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Laboratory Services Series—A Lubrication Program

H. B. Bowen
T. L. Miller

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PLANT AND EQUIPMENT DIVISION

LABORATORY SERVICES SERIES - A LUBRICATION PROGRAM

H. B. Bowen
Lubrication Engineer

and

T. L. Miller
Industrial Engineer

MAY 1976

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CONTENTS

	PAGE
Abstract	1
Introduction	1
Equipment Identification	2
Lubrication Requirements	4
Assortment of Lubricants	13
Personnel	16
Scheduling	18
Conclusion	23
Appendix - Glossary of Lubrication Terms	27

LABORATORY SERVICES SERIES - A LUBRICATION PROGRAM

H. B. Bowen
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ABSTRACT

The diversity of equipment and operating conditions at a major national research and development laboratory requires a systematic, effective lubrication program. The various phases of this program and the techniques employed in formulating and administering this program are discussed under the following topics: Equipment Identification, Lubrication Requirements, Assortment of Lubricants, Personnel, and Scheduling.

INTRODUCTION

To effectively manage and give adequate lubrication service to approximately 8000 items of building and plant service equipment at Oak Ridge National Laboratory, the Plant and Equipment Division utilizes a computer program for maintenance scheduling. The lubrication program is an integral part of the programmed maintenance (PM) system employed as a preventive maintenance tool in inspecting and maintaining equipment to prevent failure and costly downtime. Programmed maintenance has been defined as the term applied to repetitive maintenance and inspection activities of the Plant and Equipment Division scheduled through the use of electronic data processing equipment.[1]

To develop and maintain proper input for the lubrication program requires efforts of both technical and craft personnel such as: field inspection of equipment to list nameplate and other necessary data to properly identify the equipment for the computer program and the craft people who service the equipment; technical knowledge and on-the-job

[1] W. O. Graves and B. S. Bishop, *Programmed Maintenance For Oak Ridge National Laboratory*, ORNL-TM-2161.

experience in determining the lubrication requirements for equipment that is required to function in various environmental conditions; knowledge of technical specification preparation and application to be certain an assortment of proper lubricants are in Stores under various code number classifications to meet multiple requirements as to temperature, density, flash characteristics, viscosity, and additive[2] restrictions in complying with Quality Assurance (QA) requirements; proper frequencies of scheduled lubrication based on equipment operating time, usage and critical nature of operation; and the proper or best techniques to utilize in administering the lubrication program.

Of the approximately 8000 items of equipment requiring lubrication in the programmed maintenance system, many are typical standard items found throughout industry such as: pumps, compressors, blowers, refrigeration units, machine tools, cranes, hoists, elevators, motor-generator sets, and electrical switchgear. Others, however, are unique equipment found only in facilities engaged in nuclear research and development such as: remote control equipment, cell ventilating equipment, and secondary containment equipment. All of this equipment has one thing in common, a need for periodic lubrication to prevent operating failures and costly downtime.

EQUIPMENT IDENTIFICATION

The basis for determining the correct maintenance and lubricating procedures for each item of equipment is complete familiarity such as its function, process served, and its operating time. A detailed physical equipment inventory is performed by the programmed maintenance staff. Identification is very detailed such as manufacturer's nameplate data, name of equipment, manufacturer, function, model number, serial number, type, size, style, class, code, design, horsepower, RPM, volts, amps, phase, cycle, etc. In addition, the equipment is identified by property number, building location, and where applicable, shop number.

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[2] See Appendix for a Glossary of Lubrication Terms taken from the *Lubrication Engineers Manual*, First Edition, United States Steel.

These equipment data identities include an assigned equipment location identification number, each point of service on the equipment, lubrication code requirements and other maintenance check points. These identity data are entered on Programmed Maintenance Data Sheets (Fig. 1).

These sheets are then sent to the Computer Technology Center (CTC) for processing to enter the equipment as an integral part of the programmed maintenance system. Subsequent computer printouts and schedule cards are maintained in a master file, by programmed maintenance staff personnel, for ready reference.

After the equipment inventory is completed, a floor plan layout designating equipment location and route of service is drawn. The layout route of the equipment aids the craftsman in locating and servicing the equipment with minimum effort. In addition, attached to selected items of equipment is a red or silver decal inscribed with building number, route number, equipment number and annual service data. The equipment designation or location numbers are assigned in steps of five digits to provide for later modifications and additions of equipment without affecting previously assigned numbers. Building, routes and equipment are numbered as shown by the following example and the route drawing (Fig. 2) of Building 3025 and the Programmed Maintenance Schedule Service Card (Fig. 3).[3]

Building 3025:

Route 00 - Outside Building	Route 20 - Second Floor
Route 01 - Basement (See Fig. 2)	Route 30 - Third Floor
Route 10 - First Floor	Route 40 - Roof

As shown in Fig. 2, at the beginning of the route an item of equipment is numbered 001 and the next 005. This identity system permits three items of equipment to be added. The next items are 010, 015, 020, 025, etc.

---

[3] Identity points 25-38 appear on a second data sheet which is not shown with Fig. 1.

The identity of one item of equipment programmed for service for the week of December 22, 1975 is an Eastern Elevator. As noted by the Programmed Maintenance Data Sheet, Fig. 1, and Programmed Maintenance Schedule Card, Fig. 3, it is located in Building 3025 (First 4 digits), Route 01 (Next 2 digits), and equipment item 005 (Last 3 digits).

Additional identification and location is necessary on some of the machine tool equipment lubrication points. This is accomplished by attaching a drawing or picture to the machine tool, arrows pointing to the lubrication points, code letters of lubricant required, and item number of lubrication point that corresponds to the schedule card (Fig. 3) is also shown on the drawing or picture. This method of identification and location is the optimum, and in the future, we plan to identify more of our equipment lubrication points in this manner.

With all the above identification mentioned, it is of little value unless the right lubricant is used at the right place. To prevent errors in application, each dispensing container has the lubricant code letters painted that can be easily seen. In addition, each storage container has this type of identification.

With the programmed maintenance card identifying location and points for lubrication service, and a map of the service route, and lubrication trucks equipped for field and shop service, the craftsman is able to effectively service the equipment.

LUBRICATION REQUIREMENTS

The right lubricant in the right amount in the right place at the right time - these four factors spell satisfactory lubrication.[4] In a Laboratory such as the Oak Ridge National Laboratory with the complexity of equipment used in research and development, these four factors dictate a diversified group of lubricants and cutting coolants. In addition to machine tool requirements with high speeds, heavy loads,

---

[4] *Progress in the Application of Industrial Lubricants*, A Technical Publication Devoted to the Selection and Use of Lubricants, Vol. XLI, No. 5, Published by The Texas Company, May 1955.

PROGRAMMED MAINTENANCE DATA SHEET

DATE: MARCH 22, 1976

LOCATION	EQUIPMENT DESCRIPTION	PROPERTY	FOREMAN	JOB ORDER
3025-01006	EASTERN ELEVATOR			H3025E-P1 19

EQUIPMENT MANUFACTURER	MODEL	TYPE	SIZE	SERIAL NUMBER	VENDOR
EASTERN ELEVATOR CO.				A1148W	4000 LBS.

FUNCTION	SHAFT	DIMENSIONS	WARRANTY DATE
MAIN MTR PUMP UNIT DELAVEL PUMP SER M66527			

MOTOR MANUFACTURER	HP	RPM	VOLTS	AMPS	PH	CY	AC DC	TYPE	SF
IMPERIAL	30	1800	220/440		3	60	AC	EKB	

PROPERTY	SERIAL NUMBER	FRAME	MODEL	CLASS	STYLE	CODE	DES	TEMP	EQ. CL.
X-96124	305426	286							

ITEM	POINT OF SERVICE	LUB	FTNG	NO	FREQ	START	OR ALT	MINUTES TIME	CRAFT	REMARKS
1	LUB MTR BRNGS	TJ	GF	2	2Y	68				
2	LUB MTR SHAFT COUPLING	TJ			6M	20				
3	CK HYDRAULIC OIL RESV LEVEL	BE			M	0	4			
4	DR, FLUSH, REFL HYD OIL RESV	BE			Y	20				
5	CK FLEX HOSE CONN				6M	20				
6	CK, CLEAN SOLENOID VALVE				Y	20				
7	CK, CLEAN OIL STRAINERS				Y	20				
8	CK PUMP PACKING				3M	8				
9	CK PIPING, CONNS, FITTINGS				3M	8				
10	CLEAN HYD OIL DRIP PAN				3M	8				
11	CK CONTROL BOARD WIRING CONNS				6M	20				
12	FUSE CONTACTS				6M	20				
13	CK DISCON SWT, WIRING, CONNS				6M	20				
14	FUSES, CLAMPS, CONTACTS				6M	20				
15	HOISTWAY DOOR EACH LEVEL				3M	8				
16	MTR BRNGS SEALED				M	0				
17	LUB DOOR LIMIT SWITCH CAMS	BG			M	0				
18	LUB DOOR GUIDES	BG			M	0				
19	LUB DOOR LATCHES	BG			M	0				
20	LUB CONTACT HOLDER PIVOT PINS	BG			M	0				
21	LUB CAM LIFT LINKAGE PINS	BG			M	0				
22	CK SWITCHES, FLOOR LEVELING				M	0				
23	LIMIT LEVELING				M	0				
24	CK DOOR, GATE OPERATION				M	0				
25										

UCN-3637
(3 9-72)

Fig. 1. Typical Programmed Maintenance Data Sheet

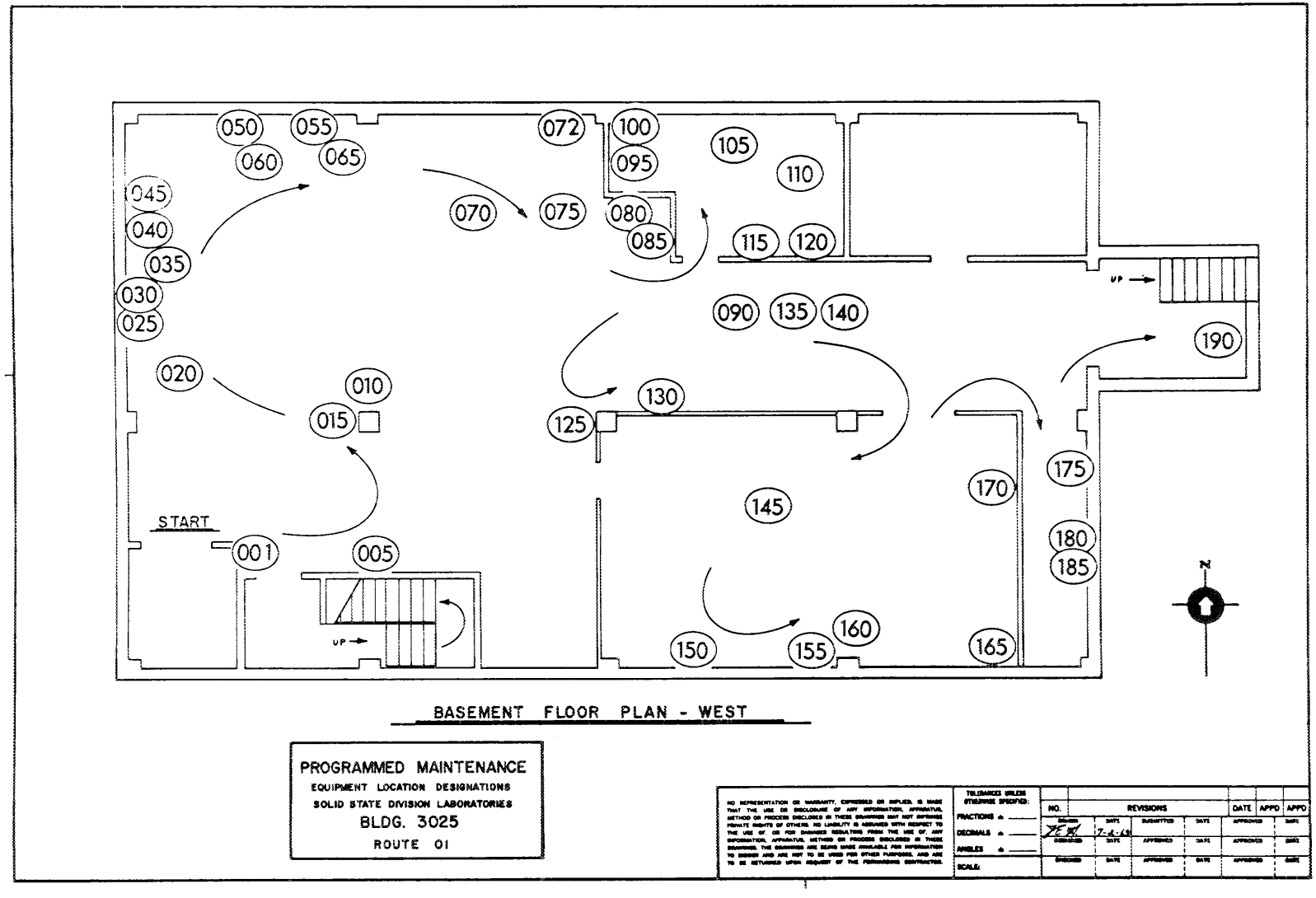

Fig. 2. Typical Equipment Layout and Route Plan

PROGRAMMED MAINTENANCE FOR WEEK OF DEC 22, 1975 FOREMAN HARTMAN
QUALITY LEVEL 4

LOCATION	EQUIPMENT DESCRIPTION	PROPERTY	JOB ORDER
3025- 01 005	EASTERN ELEVATOR		H3025E-P1

ITEM	POINT OF SERVICE	LUB	FTNG	NO	FREQ	REMARKS
3	CK HYDRAULIC OIL RESV LEVEL	BE			M	
16	MTR BRNGS SEALED				M	
17	LUB DOOR LIMIT SWITCH CAMS	BG			M	
18	LUB DOOR GUIDES	BG			M	
19	LUB DOOR LATCHES	BG			M	
20	LUB CONTACT HOLDER PIVOT PINS	BG			M	
21	LUB CAM LIFT LINKAGEPINS	BG			M	
22	CK SWITCHES,FLOOR LEVELING				M	
23	LIMIT LEVELING				M	
24	CK DOOR,GATE OPERATION				M	
SEE	NEXT CARD					

PROGRAMMED MAINTENANCE FOR WEEK OF DEC 22, 1975 FOREMAN HARTMAN

25	---CAR TOP - GATE UNIT---				M	
27	LUB CWT ROLLER CHAIN	BG			M	
28	LUB CAR GATE ROLLER CHAIN	BG			M	
29	LUB CAR GATE GUIDES	BG			M	
31	LUB LIMIT SWITCH ROLLERS	BG			M	
38	CK CYLINDER HEAD PACKING GLAND				M	

Fig. 3. Typical Programmed Maintenance Schedule Card

and close tolerance requirements, the end product, in many instances, must meet certain Reactor Research and Development (RRD) Standards and Quality Assurance (QA) requirements. The petroleum industry is constantly required to produce various types of lubricants to maintain pace with modern technological developments.

These lubricants must meet rigid ASTM specifications and the petroleum industry test procedures. To illustrate this fact, the following are some excerpts from Union Carbide Materials Specification, 11-AC-1:

> *The materials shall contain no skin irritants or other additives which may be injurous to personnel over either brief or extended exposure.*
>
> *Additives, inhibitors, and/or compounding, if present, shall remain uniformly distributed at all temperatures above the pour point specified for the fluid or fluid component.*
>
> *Fluids and fluid components shall maintain their physical and chemical stability in storage.*
>
> *Greases shall not change in hardness more than 15 points over the original penetration value when held in the container for periods up to one year.*
>
> *Cutting coolants shall produce a minimum of mist, spray, smoke, or fumes under the service conditions described in the Detailed Requirements. The coolant shall promote low tool and work piece temperatures, have low surface tension and high heat conductivity, and readily precipitate solid materials. The coolant shall be able to withstand sterilization by heating at 145°F for a period of 30 minutes without alteration of properties or performance characteristics.*
>
> *All material furnished under a given UCC-ND code shall be miscible and compatible, without deleterious affects, with the material furnished in any other shipment under the same UCC-ND Code.*
>
> *Samples for test shall be taken by the Company as follows:*

Fluids - A sample will be taken from a point at the bottom of the container, using a clean glass thief. Visible contaminants in the sample will be cause for immediate rejection of the container from which the sample was taken.

Greases - Samples will be taken in accordance with ASTM Standard D 270 Section 7.

Often in a production plant the equipment is of such design and application that two or three oils and a multi-purpose grease can meet the needs of 90 to 95 percent of the production equipment. As mentioned earlier, a research laboratory requires an assortment of lubricants to meet various applications and requirements. Some of these are as follows:

General Purpose Oils:

We are in the process of consolidation of oils so we may effectively service our equipment with only five general purpose oils. These include oils referred to as machine or turbine oils of paraffinic base. They are used in the lubrication of machine tools such as lathes, drills, jig borers, milling machines and shapers. Also journal and rolling-element bearings, turbines, hydraulic systems, gears (except hypoid), under nonshock and light to medium load conditions; also slides, ways, cams, joints, and control linkage.

Extreme Pressure Oils:

Most of the laboratory's automotive and mobile heavy equipment items require a strong extreme pressure lubricant. Included are bulldozers, graders, cranes, hoists, trucks, and tractors where worm and hypoid gears are a part of the gear transmission which operates under and subject to severe shock loading conditions.

Combustion Engine Oils:

These oils are of different viscosities and SAE numbers from SAE-10 to 50. They are designed as high detergent crankcase oils suitable for use in and lubrication of automotive, trucks, and heavy equipment diesel engines with or without spark ignition.

Special Design Oils:

Equipment items such as refrigeration compressors and air conditioning systems require an oil that is wax-free and will operate in low temperatures.

Other special oils are for the lubrication of and sealing of mechanical vacuum pumps and also for diffusion pump systems where a high vacuum is required. At the laboratory where radiation and contamination from radioactive materials are problems, it is necessary to have oils and greases that will not be affected when so exposed.

There are other general and special oils at the Laboratory that are stocked in Stores:

Fire-Resistant Hydraulic for Elevators
Cell Shielding Window Oil
Grinding Oils for Machine Grinders
Transformer Oils (Straight Mineral and Synthetics)
Synthetic High Temperature Oils and Greases
Cutting Coolant Oils (Emulsible and Nonemulsible)
Grease Lubricants and Sealants for Valves Exposed to Such Materials as Acids, Gasoline, Alcohol, Steam, Hot Water, and Natural Gas

A Four-Plant Lubrication Committee was organized, by Union Carbide Corporation - Nuclear Division, to standardize and reduce the number of types, grades, and brands of lubricants stocked by the installations. In addition, the committee develops specifications for bidding and purchasing and adopts code designations used for each lubricant. Fig. 4 is an illustration of a detailed specification for a premium grade turbine oil used at Oak Ridge National Laboratory.

This standardization by the Committee has resulted in a reduction of approximately 42% in the number of lubricant items stocked in ORNL Stores.

As a guide in selecting the proper lubricant to meet a given requirement, the Plant and Equipment Division refers to a lubrication

LUBRICANTS AND CUTTING COOLANTS

1.3 CLASSIFICATION

1.3.1 This data sheet covers a premium grade turbine oil suitable for use in and lubrication of journal and rolling-element bearings, turbines, hydraulic systems, and gears (except hypoid) under nonshock and light to medium load conditions.

3.10 DETAILED REQUIREMENTS

3.10.1 The bidder shall furnish representative typical test data in the space provided opposite the Company's specification value in the following table, or where asked to "please state."

	REQUIREMENT AND TEST	CODE BG	
1.	Nature of Base Oil	Straight Mineral	
2.	Type of Base Oil	Paraffinic	
3.	Oxidation Inhibited	Yes	
4.	Corrosion Inhibited	Yes	
5.	Compounding	None	
6.	Viscosity (ASTM D 88) SSU at 100° F	290 - 325	
	SSU at 210° F	52 - 55	
7.	Viscosity Index (ASTM D 567) Min.	100	
8.	Water and Sediment (ASTM D 96) % Max.	Nil	
9.	Gravity (ASTM D 287) Min.	30	
10.	Color (ASTM D 1500) Max.	2.5	
11.	Flash Point (ASTM D 92) ° F Min.	435	
12.	Fire Point (ASTM D 92) ° F Min.	485	
13.	Pour Point (ASTM D 97) ° F Max.	5	
14.	Carbon Residue (either method)		
	(ASTM D 189) % Max.	0.03	
	(ASTM D 524) % Max.	0.11	
15.	Ash (ASTM D 482) % Max.	Nil	

Fig. 4. Typical Specification For Lubricating Oils

11-AC-1
CODE BG
Page 2 of 2

	REQUIREMENT AND TEST	CODE BG	
16.	Moisture as Emulsion (Karl Fischer) % Max.	0.03	
17.	Sulfur (ASTM D 129) % Max.	0.19	
18.	Corrosion Appearance after 3 hrs. at 210° F		
	(both) Copper (ASTM D 130) Max.	0	
	Steel (ASTM D 66): Distilled Water	Bright	
	Syn. Sea Water	Bright	
19.	Foaming (ASTM D 892) 5 min. blow at 75° F,		
	ml Max.	10	
20.	Precipitation No. (ASTM D 91) Max.	0.00	
21.	Neutralization No. (ASTM D 664) Tan, Max.	0.07	
22.	Oxidation Stability (ASTM D 943) hrs. to		
	Neutralization No. of 2.0	2500	
23.	Emulsion Characteristics (ASTM D 1401)	Please State	
24.	Aniline Point (ASTM D 611)	Please State	
25.	Federal or Military Specification Number	Please State	

Fig. 4 (Cont'd.). Typical Specification For Lubricating Oils

manual.[5] This manual has a series of charts (Fig. 5). Considering the operating conditions such as temperature, vibration, shock, oil filter, oil makeup between changes, operating frequency, drive mechanism, lubrication mechanism, power transmission, and shaft speeds, the proper lubricant may be selected and frequency determined using the above information and the charts.

With the oil shortage and energy problems we are facing, we must take a long-range look at lubricants that will meet future operating requirements.

ASSORTMENT OF LUBRICANTS

To determine the least number of lubricants to adequately perform the required functions has been the aim of the Four-Plant Lubrication Committee and others for many years. As mentioned earlier in this report, ORNL has reduced, through standardization, the number of lubricants in Stores by approximately 42% since the program began. Efforts are continuing in this direction.

Lubricants are assorted into classes but for uniform identification are generally referred to as a particular series. This coded system, developed at Y-12, is in use throughout Union Carbide Corporation - Nuclear Division. The codes, extending from A through Z, describe the lubricants by physical and chemical characteristics rather than by end use. Most codes are now supported by specifications.

The system is coded by grouping similar lubricants and assigning a two letter code (Example: BG) to each series of lubricants. The first letter, "B", describes the general type only; the second letter, "G", describes a particular lubricant for which a specification is prepared and a stores catalog number assigned.[6]

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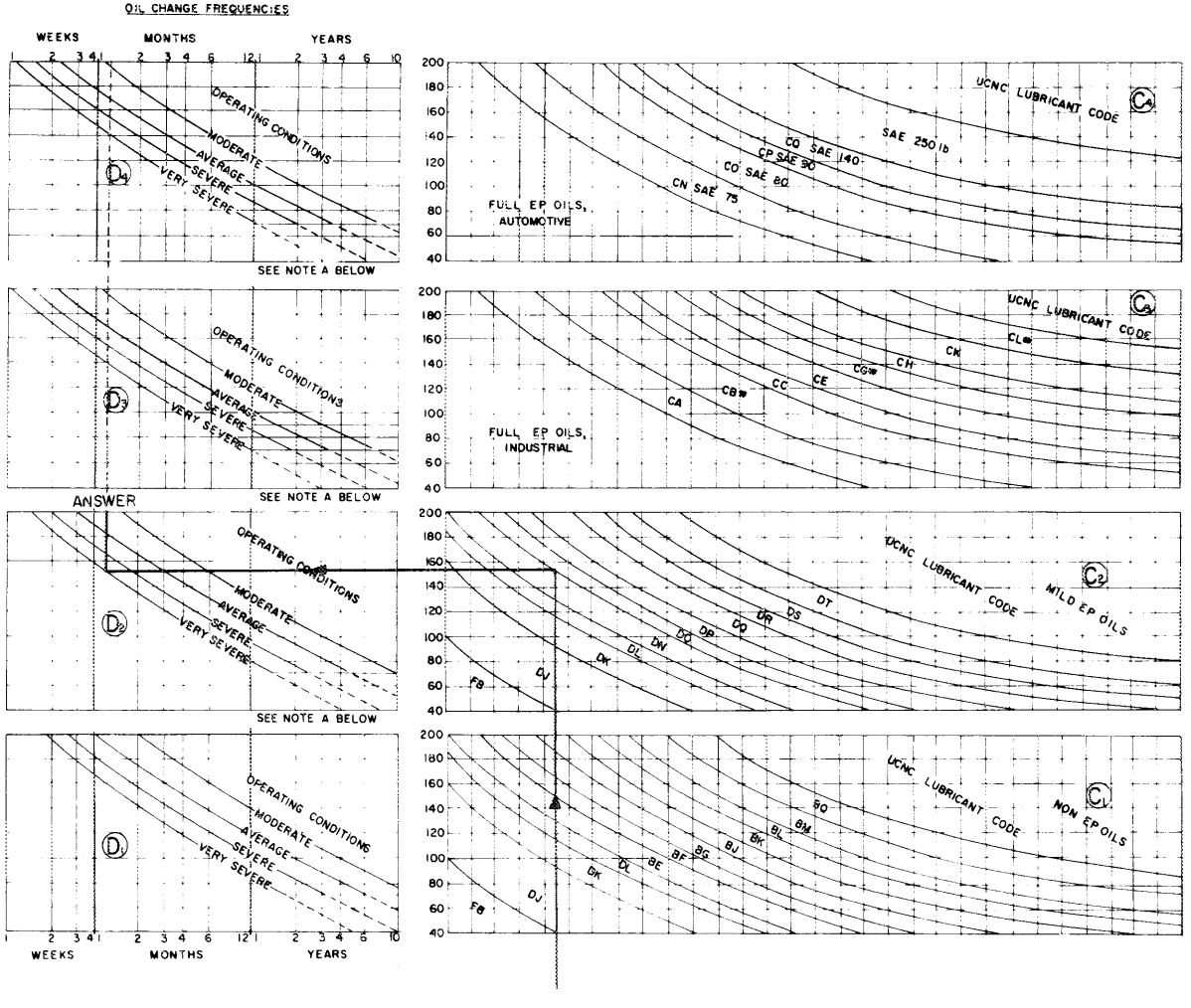
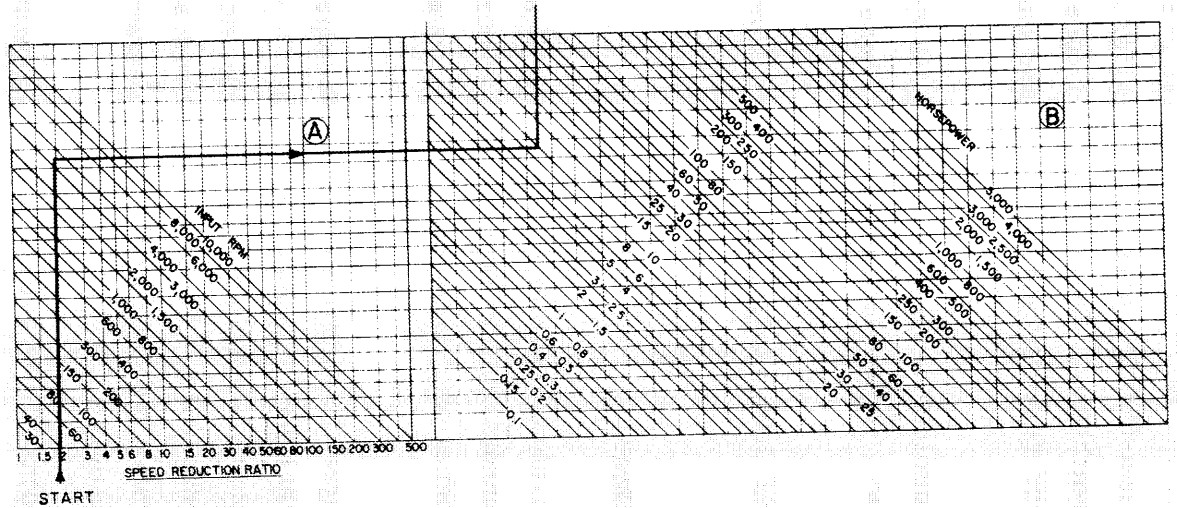
[5] *ORNL Lubrication Manual*, Section 1.3, Lubricant Selection Guides, ORNL-CF-61-1-15.

[6] D. T. Martin, *Planning a Lubrication Program*, Y-12 Plant, Union Carbide Corporation. (Unpublished)

NOTE: Change frequencies are for 24 hour, continuous service.





DIRECTIONS FOR USE OF GUIDE:

1. Determine speed reduction ratio, speed of input shaft, and horsepower from name-plate data. (This guide is applicable for speed reducing gearing and 1:1 gearing only.)
2. Determine the EP rating required from Table 1.2-A. (This determines which C Box will yield the answer.)
3. Estimate the reservoir bulk oil temperature from Figure 5.
4. Determine the operating conditions rating from Table 1.5.
5. Enter bottom of Box A with speed reduction ratio; read up to input rpm; read right into Box B to horsepower; read up into proper Box C (Box C_2 in the example) to reservoir bulk oil temperature; the proper oil for the application is determined at this point. Read left into corresponding Box D to operating conditions rating; read up to top scale of Box D. The proper change frequency is determined at this point. This is the change frequency for 24 hour, continuous service.
6. Multiply the change frequency by the appropriate factor from Table 1.6.

EXAMPLE:
The example shown is for gears with a speed reduction of 2, input shaft speed of 3600 rpm, transmitting 10 HP under very severe operating conditions. From an analysis of the gears it was found that a mild EP oil was required. The proper lubricant for this application is a code DO oil, which should be drained and replaced every 1 1/2 months (Bulk oil temperature was 150°F from Figure 5).

NOTES:

A. If the reservoir bulk oil temperature is 70°F or less, atmospheric dehumidification or dessication is necessary. (Dotted extensions of operating conditions curves, Box D).

B. If the D-Code oil indicated is not stocked in the 4 Plant Stores Catalog, use the equivalent C-Code, or full EP oil for the same bulk oil temperature. If no equivalent C-Code oil can be determined from the chart, call the lubrication engineer. (The D-Code oils stocked are: DH, DJ, DK, DL, and DR.

Gears, Oil Lubricated

STANDARD REFERENCE INFORMATION
UNION CARBIDE NUCLEAR COMPANY
A DIVISION OF UNION CARBIDE CORPORATION
OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE

NUMBER _____
DATE _____
REVISED _____
PAGE _____ OF _____

Fig. 5. Typical Chart From the ORNL Lubrication Manual

The Code BG oil mentioned above is a turbine type with a viscosity of 290-325, SSU at 100°F, rated at SAE-20.

The general groupings of oils are: uninhibited, non-extreme pressure (EP); inhibited, non-EP; strong EP; mild EP, detergent-dispersant; adhesive; and synthesized. The general groupings for greases are: water resistant, non-EP; water soluble, non-EP; EP, with subgroups for water-resistant and water-soluble; and synthetic. There is also a code series which covers various formulations of solid lubricants, grouped under appropriate subheads.[7]

There are approximately 130 lubricants in the Consolidated Stores Catalog covering the four UCC plants. Approximately 50% of these are stocked at ORNL Stores.

To illustrate the assortment of lubricants in Stores stock and their uses, refer to Fig. 6.

PERSONNEL

The keystones to an effective lubrication program are the staff personnel who provide technical, scheduling and service recommendations and the supervisors and craft personnel who carry out these recommendations.

The staff function of this program is administered by the Operations Analysis Department of the Plant and Equipment Division. A group of four people provide the input data for computer programming, scheduling, technical, and service recommendations. In addition, field engineers provide technical assistance to this group based on current operating and design data of the equipment.

The staff group functions as part of the Programmed Maintenance (PM) effort which includes scheduled PM lubrication of equipment. This group functions as follows in the lubrication program:

---

7 *Ibid.*

A maintenance engineer, functioning as a lubrication engineer, is responsible for scheduling and recommendations as to the type of lubricant to meet the application requirements. In making decisions as to the correct lubricant, he uses manufacturer's data, ORNL Lubrication Manual, The Lubrication Engineers Manual, Field Engineers recommendations, and in many instances must rely on judgment and experience. He is in daily contact with the supervisors and craftsmen who are responsible for applying the right lubricant at the right place at the right time and in the right amount. In addition, he serves on the Four-Plant Lubrication Committee which is working toward standardization of lubricants that will effectively serve the desired function and assure maximum service life. This effort will result in a Stores inventory reduction in the number of lubricant items and also a cost savings to the Laboratory. In addition, he is responsible, with draftsman help, for maintaining floor plans of each building with current equipment coding and service routes.

One staff member handles the submission of data to the ORGDP Computer Technology Center (CTC) and updates and transmits the Programmed Maintenance Schedule Cards (Fig. 3) to the proper field supervisor. He is also required to audit equipment to determine if properly lubricated, as scheduled, and to enter new equipment for scheduled service in the programmed maintenance (PM) computerized system. He aids the field supervisor and craftsmen in locating equipment and service points as scheduled by the Programmed Maintenance Schedule Card (Fig. 3). He also assists the Lubrication Engineer as required.

Without the field supervisors, who are responsible for ascertaining that programmed maintenance scheduled for equipment is completed, and the craftsmen who actually perform the work, the lubrication program could not function. Approximately 40 first-line supervisors are directly involved in supervising craftsmen in servicing equipment requiring scheduled lubrication. There is no supervisor assigned to full time programmed maintenance lubrication of equipment.

The craftsmen, supervisors, engineers, scientists and others provide invaluable input data that is necessary to administer effectively a lubrication program at ORNL.

SCHEDULING

Lubrication scheduling is an essential part of preventive maintenance which provides normal servicing of equipment on a periodic schedule. This system prevents minor irregularities from developing into breakdowns that may involve a program shutdown, major repairs or an overhaul. Establishing an effective schedule for equipment which may operate continuously and intermittently is a challenge for lubrication engineers. By obtaining technical data as well as attaining functional knowledge of the use of the equipment, an effective schedule can be established. Most equipment, regardless of frequency of operation, has some point of service that needs lubrication or inspection at least monthly.

Environmental conditions such as heat transferred from other sources, acid fumes, dust or dirt in equipment area, location of equipment (outside or inside), sheltered or unsheltered, condensation or water present from other sources are all factors that must be considered when scheduling lubrication and maintenance of equipment. In most instances, the best way to determine an effective schedule is a physical inspection of the equipment at the site of operation. This inspection will determine the environmental conditions, utilization of the equipment (such as air conditioning, heating or exhaust

LUBRICANTS AND CUTTING COOLANTS
(Assortment by Series and Uses)

SERIES DESCRIPTION	USE
A - Premium Grade Petroleum oil, straight, uninhibited (AB-AY)	A/C and refrigeration compressors, electrical insulation, quencing oil in heat treating, high temperature baths and mechanical vacuum pumps.
B - Premium grade turbine oil, inhibited (BA-BU)	Journal and Roller Element bearings, turbines, hydraulic systems, gears (except hypoid) under nonshock and light to medium load conditions.
C - Premium grade petroleum oil, inhibited, strong extreme pressure (EP) (CA-CT)	Industrial gears subject to severe shock loading, worn and hypoid gears, open gears, power transmission chains, wire rope subject to heavy-duty service, automotive and truck gears, vertical and horizontal slide-ways, apron gears, guides and rails of machine tools in heavy-duty precision service.
D - Petroleum, inhibited, mild EP (DA-DZ)	Steam cylinders, industrial gears under moderate shock loading, wire rope, spindle oil high speed journal and roller element bearings, turbines, hydraulic systems, small electric motors, office machines, dial indicating and recording instruments.
E - Petroleum, inhibited, high detergent dispersant crank-case oil (EA-EP)	Automotive, truck, tractors, and heavy equipment, engines, and diesel engines with or without spark ignition and automatic transmission fluid.
F - Cutting coolants, water type, water soluable preformed chemical emulsion, petroleum base, emulsible water base chemical-type machine fluid. (FA-FU)	General purpose grinding and machining of ferrous and nonferrous metals and heavy duty application.
G - Cutting coolants, non-water type, non-emulsible cutting coolant (GA-GW)	General purpose metal machining use with carbide tipped and high speed cutting tools for coring, drilling, grinding, milling, turning, including screw machining, small high speed diamond point drilling in carbon steels and in forming of nonferrous metals such as aluminum and

Fig. 6. Lubricant Series Stocked in Stores

SERIES DESCRIPTION	USE
G - CONT'D.	magnesium. Fine finish high accuracy grinding of hardened steels, heavy-duty machining of high alloy and stainless steel, including iron base heat resistant and super alloys. Fire resistant and EP.
H - Synthesized fluids, covers an application requiring fire-resistance properties (HA-HZ)	Hydraulic systems, vane-type pumps, elevators, electrical transformers.
I - Speciality Items, Miscellaneous (IA-IG)	Penetrating oil for frozen nuts, bolts, and leather conditioner.
J - Speciality Items, Electrical (JA-JL)	Hydraulic applications under extreme temperature variations, hydraulics dashpot, circuit breakers, electrical potting and lubricating applications.
K - Solid lubricants, dry powder Molybdenum disulfide (KB-KF)	Slides, cams, locks, hinges, instruments, anti-seize compound, splines.
L - Solid lubricants, concentrates, Molybdenum disulfide (LA-LH)	Slides, points, ways, guides, tapping, bearings, galling, seizing, cams, splines, tapers, wedges.
M - Solid lubricants, bonded coating, Molybdenum-disulfide graphite powder (MA-MD)	Louver bearings, joints, slides, cams, valve stems, chains, small gears.
N - Solid lubricants, greases (NA-NC)	Shaft bearings, gears, slides, dies, cams, splines, punches.
O - Solid lubricants, dispersions. These lubricants cover a dispersion of graphite in petroleum oil for lubrication and penetrating applications. (OA-OF)	Small gears, screws, bearings, valve stems, bolts, nuts, splines, joints.
P - Vacuum Fluids, synthetic silicone and hydracarbon fluids. (PB-PT)	Diffusion pumps, ultra-high vacuum systems, optical equipment, fractionating pumps.
Q - Vacuum greases	Stopcock vacuum applications, bell jars, valves, joints.
R - Greases and automotive miscellaneous (RA-RI)	Chassis, wheel bearings, water pumps, cams, brake fluid.
S - Radiation items, greases and oils (SA-SD)	Radiation applications.

Fig. 6 (Cont'd.). Lubricant Series Stocked in Stores

SERIES DESCRIPTION	USE
T - Greases, general multi-purpose (TC-TK)	Roller element bearings, chassis, water resistance gears, universal joints, cams, high temperatures, sealed-for-life bearings and sub-temperatures.
U - Greases, general multi-purpose full EP (UB-UL)	Roller element bearings and packings, universal joints, cams, slides, journal bearings, water pumps.
V - Greases, valves (VB-VZ)	Valves subjected to acids, alkalines, alcohol, chlorine, gasoline, steam, natural gas and hot caustics.
W - Greases, synthesized (WF-WQ)	Roller element bearings, high speed, high temperature, low temperature, precision bearings.
Z - Lubricants, spare parts (ZA-ZO)	Air conditioning system filters.

Fig. 6 (Cont'd.). Lubricant Series Stocked in Stores

systems), and frequency of operation if supporting research programs.

Based on known data and reference to operating and maintenance manuals a schedule is prepared for servicing the equipment. Care has been taken to schedule equipment in a given area at the same time. This action reduces the number of trips made to the area to service minimum numbers of equipment items. Most maintenance lubrication manuals recommend service frequencies based on 8, 16, and 24-hour operation periods. Service frequencies can vary from weekly to a 10-year interval. This situation is illustrated in the following table which shows the code indicating the scheduled frequency that appears on the programmed maintenance Schedule Card, Fig. 3:

CODE	FREQUENCY	CODE	FREQUENCY
W	Every week	2Y	Every 2 years
2W	Every two weeks	3Y	Every 3 years
M	Every month	4Y	Every 4 years
6W	Every 6 weeks	5Y	Every 5 years
2M	Every 2 months	6Y	Every 6 years
3M	Every 3 months	7Y	Every 7 years
4M	Every 4 months	8Y	Every 8 years
6M	Every 6 months	9Y	Every 9 years
8M	Every 8 months	10Y	Every 10 years
Y	Every year	S	Standby - no service scheduled

The programmed maintenance schedule cards are sent to the nine work centers two weeks before scheduled time for lubrication and maintenance service of the equipment. The printing at the top of the card indicates the week for which lubrication has been scheduled for that designated item of equipment (Fig. 3). The time allowed for completion of scheduled service depends on the frequency indicated on the card (Fig. 3). If the card indicates only weekly service, items must be completed on the scheduled day within that week. Monthly items are to be completed in the scheduled week ± five days.

The following table shows the service frequency and the time allowed for completion of the required service.

Scheduled Frequency	Time Allowed For Completion
Weekly	Regular Day Within the Week
2 Weeks	± 2 Days
Monthly	± 5 Days
2 Months	± 8 Days
3 Months	± 2 Weeks
4 Months	± 2 Weeks
6 Months	± 3 Weeks
Yearly	± 4 Weeks

The above schedule is followed unless situations arise that prevent compliance. During a scheduled equipment shutdown, as much normal maintenance will be performed as possible. This effort will not necessarily follow the programmed maintenance schedule.

CONCLUSION

Some form of preventive maintenance has been used in industry for years. The maintenance and operating requirements of a national scientific laboratory are unique. This uniqueness is not altogether from the range of equipment items, but from the fact that a breakdown of equipment may cause loss of valuable scientific data or create potential safety problems.

In adapting programmed maintenance for the Laboratory needs, we believe we have a versatile system. The computer program for the system is written in a manner that any change in data input on the data sheet will automatically be adjusted on the master tape and reflected in the printout sheets and cards. This type of program permits adjustments at any time, and scheduling is automatic.

The lubrication program, as employed through the programmed maintenance system by the Plant and Equipment Division, has been very effective. For its effectiveness to continue, the staff and line personnel must be kept abreast of the latest techniques in methods of application and the proper lubricant to apply for maximum equipment life and efficiency. The familiar grease gun and squirt can will probably stay with us for

many years. However, this method can contribute to over or under lubrication because we are depending entirely on the human element.

The design of modern machines has practically eliminated the hand type of application. The equipment items of today and the future are, and will be, precision-built to operate at much more severe conditions. Satisfactory operation depends on the right lubricant at the right place and in the right amount. Controlled application is essential and requires consideration of the centralized automatic lubrication systems. Some older equipment, which is inadequately designed from a lubrication standpoint, is a fertile field for this type of application.

> *Installing centralized systems on the older equipment should reduce lubrication consumption and increase machine life.*[8]

On the first installations, the before and after costs of centralized system maintenance should be recorded to show improvements in overall cost.[9]

In addition to a need for more centralized automatic systems, the lubrication engineer and others are often required to establish and continue a lubrication frequency schedule of a given item(s) of equipment that may be inadequate. This is especially true of equipment that operates intermittently. To provide a quick check on adequacy of frequency there is a need for invention or development of a portable field instrument that would immediately analyze a lubricant indicating oxidation, viscosity, acidity, water, dielectric strength and certain additives. Through the use of this type of instrument, rather than the present time consuming process of laboratory analysis, much time and money can be saved and will provide the lubrication engineer and others another tool in maintaining an effective lubrication program.

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[8] Charles A. Bailey and Joseph S. Aarons, *The Lubrication Engineers Manual*, United States Steel Corporation, First Edition.

[9] *Ibid.*

An infallible system does not exist. The Plant and Equipment Division, with help from others, is continuing to search for methods and ways to improve the lubrication program. One of the areas for improvement is in the scheduling of manpower to meet the service frequency in the time scheduled for completion. Another area is obtaining more feedback data from field personnel to the programmed maintenance staff group regarding equipment usage, equipment removed from service, new additions and equipment operating conditions. One other problem, and perhaps is the most urgent, is directing more effort toward standardization to reduce the number of lubricants in use, while continuing to maintain an effective lubrication program.

With the continued efforts of the Four-Plant Committee, supervisors, craftsmen, engineers and scientists we will continue to improve the lubrication program at Oak Ridge National Laboratory.

APPENDIX

GLOSSARY OF LUBRICATION TERMS

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A GLOSSARY OF LUBRICATION TERMS

Abrasion—A general wearing away of a surface by constant scratching, usually due to the presence of foreign matter such as dirt, grit, or metallic particles in the lubricant. It may also cause a breaking down of the material (such as the tooth surfaces of gears). Lack of proper lubrication may result in abrasion.

Absolute Viscosity, see **Viscosity**—A term used interchangeably with viscosity to distinguish it from either kinematic viscosity or commercial viscosity. It is occasionally referred to as dynamic viscosity.

Absolute viscosity and kinematic viscosity are expressed in fundamental units. Commercial viscosity such as Saybolt viscosity is expressed in arbitrary units of time, usually seconds.

Acid—In a restricted sense, any substance containing hydrogen in combination with a nonmetal or nonmetallic radical and capable of producing hydrogen ions in solution.

Acidity—In lubricants, acidity denotes the presence of acid-type constituents the concentration of which is usually defined in terms of acid number. The constituents vary in nature and may or may not markedly influence the behavior of the lubricant. (See also **Acid Number.**)

Acid Number. See **Strong Acid Number.** See **Total Acid Number.**

Additive—A chemical compound or compounds added to a lubricant for the purpose of imparting new properties or of enhancing those properties the lubricant already has.

Adhesion—The property of a lubricant that causes it to cling or adhere to a solid surface.

Alkali—Any substance having basic (as opposed to acidic) properties. In a restricted sense it is applied to the hydroxides of ammonium, lithium, potassium and sodium.

Aluminum-Base Grease—A grease prepared from a lubricating oil and an aluminum soap.

Anhydrous—Devoid of water.

Aniline Point—As applied to a petroleum product, the lowest temperature at which the product is completely miscible with an equal volume of freshly distilled aniline.

API Gravity—A gravity scale established by the American Petroleum Institute and in general use in the petroleum industry, the unit being called the "API degree". This unit is defined in terms of specific gravity as follows:

$$\text{Degrees API} = \frac{141.5}{\text{sp. gr. } 60/60°\text{F}} - 131.5$$

Apparent Viscosity—A term used in referring to the resistance to flow of fluids the viscosity of which varies with the rate of shear. It can be evaluated in a capillary type instrument where it is defined as the shear stress at the capillary wall divided by the mean rate of shear as computed from the Poiseuille equation. It is expressed in fundamental viscosity units at a given rate of shear.

Asphaltic—Essentially composed of or similar to asphalt. Frequently applied to lubricating oils derived from crudes which contain asphalt.

Axial-Load Bearing—A bearing in which the load acts in the direction of the axis of rotation.

Ball Bearing—A rolling type bearing containing rolling elements in the form of balls.

Barium Base Grease—A grease prepared from lubricating oil and a barium soap.

Base—In a restricted sense, a compound that yields hydroxyl ions in aqueous solution or one that reacts with an acid to form a salt and water.

Bearing—A support or guide by means of which a moving part is positioned with respect to the other parts of a mechanism.

Black Oils—Any dark colored lubricating oil used for the lubrication of machine parts under exposed conditions.

Bleeding—The tendency of a liquid component to separate from a liquid-solid or liquid-semi-solid mixture; as an oil from a grease.

Block Grease—A grease of moderate dropping point which, under normal temperatures, is firm to the touch and can be handled in block or stick form.

Block Penetration—The penetration at 77F of a grease which is sufficiently hard to hold its shape. (ASTM Designation D 217.)

Blown Oils—Fatty oils, such as rapeseed, whale, or various fish oils, which are artificially thickened by blowing a current of air through them.

Body—A loose term, usually used to designate viscosity or consistency.

GLOSSARY OF LUBRICATION TERMS

Bomb—In lubrication terminology, a closed container used for conducting tests under elevated pressures.

Bone Oil—Fatty oil obtained by the dry distillation of bones.

Boundary Lubrication—A condition of lubrication in which the friction between two surfaces in relative motion is determined by the properties of the surfaces and by the properties of the lubricant other than viscosity.

Bright Stock—A term referring to high-viscosity lubricating oils that have been refined to make them clear products of good color.

Btu—British thermal unit. The amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

Bulk Modulus—The measure of resistance to compressibility of a fluid. It is the reciprocal of the compressibility.

Bushing—A short externally threaded connector with a smaller size internal thread.

Bypass Filtration—A system of filtration in which only a portion of the total flow of a circulating fluid system passes through a filter at any instant or in which a filter having its own circulating pump operates in parallel to the main flow.

Capillarity—A property of a solid-liquid system manifested by the tendency of the liquid in contact with the solid to rise above or fall below the level of the surrounding liquid; this phenomenon is seen in a smallbore (capillary) tube.

Carbon Residue—The residue remaining after the evaporation of a sample of mineral oil under specified conditions.

Ramsbottom method—See ASTM designation D 524.

Conradson method—See ASTM designation D 189 (this method superseded by Ramsbottom method).

Cavitation—A localized gaseous condition within a liquid stream which occurs where the pressure is reduced to the vapor pressure.

Centipoise (cp)—A unit of absolute viscosity. 1 centipoise = 0.01 poise.

Centistoke (cstk)—A unit of kinematic viscosity. 1 centistoke = 0.01 stoke.

Centralized Lubrication—A system of lubrication in which a metered amount of lubricant or lubricants for the bearing surfaces of a machine or group of machines are supplied from a central location.

Cetane Number—A number that expresses the ignition quality of a diesel fuel. It equals the percent by volume of cetane ($C_{16}H_{34}$) in a blend with methyl naphthalene that has the same ignition performance as the test fuel.

C.F.R. Engine—A standard engine employed to determine the octane numbers of motor fuels. Developed by the Cooperative Fuel Research Committee.

Chain Lubrication—A system of lubrication in which a continuous chain is used in a manner similar to an oil ring.

Chemical Stability—The tendency of a substance or mixture to resist chemical change.

Circulating Lubrication—A system of lubrication in which the lubricant, after having passed through a bearing or group of bearings, is recirculated by means of a pump.

Clearance Bearing—A journal bearing in which the radius of the bearing surface is greater than the radius of the journal surface.

Cleveland Open Cup. See **Flash Point, Fire Point.**

Coastal Oil—Naphthenic-type petroleum oil refined from crudes obtained from regions near the Gulf and Pacific Coasts.

Coefficient of Friction—The number obtained by dividing the friction force resisting motion between two bodies by the normal force pressing the bodies together.

Cohesion—That property of a substance that causes it to resist being pulled apart by mechanical means.

Cold Test—As referred to an oil, a test by which the pour point is determined.

Complex Soap Grease—One in which the soap crystals or fibers are formed by the co-crystallization of two compounds: (1) the normal soap and (2) a complexing agent such as water, a salt, or an additive.

Compound—(1) Chemically speaking, a distinct substance formed by the combination of two or more elements in definite proportions by weight and possessing physical and chemical properties different from those of the combining elements.

(2) In petroleum processing, generally connotes fatty oils and similar materials foreign to petroleum added to lubricants to impart special properties.

Compounded Oil—A petroleum oil to which has been added animal or vegetable oil, or other substances.

Compressibility—The change in volume of a unit volume of a fluid when subjected to a unit change of pressure.

Consistency—The degree to which a semisolid material such as grease resists deformation. (See

ASTM designation D 217.) Sometimes used qualitatively to denote viscosity of liquids.

Coolant—A fluid used to remove heat. See **Cutting Fluid.**

Corrosion—Destruction of a metal by chemical or electrochemical reaction with its environment. (Corrosion Handbook.)

Coupling—A straight connector for fluid lines.

Cracking—The process whereby large molecules are broken down by the application of heat and pressure to form smaller molecules.

Crambe Oil—A vegetable oil pressed from the seed of Crambe abyssinica, a member of the Cruciferae family and related to rape and mustard.

Cryogenics—The branch of physics relating to the production and effects of very low temperatures.

Cup Grease—A grease, generally lime base, suitable for use in grease cups.

Cutting Fluid—Any fluid applied to a cutting tool to assist in the cutting operation by cooling, lubricating or other means.

Cutting Oil—A cutting fluid composed either entirely of oil, or oil and additives which are usually oil soluble.

Degras—An animal oil extracted from the skin or wool of sheep.

Demulsibility—The ability of a fluid that is insoluble in water to separate from water with which it may be mixed in the form of an emulsion.

Density—The mass of a unit volume of a substance. Its numerical value varies with the units used.

Detergent—In lubrication, either an additive or a compounded lubricant having the property of keeping insoluble matter in suspension thus preventing its deposition where it would be harmful. A detergent may also redisperse deposits already formed.

Dielectric Strength—A measure of the ability of an insulating material to withstand electric stress (voltage) without failure. Fluids with high dielectric strength (usually expressed in volts or kilovolts) are good electrical insulators. (ASTM Designation D 877.)

Dispersant—In lubrication, a term usually used interchangeably with detergent.

Dissolved Gases—Those gases that enter into solution with a fluid and are neither free nor entrained gases.

Drop-Feed Lubrication—A system of lubrication in which the lubricant is supplied to the bearing surfaces in the form of drops at regular intervals.

Dropping Point (of Grease)—The temperature at which a grease passes from a semisolid to a liquid state under specified test conditions (ASTM Designation D 566.)

Dynamic (Kinetic) Friction—The friction between two surfaces in relative motion. Sometimes called sliding friction or the friction of motion.

Dynamic Viscosity—See **Absolute Viscosity.**

Emulsibility—The ability of a non-water-soluble fluid to form an emulsion with water.

Emulsion—A mechanical mixture of two insoluble liquids as oil and water.

EP (Extreme Pressure) Lubricants—Lubricants that impart to rubbing surfaces the ability of carrying appreciably greater loads than would be possible with ordinary lubricants without excessive wear or damage.

Fat—Originally, a naturally occurring compound of fatty acid and glycerine. Fats can be of animal or vegetable materials or can be made synthetically.

Fatty Acid—An organic acid of aliphatic structure originally derived from fats and fatty oils.

Fatty Oil—A fat that is liquid at room temperature.

Fiber Grease—Grease having a distinctly fibrous structure noticeable when a sample of the grease is pulled apart. Greases having this fibrous structure tend to resist being thrown off gears and out of bearings.

Filler—Any substance, such as talc, mica or various powders, which is added to a grease to increase its weight or consistency.

Filter—Any device or porous substance used as a strainer for cleaning fluids by removing suspended matter.

Fire Point (Cleveland Open Cup)—The temperature to which a combustible liquid must be heated so that the released vapor will burn continuously when ignited under specified conditions (ASTM Designation D 92.)

Fire Resistant Fluid—A fluid, difficult to ignite, that shows little tendency to propagate flame.

Fitted Bearing—A partial journal bearing in which the radius of the bearing surface is the same as the radius of the journal surface.

Fixed Oil—A term frequently used to describe an oil that is difficult to distill without decomposition. Generally applied to fatty oils.

GLOSSARY OF LUBRICATION TERMS

Fixed Pad Bearing—An axial or radial load type of bearing equipped with fixed pads (or lands), the surface of the lands being so contoured as to promote the establishment of a hydrodynamic film.

Flash Point (Cleveland Open Cup)—The temperature to which a combustible liquid must be heated to give off sufficient vapor to form momentarily a flammable mixture with air when a small flame is applied under specified conditions. (ASTM Designation D 92.)

Flexure Pivot—A type of bearing for limited movement in which the moving parts are guided by the flexure of elastic members rather than by rolling or sliding surfaces.

Fluid—A general classification including liquids and gases.

Fluid Friction. Friction due to the viscosity of fluids.

Fluid Power—Energy transmitted and controlled through use of a pressurized fluid.

Force Feed Lubrication—A system of lubrication in which the lubricant is supplied to the bearing under pressure.

Form Oil—An oil used to lubricate wooden or metal concrete forms in order to keep cement from sticking to them.

Fretting—Wear phenomena taking place between two surfaces having oscillatory relative motion of small amplitude.

Fretting Corrosion—Corrosion that results from fretting. Sometimes also called friction oxidation.

Friction—The resisting force encountered at the common boundary between two bodies when, under the action of an external force, one body, moves or tends to move relative to the surface of the other.

Full-Flow Filtration—A system of filtration in which the total flow of a circulating fluid system passes through a filter.

Funk Test—A test used for determining the oxidation resistance of turbine oils. The test is now seldom used.

Galling—A form of wear in which seizing or tearing of the gear or bearing surface occurs.

Gas Oil—A liquid petroleum distillate having a viscosity intermediate between that of kerosene and lubricating oil.

Graphite—A crystalline form of carbon having a laminar structure. It may be of natural or synthetic origin.

Gravity—See **Specific Gravity, API Gravity.**

Grease—A lubricant composed of an oil or oils thickened with a soap, soaps or other thickener to a semisolid or solid consistency.

Gum—A rubber-like, sticky deposit black or dark brown in color resulting from the oxidation of lubricating oils or from unstable constituents in gasoline which deposit during storage or use.

Heavy Duty Oils—A term designating a type of oil having the oxidation stability, bearing corrosion preventive properties, and detergent dispersant characteristics necessary to make it generally suitable for use in both high-speed diesel and gasoline engines under heavy-duty service conditions. (SAE Handbook)

Hydraulic Oil—An oil specially suited for use as either the specific gravity or the API gravity of a liquid.

Hydrodynamic Lubrication—A system of lubrication in which the shape and relative motion of the sliding surfaces causes the formation of a fluid film having sufficient pressure to separate the surfaces.

Hydrometer—An instrument for determining either the specific gravity of a liquid or the API gravity.

Hydrostatic Lubrication—A system of lubrication in which the lubricant is supplied under sufficient external pressure to separate the opposing surfaces by a fluid film.

Hypoid Gear Lubricant—A gear lubricant having extreme pressure characteristics for use with a hypoid type of gear (as in the differential of an automobile). (SAE Handbook)

Imperfect-Film Lubrication—A condition of lubrication in which the lubricant film is not continuous over the bearing area.

Inhibitor—Any substance that slows or prevents such chemical reactions as corrosion or oxidation.

Interfacial Tension (IFT)—The energy per unit area present at the boundary of two immiscible liquids. It is usually expressed in dynes/cm (ASTM Designation D 971.)

Intermediate Base Crude—See **Mixed Base Crude.**

Journal—That part of a shaft or axle that rotates or angularly oscillates in or against a bearing or about which a bearing rotates or angularly oscillates.

Journal Bearing—A sliding type of bearing having either rotating or oscillatory motion and in conjunction with which a journal operates. In a full journal bearing, the bearing surface is 360° in extent. In a partial bearing, the bearing surface is less than 360° in extent, i.e., 150°, 120°, etc.

Kinematic Viscosity—The absolute viscosity of a fluid divided by its mass density. In the English system, the standard unit of kinematic viscosity is the newt and is expressed in in^2/sec. In the cgs system, the standard unit of kinematic viscosity is the stoke and is expressed in cm^2/sec. (See **Viscosity and Absolute Viscosity.**)

Kinetic (Dynamic) Friction—The friction between two surfaces in relative motion. Sometimes called sliding friction or the friction of motion.

Lacquer—A deposit resulting from the oxidation and polymerization of fuels and lubricants when exposed to high temperatures. Similar to, but harder than varnish.

Lard Oil—An animal oil prepared from chilled lard or from the fat of swine.

Lead Naphthenate—A lead soap of naphthenic acids, the latter occurring naturally in petroleum.

Liquid—Any substance that flows readily or changes in response to the smallest influence. More generally, any substance in which the force required to produce a deformation depends on the rate of deformation rather than on the magnitude of the deformation (See **Solid**).

Lime-Base Grease—A grease prepared from a lubricating oil and a lime soap.

Lithium Base Grease—A grease prepared from lubricating oil and a lithium soap.

Lubricant—Any substance interposed between two surfaces in relative motion for the purpose of reducing the friction and/or the wear between them.

Manifold—A conductor that provides multiple connection ports.

Mechanical Lubricator—A mechanical device for supplying lubricant to various parts of a mechanism. With this device, the lubricant is not usually recirculated.

Micron—A millionth of a meter, or 0.0000394 inch.

Mixed Base Crude or **Intermediate Base Crude**—Crude oil, not predominantly paraffinic or naphthenic in character, found in the Mid-Continent and other districts.

Mixed Base Grease—A grease in which the thickening agent or base is generally a mixture of sodium or calcium soaps, although other soaps may be used.

Mold Oil—An oil used to ensure easy parting of a ceramic, glass, metal or other object from the mold in which it is cast. (Also see **Form Oil.**)

Naphthenic Base—A characterization of certain petroleum products prepared from naphthenic-type crudes (crudes containing a high percentage of ring-type aliphatic hydrocarbon molecules).

Neatsfoot Oil—A pale yellow animal oil made from the feet and shinbones of cattle.

Needle Bearing—A rolling type of bearing containing rolling elements that are relatively long compared to their diameter.

Neutralization Number—A term still used in the petroleum industry, but rapidly becoming obsolete in the lubrication field. (See **Acid, Strong Acid, Strong Base, Total Acid,** and **Total Base Numbers.**)

Neutral Oils—Lubricating oils of low or medium viscosity obtained in petroleum distillation and prepared without chemical treatment. They derive their name from the fact that they have not been treated with either an acid or an alkali, but have been purified by simple filtration.

Newt—The standard unit of kinematic viscosity in the English system. Expressed in in^2/sec.

n-Heptane (Normal Heptane)—A hydrocarbon compound (C_7H_{16}) with an octane rating defined as zero and used as a reference fuel ingredient in making motor fuel octane number tests.

Non-Newtonian Fluid—One that does not fall within Newton's mathematical definition of viscosity.

Nonsoap Grease—A product similar to grease in appearance and consistency but containing only heavy residual stocks and mineral oil.

Octane Number—A number indicating the knock rating or resistance to detonation of motor gasoline. It is defined as the percent by volume of iso-octane (C_8H_{18}) in a mixture with n-heptane. The mixture has the same knock rating under standard engine test conditions as the test fuel.

Oil—A greasy, unctuous liquid of vegetable, animal, mineral or synthetic origin.

Oiliness—That property of a lubricant that produces low friction under conditions of boundary lubrication. The lower the friction, the greater the oiliness.

Oil Mist or Fog—An oil atomized with the aid of compressed air and then conveyed by the air in a low-pressure distribution system to multiple points of lubricant application.

Oil Ring—A loose ring, the inner surface of which rides a shaft or journal causing the ring to rotate. The ring dips into a reservoir of lubricant from which it carries lubricant to the top of the shaft for distribution to a bearing.

Organic Acid—An organic compound, with acid properties, obtained from organic substances

such as animal, vegetable and mineral oils; for example, a fatty acid.

Pad Lubrication—A system of lubrication in which the lubricant is delivered to a bearing surface by a pad of felt or similar material.

Paraffin Base—A characterization of certain petroleum products prepared from paraffin-type crudes (crudes containing a high percentage of straight chain aliphatic or paraffin hydrocarbon molecules.)

Partial Bearing—See **Journal Bearing.**

Pedestal Bearing—A bearing which is supported on a column or pedestal rather than on the main body of a machine.

Penetration or Penetration Number—The depth, in tenths of a millimeter, that a standard cone penetrates a semisolid sample under specified conditions. (ASTM Designation D 217.) (See **Worked Penetration.**)

Penetrometer—An instrument for measuring the penetration of semisolid substances.

Pensky-Martens (Closed Cup) Test—A closed cup test for determining the flash point of oils (ASTM Designation D 93.) Used principally for fuel oils.

Petrolatum—A residual mixture of semisolid hydrocarbons composed of microcrystalline and amorphous waxes having an oily or grease-like characteristic.

pH—Term used to express the degree of acidity or alkalinity of aqueous solutions; it denotes the negative logarithm of the concentration of the hydrogen ion in gram atoms per liter. Values of pH run from 0-14, 7 indicating neutrality, numbers less than 7 representing increasing acidity, and numbers greater than 7 increasing alkalinity. Thus, a pH of 6 means a concentration of 10^{-6} or 0.000001, indicating a slight acidity.

Pinion—The smaller of two mating or meshing gears; can be either the driving or the driven gear.

Pivot Bearing—An axial-load, radial-load-type bearing which supports the end of a shaft or pivot (as on the balance wheel of a watch).

Pivoted Pad Bearing—An axial or radial-load type of bearing in which the bearing surface consists of one or more pads or shoes pivoted in such a manner as to permit them to tip and thus promote the establishment of a hydrocarbon film.

Plain Bearing—Any simple sliding type of bearing as distinguished from fixed-pad, pivoted-pad or rolling-type bearings.

Poise—The standard unit of absolute viscosity in the cgs system. Expressed in dyne-sec/cm^2

Polymerization—The chemical combination of similar-type molecules to form larger molecules.

Porous Bearing—A bearing made from porous material, such as compressed metal powders, the pores acting either as reservoirs for holding, or passages for supplying lubricant.

Pour Point—The lowest temperature at which a lubricant will pour or flow under specified conditions. (ASTM designation D 97.)

Precipitation Number—The number of milliliters of solid matter precipitated in a mixture of oil and petroleum solvent under specified conditions. (ASTM Designation D 91.)

Pressure—Force per unit area, usually expressed in pounds per square inch.

Pressure Absolute—The sum of atmospheric and gage pressures.

Pressure Atmospheric—Pressure exerted by the atmosphere at any specific location. (Sea level pressure is approximately 14.7 pounds per square inch absolute.)

Pressure Gage—Pressure differential above or below atmospheric pressure.

Pressure Viscometer (or Viscosimeter)—As applied to grease, a capillary type of instrument used for determining apparent viscosity.

Radial-Load Bearing—A bearing in which the load acts in a radial direction with respect to the axis of rotation.

Rapeseed Oil or Colza Oil—A lubricating oil pressed from rapeseed.

Rate of Shear—The difference between the velocities along the parallel faces of a fluid element divided by the distance between the faces.

Reyn—The standard unit of absolute viscosity in the English system. Expressed in lb-sec/in^2.

Rheopectic Grease—That type of grease manifesting a thickening tendency caused by severe shearing action.

Ring Lubrication—A system of lubrication in which the lubricant is supplied to the bearing by an oil ring.

Roller Bearing—A type of bearing containing rolling elements.

Rust Prevention Test (Turbine Oils)—A test to measure the effectiveness of an oil in preventing the rusting of ferrous parts in the presence of water. (ASTM Designation D 665.)

SAE Numbers-SAE Oil Viscosity Classification—Numbers applied to crankcase, transmission and rear axle lubricants to indicate their viscosity range.

Saponification—A process in which a fat (or other compound of an acid with an alcohol) reacts with an alkali to form a soap and glycerine or other alcohol.

Saponification Number—The number of milligrams of potassium hydroxide required to saponify the fats and/or esters in a 1 gram sample of a given material. (ASTM Designation D 94.)

Saybolt Universal Viscosity (SUV) or Saybolt Universal Seconds, (SUS)—The time in seconds required for 60 cubic centimeters of a fluid to flow through the orifice of the Standard Saybolt Universal Viscometer at a given temperature under specified conditions. (ASTM Designation D 88.)

Saybolt Furol Viscosity—The time in seconds required for 60 cubic centimeters of a fluid to flow through the orifice of a Saybolt Furol Viscometer at a given temperature under specified conditions. (ASTM Designation D 88.) The orifice of the furol viscometer is larger than that of the universal viscometer and is used for more viscous fluids.

Semifluid—Any substance having the attributes of both a liquid and a solid. Similar to a semisolid but being more closely related to a liquid than to a solid.

Semisolid—Any substance having the attributes of both a solid and a liquid. Similar to semiliquid but being more closely related to a solid than a liquid.

More generally, any substance in which the force required to produce a deformation depends both on the magnitude and on the rate of the deformation. (See **Solid, Liquid.**)

Shear Stress—The force per unit area acting tangentially to the surface of an element of a fluid or of a solid.

Shoe-Type Bearing—A pivoted pad bearing of either radial-load or axial-load type.

Sleeve Bearing—A journal bearing, usually a full journal bearing.

Sligh Oxidation Test—A test for determining the oxidation resistance of oils.

Sludge—Insoluble material formed as a result either of deterioration reactions in an oil or of contamination of an oil, or both.

Slushing Oil—An oil- or grease-like material used on metals to form a temporary protective coating against rust, corrosion, etc.

Soap—A compound formed by the reaction of a fatty acid with an alkali.

Soda-Base Grease—A grease prepared from lubricating oil and a sodium soap.

Solid—Any substance having a definite shape which it does not readily relinquish. More generally, any substance in which the force required to produce a deformation depends upon the magnitude of the deformation rather than upon the rate of deformation. (See **Liquid.**)

Soluble Cutting Oil—A mineral oil containing additives that enable it to be easily mixed with water to form a stable emulsion for use as cutting fluid.

Specific Gravity—The ratio of the weight in air of a given volume of a material to the weight in air of an equal volume of water at a stated temperature.

Sperm Oil—A pale-yellow oil obtained from the head cavities and blubber of the sperm whale.

Spindle Oil—A light-bodied oil used principally for lubricating spindles and light, high-speed machinery.

Splash Lubrication—A system of lubrication in which parts of a mechanism dip into and splash the lubricant onto themselves and/or other parts of the mechanism.

Sponge Grease—A soda-base grease differing from the smooth, buttery soda-base greases in that it is more fibrous and sponge-like in structure.

Static Friction—The force just sufficient to initiate relative motion between two bodies under load.

Steam Refined—With reference to lubricating oils, a term applied to unfiltered residual cylinder oils from which the lighter fractions have been distilled by the direct application of steam.

Step Bearing—A plane-surface bearing that supports the lower end of a vertical shaft.

Stick-Slip—A relaxation oscillation usually associated with variation of the coefficient of friction with relative velocity or with duration of static contact. It is also associated with the formation and destruction of interfacial junctions on a microscopic scale.

Stoke—The standard unit of kinematic viscosity in the cgs system. Expressed in cm^2/sec.

Strong Acid Number (SAN)—The quantity of base, expressed in milligrams of potassium hydroxide, required to neutralize the strong acid constituents present in 1 gram of sample. (ASTM Designation D 974.)

Strong Base Number (SBN)—The quantity of acid, expressed in terms of the equivalent number of milligrams of potassium hydroxide, required to neutralize the strong base constituents present in 1 gram of sample. (ASTM Designation D 974.)

Sulphurized Oil—Oil to which sulfur or sulfur compounds have been added.

Surface Tension—The contractile surface force of a liquid by which it tends to assume a spherical form and to present the least possible surface. It is expressed in dynes/cm or ergs/cm^2

Synthetic Lubricant—A lubricant produced by synthesis rather than by extraction or refinement.

Tacky—A descriptive term applied to greases that are particularly sticky or adhesive to metal surfaces.

Tallow—Animal fat prepared from beef and mutton.

Tapered Pad (Land) Bearing—A fixed pad (land) bearing in which the surfaces of the pads are tapered so as to promote the establishment of a hydrodynamic film.

Thief—Device for obtaining samples of liquid from different depths in a tank.

Thin Film Lubrication—A condition of lubrication in which the film thickness of the lubricant is such that the friction between the surfaces is determined by the properties of the surfaces as well as by the viscosity of the lubricant.

Thixotropy—That property of a lubricating grease which is manifested by a softening in consistency as a result of shearing followed by a hardening in consistency starting immediately after the shearing is stopped.

Thrust Bearing—An axial-load bearing.

Total Acid Number (TAN)—The quantity of base, expressed in milligrams of potassium hydroxide, that is required to neutralize all acidic constituents present in 1 gram of sample. (ASTM Designation D 974.)

Total Base Number (TBN)—The quantity of acid, expressed in terms of the equivalent number of milligrams of potassium hydroxide that is required to neutralize all basic constituents present in 1 gram of sample. (ASTM Designation D 974.)

Unctuous—Having a greasy, oily, or soapy feeling when rubbed or touched by the fingers.

Unworked Penetration—The penetration at 77 F of a sample of grease which has received only the minimum handling in transfer to the test apparatus and which has not been subjected to the action of a grease worker. (ASTM Designation D 217.)

Varnish—When applied to lubrication, a deposit resulting from oxidation and polymerization of fuels and lubricants. Similar to but softer than lacquer.

Viscometer or Viscosimeter—An apparatus for determining the viscosity of a fluid.

Viscosity—That property of a fluid, semifluid or semisolid substance that causes it to resist flow. It is defined as the shear stress on a fluid element divided by the rate of shear. The standard unit of viscosity in the English system is the reyn, which has the units of lb-sec/in^2. The standard unit of viscosity in the cgs system is the poise, which has the units of dyne-sec/cm^2. 1 reyn $= 6.895 \times 10^4$ poises.

Viscosity Index (VI)—A commonly used measure of a fluid's change of viscosity with temperature. The higher the viscosity index, the smaller the relative change in viscosity with temperature.

Viscous—Possessing viscosity. Frequently used to imply high viscosity.

VPI—Vapor pressure inhibitor. A corrosion inhibitor in the form of a vapor. Also referred to as VCI (vapor corrosion inhibitor.)

Waste—Any fibrous material such as yarn or textile waste used to supply a lubricant to a bearing through capillary action.

Waste Lubrication—A system of lubrication in which the lubricant is delivered to a bearing surface by cloth waste or yarn.

Wear—The attrition or rubbing away of the surface of a material as a result of mechanical action.

White Oil—Light-colored and usually highly-refined mineral oils frequently employed in medicinal and pharmaceutical preparations, and as a base for creams, salves and ointments. Also used as lubricants.

Wick Lubrication—A system of lubrication in which the lubricant is delivered to a bearing surface by means of a wick.

Wiping—In wear, the smearing or removal of material from one point, often followed by the redeposition of the material at another point, on the surfaces of two bodies in sliding contact.

Wool Oil—A compounded mineral oil, used in the manufacture of woolen cloth to lubricate the wool fiber so that it will suffer a minimum reduction in staple length and will spin easily.

Worked Penetration—The penetration of a sample of lubricating grease immediately after it has been brought to 77 F and then subjected to 60 strokes in a standard grease worker. ASTM Designation D 217.)

Yarn—Any fibrous material, such as wool, twisted into a loose thread and added to greases for special applications. (See also **Waste**.)

Yarn Grease—Cup, sponge, or residuum greases containing strands of wool or cotton yarn.

Yield Value—When applied to a semisolid, the minimum stress necessary to produce continuous deformation.

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