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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 262

LUBRICATING OILS, GREASES, SPECIALTY LUBRICANTS, AND LUBRICATION SYSTEMS

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TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 262

LUBRICATING OILS, GREASES, SPECIALTY LUBRICANTS, AND LUBRICATION SYSTEMS

SECTION 1

LUBRICATION FUNDAMENTALS

262-1.1 INTRODUCTION

262-1.1.1 GENERAL. This section provides an overview of the fundamentals of lubrication. Included are the basic properties and functions of a lubricant, and how a lubricant acts to reduce friction and wear, dissipate heat, and prevent corrosion.

262-1.1.2 FRICTION AND WEAR. The surfaces of machinery components appear well-finished to the naked eye. When magnified, however, surface imperfections become readily apparent. These microscopic hills and valleys are called asperities. When dry surfaces move relative to one another, asperities may rub, lock together, and break apart. The resistance generated when these adjacent surfaces come in contact is called friction. The welding together and breaking apart of asperities is a form of adhesive wear. Another form of wear may occur when a hard contaminant particle becomes trapped between two opposing surfaces. When this occurs, the contaminant acts as a miniature lathe, cutting into the softer machinery surface. This process is termed abrasive wear. Another consequence of friction is that the energy created by resistance is converted into heat. The primary functions of a lubricant, then, are the formation of a protective film between adjacent surfaces to reduce wear, and the dissipation of heat generated at these wear surfaces.

262-1.1.3 CORROSION PROTECTION. A second role provided by a lubricant is the prevention of system corrosion. In environments where contamination of the system with water is likely, protection of machinery components from corrosion is of the utmost importance. Salt water is considerably more corrosive than fresh water; thus Naval machinery must be well protected from this contaminant. Water molecules may also diffuse through the lubricant and enter surface microcracks, causing hydrogen embrittlement and subsequent surface failure. It is thus imperative that water contamination of machinery systems be minimized. To achieve corrosion protection, lubricants must form a protective barrier on machinery surfaces. Modern-day lubricants often contain corrosion inhibitors which chemically bond to the metallic surfaces of equipment components. Corrosion inhibitors are an example of a class of compounds called additives. (See paragraph 262-2.1.2).

262-1.2 IMPORTANT PROPERTIES OF LUBRICANTS

262-1.2.1 VISCOSITY. The most important physical property of a lubricant is its viscosity. Viscosity, which may be defined as a fluid's resistance to flow, is the characteristic most frequently stipulated by equipment manufacturers when making lubricant recommendations. The selection of proper lubricant viscosity is often a compromise between selecting one high enough to prevent metal to metal (wear) contact, and one low enough to allow sufficient heat dissipation. In the past, viscosity was measured in such units as Saybolt Universal Seconds (SUS), Redwood No. 1 Seconds, and Engler Degrees. The preferred unit of measurement for the U.S. Navy is the centistoke (cSt). Kinematic viscosity in centistokes is obtained by measuring the time required for a specified volume of fluid to flow through a calibrated capillary tube at a specified temperature.

262-1.2.1.1 Various industry standards exist for the characterization of lubricant viscosity. The most familiar of these is the Society of Automotive Engineers (S.A.E.) classification of automotive engine and gearcase oils. (Table 262-1-1). This system grades lubricants according to their viscosity characteristics at either -18°C (0°F) or 100°C (212°F). Oils meeting low temperature viscosity requirements are assigned a ″W″ after the grade number (for example, SAE grade 10W). Oils meeting high temperature requirements are assigned a grade number such as SAE grade 30. Multigrade oils may be formulated to meet both low and high temperature requirements (for example, SAE grade 10W-30). However, these viscosity designations are applicable primarily for the lubrication of internal combustion engines. By international agreement, all nations now recognize a universally applicable system of viscosity classification termed the International Standards Organization (ISO)/American Society of Testing and Materials (ASTM) Viscosity System for Industrial Lubricants. This system assigns viscosity grades from ISO VG2 through VG1500, where the number indicates the midpoint viscosity in centistokes of the lubricant at 40°C (104°F). (Table 262-1-2).

Table 262-1-1. SAE CLASSIFICATION OF AUTOMOTIVE ENGINE AND GEAR OILS

SAE VISCOSITY GRADE	CSTS @ 100° C		MIL SPEC EXAMPLE
	MIN	MAX	
5W	3.8	-	
10W	4.1	-	MIL-L-2104 (OE-10)**
20W	5.6	-	
20	5.6	<9.3	
30	9.3	<12.5	MIL-L-2104 (OE-30)**
40	12.5	<16.3	MIL-L-9000
50	16.3	<21.9	
SAE VISCOSITY GRADE	**CSTS @ 100° C**		**MIL SPEC EXAMPLE**
	MIN	**MAX**	
75W	4.1	-	
80W	7.0	-	
85W	11.0	-	
90	13.5	<24.0	MIL-L-2105 (80W/90)
140	24.0	<41.0	MIL-L-2105 (85W/140)

*Although not an engine oil, MIL-L-17331 (MS 2190TEP) has a viscosity approximating that of a 30 weight oil.
**MIL-L-2104 (15W-40) is a multi-grade oil (see paragraph 262-1.2.1.1).

Table 262-1-2. ISO VISCOSITY SYSTEM

VISCOSITY GRADE	MIDPOINT VISCOSITY@ 40°C	MIL SPEC (MIL SYMBOL)EXAMPLES
ISO VG2	2.2	-
ISO VG10	10.0	-
ISO VG32	32.0	MIL-H-17672 (2075TH)
ISO VG46	46.0	MIL-H-17672 (2110TH)
ISO VG68	68.0	MIL-H-17672 (2135TH)
ISO VG100	100.0	*

*The midpoint viscosity of MIL-L-17331 (MS 2190TEP) oil is approximately 86 centistokes @ 40°C.

262-1.2.2 VISCOSITY INDEX (VI). The effect of temperature on a lubricant's viscosity is a measurement of its Viscosity Index (VI). When the VI scale was introduced in 1929, a reference paraffinic base stock was assigned a VI of 100, and a naphthenic base stock a VI of 0. Most naval oils of paraffinic base stock have VI's in the 95-100 range. Naval oils prepared from synthetic stock, and multigrade engine oils typically have VI's in excess of 100. (Synthetic and paraffinic stocks are discussed further in detail in paragraph 262-2.1.2). The higher the VI, the less a given lubricant's viscosity will change with a subsequent change in temperature.

262-1.2.3 CLOUD POINT AND POUR POINT. Since petroleum stock consists of a mixture of molecular components, lubricants do not exhibit sharp freezing points. Rather, as a lubricant is cooled, certain components such as waxes will begin to precipitate out and become evident in the liquid as a cloud. The temperature at which this occurs is called the cloud point of the lubricant. If the product is further cooled, a point will be reached at which the lubricant will no longer flow or be efficiently pumped. The temperature at which this occurs is termed the pour point of the lubricant. Both properties are related to the wax content of the base stock. The pour points of high-wax lubricants may be depressed by the addition of pour point depressant additives. Pour point behavior becomes important in applications such as refrigerant compressor lubrication where the oil is subjected to low temperatures.

262-1.2.4 FLASH POINT AND FIRE POINT. As a lubricant is heated, lighter components begin to vaporize. The temperature at which sufficient vapor concentration exists above the surface of the lubricant so that ignition with a test flame is possible is called the flash point of the product. Flash point is useful for both product storage requirements and for the detection of contamination of one product with another. The fire point of a lubricant is that temperature at which sufficient vapors are present above the surface of the lubricant to sustain combustion upon ignition. This parameter is useful for storage and safety considerations.

262-1.2.5 NEUTRALIZATION NUMBER. As petroleum products are subjected to elevated temperatures, the process of oxidation occurs. Oxidation leads to the formation of organic acids in the lubricant. This increase in acidity reduces the water-separating ability of certain oils, and may also prove corrosive to certain alloys. The neutralization number measures the amount of acidity present in the lubricant. It is quantitatively defined as the amount of potassium hydroxide (KOH) required to neutralize the acid present in one gram of sample. This quantity is also referred to as the Total Acid Number (TAN).

262-1.2.6 TOTAL BASE NUMBER. Internal combustion engine oils are formulated with a highly alkaline (base) additive package designed to neutralize the acidic byproducts of combustion. The Total Base Number (TBN) is a measure of this additive package, and it may be used as an indication of when diesel engine oil should be changed.

262-1.2.7 WATER CONTENT. The most common contaminant in Naval lubricating systems is water. Common sources of water include lube oil cooler leaks, condensation, steam turbine gland seal leaks, and diesel engine piston blow-by and jacket water leaks. The acceleration of system corrosion by water contamination cannot be overemphasized. In addition, excessive water contamination increases the viscosity and decreases the fluid film strength of an oil. This may result in accelerated wear due to rupture of the oil film and resultant surface-to-surface contact. A qualitative assessment of the amount of water present in some lubricants may be made by inspecting the oils' appearance (see paragraph 262-5.1.2). Another method for determining water contamination levels is the Bottom Sediment & Water (B.S.& W.) test (see paragraph 262-5.1.3.3).

262-1.2.8 DEMULSIBILITY. Demulsibility refers to a lubricant's ability to readily separate from water. Oils used in force-feed lubrication systems should possess good water separability to prevent emulsification.

262-1.2.9 HARDNESS. Greases are classified according to a hardness scale developed by the National Lubricating Grease Institute (NLGI). According to this system, softer greases are assigned a low NLGI number, and stiffer greases a high NLGI number (see Table 262-1-3). The penetration numbers refer to the depth, in tenths of millimeters, that a weighted cone penetrates the grease. Most Naval greases have NLGI numbers from 1 to 2, and are classified as medium consistency greases.

262-1.2.10 DROPPING POINT. Greases exist in an essentially semi-solid form. The temperature at which a grease changes from a semi-solid to a liquid is termed its dropping point. Dropping point provides some indication of the high temperature characteristics of a grease.

262-1.2.11 WATER WASHOUT. Greases subjected to splashing or impinging water must possess good water washout resistance. Greases with good resistance will maintain an adequate lubricating film under excessive water contamination conditions.

262-1.2.12 LOAD CARRYING ABILITY. The ability of a lubricant to maintain an effective lubricating film under high loads or pressures is a measure of its load carrying or extreme pressure (EP) characteristics. The load carrying ability of a lubricant may be enhanced by the addition of EP additives (see Table 262-2-1).

Table 262-1-3. NLGI GREASE CLASSIFICATIONS

NLGI NUMBER	PENETRATION @ 25°C(ASTM-D217)	MIL SPEC EXAMPLES
000	445-475	-
00	400-430	-
0	355-385	-
1	310-340	*
2	265-295	*
3	220-250	-
4	175-205	-
5	130-160	-
*Grease conforming to MIL-G-15719, MIL-G-23549, MIL-G-24139, A-A-50433, and DOD-G-24508 have hardness in the NLGI 1-2 range.		

SECTION 2

LUBRICANT TYPES AND APPLICATIONS

262-2.1 TYPES OF LUBRICANTS

262-2.1.1 INTRODUCTION. The three major types of lubricants in use aboard Naval vessels are lubricating oils, greases, and solid lubricants. The selection of a lubricant type is dependent on the type of machinery to be lubricated, the complexity of the lubricating system allowed by machinery design, and the frequency of lubrication required.

262-2.1.2 LUBRICATING OILS. Lubricating oils are used for the majority of applications. They may be classified according to their viscosities and any special properties imparted to them by additives. Oils whose base stocks are derived primarily from crude oil refining are called mineral or petroleum oils. Petroleum oils may be further classified as being paraffinic or naphthenic based on the types of hydrocarbons comprising the base stock. Oils that have been manufactured by chemical synthesis such as polymerization are called synthetic oils. Additives may be blended into the base stock to impart special properties to the finished product. A list of commonly used lubricant additives is provided in Table 262-2-1.

Table 262-2-1. COMMON LUBRICANT ADDITIVES

Additive Type	Compounds Used	Function
Extreme Pressure (EP)	Sulfur-Phosphorous compounds.	Increase load carrying ability.
Antioxidant	Hindered phenols. Amines.	Prolong oil life by slowing oxidation.
Antifoam	Silicones.	Control foaming in forcefeed systems.
Anticorrosion	Zinc dithiophosphates. (ZDDP)	Form anticorrosion film.
Detergent or Dispersant	Calcium sulfonates.	Prevent deposition of carbon.
Alkalinity (TBN)	Calcium carbonates. Magnesium Sulfonates.	Neutralize acidic engine byproducts.
Antiwear	Zinc dithiophosphates. (ZDDP)	Reduce wear.
Pour Point Depressant	Methacrylate polymers.	Lower pour point.
VI Improvers	Organic polymers.	Improve VI.

262-2.1.2.1 Steam Turbine Lubricating Oil. Steam turbine lube oils are typically composed of high VI paraffinic base stocks with EP, antioxidant, antifoaming, and anticorrosion additives. The steam turbine oil used in Naval machinery is MIL-L-17331 (MS 2190TEP) oil. Oils under this specification possess excellent water-separating abilities, high temperature stability, and contain a moderate amount of EP additive. This oil may also be used to lubricate Main Reduction Gears (MRG's), low, medium, and high speed air compressors, line shaft or spring bearings, gas turbine generators, and various other machinery.

NOTE

For miscellaneous PMS lubrication requiring a lower viscosity mineral oil, MIL-H-17672 (grades 2075TH, 2110TH, 2135TH) may be used.

262-2.1.2.2 Reciprocating Internal Combustion Engine (R.I.C.E.) Oil. Reciprocating Internal Combustion Engine (R.I.C.E.) lube oils are formulated with detergent or dispersant additives to keep soot and other combustion byproducts from depositing on engine parts. In addition, alkaline additive packages act to neutralize the acidic products of combustion. A third type of additive reduces the wear of internal parts such as cylinder liners,

rings, pistons, and bearings. The primary R.I.C.E. engine oil used by the Navy is MIL-L-9000 (MS 9250) oil. This oil is a single grade SAE 40 oil to be used in all shipboard internal combustion engines operating in ambient temperatures of 0°C (32°F) or higher. For ambient conditions below this temperature, oil conforming to MIL-PRF-2104 15W-40 should be used. In addition, certain Fleet engines, such as those found onboard MCM-1 Class vessels, shall use oil conforming to MIL-PRF-2104 OE/HDO 15W-40. The use of re-refined MIL-PRF-2104 is acceptable for Fleet diesel engine applications.

NOTE

To simplify logistics, R.I.C.E. oils may sometimes be used onboard diesel-driven ships in associated reduction gears, line shaft bearings, and thrust bearings.

262-2.1.2.3 Gas Turbine Oils. The high operating temperatures found in modern-day gas turbine engines require the oxidative stability of a synthetic oil with antiwear additives. Synthetic gas turbine oils are classified as either Type I or Type II lubricants based on the chemical structure of the base stock. Oils conforming to MIL-L-23699 are type II (polyester-based) lubricants used in some Naval aircraft and all ship gas turbine engines.

262-2.1.2.4 Refrigerant Compressor Oils. The low evaporator and high compressor temperatures encountered in refrigerant systems require an oil with low pour point and good oxidative resistance. In addition, water contamination must be extremely low, as the chlorofluorocarbon refrigerant may mix with the oil in the compressor piston area and react with water to form acidic byproducts. The Navy uses VV-L-825 oil, types II and IV, in shipboard refrigerant compressors. Type II oil is utilized in systems using R-11, R-12, R-113, or R-114 refrigerant. Type IV oil is used in equipment using R-22 refrigerant.

262-2.1.2.5 Gear Oils. The requirements placed on a gear oil depend on the type of gearing (for example, spur, helical, bevel, hypoid, or worm), gear tooth sliding speed, and gear loading. Due to the nature of gear lubrication, lubricants are required to have high levels of EP additives. Additionally, antifoaming, antioxidant, and anticorrosion additives are common. The EP gear oils used in Navy enclosed gears conform to MIL-L-2105 (GO 80W/90, GO 85W/140) oil. Since oil conforming to MIL-L-2105 has poor water separating ability, it should not be used in forced-feed lubrication systems, or in systems where water contamination is likely. For systems in which water contamination is likely, gear oils conforming to American Gear Manufacturers Association (AGMA) Standard 250.4, Grade 7 Compounded, are recommended. These oils contain a fatty oil additive that enhances their surface wetting ability under high moisture conditions.

NOTE

MIL-L-17331 (MS2190TEP) and MIL-L-9000(MS 9250) lube oils may be used as gear oils in certain application

262-2.1.3 GREASES. Greases are typically used in situations where sufficient lube oil cannot be effectively maintained on machinery surfaces, or when a simplistic lubricating system is desired or required. Greases essentially consist of a semisolid mixture of oil and thickening agent. The oil may be either petroleum or synthetic base. Thickening agents are typically alkali soaps or clay (bentonite) materials. Critical grease properties, such as hardness and water washout, are dependent on the selection of base oil and thickening agent. For example, sodium-soap greases exhibit poor water resistance; lithium-soap greases have good water resistance and are excellent general purpose lubricants. Specific grease applications are as follows:

262-2.1.3.1 Ball and Roller Bearing Greases. Ball and roller (rolling element) bearing greases must possess good mechanical stability to resist shearing, excellent oxidation resistance to prevent hardening and deposit formation, and the proper viscosity to maintain film thickness between rolling elements and raceways. The grease used to lubricate Navy ball and roller bearings is DOD G-24508. This grease consists of a synthetic-base oil and a clay thickening agent. It is also used as a general purpose grease. For electric motor ball and roller bearing lubrication, refer to paragraph 262-2.1.3.3.

262-2.1.3.2 Wire Rope Exposed Gear Greases. A wire rope is typically fabricated by helically bending metal strands around a fiber rope core. Each strand, in turn, is comprised of numerous wires bent around another smaller core. During use, individual strands and wires move with respect to one another as the wire rope flexes and bends. Wire rope grease must adequately lubricate individual wires and strands to prevent frictional wear of these components. In addition, the lubricant must penetrate to the fiber rope core to prevent drying out of this component. A third function of wire rope grease is to form an effective barrier against corrosion. The Navy uses grease conforming to MIL-G-18458 for the lubrication of wire rope and exposed gears.

262-2.1.3.3 Electric Motor Ball and Roller Bearing Greases. The Navy uses grease conforming to MIL-L-15719 for the lubrication of ball and roller bearings in Class H electric motors. This grease consists of a polymethyl phenyl-silicone base oil and a lithium soap thickener. This grease may also be used for the lubrication of boiler sliding feet. However, it should not be used to lubricate journal bearings, spiral gears, or gear trains.

262-2.1.3.4 General Purpose Greases. Greases conforming to MIL-G-23549 and MIL-G-24139 are petroleum-based, medium consistency greases useful for various lubrication applications that require water resistance or dispensing through long lengths of tubing. In addition, MIL-G-23549 contains 5 percent molybdenum disulfide for high load applications. Commercial Item Description (CID) Seawater Wash Resistant Grease A-A-50433 is recommended for use on all submarine systems and surface nuclear propulsion systems where MIL-G-24139 was previously required, with the exception of motor driven ball and roller bearing applications and the bow diving plane system onboard SSN688 Class submarines. For submarine motor driven ball and roller bearing applications, DOD-G-24508 is recommended. For bow diving plane systems, MIL-G-24139 is recommended.

262-2.1.3.5 Plug Valve Grease. This specialty grease is for the lubrication of tapered plug valves, gaskets, seals and scuppers in freshwater, salt water, and sewage systems. Greases conforming to MIL-G-6032 are available in either bulk (Type I) or stick (Type II) containers. For lubricating plug valves, gaskets, or threads on high pressure (>1500 psi) air or liquid oxygen systems, MIL-G-27617 (Type III) grease shall be used. This grease consists of a fluorinated hydrocarbon base oil and thickening agent, and is chemically resistant to oxygen.

262-2.1.3.6 Grease Application. Grease may be applied through grease cups or through hydraulic lubrication fittings. Hydraulic lubrication fittings form a readily installed and convenient means for lubricating numerous low-speed, lightly loaded, or widely separated bearings. These fittings are not acceptable for use on electric motors or generators because of the danger of grease being forced out of the bearing and onto windings (refer to **NSTM Chapter 310, Electric Power Generators and Conversion Equipment** , for further discussion). A grease gun or other pressure device shall be used for applying grease through hydraulic type fittings. When grease is applied through hydraulic lubrication fittings, pressure should be applied until grease seeps out around the edges of the bearings. In bearings fitted with felt or other seals, care shall be exercised to avoid breaking the seals by the application of too much pressure. If not, the bearing will fail due to a lack of lubrication. The type of fitting should be identified and carbon steel fittings which are corroded should be replaced with Corrosion Resistant Steel (CRES) or Monel fittings.

NOTE

Shipboard lubrication fitting are listed in Appendix C.

262-2.1.4 SOLID LUBRICANTS. Solid lubricants are typically used in situations where unusual temperature or environmental conditions preclude the use of conventional fluid lubricants, or when the application of a fluid lubricant is difficult. Solid lubricants form an essentially dry lubricating film between adjacent surfaces. The lubricant may be applied directly in powdered form, or as a colloidal suspension in a vehicle such as isopropanol. Evaporation of the vehicle leaves a thin film of the lubricant on machinery surfaces.

262-2.1.4.1 The two most commonly used solid lubricants are powdered graphite and molybdenum disulfide (MoS2). Other materials such as powdered zinc dust and red lead suspended in petrolatum or mineral oil may also be used. Specific solid lubricant applications are as follows:

262-2.1.4.2 Dry graphite conforming to SS-G-659 may be used for the lubrication of such equipment as security locks. Powdered molybdenum disulfide conforming to MIL-L-7866 is used primarily as a thread antiseize compound. For the lubrication of threaded steel nuts and bolts, including superheated steam components up to 565°C (1050°F), high temperature antiseize compound conforming to MIL-A-907 is typically used. This lubricant consists of a mixture of graphite and molybdenum disulfide suspended in mineral oil. For threaded aluminum parts engaged with similar or dissimilar metals, zinc dust-petrolatum antiseize compound MIL-T-22361 shall be used. Additional lubricants for use on threaded fasteners include colloidal graphite in isopropanol (MIL-L-24131) and molybdenum disulfide in isopropanol (MIL-L-24478).

262-2.1.5 SPECIALTY LUBRICANTS. The operating parameters encountered in high pressure (>1500 psi) air, oxygen, and oil-free nitrogen systems require a lubricant that will resist autogenous ignition. For lubrication of these systems, halocarbon oils conforming to DOD-L-24574 shall be used. In addition, plug valves, gaskets, and threads in these systems shall be lubricated with grease conforming to MIL-G-27617 (type III) as discussed in paragraph 262-2.1.3.5. A table listing O-ring lubricant applications is presented in Table 262-8-1.

262-2.1.5.1 Due to the possibility of air supply contamination, the lubricants used in compressed air diving systems must necessarily be of low toxicity. For the lubrication of diver's reciprocating air compressors, oil conforming to MIL-L-17331 (MS 2190TEP) is recommended. In addition, O-ring seals shall be lubricated during installation in accordance with paragraph 262-8.2.3. For further discussion of compressed air diving systems, see paragraph 262-8.1.

262-2.1.5.2 For mixed gas (helium-oxygen) diving systems, and oxygen saturation diving systems, reciprocating air compressors are either oil-free or water lubricated. For the lubrication of mechanical components on recompression chambers, threads, and O-rings, lubricants conforming to MIL-S-8660, DOD-L-24574, or MIL-G-27617 (TY 3) shall be used.

262-2.1.5.3 Typical Naval system lubricant applications are presented in**Appendix A** . It should be noted that the applications presented are examples, and that the lubricant specified by individual Maintenance Requirement Cards (MRC's) shall take precedence over this appendix.

262-2.2 PROCUREMENT OF NAVY LUBRICANT

262-2.2.1 Table 262-2-2 lists Military, Federal, and CID specification lubricants available from the supply system. NATO symbols are included in parentheses.

Table 262-2-2. SHIPBOARD LUBRICANTS

MIL SPEC/MIL SYMBOL(NATO CODE)	QUANTITY	NSN
MIL-L-17331/MS 2190TEP(0-250)	1 GAL CAN	9150-00-942-9343
	5 GAL CAN	9150-00-235-9061
	55 GAL DRUM	9150-00-235-9062
MIL-L-9000/MS9250(0-278)	5 GAL CAN	9150-00-181-8229
	55 GAL DRUM	9150-00-181-8097
MIL-L-23699(0-156)	8 OZ CAN	9150-00-180-6266
	1 QT CAN	9150-00-985-7099
	55 GAL DRUM	9150-00-681-5999
MIL-PRF-2104/OE/HDO-10 (O-237)	1 QT CAN	9150-00-189-6727
	5 GAL CAN	9150-00-186-6668
	55 GAL DRUM	9150-00-191-2772
MIL-PRF-2104/OE/HDO-15W-40 (O-1236)	5 GAL CAN	9150-01-152-4118 (virgin) 9150-01-421-1424 (re-refined) 9150-01-438-6082 (closed loop re-refined)
	55 GAL DRUM	9150-01-152-4119 (virgin) 9150-01-421-1432 (re-refined) 9150-01- 438-6079 (closed loop re-refined)
MIL-L-2105/75W (0-186)	1 QT CAN	9150-01-035-5390
	5 GAL CAN	9150-01-035-5391
MIL-L-2105/80W-90 (0-226)	1 QT CAN	9150-01-035-5392
	5 GAL CAN	9150-01-035-5393
	55 GAL DRUM	9150-01-035-5394
MIL-L-2105/85W-140 (0-228)	1 QT CAN	9150-01-048-4591
	1 GAL CAN	9150-01-035-5395
	55 GAL DRUM	9150-01-035-5396
VV-L-825/RCO1 (0-282)	1 GAL CAN	9150-00-664-4449
VV-L-825/RCO2 (0-283)	1 QT CAN	9150-00-598-2911
	1 GAL CAN	9150-00-292-9657
VV-L-825/RCO4 (0-290)	1 GAL CAN	9150-00-823-7905
VV-L-800 (0-190)	4 OZ CAN	9150-00-273-2389
	16 OZ CAN	9150-00-458-0075
	1 QT CAN	9150-00-231-6689
	5 GAL CAN	9150-00-231-9062
VV-L-820 (0-196)	1 OZ BTL	9150-00-261-8146
	4 OZ CAN	9150-00-252-6173
	1 QT CAN	9150-00-252-6174
	1 GAL CAN	9150-00-231-9045

Table 262-2-2. SHIPBOARD LUBRICANTS - Continued

MIL SPEC/MIL SYMBOL(NATO CODE)	QUANTITY	NSN
MIL-L-7808 (0-148)	1 QT CAN	9150-00-782-2627
DOD-G-24508	1 LB CAN	9150-00-149-1593
	5 LB CAN	9150-00-117-2928
MIL-G-23549/GGP	1.75 LB CAN	9150-00-985-7316
	7.5 LB CAN	9150-00-235-5555
	35 LB CAN	9150-00-823-8047
MIL-G-24139 (G-450)	1.75 LB CAN	9150-00-180-6381
	6.5 LB CAN	9150-00-180-6383
	35 LB CAN	9150-00-180-6383
MIL-G-18458	35 LB CAN	9150-00-530-6814
MIL-L-15719/GHT	14 OZ CART	9150-01-080-9652
MIL-G-6032/GRG(G-363)	8 OZ CAN	9150-00-190-0926
	1 LB CAN	9150-00-257-5360
	1/4X7/8 STK	9150-00-261-8287
SS-G-659 (S-732)	1 LB CAN	9620-00-233-6712
MIL-M-7866	10 OZ BTL	6810-00-816-1025
MIL-T-22361	8 OZ TUBE	8030-00-292-1102
	1/4 LB CAN	8030-00-059-2761
MIL-A-907	16 OZ CAN	8030-00-155-6444
	1 LB CAN	8030-00-251-3980
MIL-S-8660(S-736)	4 OZ TUBE	6850-00-880-7616
A-A-50433	35 LB CAN	9150-01-306-9167
MIL-G-27617 TY 3	8 OZ TUBE	9150-00-961-8995
DOD-L-24574 TY 1	1 QT CAN	9150-01-101-8834
TY 2	1 QT CAN	9150-01-101-8835
TY 3	1 QT CAN	9150-01-101-8836
MIL-H-17672/2075TH	1 QT CAN	9150-00-985-7231
2110TH	1 GAL CAN	9150-00-753-4799
2135TH	1 QT CAN	9150-00-985-7236
MIL-L-24131	2 OZ BTL	9150-00-926-8963
MIL-L-24478	KIT	9150-00-424-3224
MIL-L-24479	KIT	9150-00-424-3215

SECTION 3
ESSENTIALS OF LUBRICATION SYSTEMS

262-3.1 INTRODUCTION

262-3.1.1 This section describes the essential components commonly found in shipboard lubrication systems. In addition, the procedures for the preparation, maintenance, and securing of lubrication systems are detailed.

262-3.1.2 In general, forced lubrication systems contain the following components:

a. Lube Oil Pump. Oil is delivered to the system by this pump. If the only available pump is driven by the unit it serves, a priming pump is utilized to deliver oil to the system until the unit is started.

b. Sump Tanks. Oil is taken from and returned to the sump tank after it has passed through the system.

c. Lube Oil Coolers. Oil passes through the cooler(s) on its way to the system so that it is maintained at a desired temperature.

d. Settling Tanks. Used to allow water and other impurities to settle out of the oil. Used oil may also be stored in these tanks.

e. Stowage Tanks. Used to store new or renovated oil.

f. Strainers and Filters. Used to remove foreign debris from the oil before it reaches the bearings and oil sprays. Strainers are also important in providing an indication of the condition of the lube oil and the bearings it serves through periodic inspection of their contents (see paragraphs **262-3.4.4.e**. and **262-3.8.2**). The importance of strict attention to strainer shifting and inspection requirements cannot be overemphasized.

g. Centrifugal Purifiers. Used to remove water and other impurities not trapped by the filters or strainers from lube oil by centrifugal action. Equipment with a centrifugal purifier normally aligned to purify its oil while the equipment is operating is defined as having ″Online purification capability.″

NOTE

Centrifilters found on some equipment are not considered centrifugal purifiers.

h. Oil Heaters. Used to warm lube oil to a specific temperature before starting machinery, or heat contaminated lube oil to facilitate the removal of impurities. Heaters may be combined with the centrifugal purifier units.

i. Electrostatic Precipitators. Used to remove oil mist from gear and sump tank vents on large-capacity systems.

j. Transfer Pumps. Used to transfer lube oil between stowage, settling, and sump tanks. Most ships use the centrifugal purifier pump as the transfer pump.

k. Reduction Gear Dehumidifier. Used to remove moisture from the reduction gear casing when the lube oil system is secured for long periods. Not all ships are equipped with reduction gear dehumidifiers.

l. Gauges, Thermometers, and Other Instruments. Used to monitor system operating conditions and allow corrective action when necessary. For example, low pressure may indicate pump failure or excessive leakage. High pressure may indicate clogged lines, strainers, or filters, which could lead to serious equipment damage.

262-3.2 TYPICAL LUBE OIL SYSTEM INSTALLATIONS

262-3.2.1 STEAM TURBINE/REDUCTION GEAR LUBE OIL SYSTEM. This system typically provides lubrication to propulsion reduction gears and steam turbine bearings. The lube oil pumps take suction from the reduction gear sump tank and deliver oil by way of strainer and oil cooler to the lubricating oil header. From the header, oil is distributed to the various gear, coupling, and clutch oil sprays, attached servomechanisms, and other components, and the thrust and journal bearing serviced by the system. From these service points, the oil is returned to the sump by gravity action. System pressure may be monitored and maintained by an automatic unloading valve, which returns excess oil to the sump tank. To ensure that adequate pressure is maintained, the system may contain a sensing device that activates a standby or emergency pump whenever the pressure supplied by the operating pump is insufficient. The system may also include an automatic temperature-regulating valve at the lube oil cooler. Systems with automatic controls are usually provided with manual controls for abnormal, special, or emergency situations. A lube oil heater, when installed, is used in conjunction with the centrifugal purifier to heat the lube oil prior to turning the gears. During warmup, the unloading valve is opened manually to facilitate initial oil circulation.

262-3.2.2 DIESEL ENGINE LUBE OIL SYSTEM. In general, diesel engines installed aboard naval ships are provided with attached lube oil pumps driven by the engine. The lubricating oil pump takes suction from the engine sump or sump tank and delivers oil by way of a strainer or cooler to the engine oil header. From the header, oil is distributed to all points requiring lubrication. A filtering system, described in paragraph 262-3.2.2.1, is also provided. Lube oil systems may be classified as either wet or dry sump systems, depending upon the method used to return the oil to the sump. In the wet sump system, oil is returned directly to the sump by gravity flow as it leaves the engine. In the dry sump system, oil returns by gravity to an oil pan. An engine-driven scavenging pump continuously pumps oil from this pan to a separate sump. The oil pan is therefore kept empty (dry).

262-3.2.2.1 Diesel engine systems are also provided with full-flow lube oil filtering capabilities. Relief valves are provided to bypass the filters, but these relief valves normally remain closed. Diesel engine lube oil systems are also usually provided with a priming pump so that, before engine startup, oil can be circulated to engine parts requiring lubrication.

262-3.2.3 GAS TURBINE LUBE OIL SYSTEM

262-3.2.3.1 Introduction. This section describes the general characteristics of a typical shipboard gas turbine lube oil system.

262-3.2.3.2 General. All gas turbine engines are equipped with a self-contained engine lubrication system. Figure 262-3-1 is representative of such systems, although variations exist between different engines.

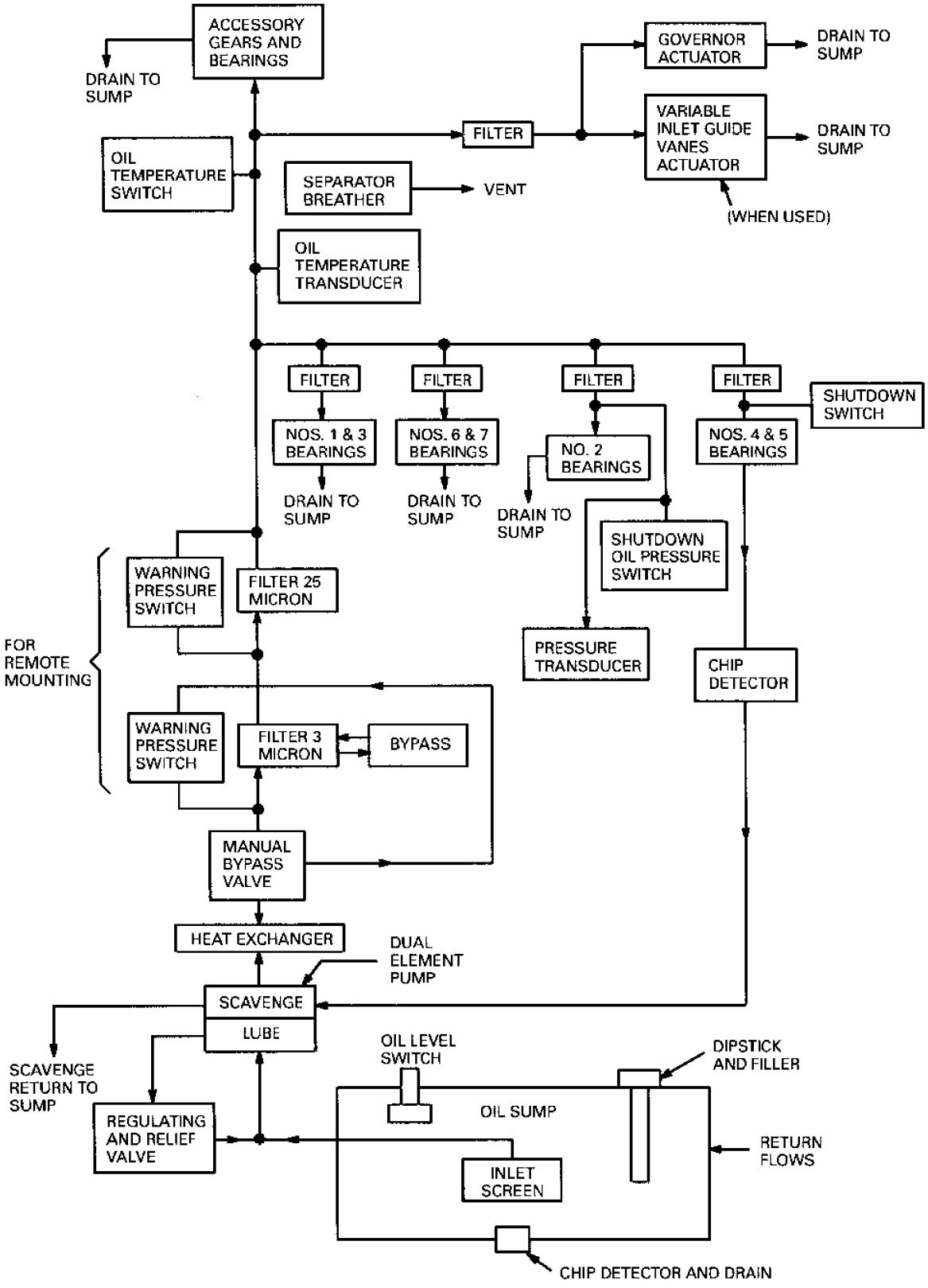

Figure 262-3-1. Simplified Schematic of Gas Turbine Internal Lubrication System

WARNING

Never enter a gas turbine module to perform maintenance on lubricating oil system components while the engine is in operation. Consult appropriate PMS documentation for engine shutdown requirements for lubricating oil system maintenance actions.

262-3.2.3.3 System Features. The principal components of a gas turbine lube oil system are as follows:

262-3.2.3.3.1 Sump. Most gas turbines have a self-contained lube oil sump. If additional oil capacity is required, a separately mounted tank may be supplied. The standard engine sump dipstick and float switch, on opposite sides of the engine, can usually be interchanged in position to facilitate engine servicing.

NOTE

The float switch is electrically connected to the engine control console to indicate when the oil level drops to a minimum normal operating level. Some installations, such as those on high-speed, highly maneuverable ships, exhibit motions resulting in engine attitudes and movement which will cause considerable sloshing of the oil in the sump. This may result in momentary low-level indications, and less than optimum inlet conditions, with possible low pressure nuisance shutdowns.

For most applications, an adjustable time-delay circuit within the electrical system, which inhibits shutdowns from short duration low-pressure conditions, is optionally available. For these applications, users are required to keep the oil sump at the full level. For extreme applications, baffles in the sump and on the oil level indicator will be installed to prevent such occurrences.

262-3.2.3.3.2 Cooling System. Gas turbine oil may be cooled by water, air, fuel, or oil. In the water-cooled arrangement, engine oil is kept at a higher pressure than that of the water. This is to prevent the incursion of water which would cause system corrosion. On other gas turbines, oil is cooled by passing air over the oil sump or by an oil-to-air heat exchanger. Regenerative (fuel) cooling can be employed on gas turbines where the cooling requirements are relatively low. In some cases, this method of cooling may be supplemented by other cooling methods. However, the majority of marine gas turbine installations use an oil-to-oil cooling system where engine oil is cooled by the main reduction gear oil. In these installations, engine oil pressure is maintained at a higher pressure than that of the cooling oil so that, in the event of a leak, cooling oil will not leak into the engine oil system. The major advantage of this type of cooling system is the decreased possibility of the engine lube oil becoming contaminated with seawater.

262-3.2.3.3.3 Venting. To prevent excessive oil loss from venting oil vapor overboard, bearing sumps are usually vented to an air-to-oil separator. The sump air is vented to the exhaust after passing through the separator and the oil is returned to the main sump.

262-3.2.3.3.4 Lube Oil Filters. Last chance filters are integrally located prior to each critical feed point. A main lube filter assembly, usually composed of a coarse filter followed by a fine filter, is supplied with each engine. For a continuous duty engine use, a valve should be provided for external bypassing of the remotely located fine filter to permit filter element changes without shutting down the engine. The coarse filter is usually mounted in the lube oil system, remote from the engine, and may have no bypass. To prevent continued use of unfiltered oil,

routed through the bypass to the engine when the filters are clogged, most filters and strainers have differential pressure gages to assist the operator in determining when the elements require changing, and alarms to warn operators of bypassing flow.

262-3.2.3.3.5 Lube Oil Strainers. Gas turbine lube oil strainers are of the same type as fuel oil strainers, although they are usually of larger mesh. Lube oil strainers usually contain a built-in pressure relief valve of a size sufficient to bypass all the oil around the strainer in the event of clogging so an uninterrupted oil flow to the engine will be maintained. The bypass line should be connected to an audible alarm to inform engine operators that strainers are clogged.

CAUTION

Never use a wire brush for cleaning strainer elements.

In duplex strainers, the element being by-passed can be removed and cleaned without disturbing the flow. In addition, the elements should be soaked in an approved solvent, such as clean naval distillate fuel or JP-5, then wiped with a soft, lint-free cloth or brush.

262-3.3 CENTRIFUGAL PURIFIER SYSTEM

262-3.3.1 Detailed operation of centrifugal purifier units is discussed in paragraph 262-3.6. Centrifugal purifiers are installed to purify oil in all reduction gear and steam turbine lube oil systems. They are also installed to purify used MIL-L-9000 (MS 9250) lube oil if this oil is used in a reduction gear system. Purifier piping system arrangement normally provides for two methods of operation: batch purification or continuous purification. Guidelines are as follow:

a. For batch purification, the lube oil is first transferred from the sump to the settling tank using the purifier pump or transfer pump. The oil is then heated in the settling tank to the temperature recommended in paragraph 262-3.6.4.3.d. This temperature is maintained for a period of twenty-four hours by the steam or electric heating elements in the tank. Water is then stripped from the tank bottom through the drain valve, and the oil is sent through the purifier to the sump from which it was taken. In the interim period while the oil is being heated in the settling tank, the sump can be immediately replenished with clean oil taken from a stowage tank via the purifier bowl. When the settling tank contents have been properly treated, they can be transferred back to the stowage tank via the purifier.

b. For continuous purification, oil is taken from a sump through the purifier and run back to the same sump while the plant is operating. This procedure is also used in conjunction with the purifier and sump heaters to warm the system up prior to getting underway.

262-3.4 OPERATION OF LUBRICATION SYSTEMS

262-3.4.1 GENERAL. Lubrication systems are operated as separate and distinct systems. A standby lube oil pump (or pumps) shall be kept warmed up or primed and ready for immediate use in case of a pump failure. In steam plants with both steam and motor-driven lube oil service pumps installed in the same system, the steam-driven pump should be considered the primary pump and the motor-driven pump the secondary pump.

262-3.4.2 PREPARING THE SYSTEM FOR USE. The following sequential procedure shall be followed each time the system is put into operation, unless otherwise specified in EOSS or PMS, to ensure that all parts of the system are fully operative and that the oil is free from impurities:

1. Take an oil sample from the sounding or sample connection of each sump tank. If a sump tank sounding or sample connection does not exist, start the lube oil purifier and draw the sample from the suction side of the purifier.

NOTE

Some gas turbine engines are not configured to take a lube oil sample prior to starting the engine.

2. If the sample obtained does not meet the satisfactory contamination requirements specified for the equipment and oil type, start the lube oil purifiers and purify the oil in the sump tanks to remove water and other impurities. If the sump tank has independent purifier suction connections, use them; if not, pump the oil to the settling tank before purifying. Repeat step 1 to check for contamination.
3. Strike down enough oil from the storage tanks to the sump tanks to make up the amount of water and impure oil discharged from the sump tanks. As a general rule, makeup oil should be added immediately after the system oil has been purified. This procedure ensures that all of the oil in the system will be pure. Clean oil added to a system containing impurities becomes contaminated. The addition of new or purified oil to contaminated oil to enhance or ″sweeten″ its properties is prohibited.
4. Carefully note and record oil level indicator readings.
5. Examine and clean all strainers. For startup after an overhaul, system modification, or industrial availability, frequent strainer shifting may be required.
6. The temperature of the oil supplied to reduction gears shall be at least 32°C (90°F) before units are turned over. Oil at a lesser temperature shall be heated by use of a centrifugal purifier heater or sump tank heater, if installed. If the purifier heater is electrically powered, energize the heater only after the oil flow has been established and the heater has been vented. To minimize carbonization, the heater shall be switched off before the oil flow is stopped.
7. Start an oil-service pump in each system. Circulate the oil and maintain a steady average service pressure at all bearings of the main engines and all auxiliaries connected to the main system. Test any installed steam and electric lube oil service pumps, using automatic controls if so fitted. Motor-driven pumps shall be tested with duplicate sources of electric power. Steam-driven lube oil pumps shall be operated using their pressure regulators, if so fitted. The oil shall be circulated at least 1 hour during warmup before getting underway, or as recommended by the main engine manufacturer instruction book.
8. Prime the diesel engine lube oil system before starting the engine (or before the engine is turned over by hand or by a motor-driven jacking gear prior to starting). Continue priming until a slight pressure is registered on the engine lube oil pressure gauge or until oil flow is observed at each sight flow indicator. Before starting the engine after a prolonged shutdown, inspect the air receiver and blower discharge passages and remove any accumulation of lube oil.
9. Inspect the oil cooling system for leaks. Repair as necessary.
10. Test the low pressure alarm by decreasing the oil pressure until the alarm sounds.
11. Secure the cooling system until needed.
12. Sample the oil using the oil cooler or strainer vent cock to see if any water has collected in the system.

13. Test the turbine-driven pump governor and motor-driven pump automatic startup controls.

14. To prevent the leakage of cooling water into the oil through leaky coolers, align cooling water to the coolers only after the oil pumps have been started and secure cooling water to the coolers before securing the oil pumps.

262-3.4.3 OIL PRESSURE. The oil pressures to be maintained at the various parts of the lubrication system differ with the type of installation. The pressure at the service pumps shall be such that the pressure at the hydraulically most remote bearing will be according to the system design requirement. To avoid flooding of the bearings (resulting in oil loss at the bearing seals), do not let pressure exceed the recommended level. If the system includes an automatic pressure regulating unloading valve, manual control is normally not required. The unloading valve is initially set to prevent excess oil pressure. The pressure shown by the oil gauges on the main gauge boards should indicate the actual pressure at the hydraulically most remote bearing.

262-3.4.4 LUBE OIL SYSTEM CORRECTIVE ACTIONS. The following corrective actions shall be taken when the following circumstances occur:

a. Sudden increase in oil pressure. If the oil pressure at the pump suddenly increases, check the oil flow at the bearings and take steps to locate and remedy the problem. A sudden pressure increase is most often caused by a clogged strainer.

b. Interruption of oil supply. Oil flow (as observed through the sight glasses fitted in the oil discharge lines at the bearings) should be uniform. Check sight glasses frequently during each watch to detect immediately any interruption in the oil supply. If the oil supply to the bearings is interrupted, notify the EOOW and follow Engineering Operating Casualty Control (EOCC) procedures. Oil sight glasses shall be kept clean and in good condition at all times. Verify frequently that oil pressure is at the correct operating level.

c. Change in bearing temperature. Bearing temperature depends upon oil viscosity, bearing design, running speed, clearances, and thermometer location and accuracy. Because all these factors shall be considered, optimum temperatures cannot be arbitrarily established for every bearing application. The normal running temperature for every bearing should be observed and recorded. Any increase above this level should be investigated. Watch abnormal bearing temperatures carefully and remedy problems as necessary. Until the bearing returns to normal temperature for the operating conditions, the machinery shall be slowed or stopped, as necessary, to avoid exceeding safe bearing temperature levels. Generally, the following guidance applies:

   1 Turbine line shaft and thrust bearings are designed to use turbine lubricating oil conforming to MIL-L-17331 (MS 2190TEP). During normal operation, the oil inlet temperature to the bearings shall be maintained at 50 to 54°C (120 to 130°F). Sump tank and cooler inlet temperatures shall not normally exceed 71°C (160°F). Operating the system with an oil inlet temperature below the design limits may increase the temperature rise through certain bearings, increase variations in bearing outlet temperature, and may even result in some bearings showing a higher outlet temperature than when supplied with oil at the correct temperature. Each manufacturer designs the bearings for a definite rise in the temperature of the oil passing through the bearings.

   2 In addition to sight flow thermometers, many journal and thrust bearings are fitted with integral Resistant Temperature Elements (RTE's), which reflect bearing temperatures more accurately and quickly than do thermometers. Some bearings have RTE's located in the oil drain lines and sight flow fittings. RTE's are automatically and continuously monitored, and can be set to activate an alarm at a specified temperature level.

   3 To prevent MRG gear tooth pitting, CG-47 and DDG-963 class ships shall maintain, whenever possible, an operating lube oil temperature between 40 to 45°C (105 to 115°F).

4 Maximum allowable temperatures for internal combustion engines are provided in engine manufacturer instruction books or provided by NAVSEA.

5 The friction loss in a journal bearing is directly proportional to the viscosity of the oil in the bearing. Therefore, for most efficient operation, oil shall be maintained at the recommended operating temperature.

6 Bearing temperature provides an indication of proper operation. The temperature of the oil, as shown by the bearing thermometer or RTE, indicates the bearing condition and shows whether or not the bearing is adequately supplied with oil. If oil temperature remains normal, operating conditions are satisfactory. If there is a sudden unexplained increase in oil temperature, trouble may have developed and shall be investigated and corrected at once. In many cases, thermometers give only the average temperature within the bearing reservoir, and a check on bearing temperature shall also be made by feeling the cap and by using sight glasses to determine that a positive oil flow is coming from the bearing.

d. Control of lube oil temperature. Lube oil temperature may be controlled through the use of the lube oil cooler. The amount of cooling water to be circulated through the cooler depends upon the temperature of the cooling water, cooler cleanliness, and the amount of heat to be removed from the oil to maintain proper bearing temperatures. The lower the temperature of the injection water, the smaller the amount of cooling water that needs to be circulated to cool a given quantity of oil a certain number of degrees. The higher the temperature of the injection water, the greater the amount of cooling water required for circulation. As soon as the temperature of the oil at the cooler outlet exceeds 49°C (120°F), oil temperature shall be decreased by increasing the quantity of water circulating to the coolers. Cooler isolation and bypass valves are locked to prevent personnel from inadvertently stopping the oil flow while the machinery is in operation. Some ships have a temperature-regulating valve installed in the lube oil piping. This valve mixes cooled oil with oil that bypasses the cooler to obtain oil of the temperature needed for the machinery. Guidelines are as follow:

1 To maintain system oil at a temperature that results in correct (design) oil viscosity, operate coolers whenever the system is operating. Do not exceed the temperature and viscosity limits for the system.

2 With the bearings in proper operating condition, a temperature of 51 ± 3°C (125 ± 5°F) for the oil discharged from the cooler shall satisfactorily meet all normal operating requirements except as noted in paragraph 262-3.4.4.c.3. Some designs include temperature-regulating valves that automatically maintain lube oil temperature within the stated range.

3 While in port, when oil coolers are unused for more than 24 hours, keep the seawater sides drained.

4 In the event that the temperature regulating valve should fail, proper lube oil temperature shall be maintained by use of the valve manual override or throttling the lube oil cooler seawater outlet valve.

e. Strainer shifting. Normally, shift and inspect main propulsion reduction gear lube oil strainer baskets once a day. Under the following circumstances, shift and inspect baskets at least once every 4 hours:

1 When there is any indication that pressure differential has shifted from normal or any indication of abnormal system operation (such as high bearing temperatures).

2 For the first 24 hours of operation following shutdowns in excess of a week, or when an abnormal pressure differential (in excess of 1-1/2 lb/in^2) is noted through the strainer.

3 For the first 48 hours of operation after repairs to the lube oil system or to any equipment serviced by the lube oil system as denoted in paragraph 262-3.1.2.

4 Under high power or heavy seas per EOP. In addition, shift strainer baskets according to the Engineering Operating Sequencing System (EOSS) (if provided) or procedures on the instruction plate located near the strainer. When shifting, carefully note the type of residue found in the strainer basket. If pieces of metal are found, determine the type of the metal. Pieces of brass or babbitt indicate a damaged or wiped bearing or that the bearing metal is breaking up. Either condition requires bearing inspection. The affected machinery shall be stopped and inspected for damage if the contaminants appear metallic and cannot be crushed between the thumbnails. The lube oil shall be transferred to a settling tank, and the system cleaned and flushed. If the contaminants are of a soft nature, lube oil system operation can be continued. If the metal

appears to be iron rust, corrosion and flaking are occurring in the system. If corrosion exists, or if other solid contaminants are present in the lube oil, clean the system and purify the oil as soon as practical. Rust and bits of metal will scratch bearings and mar thrust shoes, especially in Kingsbury thrust bearings. A sudden increase in bearing temperature, followed by a return to normal temperature, generally indicates that a foreign substance in the lube oil scratched the bearing and was then carried to the strainer basket.

f. Shifting filtration. If the propulsion machinery has 40 or 25 micrometer (micron) duplex filters installed in the lubricating oil system, the daily strainer shifting and inspection requirement does not apply. Filters may not require shifting for several weeks, but should be shifted when the differential pressure exceeds the value recommended by the filter manufacturer. Where class 6 (40 micron) or class 8 (25 micron) filter elements are specified to Military Specification MIL-S-17849, the strainer housing should be designed to accept interchangeably the specified filter elements or alternately the standard 80 mesh strainer baskets. A supply of temporary 80 mesh strainer baskets and nylon bags should be stored in the vicinity of each duplex strainer unit. The intent is to provide a safety net for the event of unusual lubricating oil system contamination, for situations of repair or overhaul, when a lubrication oil system flush is required.

262-3.5 EFFECT OF WATER IN THE OIL

262-3.5.1 GENERAL. Precautions shall be taken to keep water from entering the lubrication system; any water detected shall be removed as soon as possible. Water in the oil increases frictional resistance, causes the oil to break down prematurely, corrodes journals and any parts not continuously covered with oil, and may cause corrosion in the entire system. Rusting generally originates on exposed surfaces such as gear casings and upper portions of sump tanks where condensation occurs and, unless remedied, progresses throughout the system. Rusting due to condensation is most likely to occur in cold climates and in installations where portions of the lube oil sump tanks are integral with the skin of the ship. Precautions to be taken include the following:

a. Any drain fitted in the lowest part of a bearing pedestal should be opened and the bearings drained of any water a few hours after securing the lube oil system.

b. Lube oil from bilges, oily waste drain tanks, or miscellaneous tanks shall not be reclaimed nor added to the lubrication system.

c. Because warm, moisture-laden vapor condenses on any cool, exposed surface, any factor tending to cool casings or sump surfaces shall be eliminated. All forced draft ventilation ducts shall be permanently arranged so that no air can blow directly or indirectly on a gear casing.

d. When securing the main propulsion machinery, circulate oil through the turbines and reduction gear lubrication system by means of the ship's oil pumps for at least 1 hour (or until the machinery reaches ambient temperature), to allow machinery component temperatures to equalize. The motor-driven shaft turning gear (if provided) shall be operated during the oil circulation period. If hand jacking only is provided, the propeller shaft shall be jacked intermittently until machinery reaches ambient temperature. The circulation period will vary, depending upon the air and injection temperatures. For ships operating under low air and injection temperature conditions, the period will be somewhat longer.

e. If electrostatic precipitators are installed on turbine and reduction gear and sump vent pipes, the vented air is cleaned of oil and water mist particles only. Moisture, in the form of vapor, will flow through the precipitator unrestricted. A haze of moist air visible at the electrostatic precipitator vent discharge indicates that excessive moisture is entering the lubrication system elsewhere. Test the purifier operating efficiency and check every possible point at which water might enter the system.

f. If the propulsion reduction gear has a dehumidifier installed, the moisture in the air within the gear case and oil sump shall be maintained at 30-35 percent relative humidity, when the propulsion plant has cooled down

and been secured. Prior to starting and warmup of the lubricating oil system, the dehumidifier shall be secured, isolation valves in the dehumidification ducts shall be locked shut, and the electrostatic precipitator activated and its positive closure assembly opened. To secure the machinery, allow the oil temperature during oil circulation to cool down to approximately 10° F above ambient. Then, secure the electrostatic precipitator, close the positive closure assembly, stop the lubricating oil system pumps, unlock and open the dehumidification duct isolation valves and activate the dehumidifier. Verify once per watch that the humidity in the gear case is being maintained within the specified limits. Refer to applicable dehumidifier operational/maintenance manual if the specified gearcase humidity requirements cannot be maintained.

262-3.5.2 POINTS AT WHICH WATER ENTERS THE LUBE OIL SYSTEM. Water may enter the lube oil system at the following principle points:

a. Through leaky tubes or joints in the coolers.

b. Through the steam-sealed glands of turbines.

NOTE

See that the bilge drain for the pocket or well between the gland and the bearing is clear. In some installations, a choked drain will permit the water that flows into the pocket to be drawn into the system through the bearing oil baffles.

c. Through vents on tanks and gear casings in the form of atmospheric water vapor, which later condenses.

d. Through leaks in drain or sump tanks located in the bilges.

e. Through the leakage of water vapor (produced by combustion) past the piston rings into the crankcase of diesel engines on startup of a cold engine.

f. Through cylinder liner seals, cracked heads, injector tubes, cracked cylinder blocks, etc., on diesel engines.

262-3.6 CENTRIFUGAL PURIFIERS

262-3.6.1 GENERAL. Centrifugal purifiers, frequently called purifiers or centrifuges, are used extensively in naval service to remove lube oil impurities. A centrifuge consists of a cylindrical vessel or separator bowl (the separation chamber) which rotates at high speed while a liquid (in this case contaminated oil) passes through it. The centrifugal force created by the high rotative speed acts perpendicular to the axis of rotation (i.e., forces heavier matter toward the outer edge of the bowl). The heavier matter (water and sediment) moves to the outer most part of the bowl while the lighter purified oil moves to the center.

262-3.6.2 CAPABILITIES. The ability of a centrifuge to separate depends on the difference in specific gravities between the materials. In general, the greater the difference in specific gravity between the liquids to be separated, the greater the rate of separation. Also, particle size, fluid viscosity, and centrifuge period (time and distance particle must travel to separate) influence the effectiveness of the centrifugal process. For this reason, lubricating oils are heated before being centrifuged to decrease their viscosity.

262-3.6.3 LIMITATIONS. Only materials that are insoluble in one another (such as oil and water) can be separated by centrifugation. For example, gasoline and diesel fuel cannot be separated from lube oil by a centrifuge, nor can salt be removed from seawater because it is in solution.

262-3.6.4 DESCRIPTION OF CENTRIFUGAL PURIFIERS. Centrifugal purifiers are classified by the way they separate and remove sediment and water. Purifiers used on board Naval ships are of two basic types: solids-retaining (manual cleaning) bowl types, and solids-ejecting (self cleaning) bowl types. In addition, there are two basic styles of solids-retaining (manual cleaning) bowls: tubular and disk stack. Solids-ejecting (self cleaning) bowls are of the disk stack design.

262-3.6.4.1 Solids-Retaining (Manual Cleaning) Purifiers. In both the tubular and disk types, separated oil moves toward the center of the bowl to the purified oil discharge (light phase). The separated water and sediment move toward the outside of the bowl. The water is then discharged to the oil waste tank via the water (heavy phase) discharge. The sediment separated from the liquids is retained in the bowl assembly at the inner edge of the disk stack and inside of the bowl.

262-3.6.4.1.1 Tubular Type. The tubular type has a relatively small diameter and rotates at a comparatively high speed. The bowl has a three-wing device that keeps the liquid rotating at the high speed of the bowl and prevents liquid slippage. Liquid is fed to the tubular bowl through a nozzle from the bottom.

262-3.6.4.1.2 Disk Type. The disk type has a larger diameter bowl and rotates at a comparatively slower speed. This bowl is fitted with a series of disks that separate the liquid into thin layers, thus reducing the distance that sediment and water must travel in order to be separated. The liquid feed (contaminated oil) is fed from the bottom toward a series of holes bored through the disk stack to assist with flow and the centrifugal process.

262-3.6.4.2 Solids-Ejecting (Self-Cleaning) Purifiers. This purifier operates similarly to the manual cleaning disk type purifier. In the self-cleaning purifier, the bowl is split, and the sides are shaped so as to cause solid contaminants to funnel toward the area of separation. When the separated bowl is closed, the solids collect around the periphery. When the separated bowl is open, the solids are ejected out of the bowl by centrifugal force. The opening and closing of the bowl is accomplished through the use of an internal hydraulic operating water system. This process is termed ″shooting the bowl″ and occurs almost instantaneously.

262-3.6.4.3 To obtain maximum efficiency in purifier operation, the following instructions shall be followed:

a. Always operate purifiers at their maximum design speed and at rated capacity, except as noted below for MIL-L-9000 (MS 9250) lube oil purification. After startup, throttle flow to obtain rated capacity. Appropriate devices are provided for checking machine speeds.

b. Because turbine oils are subject to contamination by condensed water, purifier bowls shall be operated as separators, not as clarifiers, whenever turbine oil is being purified. To operate as a separator, the centrifuge is adjusted, by proper selection of ring dams, to separate and discharge two liquids. Normal operation as a separator will result in a continuous flow of oil from the oil discharge and of water, as it is separated, from the water discharge. When purifiers are operated as separators, the bowls shall be primed with fresh water before any oil is admitted. This water seals the bowl and creates an initial equilibrium of liquid layers. If the bowl is not primed, the oil will flow from the water discharge ports and be wasted. Refer to the manufacturer instruction book for the proper priming procedures.

NOTE

A centrifugal purifier may be operated either as a clarifier or as a separator. Clarification should be undertaken only for oils not contaminated with water. To

operate as a clarifier, the centrifuge is adjusted to discharge a single liquid from which the solids have been removed by centrifugal force.

c. When mixed with water, MIL-L-9000 (MS 9250) oil is subject to emulsion formation. New oil emulsifies most readily, and the tendency gradually decreases during the first 50 to 75 hours of operation. During the 50 to 75 hour period that the purifier is operated as a separator, monitor the water discharge carefully for emulsified oil, which appears tan, and for gray-black, viscous material. To best observe the discharge material, place the water outlet cover to the front of the purifier and, if the design permits, allow it to discharge into a suitable container. If emulsified oil appears, reduce the flow rate to approximately 80 percent of rated capacity and continue to operate at this reduced rate as long as an appreciable amount of free water is discharged with the emulsion.

d. Although certain oils may be satisfactorily purified at operating temperatures, the efficiency of purification may be increased by heating the oils. Most naval service oils may be heated to 82°C (180°F) without damage, but prolonged heating at temperatures higher than this may cause oil oxidation. Once oxidation has been initiated, rapid deterioration of the oil may occur. The recommended temperatures for centrifugal purification of lube oils are as follow: MIL-L-17331 (MS 2190TEP) 71 ± 2°C (160 ± 5°F) MIL-L-9000 (MS 9250) 79 ± 2°C (175 ± 5°F)

e. Ensure that the proper ring dam size has been selected. The size selected should be based on oil heated to the temperatures indicated above. Select a ring dam one size smaller than the size that would permit some oil to be discharged with the water. (For details, see equipment technical manual).

f. Clean the oil purifier bowl frequently and carefully to remove all solid contaminants. The frequency of cleaning depends upon the amount of foreign matter (dirt, grit, sludge, and particles) in the oil being purified. If in doubt, shut down the purifier for examination and cleaning at least once every 4 hours of operation, or more often if necessary. The amounts of sediment found in the bowl at several successive examinations will indicate the intervals at which the purifier will require cleaning.

g. Periodically test purifier operation. During renovation, test purifier discharge 30 minutes after starting and once every 4 hours. When underway, with continuous cleaning in the process, test once every 4 hours.

h. Draw oil for analysis from the sampling cocks, if installed, fitted to the inlet and outlet connections. In systems without inlet sampling cocks, obtain a sample from any lube oil sampling point upstream of the purifier. Purifier efficiency may be determined by observing the clarity of cleaned oil when compared to a sample obtained upstream of the purifier.

262-3.6.5 CARE AND RENOVATION OF SYSTEM OIL

262-3.6.5.1 Introduction. This section provides general guidance for the care and renovation of system lube oil.

262-3.6.5.2 Diesel Engine System Oil. For diesel engine installations, circulate oil only until a slight pressure is registered on the engine lube oil gauge. This limited circulation prevents lube oil from accumulating in air receivers, blower discharge passages, and combustion spaces in quantities that could cause the engine to overspeed as it is started.

262-3.6.5.3 Propulsion Gear System Oil. Propulsion gear oil circulation procedures shall be performed based on operational scenarios as follow. These procedures are generalized; for detailed procedures, see **NSTM Chapter 241, Propulsion Reduction Gears, Couplings, Clutches, and Associated Components** .

NOTE

Heating of lube oil is not required for performing in port maintenance actions on the main reduction gear. Rotating the gears, via use of the turning gear, can be accomplished with the lube oil at ambient temperature.

a. Extended layup. Propulsion gears and clutches remaining inoperative during layup procedures in excess of eight weeks shall be protected against rusting by the use of a dehumidifier, periodic inspections, and circulation of the lube oil. On a monthly basis, the dehumidifier shall be shut down, and the inside casing surface and rotating elements inspected for rust as specified in **NSTM Chapter 241, Propulsion Reduction Gears, Couplings, Clutches, and Associated Components** . The lube oil shall be circulated for one hour using a lube oil service pump. The temperature of the lube oil shall be approximately equal to the gear and clutch casing metal temperature to prevent condensation on the colder casing. Rotate pinion and gear elements approximately one and one-quarter turns of the bull gear during oil circulation to ensure reposition of gear meshes. When the emergency propulsion drive is an attached gear case appendage, the drive shall be declutched from the gear and rotated slowly for ten minutes after the gear is secured. If oil cannot be circulated with the lube oil service pump, then oil at approximately the casing temperature shall be applied to the inside surfaces and rotating elements. This may be done by operating the lube oil purifier and pump with bowl and heater bypassed, attaching a hose to the purifier oil discharge piping, and hosing through open casing inspection ports and unbolted appendage inspection covers, if applicable. When oil is applied in this manner, the pinion and gear elements shall not be rotated. It may be necessary to install temporary fittings in the purifier discharge piping for attachment of the hose.

NOTE

Ships which have been deactivated in accordance with **NSTM Chapter 050** , Readiness and Care of Inactive Ships, do not require the above procedure, since the machinery compartment is kept under dehumidification and the interior surfaces protected with rust preventative compound MIL-C-16173, Grade 2.

b. Rotation of Gears. The proper quantity of oil at the designed pressure and temperature must be supplied when gears are turned over with the following exceptions:

1 Turning gear rotation of the propulsion train without propulsion lube oil (PLO) system operation shall be limited. In no case shall the propulsion train be rotated more than a total of two and a half turns of the second reduction gear (two cycles of one and one quarter turns of second reduction gear with 1 hour cool down period between cycles). If the PLO system has been operated within 48 hours, coat the turning gears with lube oil immediately before rotation, and rotate propulsion train under no load (no torque) condition. If the PLO system has not been operated within the last 48 hours, supply all bearings through sight flow feed lines with enough lube oil to coat the journals, coat the turning gears with lube oil immediately before rotation, and rotate propulsion train under no load (no torque) conditions. For brake tooth (static) contact check, coat turning gears with lube oil continuously.

c. New Gears/Post Inspection of System. The possibility of having a large amount of dirt in the system is greatest with new gears or after gear casings have been lifted for repair or inspection. Particular care shall be given to checking strainers when units are new or after covers or caps have been lifted. If large amounts of dirt are found, nylon bags (see paragraph 262–3.8.2.3) (Type 7, Class 1 of CCC-C-432) shall be fitted in the strainer basket to assist in cleaning the system. To avoid accumulation of water from condensation, continue circulation of the lube oil, when the main engines are secured, until the temperature of the oil and reduction gear casings approximates the engine room temperature. While the oil is circulated, the cooler shall be operated

and the engine rotated continuously. The purifier shall be operated during circulation of the oil and long enough after circulation is completed until no further water is discharged.

d. Height of Oil in Gear Case. The oil level in the bottom of the gear case shall not rise above the lower level of the teeth of the gear unless an oil shield is fitted around the gear wheel for the purpose of carrying a higher level. If not observed, churning and aeration of the oil will occur. This condition may be indicated by an overflow of foaming oil through the vent at the top of the gear case (if so fitted) and oil leaks in the gear-casing joints. If this condition occurs, the engines shall be slowed or stopped, and the excess oil drained from the gear case, or, if oil buildup is caused by a drain blockage, the lines to the sump tank shall be examined and abnormal conditions corrected.

e. Getting Underway. Preparation includes the following:

1 Inspect sump or supply for sufficient oil in the system.

2 Inspect for water in the sump bottom, and remove as necessary.

3 Establish that circulating water is available at the lube oil cooler.

4 Ensure that the lube oil in the sumps is a minimum of 90° F before starting the main engines and rotating the main propulsion machinery.

5 Ensure that oil is flowing freely at the correct pressure to all gear shaft bearings, spray nozzles and line shaft components. When oil is flowing at operating temperature to all bearings and sprays, check the operating level in the sump or supply tank.

6 Once underway, frequently observe all oil pressures and temperatures, and enter results in the log. Check sump oil level frequently, and if changes occur, investigate immediately.

262-3.6.5.4 Renovation of Oil While Underway. Each steam-driven ship having a forced lube oil system and each diesel or gas turbine-driven ship main reduction gear lube oil system equipped with centrifugal purifiers shall operate the purifiers daily while underway until no visible indication of contamination remains in the oil and no water is discharged from the purifier. In addition, all oil in the lubrication system shall be pumped to the settling tanks and renovated when the sump tank is inspected. Should a ship experience a lube oil purifier casualty, it should be repaired as soon as possible. The ship may continue to operate while repairs are being made as long as the lube oil meets the clear and bright criteria. The decision to operate equipment not meeting these criteria should be made on a case-by-case basis between the type commander and ship, balancing good engineering judgment and the operational requirements of the ship.

262-3.6.5.4.1 When the main propulsion machinery is secured, the lube oil shall be purified until no water is discharged from the purifier.

262-3.6.5.5 Renovation of Emulsified Oil. As MIL-L-17331 (MS 2190TEP) is used, the oxidation process leads to a gradual increase in the acidity of the oil. The organic acids formed in the process combine readily with water molecules to form a stable emulsion. Eventually, a point is reached where the water/oil emulsion cannot be broken by purification. Emulsified oil shall be purified according to the following guidelines:

a. Oil that is contaminated with water and other impurities should be pumped to the settling tank and heated to the appropriate centrifugal purification temperature (see paragraph 262-3.6.4.3.d). The oil shall be heated continuously for 24 hours. The purpose of the heating is to reduce the viscosity of the oil sufficiently to allow for water and other contaminants to gravitate to the bottom of the tank. The impurities shall be drawn off through the low point drain, and the settling tank volume recirculated through the purifier three times. If the oil still fails the clear and bright test as described in paragraph 262-5.1.2 after this purification process, a stable oil/water emulsion is present which cannot be broken by centrifugal purification. The oil batch shall be discarded

into the oily waste holding tank for shore disposal. All renovated oil in settling tanks shall be passed through the purifier when returning oil to machinery sumps or stowage tanks.

CAUTION

The lube oil settling tank shall be empty before introducing oil into the tank for renovation. Any contaminated or waste oil that is already present in the settling tank shall be transferred to the oily waste tank before introducing oil for renovation.

b. To take advantage of the heat absorbed by the lube oil during system operation, warm lube oil shall be pumped directly to the settling tank immediately upon the securing of machinery rather than after the oil has cooled.

262-3.7 CARE OF NEW LUBE OIL

262-3.7.1 New oil is delivered to ships either in bulk by barge or tank trucks or as packaged products in drums, pails, or cans. The recipient of delivered oil should check for intact seals on commercial trucks and verify delivery documents. If oil quality or quantity is questionable, do not take the oil on board until the problem is resolved with the activity personnel responsible for the delivery. Delivery by Navy trucks should include a laboratory test report of lube oil quality. Additional guidelines are as follow:

1. Inspect the delivered oil for appearance. New MIL- L-17331 (MS 2190TEP) oil delivered to ships shall meet the requirements of clear and bright as described in paragraph 262-5.1.2.
2. Ensure that the truck hose is connected to the correct ship manifold. Verify the storage tank level and capacity prior to transfer. Upon completion of delivery, sound the lube oil tanks and verify that the quantity delivered equals the truck meter reading(s).
3. Packaged lube oil is normally sealed and the containers are marked to identify the contents. Do not use the oil if the container markings are unclear. Fifty-five gallon drums are fitted with cap seals on the bungs. If these seals are not intact, do not use the oil until the quality can be verified by chemical analysis. When initially opening new drums and pails, take a thief sample and visually inspect for quality. If the sample appears suspect, isolate the container and do not use until the oil quality has been established. If other containers show similar quality deficiencies, submit a defective material report according to NAVSUPINST 4440.120.
4. Do not add packaged lube oil directly into operating machinery. All packaged lube oil shall be filtered through a 60- mesh or finer screen when servicing equipment.
5. New or renovated oil from ship storage or settling tanks shall always be passed through an operating purifier to remove contaminants before introducing the oil into the circulating systems or storage tanks.

262-3.8 FLUSHING OF LUBE OIL SYSTEMS

262-3.8.1 INTRODUCTION. Cleanliness of lube oil systems is of the utmost importance. Damage to machinery can occur if lube oil systems are not properly and completely cleaned. During extended system shutdowns, such as overhaul, systems are subject to contamination from various sources, such as steel piping and sump tank oxidation, component repair or replacement, system modification, removal of system piping sections for access to other system components, and failure to protect system openings from external contamination sources. When cleanliness of a lubricating oil system has been lost due to contamination, the system should be flushed using a

detailed procedure developed from the flushing procedures described in this section. Where feasible, shop cleaning of the contaminated portion of the system may be substituted for a shipboard flush.

262-3.8.2 GENERAL GUIDELINES. The flushing procedures described in this section are intended to be the basis for more detailed industrial activity procedures. Modifications may be necessary because of individual activity practices or variations in ship configurations. Where 25 or 40 micron filter elements are installed in the reduction gear lube oil system, the system shall be flushed using temporary 80 mesh strainer baskets containing nylon bags (see paragraph 262–3.8.2.3) installed in the filter housings.

NOTE

Use of these procedures is limited to those situations in which replacement components have not been coated with a preservative. Portions that have been preserved shall be hand cleaned or flushed according to procedures approved by NAVSEA. If abrasive blasting has taken place on, or in the vicinity of, the ship during overhaul, sump tanks, strainers, filter bags, and other parts of the system involved in the flushing procedure shall be inspected with particular care. Check for abrasive material in the system. Should abrasive blasting material be found, all accessible parts of the system shall be manually wiped down with lint-free cloths soaked in kerosene. The system shall then be cleaned and flushed according to NAVSEA-approved procedures.

WARNING

Avoid skin contact with kerosene. Wash affected skin areas with soap and water upon completion of cleaning. Avoid heat or open flames. Read all pertinent material safety data sheets before using solvents.

262-3.8.2.1 Preliminary Sump and Tank Cleaning. Before system flushing, the interior surfaces of sump stowage and settling tanks shall be wiped with clean lint-free cloths soaked in cleaning oil, kerosene, or other petroleum-derived solvent to remove foreign material. Tanks shall then be wiped dry with clean, lint-free cloths and all surfaces coated with the system oil. Be sure cloths are removed after cleaning. Also, any dead-ended piping that cannot be flushed shall be hand cleaned before system flushing.

262-3.8.2.2 Hydrostatic Testing of the System. Before performing the flushing procedures, hydrostatically test the flushing arrangement by bringing the flushing oil to service pressure to ensure tightness and to prevent spraying hot oil into the compartment. Monitor the entire system during flushing so that any system failure is detected promptly.

CAUTION

Do not install filter bag with its excess length extending below the lube oil strainer basket mounting surface (to the outlet side of the basket). Bags installed with excess length extending to the outlet side may become frayed, contaminating the lube oil system with fibers.

262-3.8.2.3 Flushing Strainer Filter Bags. Nylon filter bags shall be used and shall be of a continuous filament nylon cloth, scoured finish, 80 by 80 thread, 75–100 micron fiber thickness, 125–200 micron holes in cloth. For ships with 25 or 40 micron filter elements, the nylon bags to be installed in the temporary baskets shall have the following mesh opening sizes and minimum open flow area percentage:

Mesh Opening Size (Micron)	Minimum Open Flow Area (%)
200	30
150	30
100	30
75	30
50	20
25*	15
* Applicable only to ships with 25 micron filters	

Each bag size shall be installed for an equal amount of time based on the minimum circulation time calculated in paragraph 262–3.8.3.1.6 (e.g., for ships with 25 micron filters, if the calculated minimum circulation time is 12 hours, each size bag shall be installed for a minimum of 2 hours). Filter bags should be made 1 to 2 inches larger in diameter, and approximately 4 inches longer than the strainer baskets, to prevent rupture and to allow for folding the bag at the top of the basket. There shall be no raw edges to the bag. All stitching shall be sewn either with polyester filament or nylon banded thread, size E.

262-3.8.2.4 Timing of Flush. The system shall be flushed and cleaned as near to the completion of the overhaul as is practical.

262-3.8.3 MAIN (PROPULSION), SSTG, AND SHAFT LUBE OIL SYSTEM FLUSH. The following requirements apply to lube oil systems for steam turbines and their associated reduction gears, gas turbine reduction gears, and those diesel reduction gears using oil conforming to MIL-L-17331 (MS 2190TEP):

262-3.8.3.1 Initial Flush (Piping Only - Bearings and Components Jumpered).

1. Before beginning the flushing procedure, ensure that the sump tank and one settling or stowage tank (if required to heat the oil prior to transfer to the sump tank) have been cleaned as described in paragraph 262-3.8.2.1.
2. Install nylon filter bags (see paragraph 262-3.8.2.3) in the duplex strainer basket. Where 25 or 40 micron filters are installed, replace the filter elements with temporary 80 mesh strainer baskets containing 200 micron nylon filter bags. Install pump section coarse strainers. Install temporary jumpers to bypass bearings, gear sprays, clutch control and control oil components as applicable. Remove system orifice plates. Do not install filter elements in SSTG control oil strainers.
3. Partially fill the sump tank or one previously cleaned settling or stowage tank with oil. The quantity of oil used shall be sufficient to maintain the normal operating sump tank level during system operation.
4. Heat the oil to a temperature of 165 ± 5°F (74 ± 3°C) by using temporary heaters or other suitable means, such as tank heating coils.
5. If oil was heated in a storage or settling tank, transfer the heated oil to the sump tank.
6. Start one lube oil service pump and circulate system oil through the strainer at normal operating pressure, cycling components as applicable, to purge all connected service piping. Line up the Lube Oil Fill, Transfer, and Purification (LOFTP) system to the sump tank and place it in operation. Circulate oil for a minimum

amount of time equivalent to the time required to circulate two sump volumes through the LOFTP system or 12 hours, whichever is less. During this time, maintain oil temperature at 165 ± 5°F (74 ± 3°C) by using the LOFTP or other suitable means.

7. Operate the LOFTP system continuously during these procedures until system flushing is complete.
8. During circulation, vibrate non-copper system piping periodically, particularly in the area of any new joints, by striking the piping with a wooden mallet. If tubing is copper, use a rubber mallet instead.
9. Periodically jack open relief valves and bleed gauge lines and other dead end lines into a container. Alternate operation of the lube oil service pumps and, if applicable, the coastdown pumps during the flush. Periodically cycle system valves to ensure adequate flushing through the piping.
10. During the circulation period, shift strainer baskets and examine the filter bags after a 2 to 5 psi pressure drop is indicated on the strainer gauges. Replace bags that are coated with foreign matter or that show signs of deterioration. Where 25 or 40 micron filters are installed, if there has been no more than a 5 psi pressure drop rise on the strainer gauge during the minimum time the bag is required to be installed (see paragraph 262–3.8.2.3), the nylon bag shall be replaced with a nylon bag of the next smaller micron size and the circulation process continued. For SSTG control oil strainers, install the filter elements during the last 1/6 of the flush.

NOTE

Most larger particles of dirt and foreign matter will be collected in the strainer bags during the first 2 hours of flushing. During this period, the filter bags may need to be changed as often as every 15 minutes.

11. At the end of the required circulation period, sample the oil upstream of the duplex filter and analyze for adherence to a maximum cleanliness criteria according to National Aerospace Method (NAS) 1638 Class 10 for particles 25 microns and larger. For SSTG control oil strainers with 17 micron filter elements, take an additional sample from a location downstream of the control oil strainer that is representative of the oil being supplied to the servo valves and analyze for adherence to a maximum cleanliness criteria according to NAS 1638 Class 6. If necessary, continue flushing until the cleanliness criteria has been met for a period of 2 consecutive hours.
12. Secure the lube oil service pump and remove the pump suction coarse strainers. Remove jumper lines or blanks and reassemble piping to all components.

262-3.8.3.2 Final Flush (Piping, Bearings, and Components Included in Flushing Loop).

1. For ships that do not have 25 or 40 micron filters, install clean nylon filter bags (see paragraph 262-3.8.2.3) in the duplex filter basket. Ships with 25 or 40 micron filters should install disposable filter elements. Ensure filter elements are installed in SSTG control oil strainers.
2. Heat the oil to a temperature of 125 ± 5°F (51 ± 3°C) by using temporary heaters or other suitable means, such as tank heating coils.
3. With the sump tank filled to a level sufficient to maintain the normal operating sump tank level during system operation, start one lube oil service pump and circulate system oil through the strainer at normal operating pressure, cycling components as applicable to purge all connected service piping. Line up the LOFTP system to the sump tank and place it in operation. Continue circulating flushing oil for a minimum amount of time equivalent to the time required to circulate two sump volumes through the LOFTP system or 12 hours, whichever is less. During this time, maintain oil temperature at 125 ± 5°F (51 ± 3°C) by using the LOFTP heater or other suitable means.

4. Alternate operation of the lube oil service pumps during the flush.
5. If applicable, examine gear sprays to see that they are clear, and oil sight flows on bearings for proper indicated flow. During the last 1/3 of the flush, rotate the equipment intermittently for 2 to 3 minutes at approximately 10 minute intervals.
6. While oil is being circulated through the system, take representative samples and test for the Clear and Bright criteria according to paragraph 262-5.1.2. If the samples fail to meet these criteria, repeat the flushing procedure until the criteria are met. Once the Clear and Bright criteria have been met and the required circulation period has been completed, sample the oil upstream of the duplex filter and analyze according to cleanliness criteria NAS 1638 Class 10 for particles 25 microns and larger. If necessary, continue flushing until the NAS criteria has been met for 2 consecutive hours. When the NAS cleanliness criteria has been satisfactorily met, reduce the oil temperature gradually to 105 ± 5°F (41 ± 3°F). Continue circulating oil for 2 hours and rotate the equipment intermittently. Secure the heat and continue circulating oil until the temperature of the equipment is approximately equal to ambient temperature.
7. Secure rotating the equipment and all lube oil pumps.
8. For steam propulsion turbine lubricating oil systems, open a forward turbine bearing. Examine the bearing shell, journal, and chamber for foreign material. If any foreign material is found, clean the affected parts, replace the shell, and continue circulation for a longer period. Continue this procedure until an examination of a second forward turbine bearing shows no deposits. If foreign material is found when a second forward turbine bearing is examined, repeat the process until examination of another turbine bearing indicates a clean system.
9. For shaft lubricating oil systems, open a journal bearing and examine for foreign material. If any foreign material is found, clean the affected parts, replace the shell, and continue oil circulating until an examination of another journal bearing shows no deposits.
10. Filter bags and disposable filters shall remain in propulsion machinery lubricating oil systems until sea trials are completed, except where 25 or 40 micron filter elements are required for the propulsion lubricating oil system, remove the disposable filter elements and install the applicable cleanable filter elements upon completion of sea trials.

262-3.8.4 REDUCTION GEAR SYSTEMS USING MIL-L-9000 (MS 9250) AND MIL-L-2104 (15W40) OIL. If oil conforming to either MIL-L-9000 (MS 9250) or MIL-L-2104 (15W40) is used as the reduction gear oil, the foregoing procedures shall be used except that the system oil shall be heated to 180 ± 5°F (82 ± 3°C) and circulated.

262-3.8.5 DIESEL ENGINE LUBE OIL SYSTEM FLUSH. Diesel engine flushing is comprised of two operations: initial flushing of external systems, and final flushing of the engine and its system. For a detailed discussion, of diesel engine flushing, refer to Section 8 of **NSTM Chapter 233, Diesel Engines** .

262-3.8.6 LUBE OIL FILL, TRANSFER, AND PURIFICATION SYSTEM FLUSH. The following procedures apply to system flushes of the oil fill, transfer, and purification systems:

1. Before flushing the service systems, flush the fill, transfer, and purification system piping.
2. Use the system purifier or a portable flushing rig for flushing the piping.
3. Fill one stowage or settling tank to the appropriate level with the designated system lube oil; circulate the oil through the system from tank to tank, or tank group to tank group, by means of installed purifiers. If multiple purifiers are installed, alternate them periodically.

4. Maintain the flushing oil at a temperature of 74 ± 3°C (165 ± 5°F) using the purifier heater.

5. Periodically cycle system valves to ensure adequate flushing through all piping. Circulate oil through the purifier centrifuge.

6. Clean the strainers when a pressure differential increase of 2 to 5 psi is noted in the strainer. Inspect residue for evidence of metal or rust, and if present, eliminate the cause (see paragraph 262-3.4.4). Circulate oil through the entire system until the cleanliness criteria of NAS 1638 Class 10 for particles 25 microns and larger has been met for a period of two consecutive hours

262-3.8.7 SELF-OILING BEARINGS. Certain classes of machinery are supplied with self-oiling bearings. These bearings consist of a well (situated below the journal) and oilers (oil rings, chain loops, or oil discs) that are rotated by the shaft. The lower parts of the oilers are immersed in the oil in the well and continuously supply lubrication to the bearings as they rotate. Oil rings, chain loops, and oil discs are described in more detail in **NSTM Chapter 244, Propulsion Bearings and Seals** .

262-3.8.7.1 The intervals at which oil shall be changed and oil wells cleaned depend on the service and type of machinery. If the oil does not become contaminated, it can be used for an extended period before its lubricating ability is decreased. To reduce oil contamination, bearing inspection openings shall be maintained in operating condition and shall be kept closed except when being used for actual bearing inspection. The need to renew the oil is indicated by an increase in viscosity, discoloration, or formation of sludge deposits in the reservoir, or unsatisfactory visual oil inspection. Samples shall be examined daily when operating and weekly when the ship is in port. When the oil is to be renewed, the well should be thoroughly cleaned. The oil level shall be sufficient to immerse the oilers.

262-3.8.7.2 All oil wells shall have maximum and minimum marks to show the correct level. When the ship is underway, the oil level and bearing operations shall be inspected and logged hourly.

262-3.9 MISCELLANEOUS LUBE OIL SYSTEM CLEANING REQUIREMENTS

262-3.9.1 REMOVING WATER FROM POCKETS. Open up and wipe out any pockets in the system. If indications of sludge deposits remain, dismantle oil lines and clean manually with wiping cloths. After oil lines are assembled, circulate oil through the system.

262-3.9.2 SUMP TANK INSPECTION. Sump tanks require careful inspection because any deposits that are overlooked may be circulated throughout the lube oil system. Annually, or as specified by PMS, pump all oil from these tanks to the settling tanks, lift the manhole plates, and examine the tank interiors. If any sludge or other impurities are detected, clean the tank before the system is put into operation. If the tank sides show signs of corrosion, scrape and wire brush them, taking care to prevent chips from entering the system. Do not coat or paint tanks without NAVSEA approval.

262-3.9.3 USE OF WASTE RAGS IN OIL TANKS. Never use waste rags to wipe the inside of a tank, bearing, or any lube oil system part. Use only lint-free cloths for all wiping needs, including hands. Be sure to remove cloths after cleaning.

262-3.10 LUBE OIL SYSTEM PRECAUTIONS

262-3.10.1 OPEN SYSTEM PRECAUTIONS. Whenever any part of a lube oil system is opened (such as a tank, pipe, or sump) foreign matter shall be prevented from entering the lube oil system components. If the system is opened when any contaminant-producing work (such as wire-brushing, grinding, or chipping) is in process, all openings exposed to contaminants shall be blanked off.

NOTE

The foregoing requirements for system closure apply also to lube oil system vents, such as tank and gear case vents. Whenever overhaul work is to be done in machinery spaces, and particularly when abrasive blasting is to be performed on or near the ship, every precaution shall be taken to prevent contaminants from entering through vents and other openings in the system. Abrasive blasting of any interior portion of the lube oil system is prohibited.

The blanks shall be strong, durable material to prevent rupture and shall be securely fastened to prevent them from being dislodged by normal rough handling. Loose-fitting covers (wood plugs or rags) are not satisfactory. A loose cloth, such as a canvas cover, may be used under the following circumstances:

a. The system will be open for only a short time.

b. The opening is under observation.

c. No contaminant-producing work is in process.

262-3.10.2 LEAKAGE. Lube oil systems are subject to two kinds of leaks: oil leaking from the system, and water leaking into the system. The leakage of oil from the system can be detected by an increase in oil consumption, by the presence of oil in the bilges, and by noting the flow of oil at the faulty parts. The leakage of water into the system can be detected by visually examining the oil, testing the discharge from the drain and settling tanks, noting the nature of the discharge from the purifier, and by an increase in the reading of the gauges attached to the sump tanks. To ensure that leaks are detected quickly, the following inspections shall be made:

1. Minimum once per watch (every four hours) note and log the amount of oil in the sump tanks.
2. Daily sample the water side of the oil cooler and note if there is any oil in the cooling water.
3. Frequently inspect the bilges for the presence of oil.
4. Frequently inspect the bearings, oil lines, and fittings for leaks.
5. Determine the appropriate oil level for each sump tank at various running speeds. Inspect regularly to see that neither the upper limit nor the safe lower limit is exceeded.
6. During each watch while the ship is underway, frequently inspect the sump tank float gauge to be sure it is operative.
7. Whenever machinery is secured, manifold and cup covers shall be in place.
8. Periodic visual lube oil testing shall be conducted in accordance with equipment PMS and EOSS procedures.

262-3.10.3 SAFETY PRECAUTIONS. All lubricated equipment and the lube oil systems shall be protected from damage by observance of the following precautions:

1. If the oil supply is interrupted, stop the affected machinery immediately; determine cause and correct; and restore oil supply before resuming operation.
2. If a sudden increase of pressure at the pumps is noted, inspect the flow of oil at the bearings immediately. The pressure increase is usually attributable to a clogged strainer.
3. The lubrication system shall be operated as an independent system. The standby and emergency lube oil pump shall be kept ready for immediate use.
4. Take every precaution to prevent water from entering the lube oil system; if water level exceeds system contamination limits, remove it as quickly as possible.
5. Do not permit the oil level in gear casings to rise to the point that gear teeth are immersed; such immersion causes churning, foaming, emulsification, and a sudden increase in temperature.
6. At the first sign that the temperature of the lube oil leaving a bearing or other unit is higher than normal, check oil cooler operation and investigate the cause of increased bearing temperature.
7. Operate oil coolers when oil temperature at the cooler outlet reaches system temperature specified by NAVSEA, and continue to operate as long as the oil temperature at the cooler outlet exceeds that temperature. Any rise above normal operating temperature shall be satisfactorily accounted for; the bearing condition shall be watched carefully. Any problem discovered shall be remedied immediately. Until corrected, the machinery shall be slowed or stopped to avoid exceeding the safe bearing temperature.
8. When oil coolers are unused for more than 24 hours while in port, keep the seawater side drained.
9. Use only manufacturer-recommended oils that appear on the applicable Military Specification Qualified Products List (QPL). The addition of commercial after-market or NON-MILSPEC additives to MILSPEC products is prohibited.
10. When an engine room is secured and the ship is being towed, or is being propelled by units other than its main engines, the bearings of the shafts and machinery that are turned by propeller drag shall be adequately lubricated. If adequate lubrication is unavailable, the jacking gear shall be engaged and locked. Even with the jacking gear engaged and the brake set, oil shall be supplied to the bearings underway, if practical, to provide additional safety in case the jacking gear brake should start to slip.
11. Circulate clean oil through an idle system weekly for at least 15 minutes. Jack the main engines at the same time (see paragraph 262-3.6.5.3). This precaution is not applicable to diesel engine or gas turbine installations.
12. The lube oil purifiers shall be operated each day while underway until there is no indication of water in the oil. When the main propulsion machinery is secured, the lube oil shall be purified until no water is discharged from the purifiers.
13. To prevent emulsification or acidity, oil in the drain tank shall be routed to the settling tanks, heated, and run through the purifiers as soon as the oil becomes emulsified or contaminated by water or other impurities.
14. Diesel lube oil contaminated by more than 5 percent fuel or 40 percent thickening shall be discarded.
15. Whenever any part of the lube oil system is open, however briefly, the openings shall be covered to prevent the entry of foreign matter.
16. Waste rags shall never be used to wipe the inside of a tank, a bearing, or other lubrication system part. Use lintfree wiping cloths only.
17. The oil reservoir of blowers and other independent machinery shall be monitored frequently and kept filled with clean oil of the proper quality.
18. Lube oil shall be discarded, the system cleaned, and new oil introduced when testing indicates that allowable

use limits have been exceeded or when reasonable operation of the purification facilities will not remove emulsion and sludge. The addition of new oil to used oil to enhance or ″sweeten″ its properties is prohibited.

19. To ensure that the proper grade of oil has been delivered and is free from contamination, all newly received oil shall be carefully examined before being taken on board.
20. Keep covers on oil cups of secured machinery.
21. Keep bearing inspection opening covers closed except when openings are in use for bearing examination.
22. Do not cut in coolers until after oil pumps have been started. Secure coolers before securing oil pumps. The pressure on the oil side of the cooler shall always be kept greater than that on the water side.
23. Lube oil in the bilges shall not be reclaimed nor added to the lubrication system.

262-3.11 LUBE OIL SYSTEM INSPECTIONS

262-3.11.1 The following is a list of generic inspections which shall be performed on the lube oil system unless otherwise specified by EOSS or PMS:

1. Minimum once per watch (every four hours) note and log the amount of oil in operating equipment sump tanks.
2. Hourly check oil level and temperature of spring bearings.
3. Frequently during each watch inspect float gauge in drain areas.
4. Each watch, make frequent inspections to see that there are no leaks in the lube oil system.
5. Frequently examine the sight flows of the lube oil system during each watch to see that a proper oil supply is maintained. See that all funnel drains are clear and open.
6. Clean the strainers once a day or when a pressure differential (in excess of 1 to 1-1/2 psi) is noted through the strainer. Inspect residue for metal and rust and, if they are present, eliminate the cause.
7. During renovation, test purifier discharge 30 min after starting and once every 4 hours. When underway, with continuous sump-to-sump purification in progress, test once every four hours.
8. Open and check the vent connection on the water side of the oil cooler at least daily to be sure that cooling water is free from oil.
9. Check diesel engine oil as per PMS to be sure oil is free from fuel contamination.
10. Within 24 hours prior to putting any machinery into operation, fully test lube oil condition and system operation, including low pressure oil alarm, standby pump automatic starting devices, and duplicate sources of power to motor-driven pumps.
11. Inspect and clean sump tanks as required.
12. After extensive lube oil system repairs, after repairs to any equipment served by the system, and when testing indicates, inspect and clean the entire lubrication system.

SECTION 4
NAVY OIL ANALYSIS PROGRAM (NOAP)

262-4.1 NOAP

262-4.1.1 INTRODUCTION. NOAP is part of a tri-service Joint Oil Analysis Program (JOAP) which was established to provide timely and accurate oil analysis results to Army, Navy, and Air Force customers through strategically located laboratories using standardized testing procedures. NOAP participation in JOAP is governed by OPNAVINST 4731.1 and NAVAIR 17-15-50.1 (JOAP Manual), S/N 0817-LP-305-8000. NAVAIR 17-15-50.1 shall be obtained and kept on board all U.S. Naval vessels. Requests for copies shall be made to Commanding Officer, Naval Air Technical Services Facility, 700 Robbins Avenue, Philadelphia, PA, 19111-5097.

262-4.1.2 PURPOSE OF NOAP. The Navy Oil Analysis Program (NOAP) is a preventive maintenance tool that monitors the condition of equipment and oil through the routine analysis of oil samples drawn from Navy machinery.

262-4.1.3 PHYSICAL PROPERTIES TESTING. The type of testing performed on a submitted NOAP sample is dependent on the oil type and application. NOAP physical property tests and use limits are found in Table 262-4-1. Physical property tests provide information such as the type and degree of contamination present in a lube/hydraulic oil system, and the overall quality of the lubricant itself.

262-4.1.4 SPECTROGRAPHIC ANALYSIS. In addition to physical property tests, all NOAP lube oil samples are subjected to spectrographic analysis. Through spectrographic analysis, both the type and degree of wear that is occurring in machinery may be assessed. Wear metals can be generated by friction between moving surfaces in mechanical systems. Metals may also be introduced into the system oil by corrosive or electrolytic action. Both the absolute level and rate of production of metal particles in the oil provide information regarding the condition of operating machinery. If the composition of individual machinery components is known, the types of wear metals in the oil will indicate what parts of the equipment are being worn. In addition, the rate at which these wear particles are produced will indicate whether normal or abnormal wear processes are occurring. For a normally operating piece of equipment, wear metals will be produced at a constant rate. Any condition which increases the normal friction between moving parts will greatly accelerate the rate of wear, thereby increasing the quantity of wear metal particles found in the system oil. Spectrographic analysis may be used to detect impending failures when:

a) there is a slow, progressive buildup of wear metal levels above established criteria, or

b) there are a series of rapid increases in wear metal levels over a short period of time. However, sudden catastrophic failures cannot be detected by existing techniques because these processes often occur by the rapid generation of failure particles too large to be detected by spectrographic methods.

262-4.1.5 IMPORTANCE OF OIL ANALYSIS AT CUSTOMER LEVEL. The stated purpose of NOAP is to detect changes on the condition of used oil, detect unusual wear, and to predict impending equipment failures. At the customer level, this can be translated into improved equipment operational safety and reliability and increased maintenance effectiveness through performance of maintenance on a condition basis.

262-4.1.6 CUSTOMER RESPONSIBILITIES. Customers are typically notified of abnormal results by telephone, Naval message, email, NAVGRAM or fax. The corrective action(s) recommended by the NOAP lab shall

be followed. Customers shall ensure that timely response is made to laboratory requests for resamples. When equipment inspections/repairs are made based on recommendations from a NOAP laboratory, the customer shall provide feedback to the recommending laboratory regarding conditions found upon inspection, etc. The remarks section found on Form DD-2026 shall be used for this purpose (see paragraph 262-4.1.10). In addition, customers shall establish a system of record keeping to ensure that all NOAP samples are:

a) taken correctly and on time in accordance with applicable directives,

b) correctly identified and accompanied by completed paperwork, and

c) quickly forwarded to the supporting NOAP laboratory. Samples that are not analyzed in a timely fashion may not be indicative of the current health of the equipment by the time the results are received and degradation of the sample may occur. In cases where maintenance actions could be performed based on samples that are older than 3 months, the ship may want to resample and resubmit. Furthermore, all personnel involved with NOAP shall be properly trained regarding the importance of the program.

Table 262-4-1. NOAP LABORATORY TESTING USE LIMITS

OIL TYPE/APPLICATION	TESTS PERFORMED	LIMITS ALLOWED
MIL-PRF-9000/Lube Oil (MS 9250)	Viscosity @ 104°F (40°C)	90 - 200 Centistokes (cSt)
	Water Content	Pass/Fail
	Fuel Dilution	0 – 2 percent Satisfactory 2-5 percent Notify Customer 5 percent Abnormal: Secure Machinery
	Spectrographic Analysis Performed	
MIL- PRF -17331/Lube Oil (MS 2190TEP)	Total Acid Number	0.5 mg KOH/g Max
	Viscosity @ 104°F (40°C)	Gears: 74 – 97 cSt All other systems: 70 – 73 cSt notify 74 - 97 cSt acceptable
	Water Content	0.1 percent Max
	Spectrographic Analysis Performed	
MIL-PRF-23699Lube Oil	Viscosity @ 104°F (40°C)	23 – 35 cSt
	Total Acid Number	1.5 mg KOH/g Max
	Spectrographic Analysis Performed	
MIL-PRF-17331/Hydraulic (CPP only)	Viscosity @104°F (40°C)	70 – 73 cSt Notify 74 – 97 cSt Acceptable
	Particle Count	NAS Class 9
	Total Acid Number	0.5 mg KOH/g max
	Water Content	See NSTM 245
	Spectro Analysis Performed	
MIL-PRF -17331/Hydraulic MIL-PRF-17672/Hydraulic MIL-H-5606/Hydraulic MIL-PRF-17111/Hydraulic	Water Content	0.05 percent Max
	Particle Count	NAS Class 9 Max
MIL-H-83282/Hydraulic	Water Content	0.05 percent Max
	Particle Count	NAS Class 7 Max
MIL-H-19457/Hydraulic	Water Content	0.30 percent Max
	Total Acid Number	0.30 mg KOH/g Max
	Particle Count	NAS Class 12 Max

Table 262-4-1. NOAP LABORATORY TESTING USE LIMITS - Continued

OIL TYPE/APPLICATION	TESTS PERFORMED	LIMITS ALLOWED
MIL-H-22072/Hydraulic	Viscosity @ 100°F	41 – 51 cSt
	pH	8.2 – 10.0
	Particle Count	NAS Class 9 Max

262-4.1.7 NOAP SAMPLING. Equipment enrolled in NOAP is periodically sampled by ships' force as required by individual equipment PMS. Additional samples may be requested for analysis by the supporting NOAP lab, immediately following an incident resulting from equipment malfunction or at the discretion of the ships' engineering staff. PMS procedures for sampling shall be followed to ensure that a homogeneous sample representative of the operating system is obtained for analysis. Supplies listed in Table 262-4-3 shall be used in collecting the sample. The sample, along with a completed DD2060 form, is then forwarded to a certified NOAP laboratory for analysis. The form shall be completed as discussed in paragraph 262-4.1.10. Submit the sample to any laboratory listed in Table 262-4-2. Samples may be mailed to laboratories via regular mail. In general the Joint Oil Analysis Programs (JOAP) of all three military services are eligible to use the Military Postal Service (MPS) for mailing of oil samples to laboratories for analysis, by commercial or military airlift, as well as by surface transport, as long as the oil samples meet the cited flashpoint criteria and are properly packaged to preclude spillage. It is imperative that the specially designed mailer kits or shipping sacks are utilized when mailing subject oil samples. Additionally the outside packaging should not be marked as hazardous material.

262-4.1.8 DEPLOYMENT PROCEDURES. Each customer normally uses a home port laboratory that maintains history for the ships' equipment. When using a laboratory other than the home port laboratory, request a transfer disk from the home lab to accompany the sample(s). During deployments the CV/CVN or LHA/LHD laboratory provides oil analysis service to the entire battle group (BG)/amphibious ready group (ARG). Prior to deployment, the CV/CVN or LHA/LHD laboratory will send a message stating that the laboratory is ready to accept the BG/ARG customers. On receiving this notification, each customer shall request a transfer disk from the home port lab for all the ships' equipment and submit this disk to the battle group laboratory. During deployment, samples submitted to the BG/ARG laboratory should be sent to the laboratory promptly by packaging the samples and transferring to the lab via log helo.

OIL ANALYSIS REQUEST

KEYPUNCH CODE

TO	OIL ANALYSIS LABORATORY	1-3
FROM	MAJOR COMMAND	4
FROM	OPERATING ACTIVITY *(Include ZIP Code/APO/DODAAD)*	5-10
	EQUIPMENT MODEL/APPLICATION	11-14
	EQUIPMENT SERIAL NUMBER	15-20
	END ITEM MODEL/HULL NUMBER	
	END ITEM SERIAL NUMBER/END ITEM CODE	
	DATE SAMPLE TAKEN *(Day, Mo., Yr)* / LOCAL TIME SAMPLE TAKEN	21-24
	HOURS/MILES SINCE OVERHAUL	25-29
	HOURS/MILES SINCE OIL CHANGE	30-33
	REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER *(Specify)*	34
	OIL ADDED SINCE LAST SAMPLE *(Pts, Qts, Gals)*	35-36
	ACTION TAKEN	
	DISCREPANT ITEM	
	HOW MALFUNCTIONED	
	HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW	
	HOW TAKEN ☐ DRAIN ☐ TUBE / SAMPLE TEMPERATURE ☐ HOT ☐ COLD / TYPE OIL	37-38
	REMARKS	

FOR LABORATORY USE ONLY

SAMPLE RESPONSE TIME						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
LAB RECOMMENDATION						77-78
SAMPLE NO.		SIGNATURE			FILE MAINT 79	DATA SEQ 80

DD FORM NOV 77 2026 PREVIOUS EDITION WILL BE USED.

Figure 262-4-1 (Sheet 1). Oil Analysis Request, DD 2026 (Sheet 1 of 2)

TRANSIT AIRCRAFT OIL ANALYSIS RECORD

ASSIGNED OIL ANALYSIS LABORATORY	LABORATORY TELEPHONE NO. *(Autovon):* *(Commercial):*	END ITEM MODEL AND SERIAL NO. / EQUIPMENT MODEL AND SERIAL NO.

LAB CODE	DATE	TOTAL TIME SINCE: OVERHAUL	TOTAL TIME SINCE: OIL CHG	FE	AG	AL	CR	CU	MG	NI	PB	SI	SN	TI	MO	LAB REC

DATE DEPARTED *(Return this form with aircraft)*

REMARKS

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981 — 340-979:529

Figure 262-4-1 (Sheet 2). Oil Analysis Request, DD 2026 (Sheet 2 of 2)

Table 262-4-2. LIST OF CERTIFIED NOAP LABORATORIES CAPABLE OF PHYSICAL/SPECTROGRAPHIC TESTING

Table 262-4-2. LIST OF CERTIFIED NOAP LABORATORIES CAPABLE OF PHYSICAL/ SPECTROGRAPHIC TESTING - Continued

LABNAME	ADDRESSEE	LOCATION	ADDRESS1	ADDRESS2	CITY	STATE	ZIPCODE
ATSUGI AIMD NOAP LAB	COMMANDING OFFICER	ATTN: AIMD OFFICER	PSC 477 BOX 25	NAF ATSUGI JAPAN	FPO AP		96306-1225
MAYPORT NAVAL STATION	COMMANDING OFFICER	ATTN: NOAP LAB	SHORE INTERMEDIATE MAINT ACT	MAYPORT NAVAL STATION BOX 228	MAYPORT	FL	32228
SIMA SAN DIEGO	COMMANDING OFFICER	ATTN: NOAP LAB	SHORE INTERMEDIATE MAINT ACT CODE 2400	BOX 106 BUILDING 130	SAN DIEGO	CA	92136
NAVSHIPYD PEARL HARBOR	COMMANDER CODE 134 5	ATTN: CODE 13545 NOAP LAB	PEARL HARBOR NAVAL SHIPYARD	667 SAFEGUARD ST STE 100	PEARL HARBOR	HI	96860-5033
NAVSTA ROOSEVELT ROADS	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	PASC 1008 BOX 3025	BLDG 379	FPO	AA	34051-3025
NAS SIGONELLA	COMMANDING OFFICER	ATTN: NOAP LAB	US NAS SIGONELLA	PSC 812BOX 3130	FPO	AE	09627-3130
MID-ATLANTIC REGIONAL MTLS LAB	COMMANDING OFFICER	MARCC JOAP LAB RM 261	9439 FOURTH AVE	NORFOLK NAVAL STATION	NORFOLK	VA	23511-2116
USS ABRAHAM LINCOLN	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS ABRAHAM LINCOLN CVN 72		FPO	AP	96612-2872
USS CARL VINSON	COMMANDING OFFICER	ATTN: AIMD NOAP LAB IM 2	USS CARL VINSON CVN 70		FPO	AP	96629-2840
USS CONSTELLATION	COMMANDING OFFICER	ATTN: AIMD NOAP LAB IM 2	USS CONSTELLATION CV 64		FPO	AP	96635-5780
USS DWIGHT D EISENHOWER	COMMANDING OFFICER	ATTN: AIMD SOAP LAB IM 2	USS DWIGHT D EISENHOWER CVN 69		FPO	AP	09532-2830
USS ENTERPRISE	COMMANDING OFFICER	AIMD NOAP LAB IM 2 BOX 53	USS ENTERPRISE CVN 65		FPO	AE	09543-2810
USS ESSEX	COMMANDING OFFICER	AIMD IM2 WC 470	USS ESSEX LHD 2		FPO	AP	96643-1661

Table 262-4-2. LIST OF CERTIFIED NOAP LABORATORIES CAPABLE OF PHYSICAL/ SPECTROGRAPHIC TESTING - Continued

LABNAME	ADDRESSEE	LOCATION	ADDRESS1	ADDRESS2	CITY	STATE	ZIPCODE
USS GEORGE WASHINGTON	COMMANDING OFFICER	BOX 63 AIMD NOAP LAB IM 2	USS GEORGE WASHINGTON CVN 73		FPO	AE	09550-2873
USS BOXER	COMMANDING OFFICER	AIMD JOAP LAB	USS BOXER		FPO	AP	96661-1663
USS INCHON	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS INCHON MCS 12		FPO	AA	34091-1655
USS JOHN C. STENNIS	COMMANDING OFFICER	AIMD NOAP LAB BOX 63	USS JOHN C STENNIS CVN 74		FPO	AP	96615-2874
USS JOHN F. KENNEDY	COMMANDING OFFICER	ATTN: AIMD NOAP LAP	USS JOHN F KENNEDY CV 67		FPO	AA	34095-2800
USS KEARSARGE	COMMANDING OFFICER	ATTN AIMD NOAP LAB	USS KEARSARGE LHD 3		FPO	AE	09534-1666
USS KITTY HAWK	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS KITTY HAWK CV 63		FPO	AP	96634-2770
USS NASSAU	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS NASSAU LHA 4		FPO	AE	09557-1615
USS NIMITZ	COMMANDING OFFICER	ATTN: AIMD NOAP LAB WC 470	USS NIMITZ CVN 68		FPO	AP	96697-2820
USS THEODORE ROOSEVELT	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS T ROOSEVELT CVN 71		FPO	AE	09599-2871
USS WASP	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS WASP LHD 1		FPO	AE	09556-1660
USS IWO JIMA	COMMANDING OFFICER	ATTN: AIMD NOAP LAB	USS IWO JIMA LHD 7		FPO	AE	

Table 262-4-3. LIST OF REQUIRED NOAP SAMPLING SUPPLIES

SAMPLING SUPPLIES	QTY ISSUED	NSN
Sampling Kit, Oil	1 Sampling Kit (contains 72, 8 ounce plastic bottles, 72 plastic bags, 72 shipping bags, DD-2026 forms and labels)	4940-01-525-7698
Form DD-2026	Form can be downloaded from this web site: http://www.dtic.mil/whs/directives/infomgt/forms/ddforms2000-2499.htm	

262-4.1.9 SPECIAL PRECAUTIONS. To ensure the integrity of the sample, the following guidelines shall be followed:

1. Store unused sampling materials in clean, closed containers such as the packaging boxes in which received.
2. If a sampling tube is used, avoid contact of the tube with the outside of the equipment being sampled or other surfaces which may contaminate it. Use a sampling tube one time only and discard after taking the sample.
3. Open the sample bottle only when ready to take the sample and replace the bottle cap immediately after drawing the sample.
4. In cases where samples are drawn through a sampling valve or from the bottom of the tank, sump, or case, open the drain valve and allow at least a volume of oil equal to the sample to be obtained to drain out to flush any accumulated water/sediment from the sampling port.
5. Exercise care during sampling to avoid dropping sampling material into the system, and avoid contact with hot system fluid.
6. Ensure that the sample bottle is completely filled with oil so that sufficient sample is provided for analysis.

262-4.1.10 COMPLETING FORM DD-2026. Proper completion of the Oil Analysis Request Form DD-2026 is a vital part of the NOAP evaluation/recommendation process. Completion guidelines are as follow:

1. To: Fill in address of supporting NOAP lab.
2. From: Fill in complete mailing address of customer.
3. Equipment Model/Application: Enter type, model, and series of equipment being sampled, e.g., LM-2500, main gearbox, etc.
4. Equipment Serial Number: Enter complete serial number of equipment being sampled.
5. End Item/EIC: Enter equipment identification code.
6. Date Sample Taken: Enter numeric day/month/year, for example 06/12/85 for 6 Dec 85.
7. Local Time Taken: Enter local time taken using 24-hour clock, e.g., 0700, 1600, etc.
8. Hours/Miles Since Overhaul: Enter the total hours/miles since overhaul to the nearest whole hour/mile.
9. Oil Added Since Last Sample: Enter the quantity of oil, including units (e.g., gals, qts) added since the last sample to the nearest whole number.
10. How Taken: Leave blank unless directed otherwise.
11. Sample Temperature: Leave blank unless directed otherwise.
12. Type Oil: Enter the milspec/oil type.

13. Remarks: Use as applicable.

262-4.1.10.1 Attach the completed DD-2026 form to the sample bottle and insert both in the padded mailing envelope. If a sample is a special request, it must be marked in red, both on the DD-2026 form and on the outside of the mailing container, to alert the lab to the need for immediate processing.

SECTION 5

LUBRICATING OIL SHIPBOARD TESTING AND USE LIMITS

262-5.1 INTRODUCTION

262-5.1.1 GENERAL.

NOTE

Lineshaft bearings utilizing MIL-PRF-17331 (2190TEP) oil shall be sampled and tested in conformance to that required by equipment without online purification capabilities.

This section provides information regarding the shipboard evaluation of lube oils. The qualitative and quantitative methods available to assess lube oil contamination on board ship are discussed in the following paragraphs, as are applicable shipboard lube oil log forms. Recommended onboard stock for lube oil testing is provided in Table 262-5-1.

Table 262-5-1. SUPPLIES NEEDED FOR 6-MONTH DEPLOYMENT

Item	NSN	Unit	Qty	Note
Centrifuge, B S & W	6640-01-119-7870	EA	1	
Centrifuge Tube, 100 ml	6640-00-290-4428	EA	10	
Solvent, PD-680 Type II	6850-00-274-5421	5 gal	3	Note 1
Test Tube Rack	6640-00-159-2506	EA	1	
Goggles, Safety	4240-00-190-6432	EA	2	
Bottle, Wash, 500 ml	6640-00-314-2097	EA	2	
Apron, Laboratory	8415-00-634-5023	EA	2	
Bottle, Sq. Glass	8125-00-543-7699	EA	20	
Thermometer, Dial	6685-00-663-8093	EA	2	
Test Kit, Diesel	6630-01-096-4792	EA	2	Note 2
Methanol				Note 3
Sampling Kit, NOAP	4920-01-003-0804	72/Box	2 Boxes	
Bottle, NOAP Sample	8125-01-082-9697	120/Box	1 Box	
Shipping Bag, NOAP	8105-00-290-0340	250/Box	1 Box	

NOTES:
1. BIOTEK HISOLV (NSN 6850-01-277-0595) may be substituted for PD-680 Type II solvent.
2. Required only for ships with diesel engines on board.
3. Required only for ships with gas turbine engines on board

NOTE

Lineshaft bearings utilizing MIL-L-17331 (2190TEP) oil shall be sampled and tested in conformance to that required by equipment without online purification capabilities. For lineshaft bearings utilizing MIL-L-9000 (9250) oil, refer to paragraph 262-5.3.5 for testing requirements.

262-5.1.2 CLEAR AND BRIGHT TEST. The degree of water and particulate contamination in MIL-L-17331 (MS 2190TEP) lube oil samples may be quickly assessed by the Clear and Bright test. Clear refers to the absence of visible particulate matter. Bright refers to the absence of free water, moisture or other factors that affect the color and clarity of the lube oil sample. For example, MIL-L-17331 (MS 2190TEP) oil that is free of water contamination appears bright, with no discernable haziness or cloudiness. As the amount of water contamination increases, the sample gradually assumes a hazy or cloudy appearance due to the suspension of tiny water droplets throughout the oil. When the level of water contamination reaches a point where the oil cannot dissolve any additional droplets, the excess water falls to the bottom of the sample and becomes visible as droplets or a layer of free water.

262-5.1.2.1 When performing the Clear and Bright test, the following procedure shall be followed:

WARNING

Proper safety procedures must be followed at all times. Wear proper eye protection throughout sampling and testing procedure. When there is a possibility of a splash hazard; i.e. during oil transfer or other times when the sample bottle is uncapped. Proper eye protection shall consist of a face shield and/or goggles. Gloves shall be worn to minimize hand contact with the oil. Disposable gloves are acceptable.Be familiar with all pertinent Material Safety Data Sheets (MSDS's) before performing analysis. Wash skin thoroughly after contacting lube oil or chemicals.

NOTE

If the paper gasket inside the cap of the square glass bottle is missing, seal the cap by placing a piece of thin plastic film (such as cellophane) between the bottle and the cap, to prevent oil from leaking while inverting the bottle.

1. Determine whether or not the equipment from which the sample was taken has an online purification capability.
2. Obtain a clean, dry square glass bottle (NSN 8125-00-543-7699) and draw a representative sample for inspection. The sampling connection shall be flushed free of any stagnant oil by allowing an amount of oil equivalent to the sample connection volume to drain into a clean container before filling the sample bottle. All condensate in the sump shall be drained off prior to obtaining the sample. Waste oil shall be placed in the settling tank for renovation.

NOTE

MIL-L17331 (2190)/MIL-H-17672 (2135) sampling shall be as follows:

a. Within 24 hours prior to start

b. Daily while operating (includes machinery in autostart configuration).

c. Upon receipt of oil.

d. Within a 24 hour period prior to each transfer.

e. When unusual operating conditions exist.

f. After an equipment casualty.

g. Test purifier discharge 30 minutes after starting, and at least once every four hours.

h. Equipment with sump capacities of 1 gallon or less shall not be sampled.

3. Assess the appearance of the sample by holding it in front of a strong light source. If the sample is too dark to easily determine the cloudiness or haziness, use a standard Navy 2D cell flashlight, or equivalent, placed directly against the sample bottle as the light source. Inspect the sample for the bright criterion by looking for any free water, haziness, or cloudiness in the oil. If free water is present, it will be readily apparent as bubbles or a layer on the bottom of the sample bottle. If free water is present, and the sample came from equipment without an online purification capability, perform the Bottom Sediment and Water (B.S.& W.) test in accordance with paragraph 262-5.1.3.3.

4. If the oil appears hazy or cloudy, the temperature of the sample shall be checked with a dial thermometer (NSN 6685-00-663-8093). If the sample is at operating temperature 53 ± 4°C (120 ± 5°F) and the sample appears hazy, dissolved air or water may be present; allow the sample to settle at room temperature for 30 minutes. If dissolved air is present, the sample will clear from the bottom to the top. If dissolved water is present, the sample will remain cloudy, or will begin to clear from the top to bottom. If the sample continues to appear hazy or cloudy after the 30 minute settle time, the oil fails the bright criterion. If the sample came from equipment without online purification capability, conduct the transparency test in accordance with paragraph 262-5.1.3.1.

5. If the sample is not at operating temperature, the sample shall be heated to 49 ± 3°C (120 ± 5°F) in a warm water bath. If the sample appears hazy after being heated to 49 ± 3°C (120 ± 5°F) and came from equipment without online purification capability, conduct the transparency test in accordance with paragraph 262-5.1.3.1. If the sample appears bright after the 30 minute settle time or while being heated to 49 ± 3°C (120 ± 5°F), the oil meets the bright criterion.

6. Inspect the sample for sediment by inverting the bottle and looking for visible particles. Particles found on the bottom of the sample bottle will become apparent as they fall through the liquid. If the sample is too dark to easily see particulates, let the sample sit for 10 minutes. Then invert the sample down at a 45 degree angle and observe the bottom of the sample bottle. If no visible particles are observed, the sample meets the clear criterion. If the equipment from which the sample was taken does not have an online purification capability, and visible particles are observed in the sample, perform the visible sediment test in accordance with paragraph 262-5.1.3.2.

7. If the sample meets the clear and bright test criteria it is satisfactory for use.

8. Oil samples taken from equipment with an online purification capability must pass the clear and bright test criteria to be satisfactory for use.

9. Satisfactory oil shall be returned to the equipment from which it was drawn.

262-5.1.3 TRANSPARENCY, VISIBLE SEDIMENT, AND BOTTOM SEDIMENT AND WATER (B S & W) TESTS. The Transparency, Visible Sediment, and B S & W tests may be used to assess water and particle contamination in samples which fail the Clear and Bright test.

262-5.1.3.1 Transparency Test. To perform the transparency test, hold a PMS card (or other card with standard size print) behind the sample. If the printed words can be read through the sample, the oil passes the Transparency test and must be checked for the clear criteria in accordance with paragraph 262-5.1.2.1.6. If the card cannot be read through the sample, the oil fails the Transparency test. Perform the B S & W test in accordance with paragraph 262-5.1.3.3.

262-5.1.3.2 Visible Sediment Test. This test allows a qualitative assessment of the level of particulate contamination present in a sample, and provides a means of screening lube oil samples prior to conducting the B S & W test. To perform the test, the following procedure shall be used:

1. If visible sediment is noted, let the sample bottle stand for 10 minutes or until all of the sediment has settled to the bottom. Gently lay the sample bottle on its side for 10 minutes or until all visible sediment has accumulated along the intersection of the side (on which the bottle is laying) and the normal bottom of the bottle.
2. If a solid, unbroken line of sediment is observed along this intersection, or if individual particles greater than 1/8 inch along the largest axis are observed, a B S & W test shall be performed in accordance with paragraph 262-5.1.3.3. If a broken line of individual particles is observed, none of which is greater than 1/8 inch along the largest axis, the sample passes the visible sediment test and is satisfactory for use in equipment without online purification capability.

262-5.1.3.3 Bottom Sediment & Water Test. The equipment required to perform the B S & W test is listed in Table 262-5-1. To perform the test, the following procedure shall be used:

WARNING

Proper safety procedures must be followed at all times. Wear eye protection and read all Material Safety Data Sheets (MSDS's) before performing analysis. Wash all skin thoroughly after contacting lube oil and chemicals.

1. Obtain two clean, dry centrifuge tubes and fill each with 50 ml of well-shaken sample.
2. Set the tubes in the test tube rack and fill each tube to the 100 ml mark with solvent. Tightly cork each tube and shake for 30 seconds to ensure adequate mixing of the oil and solvent. The cork shall be covered with a thin plastic film (such as cellophane) so that it can be reused.

NOTE

PD-680 Type III/BIOTEK Hi-Solv may be used for this test.

3. Place the centrifuge tubes securely on opposite sides in the centrifuge and whirl at 1500 rpm for 30 minutes.
4. Remove the tubes and obtain the percent B.S. & W. by adding the readings of the two tubes.

5. At the end of the test, dispose of oily waste in the contaminated oily waste holding tank.

6. Clean the centrifuge tubes with solvent.

262-5.1.4 Flashpoint. If required by PMS or other directives, 2190 oil can be checked for possible degradation due to severe overheating by determining flashpoint using the NAVIFLASH flashpoint tester or other closed cup flash point tester.

252-5.1.4.1 To determine a flash point on 2190 oil using the NAVIFLASH, ships shall modify their NAVIFLASH unit to perform single point flash points using the following instructions:

A. Verify that the NAVIFLASH has a current calibration as per NAVIFLASH Operating Manual. If not, perform calibration.

B. Inspect arc electrodes and temperature probes and ensure they are clean. If not, swab with cotton tipped stick or burnish with glass fiber brush supplied with testor, as required.

C. With the NAVIFLASH off, switch unit from NAVIFLASH configuration to MINIFLASH configuration by depressing the ‘stop’ and ‘->’ (right arrow) keys while turning on the tester. The display will now read ‘cca-flph ver. X.XXN’.

D. With cursor on ’measure’ field, press ’task’ key.

E. Use the up/down arrow keys to scroll to program 8.

F. Use the right/left arrow keys to move the cursor to the ’ti’ (temperature, initial) field and enter “400”. Move the cursor to the ’tf’ (temperature, final) field and enter “400”. The NAVIFLASH is now ready to perform a single go/no-go flashpoint test at 400°F.

G. Obtain sample from circulating system. Keep sample tightly closed prior to analysis, Shake sample just prior to analysis to ensure homogeneity. Smell the oil to check for any volatile burnt type or gasoline type odor. Note any abnormal odor in log.

H. Fill sample cup to line, place in sample chamber and close sample chamber door. Press ’run’ key. Oven and sample temperatures will now be heated to 400°F. When prompted, press ’run’ key a second time. NAVI-FLASH will now perform a single go/no go test for flashpoint at 400°F.

I. Record result as either ’no flash’ or ‘flash at 400°F (Single Point)’. Press ’stop’ key and remove sample cup. Press ’stop’ key to return to test screen. Allow sample cup to cool prior to running next sample.

J. Run a second flash point test on a second sample from the same bottle. Results should be within 5 degrees F. If not, re-run until results are within requirements.

K. If the sample flashes at 400°F, change the flash point ‘ti’ and ‘tf’ to 370°F and re-run with a fresh sample. Record result as either ’no flash’ or ‘flash at 370°F (Single Point)’.

L. If sample flashes at either temperature or has a burnt smell, notify NSWCCD, TYCOM, CLASSRON and Chain of Command and send samples (8 oz) to NSWCCD. If the sample flashes at 400 deg F but not at 370 deg F, there is might be some minor oil degradation present. If sample flashes at 370°F, oil degradation is more probable and use of the affected equipment shall be discontinued. Contact TYCOM/NSWCCD equipment ISEA immediately for further guidance.

M. To return unit to NAVIFLASH configuration, move cursor to left arrow field and press ’task’ key. Move cursor to ’setup’ field and press ’task’ key. Move cursor to ‘lock’ field, and press ’task’ key twice. Display will now read NAVIFLASH tester.

262-5.2 MIL-L-17331 (MS 2190TEP) USE LIMITS.

262-5.2.1 INTRODUCTION. The degree of allowable contamination in lube oil systems using MIL-L-17331 (MS 2190TEP) oil is dependent on the purification capability of the system.

262-5.2.1.1 For systems with online purification capability, the oil must meet the requirements of Clear and Bright. If the lube oil fails the Clear and Bright criteria, the machinery may be operated for a period of 48 hours while investigating for the cause of contamination, provided the oil can be purified while the machinery is in operation. If the source of contamination cannot be identified within this timeframe, continued operation shall require authorization from the Commanding Officer. Once all sources of contamination are identified and corrected, the system lube oil volume shall be continuously recirculated sump-to-sump through the centrifugal purifier three times. The purifier may be stopped for routine cleaning during the time it takes to recirculate the oil volume the equivalent of three passes through the purifier. If the oil fails the Clear and Bright criteria after passing through the purifier the equivalent of three times, a stable oil/water emulsion may exist. The centrifugal purifier will not break this emulsion, and the oil must be replaced. The procedure is outlined in Figure 262-5-1.

262-5.2.1.2 For systems without online purification capability, higher levels of contamination are permissible. These systems shall be tested as specified in Figure 262-5-2.

NOTE

Oil samples from systems without online purification capability shall be considered satisfactory until the use limits of the bottom sediment and water (B S & W) test have been exceeded. Only those samples failing the B S & W test shall be recorded as unsatisfactory.

262-5.2.1.3 A rapid change in the color of MIL-L-17331 (MS 2190) oil may also be significant. For example, overheated lube oil will quickly darken due to oxidation. Lube oil may assume a greenish cast when contaminated by copper or tin. A dark red coloration may be indicative of finely divided rust particles. Any sudden change in lube oil color shall be reported immediately to the Engineering Officer, and determination made as to cause and corrective action. A greenish or greenish-black cast to the oil may also occur due to some minor color-changing reactions that are not fully understood, but that do not effect the quality of the oil. If abnormal metallic contamination is determined not to be present, by NOAP analysis , the color of the oil is not, by itself, a reason to change the oil. Use limits as specified in 262-5.2.1.1 and 262-5.2.1.2 shall be followed.

262-5.2.1.4 Condemned oil shall be disposed of in accordance with **NSTM Chapter 593, Pollution Control** .

262-5.3 SHIPBOARD TESTING OF MIL-L-9000 (MS 9250) LUBE OIL

262-5.3.1 GENERAL. The Clear and Bright test is ineffective for darkly colored oils such as those used in internal combustion engines. Accordingly, shipboard testing of these oils focuses on physical property parameters such as changes in viscosity or acidity. Testing can be accomplished using the shipboard diesel engine lubricating oil test kit (262-5.3.2), the NSWCCD diesel meters (262-5.3.6) or the Kittiwake Oil Test Center (OTC) (262-5.3.8).

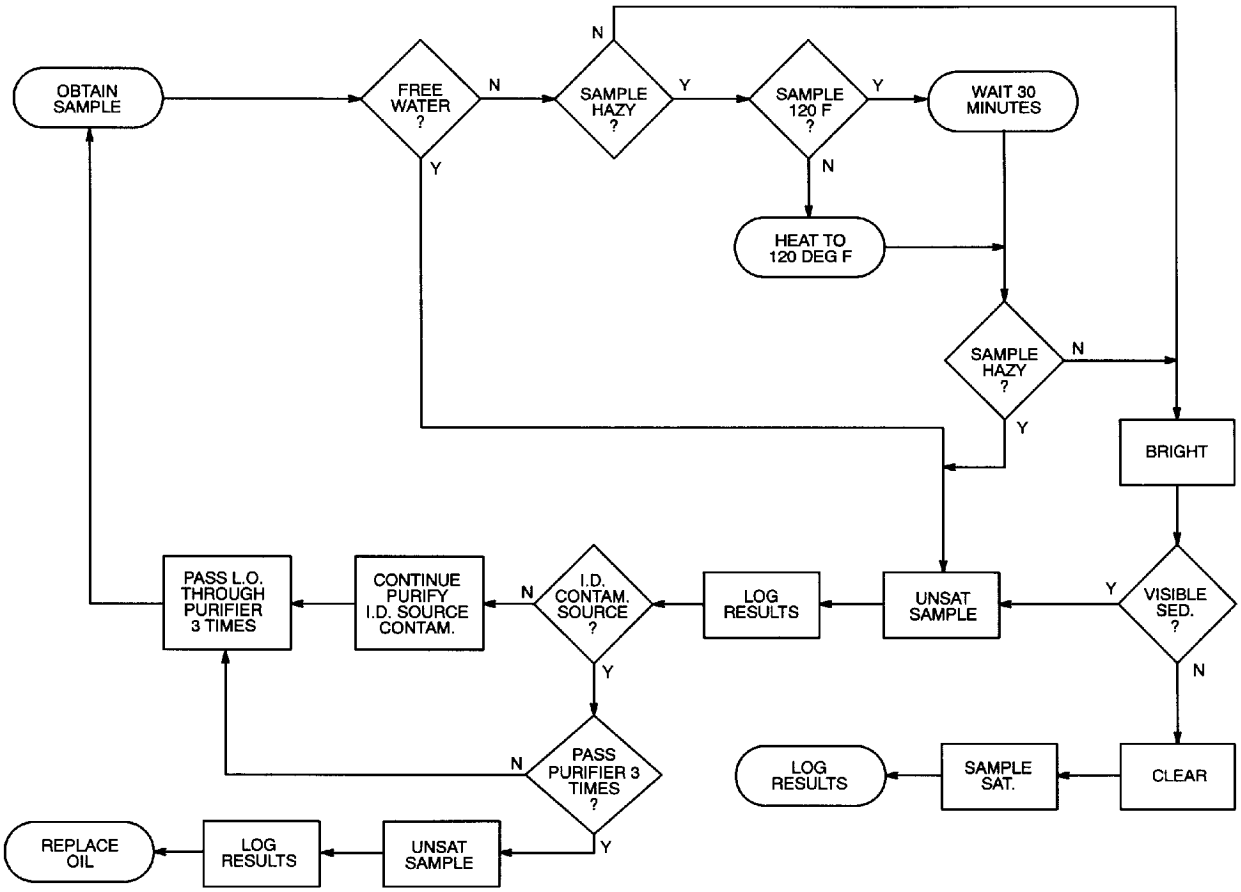

Figure 262-5-1. Flowchart for Systems with Online Purification Capability

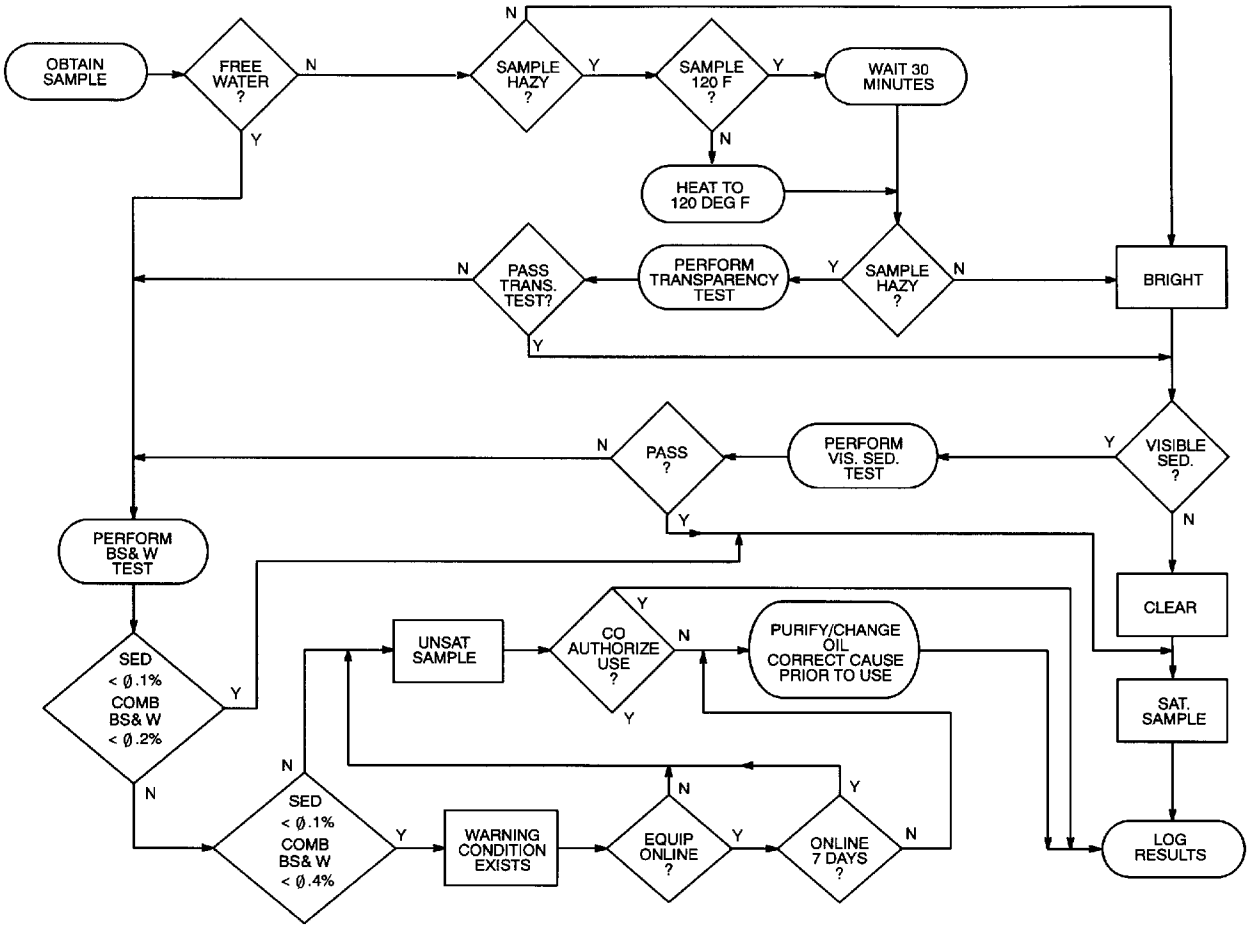

Figure 262-5-2. Flowchart for Systems Without Online Purification Capability

262-5.3.2 Diesel Engine Oil Testing Using SHIPBOARD DIESEL ENGINE LUBE OIL TEST KIT.

262-5.3.2.1 VISCOSITY TESTING. The viscosity of MIL-L-9000 (MS 9250) oil may increase due to the suspension of carbonaceous material (soot) in the oil. Conversely, the viscosity of the oil may decrease due to fuel dilution from jumper line leaks or faulty injection equipment. To assess whether or not a change in viscosity has occurred, use the following procedure with the Shipboard Diesel Engine Lubricating Oil Test Kit (NSN 6630-01-096-4792). (A complete list of parts required for shipboard diesel oil testing is provided in Table 262-5-2.)

NOTE

Diesel engine oil sampling be as follow:

a. Daily while operating for viscosity testing

b. Every 500 ± 50 operating hours for acidity/TBN test unless otherwise directed by PMS or other guidance.

c. For low and medium speed (<1500 rpm) engines, every 400 ± 50 operating hours for acidity/TBN test.

d. For MRG systems, within 24 hours prior to lightoff and daily when operating.

e. After an equipment casualty.

f. When unusual operating conditions exist.

Table 262-5-2. LUBRICATING OIL TEST KIT

QTY	SERVICE PART NUMBER	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

WARNING

Proper safety procedures must be followed at all times. Wear eye protection and be familiar with all pertinent Material Safety Data Sheets (MSDS’s) before performing analysis.

NOTE

Lube oil sample may be drawn from the prelube sample connection, if applicable, and if the prelube sample pump is not a common pump used for multiple engines.

1. Engines fitted with lube oil sampling connections shall be sampled through those connections while the engine is running. The sampling port shall be flushed free of any stagnant oil by allowing at least an amount of oil equivalent to the sample volume to drain into a waste container before drawing the sample. Procedures for sampling engines without such connections shall be as follows:

a. Secure diesel engine. Remove sample container and sampling pump from test kit. Place clean sample container on the sampling pump.

b. Remove the diesel engine sump dipstick and insert the suction pump sampling tube into the dipstick sump approximately one inch further than the dipstick insertion.

c. Place waste container under the sampling pump and draw approximately one pint of oil into the container to flush the dipstick tube. Discard, and place a clean sample container under the sampling pump.

d. Draw the sample into the sample container, remove the sampling tube, and replace the dipstick.

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

2. Obtain a 4 ounce sample of unused oil identical to the oil originally introduced into the engine sump.

3. Remove the drop ball comparator from the storage case and set up on a flat work area.

NOTE

Ensure comparator is firmly supported at an angle from the vertical position.

4. Using the thermometer provided with the kit, measure the temperature of the new and used oil samples to ensure that the difference is not greater than 1°F. If greater than 1°F, allow the sample temperatures to match.

5. Fill tube A of the comparator with the new oil sample. Fill tubes 1 and 2 with used oil samples and place the tubes in the comparator.

NOTE

Samples from two different engines may be placed in tubes 1 and 2 at the same time. Test only one used sample at a time.

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

7. Run rods A and 1 up and down at least twice. Set markers of rods A and 1 at the start line. Place rod number 2 in the down position.

8. Push in the reset button. Start rods A and 1 by pushing and holding the release button.

9. Stop the test when one of the rod markers reaches 100 on the scale.

10. Repeat the procedure for rod number 2, with rod number 1 in the down position. When complete, wipe rods, balls, and drain tubes thoroughly between tests, and properly stow upon completion of testing.

11. Use the following scale to determine the percent increase or decrease in viscosity of the used samples:

ROD A Reading*	Fuel Dilution
90 percent	1 percent
75 percent	3 percent
65 percent	5 percent

12. Compare with the use limits specified in paragraph 262-5.3.3, and take required action.

262-5.3.2.2 ACIDITY TESTING. The acidity of diesel engine oil may increase with use due to the addition of combustion byproducts containing sulfur and nitrogen. To test for acidity in MIL-L-9000 (MS 9250) oil, the following procedure shall be used:

CAUTION

Safety precautions for the use of the solvents and other chemicals specified in the diesel engine test procedures shall be in accordance with Navy Safety Precautions for Forces Afloat, OPNAVINST 5100 Series, and applicable Material Safety Data Sheets (MSDS's).

NOTE

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

1. Prepare reaction indicator solution by the following procedure:
   a Fill vial to level 3 with reaction indicator concentrate and add to empty reaction indicator bottle.
   b Add distilled water to bring level to the 180 ml mark. The solution will be blue.
   c Add weak acid, drop by drop, from the reaction indicator bottle until the solution matches the green color on the reaction indicator card.
2. To test the sample for acidity, the following procedure shall be followed:
   a Remove the reaction vial from the kit and fill to the first line with reaction indicator.
   b Add the oil sample to bring the total volume up to the second line.
   c Screw on the vial cap and shake vigorously for 30 seconds. Allow the vial to stand for 10 minutes.
   d Compare the color of the lower liquid level with the reaction indicator card. A blue color indicates a satisfactory acidity level in the oil. A yellow or green color indicates an unsatisfactory level of acidity in the oil.
   e Empty the reaction mixture into the waste oil container and clean the vial by wiping with a clean cloth.

262-5.3.3 MIL-L-9000 (MS 9250) USE LIMITS IN INTERNAL COMBUSTION ENGINES. The following criteria shall be used when evaluating the results obtained from the shipboard diesel oil test kit:

WARNING

The lube oil shall be changed when fuel dilution is 5.0 percent or greater. Fuel dilution greater than 5.0 percent is cause for serious concern about the fitness of the engine. The proper analysis of test results depends upon the size and design of the engine from which a sample has been taken. The normal range of the fuel dilution is from less than 0.5 to 2.0 percent. Fuel dilution in the range of 2.0 to 5.0 percent indicates a leak or faulty injection equipment that requires immediate correction.

TESTS PERFORMED	USE LIMITS*
Viscosity	40 percent increase from new oil or 5 percent fuel dilution
Acidity	Blue: PassYellow or Green: Fail.

TESTS PERFORMED	USE LIMITS*
*Oil which exceeds the use limits for viscosity or fails the acidity test shall be drained, and the system recharged with new oil.	

262-5.3.4 MIL-L-9000 OIL DRAIN PERIODS. If no analytical data or PMS requirement is specified, the oil drain periods shall be:

a. For large, low, and medium speed engines: after 750 hours of operation.

b. For small high speed diesel engines: after 100 hours of operation.

262-5.3.5 SHIPBOARD TESTING OF MIL-PRF-9000 (MS 9250) OIL OR OTHER DIESEL ENGINE OIL, USED IN MAIN REDUCTION GEARS AND LINE SHAFT BEARINGS. Main Reduction Gears and Line Shaft Bearings utilizing diesel engine oil shall be sampled using a standard 8 oz. square glass bottle (NSN 8125-00-543-7699) 24 hours prior to light off, and every 24 hours when operating. After obtaining the sample, the oil shall be tested in accordance with the procedure in paragraph 262-5.3.5.1 for Main Reduction Gears and paragraph 262-5.3.5.2 for Line Shaft Bearings.

Systems utilizing MIL-L-9000 (MS 9250) oil shall be sampled using a standard 8 oz. square glass bottle (NSN 8125-00-543-7699) 24 hours prior to light off, and every 24 hours when operating. After obtaining the sample, the oil shall be tested in accordance with the procedure in paragraph 262-5.3.5.1:

262-5.3.5.1 Main reduction gears have a purified sump and shall meet the clear and bright requirement.

1. To assess the oil, let the sample stand for 30 minutes to allow any entrained air to escape.
2. At the end of 30 minutes, hold the bottle up to a strong light source, and tilt the sample approximately 45°. If a stronger light source is required, a standard Navy 2D cell flashlight or equivalent can be used. See paragraph 262-5.1.2.1.3.
3. If the sample appears gray in color indicating emulsified water, or if visible free water or particles are observed on the bottom of the bottle, the sample is unsatisfactory.
4. If unsatisfactory, the source of the contamination shall be identified and corrected as appropriate.
5. If water contamination is noted, the system shall be inspected for leaks and the source of contamination corrected.
6. The oil shall be purified continuously until the equivalent of 3 times the sump volume has passed through the purifier.
7. A sample shall be taken and tested at the end of the purification period.
8. If the sample remains unsatisfactory, continue to troubleshoot the system. The MRG may be operated while investigating the cause of contamination as long as continuous purification is taking place.

262-5.3.5.2 Line shaft bearings are non-purified systems and as such, shall meet the transparency and visible sediment requirements as detailed in paragraph 262-5.1.3 for non-purified MIL-PRF-17331 sumps. Diesel engine oils do not lend themselves to bottom sediment and water (B S & W;) tests due to the dark color and the amount of additives included in the formulation which can cause the oil to hold water.

1. If oil is found unsatisfactory, the source of contamination shall be identified and corrected, and the oil shall be changed.
2. If a stronger light source is required, a standard Navy 2D cell flashlight or equivalent can be used. See paragraph 262-5.1.2.1.3.

262-5.3.6 DIESEL ENGINE OIL TESTING USING NSWCCD VISCOSITY METER, NSWCCD FUEL DILUTION METER, AND NSWCCD TOTAL BASE NUMBER METER. The following condensed operating instructions are provided for quick reference. For detailed procedures, consult the owner's manual provided with the respective meter.

1. NSWCCD Viscosity Meter.
   a SET UP. To set up, plug meter into a 120 VAC outlet, and attach drain tubing to the sensor chamber outlet. Place a collection vessel at the tip of the drain tubing to receive the waste oil.
   b CALIBRATION. Calibrate meter as follows:
      (1) Turn meter on and allow to perform self-diagnostic tests.
      (2) Select ″Calibrate″ from meter screen.
      (3) Use 5 cc pipet provided to add calibration oil to sensor chamber.
      (4) Follow screen instructions.
      (5) If successful, proceed to sample measurement. If unsuccessful, secure meter, reactivate, and repeat procedure.
   c SAMPLE TEST PROCEDURE. After calibration proceed as follows:
      (1) Select ″Measure″ from screen menu.
      (2) Follow screen prompts.
      (3) Use provided 5 cc pipet to add sample to sensor chamber. Sensor will heat oil to 40°C (104°F).
      (4) Follow screen prompts.
      (5) If successful, viscosity result will be displayed in centistokes. If unsuccessful, secure meter, reactivate, and repeat procedure.
   d MAINTENANCE. Observe the following:
      (1) Keep sensor chamber capped at all times.
      (2) Properly dispose of waste oil.
      (3) Wipe off excess oil from meter components.
      (4) Calibrate once weekly while operating.
2. NSWCCD Fuel Dilution Meter (FDM).
   a SET UP. To set up, attach power supply cable to the rear of the FDM. Plug into a 120 VAC outlet, plug the flask cable into the rear of the FDM, and attach sampling tubing to the front of the FDM.
   b CALIBRATION. Prepare two 5 percent fuel dilution standards (one using F-76 in engine oil, and the other JP-5 in engine oil).
      (1) Turn on the FDM power switch, and allow to warm up for 15 minutes.
      (2) Select the desired calibration program from the screen menu.
      (3) Following the screen prompts, connect the cap with tubing to the meter, and fill the sample flask with either the F-76 or JP-5 standard prepared earlier.
      (4) Attach the tubing to the sample flask, and place the flask into the flask holder.

(5) Follow the screen prompts, and read the result. Upon completion of calibration, detach flask from tubing and recap calibration flask with solid cap.

(6) Proceed to sample measurement.

c SAMPLE MEASUREMENT. To analyze a sample for fuel dilution, proceed as follows:

(1) Select the desired fuel dilution program from the screen menu.

(2) Shake the sample for 30 seconds.

(3) Follow the screen prompts.

(4) Fill the measurement flask to the scribed line with sample.

(5) Attach the cap with tubing to the measurement flask, and place the flask in the flask holder.

(6) Follow the screen prompts, and read result in percent fuel in oil.

(7) Return sample to the oil sump.

d MAINTENANCE. Observe the following:

(1) Wipe excess oil off of meter and adjoining areas.

(2) Clean flasks with hot water and detergent as necessary.

(3) Calibrate meter once weekly when operating.

3. NSWCCD Total Base Number (TBN) Meter.

a SET UP. To set up, attach power supply cable and vial shaker power supply cables to the rear of the TBN meter, and plug into a 120 VAC outlet. Set up the dispensers for TBN Calibration Oil and TBN Reagent.

b CALIBRATION. Perform calibration as follows:

(1) Turn on the TBN meter, and allow to warm up. Select ″Cal″ procedure from screen menu.

(2) Enter the TBN value stated on the calibration fluid label.

(3) Add 10 ml of TBN reagent to the reaction vessel.

(4) Add 10 ml of TBN calibration fluid to the reaction vessel and cap.

(5) Fix the reaction vessel to the mixer, and follow the screen prompts.

c SAMPLE MEASUREMENT. To analyze a sample, proceed as follows:

(1) Select the ″Measurement″ program from the screen menu.

(2) Shake sample for 30 seconds.

(3) Add 10 ml of TBN reagent to the reaction vessel.

(4) Add 10 ml of sample to the reaction vessel, and attach cap with tubing.

(5) Fix reaction vessel to mixer, and follow screen prompts.

(6) Dispose of spent solutions via proper waste disposal.

c MAINTENANCE. Observe the following:

(1) Wipe excess oil from meter and adjoining areas.

(2) Calibrate once weekly while operating.

262-5.3.7 USE REQUIREMENTS FOR MIL-L-9000 USING NSWCCD DIESEL METERS. Sampling shall be done as specified in 262-5.3.2.1 Note. Use limits shall be as specified in 262-5.3.3 except viscosity shall be 100 - 225 cSt at 40 deg C and acidity shall be measured by TBN and shall be 2.0 mg KOH/g oil minimum.

262-5.3.8 DIESEL ENGINE TESTING USING THE KITTIWAKE OIL TEST CENTER. The following condensed operating instructions are provided for quick reference. For detailed procedures, consult the owner’s manual and training materials provided with the test kit.

WARNING

Proper safety procedures must be followed at all times. Wear proper eye protection throughout sampling and testing procedure when there is a possibility of a splash hazard; i.e. during oil transfer or other times when the sample bottle is uncapped or reagents are in use. Proper eye protection shall consist of a face shield or goggles. Gloves shall be worn to minimize hand contact with oils and reagents. Disposable gloves are acceptable. Be familiar with all pertinent Material Safety Data Sheets (MSDS's) before performing analysis. Wash skin thoroughly after contacting lube oil or chemicals.

1. Viscosity
   a. Filling the viscometer. Support the viscometer vertically. Open the vent screw and remove the push in end cap. Ensure that the ball is in the tube, then fill the tube with oil to just above the edge of the v-plate. Slowly push in and rotate the end cap until all the air is expelled. Do not use excess force. Retighten the vent screw and clean off excess oil.
   b. Using the viscometer. Place the viscometer with the power/reset button outermost. If oil temperature is much hotter or colder then the viscometer, better accuracy is obtained by taking several readings over a period of 5 minutes. Select mode 1, viscosity. Display will show: tilt. Press the viscometer power/reset button to power the electronics. Tilt the viscometer smoothly. The ball movement will be displayed during operation. When the ball has traveled through the oil sample, the display will show: tilt. Tilt the viscometer over again. When complete, the display will give an average of the two readings in cSt at 40 deg c. To repeat the viscosity measurement, press the viscometer power/reset button and repeat the tilting procedure.

2. Total base number (TBN)
   a. Reference value (new oil). Every time new oil is added to the storage tank, the reference value for the oil shall be determined. Select mode 3 TBN on the Main Control Unit (MCU). Place cell on a level surface and remove the end cap. Shake the bottle of reagent C and attach the pourer spout. Add reagent C to the TBN cell until the level reaches the internal lip inside the cell bowl. Add 10 ml of test oil. Replace end cap and tighten.

WARNING

Reagent C is classified as an irritant. Proper safety procedures must be followed at all times. Wear proper eye protection (face shield or goggles) during testing procedure. Gloves shall be worn to minimize hand contact. Disposable gloves are acceptable. Be familiar with the pertinent Material Safety Data Sheet (MSDS) before performing analysis. Wash skin thoroughly after contacting lube oil or chemicals.

   b. Replace cell on the MCU, allow reading to stabilize then press zero to zero the reading. The display will then start to count 0 - 120 over 2 minutes. Remove the cell from the MCU and shake until the display reaches 120. Note:

NOTE

The test will not work correctly unless the test cell is shaken thoroughly, especially in cold temperatures. .

c. Replace the cell onto the MCU. The display will show the reference value for the new oil. This will then be used as the reference value for testing used samples of the batch of oil. Record this value in your log book for later use.

d. Test value (used oil). Routine test procedure for used oils. Repeat the reference value procedure but with the same quantity of used oil in place of the new oil. The displayed value will then be used as the test value for calculating the used oil depletion.

e. Calculating the used oil TBN. After obtaining the test value from above, press enter. The display will ask for the reference value. Use the up/down/speed keys to display this value. Press enter. The display will ask for the new oil TBN. Use the up/down/speed keys to display this value. For most navy oils, this value is 12. Press enter to display the used oil TBN.

3. Insolubles.

a. Select mode 2 -% insolubles w/w (ip 316).

b. Place the cell onto the MCU. Take the insolubles tube and fill with reagent J to the fill line (10 ml). Gently insert the insolubles tube into the test cell. A short length of tube will protrude from the test cell.

c. Rotate the zero knob on the side of the cell fully anti-clockwise and then slowly clockwise until the reading reaches zero.

d. Shake the oil sample thoroughly. Remove a small volume using a disposable pipette provided. Return one drop to the oil sample. Add the next drop to the test tube. Place the cap on the tube and shake until well mixed. Allow any bubbles to settle.

e. Return the tube to the test cell. Fully insert the tube and record the reading once it has stabilized.

f. The display will read directly in insolubles contamination of the oil sample.

262-5.3.9 USE REQUIREMENTS FOR MIL-L-9000 USING KITTIWAKE OTC. Sampling shall be done as specified in 262-5.3.2.1 **except** acidity shall be measured by TBN and the Insolubles test is an alternative method to determine thickening. Use limits shall be as specified in 262-5.3.3 **except** :

1) Viscosity shall be 100 - 225 cSt at 40 deg C.

2) Acidity as measured by TBN shall be 2.0 mg KOH/g oil minimum.

3) Fuel dilution shall be calculated from any % decrease in the sample viscosity over the base viscosity.

4) Viscosity thickening, when calculated as percent increase in viscosity,shall be as specified in 262-5.3.3 but when using the Kittiwake OTC, shall be measured by the insolubles test and shall be 2.5 percent maximum.

262-5.3.10 STANDARDS. Standards for viscosity and TBN shall be run quarterly to ensure accurate results are being obtained. Standards are obtainable from the stock system. NSN for the viscosity standard is 9G 6850-01-470-1231. NSN for the TBN standard is 9G 6850-01-470-1234. Log sheets shall reflect the results of any standard test run. Results for viscosity shall be considered acceptable if within plus or minus 4 cSt of the reference value. Results for the TBN standard shall be considered acceptable if within 1 TBN of the reference value. A previously analyzed sample may be retained and analyzed periodically to ensure consistency of results.

262-5.4 SHIPBOARD TESTING OF MIL-L-23699 LUBE OIL

262-5.4.1 GENERAL. The configuration of some gas turbine lubrication systems may allow the contamination of the synthetic-based MIL-L-23699 oil with mineral oil (petroleum-based) MIL-L-17331 (MS 2190TEP) oil.

262-5.4.2 PERIODIC INSPECTION. Gas turbine synthetic lube oil shall be sampled as directed by PMS, after an equipment casualty, or when unusual operating conditions exist. Due to the possible dark color of oil, the presence of contaminants or water may be difficult or impossible to assess by visual inspection. Samples shall be sent to NOAP as per PMS.

NOTE

By examining the lube oil and correcting the cause of the contamination, a serious engine failure may be prevented.

262-5.4.3 Mineral Oil Contamination. If mineral oil contamination in the synthetic gas turbine oil is suspected, a serious condition could exist. The absence of mineral oil can be confirmed by the test below. However, this test is subject to possible 'false positives' due to the presence of certain formulations of MIL-PRF-23699 (HTS) so if a positive indication for mineral oil is determined, send confirmatory samples to NSWCCD Lubricating Oil ISEA prior to condemning the oil.

262-5.4.3.1 The presence of mineral oil contamination in the synthetic gas turbine oil may be detected by the following test:

1. Hold the oil sample near a strong light source and visually assess the appearance. The sample should appear free of visible particles and cloudiness.
2. Mark an 8 ounce square glass bottle (NSN 8125-00-543-7699) by permanently etching a line at the 2 ounce and 8 ounce level.
3. Fill the prepared sample bottle to the 2 ounce line with the oil sample to be tested.
4. Add absolute methanol to the 8 ounce mark, securely close the bottle, and shake vigorously for 10 seconds.
5. Hold the bottle up to a strong light source and inspect for cloudiness. The presence of mineral oil contamination is indicated by cloudiness or turbidity in the sample.

262-5.5 SHIPBOARD LUBE OIL RECORDS

262-5.5.1 GENERAL. This section provides guidance pertaining to the maintenance of shipboard lube oil sampling, sounding, and transfer logs.

262-5.5.2 PERSONNEL RESPONSIBILITIES. Responsibilities of personnel regarding logs and records shall be in accordance with current TYCOM Instructions and the Engineering Departmental Organization Regulation Manual (EDORM).

262-5.5.3 RECORD MAINTENANCE

262-5.5.3.1 Ships may use either the forms indicated below or use their own format as long as the forms contain at least the information listed in 262-5.5.3.4.

There are 5 forms available for recording the necessary data used for lube oil quality maintenance. They may be obtained through the normal supply channels in accordance with NAVSUP Publication 2002. The records are:

1. NAVSEA 9255/50 (6-94) Lube Oil Log for 2000 Series Oils 0116-LF-019-0200
2. NAVSEA 9255/51 (6-94) Lube Oil Log for 9000 Series Oils 0116-LF-019-0300
3. NAVSEA 9255/52 (6-94) Lube Oil Log for MIL-L-23699 Oil 0116-LF-019-0400
4. NAVSEA 9255/53 (6-94) Soundings Log 0116-LF-019-0500
5. NAVSEA 9255/54 (6-94) Transfer Log 0116-LF-019-0600

262-5.5.3.2 Until available through the stock system, additional copies of these logs shall be reproduced locally from blank forms available in **Appendix D**. Logs shall be completed as per paragraphs 262-5.5.4 through 262-5.5.6.

262-5.5.3.3 All Lube Oil Logs shall be retained onboard for 2 years. Sounding and Transfer Logs shall be retained onboard for 6 months.

262-5.5.3.4. Oil logs must contain at least the following minimum information, as applicable:

1) Source of sample, ship name and hull and page number.
2) Date in format day/month/year.
3) Time in 24 hour clock basis.
4) Oil type.
5) Sample code with legend, as applicable.
6) Sump level.
7) Test results, with appropriate unit.
8) Any action taken because of the test results. If none, enter hyphen (-).
9) Where appropriate, enter findings in a remarks section. Findings should include any descriptions of unusual conditions Found, and an explanations of any test result(s) which are out of limits.
10) If oil is being transferred, indicate amount of oil transferred, source and destination tank and, if appropriate, record reasons for the transfer in a remarks section..
11) If oil tank is being sounded, enter tank number, tank type, tank capacity, sounding reading, and running total amount.
12) Initials of person performing the test/procedure.
13) Submission, review and approval signatures, as appropriate.

262-5.5.4 LUBE OIL SAMPLE LOGS FOR 2000, 9000 OR MIL-L-23699 SERIES OIL. Enter information on sheet 1 of log as follows (see **Appendix D**).

1. Enter equipment type, Equipment Identification Code (EIC), ship name and hull, and page number.
2. Enter date in format Day/Month/Year.
3. Enter time in 24 hour clock basis.
4. Enter sample code as indicated in legend.
5. Enter sump level in applicable units (i.e., qts, gals.).
6. Enter applicable test results as indicated.
7. Enter NOAP test results as indicated in legend.
8. Enter action taken as indicated in legend. If no action is warranted, enter hyphen (-).
9. Where appropriate, enter findings in remarks section found on page 2 of log. Findings should include any descriptions of unusual conditions found, explanation of any test result(s) which are out of limits, and any actions taken as a result of findings.

262-5.5.5 SOUNDING LOGS. Enter information on sheet 1 of log as follows (see **Appendix D**):

1. Enter oil type, ship name and hull number, and page number.
2. Enter month and year log is started.
3. Enter tank number.
4. Enter tank type as indicated in legend.
5. Enter date of sounding in Day/Month/Year.
6. Enter date of sounding in 24 hour clock basis.
7. Enter tank capacity in applicable units (i.e., qts, gals.)
8. Enter sounding reading.
9. Enter corresponding units of oil.
10. Enter running total in applicable units (i.e., qts, gals.)
11. Where appropriate, record events such as reasons for sounding measurements in remarks section found on page 2 of log.

262-5.5.6 TRANSFER LOGS. Enter information on sheet 1 of log as follows (see **Appendix D** .):

1. Enter ship name, hull name, start date of log, and page number.
2. Enter date in Day/Month/Year format.
4. Enter time of transfer in 24 hour clock basis.
5. Enter oil type being transferred.
6. Enter amount being transferred in applicable units (i.e., qts, gals.)

7. Enter tank identification from which oil is being transferred, and tank identification to which it is being transferred.
8. Enter initials of oil king.
9. Where appropriate, record events such as reasons for transfer in remarks section found on page 2 of log.

SECTION 6
HYDRAULIC FLUIDS

262-6.1 GENERAL

262-6-1.1 For information on Naval shipboard hydraulic fluids, see **NSTM Chapter 556, Hydraulic Equipment (Power Transmission and Control)** . The safety handling precautions specified in this chapter are applicable to lubricating oils used as hydraulic fluids. The technical point of contact for lubricating oils and hydraulic fluids is NAVSEA 03M3.

SECTION 7

HIGH PRESSURE AIR, OXYGEN, AND OIL-FREE NITROGEN SYSTEMS.

262-7.1 LUBRICANTS AND THREAD COMPOUNDS

NOTE

The information in this chapter does not authorize the use of lubricants and thread compounds that are specifically prohibited by system diagrams, maintenance instruction, or other instructions applicable to a system.

262-7.1.1 Formerly approved proprietary products considered safe from autogenous ignition (and from the resulting explosion hazard under conditions of normal use) are listed in Table 262-7-1. These proprietary lubricants and thread compounds may continue to be used only until existing supplies are depleted. Only military specification lubricants and thread compounds listed in Table 262-7-1 are now acceptable for use in high-pressure systems. Any air, oxygen, and oil-free nitrogen lubricants or thread compounds not listed in Table 262-7-1 but suggested for use in other Naval Sea Systems Command (NAVSEA) documents should not be used in these high-pressure systems unless guidance is sought immediately from NAVSEA.

262-7.2 INSTRUCTIONS FOR THE USE OF SPECIALTY LUBRICANTS

262-7.2.1 GENERAL. When dry filler lubricant and thread compounds are applied, the following special instructions shall be followed to achieve optimum performance and to avoid system contamination.

262-7.2.2 TEFLON TAPE. The only completely safe pipe sealing material capable of filling small contact imperfections is polytetrafluoroethylene (Teflon) tape manufactured according to MIL-T-27730. Apply tape under tension three threads back from the end of the male pipe thread and in the direction of the threads. For pipes less than 1 inch in diameter, use enough tape to make 1- 1/4 turns. For larger pipes (greater than 1 inch in diameter) continue wrapping until all mating surfaces of the joint are covered. A small portion of the tape shall extend outside the joint for inspection purposes.

NOTE

Teflon tape shall not be used on submarine high-pressure air, oxygen, and oil-free nitrogen systems operating at pressures higher than 1500 psi.

262-7.2.3 POWDER LUBRICANTS. Dry powders and slurries are applied to applicable systems by burnishing surfaces. Excess material shall be wiped or brushed away before installation.

262-7.2.4 STORAGE IN CONTAINERS. All lubricants and thread compounds, including Teflon tape, shall be stored in containers with closures to keep out moisture, dust, and particulate matter. Containers shall be clearly labeled.

262-7.2.5 QUANTITY TO BE APPLIED. All lubricants and sealing compounds shall be applied sparingly to the threaded portions of the male-threaded fittings to be sealed. Do not apply to the ends of the fittings or to the first three threads. To minimize extrusion of the powder when the joint is secured, threads shall not be filled in.

Excessive use of lubricants or sealants to fill gaps and loose connections is dangerous and is prohibited. This practice frequently results in leaks. Lubrication and antiseize principles are based on the properties of thin films of these substances; therefore, excess amounts are unnecessary. Excess powder shall be carefully wiped off with a clean, lint-free cloth or paper. Where reapplication is required, old lubricant or sealant shall be removed with a clean, lint-free cloth or paper to avoid contamination.

262-7.2.5.1 The only completely safe and reliable method of sealing pipe joints in oxidizing gas systems is to provide tight metal-to-metal seals. The most certain method of achieving a tight seal is to weld or braze all joints. Because of space limitations or mechanical problems, welding or brazing is sometimes impossible. To help maintain smooth, gall-free surfaces on mating metal parts, military specification lubricants listed in Table 262-7-1 may be used in very small amounts. These lubricants will not stop leaks. No organic material can be safely used to seal leaks caused by poorly fitted joints in high pressure gas systems.

Table 262-7-1. SUPERSEDING MILITARY SPECIFICATION LUBRICANTS AND THREAD COMPOUNDS FOR HIGH-PRESSURE (1500 psi AND ABOVE) AIR, OXYGEN, AND OIL-FREE NITROGEN SYSTEMS

COMPANY	PRODUCTS REPLACED	REPLACED BY
Halocarbon Product Co.	Halocarbon Oil 208	DOD-L-24574 (TY 1)
	4-11, 11E, 11ES	DOD-L-24574 (TY 1)
	10-25, 25E, 25ES	DOD-L-24574 (TY 3)
	11-14, 14E	DOD-L-24574 (TY 1)
	11-21, 21E	DOD-L-24574 (TY 2)
	13-21, 21ES	DOD-L-24574 (TY 2)
	14-25, 14-25E	DOD-L-24574 (TY 3)
	Halocarbon Grease 11-B-3, 25-20M, X90-15M, 15M5A, 25-5-S	MIL-G-27617 (TY 3)
Hooker Chemical Co.	Fluorolube S-30	DOD-L-24574 (TY 3)
	T-80	DOD-L-24574 (TY 3)
	MO-10	DOD-L-24574 (TY 1)
Hooker Chemical Co.	Fluorolube Grease GR290, 362	MIL-G-27617 (TY 3)
I DuPont de Nemours	Krytox 143 Oil AA	DOD-L-24574 (TY 2)
	AB, AC, AD, AX	DOD-L-24574 (TY 3)
	Krytox Grease AB, AC	MIL-G-27617 (TY 3)
Dow Corning Co.	Molykote Z	MIL-M-7866
Electrofilm Inc.	Electro-Moly Powder Grades 1 & 2	MIL-M-7866
EM Lubricants Inc.	Micro-Seal 100-1	SS-G-659
J.A. Sexauer Co.	Sexauer Easy Wrap Pipe Joint Tape	MIL-T-27730
Dodge Industries Inc.	Thread Seal Tape No. 121	MIL-T-27730
Saunders Engineering Co.	Teflon Thread Sealant S-22	MIL-T-27730

Notes:
(1) The lubricating oils and greases supplied by Halocarbon Product Co. and Hooker Chemical Co. contain chlorofluorocarbons and are incompatible with certain alloys, particularly those containing aluminum or magnesium.
(2) Materials listed in this table shall not be used unless the technical manual or operating instructions for the specific equipment indicate to do so.
(3) Halocarbon oils and greases shall not be mixed.

WARNING

Do not, under any circumstance, apply any oil or other petroleum-base lubricant or solvent to a part in direct contact with the air stream. It is recommended that antiseize compound in accordance with MIL-G-27617 be used on pipe unions and threads in contact with the air stream.

SECTION 8
LUBRICANTS IN DIVING SYSTEMS

262-8.1 INTRODUCTION

262-8.1.1 Divers shall be continuously supplied with breathing air or mixed gas that is free from toxic, corrosive, or flammable contaminants. These breathing media are subject to pressures ranging from 14.7 (atmospheric) to 3000 lb/in^2 . Any vapor or particulate matter left in breathing media will reach divers' lungs and life support equipment. This section provides procedures for lubricating diving systems in a manner that protects diver safety and comfort.

262-8.2 COMPRESSED AIR DIVING SYSTEMS

262-8.2.1 Lubrication in compressed air diving systems is limited to compressor lubrication, O-ring lubrication, mechanical component lubrication in recompression chambers, and thread sealant compounds.

262-8.2.2 The most common source of compressed air for breathing is the air compressor. All compressors require lubrication. The lubricant used will vaporize into the air supply and, if not condensed or filtered out, will reach the diver's lungs. In addition to removing as much lubricant from the air supply as possible, the diver shall be further protected by the use of nontoxic lubricants. All lubricants except water shall conform to the following:

a. The recommended lubricating oil for all diver's reciprocating air compressors is oil conforming to MIL-L-17331 (MS 2190TEP). This oil has an approximate viscosity of an SAE 30 weight oil. Judgment should be used when operating compressors in cold environments since it may be necessary to use an oil with a lower viscosity. For ambient temperatures below -1°C (30°F), MIL-H-17672 (grade 2135TH) shall be used.

b. Other lubricants authorized by Naval Sea Systems Command Director of Ocean Engineering may be used for specific circumstances.

c. A listing of O-ring seal lubricant applications is presented in Table 262-8-1.

Table 262-8-1. O-RING SEAL LUBRICANTS

SYSTEM TYPE	LUBRICANT	TEMP. RANGE	COMPATIBLE SEALS
Petroleum (Fuel/Lube)	MIL-G-24508	-20 to 300 F (-29 to 149 C)	Fluorocarbon, Neoprene, Nitrile
Pneumatic (2000 psi max) Vacuum Electrical	MIL-S-8660	-65 to 400 F (-54 to 204 C)	Butyl, Nitrile, Fluorocarbon, Neoprene, Ethylene-propylene Chloroprene
Life Support	MIL-G-27617 Type III	-30 to 400 F (-34 to 204 C)	Fluorocarbon, Fluorosilicone, Butyl Ethylene - Propylene, Nitrile

262-8.2.3 O-ring seals shall be lubricated during installation to ensure proper function and to prevent leaks. Later, in the course of normal operations, small quantities of the lubricant used will enter the diver's air supply. The lubricant shall be nontoxic according to MIL-S-8660, DOD-L-24574, or MIL-G-27617(TY 3).

262-8.2.4 Some mechanical components such as hinges in recompression chambers require lubrication. These components are exposed to the pressurized air in the chamber. This air is inhaled by the diver. The lubricant, therefore, must be nontoxic. Furthermore, all recompression chambers at times contain air or gas with a high percentage of oxygen (for example, during oxygen tolerance tests). Lubricants used on these mechanical components shall therefore conform to the requirements of paragraph 262-8.2.3.

262-8.2.5 The safest and most reliable method for sealing diving system pipe joints is to weld or braze all joints. If welding or brazing is not practicable, the O-ring union joint is recommended. If space limitations or mechanical conditions prevent both of these alternatives, the use of a threaded pipe joint may be required. The use of threaded joints shall be kept to an absolute minimum. A thin film of lubricant on the threaded surfaces will promote smooth mating and help achieve a tight metal-to-metal seal. These lubricants will not stop leaks in poorly fitted joints. Silicone lubricants conforming to MIL-S-8660 or Molykote Z powder shall be used. Teflon tape may be used sparingly on threaded joints. One and one-fourth wraps of Teflon tape is sufficient for threaded joints.

262-8.3 MIXED GAS DIVING SYSTEMS (HELIUM-OXYGEN)

262-8.3.1 Lubrication required for helium-oxygen mixed gas diving systems is limited to lubricants for O-rings, mechanical components in recompression and decompression chambers, and thread sealant compounds. The compressors used in mixed gas systems are either oil-free or water-lubricated. This eliminates the possibility of toxic or flammable hydrocarbons in the system.

262-8.3.2 O-ring seals in mixed gas systems can be lubricated with MIL-S-8660, DOD-L-24574, or MIL-G-27617 (TY 3) as listed in Table 262-7-1. Mechanical components in recompression chambers can be lubricated with MIL-S-8660 or those lubricants listed in Table 262-7-1.

262-8.4 OXYGEN AND SATURATION DIVING SYSTEMS

262-8.4.1 The criteria for lubricants to be used in oxygen and saturation diving systems (which also have oil-free or water-lubricated compressors) are limited to those lubricants listed in Table 262-7-1.

SECTION 9

CASUALTY CONTROL PROCEDURES

262-9.1 INTRODUCTION

262-9.1.1 For casualty control procedures, refer to **NSTM Chapter 079, Volume 3, Damage Control - Engineering Casualty Control.**

APPENDIX A

TYPICAL NAVAL OIL SYSTEM APPLICATIONS

Table A-1 TYPICAL SYSTEM APPLICATIONS

System/Use	Oil Used
Air Compressor, LP	MIL-L-17331
Air Compressor, MP	MIL-L-17331
Air Compressor, HP	MIL-L-17331
A/C Plant, R12	VV-L-825 Ty II
A/C Plant, R22	VV-L-825 Ty IV
A/C Speed Decreaser	MIL-L-17331
Anchor Wind. Lube	MIL-L-17331
Anchor Wind. Gear	MIL-L-2105
Blower, Forced Draft	MIL-L-17331
Capstan Gear	MIL-L-2105
Capstan Lube	MIL-L-17331
Contollable Pitch Propellar	MIL-L-2104, OE/HDO-15/40
Crane, B&A Gear	MIL-L-2105
Crane, Bridge Gear	MIL-L-2105
Crane, Diesel Engine	MIL-L-9000
Crane, Paravane Gear	MIL-L-2105
Crane, Quarter Gear	MIL-L-2105
Engine, Emerg. Diesel	MIL-L-9000
Engine, Main Diesel	MIL-L-2104, OE/HDO-15/40
Engine, Main Diesel	MIL-L-9000
Engine, Gas Turbine	MIL-L-23699
Engine, Emerg. G.T.	MIL-L-23699
Engine, S.S. Diesel	MIL-L-9000
Engine, S.S. Diesel	MIL-L-2104, OE/HDO-15/40
Engine, S.S. G.T.	MIL-L-23699
Gear, Main Reduction	MIL-L-17331
Gear, Main Reduction	MIL-L-9000
Gear, Main Reduction	MIL-L-2104, OE/HDO-15/40
Generator, G.T.	MIL-L-17331
Generator, 60/290 KW	MIL-L-9000
Line Shaft Bearing	MIL-L-17331
O2/N2 Plant	MIL-L-17331
Pump, Main Feed	MIL-L-17331
Pump, Fuel	MIL-L-17331
Pump, Lube Oil	MIL-L-17331
Pump, Oily Waste	MIL-L-17331
Pump, Sewage	MIL-L-17331
Transmission, Boat	MIL-L-9000

Table A-1 TYPICAL SYSTEM APPLICATIONS - Continued

Winch, Boat Gear	MIL-L-2105
Winch, Cargo Gear	MIL-L-2105
Winch, Deck Gear	MIL-L-2105
Winch, Hatches Gear	MIL-L-2105
Winch, Inhaul Gear	MIL-L-2105
Winch, Outhaul Gear	MIL-L-2105
Winch, RAST Rope	MIL-L-2105
Winch, Spanwire Gear	MIL-L-2105
Winch, Stern Gate Gr.	MIL-L-2105
Winch, Topping Gear	MIL-L-2105
Winch, Towing Gear	MIL-L-2105
Winch, Vehicle Ramp Gr.	MIL-L-2105
TYPICAL NAVAL GREASE APPLICATIONS	**TEMP RANGE**
Ball/Roller Bearings, Multipurpose	-65 to 350°F
Water Resistance, Multipurpose	0 to 230°F
Water Resistance, Multipurpose Onboard Submarines)	0 to 300°F
Steam Catapult, Low Speed/High Load (5% MoS2)	0 to 350°F
Electric Motor Ball/Roller Bearings	0 to 350°F
Wire Ropes, Exposed Gears Corrosion Protection	Ambient
Tapered Plug Valves, Gaskets Where Gasoline Oil/Alcohol/Water Resistance Required	-20 to 300°F
Tapered Plug Valves, HP Air Systems, Oxygen/Oil-Free Nitrogen Liquid Oxygen Systems(Fluoronated Grease)	-30 to 500°F

Table A-2 MISCELLANEOUS APPLICATIONS

MISCELLANEOUS LUBRICANT APPLICATIONS*	
System/Use	**Lubricant Used**
Threads on Steel Nuts, Bolts (not stainless), up to 1050°F as Antiseize	MIL-A-907
Threaded or Unthreaded Aluminum/Aluminum Alloy Components as Antiseize (Zinc Dust/Petrolatum)	MIL-T-22361
Lubricant/Sealant in Electronic Equipment, Rubber O-Rings	MIL-S-8660
*The applications presented are typical, and the actual lubricant used in an individual system may vary. The lubricant specified on the Maintenance Requirement Card (MRC) for the equipment shall take precedence over this appendix.	

APPENDIX B-1

OBSOLETE AND SUPERSEDING LUBRICANT SPECIFICATIONS

Table B-1 OBSOLETE SPECIFICATIONS

OBSOLETE SPECIFICATION	SUPERSEDED BY
JJJ-C-86, OIL, CASTOR	MIL-H-17672 (MS 2135TH)
VV-G-632, GREASE, INDUSTRIAL	DOD-G-24508
VV-G-671, GREASE, GRAPHITE	DOD-G-24508
VV-L-751, OIL, CHAIN AND WIRE ROPE	MIL-G-18458/MIL-L-2105
VV-L-820, LUBE OIL, GENERAL PURPOSE	VV-L-800
VV-L-825 (TYPES I & III)	Note 1
VV-C-850, CUTTING FLUID, SULFURIZED	Note 1
VV-L-1071, LUBE OIL, STEAM CYLINDER	MIL-L-53074 (MS 5190)
MIL-F-12070, OIL, FOG	Note 1
MIL-L-15016, LUBE OIL, GEN.PURPOSE	MIL-L-17331
MIL-L-15018, LUBE OIL, CYLINDER	MIL-L-53074 (MS 5190)
MIL-L-15019 (MS 4065, MS 5230)	Note 1
MIL-L-15019 (MS 6135)	Note 2
MIL-L-15019 (MS 8190)	MIL-L-17331
MIL-G-18709, GREASE, BALL/ROLLER BRG.	DOD-G-24508
MIL-L-19224, LUBE OIL, PRESERVATIVE	MIL-H-17672 (MS 2135TH)
MIL-H-24430, HYD. OIL, EMULSIFYING	MIL-H-17672 (MS 2110TH)
MIL-H-24459, HYD. OIL, ANTIWEAR	MIL-H-17672
MIL-L-24467, LUBE OIL, STEAM TURBINE	MIL-L-17331
MIL-L-26087, LUBE OIL, COMPRESSOR	MIL-L-17331
MIL-C-46149, CUTTING OIL, ADDITIVE	Note 1
MIL-H-46001, HYD. OIL, MACHINE TOOL	MIL-H-17672 (MS 2135TH)
MIL-L-83767, LUBE OIL, VACUUM PUMP	Note 1

NOTES:
(1) Deleted from shipboard use; no replacement.
(2) Specification cancelled; replacement oil shall conform to American Gear Manufacturers Association (AGMA) Specification 250.4 for Grade no. 7 compounded oil.

APPENDIX C

SHIPBOARD LUBRICATION FITTINGS

Table C-1 SHIPBOARD FITTINGS

MS Part No.	FIIN Class 4730	Thread	Angle	Remarks
Carbon Steel, Plated, Type I, MIL-F-3541				
MS 15001-1	050-4203		Straight	Short (1/2″)
MS 15001-2	172-0001		Straight	Long (15/16″)
MS 15001-3	050-4205	1/4-28 UNS-2A	45°	
MS 15001-4	050-4207	(Note 1)	90°	
Carbon Steel, Plated, Type II, MIL-F-3541				
MS 15002-1	172-0010	1/4-28 UNF-2A		Straight
MS 15002-2	050-4204	5/16-32 NEF-2A	Straight	*
MS 15002-3	172-0015	1/4-28 UNF-2A	45°	
MS 15002-4	050-4206	5/16-32 NEF-2A	65°	*
Carbon Steel, Plated, Type III, MIL-F-3541				
MS 15003-1	050-4208		Straight	Short (11/16″)
MS 15003-2	172-0022		Straight	Long (1-1/4″)
MS 15003-3	172-0025		30°	
MS 15003-4	172-0028	1/8-27 PTF	45°	
MS 15003-5	172-0031	SAE Short	65°	
MS 15003-6	172-0034		90°	
MS 15003-7	172-0037		105°	
Monel (Nickel/Copper), Type IV, MIL-F-3541				
MS 15004-1	172-0040	1/4-28 UNS-2A	Straight	
MS 15004-2	172-0041		45°	
MS 15004-3	172-0042		90°	
Monel (Nickel/Copper), Type V, MIL-F-3541				
MS 15005-1	172-0043	1/8-27 PTF	Straight	Short (3/4″)
MS 15005-2	172-0044	SAE Short	Straight	Long (1-1/4″)
MS 15005-3	245-0413		30°	**
MS 15005-4	172-0046		65°	
MS 15005-5	172-0047		90°	
MS 15005-6	172-0048		105°	
Carbon Steel, Plated, Leak-Proof, Type VI, MIL-F-3541				
MS 15006-1	172-0049	1/8-27 PTF	Straight	***
MS 15006-2	172-0052	SAE Short	30°	***
MS 15006-3	172-0055		65°	**, ***
MS 15006-4	172-0058		90°	***
MS 15006-5	172-0061		105°	***
CRES, Type VII, MIL-F-3541				
MS 15720-1	916-3368	1/4,-28 UNS-2A	Straight	
MS 15720-2	N/A		45°	*
MS 15720-3	N/A		90°	
CRES, Type VIII, MIL-F-3541				
MS 15721-1	972-5789	1/8-27 PTF	Straight	Short (3/4″)

Table C-1 SHIPBOARD FITTINGS - Continued

MS Part No.	FIIN Class 4730	Thread	Angle	Remarks
MS 15721-2	N/A	SAE Short	Straight	Long (1-1/4″)
MS 15721-3	245-7703		30°	**
MS 15721-4	N/A		65°	
MS 15721-5	N/A		90°	
MS 15721-6	N/A		105°	

NOTE :
1. Since 1971, new ships have been required to have fittings of MS 15004 or MS 15005 Monel for equipment and machinery exposed to the weather and in spaces normally having high humidity. MS 15001, MS 15002, MS 15003, or MS 15006 plated carbon steel is specified for use in normally dry spaces. Fittings of MS 15720 or MS 15721 CRES may be used in place of Monel fittings if Monel fittings are unavailable.
Fitting material type may be identified by the number of notches on the wrenching hexagon:
Monel: single notch
CRES: two notches
Carbon steel: no notches
Fittings should be replaced when the fitting tip is corroded or damaged, the fittings passage is blocked, or the fitting ball-check leaks.

*Thread form 1/4-28 UNS-2A is special thread with a 3/4 inch diametral taper per foot to fit tightly in a 1/4-28 UNF-3B tapped hole.
**The PTF-SAE short thread is a modified short form of the NPTF (National Pipe Taper Fuel) thread. The NPTF thread is commonly known as Dryseal or American Dryseal.
***Check valve is of Buna-N material.

APPENDIX D

BLANK LOG FORMS

Table D-1 LOGS

LUBE OIL LOG FOR 2000 SERIES OILS

EQUIPMENT _____ EIC _____ SHIP _____ DATE _____ PAGE _____

DATE	TIME	SAMPLE CODE	SUMP LEVEL	CLEAR & BRIGHT (Y/N)	VISIBLE SEDIMENT (Y/N)	B.S. & W. (%)	FREE WATER (Y/N)	NOAP RESULTS	ACTION TAKEN	EOOW/EDO INITIAL

NAVSEA 9255/50 (6-94)(FRONT) 0116-LF-019-0200

LUBE OIL LOG FOR 2000 SERIES OILS

PAGE _____

DATE	TIME	REMARKS:

LEGEND/CODE

SAMPLING CODES:

D	DAILY
W	WEEKLY
B	BIWEEKLY
M	MONTHLY
U	ABNORMAL

NOAP CODES:

AA	NORMAL
ZZ	ABNORMAL
WA	WATER
NN	ACIDITY
CS	CHANGE OIL

SUBMITTED BY: REVIEWED BY: APPROVED BY:

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LUBE OIL LOG FOR 9000 SERIES OILS

EQUIPMENT ____________ EIC ____________ SHIP ____________ DATE ____________ PAGE ______

DATE	TIME	SAMPLE CODE	SUMP LEVEL	FUEL DILUTION (%)	ACIDITY (P/F)	NOAP RESULTS	ACTION TAKEN	EOOW/EDO INITIAL

NAVSEA 9255/51 (6-94)(FRONT) 0116-LF-019-0300

LUBE OIL LOG FOR 9000 SERIES OILS . . . . .

LUBE OIL LOG FOR 9000 SERIES OILS

PAGE _____

DATE	TIME	REMARKS:

LEGEND/CODE

SAMPLING CODES:

D	DAILY
W	WEEKLY
B	BIWEEKLY
M	MONTHLY
U	ABNORMAL

NOAP CODES:

AA	NORMAL
ZZ	ABNORMAL
WA	WATER
FD	FUEL DILUTION
VS	VISCOSITY

SUBMITTED BY: REVIEWED BY: APPROVED BY:

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LUBE OIL LOG FOR MIL–L–23699 OIL

EQUIPMENT _____ EIC _____ SHIP _____ DATE _____ PAGE _____

DATE	TIME	SAMPLE CODE	SUMP LEVEL	MINERAL OIL CONTAMINATION (Y/N)		NOAP RESULTS	ACTION TAKEN	EOOW/EDO INITIAL

NAVSEA 9255/52 (6–94)(FRONT) 0116–LF–019–0400

LUBE OIL LOG FOR MIL-L-2104, OE/HDO-15/40

EQUIPMENT ______________ EIC ______________ SHIP ______________ DATE ______________ PAGE ______

DATE	TIME	SAMPLE CODE	SUMP LEVEL	FUEL DILUTION (%)	ACIDITY (P/F)	NOAP RESULTS	ACTION TAKEN	EOOW/EDO INITIAL

NAVSEA 9255/51 (6-94)(FRONT) 0116-LF-019-0300

LUBE OIL LOG FOR MIL-L-2104, OE/HDO-15/40 OIL

LUBE OIL LOG MIL-L-2104, OE/HDO-15/40

PAGE ____

DATE	TIME	REMARKS:

LEGEND/CODE

SAMPLING CODES:

D	DAILY
W	WEEKLY
B	BIWEEKLY
M	MONTHLY
U	ABNORMAL

NOAP CODES:

AA	NORMAL
ZZ	ABNORMAL
WA	WATER
FD	FUEL DILUTION
VS	VISCOSITY

SUBMITTED BY: REVIEWED BY: APPROVED BY:

NAVSEA 9255/51 (6-94)(BACK) 0116-LF-019-0300

LUBE OIL LOG FOR MIL-L-2104, OE/HDO-15/40 OIL

LUBE OIL LOG FOR MIL–L–23699 OIL

PAGE _____

DATE	TIME	REMARKS:

LEGEND/CODE

SAMPLING CODES:

D	DAILY
W	WEEKLY
B	BIWEEKLY
M	MONTHLY
U	ABNORMAL

NOAP CODES:

AA	NORMAL
ZZ	ABNORMAL
VS	VISCOSITY
NN	ACIDITY
CS	CHANGE OIL

SUBMITTED BY: REVIEWED BY: APPROVED BY:

NAVSEA 9255/52 (6–94)(BACK) 0116–LF–019–0400

SOUNDING LOG

TO BE RETAINED ONBOARD FOR 6 MONTHS

OIL TYPE ______________ SHIP ______________ MONTH __________ YEAR ________ PAGE ________

TANK	TANK TYPE	DATE	TIME	CAPACITY	SOUNDING	GALLONS	RUNNING TOTAL

NAVSEA 9255/53 (6–94)(FRONT) 0116–LF–019–0500

SOUNDING LOG . . . .(Front)

SOUNDING LOG

TO BE RETAINED ONBOARD FOR 6 MONTHS

PAGE _____

DATE	TIME	REMARKS:

LEGEND/CODE

TANK TYPE: ST STORAGE SE SETTLING

SUM TOTALS: STORAGE _____ SETTLING _____ TOTAL _____

SUBMITTED BY: REVIEWED BY: APPROVED BY:

NAVSEA 9255/53 (6-94)(BACK) 0116-LF-019-0500

SOUNDING LOG . . . . . .(Back)

TRANSFER LOG

SHIP ______________________________ DATE ______________ PAGE ________

DATE	TIME	TYPE	AMOUNT	FROM	TO	TRANSFERRED BY	EOOW/EDO INITIAL

NAVSEA 9255/54 (6-94)(FRONT) 0116-LF-019-0600

TRANSFER LOG . . . .(Front)

TRANSFER LOG

PAGE _____

DATE	TIME	REMARKS:

SUBMITTED BY: REVIEWED BY: APPROVED BY:

NAVSEA 9255/54 (6-94)(BACK) 0116-LF-019-0600

TRANSFER LOG. . . . . .(Back)

APPENDIX E

TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT (TMDER)

NOTE

Ships, training activities, supply points, depots, Naval Shipyards, and Supervisors of Shipbuilding are requested to arrange for the maximum practical use and evaluation of NAVSEA technical manuals. All errors, omissions, discrepancies, and suggestions for improvement to NAVSEA technical manuals shall be reported to the Commander, NAVSURFWARCENDIV, 4363 Missile Way, Port Hueneme, CA 93043-4307 on NAVSEA/ SPAWAR Technical Manual Deficiency/Evaluation Report (TMDER), NAVSEA Form 4160/1. To facilitate such reporting, print, complete, and mail NAVSEA Form 4160/1 below or submit TMDERS at web site https://nsdsa.nmci.navy.mil/tmder/tmder.asp?lvl=1. All feedback comments shall be thoroughly investigated and originators will be advised of action resulting therefrom.

TMDER / MAILER (ON CDROM)

Ref: NAVSEAINST 4160.3A NAVSEA S0005-AA-GYD-030/TMMP

NAVSEA/SPAWAR TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT (TMDER)

INSTRUCTIONS: Continue on 8 ½" x 11" page if additional space is needed.
1. Use this report to indicate deficiencies, problems and recommendations relating to publications.
2. For CLASSIFIED TMDERs see OPNAVINST 5510H for mailing requirements.
3. For TMDERs that affect more than one publication, submit a separate TMDER for each.
4. Submit TMDERs at web site https://nsdsa.nmci.navy.mil or mail to: **COMMANDER, CODE 310 TMDERs, NAVSURFWARCENDIV NSDSA, 4363 MISSILE WAY BLDG 1389, PORT HUENEME CA 93043-4307**

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7a. Page #	7b. Para #	7c. RECOMMENDED CHANGES AND REASONS

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