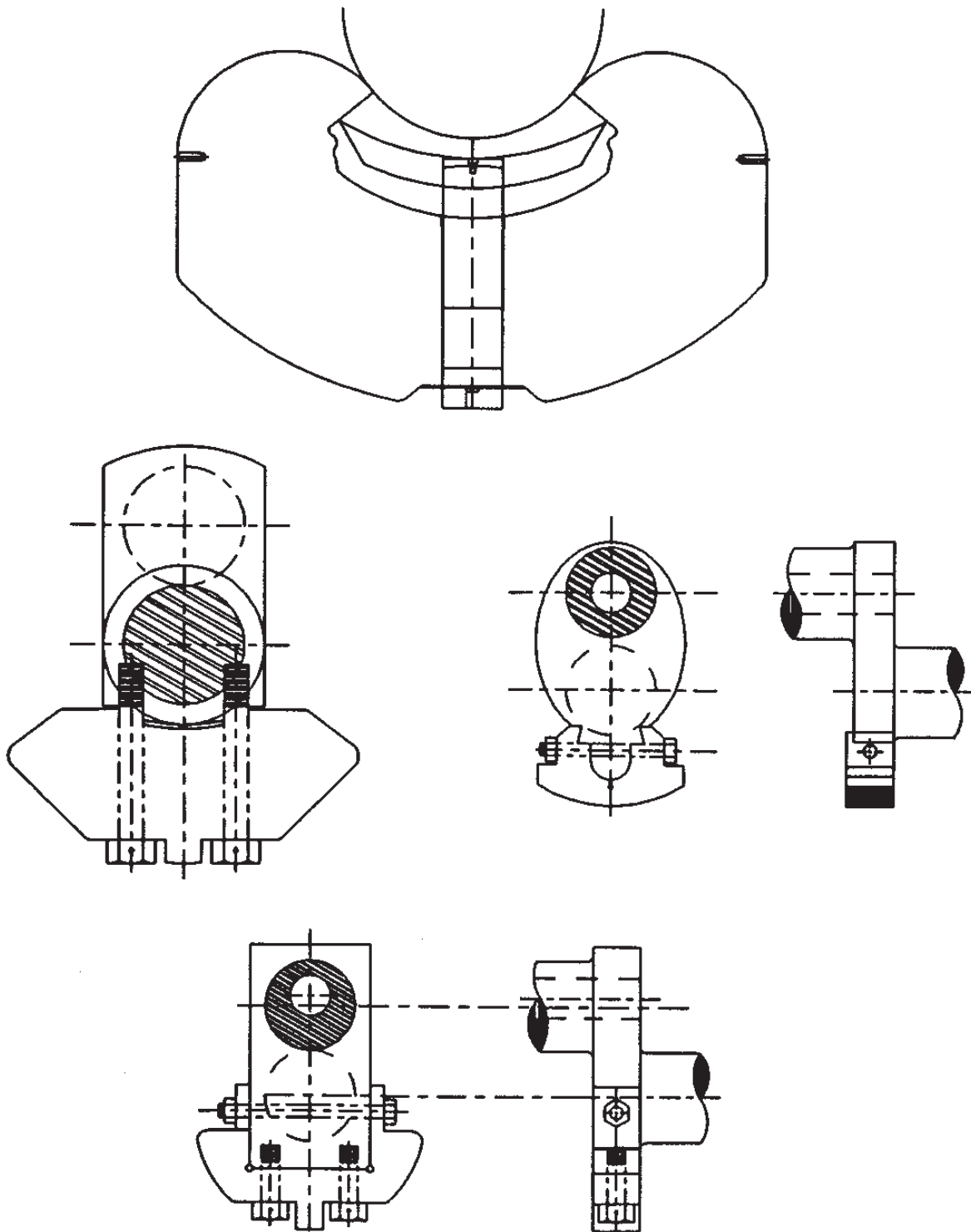


Figure 233-5-2. Typical Counterweight Assembly

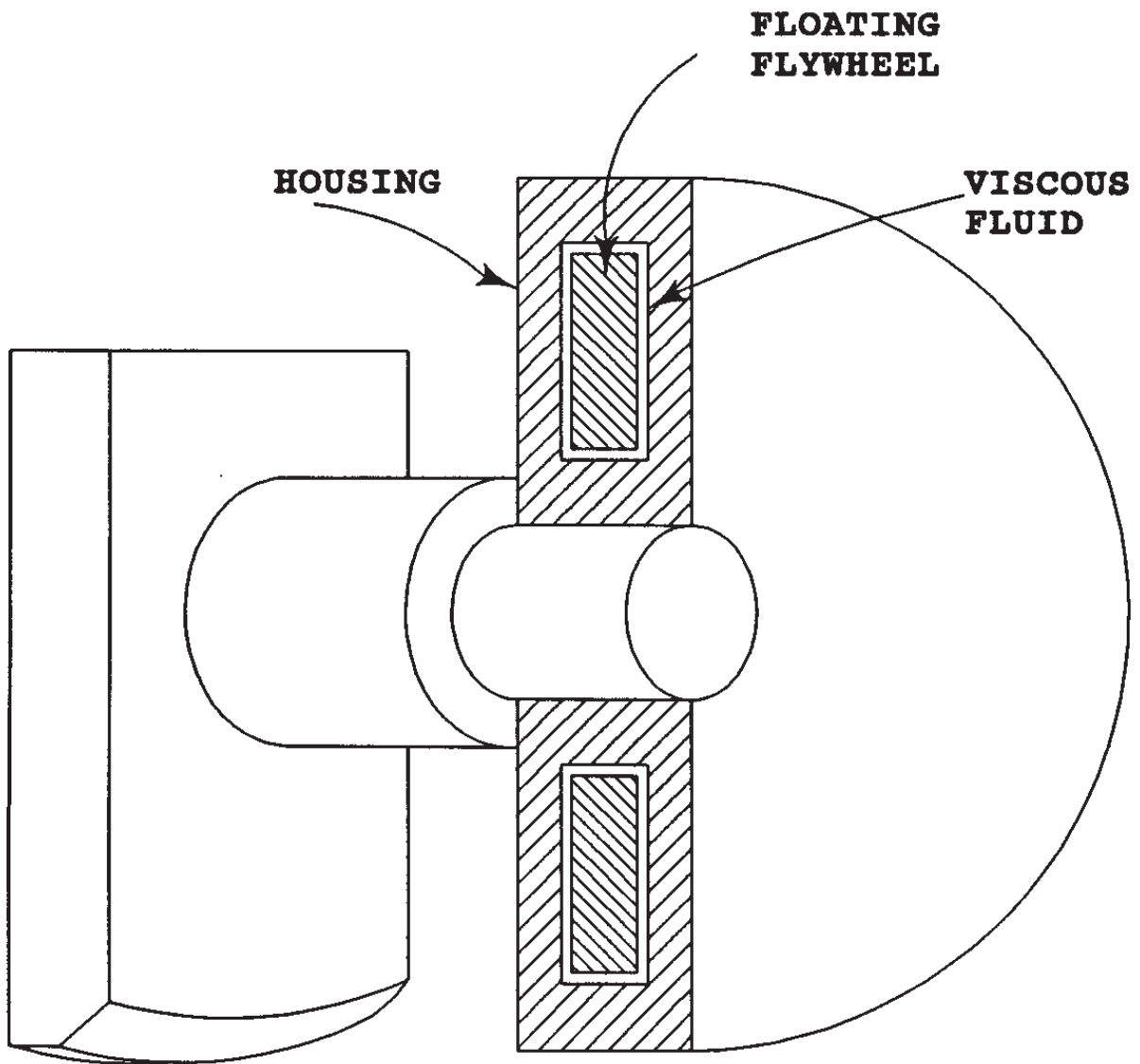


Figure 233-5-3. Vibration Damper on Free End of Crankshaft

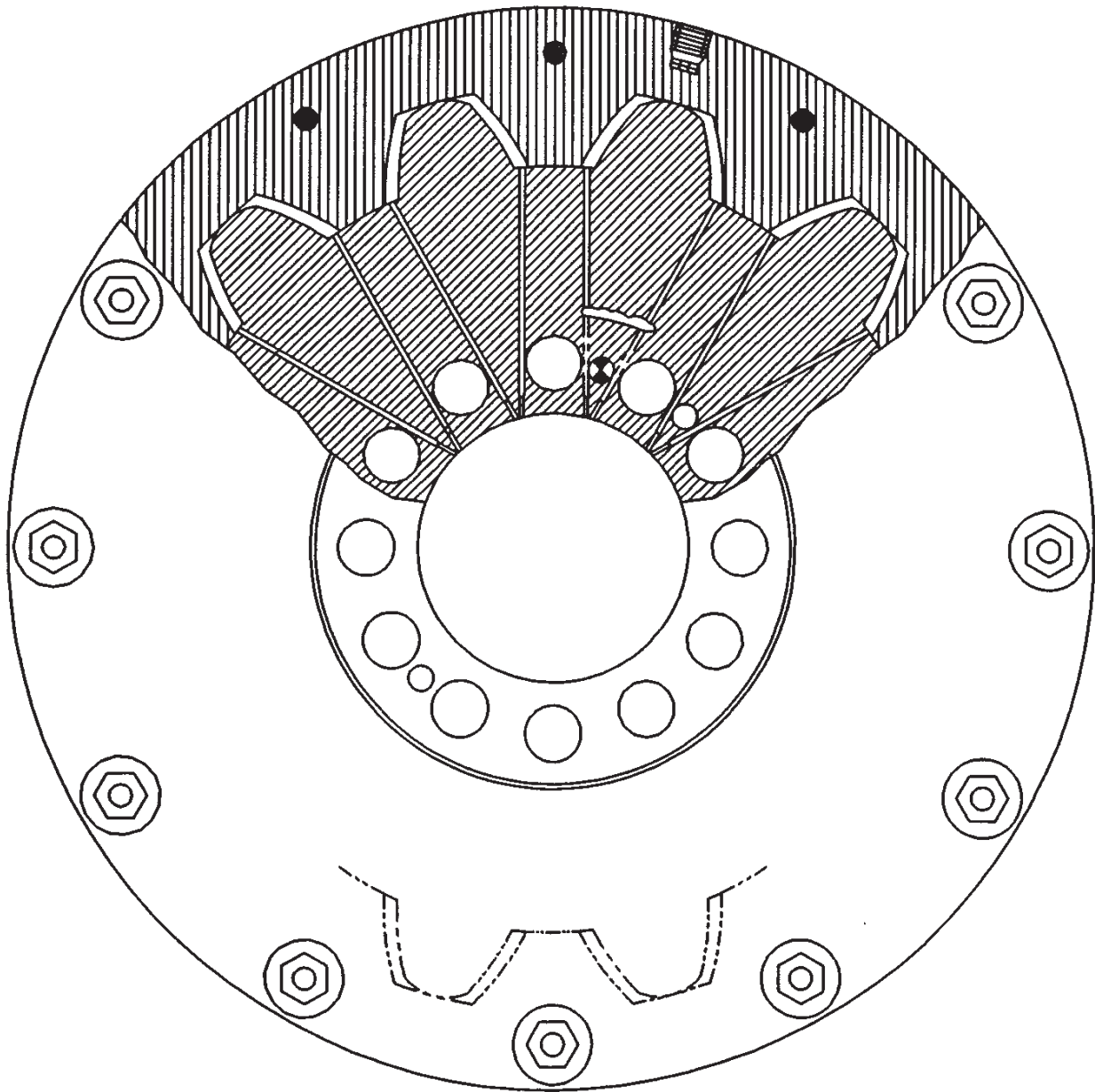


Figure 233-5-4. Gear Type or Hydraulic Type Vibration Damper



and designed to stabilize the intermediate ring as quickly as possible.

### **233.5.96 OTHER TYPES OF VIBRATION DAMPERS**

#### **233.5.97 PENDULUM TYPE**

**233.5.98** A pendulum damper consists of two or more symmetrically located, heavy steel segments or balances suspended so that they can swing in the plane of rotation, as does a pendulum. The weight of the segments and the length of the links are selected so that the natural frequency of the swing of the elements is equal to the frequency of the shaft system vibrations that should be damped out. During undisturbed rotations of the shaft, centrifugal force keeps the pendulum weights at the greatest distance from the axis of rotation. When the shaft starts to vibrate, the weights begin to swing, and they will be periodically drawn nearer the shaft axis. The work of bringing the pendulums closer to the axis against the resistance of centrifugal force is derived from the energy put into the shaft when it starts to vibrate. The work thus reduces this energy and dampens out, or at least considerably reduces, the angle of torsional vibration of the shaft. In actual construction the pendulums are suspended not on links, but on pins inserted through holes drilled in the sectors and in the housing. They are slightly larger than the pin diameter. Their action, however, is the same as that of the links. The Fairbanks Morse opposed piston engine uses damper weights mounted on pins to obtain the same effect.

#### **233.5.99 HARMONIC BALANCER**

**233.5.100** Another type of torsional vibration damper, sometimes called a harmonic balancer, is located on an auxiliary flywheel on the front of a crankshaft driven by flexible leaf springs. The vibrating energy in this case is dissipated by the friction of the leaves of the spring's inelastic couplings between the crankshaft and the main flywheel. The leaves serve to damp out some of the torsional vibration. This kind of damper usually operates in lubricating oil, which dampens the vibrations with its viscous friction and also carries away the heat generated. Similarly, hydraulic couplings or fluid drives also damp out and prevent the transmission of torsional vibration between the crankshaft and the driven load.

### **233.5.101 VIBRATION DAMPER MAINTENANCE**

**233.5.102** Consult the applicable NAVSEA Technical Manual and PMS for preventative and corrective maintenance.

**233.5.103** An inoperative damper may produce rapid failure of bearings or gears connected to it. Long term, a fatigue failure of the crankshaft will occur. Engine driven pumps are usually on the free end of the engine and severe critical vibrations may damage them. Normally, viscous vibration dampers are changed at every engine overhaul period if the time period is not specified by the applicable NAVSEA Technical Manual, TRS or PMS.

**233.5.104** When a vibrating engine is encountered, the alignment of the drive to driven unit immediately becomes suspect, and shall be checked before the vibration damper is condemned.

#### **233.5.105 ENGINE ALIGNMENT**

**233.5.106** Correct alignment shall be maintained internally between the crankshaft main bearing bores, and their bearings. Correct alignment shall be maintained between the engine, generator, reduction gears, shaft coupling or any other driven equipment. Condition of alignment shall be checked at the original machinery installation; after engine overhaul; when engine blocks are lifted or separated from sub-base (foundation), repairs to foundations, collision, grounding and after each undocking or any condition that may effect the alignment of the engine or driven equipment.

**233.5.107** To avoid duplication of efforts, whenever the engine is cast loose from the generator or shaft coupling, realignment shall be accomplished only after the ship is waterborne and with normal trim and load conditions. This procedure eliminates the possibility of aligning the machinery when the abnormal stresses of drydocking distort the hull and machinery foundation. Regardless of the machinery condition, alignment shall not be checked or realigned until a minimum of 48 hours after undocking.



**NOTE**

Specific procedures for alignment for each application see the applicable NAVSEA Technical Manual and original installation drawings.

**233.5.108** The use of shims to correct minor deficiencies in diesel engine installation alignment is an accepted practice in both commercial and military service. The shim(s) shall withstand loads imposed by the weight of the engine package and ships motions as well as mechanical vibration. Excessive deformation of shims can cause loss of bolt preloading. Only composition three shims, corrosion resistant steel, per **MIL-S-22499** up to 0.050 inch thick are acceptable for use with marine diesel engines and their driven equipment. Most high shock installations use hand fitted steel chocks. Shims shall not be used in high shock installations to fit the steel chock to the foundation or the engine.

**NOTE**

For specific instructions for the use of shims in engine alignment see the applicable NAVSEA Technical Manual and the original installation drawings.

**NOTE**

Epoxy chocks (resin type) are not authorized on shipboard diesel engines except main propulsion diesel engines and ship service diesel generators on MSO class ships. Check ship installation drawings to determine the approved type of mounting.

**233.5.109** On large diesel engines, improper main bearing bore misalignment may be found using a deflection/strain gage or by indications of wear in the main bearings. Any indications of misalignment shall be verified by the use of a mandrel. Readings shall be taken on all of the main bearing bores and analyzed.

Misalignment between drive and driven equipment is discovered through the use of a crankshaft deflection/strain gage at the drive end crankthrow. If out of specification, misalignment is indicated in the main bearing bores, the problem may be corrected by pressing, welding and reboring or a combination of two or more repair methods. See paragraph 233.5.133 for additional information. Misalignment of drive and driven units is corrected by realignment.

**233.5.110** The alignment of main bearing bores of small engines is usually checked with the crankshaft and bearing inserts removed from the engine, and the bearing caps torqued in place. The bearing bores can then be checked for alignment, using a mandrel. If serious misalignment is indicated, the most practical solution may be to replace the block.

**233.5.111** Alignment check of the engine and driven equipment is checked, not realigned by a crankshaft deflection readings taken at the crankthrow nearest the coupling. Alignment of a generator set usually is accomplished by moving the generator about until it is properly aligned and installing new chocks and or shims between the generator and its base to maintain correct alignment. When main propulsion diesel engines and couplings are found to be misaligned, the coupling should first be correctly aligned with the drive shaft. The engine is then moved about until it is properly aligned with the coupling and the engine is secured in this position. Detailed alignment procedure and allowable limits recommended for any particular installation of any specific make and model engine usually can be obtained from the applicable NAVSEA Technical Manual and drawings applicable to that installation. When this information is not adequate, additional information can be obtained on a case basis from NAVSEA and Naval Ship Systems Engineering Station, Carderock Division, Naval Surface Warfare Center (NAVSSSES), Philadelphia.

**233.5.112 CRANKSHAFT DEFLECTION**

**233.5.113** The crankshaft of any large diesel engine is one of its most expensive parts, both to purchase and to install, however the effort and time required for its periodic inspection is minimal compared to the crankshaft's importance. An engine running at 500 RPM will rotate over 60 million times a year, and it is clear that every precaution shall be taken to protect the crankshaft from all unnecessary forces that might induce a fatigue failure. The crankshaft should transmit into rotary motion the forces developed in the cylinder

and this is understood and allowed for in the original design. The manufacturer assumes the operator will maintain the shaft in a straight condition so the shaft is not subjected to additional bending loads which add to the normal shaft stresses. If the shaft does not lay in the main bearings, it will be subjected to flexing while turning. Various points on the shaft alternate between compressive and tension stresses once each revolution. If these stresses are too high, the shaft will ultimately break just as a wire will break if bent severely back and forth many times.

**233.5.114** Figure 233-5-5 is a sketch of exaggerated crankthrow flexing through one-half revolution on an out-of-line crankshaft. The stresses produced by this bending are usually greatest in the crankweb along plane A-A. The most critical point is at B where stresses are magnified by the stress concentrating tendency of the inside corner. The crankpin fillet at B is alternately placed in tension and then in compression. Obviously, if the crankshaft centerline were straight the shaft could be rotated without flexing of crankwebs or developing bending stress at the fillet.

**233.5.115** The universal method for checking crankshaft alignment is using the crank shaft deflection/strain gage. The gage is a specially adapted dial indicator which fits between the crankwebs and directly reads the flexing motion of the webs as the crankshaft is slowly turned. The gage dial reads web spreading or closing in 1/1000 of an inch graduations. The dial face is graduated with numbers increasing on each side of zero with the numbers on the left side marked + (plus) and on the right side marked - (minus). If the pointer moves toward the plus side of zero, the webs are opening. Movement toward the minus side indicates that the webs are closing.

**233.5.116** The magnitude of the indicator pointer swing depends on where the gage is located on the webs. The engine manufacturer may specify this as the dimension X shown in Figure 233-5-6 or may provide center punch marks on the webs. The general industry standard is that the dimension X equals 1/2 the engine stroke. Locating the gage further out than the recommended X dimension results in higher indicated deflection values. It is of the utmost importance to locate the deflection/strain gage at the NAVSEA, PMS and manufacturer's recommended location.

### WARNING

When the crankcase is opened for inspection or repairs, the starting system shall be de-energized and or deactivated and tagged out of service in accordance with the current shipboard and or shore tagout instructions.

**233.5.117** Crankshaft deflection readings shall always be taken with the cylinder pressure indicator valves open and the engine prelubed, if prelube pump is available. The engine shall be completely assembled. This includes cylinder heads, pistons, connecting rods, and other parts. Without the strain of the weights of these parts and that of highly stressed bolts, the engine will not assume its natural shape, and accuracy of deflection readings will be affected. The barring device normally does not need to be disengaged when reading the deflection gage.

**233.5.118** The crankshaft cannot be turned a full revolution with the connecting rod and deflection/strain gage in place. On some engines with the deflection strain gage in place, the crankthrow can not be brought to near bottom dead center because of interference with the connecting rod, crankpin and other parts.

**233.5.119** If a crankshaft is not punched marked it shall be punched marked to take and record deflection readings. The punch marks shall be equal distance from the crankshaft (X dimension) to ensure the deflection strain gage is parallel to the crankshaft.

**233.5.120** The center punch marks shall be small and made with a very sharp punch. A good tool for making this mark is the needle valve from a scrapped fuel injector.

### NOTE

The accuracy of deflection readings may be reduced if the marks are too large or not made with a sharp punch.

**233.5.121** When taking deflection readings the engine and deflection gage should be at the same ambient temperature. Readings are taken normally when engines are cold.

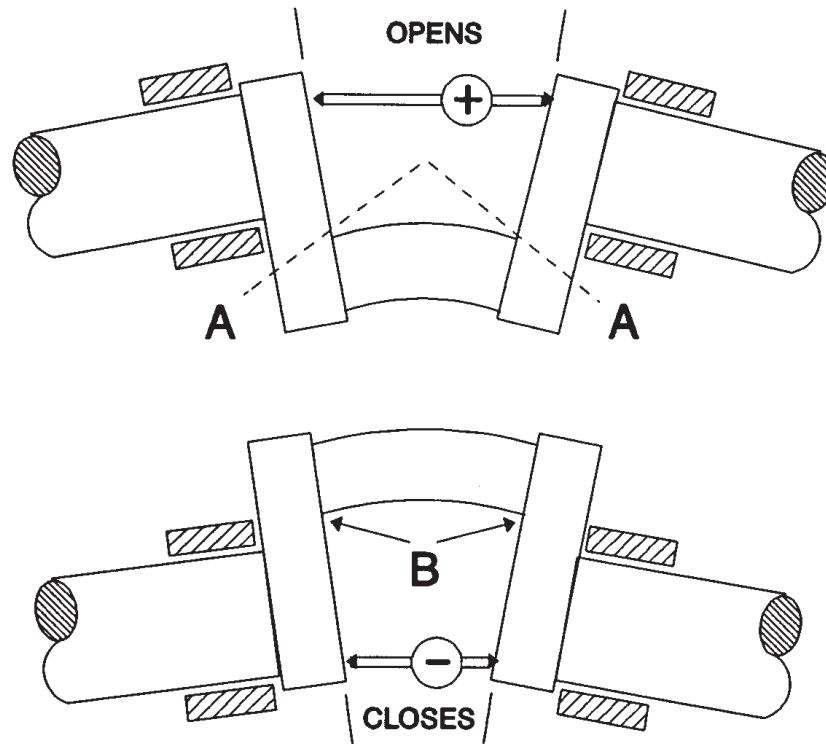


Figure 233-5-5. Out-of-Line Crankshaft Deflection

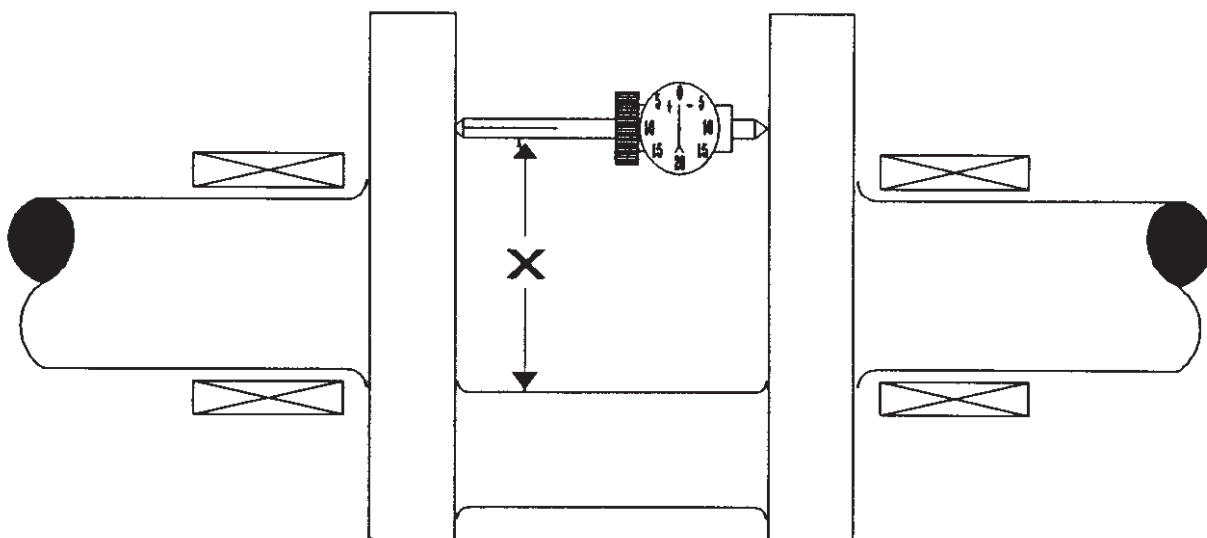


Figure 233-5-6. Mounting the Crankshaft Deflection Gage

**233.5.122** The crankpin should be near the bottom center. Ensure gage needle movement is smooth. Pre load the deflection gage 1/3 of its travel. Place the gage between the webs and adjust the gage to provide sufficient tension to hold the gage snugly in place. Twirl the gage, using the thumb and forefinger, and zero the gage. Repeat this procedure until the pointer remains on zero.

**233.5.123** When the gage maintains a constant zero reading, rotate in the reverse direction of normal engine rotation, stop before hitting the connecting rod. Bump in the normal direction of rotation and rezero the deflecting gage. Slowly turn the crankshaft in the direction of rotation and stop when the gage is in position 2 as shown in Figure 233-5-7. Record any changes in pointer deflection as a + (plus) or – (minus) reading. The magnitude of deflection is usually expressed in quarter-thousandths such as 1/4, 1/2, and 3/4 rather than the more cumbersome 0.00025, 0.00050, or 0.00075.

**233.5.124** Repeat until readings at all five of the positions shown in Figure 233-5-7 have been taken and recorded for each position. Reverse the direction of rotation back to position 1 as shown in Figure 233-5-7. Bump in the direction of rotation to reconfirm zero. If the reading is not within 1/4 thousandths of zero, a complete set of readings shall be retaken. In each instance the 1 and 5 readings should be nearly the same; readings should be repeated if 1 and 5 vary by more than 1/2 thousandths. Usually the most important reading is at position 3 because it indicates:

- a. Bearing wear
- b. Condition of foundation
- c. Position of outboard bearing.

**233.5.125** The drive end, the No. 3 position (bottom) shall show the sign of – (minus) negative, this is due to the weight of the flywheel and coupling. The exception to this is Alco model 251 diesel engines, it is zero in this position. A different method is used.

**233.5.126** When a complete set of deflection readings are taken and recorded, the relative shape of the crankshaft can be sketched as a function of the 3 position readings. Figure 233-5-8 shows three hypothetical sets of deflections illustrating relative crankshaft shapes.

The illustration shows the crankshaft in the up position or at top dead center where the 3 readings are taken.

**233.5.127** For a crankshaft with all + (plus) deflection readings, the webs are open and the crankshaft is convex upwards; – (minus) deflections close the webs and the crankshaft is convex downward, and so forth. Sketching the shaft in this way helps to visualize the shape of the shaft and aids in determining cause of the deflection.

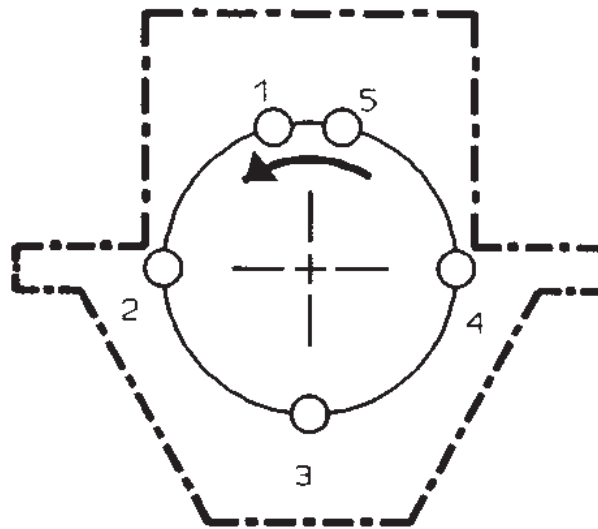
**233.5.128** PMS and the applicable NAVSEA Technical Manual provide guidance and specifications for crankshaft deflection readings. If not available, this information should be obtained from NAVSEA or Naval Ship Systems Engineering Station, Carderock Division, Naval Surface Warfare Center (NAVSES) Philadelphia.

**233.5.129** A rule-of-thumb used for deflection is 0.0001 inch for each inch of engine stroke other than the last throw on the flywheel end. Actually, the amount of deflection the crankshaft will tolerate is dependent on the design and material used. A fairly limber shaft with large fillets may be able to sustain rather large deflections whereas a more rigid shaft with small fillets would have to be held within much closer tolerances. Study the results carefully because changes in deflection patterns may be caused by worn bearings, foundation deformation, loose foundation bolts and perhaps other reasons that should be investigated. By use of regular deflection tests and bearing inspections, there is no reason why the crankshaft will not last the life of the engine.

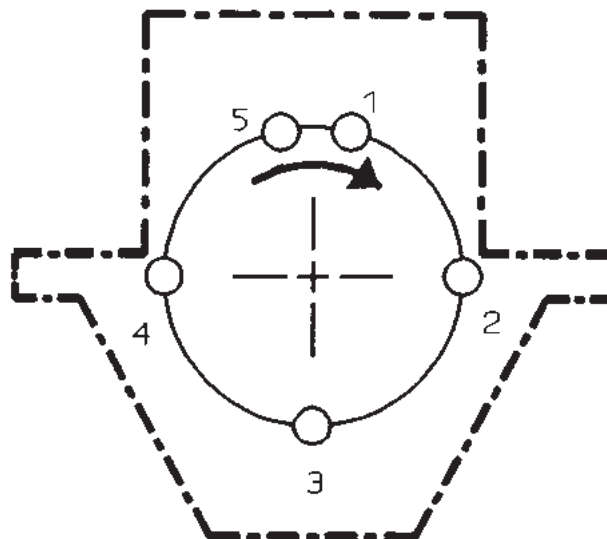
### **233.5.130 CRANKCASE, FOUNDATION AND FRAME REPAIR**

**233.5.131** Whenever large diesel engines, such as Fairbanks Morse Model 38D8-1/8, Alco, EMD or other large engines are stripped of parts for a general overhaul, the frames can be inspected by the magnetic particle method in the highly stressed area of the block. Highly stressed welds are defined as:

- a. Welds between bearing blocks (upper and lower) and the main vertical frames.
- b. Welds between decks and main frames.
- c. Welds of ribs and gussets in vertical drive housing and flywheel and frame.



**COUNTERCLOCKWISE**



**CLOCKWISE**

Figure 233-5-7. Angular Position for Taking Crankshaft Deflection

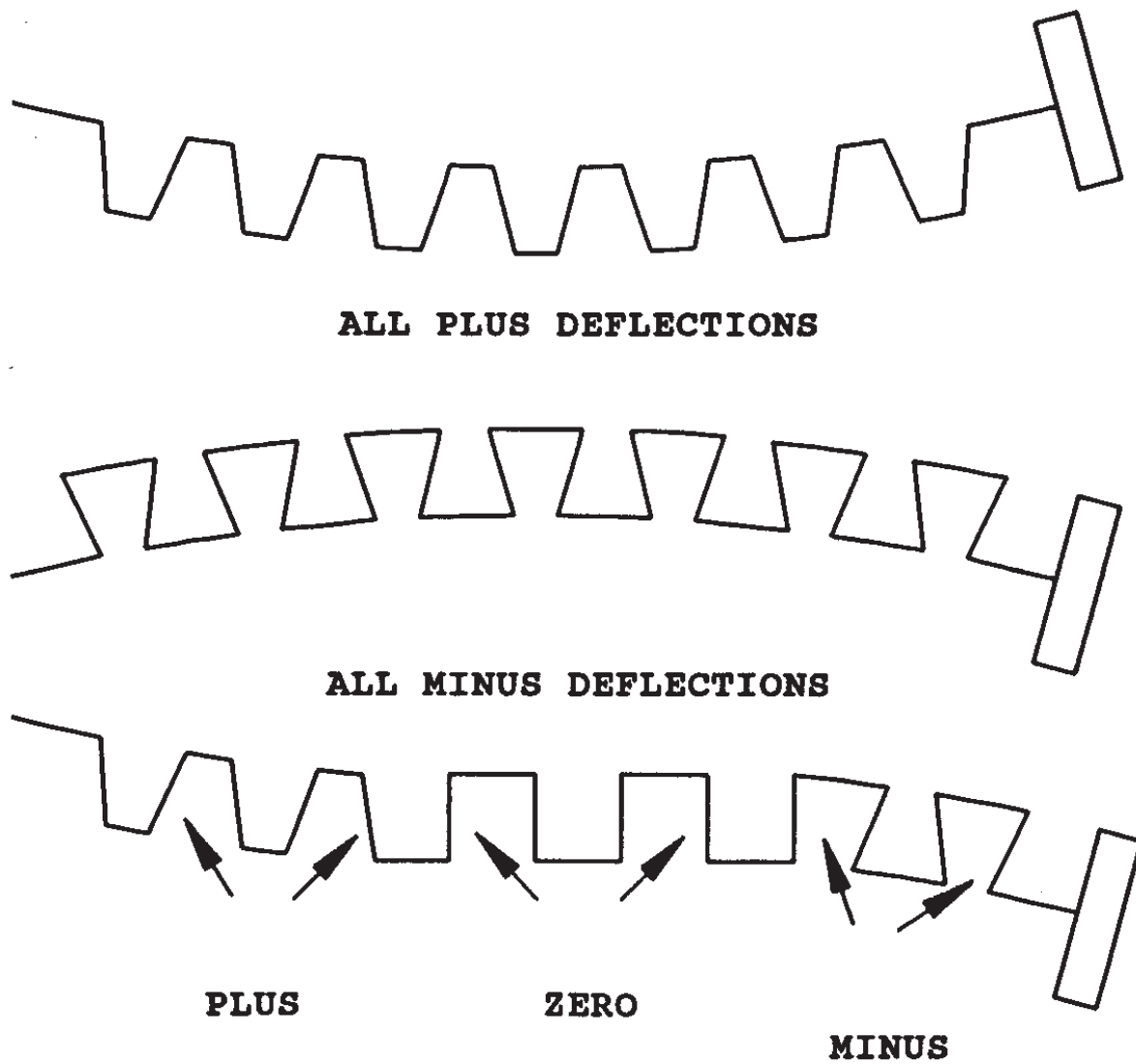


Figure 233-5-8. Sketches of a Relative Crankshaft Shape

**NOTE**

Never use magnetic particle Non Destructive Test (NDT) on Isotta Fraschini (IF) blocks or other components.

**233.5.132** The repair welding of any cracks or defects revealed shall be in accordance with MIL-STD-278 and the applicable instruction manual for the equipment.

**233.5.133** For crankcase foundation repair instructions for all engines, including non-magnetic engines, see the applicable NAVSEA Technical Manual or contact NAVSEA and Naval Ship Systems Engineering Station, Carderock Division, Naval Surface Warfare Center (NAVSSSES), Philadelphia.

**233.5.134 WELDING ON ROTATING MEMBERS**

**233.5.135** Welding on moving or rotating equipment shall not be undertaken unless facilities to maintain and check alignment comply with the fabrication document requirements. If emergency conditions require work on such items where adequate facilities and equipment are not available, a record of details of the work that was accomplished and the extent of noncompliance with the applicable fabrication document shall be made. This information shall be appropriately recorded as a departure from specification.

**233.5.136 WELDING RESTRICTIONS**

**233.5.137** No welding shall be accomplished on any diesel engine without specific approval of NAVSEA. No welding shall be accomplished on any gears, such as main propulsion units, clutch and coupling assemblies, and similar components essential to the mission of the ship without approval of NAVSEA. No welding shall be accomplished on cast or nodular iron without an approved specific procedure for the material and application from NAVSEA.

**233.5.138** When requesting approval for welding, the exact location, reason for the welding, description of the welding procedure to be used, and related information shall be forwarded to NAVSEA with the request.

**233.5.139** Crankshaft and engine block weld repairs requires formal acceptance by NAVSEA or its authorized representative. Approval shall be by

NAVSEA authorized representatives unless NAVSEA approval is specified by correspondence. Authorized representatives of NAVSEA for purposes of approval is the Naval Ship Systems Engineering Station, Carderock Division, Naval Surface Warfare Center, Philadelphia.

**233.5.140 DIESEL ENGINE MOUNTED PIPING MATERIALS****CAUTION**

Do not use copper tubing or pipe for gage lines in fuel or lube oil systems.

**233.5.141** Diesel engine mounted piping is defined as piping attached to the engine in the solid line portion of the jacket water, seawater, fuel oil, and lubrication oil piping diagrams in the engine technical manual. All other diesel engine installation related piping is defined in the applicable NAVSEA Technical Manual, or is governed by the provisions of MIL-STD-777, **Schedule of Piping Valves, Fittings, and Associated Piping Components for Naval Surface Ships**. Flexible hoses conforming to MIL-E-24455 and MIL-E-23457 may be used. Flexible hose may be used in conjunction with hard piping as needed.

a. Diesel engine fuel and lube oil system gage lines shall be in accordance with paragraph 233.5.141 and subparagraphs a.1 and a.2.

1. Corrosion resisting steel (CRES) conforming to MIL-P-1114 or ASTM A376 (Grade 304L or 316L) shall used. CRES is nearly inert in contact with petroleum based fluids, has superior mechanical properties, and can provide good service for the life of the ship.

2. Flexible hoses conforming to of MIL-E-24455 and MIL-E-23457 may be used. Flexible hose may be used in conjunction with hard piping as needed. Flexible hose offers ease of installation by field activities and can provide satisfactory service for up to ten years with annual inspection.





## SECTION 6. CORROSION PREVENTION

### 233.6.1 PROTECTION AGAINST CORROSION FOR ENGINES TEMPORARILY INACTIVE

**233.6.2** Diesel engines in active service require jacket water cooling system protection against corrosion, scale and cavitation. Section 10 and Planned Maintenance System (PMS) provides detailed procedures for jacket water cooling system protection. The lube oil and the fuel oil systems also require protection against corrosion, the fuel and the lube oil fluids provide the required protection. Engines placed in stock for use as replacements, and engines inactivated for 9 months or more require protection against corrosion. Engines inactive for less than 9 months also require protection against corrosion but to a lesser degree.

### 233.6.3 ENGINES TEMPORARILY INACTIVATED

**233.6.4** Engines temporarily inactivated from 1 to 9 months during ship repair or overhaul, shall be suitably protected against sand, dust, corrosion, weather, industrial environment and accidental damage by working personnel. PMS provides guidance for engines laid up for 1–9 months. Engine jacket water coolant need not be drained, however cooling water inhibitor chemistry shall be maintained in accordance with Section 10, and PMS.

**233.6.5** Engines removed from a ship or small craft, shall be moved to an inside secured storage area ashore. Engine openings such as air intake and exhaust, or inlet connections to the ship air or fluid systems shall be covered by use of a gasket and a bolted blank flange. Openings may be covered and taped, when blank flanges are not practical. Exterior metal surfaces should be inspected for chipping or scrapes and the engine should be painted where necessary. A simple umbrella type covering such as a tarpaulin is adequate. The engine should be positioned in an area which affords protection against excessive airborne contaminants, wetting, pilfering, or damage by warehouse activity.

#### CAUTION

Engines containing demagnetized parts, such as Isotta Fraschini (IF) shall be stored in accordance with the applicable NAVSEA Technical Manual to preserve low magnetic signature.

### 233.6.6 PRESERVATION OF DIESEL ENGINES TEMPORARILY INACTIVATED FOR 9 MONTHS OR MORE ONBOARD U.S. NAVY COMMISSIONED SHIPS, INACTIVATED SHIPS, SMALL CRAFT AND BOATS

**233.6.7** The following instructions are issued as general guidance to be amplified as the detailed design of the particular engine and application requires.

### 233.6.8 MATERIALS REQUIRED

1. MIL-L-21260 Grade 10
2. MIL-L-21260 Grade 30
3. MIL-L-21260 Grade 40
4. MIL-I-23310 Grade II
5. Lint free rags
6. Masking tape
7. Heavy cardboard or plywood 1/4"
8. Tags, waterproof

### 233.6.9 APPLICATION OF MIL-L-21260

#### CAUTION

Lint-free rags shall be used for cleaning lube oil and fuel oil system.

1. Thoroughly drain the lube oil system. Drain the cooler and all low points of the system. Discard lube oil.

#### NOTE

Refer to **NSTM Chapter 593, Pollution Control**, for proper disposal instructions.

2. Remove the oil filters, clean the interior of filter container and renew the elements.

3. Remove and clean the lube oil strainer and the interior of container, replace or clean the strainer element, as applicable.

4. Clean and wipe the lube oil sump using lint free rags only.

**CAUTION**

When the engine sump is open, care shall be taken that no foreign material is allowed to enter the lube oil sump. Never leave an open engine unattended. Before the engine lube oil sump or any part of the engine is closed, a complete inspection shall be performed to ensure that no foreign material, rags, tools, etc, is left in the lube oil sump.

5. Fill the lubricating oil system to normal capacity for operation with MIL-L-21260 Grade 40.

**NOTE**

MIL-L-21260 Grade 30 may be used as an alternative based on availability of Grade 40.

**CAUTION**

Use only MIL-I-23310 Grade II or MIL-L-21260 Grade 10 as an alternate in the fuel system.

6. Remove the fuel filters and the fuel strainer elements, clean the strainer and the interior of the filter and strainer housing. Reinstall the strainer and new filter element(s). Fill the housing with MIL-I-23310 Grade II or if unavailable use MIL-L-21260 Grade 10 before installing covers.

**CAUTION**

Do not use any other grade in the fuel system other than MIL-I-23310 Grade II or MIL-L-21260 Grade 10.

7. Disconnect the fuel oil line at the supply pump or any other convenient place in the suction side of the fuel pump.

8. Install a temporary suction connection to take a suction from a 5 gallon (minimum size) container filled with MIL-I-23310 Grade II or if unavailable use MIL-L-21260 Grade 10 to the normal fuel supply header.

9. Disconnect the return line from the fuel supply header so that the return fuel discharges to a 5 gallon container or larger.

10. If the speed control governor has its own oil supply, drain the governor and fill to the normal operating level with MIL-L-21260 Grade 30 or 40.

11. Start the engine in accordance with normal operating procedures or **Engineering Operating Sequencing System (EOSS)**.

**NOTE**

Recheck the lube oil level after priming to ensure that the engine sump is at the proper level.

**CAUTION**

Observe the lube oil pressure. If the lube oil pressure is not observed within 10 – 15 seconds secure the engine.

**NOTE**

Engine oil pressure may be higher or lower from normal when using MIL-L-21260 lube oil.

12. Let the engine idle for 5–6 minutes.

**CAUTION**

Do not let engine run out of preservative supplying the fuel system. Ensure that the fuel suction line stays submerged in the preservative.

13. Raise the engine speed to mid range of the normal operating speed.

14. Observe the fuel oil return line. Stop the engine in accordance with **EOSS** or approved operating procedure when a clear supply of the preservative is observed at the fuel return line.

#### NOTE

Engine shall run a minimum of 15 minutes before stopping.

15. Let the engine stand for 12 hours to allow all the lube oil to drain down.

16. Thoroughly drain the lube oil system. Drain all the low points of the system and coolers.

#### CAUTION

Do not bar, jack, or roll engine over. Disruption of the protective film will occur.

#### NOTE

Preservative oil, if not dirty or contaminated may be reused to preserve other engines. Extreme care shall be used to keep the preservative compound clean.

17. Drain the oil filter and the strainer housing. Do not wipe interior of the housings. Filter elements need not be removed.

18. Drain the fuel filter and strainer housing. Do not wipe interior of housing. Filter elements need not be removed.

19. Do not drain the governor. Tag the governor stating that it is filled with MIL-L-21260 Grade 30 or 40.

#### NOTE

Governor shall be flushed and filled in accordance with PMS and the applicable NAVSEA Technical Manual before reactivating engine.

20. Reconnect the fuel supply and return lines to the normal supply and return.

21. Wipe or spray MIL-L-21260 Grade 30 or 40 on the governor, fuel linkage and all exposed unpainted surfaces.

22. Ensure the jacket water treatment is in accordance with Section 10 and PMS.

23. Blank off the intake air supply and exhaust piping with plywood or other suitable material to prevent entrance of foreign material.

24. Tape and cover all other openings to prevent entrance of dirt, foreign material and water.

25. Tag the engine to indicate that the diesel engine has been treated with a rust preventative compound. The tag shall include:

a. The date the engine was laid up.

b. The statement that the engine is not to be turned over until ready to be put into operation because disruption of the protective film will occur.

c. The statement that the procedure as specified in paragraph 233.6.12 shall be followed before placing the engine in service.

d. The statement that the lubrication, cooling, and the fuel systems shall be filled before operating.

e. Any special instructions for preservation or startup.

#### 233.6.10 PRECAUTIONS DURING PRESERVATION

#### NOTE

Specific tags are needed for different locations, governor sump etc., where different preservatives have been used.

**WARNING**

When the compounds are used in confined spaces, adequate ventilation shall be provided; avoid open flames and sparks when spraying flammable liquids. All normal safety precautions for combustible material shall be applied.

**233.6.11** Used preservative compounds may be added to and reused for the same purpose. Extreme care shall be exercised to keep the compounds clean.

**233.6.12 STARTING DIESEL ENGINES AFTER PRESERVATION WITH MIL-I-23310 AND MIL-L-21260**

1. Check the preservative tags for special instructions.
2. Disconnect the fuel return lines, prime the fuel system with clean diesel fuel until a clean supply of diesel fuel is observed at the fuel return line.
3. Reconnect the fuel return lines.

**CAUTION**

Use lint-free rags only.

4. Clean and wipe excessive MIL-L-21260 from the lube oil sump.
5. Fill the sump to normal operating level with MIL-L-9000 series oil.
6. Ensure the jacket water cooling system water chemistry is in accordance with Section 10 and PMS.
7. Drain the engine governor and flush in accordance with PMS. Fill with normal operating fluid.

**NOTE**

Governor will have to be properly flushed after engine is operating in accordance with the applicable NAVSEA Technical Manual and PMS.

8. Check and verify that all other engine support systems are functioning properly and ready to support diesel engine operation.

9. Perform all applicable inactive equipment maintenance PMS related to start up or prolonged idleness.

10. Remove all the engine inspection, hand hole covers and rocker arm covers if applicable.

11. Prelube the engine, ensure that lube oil is reaching all moving visible parts, i.e., main bearings, connecting rod bearings, rocker arm assembly, crankshaft, turbocharger, blower bearings and etc.

12. Reinstall all removed inspection and hand hole covers.

13. Start the engine in accordance with normal operating procedures or **Engineering Operating Sequencing System (EOSS)**.

14. Observe all operating parameters for normal operation, if any abnormal conditions exists, the engine shall be stopped and the abnormality investigated to find and correct the cause.

**NOTE**

The engine will smoke excessively for a short period of time due to the preservative oil in the fuel injection system.

15. After 10 minutes of operation, draw a oil sample for **Naval Oil Analysis Program (NOAP)** and submit.

16. If all conditions are normal, conduct trend analysis in accordance with current PMS requirements.

17. If the trend analysis results are satisfactory, return engine to normal service.

18. After completion of trend analysis, submit a oil sample for **Navy Oil Analysis Program (NOAP)**.

**233.6.13 ENGINES TO BE STORED**

**233.6.14** An engine being placed into the Navy Supply System to be stored until issued as a replacement or government furnished equipment to

ship builders, requires extensive preservation and packaging. This requirement includes new engines, overhauled engines, and used engines which are to be held for future overhaul or use, for periods exceeding 9 months or more.

### 233.6.15 NEW ENGINES

**233.6.16** New engines should be received from the supplier completely preserved and packaged in accordance with MIL-E-23457 and MIL-E-24455. New engines need no maintenance except periodic inspection of desiccants.

### 233.6.17 OVERHAULED ENGINES

**233.6.18** Overhauled engines which will not be operated for 9 months should be preserved and packaged in accordance with **Engines, Preparation for Shipment and Storage of, Type IV**, MIL-E-10062, as supplemented by **Engines, Diesel, Propulsion and Auxiliary, Naval Shipboard**, MIL-E-24455 and MIL-E-23457.

### 233.6.19 USED ENGINES

**233.6.20** Used engines which are to be stored indefinitely awaiting overhaul, or engines installed in ships which are to be inactivated require extensive corrosion preventative measures. The engines should be completely drained of all engine fluids and corrosion resistant compounds applied. All openings, such as air intake and exhaust headers and fluid system flanges, should be covered and taped. Engines destined for shed storage, shall be packaged in accordance with Method II of MIL-P-116, which calls for a floating waterproof bag with desiccant. If a replacement engine is received in a reusable container such as a plywood box, encased zipper type plastic bag, or hermetically sealed metal can, the replaced engine should be stored in these containers after preservations have been applied.

### 233.6.21 INITIAL RECEIPT INSPECTION

**233.6.22** New or stocked engines furnished to contractors or repair facilities are usually opened for an initial receipt inspection. Unless the engine is to be installed immediately, careful opening and resealing procedures are necessary. The exterior box and engine container should be opened in accordance with instructions stenciled on the container or received from the shipping activity. After the inspection is completed, any disturbed preservative should be repaired, the container repaired as required, and resealed. The plywood box should be closed to prevent damage during

storage. The inspection should be performed in a sheltered area. In no instances should the package remain open in a salt-spray and an industrial environment.

### 233.6.23 CORROSION PREVENTION COMPOUNDS

**233.6.24** The specification for corrosion resistant compounds are covered by **Compound, Corrosion Preventive, Solvent Cutback, Cold Application**, MIL-C-16173, **Lubricating Oil, Internal Combustion Engine, Preservative**, MIL-L-21260 and **Inhibitor, Corrosion, Volatile, Oil Type** MIL-I-23310. The compound covered by MIL-L-16173 specifications are for fluid solutions at ordinary room temperatures. At temperatures approaching 1.7° C (35° F) or below, MIL-L-16173 compounds may become excessively viscous, and solid constituents tend to separate from the solution, resulting in stratification. This may be corrected by warming or agitating the compounds or both.

#### CAUTION

The flashpoint of MIL-L-16173 is approximately 37.7° C (100° F). It shall therefore be applied cold.

**233.6.25** MIL-L-16173 corrosion prevention is intended for use on metal surfaces as authorized in this section. It is not to be used on surfaces directly adjacent to electrical insulation.

#### CAUTION

All grades of MIL-L-16173 corrosion preventative and petroleum solvent cleaners are flammable materials. Continued exposure of personnel to the vapors given off by the compound may be a health hazard. Suitable precautions shall be taken to reduce the hazards.

**CAUTION**

MIL-L-11673 corrosion preventive compound is injurious to rubber and electrical insulation such as varnishes, tapes, and fabrics, and should not be permitted to come into contact with them at any time.

**233.6.26** The compounds covered by MIL-C-16173 are essentially a combination of two major elements; a solvent which evaporates, and a blend of semisolids that are left behind as a thin, tenacious protective film. These films are essentially nondrying, except for grade 1, which does dry hard in about 4 hours; even grades 2, 3 and 5 may eventually harden until it is extremely difficult to remove these compounds (particularly after long exposure periods) from small orifices or areas through which the removers cannot readily flow.

#### **233.6.27 GRADES OF COMPOUNDS AND DESCRIPTION**

**233.6.28** MIL-C-16173 has five grades of corrosion preventive compounds. Selection for use of any of the compounds depends on the degree of weather protection to be afforded the stored engine. All grades readily wet a metallic surface and will, upon evaporation of the solvent, form a coating which is continuous, noncracking, nonvolatile when dried and, except for Grade 4 which is transparent, are easily discernible by their brown or black color. These compounds are sprayable above 4.4° C (40° F) and are sufficiently dry within 4 hours to permit handling, without injury to the film or personnel involved. Description of the five grades of compounds are:

**CAUTION**

Do not use grade 1 in lubrication or cooling systems.

a. Grade 1 An asphalt base compound intended for use on ferrous or nonferrous metal surfaces subjected to all weather conditions. It may also be applied to equipment stored under cover when required. The film dries hard to the touch in about 4 hours, and maximum

protection is obtained about 2 days after application. Removal of the film upon activation is usually not required.

**CAUTION**

Do not use Grade 2 in water jackets.

b. Grade 2 This amber colored compound is for use on ferrous and nonferrous metals when extended protection is required for interior or exterior surfaces of machinery and equipment not exposed to the weather. After the solvent evaporates, the resulting film remains soft for about 4 months. It may be recoated 12 hours after application. This compound mixes readily with lubricating oils, but very long periods of flushing may be required if the compound has aged over an extended period of time. Removal after short periods is usually readily accomplished with either petroleum solvents or vapor degreasing compounds.

c. Grade 3 This compound is intended for use on ferrous and non-ferrous metals. It leaves a very thin nondrying film upon evaporation of the solvent; its ingredients have a greater affinity for metals than water has, thus giving water displacing characteristics to the film. For this reason grade 3 is used in water contact areas such as in the interiors of water jackets. A disadvantage of grade 3 is that it will not be completely removed by the circulation of steam or hot water, particularly after it has aged for a long period of time. Additional coats may be applied about 6 hours after initial application, however, this provides no particular benefit.

d. Grade 4 This is a transparent, tack free coating suitable for general purpose indoor or limited outdoor preservation. This coating will not mix with lubricating oil and shall not be employed on oil wetted surfaces. It is intended for use where a transparent film is desirable and where removal with Stoddard's solvent is important.

e. Grade 5 This is much like grade 3, and is used for the same purposes. The reason for using it is ease of removal upon activation. Low pressure steam or hot water are usually entirely effective. This property makes grade 5 particularly valuable for magnesium or aluminum surfaces where boil out with an alkaline solution would be destructive to these metals.



**233.6.29** The compounds covered by MIL-L-21260 are grade 10, 30 and 40 nondrying lubricating oils with a corrosion inhibitor additive. These compounds are used in all systems for new procurement, long term storage engines. They are most effective when Method II packing (the sealed vapor bag) is used. These compounds also would be effective when the engine room is dehumidified. To prevent damage to fuel injection components during preservation and depreservation, only Grade 10 of MIL-L-21260 should be used.

### **233.6.30 APPLICATION OF COMPOUNDS**

#### **233.6.31 APPLICATION**

**233.6.32** The compounds are applied by spraying, dipping flushing or brushing, as appropriate. Spraying and dipping are the preferable methods, because these methods produce more uniform coatings, which are neater in appearance, and cracks and crevices are penetrated. Normally it is not necessary to disassemble the apparatus for application to interior surfaces, accomplish by flushing or by fogging (spraying) through access openings. A high pressure spray, creating a fog, will satisfactorily coat the interior of gears, cylinders and blocks. For equipment with inaccessible interior surfaces, the fog or spray has a tendency to follow the normal vapor paths, and remote areas may not be coated with preservative. Take proper precautions to ensure the compressed air is dry and that water is not being mixed with the preservative. Dipping is best for small articles, such as repair parts, tools, bolts, and nuts. Flushing shall be used for the interior of lubricating systems to protect shaft journals.

#### **233.6.33 APPLICATION PRECAUTIONS**

**233.6.34** While means of application may differ, depending upon physical characteristics of machinery or equipment concerned, individual procedures in each case shall be such as to bring the compound into intimate contact with the metal to be protected, so that a continuous film is formed. It is also important that all excess compound be drained. Failure in this respect may result in leaving pools of compound, which in time solidify and can cause damage when operation of machinery is resumed. While a single unbroken film will provide adequate protection, it is advisable to apply two coats, to ensure thorough coverage. It is important that application to weather exposed surfaces be made in good, dry weather, which shall include the drying time between coats. Inclement weather, within 12 hours of

outside applications, will necessitate the reapplication of compound preceded by measures to ensure a clean dry surface. If an article preserved with the compound is touched by the bare hand, corrosion may occur unless the part is cleaned where touched and the compound is reapplied. Rotating machinery shall not be jacked or barred after preservation; to do so damages the preservation coating. If the machinery is operated or rotated, the compound shall be reapplied to wearing surfaces.

### **233.6.35 PRESERVATION OF DIESEL ENGINES BY MOTORING**

#### **CAUTION**

Ensure engine does not start while motoring.

**233.6.36** The following instructions are a general guide to be amplified as the detailed design and application of the particular engine requires. Ensure that a sufficient quantity of the appropriate grade of compound is brought into intimate contact with the metal to be protected. The compound shall displace any remaining trace of dirt, water, or oil and leave a continuous protective film on the surfaces. The excess compound is drained off to prevent the formation of stagnant pools which may, with age, tend to solidify and complicate putting an engine back into service. When engines are preserved and stored in a dehumidified space, no external preservation need be applied. Definitions of the preservatives are:

- a. MIL-L-21260, Grade 30 or 40, for all fluid systems and internal surfaces of diesel engines.
- b. Appropriate grade of MIL-C-16173 for engine water, lubricating systems and external surfaces of all engines.

**233.6.37** If motoring or operation on air is feasible, the procedural steps are:

- a. Thoroughly drain the engine of all water, lubricating oil, and fuel oil.
- b. Remove the oil cartridge type filter elements and clean the interiors of all strainer and filter housings or containers.
- c. Install new cartridge type filter elements.

d. Flush the engine seawater system with MIL-L-16173, Grade 3 or 5 preservative.

e. Drain the jacket water system and fill with MIL-L-16173, Grade 3 or 5 preservative by connecting a supply line to the drain connections for the system. Cause the system to overflow from expansion tank vent to ensure that all surfaces are coated with the preservative. All ferrous parts, such as shafts, gear, flanges, or studs should be properly treated.

f. Fill the lubricating system to normal capacity with MIL-L-16173, Grade 2 preservative so the pump can take a full suction and, in wet sump type engines, a good splash effect from the crankthrows can be attained.

g. Disconnect the suction fuel line and circulate MIL-I-23310, Grade I or if unavailable use MIL-L-21260, Grade 10 through the injectors, booster pumps, filter, and fuel lines. Spray or brush preservative on internal surfaces of fuel tanks.

h. Relieve the cylinder compression by opening the indicator cocks if installed.

i. Drain the lubricating oil and cooling water from the cooler for the engine reverse and reduction gear systems.

j. Treat all filters and strainers in the reduction and reverse gear lubricating oil system, in the same manner as described in paragraph 233.6.38 and sub-paragraphs b. and c., for the engine system.

k. Flush the reverse and reduction gear lube oil cooling system with preservative.

l. Fill the reverse and reduction gear lubrication system to normal capacity with preservative.

### CAUTION

Ensure the engine does not start while motoring.

m. Motor the engine at a speed sufficient to circulate the compound through the engine systems. Several minutes should be adequate, but visual checks

should be made to ensure that the compound is reaching all points. If an electrical starting motor is used for turning the engine, runs should be limited to 30 seconds each to prevent overheating the motor; at least 2 minutes should elapse between runs.

n. Remove the inspection and access covers and spray all gears, rockers, linkage, cams, and push rods with MIL-L-16173, Grade 2 preservative while the engine is being motored. Spray all surfaces, bearings, linkages, and working parts of dry type clutches and reverse mechanism. (No harm will be done if compound comes in contact with friction surfaces.)

o. Drain excess compound from all systems, paying particular attention to the low spots, pockets, and exposed piping in which the compound could collect. Save drained compounds for future use.

p. Reconnect all the lines for normal operation.

q. Replace all the inspection, handhole, and valve covers.

r. Seal all openings into the engine to prevent entrance of dirt or water.

s. Using MIL-L-16173, Grade 2 compound, spray or brush over all external unpainted areas. If the engine is to be exposed to the weather, Grade 1 compound should be used for this purpose. When engines are preserved and stored in a dehumidified space in a warehouse or aboard ship, no external preservative need be applied.

t. Tag the engine to indicate that the fluid systems have been treated with rust preventive. The tag shall include:

1. The date the engine was laid up.
2. The statement that the engine is not to be turned over until ready to be put into operation because disruption of protective film will occur.
3. The statement that the procedure as specified in paragraphs 233.6.44 through 233.6.46 shall be followed before placing the engine in service.
4. The statement that the lubrication, cooling, and fuel systems shall be filled before operating.
5. Any special instructions for preservation or startup.



### 233.6.38 LAYING UP DIESEL ENGINES WHEN MOTORING IS NOT POSSIBLE

**233.6.39** Where it is not practical to motor an engine over by air, starting motor, or motorized generator to treat it with thin film rust preservative compound, procedural steps for application are:

1. Drain the fuel and water systems completely.
2. Fill jacket water cooling system with preservative MIL-C-16173, Grade 3 or 5 by connecting a supply line to the drain connection for the system. Cause the system to overflow from expansion tank vent to ensure that all surfaces are coated. Drain compound from the system and close the drain connection.
3. Fill the seawater system with MIL-L-16173, Grade 3 or 5 preservative in the same manner as is done with the jacket water cooling system. If installed in a ship, ensure that the seawater inlet and overboard valves are locked closed and do not leak. All ferrous parts such as shafts, gears, flanges, or studs should be properly treated.
4. Drain the lubricating oil system. Remove the oil filter elements, clean the strainers, and wipe down the interiors of the strainers and filter containers. Install new filter elements.
5. Disconnect a pipe fitting in the lubricating oil piping system and connect the discharge side of a separately driven pump to the disconnected engine lubricating oil system fitting.
6. Use the separately driven pump to circulate the preservative MIL-C-16173, Grade 2 throughout the lubricating oil system of the engine while the engine is being jacked or barred over. The discharge pressure of the separately driven pump should approximate the operating pressure of the engine lubrication oil system. Where possible, access plates should be removed to determine that the compound reaches all points of the lubricating oil system.
7. The interior surfaces of the engine should be sprayed with preservative. This should include all internal parts such as the crankcase, connecting rods, crankshaft, and lower cylinder bores.
8. Remove the inspection and access covers and spray all gears, rockers, linkage, cams, and push rods with preservative while the engine is being jacked or barred over with the turning gear. Spray all surfaces,

bearings, linkages, and working parts of dry type clutches and reverse mechanism. (No harm will be done if compound comes in contact with friction surfaces.)

9. Circulate MIL-I-23310, Grade I or if unavailable use MIL-L-21260, Grade 10 through injectors, fuel lines, booster pump, and filters. Drain all the excess compound from the fuel system.

10. Spray or brush preservative on the internal surfaces of fuel tanks and drain off any accumulation.

11. Disconnect the separately driven pump, installed in step 5.

12. Remove excess preservative by draining compound from all the low points of the system.

13. Replace the access plates and covers using new gaskets.

14. Seal all openings into engine to prevent entrance of dirt or water.

15. Using MIL-C-16173, Grade 2 compound, spray or brush over all external unpainted areas. If the engine is to be exposed to the weather, Grade 1 compound should be used. When engines are preserved and stored in a dehumidified space in a warehouse or aboard ship, no external preservation need be applied.

16. Tag individual areas of the engine to indicate that the fluid systems have been treated with a rust preventive compound. The tag shall include:

- a. The date the engine was laid up.
- b. The statement that the engine is not to be turned over until ready to be put into operation (because this may impair the protective film).
- c. The statement that the procedure as specified in paragraphs 233.6.44 through 233.6.46 shall be followed before placing the engine in service.
- d. The statement that the lubrication, cooling, and fuel systems shall be filled before operating.
- e. Any special instructions for preservation or startup.

**233.6.40** The compounds used have excellent flushing properties. When treating a dirty engine, remove any foreign matter which may collect on screens and strainers before considering the engine properly treated and ready for future service.

**233.6.41 STARTING DIESEL ENGINES AFTER PRESERVATION WITH COMPOUNDS****WARNING**

The total volume of the combustion space is small and an excess of compound may result in a hydraulic lock and cause serious damage when the engine is started. The engine shall be turned by hand through several revolutions prior to any start attempt with the pressure indicator valves open if installed.

**233.6.42** Prior to operating an engine which has been out of service and treated with rust preventive compounds, the engine shall be hot lube oil flushed in accordance with Section 8.

**233.6.43** The procedure to be followed in removing rust preventative compound from the cooling system is:

**WARNING**

All chemicals and solutions shall be turned into the Public Works Officer or Public Works Center at any Naval Shipyard or other Naval Industrial Facility for proper disposal.

**CAUTION**

This procedure shall not be used in systems containing aluminum.

1. Fill the jacket water cooling system with water meeting the requirements of paragraph 233.10.15 and operate the engine for 5 minutes to ensure that no leaks are present in the cooling system.

2. Secure the engine and drain the cooling system.

3. Fill the cooling system with sodium metasilicate (NSN G6810-00-664-7062) and a 0.1 percent wetting agent (NSN G7930-00-282-9699) solution in water meeting the requirements of paragraph

233.10.15. This solution may be made up by adding sodium metasilicate in a concentration of 16.7 pounds of sodium metasilicate and 0.83 pounds (approximately 1/2 pint) of wetting agent for each 100 gallons of solution required.

4. Start the engine and operate for 2 hours, keeping the solution temperature at 71.1° C (160° F).

5. Drain the cleaning solution from the cooling system.

6. Flush four times with water meeting the requirements of paragraph 233.10.15 to remove all traces of cleaning solution. Disconnect several hose connections and examine waterside surfaces to ensure that they are clean.

7. If the engine is not clean, reassemble, fill with cleaning solution and repeat the cleaning and flushing operations.

**NOTE**

Run engine for 5 minutes during each flushing. The lubricating oil and the coolant should be checked for contamination after a few hours of operation, then drained and replaced, if necessary.

**233.6.44 TREATMENT AFTER IMMERSION IN SEAWATER**

**233.6.45** Machinery and equipment which has become wet and is likely to become damaged due to corrosion can be saved if prompt corrective measures are taken. Wetting of the metal may be due to the equipment having fallen overboard, flooding of the space in which it is installed or stowed, contamination of a lubricating oil system with water because of failure of a heat exchanger or oil cooler on an engine, or any other cause from which a metal surface picks up sufficient water to initiate rapid corrosion.

**233.6.46** MIL-L-16173 Grade 3 rust preventive compound is intended for displacing water and to inhibit further corrosion of machinery which has been submerged. Full advantage should be taken of the capacity of this compound to remove water

from the surface of any wetted metal subject to corrosion.

#### **233.6.47 IMMEDIATE REUSE FOLLOWING IMMERSION**

##### **NOTE**

In order to minimize engine damage from water contamination, it is critical to remove water and operate engine as soon as possible after contamination occurs. If it is suspected that water contamination occurred more than 24 hours prior to discovery, then a visual inspection of internal engine parts shall be conducted by a certified diesel engine inspector, if available

**233.6.48** If an engine, engine system or engine parts have good natural drainage, all that is necessary to remove the seawater is that they be dipped or thoroughly sprayed with MIL-L-16173, Grade 3 compound and allowed to drain. In a closed system such as the interior of an engine, the bulk of the water should first be removed by opening drains and pumping out all that can be reached. The crankcase should then be filled with the

compound and the engine rotated, if possible. If a detached pump is at hand, the pump should be connected to help circulate the compound through the lubricating system to emulsify and blot up any water trapped in pockets. Cylinders should be treated through openings in the head by removing valves or injectors, whichever would be most expedient. The emulsion formed should then be pumped out and the salvage operations repeated until no water is detected in the compound removed from the engine. A second treatment is usually sufficient, even for complicated systems. Other parts of the engine, such as cam shafts, valve mechanisms, and gears should be similarly treated, using slushing, pumping, or spraying methods, whichever is best indicated.

**233.6.49** Unless the equipment has been otherwise damaged or corroded prior to treatment, the equipment may be placed in service without additional disassembly, cleaning, or overhaul following the salvage operation. Operate the engine for 8 hours at 75–100% load to ensure elimination of all traces of water contamination. The residual film left on a mechanism is of a soft, waxy nature and will be absorbed without harmful effect in the normal lubricating process.

#### **233.6.50 ENGINES AND PARTS FOR DELAYED REPAIR**

**233.6.51** Wetted equipment which is being prepared for delayed repair should be treated in accordance with paragraph 233.6.38.



## SECTION 7. DIESEL FUEL OIL

### 233.7.1 FUEL SPECIFICATIONS

**233.7.2** Navy diesel fuel conforming to **MIL-F-16884, Naval Distillate Fuel (North Atlantic Treaty Organization (NATO) Symbol F-76)** and commonly called **Diesel Fuel Marine (DFM)** is suitable for use in all types of diesel engines used in the U.S. Navy. This fuel is recommended for use under normal conditions where readily available, and where ambient temperatures are above 0° C (32° F). Aircraft jet engine fuel meeting the requirements of **Grade JP-5 (NATO Symbol F-44) of MIL-T-5624** is also suitable for use in all types of diesel engines.

### 233.7.3 NAVAL DISTILLATE FUEL (DIESEL FUEL MARINE) (DFM)

**233.7.4** Diesel fuels compose the light to medium distillation range. The term diesel fuel includes a wide variety of fuels so it is necessary to specify requirements for a particular application. The specification for Diesel Fuel Marine (DFM) is **MIL-F-16884 (NATO Symbol F-76)**. Diesel Fuel Marine DFM is the primary fuel for Navy diesel engines.

### 233.7.5 JET PROPULSION FUEL

**233.7.6** Jet propulsion fuel (JP-5) is a kerosene type fuel with a high flash point (60° C) (140° F). **MIL-T-5624 (NATO Symbol F-44)**, covers the specification details for this fuel. JP-5 is an acceptable fuel for all Navy diesel engines. The use of JP-5 fuel instead of diesel fuel marine will usually increase fuel consumption by approximately 2 percent on a volume basis and exhaust temperatures will increase slightly.

#### NOTE

Diesel fuel marine (F-76) and JP-5 may be combined in any proportion and used in diesel engines.

### 233.7.7 TEMPERATURE CONSIDERATION AND FUEL USE

**233.7.8** Diesel fuel marine (**MIL-F-16884**) should be used whenever possible at temperatures above 0° C (32° F). At temperatures below 0° C (32° F) JP-5 (**MIL-T-5624**) is recommended. For amplifying

information refer to **NSTM Chapter 541, Fuel Oil Stowage and Equipment**.

#### CAUTION

Diesel fuel referred to as Arctic Grade and other grades under Federal Specification VV-F-800, shall not be used in naval shipboard diesel engines because the specification allows a flash point below the 60° C (140° F) minimum and constitutes a fire or explosion hazard.

### 233.7.9 FUEL CONTAMINATION

**233.7.10** Fuels are generally delivered clean and free from impurities. The transfer and handling of fuel increases the danger of contamination with foreign material. The major contaminants are:

- a. Water
- b. Rust
- c. Sediment
- d. Oil Soluble Soaps

**233.7.11** Sediment and water in fuel causes accelerated engine wear, corrosion, erratic operation, gumming of injection equipment and power loss.

**233.7.12** The presence of rust and sediment in diesel fuel can be detected by visual observation and testing. Water in diesel fuel can be detected by the cloudy appearance of the fuel oil or by the actual separation of the water from the oil during storage or testing.

**233.7.13** Oil soluble soap contamination can be detected only by a laboratory ash analysis. The usual source of such contamination is the storage of diesel fuel in galvanized containers. Diesel fuel or JP-5 should not be stored in tanks or drums or allowed to pass through piping having galvanized surfaces that will come in contact with the fuel.

**233.7.14** The tanks and fueling lines of the issuing activities and the tanks and the receiving ships shall be checked as far as practical to ensure

freedom from contaminants prior to fueling operations.

### **233.7.15 CENTRIFUGES, FILTERS AND COALESCERS**

**233.7.16** Freedom from contamination onboard ship can be obtained by the proper use of centrifuges, settling tanks, coalescers and filters in the engine fuel systems. Where installed, centrifuges and coalescers shall be used prior to the use of the fuel in an engine. Centrifuges and coalescers should be adjusted carefully and operated in accordance with the applicable NAVSEA Technical Manual, to ensure an efficient operation. The difference between the specific gravities of two different batches of fuel is often great enough to require a change in size of centrifuged discharge rings, ring dams and float assemblies from the use of DFM to JP-5 fuel. A centrifuge shall be operated as a separator (with water seal) to remove water from the fuel being purified. Instructions regarding replacement of coalescer filter elements should be carefully followed.

### **233.7.17 SUPPLEMENTAL FUEL ADDITIVES**

**233.7.18** Supplemental additives are defined as products which are marketed as fuel conditioners, smoke suppressants, tune up compounds, top oils, break in oil, graphitizers and friction reducing compounds.

**233.7.19** Diesel engines used in the U.S. Navy are designed and built in accordance with military specifications which require the finished product to perform satisfactorily using fuels which are manufactured to military specifications, MIL-F-16884 and MIL-T-5624. Diesel engines have been tested and approved using fuels conforming to these military specifications.

**233.7.20** There is no real need for supplemental fuel additives. Their use may actually negate the effectiveness of the additive package manufactured into military specification fuels and cause damage to the diesel engine. In addition, the use of supplemental additives may mask a more serious engine problem.

**233.7.21** After market supplemental fuel additive products shall not be used.

#### **NOTE**

Supplemental fuel additives do not include products which prevent or eliminate bacterial growth in diesel fuel and reduce the temperature at which fuel will flow (pour point depressants).

#### **NOTE**

The Colt-Pielstick, model PC 2.5V, LSD-41 Class Main Propulsion Diesel Engine uses a special compound added to the fuel during run in or break in, this special compound is recommended and authorized. See the applicable NAVSEA Technical Manual.

### **233.7.22 SPRAY SHIELDS (FLANGE SHIELDS)**

**233.7.23** Spray shields shall be provided for flange joints (including simplex strainer flange covers and flanged valve bonnets in piping containing flammable fluids located above the floor plates. For further information refer to NSTM Chapter 505, Piping Systems, NAVSEA dwgs 810-2117525, 803-2145518 and NAVSEA Technical Manual 0948-LP-102-2010, **Fuel and Lube Oil Strainer Safety Shield Design Guidance.**

### **233.7.24 PRECAUTIONS**

**233.7.25** The majority of engine casualties attributable to diesel fuel have been due to contaminants.

**233.7.26** Precautions and regulations dealing with proper use, storage and handling of fuel shall be followed to ensure that engines obtain clean fuel of the proper grade and specification.



## SECTION 8. LUBRICATING OILS

### 233.8.1 INTRODUCTION

**233.8.2** Lubricants are used primarily to reduce friction, dissipate heat, and prevent corrosion. Lubricants conduct friction generated heat away from bearings, gears and other motion parts, act as a seal to protect lubricated areas from contamination, and act as a carrier for materials such as rust preventatives, antifriction agents, and other additives.

### 233.8.3 FRICTION REDUCTION

**233.8.4** Whenever contacting surfaces of mechanical parts are in motion with respect to each other, a resisting force known as friction is created. Friction can be greatly decreased by using the correct lubricant for the specific application. Selection of a lubricant depends upon such factors as bearing and gear tooth pressure, operating temperatures, types of enclosures, and the nature and extent of contact between surfaces. Lubricants form a film between contacting surfaces, thereby separating the surfaces and reducing friction. Consequently, wear and seizing of parts are also reduced.

### 233.8.5 HEAT DISSIPATION

**233.8.6** Friction generated heat shall be rapidly dissipated to prevent damage to equipment. Especially sensitive to damage are bearings, high speed gear trains, and other devices having relatively small surface areas in contact. Lubricant circulation systems are designed to dissipate friction generated heat.

**233.8.7** Precautions shall be taken to avoid excessive heating caused by overfilling of the lube oil sump. An overfilled sump will result in the oil level contacting the crankshaft throws. The throws will agitate the lube oil causing aeration resulting in reduced lubrication and cooling. Excess lubricant can act as an insulating blanket around the moving parts, especially during high speed operation. Overfilling of the lube oil sump can also cause lubricants to overflow into, and damage, adjacent electrical equipment. The applicable NAVSEA Technical Manual and **Planned Maintenance System (PMS)** instructions specifying lubricants and lubrication procedures shall be followed to ensure optimum performance, reduce friction, and dissipate heat.

### 233.8.8 CORROSION PREVENTION

**233.8.9** Preventing corrosion, particularly corrosion resulting from continuous exposure to a marine environ-

ment, is a major maintenance problem. The lubricant should accomplish the following:

- a. Remain on the surface to be protected under adverse conditions of pressure and temperature.
- b. Retard or prevent the formation of corrosion, particularly in the presence of moisture or seawater.

### 233.8.10 LUBRICATION SYSTEM REQUIREMENTS

**233.8.11** Proper lubrication is vital to the operation of diesel engines. Neither the designed performance nor the designed overhaul intervals can be expected of machinery if proper lubrication practices are neglected. All rotating or sliding machinery surfaces in contact or close proximity shall receive a steady, sufficient supply of lubricant of suitable quality at the proper temperature. Contaminants such as dirt, moisture, corrosion products, and wear debris continually enter or are generated within the lubrication system, thus degrading the quality of the original lubricant. To ensure continued lubricant quality and quantity, the lubrication system shall provide for contaminant removal by filters, strainers, purification, heating or cooling, and replenishment or replacement of the lubricant.

### 233.8.12 GOVERNMENT SPECIFICATION LUBRICANT

**233.8.13** Lubricants for shipboard machinery and equipment are described by specifications. These specifications establish the lubricant requirements and characteristics necessary to ensure satisfactory performance for the intended use.

**233.8.14 MIL-L-9000 SERIES.** MIL-L-9000 (MS 9250) oil can be installed in any fleet diesel engine without any special precautions. 9250 oil has a viscosity of 12.5 – 16.3 centistokes (CST) AT 100°C (212°F).

**233.8.15 MIL-L-2104.** MIL-L-2104 Grade MS/HDO 10W has a viscosity of 5.6 – 7.4 centistokes (cSt) at 100°C (212°F).

### 233.8.16 USE OF UNTESTED LUBRICANTS

**233.8.17** NAVSEA does not approve the use of untested oils nor the purchase of oils not supplied under current contracts, except for emergency purchases in localities where military specification oils are unobtainable. Standard specification lubricants

for shipboard machinery are listed in MIL-HDBK-267, **Guide for Selection of Lubricants and Hydraulic Fluids for Use in Shipboard Equipment**.

#### 233.8.18 SUPPLEMENTAL LUBRICATING OIL ADDITIVES

**233.8.19** Supplemental lube oil additives are defined as products which are marketed as fuel conditioners, smoke suppressants, tune up compounds, top oils, break in oil, graphitizers and friction reducing compounds.

**233.8.20** Diesel engines used in the U.S. Navy are designed and built in accordance with military specifications which require the finished product to perform satisfactorily using lubricating oils which are manufactured to military specifications, MIL-L-9000 and MIL-L-2104. Diesel engines have been tested and approved using lubricating oils conforming to these military specifications.

**233.8.21** There is no real need for supplemental lube oil additives. Their use may actually negate the effectiveness of the additive package manufactured into military specification lubricating oils and cause damage to the diesel engine. In addition, the use of supplemental additives may mask a more serious engine problem.

**233.8.22** After market lubricating oil supplemental additive products shall not be used.

#### NOTE

Supplemental lubricating oil additives do not include special lubricants recommended by the specific engine manufacturer (in lieu of clean oil) to be used during the assembly process.

#### 233.8.23 PHYSICAL, CHEMICAL, AND PERFORMANCE CHARACTERISTICS

**233.8.24** Lubricants may be categorized according to physical, chemical and performance characteristics. For

complete information on lubricants see **NSTM Chapter 262, Lubricating Oils, Greases, Hydraulic Fluids and Lubrication Systems**.

#### 233.8.25 INTERNAL COMBUSTION ENGINE LUBRICANTS

**233.8.26** Reciprocating internal combustion engine lubricants are commonly known as detergent or dispersive oils, these oils contain additives that keep combustion products such as soot, wear and oxidation products in suspension, thereby reducing the amount of contaminants deposited on engine parts. This property is particularly important in modern, high speed, turbocharged shipboard diesel engines. These engine oils also contain additives that reduce wear and inhibit rusting, foaming, and oxidation. Shipboard diesels operate satisfactorily on a single viscosity grade, MIL-L-9000 (MS 9250). However, for engines that may be operating in an environment of 0° C (32° F) or below, MIL-L-2104 (MS/HDO 10) oil is recommended. For standardization reasons, engine oils are generally used in reduction gears associated with shipboard diesels. Although these engine oils are not formulated as gear oils, they perform well in such applications.

#### NOTE

Table 233-8-1 gives NSN's for ordering both MIL-L-9000 and MIL-L-2104 in various quantities.

#### 233.8.27 FORCED LUBRICATION SYSTEM

#### 233.8.28 COMPONENTS OF A DIESEL ENGINE FORCED LUBRICATION SYSTEM

#### NOTE

Depending on engine and application, the following components may or may not be installed.

**Table 233-8-1. DIESEL ENGINE LUBRICATING OILS**

USE ABOVE 0° C (32° F)		USE BELOW 0° C (32° F)	
MIL-L-9000 GRADE MS 9250		MIL-L-2104 GRADE 10 W	
9150-00-181-8229	5 GAL CONTAINER	9150-00-186-6668	5 GAL CONTAINER
9150-00-181-8097	55 GAL DRUM	9150-00-191-2772	55 GAL DRUM
9150-00-181-8232	BULK		



a. **Pumps.** Oil is delivered to the various parts of the system by pumps. If the only available pump is driven by the unit it serves, priming pumps may or may not be provided to supply oil to the system until the unit is started.

b. **Sump Tanks.** Oil is piped to the sump tanks after it passes through the various bearings and other parts of the system.

c. **Coolers.** Oil passes through coolers on its way to the system in order to maintain the oil at the desired temperature.

d. **Settling Tank.** Water and other impurities that have accumulated in the oil are allowed to settle, and used oil is stored in settling tanks.

e. **Stowage Tank.** Clean makeup lube oil is stored in stowage tanks.

f. **Strainers and Filters.** Strainers or filters remove foreign matter from the oil before it enters the engine lube oil system.

g. **Electrostatic Precipitators.** Oil mist is removed from the reduction gear, sump tank vents and diesel engines by electrostatic precipitators.

h. **Piping, Gages and Thermometers, and other Instruments.** These devices are used to indicate system operating conditions. Lower than normal pressure may indicate pump failure or excessive leakage. Higher than normal pressure may indicate unsafe conditions such as clogged lines or filters. Clogging restricts oil flow to equipments being lubricated and can cause serious equipment damage.

i. **Centrifugal Purifiers.** Water and other impurities are removed from the oil by centrifugal purifiers.

j. **Oil Heaters.** The temperature of the oil is raised before it enters the centrifugal purifier to facilitate removal of water. Heaters are available for raising the temperature whenever ambient temperatures are extremely low, particularly before starting of main propulsion machinery. Heaters may be separate or combined, and may be part of a keep warm or prestart system.

## **233.8.29 DIESEL ENGINE LUBRICATION SYSTEM**

**233.8.30** In general, diesel engines installed on naval ships are provided with attached lubricating oil pumps

driven by the engine. The lubricating oil pressure pump takes suction from the engine sump or sump tank and delivers the oil through a filter, strainer and cooler to the engine oil header. From the header, oil is distributed to all points requiring lubrication. Lubricating oil systems are classified as wet sump or dry sump systems, depending upon the method used to return oil to the sump. In the wet sump system, oil is returned directly to the attached sump by gravity flow after it lubricates the various engine parts. In the dry sump system, oil returns by gravity to an oil sump, it then drains by gravity to a separate sump, or an engine driven scavenging pump continuously pumps oil from this sump to a separate sump. The sump is therefore kept empty (dry).

**233.8.31** Diesel engines are provided with a full flow lubricating oil filtering system. Duplex (parallel) units are used to allow elements to be replaced while the unit is in operation. Relief valves are provided to bypass the filters. These relief valves normally remain closed, except during high differential pressure conditions across the filter when the oil is cold (at start up) and when the filter is dirty or clogged. Diesel engine lubricating oil systems are usually provided with a priming pump so that oil can be circulated to engine parts requiring lubrication before engine start up.

## **233.8.32 SPRAY SHIELDS (FLANGE SHIELDS)**

**233.8.33** Spray shields shall be provided for flange joints (including simplex strainer flange covers and flanged valve bonnets in piping containing flammable fluids located above the floor plates. For further information refer to **NSTM Chapter 505, Piping Systems**, NAVSEA dwgs 810-2117525, 803-2145518 and NAVSEA Technical Manual 0948-LP-102-2010, **Fuel and Lube Oil Strainer Safety Shield Design Guidance**.

## **233.8.34 CENTRIFUGAL PURIFIERS**

**233.8.35** Centrifugal purifiers are sometimes provided in diesel engine lubricating oil systems to remove water and impurities not trapped by the filter or strainer.

## **233.8.36 LUBRICATING OIL MAINTENANCE**

**233.8.37** MIL-L-9000 lubricating oil can be purified by normal shipboard methods. Water and larger size suspended particles can be removed in a properly operating shipboard purifier. Purifying for water is specified in **NSTM Chapter 262, Lubricating Oils, Greases, Hydraulic Fluids and Lubricating Systems**.

**Table 233–8–2. TESTS TO DETERMINE OIL CONDEMNING LIMITS**

TESTS	METHOD	CONDEMNING LIMIT
FUEL DILUTION (VISCOSITY)*	D445 OR D88	100 CST AT 100°F ***
THICKENING (VISCOSITY)**	D455 OR D88 AT 100°F ***	225 CST
ACIDITY	D664 (TEST KIT)	<2.0 TBN (TOTAL BASE NUMBER) (ACID FAIL)

**233.8.38 MIL–L–9000 USE IN DIRTY ENGINES**

**233.8.39** When new MIL–L–9000 oil is put into an engine which has been allowed to become very dirty, the detergent cleaner additive will loosen dirt deposits. These loose deposits will circulate with the oil and can collect elsewhere in the engine causing clogged oil holes and clogged oil pump suction screens. At best, the detergent cleaner in the new oil is used up rapidly, resulting in frequent strainer cleaning and a need for early oil and filter changes. Should this situation be encountered, give close attention to the filter and strainer differential pressure, and the engine lube oil pressure.

**233.8.40 CHANGE IN COLOR OF OIL**

**233.8.41** Diesel engine lubricating oils usually turn dark in color after a few hours of use because of the suspension of finely divided fuel soot. The change in color in no way indicates a deterioration in the lubricating quality of the oil.

**233.8.42 DRAIN PERIODS**

**233.8.43** The efficiency of an additive oil depends on the amount of compounding material it contains. This material is consumed in preventing ring sticking and the formation of sludge deposits. Optimum drain periods can best be determined by frequent oil analysis in accordance with PMS and by inspecting the condition of the engines. Exceeding any of the condemning limits in Table 233–8–2 is cause for changing the oil.

**233.8.44 CONDEMNING LIMITS**

**233.8.45** Navy Oil Analysis Program (NOAP) laboratory facilities shall be used. MIL–L–9000 oil should be subjected to the tests listed in Table 233–8–2. Exceeding

any of the defined condemning limits is cause for changing the oil.

**233.8.46** If no analytical data is available, the oil drain periods shall be:

- For large, low, and medium speed diesels (below 1500 rpm) – after 750 hours of operation.
- For small high speed diesels (above 1500 rpm) after 100 hours of operation or every 3 months, whichever comes first.

**233.8.47 SHIPBOARD TESTING****NOTE**

The Clear and Bright test is ineffective for MIL–L–9000 oil. Shipboard testing of MIL–L–9000 oil focuses on physical properties as changes in viscosity and acidity.

**233.8.48** Ships shall sample and test the physical properties (viscosity and acidity) of MIL–L–9000 lubricating oil in main propulsion diesel engines, ships service diesel generators and emergency diesel generators. Lubricating oil shall be sampled daily and tested for viscosity when the diesel engine is operating, regardless of the number of hours operated during the day. Medium speed diesel engines having a rated speed below 1500 rpm, the lubricating oil shall be sampled and tested for neutrality/acidity every 400 plus or minus 50 hours of diesel engine operation or quarterly, concurrent with the diesel engine trend analysis. High speed diesel engines having a rated speed of 1500 rpm or greater, lubricating oil shall be sampled and tested for neutrality/acidity every 100 plus or minus 10 hours of engine operation. If the results of the neutrality/acidity test are either green or yellow, the oil shall be changed. Lubricating oil is tested in accordance with PMS and **NSTM Chapter 233, Diesel Engines**, Section 8.

**NOTE**

If engine is not operated, a lubricating oil sample for viscosity is not required.

**NOTE**

When conducting engineering casualty control drills, lube oil samples are not required prior to and after engineering casualty control drills.

Table 233-8-3. LUBRICATING OIL TEST KIT

QTY	SERVICE PART NO.	NSN	ITEM
1	DCA-302	6630-01-085-1527	VISCOSITY COMPARATOR WITH 3 TUBES
2	* DCA-303	4710-01-140-4635	SPARE TUBES (ALUMINUM) FOR COMPARATOR
1	* DCA-304	6685-01-059-0624	METAL THERMOMETER, 1-1/2" FACE, 5" STEM
1	* DCA-315	9330-01-085-6586	OIL SAMPLING GUN WITH 1/4" X 4' SUCTION TUBE
1	* DCA-312		LEATHER CUP FOR SAMPLING GUN
1	DCA-305	6640-01-096-4951	8 OUNCE PLASTIC DISPENSING BOTTLE OF REACTION INDICATOR
1	* DCA-306	6810-01-118-2021	8 OUNCE PLASTIC DISPENSING BOTTLE OF REACTION INDICATOR CONCENTRATE
1	DCA-307	6810-01-118-2613	1 OUNCE DROPPER BOTTLE OF BASE FOR INDICATOR STANDARDIZATION
1	DCA-308	6810-01-118-2612	1 OUNCE DROPPER BOTTLE LABELED ACID
1	* DCA-309	6640-01-096-5777	MEASURING VIAL 1/2" X 2" GRADUATED AT 5, 3, AND 1
1	* DCA-310	6640-01-096-5776	REACTION VIAL 1 1/4" X 3"
1	* DCA-317	6630-01-098-6475	REACTION COLOR CARD YELLOW, BLUE AND GREEN SPOTS
1	* DCA-313	6640-01-096-7530	4 OUNCE WIDE MOUTH BOTTLE MARKED NEW OIL
1	* DCA-314	6640-01-096-7529	4 OUNCE WIDE MOUTH BOTTLE FOR OIL SAMPLES

**NOTE:** DCA-320 is an onboard spare parts package consisting of items marked \* NSN 1H0000-LL-CJ7-2630

**233.8.49** Table 233-8-3 lists the items included in the shipboard diesel engine lubricating oil test kit (NSN 9L 6630-01-096-4792).

#### 233.8.50 SAMPLING PROCEDURE

**233.8.51** Engines fitted with lube oil sample connections are to be sampled through those connections no sooner than 10 minutes after the engine is started. Procedural steps for sampling engines not fitted with lube oil sampling connections are as follows:

1. Remove the sample container and sampling pump from the kit.

<b>WARNING</b>
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On some engines designs and dependent upon the specific material condition of the engine, lube oil may blow out of the dipstick tube when the dipstick is removed from an operating engine. Safety precautions and equipment shall be used to prevent possible personnel injury.

2. No sooner than 10 minutes after the engine is started, carefully remove the diesel engine sump dipstick. If oil blows out of the oil dipstick tube when the dipstick is removed, reinsert the dipstick and then either take the sample when the engine

is at idle or as soon as practical after the engine has been secured.

#### NOTE

The prelube pump may be used for sampling after the engine is secured provided that the pump is operated long enough to discharge a representative sample of circulated sump oil and provided the pump is not a common prelube pump used for all engines.

3. Insert suction pump sampling tube into the dipstick tube 1 inch further than the length of the dipstick, being careful not to let the tube contact bottom of the sump.

4. Place a clean container under the pump and draw off approximately 1 pint of oil into the container to flush the dipstick tube. Then place another clean sample container on the pump.

5. Draw a sample into the sample container.

6. Remove the sample container from the sampling pump and immediately cap the container.

7. Remove the pump sampling tube from the dipstick tube and replace the dipstick in the sump.

8. Return the original 1 pint of oil removed through the dipstick tube and the residual oil in the sampling pump and tube to either the ship's oily waste tank or the engine sump.

#### NOTE

When conducting engineering casualty control drills, lube oil samples are not required prior to and after casualty control drills.

### 233.8.52 TESTING PROCEDURE

**233.8.53** Steps for testing a lube oil sample for fuel dilution and oil thickening are:

1. Place a 4-oz sample of new diesel engine lube oil, MIL-L-9000, in a clean sample bottle.

#### NOTE

The new oil sample is oil that is taken from the sump after the lube oil sump is freshly filled with new oil. The new oil sample shall be changed at oil changes or when adding 50 percent or more new oil to the lube oil sump.

2. Remove the comparator from the storage case and set up on a level steady work area.

#### NOTE

When comparator is properly set up it is firmly supported at an angle from the vertical position.

3. Using the thermometer from the kit, measure the temperature of the new and used oils to ensure that the difference is not greater than 1 degree.

4. Fill tube A of the comparator to the gallery (the enlargement of tube diameter) with new oil and place in the comparator.

5. Fill tubes 1 and 2 to the same level the with used oils and place in the comparator.

#### NOTE

Samples from two different engines may be placed in the individual comparator tubes (tubes 1 and 2) at the same time. Test is run only on one used sample tube and tube A at a time.

6. Lift the three rod markers to 100 on the scale by means of end buttons so fingers do not touch the rods.

7. Set comparator aside for at least 10 minutes to equalize the temperature.

8. Run rods A and 1 up and down in tubes at least twice.

9. Set the markers of rods A and 1 at start line. Look squarely at markers and start line to set.

#### NOTE

The rod of the other sample tube is to be placed in the down position.

10. Push in the reset button.

11. Start the rods down by pushing and holding the release button.

12. Release the button when one of the rod markers reaches the 100 mark.

13. Record rod A reading in column 3 of the diesel engine lube oil testing log.

14. Record used oil rod reading in column 4 of the diesel engine lube oil testing log.

15. Repeat steps 8 through 14 for tube 2.

16. Wipe the rods and balls and the drain tubes thoroughly between tests.

17. Replace the comparator in storage case.

### 233.8.54 TEST RESULTS

#### NOTE

The lube oil shall be changed when fuel dilution is 5.0 percent or greater.

#### CAUTION

Fuel dilution greater than 5.0 percent is cause for serious concern about the fitness of the engine.

**233.8.55** The proper analysis of test results depends upon the design and size of the engine from which a sample has been taken. The normal range of fuel dilution is from less than 0.5 percent to 2.0 percent. Fuel dilution in the range of 2.0 percent to 5.0 percent indicates a leak or faulty injection equipment that requires immediate correction.

### 233.8.56 REACTION INDICATOR SOLUTION PREPARATION

**233.8.57** The procedure for the preparation of the reaction indicator solution is:

1. Fill the vial to level 3 with the reaction indicator concentrate and add to the empty reaction indicator bottle.

2. Add distilled water to bring the level to the 180 ml mark. The solution will be blue.

#### CAUTION

Safety precautions for the use of the solvents and other chemicals specified in the diesel engine lube oil test procedures shall be in accordance with **Navy Safety Precautions for Forces Afloat**, OPNAVINST. 5100 Series.

3. Add the weak acid, drop by drop, from the dropping bottle to the reaction indicator bottle until the solution is brought to a green color, similar to that on the reaction indicator card.

#### NOTE

Be sure to shake the reaction indicator bottle while adding acid.

4. If too much acid is added, the indicator will turn yellow. It may be returned to green or blue by adding a drop or two of the "BASE" solution 0.1 KOH.

### 233.8.58 REACTION (ACIDITY) TEST

**233.8.59** Procedures for conducting the acidity reaction test are:

1. Remove the reaction vial from the kit and fill to the first level with the reaction indicator.

2. Add used engine oil to raise the liquid level in the reaction flask to the second indicator level.

3. Screw the cap on the vial and shake vigorously for 15 seconds.

4. Allow the reaction vial to stand until the oil and indicator separate (5 to 10 minutes).

5. Remove the reaction indicator card from the kit and compare the color of the separated indicator (lower level in vial) with the card.

6. If the indicator in the vial is blue, the oil is satisfactory.

7. If the indicator in the vial is either green or yellow, the oil is unsatisfactory and shall be changed.

8. Record the indicator color in column 7 of the diesel engine lube oil testing log.

9. Empty the reaction vial and clean by wiping with a clean cloth.

### 233.8.60 DATA RECORDING

**233.8.61** Viscosity and reaction (acidity) test results shall be recorded in the diesel engine lube oil test log. A log for each shipboard diesel engine shall be maintained. See Figure 233-8-1.

### 233.8.62 POST-OVERHAUL OR REPAIR, LUBE OIL SYSTEM INTENSIVE CLEANING

**233.8.63 GENERAL** In many instances lube oil contamination is a primary cause or contributing factor in diesel engine failure. Overhaul and repair

ENGINE NO. \_\_\_\_\_  
PAGE NO. \_\_\_\_\_

MONTH \_\_\_\_\_ 19\_\_\_\_

1 DATE	2 TIME	3 ROD A READING	4 USED OIL ROD READING	5 % THICKENING NOTE: 1	6 % FUEL DILUTION NOTE: 2	7 REACTION ACIDITY TEST

1. IF COLUMN 3 READING IS 100, SUBTRACT 100 FROM COLUMN 4 READING AND ENTER RESULT IN COLUMN 5 (% OIL THICKENING).

2. IF COLUMN 4 READING IS 100, CALCULATE THE PERCENT OF FUEL DILUTION PRESENT FROM CHART A AND ENTER IN COLUMN 6 (% FUEL DILUTION).

CHART A	
ROD A READING *	FUEL DILUTION
90 %	1 %
75 %	3 %
65 %	5 %
*ROD A READINGS THAT FALL BETWEEN THESE VALUES SHALL BE ADJUSTED TO THE NEAREST VALUE IN THE TABLE. ANY ROD A READING BELOW 65% IS AUTOMATICALLY CAUSE FOR OIL REPLACEMENT.	

Figure 233-8-1. Diesel Engine Lube Oil Testing Log



standards often do not include effective lube oil system cleaning procedures therefore, the potential for further engine failure remains due to particle contamination. During a casualty condition, such as bearing failure, metallic particles of the failed components are often dispersed throughout the lube oil system. This includes drilled oil passages, attached piping, and engine components. After complete overhaul or major repair of an engine, the lube oil system shall be thoroughly cleaned.

**233.8.64** To accomplish thorough cleaning of the engine block, components, and attached piping, two methods are authorized:

1. Method 1 – Soaking
2. Method 2 – Flushing

**233.8.65 SOAKING.** Soaking Is A Process In Which The Stripped Engine Block Is Immersed In An Alkaline Solution, Thoroughly Cleaned, Rinsed, And Blown Dry With Compressed Air. Soaking Is The Preferred Method For Small Block Engines.

**WARNING**

Never add water to alkaline powders as spattering or an explosive reaction will occur. Always add the powder to the water.

**WARNING**

Alkaline solutions of trisodium phosphate and especially sodium hydroxide are hazardous. Before preparation of the solution all of the following shall be secured or removed from the internal combustion engine shop: Flammable liquids, acids, and organic halogen compounds (especially trichloroethylene). Skin or eye contact with either alkaline powder or solutions can cause severe burns and shall be avoided. Their ingestion can cause serious damage to the digestive system and shall be avoided. Eyewash fountains and safety showers shall be available for immediate use in all alkaline handling areas. Alkaline powder or solutions coming into contact with eyes shall be flushed with potable water for a minimum of 15 minutes immediately after exposure. Seek immediate medical attention. In the event of skin contact with the powder, carefully remove all visible particles with a clean soft brush, then rinse affected area with cold water.

In the event of skin contact alkaline solutions, rinse affected area with cold water immediately. In the event of ingestion of alkaline powder or solutions, immediately drink large amounts of milk or water followed by diluted vinegar or fruit juice. Vomiting may occur but do not induce it. Seek immediate medical attention, avoid breathing the solution spray, mist or alkaline powder. When handling these chemicals, the following protective equipment shall be worn: full face shield, rubber gloves, and apron. A dust respirator shall also be worn when handling alkaline powder.

**CAUTION**

All aluminum parts such as bearings, shall be removed from the engine block before soaking. Only iron or steel engine blocks may be cleaned by this method.

a. Installation of alkaline soak solution in a diesel engine block soaking tank:

**WARNING**

Never use hot water as a violent reaction will occur.

1. Fill the soaking tank to the appropriate level with cold, fresh water.
2. Reserve 1/2 pound of alkaline powder (either trisodium phosphate or sodium hydroxide) for each gallon of water in the soaking tank. When preparing solutions always add the powder slowly and in small amounts to the water to avoid violent boiling and spattering. Then add 1-fluid ounce of nonionic detergent (MIL-D-16791, Type 1) for each gallon of water.
3. Air agitate the solution until well mixed.
- b. Degreasing of engine block in the soaking tank:
  1. If feasible heat the solution to between 71° to 82.2° C (160° and 180° F) before use.
  2. Slowly immerse the engine block in the solution.
  3. Soaking time varies with the condition of the engine block. The minimum time is 1 hour.
  4. Upon completion of soaking, carefully and thoroughly rinse the block with warm water to remove all traces of alkaline solutions and blow dry.

c. Disposal of alkaline soak solution when exhausted:

1. Slowly and carefully drain the alkaline solution into steel drums according to OPNAVINST 5090.1 and **NSTM Chapter 593, Pollution Control**.

2. Drums containing alkaline wastes will be turned into the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy Industrial Facility.

**233.8.66 FLUSHING.** Engine lube oil flushing is a process that requires forcing clean, hot lube oil through engine internal and external lube oil passages using pumps, heaters, and filtering mediums.

**233.8.67 QUALIFICATION.** Diesel Engines and Lube oil systems shall be intensively cleaned by flushing after:

- a. Complete overhaul.
- b. Main or connecting rod bearing failures.
- c. Casualties, in which particles from failed components have been circulated in the lube oil system and found in the lube oil filters and strainers and visible contamination in the lube oil.
- d. Complete or partial overhaul. Rebuilt engines from OEM's, commercial engine repair facilities and Naval repair facilities shall be flushed by the overhauling activity prior to delivery.
- e. New or stored engine where the internal lube oil system has been preserved with MIL-C-16173.
- f. Fresh (jacket water) or salt water contamination of lube oil system. (See paragraph 233.8.101.

**233.8.68 EXEMPTIONS.** New engines preserved with MIL-L-21260 shall not be lube oil flushed, however, the external Lube oil systems shall be flushed.

**233.8.69** Engines that are being repaired that require removal of internal components do not require flushing provided that precautions are taken to prevent internal lube oil wetted surfaces from becoming contaminated. A certified Diesel Engine Inspector will make final determination of flushing requirement prior to completion of the repair.

**233.8.70 ENGINES THAT REQUIRE HOT OIL FLUSHING.** The following engines require hot oil flushing:

- a. All models of Fairbanks Morse
- b. All models of EMD and GM
- c. All Colt-Pielstick
- d. Caterpillar models 3500 and 3600 series
- e. Ruston Paxman
- f. DDA(C) Stewart Stevenson model 149
- g. All models of Alco

#### NOTE

All engines regardless of make or model, if they have an external lube oil system, the external lube oil system shall be hot oil flushed. See Figure 233-8-2, and Figure 233-8-3.

**233.8.71 PROCEDURE.** In general, the flushing procedure is comprised of two operations that use various pumps, filters and heaters rigged according to engine configuration.

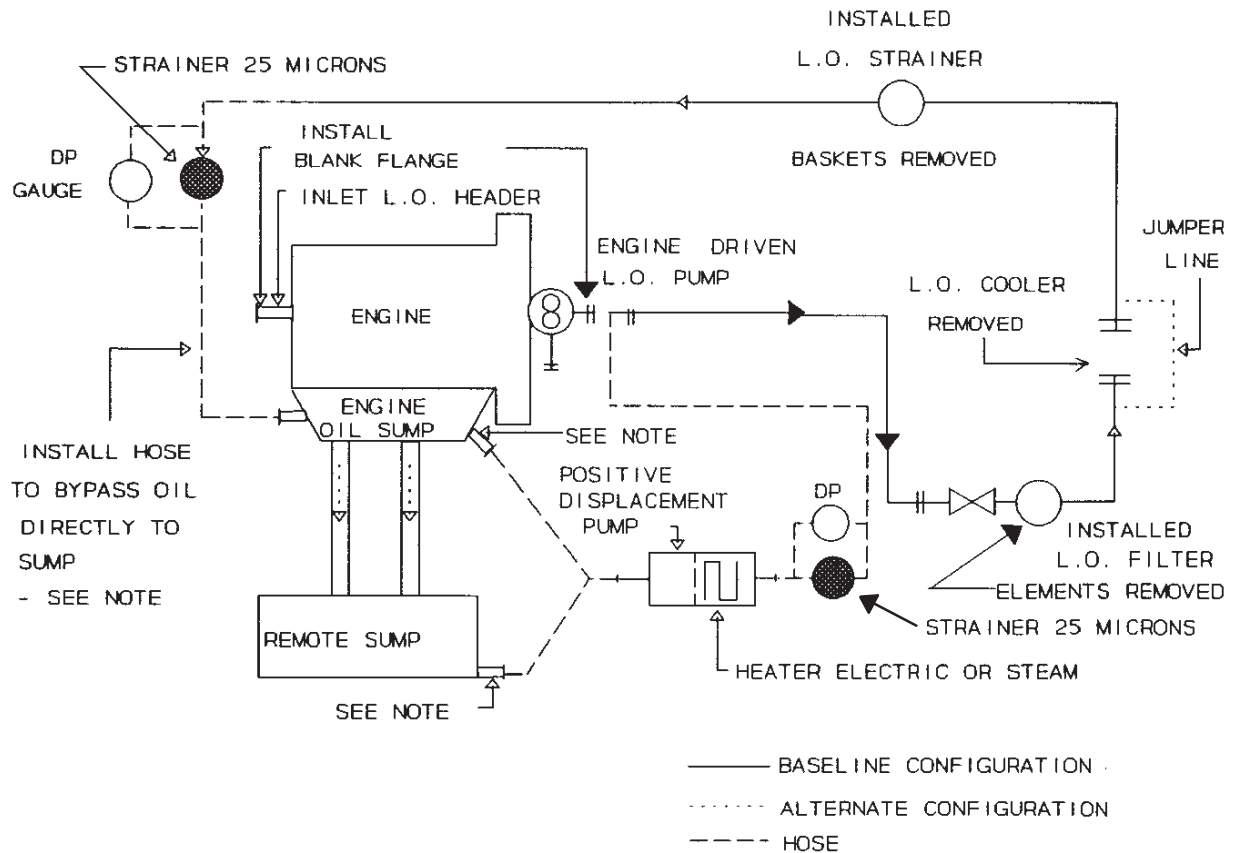
- a. External piping system.
- b. External piping and internal lube oil systems.

**233.8.72 EXTERNAL FLUSHING PROCEDURE FIRST OPERATION.** External Flushing is the initial flushing operation. The engine external lube oil system is isolated from the engine and flushed separately. This is necessary to avoid foreign particles being carried into engine internal lube oil passages, where clogging might occur. External flushing pertains only to the external lube oil piping systems including filters, strainers, and lube oil sumps.

**233.8.73 INTERNAL AND EXTERNAL FLUSHING PROCEDURE – FINAL FLUSH.** The second or final flushing operation flushes the external and internal lube oil systems together to a specified cleanliness.

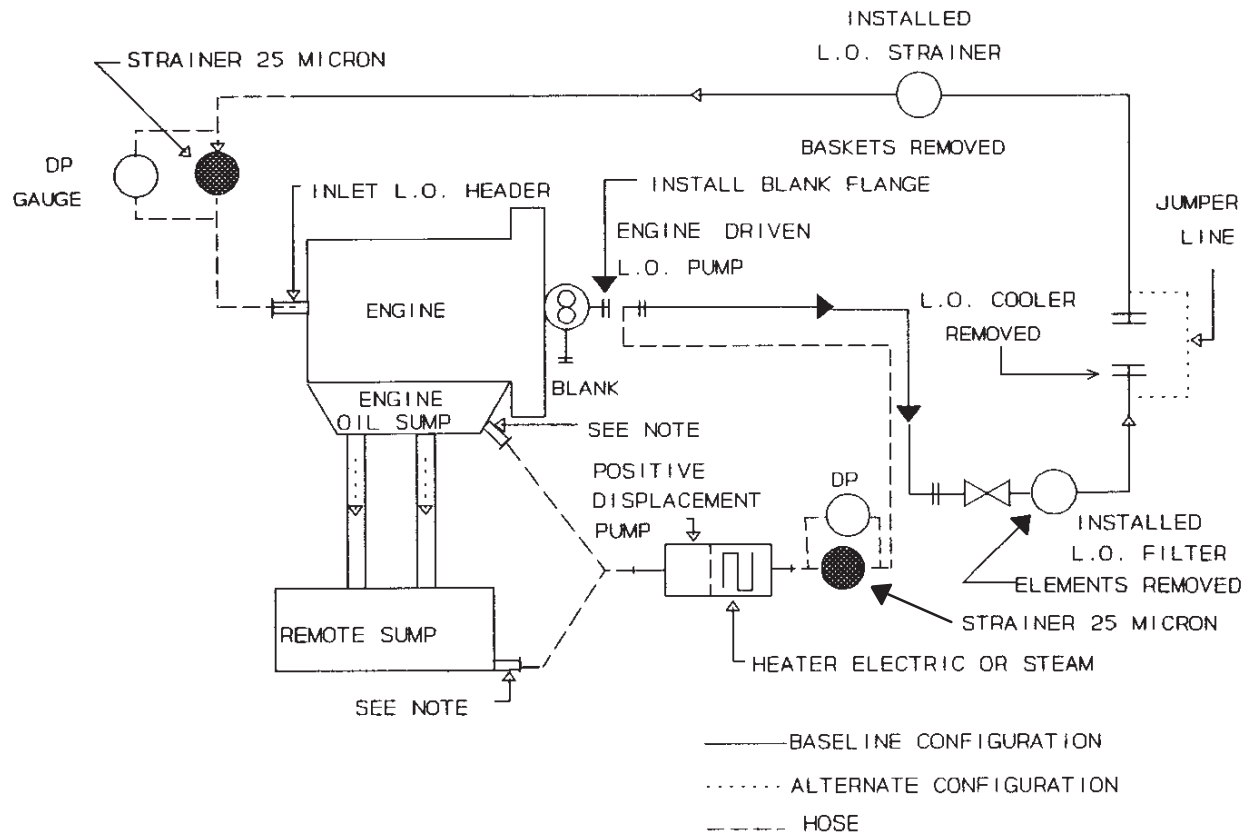
**233.8.74 FLUSHING MEDIUM.** MIL-L-2104 Grade MS-HDO 10W shall be used for hot lube oil flushing.





NOTE: Connections shown on engine sump (or remote sump) may or may not actually exist. If not, do not modify sump. Make use of other existing connections or inspection and or hand hole covers to take suction and return lube oil to sump.

Figure 233-8-2. Typical Flushing Diagram of the External Lube Oil System



NOTE: Connections shown on engine sump (or remote sump) may or may not actually exist. If not, do not modify sump. Make use of other existing connections or inspection and or hand hole covers to take suction and return lube oil to sump.

Figure 233-8-3. Typical Flushing Diagram of the Internal and External Lube Oil System

**NOTE**

MIL-L-9000 may be used for flushing when MIL-L-2104 is unavailable or in an emergency. However, if MIL-L-9000 lube oil is used, the flushing pump shall meet or exceed the flow rate or the attached lube oil pump and 79.5° to 87.7°C (175° to 190°F) oil temperature must be maintained.

**NOTE**

Upon completion of lube oil flushing, the flushing oil may be returned to clean containers and can be used for the next hot lube oil flush provided cleanliness of lube oil can be maintained.

**233.8.75 FLUSHING EQUIPMENT.** Equipment required for hot lube oil flushing:

**CAUTION**

All flushing equipment, including the flushing pump shall be rated for a minimum flow of 260 GPM when using MIL-L-2104. Ensure that flow is not restricted by use of fittings smaller than existing piping system. Maximum flushing pressure shall not exceed 110 percent of attached lube oil pump relief valve setting.

**NOTE**

The Navy standard diesel engine flushing system is supported by Allowance Parts List (APL) 41795001.

**NOTE**

When using **MIL-I-2104**, the standard Navy flushing rig (260 GPM) can be used for all engines with an attached lube oil pump flow rate of 450 GPM or less. All engines with an attached lube oil pump flow rate greater than 450 GPM shall use two Navy standard flushing system pumps in parallel (260 GPM + 260 GPM = 520 GPM).

**NOTE**

Sandpiper or diaphragm type pumps may be used if they meet the requirements of flow. When using diaphragm type pumps, flow meters shall be used to assure minimum flow requirements.

a. Heating device electric or steam capable of maintaining oil at 71° to 87.7° C (160° to 190° F).

b. Two duplex or simplex basket type strainer assemblies fitted with magnets and 25 micron muslin filter bags with differential pressure indicators and capable of handling flow rate of pump used for flushing.

**NOTE**

One of the basket type strainers is installed before return oil to the sump and the other is installed after the flushing pump discharge. See Figure 233-8-2 and Figure 233-8-3.

c. Hose assembly (engine sump to pump), as required, MIL-H-24135. (suction application).

d. Hose assembly (pump discharge to engine), as required, MIL-H-24135.

e. Muslin bag filter – (sized to suit strainer basket), as required, FED SPEC C-C-432, Type 7, Class 1. (Nylon is not an acceptable substitute for MIL. SPEC. Muslin).

f. Heavy duty plastic or canvas, as required.

g. Lint-free rags, as required.

h. Miscellaneous components; hose MIL-H-24135 (cut to suit), hose clamps, pipe nipples, fittings, valves, etc. As required per engine configuration.

**233.8.76 FLUSHING PREREQUISITES.** External, flush prerequisite (See Figure 233-8-2):

**NOTE**

Ensure that flushing arrangement is set up as a series flow circuit. That is, each component in line consecutively with the next. Parallel flow paths shall be avoided because this divides the flow and makes flushing less effective. Where parallel flow paths cannot be eliminated they shall be blanked off in turn to ensure a complete flush.

a. The lube oil cooler shall be removed for independent cleaning. Install a jumper line in place of the cooler.

#### NOTE

The lube oil cooler is designed for a low velocity flow and as a result lube oil system contamination will collect in the cooler.

b. Strainer baskets shall be removed from system strainer.

c. Filter elements shall be removed from system housing.

d. Remove and jumper system relief valves. Ensure filter and strainer bypass valves are properly set prior to reinstallation.

e. All dead end run or blanked off piping shall be cleaned by hand.

f. Engine sump shall be drained and wiped clean with lint free rags. Internal lube oil pump suction piping shall be cleaned by hand from the suction bell mouth or strainer to the pump inlet.

g. Lube oil inlets to engine shall be blanked.

**233.8.77 EXTERNAL FLUSHING.** External flushing procedure

#### CAUTION

During the start of a flush a seriously contaminated system can clog the filters and strainers instantly. Observe the differential pressure gage and clean filters as required.

1. Heat clean MIL-L-2104 oil, equaling 60 to 70 percent of sump capacity, to a temperature of 71 to 87.7° C (160° to 190° F), and circulate throughout the external lube oil circuit.

2. Circulate hot oil through Mil. Spec. muslin bags or filters rated at 25 microns for a period of not less than 12 hours. (Flushing cannot be estimated by time but is conditional on the level of system contamination).

3. During the flush the external piping system shall be manually shocked or vibrated using soft mallets or mechanical vibrators to dislodge contaminants within the piping.

4. During the flush, clean the filters or change the muslin bags a minimum of every two hours so that a pres-

sure differential of no more than 5 psig higher than the differential of a clean filter or muslin bag can be maintained.

5. The flush shall be continued until a differential pressure increase of less than 2 psig higher than the differential pressure of a clean filter or muslin bag can be maintained for a period of 2 hours and a visual inspection of the muslin bag and strainer magnets indicates that the sum total of contaminants (solid, solid based and non-solid) at the end of that two hour period does not exceed a volume larger than one 25 cent piece. The muslin bags and strainer magnets shall contain no more than 15 solid or solid-based contaminants—no one larger in size than 1/64 inch in any dimension. The filters or muslin bags shall contain no nonsolid contaminant larger than 1/16 inch in any dimension except for hair like particles which can be up to 1/8 inch long. Continue the flush until the above criteria are achieved. Upon completion of the external flush change the muslin bags and modify the system for final flushing.

#### NOTE

Solid and solid-based contaminants are those that cannot be crushed between the thumbnail and the finger.

#### 233.8.78 FINAL FLUSHING PROCEDURE

#### CAUTION

If the engine being flushed drives a generator set and the engine lube oil provides lubrication to the generator bearings, for example Fairbanks Morse, either blank off or bypass the generator oil lines to the sump to avoid flooding the generator windings with oil. Bypassing the generator oil lines to the sump is preferred to ensure thorough flushing of the generator oil lines. The generator drain pumps that are engine driven will not remove oil pumped to the generator bearings while flushing and will cause flooding of the generator if the generator oil lines are not bypassed or blanked off.

**233.8.79** Internal and external flushing is the final flush operation. The engine block, internal oil passages and external piping are flushed together to a specified cleanliness.

**233.8.80** Final flushing procedure prerequisites (See Figure 233-8-3).

- a. Blank off pedestal bearing oil feed lines.
- b. Blank off turbocharger and blower lube oil feed lines.
- c. Remove lube oil main bearing jumper lines.
- d. Remove end plugs or caps on main lube oil header.

#### NOTE

On Fairbanks Morse engines remove both upper and lower crankshaft main bearing lube oil jumper lines and end plugs on lower main lube oil header. After the first two hours of flush, reinstall the end plug on the lower lube oil header and reinstall the lower bearing lube oil jumper lines. Remove the end plug on the upper main lube oil header and flush for additional two hours. After the second two hour flush, reinstall end plug on the upper main lube oil header and reinstall upper main bearing lube oil jumper lines.

#### NOTE

On Alco engines model 251-8 cylinders, remove and blank oil supply lines to balance shaft.

**233.8.81** For Internal and External Flushing procedures.

1. Heat a quantity of clean MIL-L-2104 oil, equaling 60 to 70 percent of sump capacity, to a temperature of 71 to 87.7° C (160° to 190° F) and circulate throughout the external and internal lube oil circuit.
2. Filter circulating oil using Mil. Spec. Muslin bags or filters rated at 25 microns.
3. Change muslin bags a minimum of every 2 hours to maintain a differential pressure increase of no more than 5 psig over the differential pressure of a clean filter or muslin bag.
4. After 2 hours replace main bearing jumper lines and replace end plugs on main internal lube oil header.

5. Continue flush for a minimum of 12 hours and during this period manually rotate the engine crankshaft through 90 degrees travel at 20 minute intervals.

6. After this 12 hour period the flush shall be continued, without engine rotation until a differential pressure increase of less than 2 psig higher than the differential of a clean filter or muslin bag can be maintained for a period of 2 hours and a visual inspection of the filters or muslin bag and strainer magnets indicates that the sum total of contaminants (solid, solid based and nonsolid) at the end of that two hour period does not exceed a volume larger than a ten cent piece. The filters or muslin bags and strainer magnets shall contain no more than five solid or solid-based contaminants, no one larger than 1/64 inch in any dimension. The filters or muslin bags shall contain no non-solid contaminant larger than 1/16 inch in any dimension except for hairlike particles which can be up to 1/8 inch long.

#### NOTE

Ensure lube oil is reaching all internal oil passages by doing a visual inspection, e.g.: rocker arms, camshafts and gear trains.

#### CAUTION

Use extreme care to maintain cleanliness while the engine system is being flushed. Openings into the engine shall be closed or covered with heavy duty plastic or canvas.

**233.8.82** The keep warm, prelube system on ships with MACHALT-184 installed shall be flushed separately. Remove and clean the heater. Disconnect the return line to engine and using the keep warm pump, flush through a separate filter bag to determine system cleanliness according to above criteria. Reconnect system when final flush is complete.

**233.8.83 POST-FLUSH CLEAN UP.** Upon completion of engine flushing:

1. Drain flushing oil from sump, piping, filter and strainer housings, place flushing oil in clean containers.

**NOTE**

Every effort shall be made to remove **MIL-L-2104** from the lube oil system. This will ensure a satisfactory NOAP report for viscosity, which will eliminate the need to change oil after a few hours of engine operation.

**NOTE**

Careful use of clean low pressure air (100 psi or less) may be used to blow flushing lube oil back to the engine sump through the filter and strainer housings.

**NOTE**

Upon completion of lube oil flushing, the flushing oil may be returned to clean containers and can be used for the next hot lube oil flush provided cleanliness of lube oil can be maintained.

2. De-energize, secure and remove all flushing equipment.

3. Restore lube oil system to original configuration in preparation for engine run. Remove jumper line and reinstall lube oil cooler.

4. Remove blank flanges from generator bearings, turbocharger(s) and blower. Reinstall Alco engine balance shaft oil supply lines.

5. Clean and inspect lube oil sump using lint free rags. Clean and inspect internal lube oil pump suction piping from the suction bell mouth or strainer to the pump inlet.

6. Clean lube oil filter housing and install new lube oil filters.

7. Clean and inspect system lube oil strainer and housing. Install system strainer baskets. Install Muslin bags in system strainer baskets if configuration permits.

**233.8.84 ENGINE RUN AFTER COMPLETION OF FLUSHING****CAUTION**

Thorough inspection of the engine through the air box(es) and engine blower(s) (where applicable) is necessary to avoid the damage of hydraulic lock.

**CAUTION**

Ensure all temporary modifications to lube oil piping, resulting from flush operation have been reconfigured to the original installation. Ensure lockwire on all main bearing jumper lines and lube oil gallery end plugs has been reinstalled.

**CAUTION**

Ensure blank flanges to generator bearings, turbocharger(s) blowers and main bearings (if installed) are removed.

**CAUTION**

Ensure the lube oil cooler and relief valves jumper lines is removed (if installed). Reinstall lube oil cooler, relief valves and associated piping (if removed). Ensure strainer and filter bypass valves are properly set.

1. Fill the engine sump or remote sump, if applicable with new oil (MIL-L-9000) to the required level for engine operation.

2. If the lube oil flush was accomplished after an overhaul or major repair, operate the engine in accordance with the standard run in schedule for an overhauled engine (see paragraph 233.3.9 through 233.3.39).

3. Before starting the engine, see Preparation for Starting After Overhaul or Long Idle Periods (paragraphs 233.3.7 through 233.3.8).

**CAUTION**

Lube oil shall be sampled and tested for viscosity after 15 minutes of engine operation (See paragraph 233.8.52).

4. Run engine at no load at idle speed for 15 minutes. After this 15 minutes of no load operation

sample and test lube oil for viscosity in accordance with NOAP requirements.

5. Continue to run engine at no load and increase engine speed from idle to full speed over a 15 minute period.

**CAUTION**

Monitor the differential pressure across the strainer and filter during engine operation. Ensure the differential pressure does not exceed bypass valve set point. If the strainer and/or filter require repeated cleaning to maintain proper differential pressure, the entire flushing procedure shall be repeated.

**NOTE**

Although an engine run in procedure is conducted to wear in/seat new parts, the wear occurring during a properly conducted run in should not be sufficient to release visible particles.

6. Continue to run the engine at no load full speed for an additional 15 minutes. Stop the engine.

7. Open, inspect and clean the strainer. If the strainer has solid contaminants larger than 1/64 inch or volume of solid contaminants is larger than a dime, repeat the final flush procedures until an acceptable criteria is obtained.

8. If engine is being run-in, stop the engine after first two hours and open, inspect and clean the strainer. If the strainer has solid contaminants as noted above, repeat the final flush procedure. If the strainer is clean continue with engine run-in. Stop and inspect the strainer to the above criteria every two hours until run-in is complete.

9. If engine is not being run-in, operate engine at minimum of 60 percent load at rated speed for two hours. After two hours stop the engine and inspect the strainer for solid contaminants to the above criteria. Repeat this step until an acceptable criteria is obtained.

10. Operate engine at 80 percent load at rated speed for 1 hour. Stop and inspect strainer to above criteria. Repeat until acceptable criteria is obtained.

11. Operate engine at 100 percent load at rated speed for 1 hour. Stop and inspect strainer to above criteria. Repeat until acceptable criteria is obtained. When the strainer meets the cleanliness criteria stated above after run-in or 100 percent load the flush is complete.

**233.8.85 WATER CONTAMINATION FLUSH.** Lube oil systems that have been contaminated with water that cannot be removed by purification shall be flushed as follows immediately or soon as possible after water contamination occurs:

**NOTE**

The following procedure is to be used only under the following conditions:

- a. Cracked or broken liners or cylinder heads.
- b. Failed jacket water gaskets or seals.
- c. Failed lube oil cooler.
- d. Failed lube oil steam heaters for purifiers or sumps.
- e. Water contamination from washing and cleaning of the engine.
- f. False start on submarine diesel engines where the outboard exhaust valve failed to shut and allowed salt water to enter the engine. Ensure no other engine damage has occurred.
- g. If engine or engine space has been flooded refer to **NSTM Chapter 233, Diesel Engines, Section 6**.

**NOTE**

In order to minimize engine damage from water contamination it is critical to remove water and operate engine as soon as possible after contamination occurs. If it is suspected that water contamination occurs. If it is suspected that water contamination occurred more than 24 hours prior to discovery, then a visual inspection of internal engine parts shall be conducted.

1. The system shall be completely drained. Dispose of oil in accordance with **NSTM Chapter 593, Pollution Control** and OPNAVINST 5090.1.
2. The valve gear and exposed internal engine components shall be cleaned with lint free rags.
3. The sump shall be completely drained and cleaned with lint free rags. Ensure that all frame



members and pockets that could trap water are wiped out.

4. Strainer and filter housing shall be cleaned with lint free rags. Clean strainer and reinstall, renew filters.

5. The cooler should be drained separately if possible.

6. The system shall be filled to 100 percent capacity with new MIL-L-9000 oil.

<b>CAUTION</b>
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During the prelube operation for the additional 2–3 minutes, ensure pedestal bearing does not flood and overflow to the generator.

7. Immediately prior to starting the engine, prelube until oil is observed at the main and rod bearings. Continue to prelube for an additional 2–3 minutes.

8. Start engine in accordance with **EOSS** or normal operating procedures. Run engine at idle for 5 minutes. Take a lube oil sample while operating. Visually inspect lube oil sample for the presence of water. **MIL-L-9000** series oil has an affinity for water. Oil will turn to a coffee cream or khaki color if oil is contaminated with water. If color of lube oil changes, repeat steps 1 through 8. Continue to sample lube oil every 5 minutes until 30 minutes has elapsed without a color change to the lube oil.

9. Gradually load engine to a minimum of 80 percent and run for a period of 2 hours. Ensure oil temperature is above 71°C (160°F). Sample oil for color change every 15 minutes. If oil turns to a coffee cream or khaki color, oil is contaminated. Repeat steps 1 through 9.

10. Continue to flush and run engine until oil sample remains dark green or black color. Submit oil sample to **NOAP** for water content.



## SECTION 9. FILTERS AND STRAINERS

### 233.9.1 FUNCTION AND DESCRIPTION

**233.9.2** Filters and strainers are installed on diesel engines for the following reasons:

- a. Filters and strainers remove abrasive and foreign materials from the lubricating oil to decrease wear and reduce deterioration of the lubricating oil.
- b. Filters and strainers remove foreign substances from the fuel oil to decrease wear of the fuel pumps and injection valves and deter clogging of the nozzles.
- c. Filters are used to clean intake air before it enters the engine. Air filters may be of the disposable type or the type that require periodic cleaning.

**233.9.3** According to Navy diesel terminology, all metal-edge devices and wire mesh devices are termed strainers, while all disposable, fibrous depth and surface-type element devices are called filters.

#### WARNING

Safety and fire hazard precautions presented in **Chapter 505, Piping Systems and Planned Maintenance System (PMS)** shall be carefully adhered to when cleaning fuel oil or lube oil filters and strainers.

### 233.9.4 FUEL OIL STRAINERS

**233.9.5** Fuel oil strainers are made in both simplex and duplex types. A strainer consists of a metal-edge element surrounded by a case which serves as a sump to collect foreign material and water which are caught by the strainer. Some strainers have devices for manually rotating the strainer elements against a metallic scrapers to remove material caught by the strainer. Strainers also are normally provided with vents for venting air from the fuel or lube oil system.

**233.9.6** Fuel oil strainers shall not contain pressure relief valves because such valves would permit dirty fuel to bypass the strainer element and damage the fuel injection equipment.

**233.9.7** A duplex fuel (MIL-S-17849) strainer is a two strainer elements built into one assembly which has a manual valve for directing the flow of fuel or lube oil through either one of the elements or both. Each element of the strainer shall be capable of passing the full flow of the system.

### 233.9.8 MAINTENANCE OF FUEL OIL STRAINERS

**233.9.9** Some metal edge strainers may be cleaned by rotating the knife edge past a cleaner blade causing the sludge and foreign matter on the surfaces to drop into the sump. Whenever possible metal edge strainer cleaning should be done while fuel is not passing through the strainer.

#### CAUTION

A wire brush shall never be used in cleaning strainer elements.

**233.9.10** Other strainers are designed so the engine strainer element shall be removed and washed. Care shall be exercised in the cleaning of all strainers to prevent damage to the elements. Strainers should be washed in fuel oil or some other approved solvent, using a soft cloth or brush.

**233.9.11** The sumps of fuel oil strainers should be checked periodically and drained at a frequency, based on experience for that particular installation, to remove any collection of water or sludge. Maintenance is done in accordance with the applicable NAVSEA Technical Manual and PMS.

### 233.9.12 LUBRICATING OIL STRAINERS

#### WARNING

Do not gag the lube oil filter or strainer by pass relief valve to prevent their operation, severe engine damage will occur.

**233.9.13** Lubricating oil strainers can be of the simplex and duplex types. Lubricating oil strainers

are similar in construction to fuel oil strainers but usually are of larger mesh and will permit the passage of larger sized particles.

**233.9.14** All lubricating oil strainers shall contain a built-in, spring loaded, pressure relief valve of a size sufficient to bypass all the oil around the strainer, so an uninterrupted flow of lubricating oil will be maintained to the engine at all times.

**233.9.15** Where duplex strainers are supplied in lubricating oil systems, the element being bypassed can be removed and cleaned while the engine is running without disturbing the flow of oil to the engine.

**233.9.16** The same precautions exercised in cleaning fuel oil strainers shall also be taken in cleaning lubricating oil strainers.

### **233.9.17 LUBRICATING OIL FILTERS**

#### **233.9.18 FULL FLOW FILTERS**

**233.9.19** Lubricating oil filter elements should be manufactured in accordance with FED SPEC F-F-351.

### **NOTE**

Sock type oil filters shall not be used in Navy diesel engines. Sock type filter is defined as a filter element that has an outer covering of cloth only.

**233.9.20** The full flow element is designed for high flow rates, permitting entire lube oil pump discharge delivery to pass through the filter elements. A relief valve is installed with this system to protect the engine. During normal operation the relief valve will remain closed. The relief valve will bypass the entire oil flow when the pressure across the filter increases to a predetermined set point. This will occur when filters are clogged or when oil is cold. A differential pressure gage installed around

the relief valve will assist the operator to determine when elements require changing. When the pressure drop across the differential pressure gage reaches a predetermined value, the dirt collecting capacity of the element has reached a point where their continued use results in no appreciable filtration of the lubricating oil.

#### **233.9.21 BYPASS FILTER SYSTEM**

**233.9.22** The bypass filter system is designed to filter a portion of the lubricating oil being delivered to the engine. An orifice plate is installed either in the filter or in the line to the filter to control the amount of oil removed from the system by taking only 10 to 15 percent from the pressure line, filtering it, and returning the filtered oil to the sump. The remainder of the oil, the unfiltered portion, is delivered to the engine.

#### **233.9.23 FUEL OIL FILTERS**

**233.9.24** Fuel oil filter elements should be manufactured in accordance with MIL-F-20627.

**233.9.25** Fuel oil filters approved for Navy use consist of replaceable throwaway filter elements mounted in a suitable casing. Fuel oil filters contain no bypass or relief valve and shall be of a size adequate to take the full flow of the fuel oil pumps.

**233.9.26** Fuel oil filter elements are designed for an operation life of 500 hours. The varying quality and cleanliness of the fuel used may necessitate changing elements at more frequent intervals. When a gage is installed across a fuel oil filter, the element should be changed when the pressure drop reaches the value specified in the applicable NAVSEA Technical Manual and PMS.

#### **233.9.27 FILTER REPLACEMENT**

**233.9.28** For specific instructions concerning replacement of filter elements, sizes to be used, and installation instructions, reference should be made to the applicable NAVSEA Technical Manual and PMS. Lubricating oil filter elements shall be changed at the same time lubricating oil is changed.

## SECTION 10. COOLING WATER SYSTEMS

### 233.10.1 ENGINE COOLANT

**233.10.2** Engine coolant accepts heat from the hot areas of an engine and rejects heat at a heat exchanger. The coolant thus provides a medium for transferring heat from the hot engine to the cool heat exchanger. Without engine coolant, engine components would rapidly overheat and fail due to the large amounts of heat produced by combustion.

### 233.10.3 EFFECTS OF UNTREATED COOLANT

**233.10.4** Scale, corrosion and cavitation corrosion will occur in engine cooling systems if untreated coolant is used. In order to minimize these problems, high quality water treated with corrosion inhibitors is used in engine cooling systems. There are four types of corrosion inhibitor treatments currently authorized for use by the Navy in engine cooling systems. These are: MIL-A-53009 inhibitor, Nalcool 2000, inhibited antifreeze (MIL-A-46153), and soluble oil (MIL-I-24453).

### 233.10.5 WATER

**233.10.6** Water is used as coolant because it is readily available and because of its large heat capacity (i.e., the quantity of heat it can absorb). Depending on its source, water quantity can vary widely. For example, seawater contains large amounts of dissolved salts. Shore waters contain significantly lower levels of dissolved salts than seawater, although shore waters vary in composition from location to location. Shore waters include municipal water (tap, city, potable, fresh or dock) as well as water originating from rivers, lakes or wells.

### 233.10.7 WATER IMPURITIES

**233.10.8** Certain constituents of the dissolved salts in both shore waters and seawater can be troublesome.

### 233.10.9 HARDNESS

**233.10.10** Hardness (dissolved calcium and magnesium) can lead to scale formation. Scale consists of compounds of calcium and magnesium which form deposits on hot metal surfaces. Scale acts as an insulator, thereby reducing the transfer of heat from hot metal surfaces in the engine to the coolant. This can cause overheating.

### 233.10.11 CHLORIDE AND SULFATE

**233.10.12** Chloride and sulfate tend to break down the protective layers formed on metal surfaces by corrosion inhibitor treatment chemicals and make the layers more difficult to reform. Thus, chloride and sulfate can lead to corrosion problems.

### 233.10.13 IMPURITIES IN SHORE WATERS AND SEAWATER

**233.10.14** Unprocessed shore waters contain varying amounts of hardness, chloride and sulfate. Water purification processes such as distillation, demineralization or reverse osmosis remove most hardness, chloride and sulfate from water. Seawater contains significantly greater amounts of these constituents. Since most diesel engine cooling systems employ seawater cooled heat exchangers, heat exchanger leaks can allow seawater to contaminate the engine coolant. Seawater contamination is detected by testing the engine coolant for chloride.

### 233.10.15 WATER REQUIREMENTS

**233.10.16** An important part of a coolant treatment program is using water containing minimal amounts of hardness, chloride and sulfate for filling or topping off cooling systems. Water used for final flushing, fresh filling or topping off cooling systems or for mixing treatment chemicals for addition to cooling system shall be as follows in order of precedence:

a. Shipboard boiler feedwater or condensate meeting the requirements of **NSTM Chapter 220 Volume 2, Boiler Water/Feedwater Water Chemistry, Test and Treatment**.

b. Shore source water meeting the requirements of **NSTM Chapter 220, Volume 2, Boiler Water/Feedwater Water Chemistry, Test and Treatment**, for shore source feedwater.

c. Water produced by shore-based or shipboard distilling plants, demineralizers or reverse osmosis units. (Prior to use, the water shall be tested for chloride. The maximum acceptable limit is 60 ppm Cl<sup>-</sup>).

d. Potable water (brominated or chlorinated) produced by shipboard distilling plants. (Prior to use, the water shall be tested for chloride. The maximum acceptable limit is 60 ppm Cl<sup>-</sup>).

**NOTE**

Only in emergency situations when the above waters are not available can clean fresh water (shore source potable water) be used.

**NOTE**

Water used for cleaning and flushing cooling systems may be clean fresh water provided that a final flush is performed with water meeting the above requirements.

**233.10.17 INITIATING COOLANT TREATMENT**

**233.10.18** Before initiating coolant treatment, the cooling system of the engine shall be inspected. If oil is present, clean the system in accordance with the procedure starting in paragraph 233.10.256. If corrosion or scale deposits are noted, clean the system using the procedure starting in paragraph 233.10.260. The system shall be thoroughly flushed with water meeting the requirements of paragraph 233.10.15 after any cleaning to ensure complete removal of all cleaning chemicals.

**WARNING**

Water treated with any corrosion inhibitor cannot be used as a source of emergency drinking water. Cooling system expansion tanks shall have signs affixed which state: **Poison. Not to be used for emergency drinking water.**

**233.10.19 FRESH FILL AND TREATMENT OF COOLING SYSTEMS****WARNING**

Wear proper protective equipment when handling inhibitor chemicals. Refer to the paragraphs that are applicable to the specific inhibitor treatment used and also paragraphs 233.10.238 through 233.10.253.

**233.10.20** Refer to Table 233-10-1 for a listing of inhibitor treatments for each ship class. The capacity of the cooling system, in gallons of water, shall be determined in order to calculate the correct dosage of chemicals. Add water meeting the requirements of paragraph 233.10.15 to the system. (If the system is to be hydrostatically tested, do not fill the system until just before the hydro. Delay chemical treatment until completion of a satisfactory hydro). The chemical solution may usually be added to the system at the jacket water expansion tank or the chemical injection tank. Top off the system, then recirculate for at least 10 minutes after operating temperature has been reached. Obtain a sample after the system has been recirculated.

**NOTE**

The cooling system shall be recirculated as soon as possible following the addition of chemicals in order to mix them thoroughly. Do not sample a cooling system until it has been recirculated so that a representative sample will be obtained.

**233.10.21 SAMPLING**

**233.10.22** Samples of engine coolant are obtained and tested to ensure that the coolant contains the correct level of inhibitor chemicals and to detect any seawater contamination of the cooling system.

**233.10.23 SAMPLING FREQUENCY**

**233.10.24** The paragraphs covering the specific inhibitor treatments give details concerning

**Table 233-10-1. INHIBITOR TREATMENTS AUTHORIZED FOR DIFFERENT SHIP CLASSES**

<b>TREATMENT</b>	<b>SHIPS</b>
Nalcool 2000 (Note 1)	FFG-7 Class PB Mk III PRB Mk II Seafox Boats Sea Viking Boats
Soluble Oil, MIL-I-24453 (Note 2)	MSO Class PHM Class MCM-1, 2
Inhibited Antifreeze, MIL-A-46153	MCM-3 through 14 MHC Class All small craft and all small boats not listed elsewhere.
MIL-A-53009 Inhibitor Treatment (Note 3)	AOE-6 Class LHD-1 Class LHA Class ARS Class ASR Class ATF Class ATS-1 Class LSD-41 Class LSD-49 (CV) Class LST-1179 Class MTS Class YTB Class YTM Class Submarines All diesel engines and all diesel generators on ships not listed elsewhere.
<p>Note 1: Refer to paragraphs 233.10.105 through 233.10.110 if freezing protection is required.</p> <p>Note 2: Refer to paragraph 233.10.150 if freezing protection is required.</p> <p>Note 3: Refer to paragraphs 233.10.46 through 233.10.48 if freezing protection is required.</p>	

sampling frequency requirements. Regardless of inhibitor treatment, samples shall be obtained after fresh fill and treatment, following the addition of water or inhibitors and monthly. Whenever treatment chemicals

or makeup water have been added, the cooling system shall be recirculated for at least 10 minutes after reaching operating temperature prior to obtaining a sample. When

routine samples are taken, prior recirculation of the cooling system is not required.

### 233.10.25 SAMPLING PROCEDURE

**233.10.26** Obtain engine coolant samples as follows:

#### WARNING

When sampling a cooling system, wear face shield, rubber gloves and apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

1. Allow engine coolant to flow from the drain cock long enough to thoroughly flush the drain cock.
2. Rinse the sample bottle and cap with coolant.
3. Fill the sample bottle with coolant.
4. Cap the sample bottle after collecting the sample.
5. Cool the sample to 100° F (38° C) or less before testing.

### 233.10.27 JACKET COOLING WATER SYSTEM RECORDS

**233.10.28** Diesel engine jacket cooling water system logs provide a method for keeping records of all test results and treatment and other actions which affect the cooling system. The logs provide a tool to be used by the Engineering Officer and his assistants for ensuring proper cooling system maintenance. The review of these logs shall support the decision making process involved in an effective coolant treatment program. The logs and instructions are contained in the paragraphs pertaining to the specific coolant treatments. After recording the required information in the diesel engine jacket cooling water system log, test results and treatment actions shall also be recorded in the remarks section of the daily engine operating log. The monthly cooling water system logs shall be retained for 2 years.

### 233.10.29 PERSONNEL RESPONSIBILITIES

**233.10.30** The responsibilities of personnel regarding logs are as follows:

- a. Tester:
  1. Maintains the diesel engine jacket cooling water system log.
  2. Recommends treatment action based on log entries.
  3. Circles any result which is out of limits.
- b. Leading Chief Petty Officer (LCPO):
  1. Supervises the maintenance of the records and reviews the records.
  2. Maintains the central file (and an adequate supply) of the logs.
- c. Engineer Officer of the Watch (EOOW) and or Engineering Duty Officer (EDO):
  1. Initials all test results
  2. Initials any test results which is out of limits.
- d. Main Propulsion Assistant (MPA):
  1. Reviews the logs.
- e. Engineer Officer:
  1. Responsible for decisions regarding all diesel engine jacket water cooling system treatment actions.
  2. Reviews the logs.
  3. Initials any test result which is out of limits and ensures that the cause, if known, is noted in the remarks section.
  4. Reviews and signs the logs.

### 233.10.31 TEST FACILITY

**233.10.32** Test facilities used for testing diesel engine coolant samples shall be equipped as follows:

- a. Sink with drain and running water.
- b. Source of distilled water.
- c. Minimum six month supply of test chemicals and equipment specified for the specific treatment used.
- d. Safety equipment required for the treatment used.



e. Stowage space for the chemicals and equipment.

f. Container for hazardous waste storage.

g. Chemical test procedures available for ready reference. A workbook containing a current copy of each test procedure, protected in plastic, is recommended for ease in use.

h. A current copy of NSTM Chapter 233, Diesel Engines. Test facilities shall be well lighted and ventilated and maintained in a clean and orderly condition.

### 233.10.33 DISPOSAL OF TREATED COOLANT

**233.10.34** MIL-A-53009 inhibitor, Nalcool 2000, inhibited antifreeze and soluble oil treated coolant shall be disposed of in accordance with the **Environmental and Natural Resources Protection Manual** OPNAVINST 5090.1 and **NSTM Chapter 593, Pollution Control**. MIL-A-53009 inhibitor contains sodium metaborate and other chemicals. Nalcool 2000 contains sodium borate, sodium nitrite and other chemicals. Inhibited antifreeze contains ethylene glycol, sodium borate and other chemicals.

### 233.10.35 MIL-A-53009 INHIBITOR TREATMENT

#### WARNING

MIL-A-53009 corrosion inhibitor is hazardous. Skin or eye contact with MIL-A-53009 inhibitor or coolant containing MIL-A-53009 inhibitor shall be avoided. When handling MIL-A-53009 inhibitor or when sampling a cooling system containing MIL-A-53009 inhibitor, wear face shield, rubber gloves and apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

**233.10.36** MIL-A-53009 consists of a blend of inhibitor chemicals in aqueous solution. These chemical are: sodium metaborate, potassium silicate and mercaptobenzothiazole (MBT). Sodium metaborate is

an alkaline buffer which neutralizes acidic by-products resulting from combustion blowby gases leaking into the coolant. Potassium silicate forms a silicate film on metal surfaces which provides effective corrosion protection for mixed metal systems. MBT chemically bonds with copper contained in copper alloys resulting in formation of a protective layer on the surface.

### 233.10.37 LIMITS

**233.10.38** The following limits apply to MIL-A-53009 inhibitor treated coolant:

MBT-100 to 500 ppm

Reserve 6 RA units minimum Alkalinity

Chloride 100 ppm maximum

#### NOTE

MBT levels in a properly treated freshly filled and treated system will be 300–400 ppm. The 500 ppm upper limit allows some leeway for inadvertent overtreatment. Do not attempt to treat to the upper limit.

#### NOTE

MBT levels below 100 ppm can result in accelerated corrosion. Reserve alkalinity levels less than 6 RA units can also result in accelerated corrosion. MBT levels in excess of 500 ppm indicate overtreatment to an undetermined degree (since the maximum level detectable by the MBT procedure is 500 ppm). Gross overtreatment can result in corrosion inhibitor chemicals precipitating out of solution which can restrict heat transfer. Chloride levels above 100 ppm indicate that seawater has leaked into the cooling system. This makes the coolant more corrosive. In addition, seawater contains hardness which will cause scale formation on hot metal surfaces.

**233.10.39 INITIAL TREATMENT DOSAGE**

**233.10.40** When freshly filling a cooling system, add three gallons (12 quarts) of MIL-A-53009 inhibitor for each 100 gallons of cooling system capacity. Since the actual engine cooling system capacity may differ from the volume given in the applicable NAVSEA technical manual, ships using MIL-A-53009 inhibitor treatment can determine the actual cooling system volume as follows:

1. Freshly fill and treat the system in accordance with paragraph 233.10.41 using the system volume from the applicable NAVSEA Technical manual.
2. Recirculate the coolant for at least ten minutes after the engine has reached operating temperature. Obtain a sample and test for MBT.
3. Determine the actual system volume using the following equation:

$$V = (350/\text{MBT}) \times \text{VTM}$$

Where:

V = Actual cooling system volume (gallons).

MTB = MBT sample test result (ppm).

VTM = Volume from technical manual (gallons).

4. The calculated cooling system volume should be recorded in the log for each jacket cooling water system and should be used for all future treatments.

**233.10.41 INITIATING MIL-A-53009 INHIBITOR TREATMENT FOR THE FIRST TIME****NOTE**

Use water meeting the requirements of paragraph 233.10.15 for freshly filling cooling systems.

1. If converting from soluble oil treatment:
  - a. Open all low point drains and completely dump the cooling system.
  - b. Flush the system using the procedure in paragraphs 233.10.256 through 233.10.259.

c. Freshly fill and treat using the treatment dosage in paragraph 233.10.39.

2. If converting from chromate treatment:

a. Open all low point drains and completely dump the cooling system.

b. Manually override all temperature control valves or remove temperature control elements and blank remaining openings.

c. Fill the system with clean, fresh water, and vent to ensure that the system is completely filled.

d. Operate the engine and all auxiliary systems. Assure proper alignment of the system to ensure circulation through the entire system.

e. Circulate the water through the entire system for 10 minutes.

f. Secure the engine, then let the engine cool for 30 minutes.

g. Open all low point drains and completely dump the cooling system.

h. Repeat steps c. through g. until the effluent is clear (yellow color indicates the presence of chromate).

i. Fill the cooling system with water meeting the requirements of paragraph 233.10.15, then open all low point drains and completely dump the system.

j. Restore the engine cooling system to its original configuration.

k. Freshly fill and treat using the treatment dosage in paragraph 233.10.39.

3. If converting from inhibited antifreeze treatment:

a. Open all low point drains and completely dump the cooling system.

b. Fill the system with water meeting the requirements in paragraph 233.10.15, then dump.

c. Freshly fill and treat using the treatment dosage in paragraph 233.10.39.

**233.10.42 SAMPLING FREQUENCY**

**233.10.43** Engine coolant samples shall be obtained and tested for MBT, reserve alkalinity and chloride in accordance with the following requirements:



- a. After freshly filling and treating.
- b. After adding water to the cooling system.
- c. After adding inhibitor to the cooling system.
- d. At least monthly.
- e. In accordance with the Planned Maintenance System (PMS).

#### **233.10.44 ACTIONS FOR OUT-OF-LIMITS RESULTS**

**233.10.45** Whenever test results are not within the limits specified, the following actions shall be taken:

#### **NOTE**

Use water meeting the requirements of paragraph 233.10.15 for flushing the cooling system or adding water to the cooling system.

- a. If the MBT level is below 100 ppm, add one gallon of MIL-A-53009 inhibitor for each 100 gallons of cooling system capacity.
- b. If the reserve alkalinity level is less than 6 RA units, add 1.5 gallons of MIL-A-53009 inhibitor for each 100 gallons of cooling capacity.
- c. If both MBT and reserve alkalinity are below limits, add 1.5 gallons of MIL-A-53009 inhibitor for each 100 gallons of cooling system capacity.
- d. If MBT exceeds the 500 ppm upper limit, drain some of the treated coolant and replace with water meeting the requirements of paragraph 233.10.15.
- e. If the chloride concentration exceeds 100 ppm:
  - 1. Dump the entire system.
  - 2. Locate and correct the source of seawater contamination.
  - 3. Fill the cooling system with water meeting the requirements of paragraph 233.10.39 and dump.
  - 4. Test the effluent for chloride using the procedure specified in paragraph 233.10.59.
  - 5. Repeat steps c. and d. until the chloride level in the effluent is less than 50 ppm.

- 6. Freshly fill and treat using the treatment dosage in paragraph 233.10.39.

#### **NOTE**

If overheating occurred during the contamination incident, inspect the cooling system prior to refilling for the presence of scale or corrosion deposits to determine the need for chemical cleaning. Inspection is also recommended if it is suspected that the contamination was severe or long term. If chemical cleaning is necessary, use the cleaning procedure starting in paragraph 233.10.260.

#### **233.10.46 CONVERTING FROM MIL-A-53009 INHIBITOR TO ANTIFREEZE OR FROM ANTIFREEZE TO MIL-A-53009**

**233.10.47** Ships authorized to use MIL-A-53009 inhibitor treatment shall convert to inhibited antifreeze if freezing protection is required. Maintain antifreeze treatment in accordance with paragraphs 233.10.150 through 233.10.196. When freezing protection is no longer required, reconvert to MIL-A-53009 inhibitor during the next normal change out of engine coolant. If it is anticipated that freezing protection will again be required in the near future, continue maintaining antifreeze treatment rather than reconvert to MIL-A-53009 inhibitor.

#### **WARNING**

Antifreeze shall only be used in the main engines of ships with single loop waste heat distilling plants during periods when freezing protection is necessary. Refer to paragraph 233.10.160. As soon as freezing protection is no longer required, reconvert to MIL-A-53009 inhibitor treatment.

**233.10.48** MIL-A-53009 inhibitor and inhibited antifreeze shall not be used together in a cooling system together. Overtreatment with MIL-A-53009 inhibitor and antifreeze can result in the formation of silicate gel deposits in heat exchangers. This can cause overheating. When converting from MIL-A-53009 inhibitor to inhibited antifreeze or from antifreeze to MIL-A-53009, dump the cooling system, fill with water meeting the requirements of paragraphs

233.10.15, dump the water and then freshly fill with water meeting the requirements of paragraph 233.10.15 and treat.

#### **233.10.49 DISTILLATE ON SHIPS WITH LOOP WASTE HEAT DISTILLING PLANTS**

##### **WARNING**

Distillate contaminated with MIL-A-53009 inhibitor shall not be used as drinking water.

**233.10.50** In the event of distiller heat exchanger failure on ships with single loop waste heat distilling plants, MIL-A-53009 inhibitor treated coolant will leak into the distiller. The potential would then exist for contaminating distillate (and therefore potable water) with toxic MIL-A-53009 inhibitor. Personnel shall be alert for signs of unexplained coolant loss such as a decrease in expansion tank level.

#### **233.10.51 DISTILLATE SAMPLING REQUIREMENTS**

**233.10.52** Distillate shall be sampled and tested for the presence of MIL-A-53009 inhibitor prior to sending distillate to a potable water tank and whenever unexplained coolant losses occur. These sampling requirements apply when waste heat from main propulsion engines is used to operate the distilling plant. Distillate test results shall be recorded in the engineering log.

#### **233.10.53 DISTILLATE SAMPLING PROCEDURE**

**233.10.54** Obtain distillate samples as follows:

1. Allow distillate to flow from the drain cock long enough to thoroughly flush the drain cock.
2. Using a one quart plastic bottle, thoroughly rinse the sample bottle and cap using distillate.
3. Fill the bottle to the top and immediately cap the bottle.

##### **NOTE**

The distillate contamination test shall be completed within 30 minutes of sampling. The sample shall be 100° F (38° C) or less before testing. Cool the sample if necessary. Designate a specific sample bottle for distillate samples.

##### **NOTE**

When testing for distillate contamination, never use a sample bottle which has been used for engine coolant or boiler water samples.

#### **233.10.55 DISTILLATE LIMIT AND CORRECTIVE ACTION**

**233.10.56** Distillate shall be colorless to phenolphthalein when tested in accordance with paragraph 233.10.68. If a pink color is noted when the test is performed, immediate corrective action shall be taken. Do not send distillate to potable water tanks. Dump all potable water tanks to which distillate was sent subsequent to the last sample which had satisfactory test results. Do not use potable water from these tanks. Locate and correct the source of the contamination in the distiller. Flush the potable water tanks with distillate (when satisfactory distillate is available). Sample during the flush operations. Continue flushing until the samples are colorless to phenolphthalein.

#### **233.10.57 TESTING PROCEDURES FOR MIL-A-53009 INHIBITOR TREATMENT**

**233.10.58** Effective treatment of cooling systems is based upon the accurate performance and interpretation of the tests that determine coolant quality. If these tests are not performed properly, the coolant will not be treated properly. It is necessary to carefully follow these test procedures in order to ensure accurate results.

##### **WARNING**

MIL-A-53009 inhibitor treated coolant is hazardous. Skin or eye contact with coolant samples containing MIL-A-53009 inhibitor shall be avoided. Wear goggles, plastic gloves and rubber apron when handling coolant samples. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

**233.10.59 CHLORIDE TEST FOR COOLANT**

**233.10.60** Two dippers of cupric sulfate are added to a 10 mL sample of MIL–A–53009 inhibitor treated coolant. After a brief standing period, the sample is filtered. The end of a Quantab chloride test strip is immersed in the sample. After an exposure interval, the Quantab is removed from the solution and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart.

## a. Apparatus:

1. Filter paper.
2. Funnel.
3. Brass dipper.
4. Beaker, 50 mL (2).
5. Graduated cylinder, 10mL.
6. Quantab chloride test strips.
7. Stirring rod.

## b. Reagents:

1. Distilled water.
2. Cupric sulfate pentahydrate.

## c. Interferences:

1. The MBT present in MIL–A–53009 inhibitor interferes with the Quantabs. The addition of cupric sulfate to the sample causes the MBT to precipitate out, thus eliminating the interference.

**WARNING**

Cupric sulfate is hazardous. Skin or eye contact with cupric sulfate shall be avoided. When handling cupric sulfate wear goggles, plastic gloves and rubber apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

## d. Procedure:

1. Rinse the 10 mL graduated cylinder, the funnel, the stirring rod and two 50 mL beakers with distilled water.

2. Rinse the 10 mL graduated cylinder with a small portion of sample.

3. Measure 10 mL of sample in the graduated cylinder. Pour the sample into one of the 50 mL beakers.

4. Add 2 dippers of cupric sulfate to the sample in the beaker. Stir to mix using the stirring rod.

5. Let the solution stand five minutes.

6. Filter the sample as follows:

(a) Fold the circular filter paper in half and then fold in half again.

(b) Open the folded filter paper to form a cone. Place the cone in the funnel.

(c) Place the funnel in the other 50 mL beaker.

(d) Carefully pour the sample into the filter paper cone inside the funnel. Do not allow the level to reach the upper edge of the paper.

7. Open the Quantab bottle, remove one test strip and recap the bottle.

**NOTE**

Check the expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

**NOTE**

The Quantab bottle shall be kept tightly closed.

8. Into the beaker containing the filtered sample, place the test strip with the word “Quantab” up and the numbered scale facing the person performing the test. Note the time.

**NOTE**

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

9. Leave the test strip in the beaker until the horizontal yellow–orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

10. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the log.

11. Find the scale reading and the corresponding chloride level (column marked “ppm Cl<sup>-</sup>”) on the calibration chart provided with the bottle of Quantabs. Record the chloride result in the log.

(a) If the scale reading is lower than the lowest reading on the chart, record “< (lowest chloride concentration on the chart).” For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record “<30” in the log.

12. Pour the samples containing MIL–A–53009 inhibitor into a plastic 5 gallon or smaller bottle identified as containing borate and cupric sulfate wastes.

13. Rinse the graduated cylinder, funnel and beakers with distilled water. Pour the sample waste water into the waste bottle. Place the soiled filter paper into the waste bottle.

**WARNING**

Bottles containing borate and cupric sulfate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other facility.

**233.10.61 MBT TEST**

**233.10.62** A sample of MIL–A–53009 inhibitor treated coolant is drawn into a Titret containing reagents that are pink in color. The sample is drawn in until the color changes to a pale yellow. When the color change occurs, the Titret is inverted and the liquid level is measured on the scale marked on the Titret. The scale reading multiplied by 50 gives the MBT concentration in ppm.

a. Apparatus:

1. Valve assembly.
2. Sample cup.

b. Reagents:

1. Titret. A titret containing the needed reagents is supplied.

2. Distillate water.

c. Interferences:

1. None normally present in this type of sample.

d. Procedure:

1. Remove one Titret, one valve assembly and the sample cup from the test kit box.

2. Rinse the sample cup with distilled water, then rinse with a small portion of the sample.

3. Fill the sample cup to approximately the 25 mL mark with sample.

4. Slide the open end of the valve assembly over the tapered tip of the Titret so that it fits snugly. See Figure 233–10–1.

5. Carefully snap the tip of the Titret.

6. Immerse the tip of the sample tube in the sample.

7. Squeeze the bead valve briefly to allow a small amount of sample to be drawn into the Titret. See Figure 233–10–2.

**NOTE**

Do not squeeze the bead valve unless the tip of the sample tube is immersed in the sample.

8. Again squeeze the bead valve briefly to allow a small amount of sample to be drawn into the Titret.

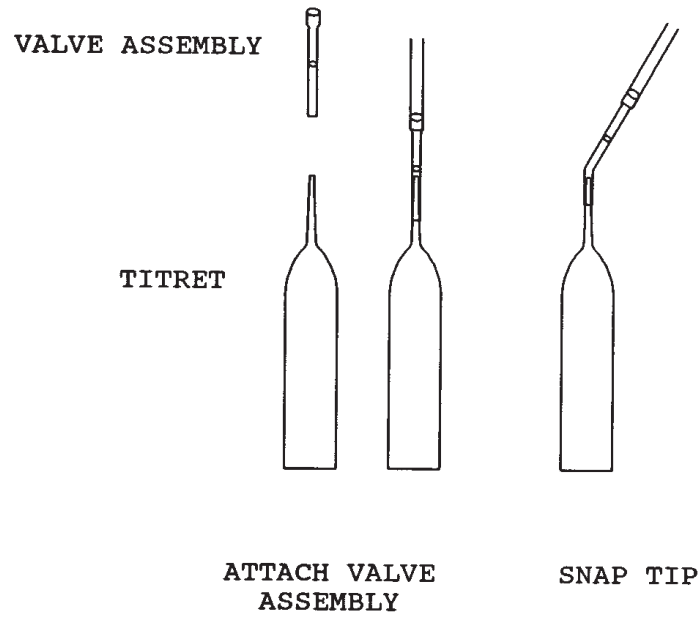
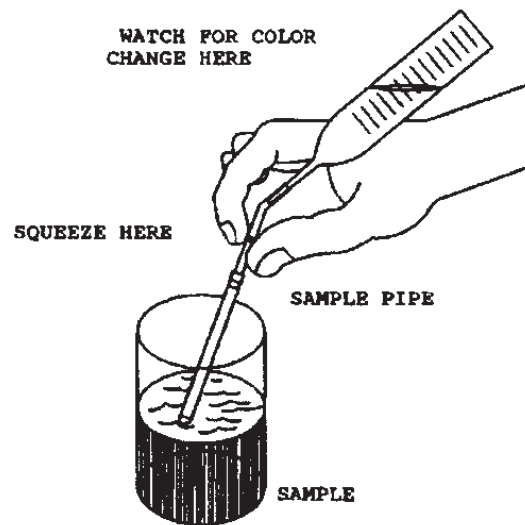


Figure 233-10-1. Titret and Valve Assembly



\* SQUEEZE BEAD VALVE BRIEFLY - SAMPLE FLOWS INTO TITRET

Figure 233-10-2. Drawing Sample into Titret

9. Rock the Titret back and forth several times to mix the contents. Watch for a color change from pink to pale yellow.

10. If the color change did not occur yet, repeat steps h. and i until the color change occurs.

11. After the color change occurs, hold the Titret upright so that the numbers on the scale are right side up. Read the number of the scale corresponding to the level of liquid in the Titret. Record the scale reading in the log.

#### NOTE

Read the liquid level at the bottom of the meniscus (curvature at the upper surface of the liquid).

12. Multiply the scale reading by 50 and record the result in ppm MBT in the log. For example, for a scale reading of 7, MBT is calculated as follows:  $7 \times 50 = 350$  ppm MBT

#### NOTE

If the liquid level does not reach the scale, record ">10" for the scale reading and ">500" for ppm MBT.

13. Dispose of the used titret and valve assembly in such a manner that the broken glass does not present a safety hazard to personnel.

14. Pour the sample in the sample cup into a plastic 5 gallon or smaller bottle identified as containing borate wastes.

15. Rinse the sample cup with distilled water. Pour the sample waste water into the waste bottle.

#### WARNING

Bottles containing borate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

### 233.10.63 RESERVE ALKALINITY TEST

**233.10.64** A Radi-Aider® test stick is dipped into a sample of MIL-A-53009 inhibitor treated coolant. After a brief development time, the color on the stick's second zone (not the one on the end) is compared to a color chart to determine the reserve alkalinity level.

#### a. Apparatus:

1. Radi-Aider® test kit.

#### b. Interferences:

1. None normally present in this type of sample.

#### c. Procedure:

1. Open the bottle of Radi-Aider® test sticks, remove one test stick and recap the bottle.

#### NOTE

Check the expiration date on the bottle of Radi-Aider® test sticks. Do not use the test sticks if the expiration date has passed. In addition, inspect the second test zone (not the one the end) on the test stick. The zone should be yellow. Discard the test stick if the zone is pale blue or white since this indicates deterioration of the test stick due to moisture. Although the test zone on the end of the stick is designed for determining freezing protection, it is not used. MIL-A-53009 inhibitor has no freezing protection properties.

#### NOTE

The Radi-Aider® test stick bottle shall be kept tightly closed.

2. Dip the test stick, test zone down, into the sample far enough to immerse the second test zone. Remove immediately.

3. Shake excess fluid from the test area.

4. Wait 15 seconds to allow the color to develop.

5. Compare the color on the second test zone of the test stick (not the one on the end) with the corrosion protection color chart on the side of the test stick bottle. Do not use the freezing protection color chart.

(a) If the color on the strip matches the 6 square or the 10 square in the color chart, record that reserve alkalinity value (6 or 10) in the log.

(b) If the color on the strip is a darker blue than the 10 square, record ">10" in the log.

(c) If the color on the strip is between the 6 and the 10 squares, record "8" in the log.

(d) If the color on the strip is more yellow or green than the 6 square, record "<6" in the log.

#### NOTE

On some Radi-Aider® bottles the color squares are labeled "poor", "borderline" and "good" (instead of "3", "6" and "10"). On these bottles write "3" below the word "poor", "6" below "borderline" and "10" below "good".

6. Pour the sample containing MIL-A-53009 inhibitor into a plastic 5 gallon or smaller bottle identified as containing borate wastes.

#### WARNING

Bottles containing borate wastes shall be turned into the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

#### 233.10.65 DISTILLATE CONTAMINATION TEST FOR SHIPS WITH SINGLE LOOP WASTE HEAT DISTILLING PLANTS

#### 233.10.66 PREPARING PHENOLPHTHALEIN INDICATOR

**233.10.67** The phenolphthalein indicator solution used in the distillate contamination test is 1 percent phenolphthalein in isopropyl alcohol and distilled water. The solution is prepared from phenolphthalein dry powder as follows:

1. Rinse the phenolphthalein indicator dropper bottle and its stopper with a small portion of isopropyl alcohol.

#### WARNING

Isopropyl alcohol is toxic and flammable.

2. Using a brass dipper, measure 2 level dippers of the phenolphthalein into the dropper bottle.

#### NOTE

Thoroughly clean the dipper before and after measuring phenolphthalein.

3. Rinse a 100 mL graduated cylinder with distilled water and then with a small portion of isopropyl alcohol.

4. Measure 25 mL of isopropyl alcohol with the graduated cylinder and pour it into the dropper bottle, washing down any of the phenolphthalein powder clinging to the inside walls.

5. Stopper the bottle in closed position and shake until all of the phenolphthalein is dissolved.



6. Measure 25 mL of distilled water with the graduated cylinder and pour it into the dropper bottle.

7. Stopper the bottle in the closed position and shake to mix.

#### 233.10.68 DISTILLATE CONTAMINATION TEST

**233.10.69** Phenolphthalein indicator is added to a 200 mL sample of distillate. MIL-A-53009 inhibitor contamination of distillate is indicated by the presence of a pink color.

#### NOTE

Minimize exposure of the sample to atmosphere. The test shall be completed within 30 minutes after obtaining the sample.

a. Apparatus:

1. Casserole.
2. Graduated cylinder, 100 mL.

b. Reagents:

1. Phenolphthalein indicator (prepared in accordance with paragraph 233.10.66).
2. Distilled water

c. Interferences:

1. Absorption of carbon dioxide from the atmosphere can mask the presence of MIL-A-53009 inhibitor in the distillate sample.

d. Procedure:

1. Rinse the casserole with distilled water.

#### NOTE

A clean casserole free from stains is necessary in order to observe the presence or absence of color. A specific casserole shall be designated for use in this test procedure only.

2. Rinse the 100 mL graduated cylinder with distilled water and then with some of the water to be tested.

3. Using the graduated cylinder, measure 200 mL of the sample into the casserole.

4. Hold the casserole under a bright, direct light. Add 5 drops of phenolphthalein indicator. Watch the sample carefully while adding the phenolphthalein.

(a) If the sample remains colorless, the test result is satisfactory.

(b) If the sample turns pink, the distillate is contaminated with MIL-A-53009 inhibitor.

5. Record the test result in the engineering log.

#### WARNING

If the sample turns pink upon addition of phenolphthalein indicator, immediate corrective action shall be taken. Refer to paragraph 233.10.56.

6. Discard the sample. Rinse the casserole and graduated cylinder with distilled water.

#### 233.10.70 CHLORIDE TEST FOR WATER

**233.10.71** A Quantab chloride test strip is immersed in the sample of water to be tested. After an exposure interval, the Quantab is removed from the sample and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart.

a. Apparatus:

1. Quantab chloride test strips.

b. Interferences:

1. None normally present in this type of sample.

c. Procedure:

1. Open the Quantab bottle, remove one test strip and recap the bottle.

**NOTE**

Check expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

**NOTE**

The Quantab bottle shall be kept tightly closed.

2. Place the test strip in to the sample with the word “Quantab” up and the numbered scale facing the person performing the test. Note the time.

**NOTE**

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

3. Leave the test strip in the beaker until the horizontal yellow–orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

4. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the remarks section of the log.

5. Find the scale reading and the corresponding chloride level (column marked “ppm Cl<sup>-</sup>”) on the calibration chart provided with the bottle of Quantabs. Record the chloride results in the remarks section of the log.

(a) If the scale reading is lower than the lowest reading on the chart, record “< (lowest chloride concentration on the chart).” For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record “<30” in the log.

**233.10.72 SUPPLY INFORMATION FOR MIL–A–53009 INHIBITOR TREATMENT****233.10.73 TREATMENT CHEMICALS**

**233.10.74** The chemicals needed for treatment (MIL–A–53009 corrosion inhibitor) are as follows:

ITEM and NSN

Inhibitor, corrosion, 1 qt  
9G 6850–01–160–3868

Inhibitor, corrosion, 1 gal  
9G 6850–01–287–8067

**233.10.75 SAMPLING EQUIPMENT**

**233.10.76** Equipment for sampling engine coolant or distillate is as follows:

ITEM and NSN

Bottle, polyethylene, screw cap, 1 qt  
9G 8125–00–819–6085

Bottle, polyethylene, screw cap, 1/2 pt  
9G 8125–00–680–0141

**233.10.77 TEST EQUIPMENT AND CHEMICALS**

**233.10.78** Equipment and chemicals needed for testing engine coolant samples are as follows:

ITEM and NSN

Thermometer, dial type 0 to 220° F  
9G 6685–00–373–3436

Chloride test strips, Quantabs (bt of 50)  
9G 6850–00–180–6165

Cupric sulfate pentahydrate, 1 lb  
9G 6810–00–241–1203

Test kit, antifreeze (reserve alkalinity)  
9L 6630–01–011–5039

Graduated cylinder, 10 mL  
9L 6640–00–419–7000

Beaker, 50 mL  
9L 6640–01–328–9684

Rod, stirring, glass, 7 in. long (pk of 6)  
9L 6640–00–290–0154

Funnel, plastic  
9L 6640–00–165–5851

Filter paper (pk of 100)  
9L 6640–00–866–1645

Brass measuring dipper  
1H 4410–01–077–2467

Test kit, MBT  
9L 6630-01-327-0617

Jerrican, polyethylene, screw cap, 5 gallons  
9L 6640-01-083-9756

Bottle, screw cap plastic, 2.5 gal  
9L 6640-01-083-9755

Gloves, plastic  
9D 8415-00-682-6786

Goggles, chemical safety  
9G 4240-00-190-6432

#### NOTE

A 2.5 gallon container may be used for commands where the 5 gallon container is not practical.

### 233.10.79 TEST EQUIPMENT AND CHEMICALS FOR DISTILLATE

**233.10.80** Equipment and chemicals needed for testing distillate for contamination by MIL-A-53009 inhibitor are as follows:

ITEM and NSN

Phenolphthalein, 4 oz  
9G 6810-00-223-7612

Isopropyl alcohol (isopropanol, 2-propanol), 1 gal  
9G 6810-00-227-0410

Casserole, porcelain, white  
9L 6640-00-412-8400

Graduated cylinder, 100 mL  
9L 6640-00-420-0000

Bottle, drop-dispenser, plastic, 60 mL  
1H 6440-01-077-2468

### 233.10.81 SAFETY EQUIPMENT

**233.10.82** Protective equipment required when handling inhibitor, test chemicals, or engine coolant samples is as follows:

ITEM and NSN

Face shield, industrial  
9Q 4240-00-542-2048

Apron, synthetic rubber  
9D 8415-00-634-5023

Gloves, rubber  
9D 8415-00-266-8677

### 233.10.83 ENGINE COOLANT RECORD MIL-A-53009 INHIBITOR TREATMENT

**233.10.84** The MIL-A-53009 inhibitor treatment log provides a means for keeping a record of all test results, treatments and other actions which affect the cooling system. The log can therefore be of invaluable assistance in proper cooling system maintenance.

### 233.10.85 DIESEL ENGINE JACKET COOLING WATER SYSTEM, MIL-A-53009 INHIBITOR TREATMENT LOG

**233.10.86** The monthly log (Figure 233-10-3 sheets 1 and 2) consists of the following sections:

- a. Chemical Test Results.
- b. Chemical Treatment.
- c. Remarks.

**233.10.87** Initiate the monthly log for each engine by inserting the engine number, ship name, hull number, month and year.

### 233.10.88 CHEMICAL TEST RESULTS SECTION

**233.10.89** This section shall be maintained as follows:

1. On a 2400 hour clock basis, enter the date and time for the following:
  - a. Completion of jacket water sampling.
  - b. Completion of draining a portion of jacket water.
  - c. Completion of dumping the entire jacket water system.
  - d. Completion of freshly filling.
  - e. Completion of water additions.
2. Enter the appropriate code as given on the back of the log. The codes and explanations are as follows:
  - a. FF, freshly filled, is used when a jacket water system is filled with water after being empty.
  - b. ACA, after chemical addition, denotes a jacket water sample obtained after chemical treatment. This includes samples obtained after freshly filling and treating.

ENGINE NO. \_\_\_\_\_ SHIP \_\_\_\_\_ MONTH \_\_\_\_\_ 19 \_\_\_\_\_  
 PAGE \_\_\_\_\_  
 CHEMICAL TEST RESULTS

DATE	TIME	CODE	CHLORIDE		MBT		RESERVE ALKALINITY	INITIALS	
			DIVISION ON QUANTAB	PPM CHLORIDE (FROM CHARTS)	SCALE READING	SCALE X 50 PPM MBT	RA UNITS  MINIMUM: 6 RA UNITS	TESTER	EOOW/ EDO
				LIMIT: 100 PPM		RANGE: 100–500 PPM			

## CHEMICAL TREATMENT

MIL–A–53009 CORROSION INHIBITOR GALLONS	DATE	TIME	INITIALS

Figure 233–10–3. Diesel Engine Jacket Cooling Water System  
 MIL–A–53009 Inhibitor Treatment Log (Sheet 1 of 2)

PAGE \_\_\_\_\_

[illegible]

FF — FRESHLY FILLED  
ACA — AFTER CHEMICAL ADDITION  
DRN — PORTION OF COOLANT DRAINED  
WA — WATER ADDITION

AWA — AFTER WATER ADDITION  
RTE — ROUTINE SAMPLE  
D — DUMPED  
OTH — OTHER

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

**Figure 233-10-3. Diesel Engine Jacket Cooling Water System  
MIL-A-53009 Inhibitor Treatment Log (Sheet 2 of 2)**

c. AWA, after water addition, denotes a sample obtained following addition of water to the system.

d. RTE, routine, denotes a routine periodic sample.

e. DRN, portion of jacket water drained, is used when the jacket water system is partially drained.

f. D, dumped, is used when the jacket water system is emptied.

g. WA, water addition, is used when water is added to the jacket water system.

h. OTH, other, is used to indicate events related to the jacket water system not covered by a specific code.

3. For each jacket water sample, record:

a. The Quantab scale reading and the chloride test result from the Quantab calibration chart.

b. The MBT Titret scale reading and the calculated MBT test result.

c. The reserve alkalinity test result.

#### NOTE

Out-of-limits test results shall be circled.

4. The tester enters his or her initials and the reviewing EOW and or EDO enters his or her initials upon completion of the tests.

#### 233.10.90 CHEMICAL TREATMENT SECTIONS

**233.10.91** This section shall be maintained as follows:

1. Enter the gallons of MIL-A-53009 inhibitor required.

2. Enter the date and time of completion of the chemical addition.

3. The person who performed the chemical treatment calculations enters his or her initials.

#### 233.10.92 REMARKS SECTION

**233.10.93** The remarks section shall describe significant events related to the jacket cooling system of that diesel engine. Additional pages for remarks shall be inserted as necessary. All remarks are accompanied by the date and time as appropriate. If a doubt exists as to whether or not an entry should be made, enter it. The following types of information shall be recorded.

a. The source and type of water used for filling or topping off a cooling system:

1. Shipboard boiler feedwater or condensate.
2. Shore source feedwater.
3. Water produced by shore or shipboard distilling plants, demineralizers or reverse osmosis units.
4. Potable water (brominated or chlorinated) produce by shipboard distilling plants.

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

c. The reason for a chloride test result above the limit and follow up action taken.

**233.10.94** The LCPO and the MPA shall review and initial the log and the log shall be reviewed and signed by the Engineer Officer.

#### 233.10.95 NALCOOL 2000 TREATMENT

##### WARNING

Nalcool 2000 is hazardous. Skin or eye contact with Nalcool 2000 or coolant containing Nalcool 2000 shall be avoided. When handling Nalcool 2000 or when sampling a cooling system containing Nalcool 2000, wear face shield, rubber gloves and apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

**233.10.96** Nalcool 2000 consists of a blend of inhibitor chemicals in aqueous solution. The major

components are: sodium nitrite, sodium borate, sodium silicate and an organic copper inhibitor. Sodium nitrite aids in the formation of a protective oxide layer on ferrous metal surfaces. Sodium borate is an alkaline buffer which neutralizes acidic byproducts resulting from combustion blowby gasses leaking into the coolant. This provides a less corrosive environment in the engine coolant. Sodium silicate forms a silicate film on metal surfaces and provides effective corrosion protection for mixed metal systems. The organic copper inhibitor chemically bonds with copper contained in copper alloys resulting in a protective layer on the surface.

### 233.10.97 LIMITS

**233.10.98** The following limits apply to Nalcool 2000 treated coolant:

Nitrite ( $\text{NO}_2^-$ )	1000 ppm minimum
Chloride 100	ppm maximum

If the nitrite level is below 1000 ppm, the Nalcool 2000 will not provide adequate corrosion protection. Chloride levels above 100 ppm indicate that seawater has leaked into the cooling system. This makes the coolant more corrosive and decreases the effectiveness of the Nalcool 2000. In addition, seawater contains hardness which will cause scale formation on hot metal surfaces.

### 233.10.99 INITIAL TREATMENT DOSAGE

**233.10.100** When freshly filling a cooling system, add three gallons of Nalcool 2000 for each 100 gallons of cooling system capacity.

#### NOTE

The cooling system shall be recirculated as soon as possible following the addition of chemicals in order to mix them thoroughly. Without recirculation, there will be variations in the Nalcool 2000 concentration throughout the coolant. This can result in accelerated corrosion in areas exposed to dilute coolant.

### 233.10.101 SAMPLING FREQUENCY

**233.10.102** Engine coolant samples shall be obtained and tested for nitrite and chloride in accordance with the following requirements:

- After freshly filling and treating.
- After adding water to the cooling system.
- After adding chemicals to the cooling system.
- At least monthly.
- In accordance with PMS.

### 233.10.103 ACTIONS FOR OUT-OF-LIMIT RESULTS

**233.10.104** Whenever test results are not within the limits specified, the following actions shall be taken:

#### NOTE

Use water meeting the requirements of paragraph 233.10.15 for flushing the cooling system or adding water to the cooling system.

- If the nitrite level is below 1000 ppm, add 1 gallon (8 pints) of Nalcool 2000 for each 100 gallons of cooling system capacity.
- If the chloride concentration exceeds 100 ppm:
  - Dump the entire system.
  - Locate and correct the source of seawater contamination.
  - Fill the cooling system with water meeting the requirements of paragraph 233.10.15 and dump.
  - Test the effluent for chloride using the procedure specified in paragraph 233.10.121.
  - Repeat steps c. and d. until the chloride level in the effluent is less than 50 ppm.
  - Freshly fill and treat using the treatment dosage in paragraph 233.10.99.



**NOTE**

If overheating occurred during the contamination incident, inspect the cooling system prior to refilling for the presence of scale or corrosion deposits to determine the need for chemical cleaning. Inspection is also recommended if it is suspected that the contamination was severe or long term. If chemical cleaning is necessary, use the cleaning procedure starting in paragraph 233.10.260.

**233.10.105 USE OF ANTIFREEZE AND NALCOOL 2000**

**233.10.106** Ships authorized to use Nalcool 2000 treatment shall use inhibited antifreeze (MIL-A-46153) when freezing protection is required. Although inhibited antifreeze contains corrosion inhibitors, Nalcool 2000 shall also be used in order to ensure adequate corrosion protection. The diesel engines on ships authorized to use Nalcool 2000 treatment are subject to cavitation corrosion of cylinder liners if Nalcool 2000 is not used.

**233.10.107 TREATMENT DOSES FOR ANTIFREEZE AND NALCOOL 2000**

**233.10.108** When converting from Nalcool 2000 to inhibited antifreeze/Nalcool 2000, the cooling system shall first be dumped. For each 100 gallons of cooling system capacity, add 33 gallons of inhibited antifreeze and 3 gallons of Nalcool 2000. This provides freezing protection to 0° F. If additional freezing protection is required, use 50 gallons (instead of 33 gallons) of antifreeze, plus 3 gallons of Nalcool 2000, per 100 gallons of cooling system capacity. This provides freezing protection to -34° F.

**CAUTION**

Dilute the antifreeze with water meeting the requirements of paragraph 233.10.15 in the cooling system before adding the Nalcool 2000. Do not combine concentrated antifreeze and Nalcool 2000 together; otherwise inhibited chemicals will precipitate out, adversely impacting engine reliability.

**WARNING**

Do not use higher doses of antifreeze and Nalcool 2000 than specified. Use of higher doses can result in the formation of silicate gel deposits in heat exchangers. This can result in overheating.

**233.10.109 MAINTENANCE OF ANTI-FREEZE AND NALCOOL 2000**

**233.10.110** The limits for Nalcool 2000 treatment also apply when Nalcool 2000 and antifreeze are used together. However, use the chloride test procedure for antifreeze treated coolant. This procedure is the same as the chloride test for Nalcool 2000 treated coolant except that the sample is diluted (due to the presence of ethylene glycol in the antifreeze) and the result is multiplied by two. Refer to paragraph 233.10.166. The same sampling frequency also applies with the following exceptions:

- a. Test the samples obtained following fresh fill and treatment, chemical addition or water addition for freezing protection (as well as nitrite and chloride).
- b. Obtain and test a sample for freezing protection at least quarterly. Refer to paragraph 233.10.170 for the freezing protection test procedure. Record results of freezing protection test in the remarks section of the treatment log.

**233.10.111 WASTE HEAT RECOVERY LOOP ON FFG-7 CLASS**

**233.10.112** FFG-7 class ships are equipped with a distilled water loop which transfers waste heat from the engine coolant to the distilling plant. In the event of dual heat exchanger failures, Nalcool 2000 treated coolant can leak into the waste heat recovery loop and then into the distiller. The potential would then exist for contaminating distillate (and therefore potable water) with toxic Nalcool 2000. Personnel shall remain alert for signs of unexplained coolant loss such as a decrease in expansion tank level.

**233.10.113 WASTE HEAT RECOVERY LOOP SAMPLING REQUIREMENTS**

**233.10.114** The waste heat recovery loop shall be sampled and tested for nitrite level daily. This requirement applies when waste heat is used to

operate the distilling plant at any time during the day. Waste heat recovery loop test results shall be recorded in the engineering log.

### **233.10.115 WASTE HEAT RECOVERY LOOP SAMPLING PROCEDURE**

**233.10.116** Obtain the sample from a convenient location in the common line upstream of the supplementary electric heater as follows:

1. Allow sample to flow from the drain cock long enough to thoroughly flush the drain cock.
2. Thoroughly rinse the sample bottle and cap with sample.
3. Fill the sample bottle with sample and cap it.

#### **NOTE**

Designate a specific sample bottle for waste heat recovery loop samples. Never use a sample bottle which has been used for engine coolant samples to test for distillate contamination.

### **233.10.117 WASTE HEAT RECOVERY LOOP NITRITE LIMIT AND CORRECTIVE ACTION**

**233.10.118** The nitrite level in the waste heat recovery loop shall not exceed 25 ppm. If the nitrite level exceeds 25 ppm, take the following corrective actions immediately:

1. Secure the distilling plant.
2. Dump the waste heat recovery loop.
3. Locate and correct the source of contamination.
4. Flush the waste heat recovery loop with distillate.
5. Sample and test during the flush operations.
6. Continue flushing until the nitrite level is satisfactory.

### **233.10.119 TESTING PROCEDURE FOR NALCOOL 2000 TREATMENT**

**233.10.120** Effective treatment of cooling systems is based upon the accurate performance and interpretation

of the tests that determine coolant quality. If these tests are not performed properly, the coolant will not be treated properly. It is necessary to carefully follow these test procedures in order to ensure accurate results.

#### **WARNING**

Nalcool 2000 treated coolant is hazardous. Skin or eye contact with coolant samples containing Nalcool 2000 shall be avoided. Wear goggles, plastic gloves and rubber apron when handling coolant samples. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

### **233.10.121 CHLORIDE TEST FOR COOLANT**

**233.10.122** Two dippers of cupric sulfate are added to a 10 mL sample of Nalcool 2000 treated coolant. After a brief standing period, the sample is filtered. The end of a Quantab chloride test strip is immersed in the sample. After an exposure interval, the Quantab is removed from the solution and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart.

- a. Apparatus:
  1. Filter paper.
  2. Funnel.
  3. Brass dipper.
  4. Beaker, 50 mL (2).
  5. Graduated cylinder, 10 mL.
  6. Quantab chloride test strips.
  7. Stirring rod.
- b. Reagents:
  1. Distilled water.
  2. Cupric sulfate pentahydrate.
- c. Interferences:

1. The organic copper inhibitor present in Nalcool 2000 interfaces with the Quantabs. The addition of cupric sulfate to the sample causes the organic copper inhibitor to precipitate out, thus eliminating the interference.

**WARNING**

Cupric sulfate is hazardous. Skin or eye contact with cupric sulfate shall be avoided. When handling cupric sulfate wear goggles, plastic gloves and rubber apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

d. Procedure

**NOTE**

The following chloride procedure is for use on ships using Nalcool 2000 alone. Ships using Nalcool 2000 plus antifreeze shall use the procedure in paragraph 233.10.162.

1. Rinse the 10 mL graduated cylinder, the funnel, the stirring rod and two 50 mL beakers with distilled water.

2. Rinse the 10 mL graduated cylinder with a small portion of sample.

3. Measure 10 mL of sample in the graduated cylinder. Pour the sample into one of the 50 mL beakers.

4. Add 2 dippers of cupric sulfate to the sample in the beaker. Stir to mix using the stirring rod.

5. Let the solution stand five minutes.

6. Filter the sample as follows:

(a) Fold the circular filter paper in half and then fold in half again.

(b) Open the folded filter paper to form a cone. Place the cone in the funnel.

(c) Place the funnel in the other 50 mL beaker.

(d) Carefully pour the sample into the filter paper cone inside the funnel. Do not allow the level to reach the upper edge of the paper.

7. Open the Quantab bottle, remove one test strip and recap the bottle.

**NOTE**

Check the expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

**NOTE**

The Quantab bottle shall be kept tightly closed.

8. Into the beaker containing the filtered sample, place the test strip with the word "Quantab" up and the numbered scale facing the person performing the test. Note the time.

**NOTE**

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

9. Leave the test strip in the beaker until the horizontal yellow-orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

10. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the log.

11. Find the scale reading and the corresponding chloride results (column marked "ppm Cl<sup>-</sup>") on the calibration chart provided with the bottle of Quantabs. Record the chloride result in the log.

(a) If the scale reading is lower than the lowest reading on the chart, record "< (lowest chloride concentration on the chart)." For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record "<30" in the log.

12. Pour the samples containing Nalcool 2000 into a plastic 5-gallon bottle identified as containing nitrite, borate and cupric sulfate wastes.

13. Rinse the graduated cylinder, funnel and beakers with distilled water. Pour the sample waste water into the waste bottle. Place the soiled filter paper into the waste bottle.

### WARNING

Bottles containing nitrite, borate and cupric sulfate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

## 233.10.123 NITRITE TEST

**233.10.124** One mL of Nalcool 2000 treated coolant is diluted to 100 mL with distilled water. A nitrite test stick is dipped into the diluted sample. After a brief development time, the color on the stick is compared to a color chart to determine the nitrite content.

a. Apparatus:

1. Nalfleet test kit (includes graduated dropper, 100 mL measuring cylinder and nitrite test stick).

b. Reagents:

1. Distilled water.

c. Interferences:

1. The sample shall be diluted so that the nitrite level will be within the range of the test sticks.

d. Procedure:

1. Rinse the graduated dropper with distilled water.

2. Rinse the graduated dropper with a small portion of sample.

3. Using the graduated dropper, add one mL of sample to the 100 mL measuring cylinder.

4. Add distilled water to the 100 mL mark. Mix well.

5. Open the container of nitrite test sticks, remove one test strip and recap the container.

### NOTE

Check the expiration date on the nitrite test stick container label. Do not use the test sticks if the expiration date has passed.

### NOTE

The nitrite test stick container shall be kept tightly closed.

6. Dip a nitrite test stick, test zone down, into the dilute solution for three seconds.

7. After removing the test stick, wait 15 seconds to allow the color to develop.

8. Compare the color on the test stick with the color chart on the side of the test stick container.

(a) If the color is equal to or darker than 10, the nitrite level is equal to or greater than the 1000 ppm minimum required. Record "1000 or ">1000" in the log as appropriate.

(b) If the color is lighter than 10, the nitrite level is less than the 1000 ppm minimum required. Record "<1000" in the log.

9. Pour the sample containing Nalcool 2000 into a plastic 5 gallon bottle identified as containing nitrite and borate wastes.

10. Rinse the graduated dropper and measuring cylinder with distilled water. Pour the sample waste water into the waste bottle.

**WARNING**

Bottles containing nitrite and borate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

**233.10.125 WASTE HEAT RECOVERY LOOP NITRITE TEST FOR FFG-7**

**233.10.126** A nitrite test stick is dipped into a sample from the waste heat recovery loop. After a brief development time, the color on the stick is compared to a color chart to determine the nitrite concentration.

- a. Apparatus:
  - 1. Nitrite test sticks.
- b. Interferences:
  - 1. None normally present in this type of sample.
- c. Procedure:
  - 1. Open the container of nitrite test sticks, remove one test stick and recap the container.

**NOTE**

Check the expiration date on the test stick container label. Do not use the test sticks if the expiration date has passed.

**NOTE**

The nitrite test stick container shall be kept tightly closed.

2. Dip the nitrite test stick, test zone down, into the sample for three seconds.

3. After removing the test stick, wait 15 seconds to allow the color to develop.

4. Compare the color on the test stick with the color chart on the side of the test stick container.

(a) If the color is equal to or lighter than 25, the nitrite level is equal to or less than the 25 ppm limit. In the engineering log, record the concentration that most closely matches the color.

(b) If the color is darker than 25, the nitrite level exceeds the 25 ppm limit. In the engineering log, record the concentration that most closely matches the color.

**WARNING**

If the nitrite concentration is 25 ppm or more, immediate corrective action shall be taken. Refer to paragraph 233.10.117.

**233.10.127 CHLORIDE TEST FOR WATER**

**233.10.128** A Quantab chloride test strip is immersed in the sample of water to be tested. After an exposure interval, the Quantab is removed from the sample and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart.

- a. Apparatus:
  - 1. Quantab chloride test strips.
- b. Interferences:
  - 1. None normally present in this type of sample.
- c. Procedure:
  - 1. Open the Quantab bottle, remove one test strip and recap the bottle.

**NOTE**

Check the expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

**NOTE**

The Quantab bottle shall be kept tightly closed.

2. Place the test strip into the sample with the word “Quantab” up and the numbered scale facing the person performing the test. Note the time.

**NOTE**

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

3. Leave the test strip in the beaker until the horizontal yellow–orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

4. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the remarks section of the log.

5. Find the scale reading and the corresponding chloride level (column marked “ppm cl<sup>-</sup>”) on the calibration chart provided with the bottle of Quantabs. Record the chloride result in the remarks section of the log.

(a) If the scale reading is lower than the lowest reading on the chart, record “< (lowest chloride concentration on the chart).” For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record “<30” in the log.

**233.10.129 SUPPLY INFORMATION FOR NALCOOL 2000 TREATMENT****233.10.130 TREATMENT CHEMICALS**

**233.10.131** The chemicals needed for treatment are as follows:

ITEM and NSN

Inhibitor, corrosion (Nalcool 2000) 64 oz (1/2 gal)  
9G 6850–01–085–4718

Inhibitor, corrosion (Nalcool 2000) 15 gal  
9G 6850–01–087–4045

Inhibitor, corrosion (Nalcool 2000) 55 gal  
9G 6850–01–086–3438

**233.10.132 SAMPLING EQUIPMENT**

**233.10.133** Equipment for sampling engine coolant or waste heat recovery loop is as follows:

ITEM and NSN

Bottle, polyethylene, screw cap, 1 qt  
9G 8125–00–819–6085

Bottle, polyethylene, screw cap, 1/2 pt  
9G 8125–00–680–0141

**233.10.134 TEST EQUIPMENT AND CHEMICALS**

**233.10.135** Equipment and chemicals needed for testing engine coolant or waste heat recover loop samples are as follows:

ITEM and NSN

Thermometer, dial type, 0° to 220° F  
9G 6685–00–373–3436

Nalfleet test kit  
1H 6850–01–154–3655

Nitrite test sticks (2 tubes of 100)  
1H 6850–01–154–3653

Cupric sulfate pentahydrate, 1 lb  
9G 6810–00–241–1203

Chloride test strips, Quantabs (bt of 50)  
9G 6850–00–180–6165

Brass measuring dipper  
1H 4410–01–077–2467

Graduated cylinder, 10 mL  
9L 6640–00–419–7000

Funnel, plastic  
9L 6640–00–165–5851



Filter paper (pk of 100)  
9G 6640-00-866-1645

Beaker, 50 mL, pk of 12  
9G 6640-01-328-9684

Rod, stirring, glass, 7 in. long (pk of 6)  
9L 6640-00-290-0154

Jerrican, polyethylene, screw cap 5-gal  
9L 6640-01-083-9756

### 233.10.136 SAFETY EQUIPMENT

**233.10.137** Protective equipment required when handling inhibitor or test chemicals, or engine coolant samples is as follows:

ITEM and NSN

Face shield, industrial  
9Q 4240-00-542-2048

Apron, synthetic rubber  
9D 8415-00-634-5023

Gloves, rubber  
9D 8415-00-266-8677

Gloves, plastic  
9D 8415-00-682-6786

Goggles, chemical safety  
9G 4240-00-190-6432

### 233.10.138 ENGINE COOLANT RECORD NALCOOL 2000 TREATMENT

**233.10.139** The Nalcool 2000 treatment log provides a means for keeping a record of all test results, treatment and other actions which affect the cooling system. The log can therefore be of invaluable assistance in proper cooling system maintenance.

### 233.10.140 DIESEL ENGINE JACKET COOLING WATER SYSTEM NALCOOL 2000 TREATMENT LOG

**233.10.141** The monthly log (Figure 233-10-4 sheets 1 and 2) consist of the following sections:

- a. Chemical Test Results.
- b. Chemical Treatment.
- c. Remarks.

**233.10.142** Initiate the monthly log for each engine by inserting the engine number, ship name, hull number, month and year.

### 233.10.143 CHEMICAL TEST RESULTS SECTION

**233.10.144** This section shall be maintained as follows:

1. On a 2400 hour clock basis, enter the date and time for the following:
  - a. Completion of jacket water sampling.
  - b. Completion of draining a portion of the jacket water.
  - c. Completion of dumping the entire jacket water system.
  - d. Completion of freshly filling.
  - e. Completion of water additions.
2. Enter the appropriate code as given on the back of the log. The codes and explanations, are as follows:
  - a. FF, freshly filled, is used when an empty jacket water system is filled with water.
  - b. ACA, after chemical addition, denotes a jacket water sample obtained following chemical treatment. This includes samples obtained following freshly filling and treating.
  - c. AWA, after water addition, denotes a sample obtained after addition of water to the system.
  - d. RTE, routine, denotes a routine periodic sample.
  - e. DRN, portion of jacket water drained, is used when the jacket water system is partially drained.
  - f. D, dumped, is used when the jacket water system is emptied.
  - g. WA, water addition, is used when water is added to the jacket water system.
  - h. OTH, other, is used to indicate events related to the jacket water system not covered by a specific code.
3. For each jacket water sample, record:
  - a. The Quantab scale reading and the chloride test result from the Quantab calibration chart.
  - b. The nitrite test result.

### NOTE

Out-of-limits test results shall be circled.



4. The tester enters his or her initials and the reviewing EOOW and or EDO enters his or her initials upon completion of the tests.

#### **233.10.145 CHEMICAL TREATMENT SECTION**

**233.10.146** This section shall be maintained as follows:

1. Enter the amount of Nalcool 2000 required.
2. Enter the date and time of completion of the chemical addition.
3. The person who performed the chemical treatment calculations enters his or her initials.

#### **233.10.147 REMARKS SECTION**

**233.10.148** The remarks section shall describe significant events related to the jacket cooling water system of that diesel engine. Additional pages for remarks shall be inserted as necessary. All remarks are accompanied by the date and time as appropriate. If a doubt exists as to whether or not an entry should be made, enter it. The following types of information shall be recorded:

- a. The source and type of water used for filling or topping off a cooling system:
  1. Shipboard boiler feedwater or condensate.
  2. Shore source feedwater.
  3. Water produced by shore or shipboard distilling plants, demineralizers or reverse osmosis units.
  4. Potable-water (brominated or chlorinated) produce by shipboard distilling plants. Enter the Quantab scale reading and corresponding chloride test result for water produced by shore or shipboard distilling plants, demineralizers or reverse osmosis units or potable water (brominated or chlorinated) produced by shipboard distilling plants.
- b. The reason for partially draining or dumping a cooling system.
- c. The reason for a chloride test result above the limit and follow up action taken.

d. The results of freezing protection tests for ships using inhibited antifreeze and Nalcool 2000 treatment.

**233.10.149** The LCPO and the MPA shall review and initial the log and the log shall be reviewed and signed by the Engineer Officer.

#### **233.10.150 INHIBITED ANTIFREEZE TREATMENT**

##### **WARNING**

Inhibited antifreeze or coolant containing inhibited antifreeze is hazardous. Skin or eye contact with inhibited antifreeze shall be avoided. When handling concentrated antifreeze or when sampling an antifreeze treated cooling system wear face shield, rubber gloves and apron. In case of skin or eye contact flush with cold, potable water immediately, then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional safety information.

**233.10.151** Inhibited antifreeze (MIL-A-46153) consists of ethylene glycol and corrosion inhibiting chemicals (sodium borate, trisodium phosphate and an organic copper inhibitor). A mixture (solution) of ethylene glycol and water has a lower freezing point than either water or ethylene glycol alone. Thus, treating a cooling system with a mixture of ethylene glycol and water provides freezing protection. Sodium borate is an alkaline buffer which neutralizes acidic by products resulting from combustion blowby gases leaking into the coolant. Trisodium phosphate contributes additional alkalinity and aids in the formation of a protective layer on metal surfaces. The organic copper inhibitor chemically bonds with copper contained in copper alloys resulting in a protective film on the surfaces.

ENGINE NO. \_\_\_\_\_ SHIP \_\_\_\_\_ MONTH \_\_\_\_\_ 19 \_\_\_\_\_ PAGE \_\_\_\_\_

## CHEMICAL TEST RESULTS

DATE	TIME	CODE	CHLORIDE		NITRITE		INITIALS	
			DIVISION ON QUANTAB	PPM CHLORIDE (FROM CHART)	PPM NO <sub>2</sub> –		TESTER	EOOW/ EDO
				LIMIT 100 PPM	MINIMUM: 1,000 PPM			

## CHEMICAL TREATMENT

NALCOOL 2000 GALLONS	DATE	TIME	INITIALS

Figure 233-10-4. Diesel Engine Jacket Cooling Water System  
Nalcool 2000 Treatment Log (Sheet 1 of 2)

PAGE \_\_\_\_\_

[illegible]

FF — FRESHLY FILLED  
ACA — AFTER CHEMICAL ADDITION  
DRN — PORTION OF COOLANT DRAINED  
WA — WATER ADDITION

AWA — AFTER WATER ADDITION  
RTE — ROUTINE SAMPLE  
D — DUMPED  
OTH — OTHER

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

**Figure 233-10-4. Diesel Engine Jacket Cooling Water System  
Nalcool 2000 Treatment Log (Sheet 2 of 2)**

**NOTE**

Use only MIL–A–46153 inhibited antifreeze. This antifreeze, is labeled: “U.S. Government Property. Ethylene Glycol, anti–freeze.” The label also contains the stock number. Verify that the stock number matches the appropriate number (depending on container size) given in paragraph 233.10.176. Different brands of commercial antifreezes are formulated with different corrosion inhibiting chemicals which may or may not be effective. The different inhibitor packages may also be incompatible with each other and with the inhibitors in MIL–A–46153 antifreeze. In addition, the antifreeze test procedures will only give accurate results for coolant treated with MIL–A–46153 inhibited antifreeze.

**233.10.152 LIMITS**

**233.10.153** The following limits apply to antifreeze treated coolant:

Reserve Alkalinity units	6 RA units minimum
Chloride	100 ppm maximum

Freezing Protection: (See Table 233–10–2 and paragraph 233.10.154)

Reserve alkalinity levels less than 6 RA units can result in accelerated corrosion. Chloride levels above 100 ppm indicate that seawater has leaked into the cooling system. This makes the coolant more corrosive and decreases the ability of the inhibited antifreeze to inhibit corrosion. In addition, seawater contains hardness which can result in scale formation on hot metal surfaces.

**233.10.154 TREATMENT DOSAGES****CAUTION**

Never use antifreeze concentrations greater than 67 percent or less than 33 percent.

**NOTE**

Use water meeting the requirements of paragraphs 233.10.15 when adding water to a cooling system.

**233.10.155** Table 233–10–2 gives antifreeze mixtures which provide different degrees of freezing protection. However, the treatment dosage normally recommended is 50 percent antifreeze (one gallon of antifreeze mixed with one gallon water for every two gallons of cooling system capacity.) This mixture provides freezing protection down to –30 °F and supplies an ample amount of corrosion inhibitors. If conditions are such that additional freezing protection is required, up to 67 percent antifreeze can be used (six gallons of antifreeze mixed with three gallons of water.) This mixture provides freezing protection down to –77° F. The specific gravity of the 67 percent antifreeze mixture is 1.0970 at 60° F. Never use antifreeze concentrations greater than 67 percent because the following will occur:

- Less freezing protection is provided (pure antifreeze freezes at 9° F).
- The engine may overheat because ethylene glycol has a lower heat capacity than water.
- The corrosion inhibitors will not function properly.

**CAUTION**

Do not use antifreeze concentrations less than 33 percent (one gallon of antifreeze mixed with two gallons of water) because there will not be sufficient corrosion inhibitors to provide adequate corrosion protection. Antifreeze treated coolant shall be changed out every two years.

Table 233–10–2. FREEZE PROTECTION OF ANTIFREEZE MIXTURES

LOWEST TEMPERATURE ANTICIPATED	QUARTS OF ANTIFREEZE	QUARTS OF WATER	ANTIFREEZE CONCENTRATION (PERCENT)	SPECIFIC GRAVITY OF MIXTURE AT 60° F
1° F	1	2	33	1.0494
–10° F	2	3	40	1.0601
–19° F	4	5	44	1.0670
–30° F	1	1	50	1.0745
–77° F	2	1	67	1.0970
NOTE: 50 percent antifreeze is normally recommended.				

**233.10.156 SAMPLING FREQUENCY**

**233.10.157** Engine coolant samples shall be obtained and tested for reserve alkalinity, chloride and freezing protection in accordance with the following requirements:

- After freshly filling and treating.
- After adding water to the cooling system.
- After adding antifreeze to the cooling system.
- At least monthly for reserve alkalinity and chloride (quarterly for freezing protection).
- In accordance with PMS.

**233.10.158 ACTIONS FOR OUT-OF-LIMITS RESULTS**

**233.10.159** Whenever test results are not within the limits specified, the following actions shall be taken:

**NOTE**

Use water meeting the requirements of paragraph 233.10.15 for flushing the cooling system or adding water to the cooling system.

- If freezing protection is inadequate for anticipated weather conditions or if the antifreeze

concentrations is less than the 33 percent minimum, (specific gravity lower than 1.0494 at 60° F), drain some of the coolant and replace with a quantity of antifreeze sufficient to provide the needed freezing protection.

- If the antifreeze concentration exceeds the 67 percent maximum (specific gravity greater than 1.0970 at 60° F), drain some of the coolant and replace with water meeting the requirements of paragraph 233.10.15.

- If the reserve alkalinity is less than 6 RA units:

- Dump the entire cooling system.
- Freshly fill and treat.

- If the chloride concentration exceeds 100 ppm:

- Dump the entire system.
- Locate and correct the source of seawater contamination.
- Fill the cooling system with water meeting the requirements of paragraph 233.10.15 and dump.
- Test the effluent for chloride using the procedure specified in paragraph 233.10.166.
- Repeat steps c. and d. until the chloride level in the effluent is less than 100 ppm.
- Freshly fill and treat using the treatment dosage in paragraph 233.10.154.

**NOTE**

If overheating occurred during the contamination incident, inspect the cooling system prior to refilling for the presence of scale or corrosion deposits to determine the need for chemical cleaning. Inspection is also recommended if it is suspected that the contamination was severe or long term. If chemical cleaning is necessary, use the cleaning procedure starting in paragraph 233.10.260.

**233.10.160 ANTIFREEZE ON SHIPS WITH SINGLE LOOP WASTE HEAT DISTILLING PLANTS**

<b>WARNING</b>
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Antifreeze contaminated distillate shall not be used as drinking water.

**233.10.161** When antifreeze treatment is used in the main diesel engine on ships equipped with single loop waste heat distilling plants, failure of the heat exchanger supplying waste heat to the distiller will allow antifreeze to leak into the distiller. If this happens, tests have shown that the distillate (and therefore potable water) will become contaminated with toxic ethylene glycol.

**NOTE**

Antifreeze shall only be used on ships with single loop waste heat distilling plants during periods when freezing protection is necessary. As soon as freezing protection is no longer required, convert to the cooling system treatment authorized for use when freezing protection is not required (refer to Table 233–10–1).

**233.10.162 REQUIRED PRECAUTIONS FOR SHIPS WITH SINGLE LOOP WASTE HEAT DISTILLING PLANTS**

**233.10.163** When antifreeze is used in the main diesel engines on ships with single loop waste heat distillers, the following actions shall be taken:

1. Log the jacket water expansion tank level hourly.
2. The log shall be reviewed prior to sending distillate to a potable water tank.
3. If coolant loss has occurred, do not send distillate to the potable water tank until the source of the loss is determined.
4. If the source of the loss cannot be found, assume that a leak has occurred in the heat exchanger supplying waste heat to the distiller.

<b>WARNING</b>
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In the event of a heat exchanger leak, immediate corrective action shall be taken. Do not send distillate to potable water tanks. Dump all potable water tanks to which distillate has been sent since the leak occurred or since the last satisfactory expansion tank reading. Locate and correct the source of the leakage. Thoroughly flush the affected potable water tanks with distillate (when satisfactory distillate is available).

**233.10.164 TESTING PROCEDURES FOR INHIBITED ANTIFREEZE TREATMENT**

**233.10.165** Effective treatment of cooling systems is based upon the accurate performance and interpretation of the tests that determine coolant quality. If these tests are not performed properly, the coolant will not be treated properly. It is necessary to carefully follow these test procedures in order to ensure accurate results.

**WARNING**

Antifreeze treated coolant is hazardous. Skin or eye contact with coolant samples containing antifreeze shall be avoided. Wear goggles, plastic gloves and rubber apron when handling coolant samples. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

**233.10.166 CHLORIDE TEST FOR COOLANT**

**233.10.167** A 10 mL sample of antifreeze treated coolant is diluted with 10 mL of distilled water. Two dippers of cupric sulfate are added to the diluted sample. After a brief standing period, the sample is filtered. The end of a Quantab chloride test strip is immersed in the sample. After an exposure interval, the Quantab is removed from the solution and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart and multiplying the result by two.

## a. Apparatus:

1. Filter paper.
2. Funnel.
3. Brass dipper.
4. Beaker, 50 mL (2).
5. Graduated cylinder, 10 mL.
6. Quantab chloride test strips.
7. Stirring rod.

## b. Reagents:

1. Distilled water.
2. Cupric sulfate pentahydrate.

## c. Interferences:

1. The organic copper inhibitor present in inhibited antifreeze interferes with the Quantabs. The addition of cupric sulfate to the sample causes the copper inhibitor to precipitate out, thus eliminating the interference.

2. The ethylene glycol in the antifreeze causes the Quantab to work very slowly. Diluting the sample eliminates the problem.

**WARNING**

Cupric sulfate is hazardous. Skin or eye contact with cupric sulfate shall be avoided. When handling cupric sulfate wear goggles, plastic gloves and rubber apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

## d. Procedure:

1. Rinse the 10 mL graduated cylinder, the funnel, the stirring rod and two 50 mL beakers with distilled water.

2. Rinse the 10 mL graduated cylinder with a small portion of sample.

3. Measure 10 mL of sample in the graduated cylinder. Pour the sample into one of the 50 mL beakers.

4. Rinse the graduated cylinder with distilled water. Measure 10 mL of distilled water in the graduated cylinder. Pour the distilled water into the beaker containing the sample.

5. Add 2 dippers of cupric sulfate to the diluted sample in the beaker. Stir to mix using the stirring rod.

6. Let the solution stand five minutes.

7. Filter the sample as follows:

- (a) Fold the circular filter paper in half and then fold in half again.

- (b) Open the folded filter paper to form a cone. Place the cone in the funnel.

- (c) Place the funnel in the other 50 mL beaker.

- (d) Carefully pour the sample into the filter paper cone inside the funnel. Do not allow the level to reach the upper edge of the paper.



8. Open the Quantab bottle, remove one test strip and recap the bottle.

**NOTE**

Check the expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

**NOTE**

The Quantab bottle shall be kept tightly closed.

9. Into the beaker containing the filtered sample place the test strip with the word “Quantab” up and the numbered scale facing the person performing the test. Note the time.

**NOTE**

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

10. Leave the test strip in the beaker until the horizontal yellow–orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

11. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the log.

12. Find the scale reading and the corresponding chloride result (column marked “ppm Cl<sup>-</sup>”) on the calibration chart provided with the bottle of Quantabs. Record the chloride reading in the log.

(a) If the scale reading is lower than the lowest reading on the chart, record “<(lowest chloride concentration on the chart).” For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record “<30” in the log.

13. Multiply the chloride reading from the chart by 2 and record the result in ppm chloride in the log. Using the above example,  $<30 \times 2 = <60$ . Record “<60” in the log.

14. Pour the samples containing inhibited antifreeze into a plastic 5 gallon bottle identified as containing ethylene glycol, borate and cupric sulfate wastes.

15. Rinse the graduated cylinder, funnel and beakers with distilled water. Pour the sample waste water into the waste bottle. Place the soiled filter paper into the waste bottle.

**WARNING**

Bottles containing ethylene glycol, borate and cupric sulfate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

**233.10.168 CORROSION INHIBITOR LEVEL (RESERVE ALKALINITY) TEST**

**233.10.169** A Radi–Aider® test stick is dipped into a sample of antifreeze treated coolant. After a brief development time, the color on the stick’s second test zone (not the one on the end) is compared to a color chart to determine the corrosion inhibitor level.

a. Apparatus:

1. Radi–Aider® test kit.

b. Interferences:

1. None normally present in this type of sample.

c. Procedure:

1. Open the bottle of Radi–Aider® test sticks, remove one test stick and recap the bottle.

**NOTE**

Check the expiration date on the bottle of Radi-Aider® test sticks. Do not use the test sticks if the expiration date has passed. In addition, inspect the second test zone (not the one on the end) on the test stick. The zone should be yellow. Discard the test stick if the zone is pale blue or white since this indicates deterioration of the test stick due to moisture. Although the test zone on the end of the test stick is designed for determining freezing protection, it is not used in Navy tests. Only the freezing protection test procedure in paragraph 233.10.170 is authorized.

**NOTE**

The Radi-Aider® test stick bottle shall be kept tightly closed.

2. Dip the test stick, test zone down, into the sample far enough to immerse the second test zone. Remove immediately.

3. Shake excess fluid from the test area.

4. Wait 15 seconds to allow the color to develop.

5. Compare the color on the second test zone of the stick (not the one on the end) with the corrosion protection color chart on the side of the test stick bottle. (Do not use the freezing protection color chart.)

(a) If the color on the strip matches the 6 square or the 10 square in the color chart, record that reserved alkalinity value (“6” or “10”) in the log.

(b) If the color on the strip is a darker blue than the 10 square, record “>10” in the log.

(c) If the color on the strip is between the 6 and the 10 squares, record “8” in the log.

(d) If the color on the strip is more yellow or green than the 6 square, the corrosion inhibitor level is below the required level. Record “<6” in the log.

**NOTE**

On some Radi-Aider® bottles the color squares are labelled “poor”, “borderline” and “good” (instead of “3”, “6”, and “10”). On these bottles write “3” below the word “poor”, “6” below “borderline”, and “10” below “good”.

6. Pour the sample containing antifreeze into a plastic 5 gallon bottle identified as containing ethylene glycol and borate wastes.

**WARNING**

Bottles containing ethylene glycol and borate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

**233.10.170 FREEZING PROTECTION TEST**

**233.10.171** A sample of antifreeze treated coolant is drawn into an antifreeze tester. Float and temperature readings are taken. Freezing protection is determined using a temperature variance table.

a. Apparatus:

1. Antifreeze tester.

b. Reagents:

1. Distilled water.

c. Interferences:

1. None normally present in this type of sample.

d. Procedure:

1. Draw distilled water into the antifreeze tester and rinse it.

2. Insert the tester into the sample.

3. Draw sample into the tester and rinse it.
4. Insert the tester into the sample.
5. Draw sample into the tester.
6. Observe coolant protection float and temperature readings.
7. Determine the adjusted coolant protection (freezing protection) using the temperature variance table provided with the antifreeze tester.
8. Pour the sample containing antifreeze into a plastic 5 gallon bottle identified as containing ethylene glycol and borate wastes.
9. Rinse the antifreeze tester with distilled water. Pour the sample waste water into the waste bottle.

<b>WARNING</b>
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Bottles containing ethylene glycol and borate wastes shall be turned in to the Public Works Officer of Public Works Center at any Naval Shipyard or other Navy industrial facility.

### 233.10.172 CHLORIDE TEST FOR WATER

**233.10.173** A Quantab chloride test strip is immersed in the sample of water to be tested. After an exposure interval, the Quantab is removed from the sample and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart.

- a. Apparatus:
  1. Quantab chloride test strips.
- b. Interferences:
  1. None normally present in this type of sample.
- c. Procedure:
  1. Open the Quantab bottle, remove one test strip and recap the bottle.

#### NOTE

Check the expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

#### NOTE

The Quantab bottle shall be kept tightly closed.

2. Place the test strip into the sample with the word "Quantab" up and the numbered scale facing the person performing the test. Note the time.

#### NOTE

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

3. Leave the test strip in the beaker until the horizontal yellow-orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

4. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the remarks section of the log.

5. Find the scale reading and the corresponding chloride level (column marked "ppm cl<sup>-</sup>") on the calibration chart provided with the bottle of Quantabs. Record the chloride result in the remarks section of the log.

- (a) If the scale reading is lower than the lowest reading on the chart, record "< (lowest chloride concentration on the chart)." For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record "<30" in the log.

**233.10.174 SUPPLY INFORMATION FOR INHIBITED ANTIFREEZE TREATMENT**

**233.10.175 TREATMENT CHEMICALS**

**233.10.176** The chemicals needed for treatment are as follows:

ITEM and NSN

Antifreeze, ethylene glycol, inhibited, heavy duty (MIL–A–46153) 1 gal  
9G 6850–00–181–7929

Antifreeze, ethylene glycol, inhibited, heavy duty (MIL–A–46153) 5 gal  
9G 6850–00–181–7933

Antifreeze, ethylene glycol, inhibited, heavy duty (MIL–A–46153) 55 gal  
9G 6850–00–181–7940

**233.10.177 SAMPLING EQUIPMENT**

**233.10.178** Equipment for sampling engine coolant is as follows:

ITEM and NSN

Bottle, polyethylene, screw cap, 1 qt.  
9G 8125–00–819–6085

Bottle, polyethylene, screw cap, 1/2 pt  
9G 8125–00–680–0141

**233.10.179 TEST EQUIPMENT AND CHEMICALS**

**233.10.180** Equipment and chemicals needed for testing engine coolant samples are as follows:

ITEM and NSN

Thermometer, dial type, 0° to 200° F  
9G 6685–00–373–3436

Test kit, antifreeze (reserve alkalinity)  
9L 6630–01–011–5039

Cupric sulfate pentahydrate 1 lb  
9G 6810–00–241–1203

Chloride test strips, Quantabs (bt of 50)  
9G 6850–00–180–6165

Graduated cylinder, 10 mL  
9L 6640–00–419–7000

Beaker, 50 mL, pk of 12  
9L 6640–00–328–9684

Rod, stirring, glass 7 in. long (pk of 6)  
9L 6640–00–290–0154

Funnel, plastic  
9L 6640–00–165–5851

Filter paper (pk of 100)  
9L 6640–00–866–1645

Brass measuring dipper  
1H 4410–01–077–2467

Antifreeze tester (freeze protection)  
9L 6630–00–247–2968

Jerrican, polyethylene, screw cap, 5 gal  
9L 6640–01–083–9756

**233.10.181 SAFETY EQUIPMENT**

**233.10.182** Protective equipment required when handling inhibitor or test chemicals, or engine coolant samples is as follows:

ITEM and NSN

Face shield, industrial  
9Q 4240–00–542–2048

Apron, synthetic rubber  
9D 8415–00–634–5023

Gloves, rubber  
9D 8415–00–266–8677

Gloves, plastic  
9D 8415–00–682–6786

Goggles, chemical safety  
9G 4240–00–190–6432

**233.10.183 ENGINE COOLANT RECORD ANTIFREEZE TREATMENT**

**233.10.184** The antifreeze treatment log provides a means for keeping a record of all test results and treatment and other actions which affect the cooling system. The log can therefore be of invaluable assistance in proper cooling system maintenance.

**233.10.185 DIESEL ENGINE JACKET COOLING WATER SYSTEM, ANTIFREEZE TREATMENT LOG**

**233.10.186** The monthly log (Figure 233–10–5 sheets 1 and 2) consists of the following section:

- a. Chemical Test Results.
- b. Freeze Protection Test Results.
- c. Chemical Treatment.
- d. Remarks.

ENGINE NO. \_\_\_\_\_ SHIP \_\_\_\_\_ MONTH \_\_\_\_\_ 19 \_\_\_\_\_ PAGE \_\_\_\_\_

## CHEMICAL TEST RESULTS

DATE	TIME	CODE	CHLORIDE			RESERVE ALKALINITY	INITIALS	
			DIVISION ON QUANTAB	PPM CHLORIDE (FROM CHART)	CHART X 2 PPM CHLORIDE	RA UNITS	TESTER	EOOW/ EDO
					LIMIT 100 PPM	MINIMUM, 6 RA UNITS		

## FREEZE PROTECTION TEST RESULTS

DATE	TIME	CODE	FREEZE PROTECTION			INITIALS	
			FLOAT READING	TEMPERATURE READING	FREEZE PROTECTION DEGREES F (FROM TABLE)	TESTER	EOOW/ EDO

## CHEMICAL TREATMENT

MIL-A-46153 ANTIFREEZE GALLONS	DATE	TIME	INITIALS

Figure 233-10-5. Diesel Engine Jacket Cooling Water System  
Antifreeze Treatment Log (Sheet 1 of 2)

PAGE \_\_\_\_\_

[illegible]

## CODES

FF — FRESHLY FILLED  
ACA — AFTER CHEMICAL ADDITION  
DRN — PORTION OF COOLANT DRAINED  
WA — WATER ADDITION

AWA — AFTER WATER ADDITION  
RTE — ROUTINE SAMPLE  
D — DUMPED  
OTH — OTHER

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

**Figure 233–10–5. Diesel Engine Jacket Cooling Water System  
Antifreeze Treatment Log (Sheet 2 of 2)**

**233.10.187** Initiate the monthly log for each engine by inserting the engine number, ship name, hull number, month and year.

### **233.10.188 CHEMICAL TEST RESULTS SECTION**

**233.10.189** This section shall be maintained as follows:

1. On a 2400 hour clock basis, enter the date and time for the following:

- a. Completion of jacket water sampling.
- b. Completion of draining a portion of jacket water.
- c. Completion of dumping the entire jacket water system.
- d. Completion of freshly filling.
- e. Completion of water additions.

2. Enter the appropriate code as given on the back of the log. The codes and explanations, are as follows:

- a. FF, freshly filled, is used when a jacket water system is filled with water after being empty.
- b. ACA, after chemical addition, denotes a jacket water sample obtained following chemical treatment. This includes samples obtained following freshly filling and treating.
- c. AWA, after water addition, denotes a sample obtained following addition of water to the system.
- d. RTE, routine, denotes a routine periodic sample.
- e. DRN, portion of jacket water drained, is used when the jacket water system is partially drained.
- f. D, dumped, is used when the jacket water system is emptied.
- g. WA, water addition, is used when water is added to the jacket water system.
- h. OTH, other, is used to indicate events related to the jacket water system not covered by a specific code.

3. For each jacket water sample, record:

- a. The Quantab scale reading, the chloride reading from the Quantab calibration chart and the calculated chloride test result.

- b. The reserve alkalinity test result.

### **NOTE**

Out-of-limits test results shall be circled.

4. The tester enters his or her initials and the reviewing EOOW and or EDO enters his or her initials upon completion of the tests.

### **233.10.190 FREEZE PROTECTION TEST RESULTS SECTION**

**233.10.191** This section shall be maintained as follows:

1. On a 2400 hour clock basis, enter the date and time for the completion of jacket water sampling.

2. For each jacket water sample tested for freeze protection, record:

- a. The float reading from the tester.
- b. The temperature reading from the tester.
- c. Freeze protection from the table.

3. The tester enters his or her initials and the reviewing EOOW and or EDO enters his or her initials upon completion of the tests.

### **233.10.192 CHEMICAL TREATMENT SECTION**

**233.10.193** This section shall be maintained as follows:

1. Enter the amount of MIL-A-46153 inhibited antifreeze required.

2. Enter the date and time of completion of the chemical addition.

3. The person who performed the chemical treatment calculations enters his or her initials.

### **233.10.194 REMARKS SECTION**

**233.10.195** The remarks section shall describe significant events related to the jacket cooling water system of that diesel engine. Additional pages for remarks shall be inserted as necessary. All remarks are accompanied by the date and time as appropriate. If a doubt exists as to whether or not an entry should be made, enter it. The following types of information shall be recorded:



a. The source and type of water used for filling or topping off a cooling system:

1. Shipboard boiler feedwater or condensate.
2. Shore source feedwater.
3. Water produced by shore or shipboard distilling plants, demineralizers or reverse osmosis units.
4. Potable water (brominated or chlorinated) produce by shipboard distilling plants.

Enter the Quantab scale reading and corresponding chloride test result for water produced by shore or shipboard distilling plants, demineralizers or reverse osmosis units or potable water (brominated or chlorinated) produced by shipboard distilling plants.

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

c. The reason for a chloride test result above the limit and follow up action taken.

d. Information concerning the degree of freezing protection required.

**233.10.196** The LCPO and the MPA shall review and initial the log and the log shall be reviewed and signed by the Engineer Officer.

### **233.10.197 SOLUBLE OIL TREATMENT**

#### **WARNING**

Soluble oil can be irritating to the skin or eyes. When handling soluble oil or sampling a cooling system, wear face shield, rubber gloves and apron. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact occurs. See paragraphs 233.10.238 through 233.10.253 for additional information.

**233.10.198** Soluble oil provides a thin protective oil film on metal surfaces which helps minimize corrosion.

### **233.10.199 LIMITS**

**233.10.200** The following limits apply to soluble oil treated coolant:

Soluble Oil	1.0 to 2.0 percent
Chloride	100 ppm maximum

Soluble oil levels below 1.0 percent will not provide adequate corrosion protection. Soluble oil levels above 2.0 percent can lead to the formation of insulating films which restrict heat transfer and can cause overheating. High soluble oil levels can also cause the soluble oil to separate from the water. Chloride levels above 100 ppm indicate that seawater has leaked into the cooling system. This makes the coolant more corrosive. Seawater contains hardness which will cause scale formation on hot metal surfaces. In addition, seawater can cause the soluble oil to separate from the water.

### **233.10.201 INITIAL TREATMENT DOSAGE**

**233.10.202** When freshly filling a cooling system, premix one pint of soluble oil with one gallon of water meeting the requirements of paragraph 233.10.15 for each 8 gallons of cooling system capacity. Mix thoroughly before adding to the cooling system.

#### **NOTE**

Premixing of the soluble oil prior to installation is essential to obtain adequate corrosion protection and to avoid separation of the soluble oil from the water in the cooling system. Do not add soluble oil directly to the cooling system.

### **233.10.203 SAMPLING FREQUENCY**

**233.10.204** Engine coolant samples shall be obtained and tested for soluble oil and chloride in accordance with the following requirements:

- a. After freshly filling and treating.
- b. After adding water to the cooling system.
- c. After adding chemicals to the cooling system.
- d. At least monthly.

- e. In accordance with PMS.

### **233.10.205 ACTIONS FOR OUT-OF-LIMITS RESULTS**

**233.10.206** Whenever test results are not within the limits specified, the following actions shall be taken:

#### **NOTE**

Use water meeting the requirements of paragraph 233.10.15 for premixing soluble oil, flushing the cooling system or adding water to the cooling system.

a. If the soluble oil content is below 1.0 percent, add 1 pint of soluble oil premixed with 1 gallon of water for every 16 gallons of cooling system capacity.

b. If the soluble oil content is above 2.0 percent, drain some of the treated coolant and replace with water.

c. If the chloride concentration exceeds 100 ppm:

1. Dump the entire system.
2. Locate and correct the source of seawater contamination.
3. Fill the cooling system with water meeting the requirements of paragraph 233.10.15 and dump.
4. Test the effluent for chloride using the procedure specified in paragraph 233.10.213.
5. Repeat steps 3. and 4. until the chloride level in the effluent is less than 100 ppm.
6. Freshly fill and treat using the treatment dosage in paragraph 233.10.201.

#### **NOTE**

If overheating occurred during the contamination incident, inspect the cooling system prior to refilling for the presence of scale or corrosion deposits to determine the need for chemical cleaning. Inspection is also recommended if it is suspected that the contamination was severe or long term. If chemical cleaning is necessary, use the cleaning procedure starting in paragraph 233.10.260. Before this cleaning method can be applied, soluble oil residues shall be removed from the cooling system since these residues can render the cleaning procedure ineffective. Follow the procedure starting in paragraph 233.10.256 for removal of soluble oil residues.

### **233.10.207 CONVERTING FROM SOLUBLE OIL TO ANTIFREEZE OR FROM ANTI-FREEZE TO SOLUBLE OIL**

#### **WARNING**

Antifreeze shall only be used when freezing protection is necessary in main engines on ships authorized to use soluble oil treatment. Refer to paragraph 233.10.160. As soon as freezing protection is no longer required, convert to soluble oil treatment.

**233.10.208** Cooling system fouling can result from having soluble oil and antifreeze together in the same system. In converting from soluble oil to antifreeze:

- a. Converting from soluble oil to antifreeze:
  1. Open all low point drains and completely dump the cooling system.
  2. Clean the system using the procedure starting in paragraph 233.10.256 to remove soluble oil residues.
  3. Maintain antifreeze treatment in accordance with paragraphs 233.10.150 through 233.10.196.

## b. Converting from antifreeze to soluble oil:

1. Open all low point drains and completely dump the cooling system.
2. Fill the system with clean, fresh water, then dump.
3. Repeat step 2. until the effluent is clear to ensure complete removal of all antifreeze. (Blue or green effluent indicates the presence of antifreeze).
4. Fill the system with water meeting the requirements of paragraph 233.10.15.
5. Dump the water, then freshly fill and treat using water meeting the requirements of paragraph 233.10.15.

**233.10.209 TESTING PROCEDURES FOR SOLUBLE OIL**

**233.10.210** Effective treatment of cooling systems is based upon the accurate performance and interpretation of the tests that determine coolant quality. If these tests are not performed properly, the coolant will not be treated properly. It is necessary to carefully follow these test procedures in order to ensure accurate results.

**WARNING**

Soluble oil treated coolant can be irritating to the skin or eyes. Wear goggles, plastic gloves and rubber apron when handling coolant samples. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

**233.10.211 SOLUBLE OIL TEST**

**233.10.212** Calcium chloride is added to a sample of soluble oil treated coolant contained in a Stoddard solvent bottle. The calcium chloride causes the soluble oil to separate from the water. The sample is allowed to stand while the separation occurs. The depth of the separated oil is determined and a conversion chart is used to convert the reading to percent soluble oil.

## a. Apparatus:

1. Stoddard solvent (unsaturation) bottle.
2. Spatula, scoop (scoopula).
3. Funnel.

## b. Reagents:

1. Calcium chloride, anhydrous.
2. Isopropyl alcohol.
3. Distilled water.

## c. Interferences:

1. Incomplete separation of the soluble oil can occur if the sample is not allowed to stand for the specified time following the addition of the calcium chloride.

## d. Procedure:

1. Rinse a Stoddard solvent bottle and stopper with distilled water.
2. Rinse the Stoddard solvent bottle and stopper with a small portion of sample.
3. Fill the Stoddard solvent bottle to the 0 percent mark with sample.
4. Using the scoopula and funnel, add calcium chloride to the sample until the liquid level reaches the 100 percent mark.

**CAUTION**

The bottle will heat up while calcium chloride is dissolving and shall therefore be handled with care.

5. Allow the sample to stand for four (4) hours while the oil is separating from the water.

6. Determine the depth of the oil layer by counting divisions on the bottle.

7. Refer to the soluble oil conversion chart, Figure 233-10-6. Find the number of oil divisions from the bottle on the left of the chart. Read across to the diagonal line and then down to percent soluble oil.

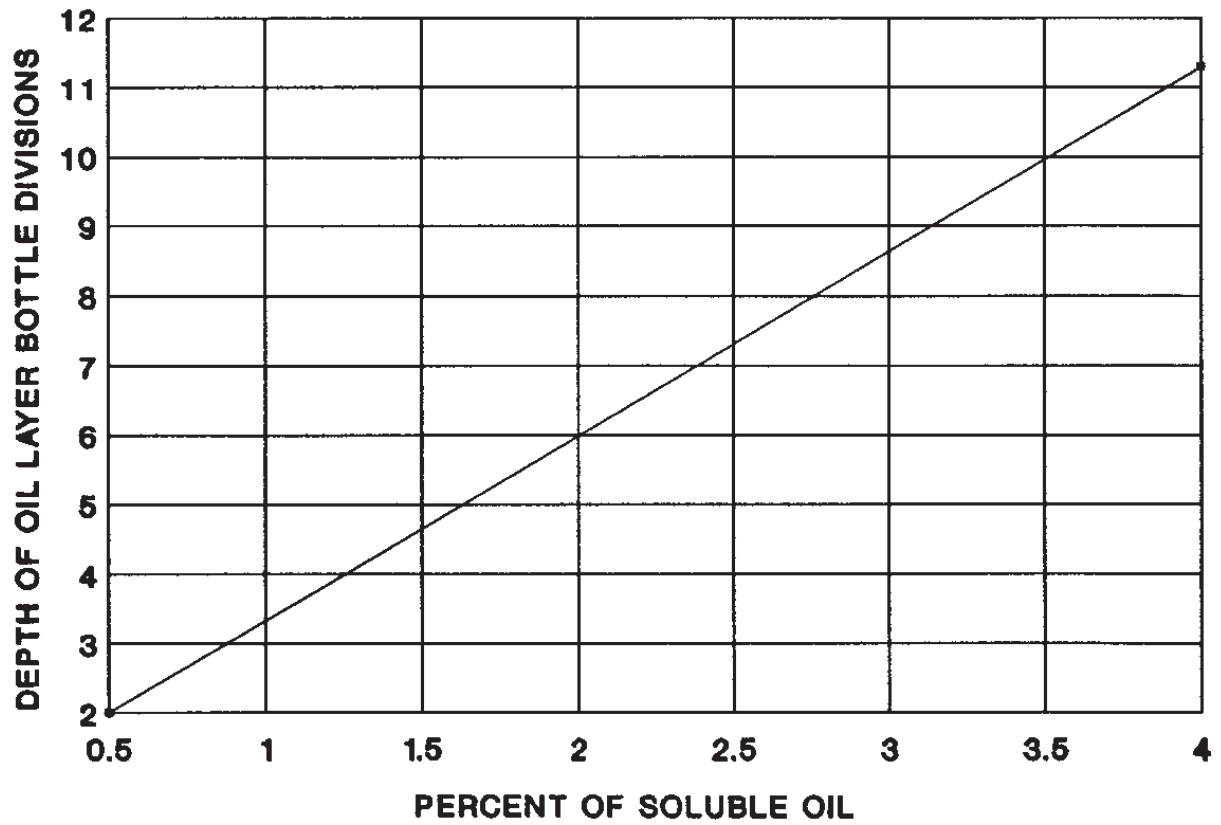


Figure 233-10-6. Soluble Oil Conversion Chart

(a) For example, if the depth of the oil layer is six divisions, the soluble oil content is 2.0 percent.

(b) Empty the sample bottle and rinse three times with isopropyl alcohol.

**CAUTION**

Isopropyl alcohol is toxic and flammable.

8. Rinse with distilled water and allow to drain dry.

### 233.10.213 CHLORIDE TEST FOR COOLANT

**233.10.214** Sodium chromate solution and a chloride test tablet are added to 50 mL of soluble oil treated coolant or untreated water. The tablet is dissolved and the chloride concentration is determined by the color of the solution.

a. Apparatus:

1. Graduated cylinder, 100 mL with stopper.
2. Dropper bottle.
3. Teaspoon.

b. Reagents:

1. Chloride test tablets.
2. Sodium chromate, anhydrous, technical.
3. Distilled water.

c. Interferences:

1. The test will not work unless chromate is present in the sample. The addition of sodium chromate solution to the sample provides the necessary chromate.

d. Preparation of Sodium Chromate Solution.

**WARNING**

Sodium chromate is hazardous. Skin or eye contact with sodium chromate powder or solutions shall be avoided. When handling sodium chromate powder or solution wear goggles, plastic gloves and rubber apron. A dust respirator shall also be worn when handling sodium chromate powder. In case of skin or eye contact flush with cold, potable water immediately; then wash skin with soap and water. Seek immediate medical attention if eye contact or ingestion occurs. Refer to paragraphs 233.10.238 through 233.10.253 for additional information.

1. Rinse the 100 mL graduated cylinder with distilled water.

2. Fill the graduated cylinder to the 50 mL mark with distilled water.

3. Add one level teaspoon of sodium chromate. Stopper and shake to dissolve.

**WARNING**

The teaspoon used to measure sodium chromate shall not be used for any other purpose.

4. Carefully pour the sodium chromate into a dropper bottle.

5. Label the bottle "sodium chromate solution".

6. Rinse the graduated cylinder with distilled water. Pour the rinsing into a plastic 5 gallon bottle identified as containing chromate wastes.

e. Procedure:

1. Rinse the 100 mL graduated cylinder with distilled water.

2. Rinse the graduated cylinder with a small portion of sample.

3. Fill the graduated cylinder to the 50 mL mark with sample.

4. Add 10 drops of sodium chromate solution to the sample.

5. Stopper and shake the cylinder.

6. Remove the stopper. Add one chloride test tablet.

7. Stopper and shake the cylinder until the tablet dissolves.

8. Inspect the sample color:

(a) If the sample develops a reddish–brown color, the chloride is within the 100 ppm limit. Record “<100” in the log.

(b) If the sample develops a yellow–green color, the chloride exceeds the 100 ppm limit. Record “>100” in the log.

9. Pour the samples containing chromate into a plastic 5 gallon bottle identified as containing chromate wastes.

10. Rinse the graduated cylinder with distilled water. Pour the sample waste water into the waste bottle.

### WARNING

Bottles containing chromate wastes shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Navy industrial facility.

## 233.10.215 CHLORIDE TEST FOR WATER

**233.10.216** A Quantab chloride test strip is immersed in the sample of water to be tested. After an exposure interval, the Quantab is removed from the sample and the scale reading is obtained. The reading is converted to ppm chloride by using a conversion chart.

a. Apparatus:

1. Quantab chloride test strips.

b. Interferences:

1. None normally present in this type of sample.

c. Procedure:

1. Open the Quantab bottle, remove one test strip and recap the bottle.

### NOTE

Check the expiration date on the Quantab bottle label. Do not use the Quantabs if the expiration date has passed.

### NOTE

The Quantab bottle shall be kept tightly closed.

2. Place the test strip into the sample with the word “Quantab” up and the numbered scale facing the person performing the test. Note the time.

### NOTE

Never immerse the entire Quantab strip beneath the level of the solution being tested; otherwise the test strip will give a false low result.

3. Leave the test strip in the beaker until the horizontal yellow–orange band across the top of the strip turns dark blue. This normally takes about 10–20 minutes. The blue color signals that the test is ended. Remove the test strip from the beaker within 5 minutes after the blue color appears.

4. Read the number on the scale corresponding to the highest point at the upper tip of the white color change. Estimate to the nearest half division. Each division equals 0.2. Record the scale reading in the remarks section of the log.

5. Find the scale reading and the corresponding chloride level (column marked “ppm cl<sup>-</sup>”) on the calibration chart provided with the bottle of Quantabs. Record the chloride result in the remarks section of the log.

(a) If the scale reading is lower than the lowest reading on the chart, record "< (lowest chloride concentration on the chart)." For example, if the lowest scale reading on the chart is 1.4 and this corresponds to 30 ppm chloride, record "<30" in the log.

### **233.10.217 SUPPLY INFORMATION FOR SOLUBLE OIL TREATMENT**

#### **233.10.218 TREATMENT CHEMICALS**

**233.10.219** The chemicals needed for treatment are as follows:

ITEM and NSN

Inhibitor, corrosion, soluble oil  
(MIL-I-24453) 1 gal  
9G 6850-00-139-5318

Inhibitor, corrosion, soluble oil  
(MIL-I-24453) 5 gal  
9G 6850-00-139-5319

#### **233.10.220 SAMPLING EQUIPMENT**

**233.10.221** Equipment for sampling engine coolant is as follows:

ITEM and NSN

Bottle, polyethylene, screw cap, 1 qt  
9G 8125-00-819-6085

### **233.10.222 TEST EQUIPMENT AND CHEMICALS FOR ENGINE COOLANT**

**233.10.223** Equipment and chemicals needed for testing engine coolant are as follows:

ITEM and NSN

Thermometer, dial type, 0° to 220° F  
9G 6685-00-373-3436

Teaspoon  
9Q 7340-00-205-3340

Bottle, dropper, 60 mL, plastic  
1H 6640-01-077-2468

Graduated cylinder with stopper, 100 mL (pk of 4)  
\* Fisher P/N 08-566-10D

Bottle, unsaturation  
9L 6640-00-359-9663

Brush, bottle  
9Q 7920-01-091-1759

Spatula, scoop  
9L 6640-00-441-2000

Chloride test tablets  
9G 6810-00-201-1257

Sodium chromate, anhydrous 1 lb  
9G 6810-00-240-2119

Calcium chloride, anhydrous  
9G 6810-01-126-2694

Isopropyl alcohol (isopropanol, 2-propanol)  
9G 6810-00-227-0410

Jerrican, polyethylene, screw cap, 5 gal  
9L 6640-01-083-9756

\* Available from Fisher Scientific Co. (regional offices)

### **233.10.224 SAFETY EQUIPMENT**

**233.10.225** Protective equipment required when handling inhibitor or test chemicals, or engine coolant samples is as follows:

ITEM and NSN

Face shield, industrial  
9Q 4240-00-542-2048

Apron, synthetic rubber  
9D 8415-00-634-5023

Gloves, rubber  
9D 8415-00-266-8677

Gloves, plastic  
9D 8415-00-682-6786

Goggles, chemical safety  
9G 4240-00-190-6432

Respirator, air filter  
9G 4240-00-629-8199

### **233.10.226 ENGINE COOLANT RECORD SOLUBLE OIL TREATMENT**

**233.10.227** The soluble oil treatment log provides a means for keeping a record of all test results and treatment and other actions which affect the cooling system. The log can therefore be of invaluable assistance in proper cooling system maintenance.

### **233.10.228 DIESEL ENGINE JACKET COOLING WATER SYSTEM, SOLUBLE OIL TREATMENT LOG**

**233.10.229** The monthly log (Figure 233-10-7 sheets 1 and 2) consists of following section:

a. Chemical Test Results.



ENGINE NO. \_\_\_\_\_ SHIP \_\_\_\_\_ MONTH \_\_\_\_\_ 19 \_\_\_\_\_ PAGE \_\_\_\_\_

## CHEMICAL TEST RESULTS

DATE	TIME	CODE	SOLUBLE OIL		CHLORIDE	INITIALS	
			DIVISION ON BOTTLE	PERCENT	PPM	TESTER	EOOW/ EDO
				RANGE 1.0 – 2.0 %	LIMIT: 100 PPM		

## CHEMICAL TREATMENT

SOLUBLE OIL PINTS	(NOTE: PREMIX SOLUBLE OIL BEFORE ADDING TO JACKET WATER SYSTEM)	DATE	TIME	INITIALS

Figure 233-10-7. Diesel Engine Jacket Cooling Water System  
Soluble Oil Treatment Log (Sheet 1 of 2)

PAGE \_\_\_\_\_

[illegible]

## CODES

FF — FRESHLY FILLED  
ACA — AFTER CHEMICAL ADDITION  
DRN — PORTION OF COOLANT DRAINED  
WA — WATER ADDITION

AWA — AFTER WATER ADDITION  
RTE — ROUTINE SAMPLE  
D — DUMPED  
OTH — OTHER

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

**Figure 233-10-7. Diesel Engine Jacket Cooling Water System  
Soluble Oil Treatment Log (Sheet 2 of 2)**

- b. Chemical Treatment.
- c. Remarks.

**233.10.230** Initiate the monthly log for each engine by inserting the engine number, ship name, hull number, month and year.

### **233.10.231 CHEMICAL TEST RESULTS SECTION**

**233.10.232** This section shall be maintained as follows:

- a. On a 2400 hour clock basis enter the date and time for the following:
  - 1. Completion of jacket water sampling.
  - 2. Completion of draining a portion of jacket water.
  - 3. Completion of dumping the entire jacket water system.
  - 4. Completion of freshly filling.
  - 5. Completion of water additions.
- b. Enter the appropriate code as given on the back of the log. The codes, and explanations, are as follows:
  - 1. FF, freshly filled, is used when an empty jacket water system is filled with water.
  - 2. ACA, after chemical addition, denotes a jacket water sample obtained after chemical treatment. This includes samples obtained after freshly filling and treating.
  - 3. AWA, after water addition, denotes a sample obtained after addition of water to the system.
  - 4. RTE, routine, denotes a routine periodic sample.
  - 5. DRN, portion of jacket water drained, is used when the jacket water system is partially drained.
  - 6. D, dumped, is used when the jacket water system is emptied.
  - 7. WA, water addition, is used when water is added to the jacket water system.
  - 8. OTH, other, is used to indicate events related to the jacket water system not covered by a specific code.
- c. For each jacket water sample, record:

- 1. The bottle scale reading and the soluble oil test result from the soluble oil conversion chart.
- 2. The chloride test result.

### **NOTE**

Out-of-limits test results shall be circled.

- d. The tester enters his or her initials and the reviewing EOW and or EDO enters his or her initials upon completion of the tests.

### **233.10.233 CHEMICAL TREATMENT SECTION**

**233.10.234** This section shall be maintained as follows:

- a. Enter the amount of soluble oil required.
- b. Enter the date and time of completion of the chemical addition.
- c. The person who performed the chemical treatment calculations enters his or her initials.

### **233.10.235 REMARKS SECTION**

**233.10.236** The remarks section shall describe significant events related to the jacket cooling water system of that diesel engine. Additional pages for remarks shall be inserted as necessary. All remarks are accompanied with the date and time as appropriate. If a doubt exists as to whether or not an entry should be made, enter it. The following types of information shall be recorded:

- a. The source and type of water used for filling or topping off a cooling system:
  - 1. Shipboard boiler feedwater or condensate.
  - 2. Shore source feedwater.
  - 3. Water produced by shore or shipboard distilling plants, demineralizers or reverse osmosis units.
  - 4. Potable water (brominated or chlorinated) produce by shipboard distilling plants.
- b. The reason for partially draining or dumping a cooling system.
- c. The reason for a chloride test result above the limit and follow-up action taken.

**233.10.237** The LCPO and the MPA shall review and initial the log and the log shall be reviewed and signed by the Engineer Officer.

### **233.10.238 CHEMICAL SAFETY PRECAUTIONS, HANDLING, AND STORAGE PROCEDURES**

**233.10.239** A number of safety precautions shall be observed when treating or testing engine coolant. Many of the chemicals employed are alkalies. Some are acids. All are poisons when ingested. Protective equipment shall be worn when handling any of the chemicals. Refer to paragraph 233.10.250. Do not handle any of the chemicals directly. Immediate medical attention shall be obtained if eye contact or ingestion of any chemical occurs. Contaminated clothing shall be laundered prior to reuse. Do not store, carry or consume food or tobacco in areas where the chemicals are stored, handled or dispensed.

#### **233.10.240 ALKALIES**

**233.10.241** Nalcool 2000, inhibited antifreeze and MIL-A-53009 inhibitor contain strong alkalies. Do not mix alkalies directly with acids because the heat generated may cause the chemicals to spatter. If alkalies contact the skin, flush the affected skin with cold water until the slippery feeling disappears. If a burning or itching sensation persists, seek medical attention. If alkalis come in contact with the eyes, flush with large amounts of potable water and seek immediate medical attention. All alkalies shall be stored separately from acids.

#### **233.10.242 ACIDS**

**233.10.243** Cupric sulfate pentahydrate used in the chloride test (for coolant treated with MIL-A-53009 inhibitor, Nalcool 2000 or inhibited antifreeze) is an acid. Do not mix acids with alkalies. If acids contact the skin, flush the affected skin area with cold water. If a burning or itching sensation persists or a skin rash develops, seek medical attention. If acids come in contact with the eyes, flush with large amounts of potable water and obtain immediate medical attention.

#### **233.10.244 POISONS**

**233.10.245** All of the test and treatment chemicals are poisons having varying degrees of toxicity. Isopropyl alcohol is very different from ethyl alcohol. Small amounts of isopropyl alcohol, if swallowed, can cause serious illness. Sodium chromate is very poisonous by ingestion, inhalation or skin absorption and is irritating

to the eyes, skin and mucous membranes. Inhibited antifreeze consists primarily of ethylene glycol which is toxic by ingestion. Its vapors are also toxic. MIL-A-53009 inhibitor and Nalcool 2000 are both toxic by ingestion. Cupric sulfate pentahydrate is toxic and is irritating to the eyes, skin and mucous membranes. Phenolphthalein is used medicinally in extremely small amounts but in larger amounts it is a poison. Soluble oil, although relatively low in toxicity, can irritate the eyes and skin. In addition, soluble oil shall not be ingested.

#### **233.10.246 FLAMMABLES**

**233.10.247** Isopropyl alcohol is a flammable and combustible material. The flash point of isopropyl alcohol is 59° F (15° C). Antifreeze and soluble oil are low fire hazard materials.

#### **233.10.248 OXIDIZERS**

**233.10.249** Sodium chromate is an oxidizing material and shall not be stored with or allowed to come in contact with reducing materials.

### **233.10.250 HANDLING PROCEDURES**

**233.10.251** Face shield, rubber gloves and rubber apron shall be worn when accomplishing the following:

- a. Handling corrosion inhibitor chemicals or concentrated treatment solutions (MIL-A-53009 inhibitor, Nalcool 2000, inhibited antifreeze or soluble oil).

- b. Sampling a cooling system.

**233.10.252** Goggles, plastic gloves and apron shall be worn when handling the following:

- a. Engine coolant samples.

- b. Test chemicals.

In addition, a dust respirator shall be worn when handling dry sodium chromate powder (used in the chloride test for soluble oil treated coolant).

**233.10.253** Goggles, rubber gloves and rubber apron shall be worn when performing maintenance or repair work on engines or cooling systems in which personnel might come in contact with treated engine coolant. Inhalation of ethylene glycol vapors (from hot coolant treated with antifreeze) shall also be avoided.

### **233.10.254 CLEANING DIESEL ENGINE COOLING WATER SYSTEMS**

**233.10.255** The presence of excessive deposits in cooling systems, due to scale formation or corrosion

products, can cause uneven heat transfer and overheating. This sets up stresses in the affected areas which can result in cracked heads, liners or other parts. The presence of lubricating oil (or separated soluble oil) in cooling systems can cause similar problems. Cleaning is necessary for removal of oil or excessive deposits from cooling systems.

### **233.10.256 CLEANING FOR OIL REMOVAL**

**233.10.257** Recirculation of a hot detergent solution through a cooling system will remove soluble oil residues (for converting to antifreeze treatment) or oil residue due to minor lube oil contamination. The procedure may not be completely successful in removing major lube oil contamination. If such a situation is encountered, consult with NAVSEA or Naval Ship Systems Engineering Station, Carderock Division, Naval Surface Warfare Center (NAVSSSES), Philadelphia.

### **233.10.258 PROCEDURE FOR OIL REMOVAL**

**233.10.259** The entire cooling system shall be flushed including the entire block, associated piping, expansion tank and jacket water and lube oil coolers. (Where applicable, the jacket water side of the distilling plant shall also be flushed). An external pump and tank with a heating coil shall be used for heating and circulating the detergent solution. The tank shall be located higher than the engine during the flush. The procedure is as follows:

1. Open all low point drains and completely dump the cooling system.
2. Fill the cooling system with clean, fresh water. Fill the mixing tank to 1/3 capacity.
3. Circulate and heat the water to  $150 \pm 5$  °F ( $65.5^\circ \text{C} \pm 2.7^\circ \text{C}$ ).
4. Add nonionic detergent (MIL-D-16791 Type I) to the tank. Add 1/2 ounce of detergent for each gallon of water in the system.
5. Circulate the detergent solution for 30 minutes at  $150 \pm 5$  °F ( $65.5^\circ \text{C} \pm 2.7^\circ \text{C}$ ).
6. Drain the cooling system. Drain the tank separately to avoid reintroducing removed oil into the cooling system.
7. Repeat the flush if large amounts of oil are seen in the flush solution.

8. After completing the detergent flush, flush with clean, fresh water until the effluent is clear and no sudsing is evident.

9. Flush once with water meeting the requirements of paragraph 233.10.15.

10. Inspect the cooling system to determine the success of the cleaning. (Inspection is not required if the cleaning was conducted for removing soluble oil residue to prepare for converting to a different inhibitor treatment.)

### **233.10.260 CLEANING FOR REMOVAL OF SCALE OR CORROSION PRODUCTS**

**233.10.261** Recirculation of a hot descalant solution is employed for the removal of scale or corrosion products. If oil residues are also present, the system shall first be cleaned using the procedure starting in paragraph 233.10.256; otherwise, the descalant will not work properly.

### **233.10.262 APPLICABILITY**

**233.10.263** Paragraphs 233.10.264 through 233.10.270 give the procedure for removing rust and water-formed deposits from cooling systems in which cast iron or aluminum are present.

### **CAUTION**

During the cleaning operation, foul weather gear, rubber gloves, goggles and face masks shall be worn by personnel engaged in the cleaning operation. Adequate ventilation shall be provided. Smoking, welding or open flames shall not be permitted in the cleaning area.

### **233.10.264 CHEMICALS REQUIRED**

**233.10.265** For each 50 gallons of water required to fill the cooling system, the chemicals required are:

1. 40 pounds of ammonium citrate, dibasic, ACS grade, NSN 6810-00-975-2503.
2. 2 pounds of 1,3 diethylthiourea Pennwalt No. 266.
3. 3 ounces non-ionic wetting agent, NSN 7930-00-282-9699.

**233.10.266 EQUIPMENT REQUIRED**

**233.10.267** For the cleaning and treating operation, the equipment required is:

a. **Pump.** The pump should be acid resistant, nonferrous, rubber or plastic construction; capable of pumping 5 to 10 gallons per minute against a static head of 5 to 20 psi. A brine pump similar to those employed with seawater evaporators is acceptable. Also acceptable is JABSCO Model 2187, JABSCO Pump Co., 2031 N. Lincoln St, Burbank, CA.

b. **Mixing Tank.** The tank capacity should be approximately 100 gallons. (Two nominal 50 gallon steel drums interconnected near the bottom with 1–1/2 inch pipe are acceptable).

c. **Heating Coil.** This 3/4 inch ID coil should have 20 feet of heating surface capable of withstanding applied steam pressure, be fabricated to fit into the mixing tank, and contain a steam trap on the outlet side of the coil.

d. **Acid Hose.** The acid hose shall be 1–inch ID acid resistant. The hose shall be capable of safely recirculating hot descaling solution (160° F or 71° C). Hoses shall be of sufficient length to connect the mixing tank and pump to the cooling side of the engine and return to the mixing tank.

e. **Steam Hose.** The steam hose shall be 1 inch inside diameter. The hose shall be of sufficient length to connect the steam source to the heating coil.

f. **Steam Source.** Steam source shall be 25 to 100 psi.

**233.10.268 PREPARATION FOR CLEANING**

**233.10.269** Figure 233–10–8 is a schematic for cleaning the cooling side of diesel engines.

**233.10.270** Procedure for cleaning the cooling water system is:

1. Blank off all parts of the system external to the engine.
2. Determine the capacity of the system to be cleaned. This can be done by filling the system and draining into a container of known capacity.
3. After draining the system thoroughly, flush the watersides with clean, fresh water for 30 minutes.
4. Isolate the engine cooling system pump to prevent contact with the descaling solution.

5. Connect an acid hose from the mixing tank to the suction side of the acid or brine pump. Attach another acid hose to the discharge side of the pump and to the engine coolant inlet. Attach an acid hose to the engine coolant outlet and return it to the mixing tank. Fasten the acid hose inside the tank to prevent whipping during circulation of the descalant.

6. Fill the system with clean, fresh water. Fill the mixing tank to 1/3 capacity. Circulate the water through the cooling system and mixing tank. Add steam to the heating coil to raise the temperature of the circulating water to 160° F (71° C).

7. While recirculating the hot water, slowly add the required quantities of chemicals based on the calculated system capacity, include the water in the mixing tank.

8. After all the chemicals have been added, obtain a representative sample to determine solution strength. (see paragraph 233.10.271).

9. Recirculate the solution through the cooling system for 15 minutes maintaining the temperature at 160° F (71° C).

10. Continue cleaning for 6 hours. Every hour, recirculate the solution for 15 minutes. Use the heating coil to maintain the temperature at 160° F (71° C).

11. Check the acid concentration at 2, 4, and 6 hour intervals. The initial concentration is approximately 10 percent by weight.

12. After 6 hours, dump the cleaning solution.

**WARNING**

All descalant and descalant solutions shall be turned in to the Public Works Officer or Public Works Center at any Naval Shipyard or other Naval Industrial Facility for proper disposal.

13. Fill the system with hot (120° F or 49° C) water, recirculate for 15 minutes and dump. Apply two additional rinses with water meeting the requirements of paragraph 233.10.15. Ensure that the system is emptied after each rinse.

14. Disconnect the cleaning equipment and reinstall the cooling system pump. Remove all

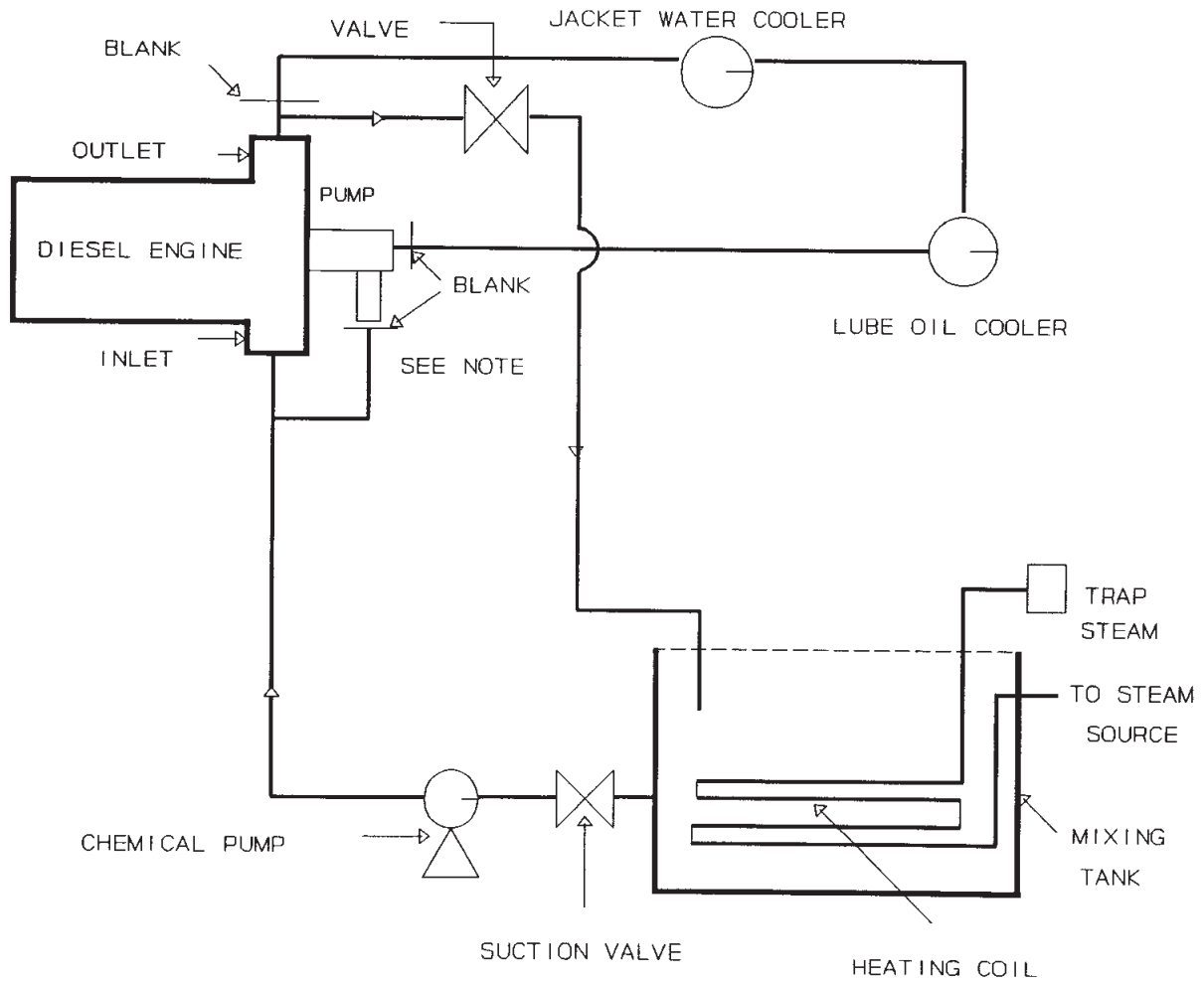


Figure 233-10-8. Typical Diagram for Cleaning the Cooling Side of a Diesel



blanks. Ensure that the cooling system is in proper operating condition.

#### **233.10.271 PROCEDURE FOR DETERMINING APPROXIMATE DESCALING SOLUTION STRENGTH**

**233.10.272** To determine the approximate descaling solution strength:

1. Pipette exactly 2 mL of the descaling solution into a clean 150 mL Erlenmeyer flask containing about 25 mL of distilled water.
2. Add two to three drops of phenolphthalein indicator. No color change will occur. Swirl to mix the contents.
3. Titret using a 0.1 N solution of sodium hydroxide. The first faint pink color that persists for about 30 seconds is the end point.

4. Percentage descalant strength is equivalent to the volume of sodium hydroxide required to turn the sample pink. For example, if 7.2 mL were required, the strength of the descalant is approximately 7.2 percent.

#### **NOTE**

Do not flush solution through the engine cooling system pump. Pump shall be bypassed or removed.

#### **233.10.273 HYDROSTATIC TESTING**

**233.10.274** Following the cleaning procedure, the cooling system should be subjected to a hydrostatic test in accordance with equipment (NAVSEA) technical manual and PMS.

## SECTION 11. SPARE PARTS AND ALLOWANCE LISTS

### 233.11.1 GENERAL

**233.11.2** The availability of spare parts, in the proper ratio and of the proper types, is mandatory for the successful continued operation of diesel engines. Improvising for precision parts or substituting unapproved and nonstandard components may imperil the entire engine and should be resorted to only in extreme necessity.

### 233.11.3 REPAIR PARTS

**233.11.4** Repair parts are of prime importance to material readiness of a ship. Ready availability of these items significantly determines capability of a ship to maintain continuous operations over an extended period of time. Lack of a needed part could seriously affect the military efficiency of a ship. A complete stock of onboard repair parts is a vital asset in day-to-day ship operations.

**233.11.5** Repair part refers to any item, including a spare module (which is itself a repairable item) and consumable type material. In addition, the item shall also have an equipment application and shall appear on an **Allowance Parts List (APL)**, NAVSEA drawing or in the applicable NAVSEA Technical Manual. Examples of repair parts are bearings, cam shaft sections, and pump impellers. The **Coordinated Shipboard Allowance List (COSAL)** (Section A, Parts III) lists repair parts and equipment related consumables normally stocked by the supply department.

**233.11.6** Shipboard allowance for repair parts is developed in accordance with specific logistic support doctrine set forth by the Chief of Naval Operations (CNO). Calculation of the allowance is a mathematical model based on failure rates, population, and Planned Maintenance System (PMS) requirements.

### 233.11.7 ALLOWANCE LISTS

### 233.11.8 INTRODUCTION

**233.11.9** The Commander, Naval Sea Systems Command (NAVSEA) directs, coordinates and participates in preparation and verification of the accuracy and completeness of allowance lists for ships and shipboard systems.

### 233.11.10 PURPOSE

**233.11.11** A ship's allowance list is designed to provide the ship with self support capability over an extended

period of operation. It specifies the kind and quantity of equipment and supporting materials a ship in commission is required to carry onboard. (Ships ordinarily are required to carry a full allowance of such material.) The allowance list provides both technical and supply management data. It is used to prepare custody, stock, and locator records, to determine maintenance philosophy for equipment, to identify technical repair parts, and to determine sources of supply.

### 233.11.12 COORDINATED SHIPBOARD ALLOWANCE LIST (COSAL)

**233.11.13** The Coordinated Shipboard Allowance List (COSAL) is an authoritative document which lists:

- a. Equipment and components installed onboard ship to perform its operational mission.
- b. Repair parts and special tools required for operation, overhaul, and repair of equipment and components.
- c. Operating space items (OSI's) and consumables necessary for safety, care, and upkeep of the ship.

**233.11.14** The COSAL is both a technical and supply document. It is a technical document in that equipment, component and part nomenclatures, operating characteristics, technical manuals, and so on, are described in APL's or **Allowance Equipage Lists (AEL's)**. It is a supply document, in that the COSAL provides a list of items required to achieve maximum, self supporting capability for an extended period of time. It is a bridge between a part number in a technical manual and the repair part carried by supply.

### 233.11.15 RESPONSIBILITIES

### 233.11.16 SUPPLY OFFICERS

**233.11.17** On most ships, allowance of both repair parts and consumables is located in storerooms under the cognizance of the Supply Officer. The Supply Officer is responsible for ordering, receiving, storing, and issuing the ship's allowance of these items. In addition, the Supply Officer maintains complete, accurate, and up-to-date records of all transactions, including location records.

**233.11.18** All consumables which cannot be stored in supply department spaces will be procured

for direct turnover (DTO) to the department which will use them. Certain repair parts, such as bulkhead mounted spares, may require storage in spaces under control of other department heads. The Supply Officer, however, will continue to exercise inventory control over such material.

#### **233.11.19 TECHNICIANS**

**233.11.20** To accomplish equipment maintenance or repair, technicians shall have the right tools and necessary repair parts. By knowing what is required in terms of material, the technician becomes a vital link in the requisitioning and issuing process. As part of the job planning, the technician shall furnish necessary job

related information so smooth material flow can be initiated in support of equipment repair.

#### **233.11.21 TURN IN REPAIRABLE ITEMS**

**233.11.22** Mandatory Turn in Repairable Items (MTR) are those repair parts which, based on unit cost, annual demand, difficulty of repair, or other economic considerations, have been designated for special inventory control. MTR items are identified in NAVSUP Publication 4107, **Master Repairable Item List (MRIL)**.

**233.11.23** For specific guidance refer to **NSTM Chapter 083, Allowances, Issues, Expendables or Material, and Repair Parts**.

## SECTION 12. INSPECTIONS, RECORDS, AND REPORTS

### 233.12.1 PROPULSION EXAMINING BOARD (PEB) REQUIREMENTS

**233.12.2** Inspections by conventional Propulsion Examining Boards (PEB) have been established by the Atlantic and Pacific Fleet Commanders in Chief to ensure strict adherence to propulsion plant readiness standards and to ensure that these plants are operated properly and safely. OPNAVINST 3540.4 establishes the PEB's and describes their authority and responsibility, designates membership, and prescribes administrative procedures. Refer to **NSTM Chapter 090, Inspections, Tests, Records and Reports** for further information.

### 233.12.3 DIESEL ENGINE INSPECTORS AND DIESEL INSPECTION REPORTS

**233.12.4** The OPNAV Diesel Inspector Certification program provides fleet support by certifying personnel fully capable of a systematic and effective evaluation inspection of diesel engines.

**233.12.5** Certified diesel engine inspectors are personnel with in-depth knowledge of diesel engine operation and maintenance experience. OPNAVINST 9233.1 provides guidance for the DEI program.

**233.12.6** Certified Diesel Engine Inspectors (DEI) can troubleshoot, investigate engine casualties and provide repair recommendations. The DEI can also provide shipboard diesel engine training on preventive maintenance, corrective maintenance and diesel engine trend analysis program.

**233.12.7** Requirements for scheduling diesel engine inspections by a certified diesel engine inspector are given in OPNAVINST. 9233.1, **Planned Maintenance System (PMS)**, and TYCOMS instructions.

**233.12.8** All diesel inspections are conducted in accordance with OPNAVINST. 9233.1 and the NAVSEA Handbook S9233—CJ—HBK—010, **U.S. Navy Diesel Engine Inspector Handbook, Part 1 Inspection Procedures**, and TYCOM instructions.

**233.12.9** Diesel Inspection reports shall be maintained onboard for ten years or until a major diesel engine overhaul. Diesel Inspection reports provide valuable information for troubleshooting,

past engine performance and recurring maintenance problems.

### 233.12.10 SHIPS' MAINTENANCE AND MATERIAL MANAGEMENT (3—M) SYSTEM

**233.12.11** The **Ship's Maintenance and Material Management (3—M) Manual** has been promulgated (OPNAVINST. 4790.4) to assist Navy Commanders and Managers to attain and maintain readiness in the fleet. Main objective of the Navy's record system is to improve record keeping through standardization, automation, speed, and efficiency. Included in the 3—M system are the PMS, which delineates preventive maintenance requirements, and the Maintenance Data System (MDS) which provides the means for recording and reporting maintenance data by use of automatic data processing equipment. Although additional records and reports are required, the 3—M system is the main vehicle for recording and reporting equipment maintenance data.

**233.12.12** The MDS provides documents on which maintenance personnel record, at the source, information concerning corrective or deferred maintenance action tests and alterations. The basic procedures and criteria for reporting are described in the 3—M Manual (OPNAVINST. 4790.4) as supplemented by Type Commander directives.

**233.12.13** In addition to the coded information reported through MDS, the material history also will contain any narrative remarks included on OPNAV Form 4790/2K. For example, clearances and tolerances or other readings would be reported in this section. With this narrative remark capability, the machinery history reports can be comprehensive, and the requirements are usually determined by the Department Head. This does not include routine readings and measurements if such readings and measurements are normal and are not taken in conjunction with a casualty or equipment malfunction.

### 233.12.14 OPERATING RECORDS

**233.12.15** Data recorded on operating records ensure frequent observation of the machinery by the watch standers and provide a basis for performance analysis. Such records should be examined daily by the Division Officer and the Engineering Officer, as appropriate.

**233.12.16 DIESEL ENGINE TREND ANALYSIS PROGRAM**

**233.12.17** The optimum performance and reliability of marine diesel engines is essential to the readiness of a large number of Navy ships. The high temperature, numerous moving parts, and rigid technical specifications which characterize the marine diesel require that these engines are properly operated and maintained. The Diesel Engine Trend Analysis (DETA) and the Automated Diesel Engine Trend Analysis (ADETA) programs provide for the manual collection and analysis of diesel engine operating parameters to more effectively monitor engine operation and determine corrective maintenance and overhaul requirements. Greater engine operating efficiency and longer periods between overhauls and major maintenance are potential benefits of the ADETA and DETA Program.

**233.12.18** All fleet diesel engines, with trend analysis Maintenance Requirement Cards (MRC's), will be monitored by the formalized DETA Program.

**233.12.19** The Trend Analysis Program incorporates two components; collection of engine operating data and analysis of the collected information. The procedures for data collection are provided in accordance with PMS. The ADETA Program automates the analysis and management of the Trend Analysis data.

**233.12.20** Complete instructions for the Trend Analysis Program are provided in OPNAVINST. 9233.2, **U.S. Navy Diesel Engine Trend Analysis Program** and NAVSEA Handbook S9233–C3–HBK–010/010 Revision 1, **Engine, Diesel, Trend Analysis Handbook**.

**233.12.21** Refer to NSTM Chapter 090, Inspection, Test Records and Reports for more additional information.

MRC (CS913E )		October 1989
		MRC CODE _____
		E-101 18M-1R
EQUIPMENT _____		RATES <u>  </u> M/H _____
Propulsion Diesel Engine		ENG OFF AND NEC 4314
MAINTENANCE REQUIREMENT DESCRIPTION _____		
1. Schedule/accomplish diesel inspection.		
SAFETY PRECAUTIONS _____		
1. Forces afloat comply with Navy Safety Precautions for Forces Afloat, OPNAVIST 5100 series.		
TOOLS, PARTS, MATERIALS, TEST EQUIPMENT _____		
MISCELLANEOUS _____ 1 OPNAVINST 9233.1 2 Diesel Inspectors Handbook, NAVSEA S9233-CJ-HBK-010 (See NOTE 2)		
PROCEDURE _____		
DISTRIBUTION STATEMENT D:      DISTRIBUTION AUTHORIZED TO DOD COMPONENTS AND DOD CONTRACTORS ONLY; CRITICAL TECHNOLOGY; OCTOBER 1989; OTHER REQUESTS SHALL BE REFERRED TO THE NAVAL SEA SYSTEMS COMMAND (CEL-TD). DESTROY BY ANY METHOD THAT WILL PREVENT DISCLOSURE OF CONTENTS OR RECONSTRUCTION OF THE DOCUMENT.		
NOTE 1: Accomplish every eighteen months or as specified in TYCOM directives.		
NOTE 2: Inspectors handbook, NAVSEA S9233-CJ-HBK-010 is held by Diesel Inspectors.		
1. Schedule/Accomplish Diesel Inspection. a. Engineering Officer schedule diesel engine inspection by a certified Diesel Inspector (NEC 4314) in accordance with OPNAVIST 9233.1 and TYCOM instructions. b. Diesel Inspector inspect diesel engine in accordance with OPNAVINST 9233.1, NAVSEA S9233-CJ-HBK-010, and TYCOM instructions. c. Diesel Inspector report results of inspection in accordance with NAVSEA S9233-CJ-HBK-010		
END MRC A98MRZN		

Figure 233-12-1. Sample Diesel Inspection Maintenance Requirement Card





## SECTION 13. SAFETY PRECAUTIONS

### 233.13.1 GENERAL INSTRUCTIONS

**233.13.2** In addition to the specific safety precautions prescribed in the applicable NAVSEA Technical Manual and the Planned Maintenance System (PMS), maintenance and operating personnel shall continuously exercise good judgment and employ common sense to prevent damage to machinery and injury to personnel.

**233.13.3** Damage to diesel engines may be prevented by proper operation of the engines in accordance **Engineering Operating Sequencing System (EOSS)** or **Engineering Operating Procedures (EOP)**, the applicable NAVSEA Technical Manual, PMS, **Automated Diesel Engine Trend Analysis (ADETA)**, **Diesel Engine Inspection Program** and the **Navy Oil Analysis Program (NOAP)**. A thorough knowledge and familiarity of all aspects of diesel engine operations and maintenance will enhance diesel operational safety and readiness.

**233.13.4** Damage to the ship may be prevented by eliminating conditions which constitute fire or explosion hazards. Proper operation of the diesel engine will assure that no loss of power will be encountered at inopportune times, and that the engines will be ready for service in any emergency.

**233.13.5** Injury to personnel may be prevented by a thorough knowledge of duties and responsibilities and proper maintenance. Safety precautions around moving or rotating parts shall be strictly adhered to by all personnel involved in operation and maintenance. Adequate guards shall be installed at exposed danger points of rotating shafts and couplings. Training programs shall be conducted to eliminate carelessness and thoughtlessness and teach safety awareness.

### 233.13.6 CRANKCASE EXPLOSIONS

#### 233.13.7 DEFINITION OF CRANKCASE EXPLOSIONS

**233.13.8** Three elements are needed for a crankcase explosion; fuel, oxygen and high heat. While the engine is operating, fuel and oxygen are present at all times in the crankcase in a combustible vapor form. The heat generated during normal operation is not of sufficient temperature to ignite this combustible vapor. The high heat necessary to ignite combustible crankcase vapors can originate at any moving part in the enclosed

crankcase or any external part with a direct path to the crankcase, i.e.: oil drain piping. Parts that have been known to generate the heat necessary to cause an explosion are (but not limited to): rod and main bearings; pistons; piston pins; cylinders liners; gears; roller and ball bearings.

**233.13.9** Localized heating of the combustible vapor by a "hot spot" on a failing or failed part always precedes ignition. Once combustion or ignition has occurred, the flame propagates throughout the crankcase. The speed of the flame depends on the distribution and volume of the combustible vapor in the crankcase. The development of the explosive pressure is due to the fact that the flame travels with a vibratory or wave motion leading to increased flame velocity thereby increasing the pressure in the crankcase. Without pressure development there would only be a fire.

**233.13.10** Normally the pressure developed by a crankcase explosion in an enclosed crankcase is evenly distributed. However, detonation may occur due to the formation of an intense shock wave. Detonation produces a hammer blow effect which can destroy any portion of the engine frame or structure not strong enough to withstand the blow. If the engine is not strong enough to contain the explosion or if a means is not provided to relieve the pressure, a second explosion can be expected. The second explosion is a result of fresh air rushing back into the crankcase to equalize the pressure differential, this air combines with the combustible vapor remaining from the previous explosion. Usually a fire results from the second explosion causing the most damage.

**233.13.11** There is a mistaken belief that crankcase explosions occur without prior warning and that nothing can be done to prevent these explosions. Usually it takes time to heat a malfunctioning part to a degree required to start a crankcase explosion. The one exception to this may be a cracked or a blown piston.

**233.13.12** Signs of an impending crankcase explosion may be white smoke coming from around crankcase covers, doors and other openings, and excessive engine vibration and noise. Engine operators shall watch for changes in temperature, pressures, and especially changes in crankcase vacuum and or pressure readings. On engines designed to run with a crankcase vacuum, the

gaskets and seals on crankcase covers and all other access openings shall be checked in accordance with PMS and the applicable NAVSEA Technical Manual. This shall be done to keep fresh air leakage into the crankcase at a minimum. These air leaks are a source of combustion air.

#### NOTE

It should be remembered that while there is no absolute method to predict a crankcase explosion, proper engine operation and approved maintenance procedures will reduce and in most cases eliminate the possibility of a crankcase explosion.

**233.13.13** The following warning statement shall be attached to all diesel engines, main propulsion, emergency generators, ships service generators, small boats and crafts. The statement shall be displayed on both sides of the engine in a conspicuous location.

#### WARNING

DO NOT REMOVE ENGINE CRANKCASE COVERS OR ANY ACCESS COVERS UNTIL AT LEAST 30 MINUTES HAVE ELAPSED AFTER SHUTDOWN WHEN IT IS KNOWN OR SUSPECTED THAT THERE HAS BEEN A CRANKCASE EXPLOSION, FIRE OR AN OVERHEATED PART IN THE CRANKCASE.

#### NOTE

On small boats and craft the warning statement may be attached to the engine access covers in a conspicuous location.

#### 233.13.14 CRANKCASE RELIEF VALVES

**233.13.15** Crankcase relief valves shall be checked periodically in accordance with PMS and

the applicable NAVSEA Technical Manual to ensure that they are in proper working order. The purpose of these

valves is to release burnt gases resulting from a crankcase explosion. This maintains the pressure in the crankcase within a safe range for the strength of the crankcase. The relief valves are designed to shut immediately after releasing the pressure to prevent re-entry of fresh air into the crankcase. This prevents a second explosion. These valves shall operate freely and reseal perfectly so that a minimum of fresh air is allowed to be drawn into the crankcase.

#### 233.13.16 UNINTENTIONAL ROTATION OF AN ENGINE

**233.13.17** Precautions against unintentional starting or rotation of an engine shall be strictly adhered to before commencing overhaul or repair operations. The starting system shall be secured in at least two places and in accordance with shipboard and or shore tag out procedures. Only when the engine is completely secured shall maintenance personnel be allowed to work in the engine crankcase or otherwise come in contact with movable parts. If an engine is provided with a remote control station, positive steps shall be taken to see that the remote controls are made inoperative and tagged out of service.

**233.13.18** If a propulsion engine is to be worked on while underway, steps shall be taken to positively secure the engine from turning so it can not be rotated by its connected propeller shafting or through clutch windage. Suggested methods of accomplishing this are:

- a. Engage jacking gear.
- b. Use timbers or heavy wooden blocks in crankcase to prevent crankshaft rotation.

#### 233.13.19 CYLINDER RELIEF VALVES

**233.13.20** If the relief valve on any cylinder opens the engine shall be stopped immediately and the cause of the trouble determined and remedied.

**233.13.21** Relief valves shall never be locked closed except in case of an emergency.

#### 233.13.22 OVERHEATED ENGINE

**233.13.23** Under no circumstances shall a large amount of cold water be allowed suddenly to enter a hot engine. The rapid cooling may crack the cylinder liner and head or seize the piston.

**233.13.24** When the volume of circulating water cannot be increased and the temperatures are too high, stop the engine.

**233.13.25** In freezing weather, all spaces containing fresh water and subject to freezing shall be carefully drained unless an antifreeze solution is added. In many cases, multiple drains shall be opened to drain the water from all low points.

#### **233.13.26 INTAKE AIR**

**233.13.27** Intake air shall be kept as clean as possible; accordingly, all ducts and passages shall be kept clean.

#### **233.13.28 CLEANLINESS**

**233.13.29** Engines shall be kept clean at all times and the accumulation of oil in the bilges or other pockets shall be prevented.

**233.13.30** Care shall be taken that water in the bilges cannot reach electrical machinery or wiring, both with an even keel and when rolling and pitching.

**233.13.31** Cleanliness is one of the most important basic essentials in operation and maintenance of diesel engines. Clean fuel, clean air, clean coolants, clean lubricants, and clean combustion shall be maintained.

**233.13.32** Do not use burlap or other materials containing lint for wrapping journals or wiping polished bearing surfaces.

**233.13.33** Do not paint internal engine surfaces that are oil wetted during normal engine operation.

#### **233.13.34 SUBMARINE ENGINES**

**233.13.35** Engines on submarines shall not be started until steps have been taken to ascertain that there is no water in the cylinders.

#### **233.13.36 OVERSPEED TRIPS AND OVERSPEED GOVERNORS**

**233.13.37** Overspeed trip and governor mechanisms shall be tested once each quarter and after each major engine overhaul to verify that the complete mechanism is in proper working order. When making this test, a tachometer shall be used to check the speed at which the

overspeed mechanism operates. This mechanism shall operate at the speed specified in PMS or the applicable NAVSEA Technical Manual.

#### **NOTE**

Two independent speed measuring devices are required when testing speed limiting governors and overspeed trips. A portable single range, single scale, hand held tachometer is the preferred primary measurement device. Backup speed verification can be accomplished by the unit installed tachometer.

**233.13.38** If any irregularity is observed, the complete mechanism shall be checked and the condition corrected.

#### **233.13.39 PREVENTION OF FIRES IN MACHINERY SPACES**

**233.13.40** The uncooled portions of exhaust connections, piping, expansion joints, turbochargers, support brackets, or any other part of diesel engines where surface temperatures exceed 125° F during any service condition, shall be insulated wherever practical and necessary to protect personnel. Temperatures which exceed 400° F during any service condition and are not insulated to protect personnel and are subject to fuel or lube oil leaks or sprays shall be shielded. Metal lagging shall be installed wherever necessary to protect insulation from physical damage and where insulation can become oil or water soaked. These precautions will prevent fires. For additional information. See **NSTM Chapter 555, Shipboard Firefighting**.

**233.13.41** Wherever possible, lubricating and fuel oil lines shall be located so any pipe or fitting leaks will not drip or spray on hot engine surfaces or into air intakes. Any fuel oil or lube oil system component which cannot be so located shall be shielded as necessary to minimize the fire hazard.

**233.13.42 DIESEL ENGINE CASUALTY CONTROL PROCEDURES****CAUTION**

CO<sub>2</sub> from portable fire extinguisher bottles or Halon will have little or no effect on securing the diesel, due to the large volume of air consumed by the diesel as compared to the small volume of CO<sub>2</sub> in the fire extinguisher bottles, or the small volume of Halon in the atmosphere. See paragraph 233.13.50.

**233.13.43** Most Navy ships have Engineering Operational Casualty Control (EOCC) Procedures for diesel engines. Ships that do not have (EOCC) have locally prepared and approved Engineering Casualty Control Procedures (ECCP) for diesel engines.

**233.13.44** EOCC and ECCP shall provide technically correct and logically required procedures for responding to and controlling common diesel engine casualties. When properly followed these procedures result in placing the diesel engine in a safe and stable condition while the cause of the casualty is being determined.

**233.13.45** In an emergency situation, recommended procedures to stop the engine should the diesel fail to stop by normal means are:

1. Secure the fuel supply to the diesel.
2. Secure the diesel intake air supply:
  - a. Shut the air intake flapper(s).
  - b. Install intake covers.
  - c. Cover blower intake.

**233.13.46 DIESEL ENGINE LUBE AND FUEL OIL LEAKAGE GUIDANCE**

**233.13.47** Diesel engines will not be free of lube oil leakage. Slight weeping of lube oil at gaskets and seals is acceptable.

**233.13.48** Diesel engines should be leak free of fuel oil leaks. Leak free does not mean that traces of fuel oil at the injector pump racks will not exist. Fuel traces around shifting lever shafts in fuel oil strainers are acceptable. These trace amounts are normal and are needed for proper lubrication of the fuel racks and strainer shifting levers. These trace amounts do not indicate an unsafe condition.

**233.13.49** The presence of a few small leaks that develop during normal continuous operation is acceptable if they do not become a steady drip or flow. If fuel collects very slowly and drips at prolonged intervals and causes surface wetting, this is not an unsafe condition. More than one of these leaks is acceptable, SAFETY is the criteria.

**233.13.50 DISCHARGE OF HALON IN DIESEL ENGINE SPACE****WARNING**

Halon becomes extremely toxic when ingested and burned within the diesel engine. Avoid breathing or coming in contact with the yellow-orange exhaust smoke. This exhaust contains by products consisting of hydrogen fluoride, hydrogen bromide and possibly bromine which result from the decomposition of halon at the elevated temperatures within the cylinders.

**NOTE**

If an engine has been run while pulling combustion air from an engine room or other space that has had a Halon discharge, the engine lube oil acidity will increase. The engine lube oil shall be checked for viscosity and acidity immediately after exposure to a Halon discharge. If oil is not replaced, retest for viscosity and acidity 50 hours after Halon discharge. Engine lube oil shall be replaced if NOAP or PMS condemning limits are exceeded.

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4. REV. DATE OR TM CH. DATE		5. SYSTEM/EQUIPMENT		6. IDENTIFICATION/NOMENCLATURE (MK/MOD/AN)	
7. USER'S EVALUATION OF MANUAL (Check Appropriate Blocks)					
A. EXCEL-LENT		B. GOOD		C. FAIR	
				D. POOR	
				E. COM-LETE	
				F. INCOM-LETE	
8. GENERAL COMMENTS:					
9. RECOMMENDED CHANGES TO PUBLICATION					
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