



LUBRICANTS

TECHNICAL HANDBOOK



TABLE OF CONTENTS

Phillips 66 Lubricants Customer Support
– Hotlines and Web Sites 1

How to Obtain Safety Data Sheet (SDS) 2

API Engine Oil Service Categories for Automotive
Diesel Engines 3-6

API Engine Oil Service Categories for Automotive
Gasoline Engines 7-8

API License Marks 9

SAE Viscosity Classifications for Engine Oils and
Automotive Gear Lubricants..... 10

API Service Classifications for Automotive Gear Oils 11

Viscosity Grade Systems 12

ISO/ASTM Viscosity Classifications for Industrial Oils 13

NLGI Grades for Greases/Grease Mixture Compatibility Chart 14

NLGI Service Classifications for Automotive Greases 15

ISO 4406:1999 Oil Cleanliness Standard 16

NSF International Registration for Food-Grade Lubricants 17

Weight-Volume Conversions – API Gravity vs. Specific Gravity 18

Product Loading Compatibility Matrix 19

Glossary 20-35



Phillips 66 Lubricants Customer Support

Lubricants Product Support

To better serve our customers, Phillips 66 Lubricants operates several toll-free "Hotlines." These numbers are available during regular business hours in the United States to assist customers with placing orders, answering technical lubrication questions and/or addressing their specific complaints. Phillips 66 Lubricants customers are encouraged to use these services.

To place orders or to report specific complaints, call the Customer Service Center Hotline, 7:00 a.m. to 6:00 p.m. Central Standard Time, for the appropriate brand at one of the numbers listed below:

U.S. Customer Service: 1-800-368-7128

International Customer Service: 1-832-765-2500

E-mail address: phillips66lubricants@p66.com

For technical services inquiries or lubricant product recommendations, call the Technical Support Hotline, 7:00 a.m. to 6:00 p.m. Central Standard Time, at the number listed below:

Phillips 66 Lubricants: 1-877-445-9198

Phillips 66 Lubricants Web Site:

<http://www.phillips66lubricants.com>

Phillips 66 Aviation Web Site:

<http://www.phillips66aviation.com>



LUBRICANTS

How to Obtain Safety Data Sheet (SDS)

To comply with OSHA's Worker's Right-To-Know regulation, Phillips 66 maintains a comprehensive file of OSHA Safety Data Sheets (SDS) for all Phillips 66 lubricants. To obtain an SDS on a Phillips lubricant, contact:

Phillips 66 Lubricants SDS

SDS Web Site:

<http://www.phillips66.com/EN/products/Pages/MSDS.aspx>

SDS Hot Line:

1-800-762-0942

Phillips 66 Lubricants:

1-877-445-9198



API Engine Oil Service Categories for Automotive Diesel Engines

The following descriptions of the categories in the API Engine Service Classification System are intended as guides to aid in the selection of proper engine oils for significantly different engine service conditions. The performance requirements for these categories are technically described in SAE J183 MAR2006 Standard, Engine Oil Performance and Engine Service Classification (other than “Energy Conserving”).

“C” – COMMERCIAL (Fleets, Contractors, Farmers, etc.)

CF-4 – 1990 Diesel Engine Service (Obsolete)

Service typical of high-speed, 4-stroke cycle diesel engines. API CF-4 oils exceed the requirements for the API CE category, providing improved control of oil consumption and piston deposits. These oils should be used in place of API CE oils. They are particularly suited for on-highway, heavy-duty truck applications. When combined with the appropriate “S” category, they also can be used in gasoline and diesel powered personal vehicles – i.e., passenger cars, light trucks and vans – when recommended by the vehicle or engine manufacturer.

CF-2 – 2-Stroke Cycle Diesel Engine Service (Obsolete)

Service typical of 2-stroke cycle diesel engines requiring highly effective control of wear and deposits. Oils designed for this service have been in existence since 1994 and also may be used when API Service Category CD-II is recommended. These oils do not necessarily meet the requirements of API CF or CF-4, unless these oils have specifically met the performance requirements of these categories.



CF – For Off-Road Indirect Injected Diesel Engine Service (Obsolete)

Service typical of off-road indirect injected diesel engines and other diesel engines that use a broad range of fuel types, including those using fuel with higher sulfur content (>0.5% by weight). Effective control of piston deposits, wear and corrosion of copper containing bearings is essential for these engines, which may be naturally aspirated, turbocharged or supercharged. Oils designated for this service have been in existence since 1994. Oils designated for this service also may be used when API Service Category CD is recommended.

CH-4 – For 1998 Severe Duty Diesel Engine Service (Current)

API Service Category CH-4 oils are suitable for high-speed, 4-stroke diesel engines designed to meet 1998 exhaust emissions standards. CH-4 oils are specifically compounded for use with diesel fuels ranging in sulfur content up to 0.5% by weight. CH-4 oils are superior in performance to those meeting API CF-4 and API CG-4 and can effectively lubricate engines calling for those API Service Categories.

CI-4 – 2002 Severe-Duty Diesel Engine Service (Current)

The API CI-4 Service Category describes oils for use in those high-speed, 4-stroke cycle diesel engines designed to meet 2004 exhaust emission standards, to be implemented October 2002. These oils are compounded for use in all applications with diesel fuels ranging in sulfur content up to 0.05% by weight. These oils are especially effective at sustaining engine durability where Exhaust Gas Recirculation (EGR) and other exhaust emission componentry may be used. Optimum protection is provided for control of corrosive wear tendencies, low- and high-temperature stability, soot-handling properties, piston deposit control, valvetrain wear, oxidative thickening, foaming and viscosity loss due to shear. API CI-4 oils are superior in performance to those meeting API CH-4, CG-4 and CF-4 and can effectively lubricate engines calling for those API Service Categories.



CI-4 PLUS – 2004 Severe-Duty Diesel Engine Service

API Service Category CI-4 engine oils that also carry the classification CI-4 PLUS are formulated to provide a higher level of protection against soot-related viscosity increase and viscosity loss due to shear in vehicles powered by diesel engines. Starting Sept. 1, 2004, oils that meet the requirements of CI-4 PLUS and are properly licensed may display “CI-4 PLUS” in the lower portion of the API Service Symbol in conjunction with API Service Category CI-4 in the upper portion. Oils that meet CI-4 PLUS requirements are superior in performance to those meeting API CI-4, CH-4, CG-4 and CF-4 and can effectively lubricate engines calling for those API Service Categories.

CJ-4 – 2007 Severe-Duty Diesel Engine Service

API Service Category CJ-4 describes oils for use in high-speed, 4-stroke cycle diesel engines designed to meet 2007 model-year on-highway exhaust emission standards, as well as for previous model years. These oils are compounded for use in all applications with diesel fuels ranging in sulfur content up to 500 ppm (0.05% by weight). However, use of these oils with greater than 15 ppm (0.0015% by weight) sulfur fuel may impact exhaust after treatment system durability and/or oil drain interval. These oils are effective at sustaining emission control system durability where particulate filters and other advanced after treatment systems are used. Optimum protection is provided for control of catalyst poisoning, particulate filter blocking, engine wear, piston deposits, low- and high-temperature stability, soot handling properties, oxidative thickening, foaming, and viscosity loss due to shear. API CJ-4 oils exceed the performance criteria of API CI-4 with CI-4 PLUS, CI-4, CH-4, CG-4 and CF-4 and can effectively lubricate engines calling for those API Service Categories. When using CJ-4 oil with higher than 15 ppm sulfur fuel, consult the engine manufacturer for service interval.

CK-4 (Most Current)

API CK-4 oils are especially effective at sustaining emission control system durability where particulate filters and other advanced after treatment systems are used. API CK-4 oils are designed to



provide enhanced protection against oil oxidation, viscosity loss due to shear, and oil aeration as well as protection against catalyst poisoning, particulate filter blocking, engine wear, piston deposits, degradation of low- and high-temperature properties, and soot-related viscosity increase.

API CK-4 oils exceed the performance criteria of API CJ-4, CI-4 with CI-4 PLUS, CI-4, and CH-4 and can effectively lubricate engines calling for those API Service Categories. When using CK-4 oil with higher than 15 ppm sulfur fuel, consult the engine manufacturer for service interval recommendations.

FA-4 (Most Current)

API FA-4 oils are blended to a high temperature high shear (HTHS) viscosity range of 2.9cP-3.2cP to assist in reducing GHG emissions. These oils are especially effective at sustaining emission control system durability where particulate filters and other advanced after treatment systems are used. API FA-4 oils are designed to provide enhanced protection against oil oxidation, viscosity loss due to shear, and oil aeration as well as protection against catalyst poisoning, particulate filter blocking, engine wear, piston deposits, degradation of low- and high-temperature properties, and soot' related viscosity increase.

API FA-4 oils are neither interchangeable nor backward compatible with API CK-4, CJ-4, CI-4 with CI-4 PLUS, CI-4, and CH-4 oils. Refer to engine manufacturer recommendations to determine if API FA-4 oils are suitable for use. API FA-4 oils are not recommended for use with fuels having greater than 15 ppm sulfur. For fuels with sulfur contents greater than 15 ppm, refer to engine manufacturer recommendations.



API Engine Oil Service Categories for Automotive Gasoline Engines

The following descriptions of the categories in the API Engine Service Classification System are intended as guides to aid in the selection of proper engine oils for significantly different engine service conditions. The performance requirements for these categories are technically described in the SAE J183 (Rev. MAR2006) Standard, *Engine Oil Performance and Engine Service Classification (other than "Energy Conserving")*.

"S" – SERVICE STATION

(Service Stations, Garages, New Car Dealers, etc.)

SL – 2001 Gasoline Engine Warranty Maintenance Service (Active)

API Service Category SL was adopted to describe engine oils for use in 2001. These oils are for use in service typical of gasoline engines in present and earlier passenger cars, sport utility vehicles, vans and light trucks operating under vehicle manufacturers' recommended maintenance procedures. Oils meeting API Service Category SL requirements have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing. These oils may be used where API Service Category SJ and earlier categories are recommended.

SM – 2005 Gasoline Engine Warranty Maintenance Service (Current)

API Service Category SM was adopted to describe engine oils available for use in 2004. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans and light trucks operating under vehicle manufacturers' recommended maintenance procedures. Oils meeting API Service Category SM requirements have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing. These oils may be used where API Service Category SL and earlier S categories are recommended.



SN – 2011 Gasoline Engine Warranty Maintenance Service (Most Current)

API Service Category SN was adopted to describe engine oils available for use in 2011. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans and light trucks operating under vehicle manufacturers' recommended maintenance procedures. Oils meeting API Service Category SN requirements have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing. These oils may be used where API Service Category SM and earlier S categories have been recommended.

ILSAC GF Categories

The International Lubricant Standardization and Approval Committee (ILSAC) is a joint activity of the American Automobile Manufacturers Association (AAMA) and the Japan Automobile Manufacturers Association Inc. (JAMA). ILSAC issued its first minimum performance standard for gasoline-fueled passenger cars, ILSAC GF-1, in 1990. This standard listed the performance requirements and chemical and physical properties deemed necessary by vehicle manufacturers for satisfactory equipment life and performance. This standard has been upgraded as OEM requirements change: ILSAC GF-2 was issued in November 1995; ILSAC GF-3, coinciding with the introduction of API Service Category SL, became effective July 1, 2001; ILSAC GF-4, coinciding with the introduction of API Service Category SM, became official July 31, 2004; and ILSAC GF-5, coinciding with API Service Category SN, became official October 1, 2010.



API License Marks

API licenses two types of Marks: the API Service Symbol, or “donut” logo (Figure 1), and the API Certification Mark, or “starburst” symbol (Figure 2). The API Service Symbol indicates a licensed oil’s performance properties based on the alphanumeric system of API Service Categories and, if applicable, the Energy Conserving designation. The API Certification Mark identifies oils meeting ILSAC minimum performance standards. The API Certification Mark does not change as improvements are made to oil performance standards. Annual licenses for the API Certification Mark are issued only for engine oils that meet the current ILSAC performance requirements.



Figure 1 – API Service Symbol



Figure 2 – API Certification Symbol

Oils designated as energy conserving are formulated to improve the fuel economy of passenger cars, sport utility vehicles, vans and light trucks powered by gasoline engines. These oils have produced a fuel economy improvement in the Sequence VIB (current) test when compared with the standard reference oil. The fuel economy obtained by individual vehicle operators using these oils may differ because of many factors, including the type of vehicle and engine, the mechanical condition and maintenance of the engine, operating conditions, and driving habits.



SAE Viscosity Classifications for Engine Oils and Automotive Gear Lubricants

SAE VISCOSITY GRADES FOR ENGINE OILS ⁽¹⁾⁽²⁾ (SAE J300 JANUARY 2015)

SAE Viscosity Grade	Low-Temperature (°C) Cranking Viscosity ⁽³⁾ , cP Max.	Low-Temperature (°C) Pumping Viscosity ⁽⁴⁾ , cP Max. With No Yield Stress ⁽⁴⁾	Low-Shear-Rate Kinematic Viscosity ⁽⁵⁾ , cSt at 100°C Min.	Low-Shear-Rate Kinematic Viscosity ⁽⁵⁾ , cSt at 100°C Max.	High-Shear-Rate Viscosity ⁽⁶⁾ , (cP) at 150°C Min.
0W	6,200 at -35	60,000 at -40	3.8	–	–
5W	6,600 at -30	60,000 at -35	3.8	–	–
10W	7,000 at -25	60,000 at -30	4.1	–	–
15W	7,000 at -20	60,000 at -25	5.6	–	–
20W	9,500 at -15	60,000 at -20	5.6	–	–
25W	13,000 at -10	60,000 at -15	9.3	–	–
16	–	–	6.1	<8.2	2.3
20	–	–	5.6	<9.3	2.6
30	–	–	9.3	<12.5	2.9
40	–	–	12.5	<16.3	3.5 (0W-40, 5W-40 and 10W-40 grades)
40	–	–	12.5	<16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades)
50	–	–	16.3	<21.9	3.7
60	–	–	21.9	<26.1	3.7

⁽¹⁾ Note: 1 cP = 1 mPa.s; 1 cSt = 1 mm²/s.

⁽²⁾ All values, with the exception of the low-temperature cranking viscosity, are critical specifications as defined by ASTM D3244 (see text, Section 3).

⁽³⁾ ASTM D5293: Cranking viscosity - The non-critical specification protocol in ASTM D3244 shall be applied with a P value of 0.95.

⁽⁴⁾ ASTM D4684. Note that the presence of any yield stress detectable by this method constitutes a failure regardless of viscosity.

⁽⁵⁾ ASTM D445.

⁽⁶⁾ ASTM D4683, CEC L-36-A-90 (ASTM D4741), or ASTM D5481.

AUTOMOTIVE GEAR LUBRICANT VISCOSITY CLASSIFICATION (SAE J306 JUNE 2005)

SAE Viscosity Grade	Maximum Temperature (°C) for Viscosity of 150,000 cP ⁽¹⁾⁽²⁾	Kinematic Viscosity at 100°C, cSt ⁽³⁾	
		Minimum ⁽⁴⁾	Maximum
70W	-55(5)	4.1	–
75W	-40	4.1	–
80W	-26	7.0	–
85W	-12	11.0	–
80	–	7.0	<11.0
85	–	11.0	<13.5
90	–	13.5	<18.5
110	–	18.5	<24.0
140	–	24.0	<32.5
190	–	32.5	<41.0
250	–	41.0	–

Notes: 1 cP=1mPa.s; 1 cSt=1 mm²/s

⁽¹⁾ Using ASTM 02983

⁽²⁾ Additional low-temperature viscosity requirements may be appropriate for fluids intended for use in light-duty synchronized manual transmission.

⁽³⁾ Using ASTM 0445.

⁽⁴⁾ Limit also must be met after testing in CEC L-45-T-93. Method C (20 hours).

⁽⁵⁾ The precision of ASTM 02983 has not been established for determinations made at temperatures below -40°C. This fact should be taken into consideration in any producer-consumer relationship.

SAE Standard J306 is intended for use by equipment manufacturers in defining and recommending automotive gear, axle and manual transmission lubricants. The SAE viscosity grades shown in the Table constitute a classification in rheological terms only. This classification is based on the lubricant viscosity measured at both high and low temperatures.

Automotive gear lubricant SAE viscosity grades should not be confused with engine oil SAE viscosity grades. A gear lubricant and an engine oil having the same viscosity will have widely different SAE viscosity grade designations as defined by SAE J306 and SAE J300, respectively. For example, an SAE 90 gear lubricant viscosity can be similar to that of an SAE 40 or SAE 50 engine oil (see Chart on Page 3).



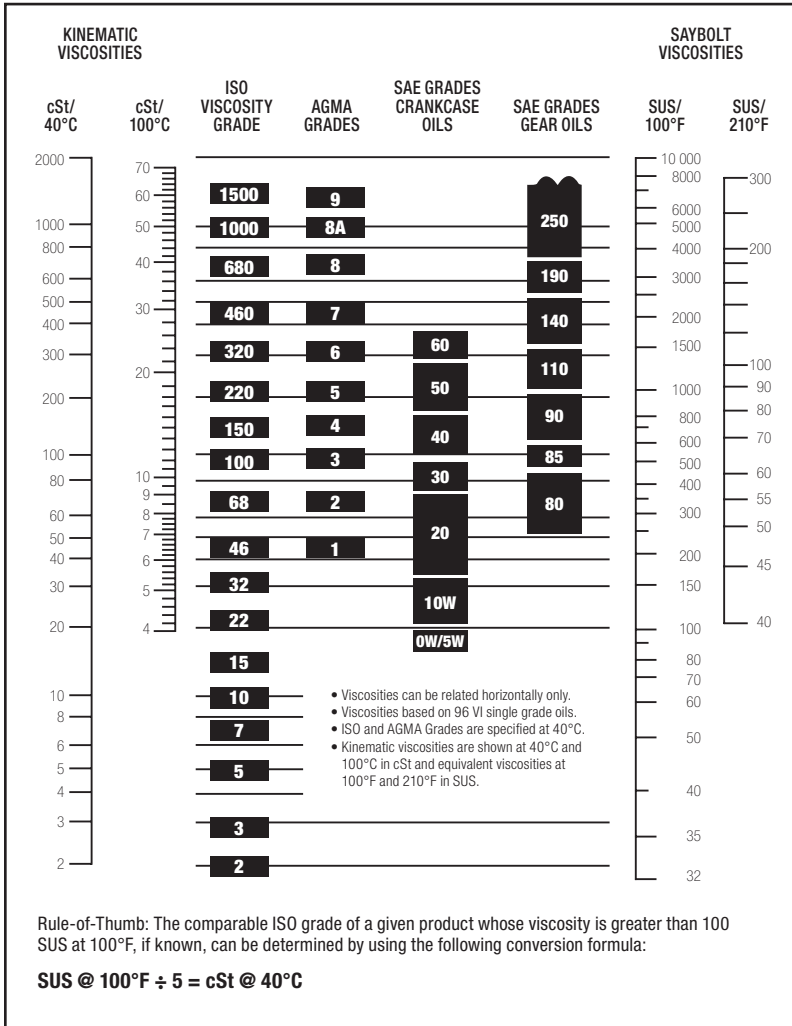
API Service Classifications for Automotive Gear Oils

Classifications	Type	Typical Application
GL-1 (Inactive)	Straight mineral oil	Some manual transmissions (tractors and trucks)
GL-2 (Inactive)	Usually contains fatty materials	Worm gear drives, industrial gear oils
GL-3 (Inactive)	Contains mild EP additive	Manual transmissions and spiral bevel final drives (GL-3 not widely used)
GL-4 (Current) (See Footnote)	Equivalent to obsolete MIL-L-2105 Specification. Usually satisfied by 50% GL-5 additives level	Manual transmissions, spiral bevel and hypoid gears where moderate service prevails
GL-5 (Current)	Equivalent to present MIL-L-2105D Specification. Primary field service recommendation of most passenger car and truck builders worldwide	Used for moderate and severe service in hypoid and all other types of gears. Also may be used in manual transmissions
GL-6 (Obsolete)	Technically obsolete. Same performance as Ford M2C105A (still in use for Ford light trucks)	Typically recommended in service conditions where more anticorrosion protection is required than provided by GL-5 lubes
MT-1 (Most Current)	Addresses thermal degradation, component wear and oil seal deterioration, which is not provided by lubricants meeting only the requirements of API GL-1 through GL-5	Non-synchronized manual transmissions in buses and heavy-duty trucks

**While the GL-4 service designation still is used commercially to describe lubricants, some test equipment used for performance verification is no longer available. SAE is reviewing the performance requirements of this category.*



Viscosity Grading Systems





ISO/ASTM Viscosity Classifications for Industrial Oils

Viscosity Ranges for ISO and ASTM Systems

ISO Viscosity Grade	Mid-Point Kinematic Viscosity	Kinematic Viscosity Limits cSt at 40°C (104°F)		ASTM, Saybolt Viscosity Number	Saybolt Viscosity SUS 100°F (37.8°C)	
		Min.	Max.		Min.	Max.
2	2.2	1.98	2.42	32	34.0	35.5
3	3.2	2.88	3.52	36	36.5	38.2
5	4.6	4.14	5.06	40	39.9	42.7
7	6.8	6.12	7.48	50	45.7	50.3
10	10	9.00	11.0	60	55.5	62.8
15	15	13.5	16.5	75	72	83
22	22	19.8	24.2	105	96	115
32	32	28.8	35.2	150	135	164
46	46	41.4	50.6	215	191	234
68	68	61.2	74.8	315	280	345
100	100	90.0	110	465	410	500
150	150	135	165	700	615	750
220	220	198	242	1000	900	1110
320	320	288	352	1500	1310	1600
460	460	414	506	2150	1880	2300
680	680	612	748	3150	2800	3400
1000	1000	900	1100	4650	4100	5000
1500	1500	1350	1650	7000	6100	7500



NLGI Grades for Greases/Grease Mixture Compatibility Chart

NLGI ⁽¹⁾ Grade No.	Penetration, ASTM ⁽²⁾	Description and Typical Use
000	445-475	Semifluid; Centralized Systems
00	400-430	Semifluid; Centralized Systems
0	355-385	Semifluid; Centralized Systems
1	310-340	Very Soft; Grease Guns or Centralized Systems
2	265-295	Soft; Grease Guns or Centralized Systems
3	220-250	Light; Grease Guns
4	175-205	Medium; Pressure Guns
5	130-160	Heavy; Grease Cups
6	85-115	Block; Open Grease Cellars

⁽¹⁾ National Lubricating Grease Institute

⁽²⁾ Worked Penetration at 25°C (77°F), 60 strokes, ASTM D217

Grease Mixture Compatibility Chart

	Aluminum Complex	Barium	Bentonite Clay	Calcium 12-Hyd.	Calcium Complex	Calcium Sulfonate	Lithium 12-Hyd.	Lithium Complex	Polyurea	Polyurea EP	Silica Gel	Sodium
Aluminum Complex	C	I	I	C	I	I	I	I	I	I	I	I
Barium	I	C	I	C	I	I	I	I	I	I	I	I
Bentonite Clay	I	I	C	C	I	I	I	I	I	I	I	I
Calcium 12-Hydroxy	C	C	C	C	I	C	C	C	I	I	I	I
Calcium Complex	I	I	I	I	C	C	I	C	C	I	I	I
Calcium Sulfonate	I	I	I	C	C	C	C	C	C	I	I	I
Lithium 12-Hydroxy	I	I	I	C	I	C	C	C	I	I	I	I
Lithium Complex	I	I	I	C	C	C	C	C	I	I	I	I
Polyurea	I	I	I	I	C	C	I	I	C	C	I	I
Polyurea EP	I	I	I	I	I	I	I	I	C	C	I	I
Silica Gel	I	I	I	I	I	I	I	I	I	I	C	I
Sodium	I	I	I	I	I	I	I	I	I	I	I	C

I = Incompatible

C = Compatible

Note: This chart is meant only to serve as a guideline for determining compatibility. For the purpose of changing products in the field, the compatibility of the greases in question should be determined by laboratory testing.



NLGI Service Classification for Automotive Grease

SERVICE CATEGORY “L” CHASSIS GREASES

LA Mild duty

For the lubrication of chassis components and universal joints operating under mild conditions with frequent relubrication (2,000 miles or less).

LB Mild-to-severe duty

For the lubrication of chassis components and universal joints subject to heavy loads or water exposure, and operating at temperatures ranging from -40°F to 248°F with relubrication intervals greater than 2,000 miles.

SERVICE CATEGORY “G” WHEEL BEARING GREASES

GA Mild duty

For the lubrication of wheel bearings over a limited temperature range.

GB Moderate duty

For the lubrication of wheel bearings over a wide temperature range, where bearing temperatures may range down to -40°F, with frequent excursions to 248°F and occasional excursions to 320°F. Typical of vehicles operated under normal highway service.

GC Severe duty

For the lubrication of wheel bearings over a wide temperature range, where bearing temperatures may range down to -40°F, with frequent excursions to 320°F and occasional excursions to 392°F. Typical of vehicles operated under frequent stop-and-go service (buses, taxis, etc.) or under severe braking service (trailer towing, mountain driving, etc.)

Greases tested in accordance with ASTM D4950.



ISO 4406:1999 Oil Cleanliness Standard

Range Number	Number of Particles per ml Greater Than	Number of Particles per ml Up to and Including
30	5,000,000	10,000,000
29	2,500,000	5,000,000
28	1,300,000	2,500,000
27	640,000	1,300,000
26	320,000	640,000
25	160,000	320,000
24	80,000	160,000
23	40,000	80,000
22	20,000	40,000
21	10,000	20,000
20	5,000	10,000
19	2,500	5,000
18	1,300	2,500
17	840	1,300
16	320	840
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64

The ISO 4406:1999 Cleanliness Code references the number of particles greater than 4, 6 and 14 microns in each milliliter of fluid. A corresponding cleanliness code, such as 18/15/13, is then given to the fluid. For particle concentration that fall between two adjacent particle concentration, the higher range is used.



NSF International Registration for Food-Grade Lubricants

(Formerly USDA/FDA Food Safety Inspection Service)

As of Sept. 30, 1998, the U.S. Department of Agriculture (USDA) Food Safety Inspection Service (FSIS) discontinued listing and certification of food-grade lubricants for use in the food processing industry. The absence of this listing created a void in the industry which necessitated action by inspectors who manage the risk of chemical hazards.

In 1999, NSF International (www.nsf.org/usda) initiated the NSF Nonfood Compounds Registration and Listing Program to fill the void created by the USDA. Those products that were formally approved prior to that date and are listed in the USDA's 1998 publication, "List of Proprietary Substances and Nonfood Compounds," can now be registered with NSF and listed under "H1, H2 or H3 Approved Grades."

For further information on which Phillips 66 products are listed with NSF International, please contact your Hot Line consultant.



Weight-Volume Conversions – API Gravity vs. Specific Gravity

ASTM D287/ANSI Z11.31*

Conversion Formula: $API = \frac{141.5}{SG} - 131.5$

Table Showing Gravity Conversions, Weights and Heating Values of Oils Used for Fuels

Degrees API at 60°F	Specific Gravity at 60°F	Pounds Per Gallon at 60°F	Gallons Per Pound at 60°F	BTU Per Pound	BTU Per Gallon
0	1.0760	8.962	.1116		
1	1.0679	8.895	.1124		
2	1.0599	8.828	.1133		
3	1.0520	8.762	.1141	18,190	159,300
4	1.0443	8.698	.1150	18,240	158,500
5	1.0366	8.634	.1158	18,290	157,800
6	1.0291	8.571	.1167	18,340	157,100
7	1.0217	8.509	.1175	18,390	156,300
8	1.0143	8.448	.1184	18,440	155,300
9	1.0071	8.388	.1192	18,490	155,100
10	1.0000	8.328	.1201	18,540	154,600
11	.9930	8.270	.1209	18,590	153,900
12	.9861	8.212	.1218	18,640	153,300
13	.9792	8.155	.1226	18,690	152,600
14	.9725	8.099	.1235	18,740	152,000
15	.9659	8.044	.1243	18,790	151,300
16	.9593	7.989	.1252	18,840	150,700
17	.9529	7.935	.1260	18,890	150,000
18	.9465	7.882	.1269	18,930	149,400
19	.9402	7.830	.1277	18,980	148,800
20	.9340	7.778	.1286	19,020	148,100
21	.9279	7.727	.1294	19,060	147,500
22	.9218	7.676	.1303	19,110	146,800
23	.9159	7.627	.1311	19,150	146,200
24	.9100	7.578	.1320	19,190	145,600
25	.9042	7.529	.1328	19,230	145,000
26	.8984	7.481	.1337	19,270	144,300
27	.8927	7.434	.1345	19,310	143,700
28	.8871	7.387	.1354	19,350	143,100
29	.8816	7.341	.1362	19,380	142,500
30	.8762	7.296	.1371	19,420	141,800
31	.8708	7.251	.1379	19,450	141,200
32	.8654	7.206	.1388	19,490	140,600
33	.8602	7.163	.1396	19,520	140,000
34	.8550	7.119	.1405	19,560	139,400
35	.8498	7.076	.1413	19,590	138,800
36	.8448	7.034	.1422	19,620	138,200
37	.8398	6.993	.1430	19,650	137,600
38	.8348	6.951	.1439	19,680	137,000
39	.8299	6.910	.1447	19,720	136,400
40	.8251	6.870	.1456	19,750	135,800
41	.8203	6.830	.1464	19,780	135,200
42	.8155	6.790	.1473	19,810	134,700
43	.8109	6.752	.1481	19,830	134,100
44	.8063	6.713	.1490	19,860	133,500
45	.8017	6.675	.1498	19,890	132,900

*ASTM D1298 and ASTM D287 are the international versions, similar to ASTM D287, but they include non-petroleum products, too. International tables are employed to convert from one system to another.



Product Loading Compatibility Matrix

Instructions: Find the column across the top of the chart for the product to be loaded next (bulk transports, tanks & vessels) and then read down to the row for the previous product loaded as listed in the left-hand column. A “Yes” in the box indicates that the product can be loaded without cleaning. A “No” indicates that the compartment must be cleaned with a compatible material prior to loading (typically clear diesel, but not biodiesel). Please consider all footnotes indicated. **Transports must be completely drained prior to loading regardless of the compatibility classification. Special instructions or procedures must be adopted at all times in handling respective products through the entire supply chain, including product receiving, storing/packaging and delivering to the end customer.**

Previous Product ⁽⁶⁾ ↓	Product To Be Loaded Next →												
	Base Oil	Engine Oil, SAE 0W-20	Engine Oil, All Other Grades	ATF	Off-Road Trans Fluid	Ashless Engine Oil (zinc-free)	Automotive Gear Oil	Industrial Gear Oil	Ashless Hydraulic Oil & R&O Oil	AW Oil (w/zinc)	Turbine Oil (except Diamond Class & Ultra-Clean Oil)	Diamond Class® & Ultra-Clean Oil	Emulsifiable / EP Oil
Ethanol	No	No	No	No	No	No	No	No	No	No	No	No ⁽⁵⁾	No
Clear Diesel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No ⁽⁵⁾	Yes
Dyed Diesel (not Biodiesel)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No ⁽⁵⁾	Yes
Biodiesel	No	No	No	No	No	No	No	No	No	No	No	No ⁽⁵⁾	No
Base Oil	Yes	Yes	Yes	Yes ⁽¹⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No ⁽⁵⁾	Yes
Engine Oil, SAE 0W-20	No	Yes	Yes ⁽²⁾	No	Yes	No	No	No	No	No	No	No ⁽⁵⁾	No
Engine Oil, All Other Grades	No	Yes ⁽⁷⁾	Yes ⁽²⁾	No	Yes	No	No	No	No	No	No	No ⁽⁵⁾	No
ATF	No	No	No	Yes ⁽²⁾	No	No	No	No	No	No	No	No ⁽⁵⁾	No
Off-Road Trans Fluid	No	Yes ⁽⁷⁾	Yes	No	Yes	No	No	No	No	No	No	No ⁽⁵⁾	No
Ashless Engine Oil (zinc-free)	No	Yes ⁽⁷⁾	Yes	Yes	Yes	Yes	No	No	No	No	No	No ⁽⁵⁾	Yes
Automotive Gear Oil	No	No	No	No	No	No	Yes	No	No	No	No	No ⁽⁵⁾	Yes
Industrial Gear Oil	No	No	No	No	No	No	Yes	Yes	No	No	No	No ⁽⁵⁾	Yes
Ashless Hydraulic Oil & R&O Oil	No	Yes ⁽⁷⁾	Yes	Yes ⁽¹⁾	Yes	Yes ⁽⁴⁾	Yes	Yes	Yes	No	Yes	No ⁽⁵⁾	Yes
AW Oil (w/zinc)	No	Yes ⁽⁷⁾	Yes	No	Yes	No	No	No	No	Yes	No	No ⁽⁵⁾	No
Turbine Oil (except Diamond Class® & Ultra-Clean Oil)	No	Yes ⁽⁷⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No ⁽⁵⁾	No
Diamond Class® & Ultra-Clean Oil	No	Yes ⁽⁷⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Emulsifiable / EP Oil	No	No	No	No	No	No	No	No	No	No	No	No ⁽⁵⁾	Yes
Incompatible	No	No	No	No	No	No	No	No	No	No	No	No ⁽⁵⁾	No

Notes:

- ⁽¹⁾ “Yes” permitted only if the ISO grade of the previous product is 32 or lower.
- ⁽²⁾ Except if previous product is Type F ATF.
- ⁽³⁾ Any SAE 5W-XX or 10W-XX grade or tractor fluid should not be loaded after an SAE 40, 50, 60 or 20W-50 grade engine oil.
- ⁽⁴⁾ “Yes” permitted only if the ISO grade of the previous product is 100 or lower.
- ⁽⁵⁾ Bulk transport of Diamond Class® Turbine Oils requires either (a) a dedicated trailer or (b) a tanker and hoses processed through a wash bay and thoroughly dried.
- ⁽⁶⁾ Certificate of Cleanliness/Wash or evidence of previous haul presented prior to loading. Additional requirements may apply:
 - >Full-synthetic industrial oils should not be loaded after any other product
 - >Full-synthetic and synthetic blend engine oils can be loaded after engine oils
 - >No products may be loaded behind or on top of biodiesel product
- ⁽⁷⁾ SAE 0W-20 engine oil should be loaded only through a cleaned transfer system. SAE 0W-20 engine oil may be loaded subsequent to SAE 5W-20 or 5W-30 engine oil only if the line is first flushed with one times (1x) the line volume with either the SAE 0W-20 oil or 100N oil. For loading the SAE 0W-20 oil subsequent to any other products in the compatible engine oil group, the line must be flushed with three times (3x) the line volume.



Glossary

A

absolute viscosity — The ratio of shear stress to shear rate. It is a fluid's internal resistance to flow. The common unit of absolute viscosity is the poise (see *viscosity*). Absolute viscosity divided by the fluid's density equals *kinematic viscosity*.

absorption — The taking up, assimilation or incorporation of one material into another.

acid — A chemical substance that can react with metals to form salts and with bases or alkalis to form salts plus water. Acids contain hydrogen, and they form hydrogen ions (H^+) in water. They are considered strong or weak depending on the hydrogen ion concentration in the solution.

acid number — See *neutralization number*.

additive — A chemical added in small quantities to a petroleum product to impart or improve certain properties.

AGMA — American Gear Manufacturers Association, which as one of its activities establishes and promotes standards for gears and lubricants.

alkaline — The property of a substance, product, or mixture that gives it the chemical character of a base or alkali, as contrasted to an acid.

aniline point — Lowest temperature at which a specified quantity of aniline (a benzene derivative) is soluble in a specified quantity of a petroleum product, as determined by test method ASTM D611 or D1012; hence, an empirical measure of the solvent power of a hydrocarbon.

antifoam agent — One of two types of *additives* used to reduce foaming in petroleum products: silicone oil to break up large surface bubbles; and various kinds of *polymers* that decrease the amount of small bubbles entrained in the oils.

anti-friction bearing — A rolling contact type bearing in which the rotating or moving member is supported or guided by means of ball or roller elements. Does not mean without friction.

antioxidant — See *oxidation inhibitor*.

antiwear agent — An additive that minimizes wear caused by metal-to-metal contact during conditions of mild boundary lubrication (e.g., stops and starts, oscillating motion). The additive reacts chemically with, and forms a film on, metal surfaces under normal operating conditions.

API (American Petroleum Institute) — Trade association of petroleum producers, refiners, marketers and transporters; organized for the advancement of the petroleum industry by conducting research, gathering



and disseminating information, and maintaining cooperation between government and the industry on all matters of mutual interest.

API Engine Service Categories — Gasoline and diesel engine oil quality levels established jointly by *API*, *SAE* and *ASTM*, and sometimes called *SAE* or *API/SAE* categories; formerly called *API Engine Service Classifications*.

API Gravity — A gravity scale established by the *API* and in general use in the petroleum industry, the unity being called the “*API degree*.” This unit is defined in terms of specific gravity as follows:

$$^{\circ}\text{API} = (141.5 \div \text{sp. gr. @60}^{\circ}/60^{\circ}\text{F}) - 131.5$$

apparent viscosity — A measure of the resistance to flow of a grease whose viscosity varies with shear rate. It is defined as the ratio of the shear stress to the shear rate calculated from Poiseuille’s equation at a given rate of shear and is expressed in poises.

aromatic — *Unsaturated hydrocarbon* identified by one or more *benzene* rings or by chemical behavior similar to benzene.

ash content — Noncombustible residue of a lubricating oil or fuel, determined in accordance with *ASTM D582* and *D874 (sulfated ash)*.

ashless dispersant — Cleanliness additive for crankcase oils. It is widely used in lubricants for aviation piston engines. Unlike conventional crankcase oil detergents, ashless dispersants do not contain metallic compounds. See *dispersant*.

ASLE (American Society of Lubrication Engineers) — Organization intended to advance the knowledge and application of lubrication and related sciences.

ASTM (American Society for Testing and Materials) — Organization devoted to “the promotion of knowledge of the materials of engineering, and the standardization of specifications and methods of testing.” A preponderance of the data used to describe, identify, or specify petroleum products is determined in accordance with *ASTM* test methods.

auto-ignition temperature — Minimum temperature at which a combustible fluid will burst into flame without an extraneous ignition source.

axial load bearing — A bearing in which the load acts in the direction of the axis of rotation.

B

babbitt — A soft, white, nonferrous alloy bearing material composed principally of copper, antimony, tin and lead.

ball bearing — An antifriction bearing comprising rolling elements in the form of balls.

barrel — Standard unit of measurement in the petroleum industry, equivalent to 42 standard U.S. gallons, or approximately 35 Imperial gallons.



base — One of a broad class of compounds that react with acids to form salts plus water.

base number — See *neutralization number*.

base oils — Base stocks and base stock blends used as an inert ingredient or diluent in the manufacture of automotive and industrial lubricants, and some industrial, agricultural and consumer chemicals.

base stock — A primary refined petroleum fraction, usually a lube oil, into which *additives* and other oils are blended to produce finished products.

bearing — A support or guide by means of which a moving part, such as a shaft or axle, is positioned with respect to the other parts of a mechanism.

BIA — Boating Industry Association. See *NMMA*.

bleeding — The tendency of a liquid component to separate from a solid or semisolid mixture as an oil from a grease.

block grease — Generally, a grease of high soap content which under normal temperatures is firm to the touch and can be handled in block or stick form.

bloom — A sheen or fluorescence evident in some petroleum oils when viewed by reflected light.

boundary lubrication — A condition of lubrication in which the bulk viscosity characteristics of the lubricant do not apply or in which partial contact takes place between the mating surfaces. Also refers to a thin film, imperfect, or nonviscous lubrication.

bright stock — High-viscosity oils, highly refined and dewaxed to make clear products of good color, produced from residual stocks, or *bottoms*; used for blending with lower viscosity oils.

Brookfield viscosity — *Apparent viscosity* of an oil, as determined under test method ASTM D 2983.

bulk modulus — Measure of a fluid's resistance to compressibility; the reciprocal of compressibility.

C

°C (Celsius) — See *temperature scales*.

carbon — A nonmetallic element — No. 6 in the periodic table. Diamonds and graphite are the two pure forms of carbon. Carbon is a constituent of all organic compounds.

carbon dioxide — CO₂. A colorless, odorless gas produced by complete combustion of a hydrocarbon fuel-air mixture.



carbon monoxide (CO) — Colorless, odorless, poisonous gas, formed by the incomplete combustion of any carbonaceous material (e.g., gasoline, wood, coal).

carbon residue — Percent of coked material remaining after a sample of lubricating oil has been exposed to high temperatures under ASTM Method D189 (Conradson) or D524 (Ramsbottom). Results of these tests are reported as a percentage of the weight of the original sample.

catalyst — Substance that contributes to a chemical reaction without, itself, undergoing any change.

Celsius (°C) — See *temperature scales*.

centigrade — See *temperature scales*.

centipoise — See *viscosity*.

centistoke — See *viscosity*.

centralized lubrication — System under which grease or oil is dispensed automatically from a reservoir directly to the lubricated parts of one or more machines. Flow is maintained by a pump or battery of pumps operating on a common rail, and the amount of lubricant supplied to each point can be regulated by metering devices at each point.

cetane number — Measure of the ignition quality of a *diesel fuel*, expressed as the percentage of cetane that must be mixed with liquid methylnaphthalene to produce the same ignition performance as the diesel fuel being rated, as determined by test method ASTM D613.

channel point — A measure of the lowest temperature at which a gear lubricant may be used safely.

Cleveland Open Cup (COC) — Test (ASTM D92) for determining the *flash point* and *fire point* of all petroleum products except fuel oil and products with flash points below 70°C (175°F).

cloud point — Temperature at which a cloud or haze of wax crystals appears at the bottom of a sample of lubricating oil in a test jar, when cooled under conditions prescribed by test method ASTM D2500.

Cold Cranking Simulator (CCS) — A high shear viscometer used to measure viscosity of crankcase oils at low temperature (0°F).

compatibility — The ability of petroleum products to form a homogeneous mixture that neither separates nor is altered by chemical interaction.

compounded oil — Special blend of petroleum oil with small amounts of fatty or synthetic fatty oils.

compounds — 1. Chemically, any substance formed by a combination of two or more elements. 2. In petroleum processing, compound or compounding means fatty oils and similar materials foreign to petroleum but added to lubricants to impart special properties to them.



compressor — Any of a wide variety of mechanisms designed to compress air or other gas to produce useful work.

corrosion — Chemical attack on a metal or other solid by contaminants in a lubricant.

corrosion inhibitor — *Additive* for protecting lubricated metal surfaces against chemical attack by water or other contaminants.

cutting fluid — Fluid, usually of petroleum origin, for cooling and lubricating the tool and work in machining and grinding.

D

demulsibility — Ability of an oil to separate from water, as determined by test method ASTM D1401 or D2711.

density — The mass of a unit volume of a substance. Its numerical value varies with the units used. See *specific gravity*.

deposits — See *engine deposits*.

detergent — An *additive* in *crankcase oils* generally combined with (and confused with) *dispersant* additives. A detergent chemically neutralizes acidic contaminants in the oil before they become insoluble and fall out of the oil, forming sludge.

detergent-dispersant — Engine oil *additive* that is a combination of a *detergent* and a *dispersant*; important in preventing the formation of *sludge* and other engine deposits.

dielectric strength (breakdown voltage) — Minimum voltage required to produce an electric arc through an oil sample, as measured by test method ASTM D877; hence, an indication of the insulating (arc preventive) properties of a transformer oil. A low dielectric strength may indicate contamination, especially by water.

dispersant — Engine oil *additive* that helps prevent *sludge*, varnish and other engine deposits by breaking up insoluble contaminant particles already formed. Particles are kept finely divided so that they can remain “dispersed” or colloiddally suspended in the oil.

drop feed lubrication — A system of lubrication in which the lubricant is applied to the bearing surfaces in the form of drops at regular intervals.

dropping point — Normally related to a *grease*. The temperature at which a grease passes from a semisolid to a liquid state under specified test conditions ASTM D556. It is an indication of whether a grease will flow from a bearing at operating temperature.

drum — A container with a capacity of 55 U.S. gallons.

dynamic viscosity — See *absolute viscosity*



E

emulsibility — The ability of an oil to emulsify with water. The oil becomes suspended in the water in minute particles in a more or less stable form.

emulsion — Intimate mixture of oil and water, generally of a milky or cloudy appearance.

energy conservation — Employment of less energy to accomplish the same amount of useful work; also, the reduction or elimination of any energy-consuming activity.

engine deposits — Hard or persistent accumulations of *sludge*, *varnish* and carbonaceous residues due to *blow-by* of unburned and partially burned (partially oxidized) fuel, or from partial breakdown of the crankcase lubricant.

EP additive — Lubricant *additive* that prevents sliding metal surfaces from seizing under conditions of extreme pressure (EP). At the high local temperatures associated with metal-to-metal contact, an EP additive combines chemically with the metal to form a surface film that prevents the welding of opposing *asperities*, and the consequent *scoring* that is destructive to sliding surfaces under high loads.

EPA (Environmental Protection Agency) — Agency of the federal executive branch, established in 1970 to abate and control pollution through monitoring, regulation, and enforcement, and to coordinate and support environmental research.

F

°F (Fahrenheit) — See *temperature scales*.

FDA (Food and Drug Administration) — Agency administered under the U.S. Department of Health and Human Services (formerly Health, Education and Welfare) “to enforce the Federal Food, Drug and Cosmetic Act and thereby carry out the purpose of Congress to ensure that foods are safe, pure, and wholesome, and made under sanitary conditions; drugs and therapeutic devices are safe and effective for their intended uses; cosmetics are safe and prepared from appropriate ingredients; and that all of these products are honestly and informatively labeled and packaged.”

film strength — Property of a lubricant which acts to prevent scuffing or scoring of bearing surfaces.

fire point — The minimum sample temperature at which vapor is produced at a sufficient rate to sustain combustion. Specifically, it is the lowest sample temperature at which the ignited vapor persists in burning for at least 5 seconds.

flash point — Minimum temperature of a petroleum product or other combustible fluid at which vapor is produced at a rate sufficient to yield a combustible mixture. Specifically, it is the lowest sample temperature at



which the air vapor mixture will “flash” in the presence of an ignition source (small flame).

floc point — Temperature at which waxy materials in a lubricating oil separate from a mixture of oil and FREON® R-12 refrigerant, giving a cloudy appearance to the mixture.

fluid friction — A liquid’s internal resistance to flow. See *friction*.

foam inhibitor — An additive which causes foam to dissipate more rapidly. It promotes the combination of small bubbles into large bubbles which burst more easily.

foaming — Occurrence of a frothy mixture of air and a petroleum product (e.g., lubricant, fuel oil) that can reduce the effectiveness of the product, and cause sluggish hydraulic operation, air binding of oil pumps, and overflow of tanks or sumps.

force feed lubrication — A system of lubrication in which the lubricant is supplied to the bearing surface under pressure.

freezing point — A specific temperature that can be defined in two ways, depending on the ASTM test used.

fretting corrosion — A process of mechanical attrition combined with chemical reaction taking place at the common boundary of loaded contact surfaces having small oscillatory relative motion.

friction — Resistance to the motion of one surface relative to another. The amount of friction is dependent on the smoothness of the contacting surfaces, as well as the force with which they are pressed together.

G

gallon (Imperial) — Unit of liquid volume used in Canada, England and other countries. Defined as the volume of 10 lb. of water at 68°F. One Imperial gallon equals 1.20095 U.S. gallons.

gallon (U.S.) — Unit of liquid volume equal to 231 cu. in.

gas — The vapor state of any substance that has neither independent shape nor volume.

gel — An elastic solid mixture of a *colloid* and a liquid, it possesses a yield point and a jelly-like texture.

gram — A metric unit of mass and weight equal to 1/1000 kilogram and nearly equal to the mass (weight) of 1 cc of water at its maximum density.

graphite — A crystalline form of carbon either natural or synthetic in origin, which is used as a lubricant.



gravity — Weight-per-unit-volume relationship. With petroleum products, this relationship may be expressed as *specific gravity*, the ratio of the weight of a volume of the product at a designated temperature to the weight of an equal volume of water — also at a designated temperature.

grease — Mixture of a fluid lubricant (usually a petroleum oil) and a thickener (usually a soap) dispersed in the oil. Because greases do not flow readily, they are used where extended lubrication is required and where oil would not be retained.

gum — A rubber-like, sticky deposit black or dark brown in color, which results from oxidation of lubricating oils in service.

H

heat content — 1. *Gross*. Total heat evolved by complete combustion of a unit weight of substance usually expressed in BTU/lb. 2. *Net*. Gross heat of combustion less the latent heat of condensation of any water produced.

heat of combustion — Measure of the available energy content of a fuel, under controlled conditions specified by test method ASTM D240 or D2382.

heating value — See *heat of combustion*.

hydraulic oil — An oil specially suited for use as a power transmission medium in hydraulically operated equipment.

hydrocarbon — Chemical compound of hydrogen and carbon; also called an *organic compound*. Hydrogen and carbon atoms can be combined in virtually countless ways to make a diversity of products.

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.

hydrogenation — The chemical addition of hydrogen to a material. In non-destructive hydrogenation, hydrogen is added to a molecule only if, and where, unsaturation with respect to hydrogen exists. In destructive hydrogenation, the operation is carried out under conditions which result in rupture of some of the hydrocarbon chains (cracking); hydrogen is added where the chain breaks have occurred.

hydrolytic stability — Ability of additives and certain *synthetic lubricants* to resist chemical decomposition (hydrolysis) in the presence of water.

hydrotreating — A process which converts and removes undesirable components with the use of a catalyst.

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.



hypoid gears — Gears in which the pinion axis intersects the plane of the ring gear at a point below the ring-gear axle and above the outer edge of the ring gear, or above the ring-gear axle and below the outer edge of the ring gear.

HVI — High Viscosity Index, typically from 80 to 100 VI units.

I

inhibitor — Additive that improves the performance of a petroleum product through the control of undesirable chemical reactions. See *corrosion inhibitor, oxidation inhibitor, rust inhibitor*.

inorganic compound — Chemical compound, usually mineral, that does not include *hydrocarbons* and their derivatives.

insolubles — Test for contaminants in used lubricating oils, under conditions prescribed by test method ASTM D893.

ISO — International Standards Organization.

ISO viscosity classification system — International system, approved by the International Standards Organization (ISO), for classifying industrial lubricants according to *viscosity*. Each ISO viscosity grade number designation corresponds to the mid-point of a viscosity range expressed in centistokes (cSt) at 40°C.

J

journal bearing — A sliding type of bearing in conjunction with which a journal operates. In a full- or sleeve-type journal bearing, the bearing surface is 360° in extent. In a partial bearing, the bearing surface is less than 360° in extent.

K

ketones — These are organic compounds characterized by a carbonyl group joined to two hydrocarbon radicals. The ketones have very high diluent tolerance and good viscosity reduction power.

kinematic viscosity — *Absolute viscosity* of a fluid divided by its density at the same temperature of measurement. It is the measure of a fluid's resistance to flow under gravity, as determined by test method ASTM D445.

L

lacquer — An organic coating that dries by solvent evaporation.

latent heat — Quantity of heat absorbed or released by a substance undergoing a change of state (e.g., ice changing to liquid water, or water to steam) without change of temperature.



LC₅₀ — Lethal concentration, 50 percent mortality; a measure of inhalation toxicity. It is the concentration in air of a volatile chemical compound at which half the test population of an animal species dies when exposed to the compound. It is expressed as parts per million by volume of the toxicant per million parts of air for a given exposure period.

load wear index — Measure of the relative ability of a lubricant to prevent wear under applied loads; it is calculated from data obtained from the Four-Ball EP Method.

lubrication — Control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact. The lubricant used may be a fluid, solid or plastic substance.

lubricity — Ability of an oil or grease to lubricate; also called *film strength*. Lubricity can be enhanced by *additive* treatment.

M

melting point — The temperature at which a solid substance melts or becomes liquid. Grease melting point is determined by placing a small amount of the grease on the bulb of a thermometer and heating in hot air until the grease begins to run off. Also see *dropping point*.

mg — Milligrams.

mineral oil — Any petroleum oil, as contrasted to animal or vegetable oils. Also, a highly refined petroleum *distillate*, or *white oil*, used medicinally as a laxative.

miscible — Capable of being mixed in any concentration without separation of phases.

moly, moly sulfide — See *molybdenum disulfide*.

molybdenum disulfide — A black, lustrous powder (MoS₂) that serves as a dry-film lubricant in certain high-temperature and high-vacuum applications.

multigrade oil — Engine oil that meets the requirements of more than one SAE (Society of Automotive Engineers) viscosity grade classification (see *SAE viscosity grades*), and may therefore be suitable for use over a wider temperature range than a single-grade oil.

N

naphthene — Hydrocarbon characterized by saturated carbon atoms in a ring structure, and having the general formula C_nH_{2n}; also called *cycloparaffin* or *cycloalkane*. Naphthenic lubricating oils have *low pour points*, owing to their very low wax content, and good solvency properties.

naphthenic — See *naphthene*.



natural gas — Naturally occurring mixture of gaseous *saturated hydrocarbons*, consisting of 80 percent to 95 percent *methane* (CH_4), lesser amounts of *propane*, *ethane*, and *butane*, and small quantities of nonhydrocarbon gases (e.g., nitrogen, helium).

needle bearing — A bearing comprising rolling elements in the form of rollers which are relatively long compared to their diameter.

neutral oils — Lubricating oils of low or medium viscosity obtained in petroleum distillation and prepared by various methods. They derive their name from the fact that they have not been treated with either an acid or an alkali.

neutralization number — Also called *neut number*, an indication of the acidity or alkalinity of an oil; the number is the weight in milligrams of the amount of acid (hydrochloric acid [HCL]) or base (potassium hydroxide [KOH]) required to neutralize one gram of the oil, in accordance with test method ASTM D664 (potentiometric method) or ASTM D974 (colorimetric method).

Newtonian fluid — Fluid, such as a *straight mineral oil*, whose *viscosity* does not change with rate of flow.

NLGI (National Lubricating Grease Institute) — Trade association whose main interest is grease and grease technology.

NLGI consistency grades — Simplified system established by the National Lubricating Grease Institute (NLGI) for rating the consistency of grease.

NMMA — National Marine Manufacturers Association (formerly BIA).

O

octane number — Expression of the *antiknock* properties of a gasoline, relative to that of a standard reference fuel. There are two distinct types of octane number measured in the laboratory: *Research Octane Number (RON)* and *Motor Octane Number (MON)*, determined in accordance with ASTM D2699 and D2700, respectively.

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

oil ring — A loose ring, the inner surface of which rides a shaft or journal and dips into a reservoir of lubricant from which it carries the lubricant to the top of a bearing by its rotation with the shaft.

organic compound — Chemical substance containing carbon and hydrogen; other elements, such as nitrogen or oxygen, may also be present.

oxidation — A form of chemical deterioration to which petroleum products —like most other organic materials — are subject. The resistance of many petroleum products to oxidation, however, is very high. Oxidation usually involves the addition of oxygen atoms, and the result is nearly always one of degradation.



oxidation inhibitor — Substance added in small quantities to a petroleum product to increase its oxidation resistance, thereby lengthening its service or storage life; also called an *antioxidant*.

oxidation stability — Resistance of a petroleum product to oxidation; hence a measure of its potential service or storage life. There are a number of ASTM tests to determine the oxidation stability of a lubricant or fuel, all of which are intended to simulate service conditions on an accelerated basis.

P

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

pale oil — Straight naphthenic mineral oil, straw or pale yellow in color, used as a once-through lubricant and in the formulation of *process oils*.

paraffin — Hydrocarbon identified by saturated straight (normal) or branched (iso) carbon chains. Paraffins are relatively nonreactive and have excellent *oxidation stability*. In contrast to naphthenic (see *naphthene*) oils, paraffinic lube oils have relatively high wax content and *pour point*, and generally have a high *viscosity index* (V.I.).

paraffinic — See *paraffin*.

penetration (grease) — Measure of the consistency of a grease, utilizing a *penetrometer*. Penetration is reported as the tenths of a millimeter (penetration number) that a standard cone, acting under the influence of gravity, will penetrate the grease sample under test conditions prescribed by test method ASTM D217. Standard test temperature is 25°C (77°F). The higher the penetration number, the softer the grease.

petrolatum — A jelly-like product obtained from petroleum and having a microcrystalline structure. Often used in rust preventives.

plain bearing — Any simple sliding-type bearing as distinguished from tapered land, tilting pad, or antifriction bearings, etc.

poise — CGS unit of absolute viscosity; shear stress (in dynes per square centimeter) required to move one layer of fluid along another over a total layer thickness of one centimeter at a shear rate of one centimeter per second. Dimensions are dyne-sec/cm². The *centipoise* (cP) is 1/100 of a poise and is the unit of absolute viscosity most commonly used.

pour point — Is a widely used low-temperature flow indicator and is 5°F above the temperature to which a normally liquid petroleum product maintains fluidity.

pour point depressant — *Additive* used to lower the *pour point* of a petroleum product.

ppm — Parts per million.



pressure — Force per unit area, measured in kilopascals (kPa) or pounds per square inch (psi).

process oil — Oil that serves as a temporary or permanent component of a manufactured product.

psi — Pounds per square inch.

Q

quenching — Immersion of a heated manufactured steel part, such as a gear or axle, in a fluid to achieve rapid and uniform cooling. Petroleum oils are often used for this purpose. Quenching provides hardness superior to that possible if the heat-treated part were allowed to cool slowly in air.

R

R&O — Rust- and oxidation-inhibited term applied to highly refined industrial lubricating oils formulated for long service in circulating systems, compressors, hydraulic systems, bearing housings, gear cases, etc. The finest R&O oils are often referred to as *turbine oils*.

refining — Series of processes for converting crude oil and its fractions to finished petroleum products.

rheology — Study of the deformation and flow of matter in terms of stress, strain, temperature and time. The rheological properties of a grease are commonly measured by penetration and *apparent viscosity*.

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

roller bearing — An antifriction bearing comprising rolling elements in the form of rollers.

rust — See *compounds and additives, corrosion inhibitors*.

rust inhibitor — A lubricant additive for protecting ferrous (iron and steel) components from rusting caused by water contamination or other harmful materials from oil degradation.

Rust Prevention Test (Turbine Oils) — A test for determining the ability of an oil to aid in preventing the rusting of ferrous parts in the presence of water.

S

SAE (Society of Automotive Engineers) — Organization responsible for the establishment of many U.S. automotive and aviation standards, including the viscosity classifications of engine oils and gear oils.

SAE viscosity grades — Engine oil classification system developed by the Society of Automotive Engineers (SAE), based on the kinematic viscosities of the oil measured at 100°C under low-shear conditions and at 150°C



under high-shear conditions. Multigrade oils, designated with a “W” for “winter use” (e.g., SAE 10W-30), are further defined by their low-temperature cranking viscosity measured at -10°C to -35°C, and their low-temperature pumping viscosity measured at -15°C to -40°C.

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. The orifice of the furol viscometer is larger than that of the universal viscometer, the former instrument being used for more viscous fluids.

Saybolt Universal Viscosity — 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.

shear — Deformation which occurs when parallel planes of a body are displaced relative to each other in a direction parallel to themselves.

shear rate — Rate at which adjacent layers of a fluid move with respect to each other, usually expressed as reciprocal seconds.

shear stability — Mechanical stability.

shear stress — Frictional force overcome in sliding one “layer” of fluid along another, as in any fluid flow. The shear stress of a petroleum oil or other *Newtonian fluid* at a given temperature varies directly with *shear rate* (velocity). The ratio between shear stress and shear rate is constant; this ratio is termed *viscosity*.

sleeve bearing — A journal bearing, usually a full journal bearing.

sludge — In gasoline engines, a soft, black, mayonnaise-like emulsion of water, other combustion byproducts, and oil formed during low-temperature engine operation.

soap — The salt of an acid derived from animal or vegetable matter. Metallic soaps are used in the manufacture of grease.

specific gravity — For petroleum products, the ratio of the mass of a given volume of product and the mass of an equal volume of water, at the same temperature. The standard reference temperature is 15.6°C (60°F). Specific gravity is determined by test method ASTM D1298. The higher the specific gravity, the heavier the product.

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

straight mineral oil — Petroleum oil containing no *additives*.

static friction — The friction between two surfaces not in relative motion but tending to slide over one another. The value of the static friction at the instant relative motion begins is termed break-away friction.



sulfated ash — The ash content of fresh, compounded lubricating oil as determined by ASTM Method D874. Indicates level of metallic additives in the oil.

synthetic lubricant — Lubricating fluid made by chemically reacting materials of a specific chemical composition to produce a compound with planned and predictable properties; the resulting *base stock* may be supplemented with additives to improve specific properties.

T

tackiness agent — Additive used to increase the adhesive properties of a lubricant, improve retention and prevent dripping and splattering.

temperature scales — Arbitrary thermometric calibrations that serve as convenient references for temperature determination. There are two thermometric scales based on the freezing and boiling point of water at a pressure of one atmosphere: the Fahrenheit (F) scale (32 degrees = freezing, 212 degrees = boiling) and the Celsius (C), or Centigrade, scale (0 degrees = freezing, 100 degrees = boiling).

texture — That property of a lubricating grease which is observed when a small portion of it is compressed and the pressure slowly released.

thermal stability — Ability to resist chemical degradation at high temperatures.

Timken EP Test — The Timken Extreme-Pressure Test is one of many laboratory machines used in determining the load-carrying capacities of oils and greases. In this test, a Timken bearing cup is rotated against a steel block. The highest load under which a lubricant prevents scoring of the steel block by the rotating cup is the reported value.

total acid number — See *neutralization number*.

total base number — See *neutralization number*.

tribology — Science of the interactions between surfaces moving relative to each other. Such interactions usually involve the interplay of two primary factors: the load, or force, perpendicular to the surfaces, and the frictional force that impedes movement.

U

unworked penetration — The penetration at 77°F of a sample of grease which has received only the minimum handling in transfer from a sample can to the test apparatus and which has not been subjected to the action of a grease worker.

USDA — United States Department of Agriculture.

USP (United States Pharmacopeia) — Compendium of drugs, drug



formulas, quality standards and tests published by the United States Pharmacopeial Convention, Inc., which also publishes the NF (National Formulary).

V

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

V.I. — See *viscosity index* (V.I.).

viscosity— Measurement of a fluid's resistance to flow. The common metric unit of *absolute viscosity* is the *poise*, which is defined as the force in dynes required to move a surface one square centimeter in area past a parallel surface at a speed of one centimeter per second, with the surfaces separated by a fluid film one centimeter thick.

viscosity index (V.I.)— Empirical, unitless number indicating the effect of temperature change on the *kinematic viscosity* of an oil. Liquids change *viscosity* with temperature, becoming less viscous when heated; the higher the V.I. of an oil, the lower its tendency to change viscosity with temperature.

viscosity index (V.I.) improver — Lubricant *additive*, usually a high molecular weight *polymer*, that reduces the tendency of an oil to change *viscosity* with temperature. *Multigrade oils*, which provide effective lubrication over a broad temperature range, usually contain V.I. improvers.

Volatility — Expression of evaporation tendency. The more volatile a petroleum liquid, the lower its boiling point and the greater its flammability.

W

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

white oil — Highly refined *straight mineral oil*, essentially colorless, odorless, and tasteless. White oils have a high degree of chemical stability.

worked penetration — The penetration of a sample of lubricating grease immediately after it has been brought to 77°F +/- 1°F and then subject to 60 strokes in the ASTM standard grease worker.

Z

ZDDP (zinc dialkyl dithiophosphate or zinc diary dithiophosphate) — Widely used as an antiwear agent in motor oils to protect heavily loaded parts, particularly the valve train mechanisms (such as the camshaft and cam followers) from excessive wear. It also is used as an antiwear agent in *hydraulic fluids* and certain other products.