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## ZPlus™ Tech Brief #3

### Lubrication Terminology

The avid automobile enthusiast can often be found reading papers on engine and oil technology. As is the case with all fields of specialization, the lubrication industry has its own terminology and abbreviations. The people at ZPlus figured it would be a useful tool to have a short glossary of terminology and abbreviations, as well as links to more in-depth information as presented in our other Tech Briefs.

#### **Navigating:**

Cross-references are hyperlinked for convenience, just click on the link.

Links to in-depth information in other ZPlus™ Tech Briefs are denoted by [TBxx pg.x](#).

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#### **- A -**

' $\alpha$ ' - or alpha, the viscosity increase of oil with applied pressure, a characteristic exploited in the elasto-hydrodynamic lubrication mode. Oils with a high ' $\alpha$ ' can maintain a thicker oil film under extreme pressure than oils with a low ' $\alpha$ '.

See [TB10 pg.7](#).

**ABRASIVE WEAR** - progressive removal of material from a rubbing surface as evidenced by surface lapping caused by fine particles carried in the lubricant, fuel or air, or embedded in the surface.

**ACID** - hydrogen containing compound that reacts with metals to form salts, and with metallic oxides and bases to form a salt and water. The strength of an acid depends on the extent to which its molecules ionize or dissociate in water, and on the resulting concentration of hydrogen ions (H+) in solution. Petroleum hydrocarbons, in the presence of oxygen and heat, can oxidize to form weak acids, which attack metals. See [CORROSION](#).

**ACID NUMBER** - See [NEUTRALIZATION NUMBER](#).

**ACID TREATING** - refining process for improving the color, odor, and other properties of white oils or lube stocks, whereby the unfinished product is contacted with sulfuric acid to remove the less stable hydrocarbon molecules.

**ADDITIVE** - chemical substance added to a petroleum product to impart or improve certain properties. Common petroleum product additives are: anti-foam agent, anti-icing additive, anti-wear additive, corrosion inhibitor, demulsifier,

detergent, dispersant, emulsifier, EP additive, oiliness agents, oxidation inhibitor, pour point depressant, rust inhibitor, tackiness agent, and viscosity improver. Additives can make up between 10% and 20% of passenger car engine oil by mass. Most recently the amount of the anti-wear additive ZDDP has been declining due to EPA requirements. See [ANTI-WEAR ADDITIVE](#).

**ADHESIVE WEAR** - also called galling, the removal of material from a rubbing surface caused by seizing, scoring or scuffing.

**ALIPHATIC HYDROCARBON** - hydrocarbon in which the carbon atoms are joined in open chains, rather than rings. See [HYDROCARBON](#), [NORMAL PARAFFIN](#).

**ALKYL** - any of a series of monovalent radicals having the general formula  $(C_nH_2)n+1$ , derived from aliphatic hydrocarbons by the removal of a hydrogen atom: for example,  $CH_3$  (methyl radical, from methane).

**ANTI-FOAM 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. See [FOAMING](#), [TB12 pg.11](#).

**ANTI-OXIDANT** - See [OXIDATION INHIBITOR](#).

**ANTI-WEAR ADDITIVE** - a chemical that reduces wear in mechanical systems that operate in the boundary lubrication regime. They typically act by decomposing at the contact point between two sliding surfaces in response to the pressure and friction-induced local heating. The decomposition products form a sacrificial protective layer over the base metal, greatly reducing wear. Antiwear compounds (for example, ZDDP and TCP) start decomposing at 90 degrees to 100 degrees C or lower if 25 to 50 ppm of water is present. Molybdenum antiwear compounds have been known to cause corrosion to copper-bearing parts. See [BOUNDARY LUBRICATION](#), [TB11 pg.2](#).

**AROMATIC** - unsaturated hydrocarbon identified by one or more benzene rings or by chemical behavior similar to benzene. The benzene ring is characterized by three double bonds alternating with single bonds between carbon atoms (compare with olefins). Because of these multiple bonds, aromatics are usually more reactive and have higher solvency than paraffins and naphthenes. Aromatics readily undergo electrophilic substitution; that is, they react by adding other active molecular groups, such as nitrates, sulfonates, etc. Aromatics are used extensively as petrochemical building blocks in the manufacture of pharmaceuticals, dyes, plastics, and many other chemicals.

**ARYL** - any organic group derived from an aromatic hydrocarbon by the removal of a hydrogen atom, for example,  $C_6H_5$  (phenyl radical, from benzene).

**ASH** - inorganic residue of combustion. Lubricating oil detergent additives contain metallic derivatives, such as barium, calcium, and magnesium sulfonates, all of which are common sources of ash. Ash deposits can impair engine efficiency and power. See [DETERGENT](#), [SULFATED ASH](#).

**ASPERITIES** - microscopic projections on metal surfaces resulting from normal surface-finishing processes. Interference between opposing asperities in sliding or rolling applications is a source of friction, and can lead to metal welding and scoring. Due to the extremely small size of most asperities and the fact that they bear most of the contact pressure, their temperature under load and movement can be much higher than the surrounding surfaces. Ideally, the lubricating film between two moving surfaces should be thicker than the combined height of the opposing asperities. See [BOUNDARY LUBRICATION](#), [EP ADDITIVE](#), [TB11 pg.1](#).

**ASTM** - or ASTM International, originally known as the American Society for Testing and Materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. The ASTM has standardized a wide range of tests to characterize the performance of oil. These test methods are most often referred to as ASTM Dxxx. See [TB4 pg.1](#).

## - B -

**BABBITT** - a white metal alloy commonly used as a lining for engine bearing inserts. A few common compositions for Babbitt alloys are: 90% tin 10% copper, or 89% tin 7% antimony 4% copper, or 80% lead 15% antimony 5% tin. The babbitt lining on most modern bearing inserts is between 0.0005" and 0.002" thick. See [TB11 pg.7](#), [TB12 pg.2](#).

**BARREL** - standard unit of measurement in the petroleum industry, equivalent to 42 standard U.S. gallons.

**BASE** - any of a broad class of compounds, including alkalis, that react with acids to form salts, plus water. Also known as hydroxides. Hydroxides ionize in solution to form hydroxyl ions (OH<sup>-</sup>); the higher the concentration of these ions, the stronger the base. Bases are used extensively in petroleum refining in caustic washing of process streams to remove acidic impurities, and are components in certain additives that neutralize weak acids formed during oxidation.

**BASE NUMBER** - See [NEUTRALIZATION NUMBER](#).

**BASE STOCK** - crude oil fractions of suitable viscosities and volatilities, generally refined to remove unstable and waxy components, and are classified as Neutrals and Bright Stocks. Lubricating oil base stocks are broken into "Groups" by degree and method of refining. See [DISTILLATION](#), [TB10 pg.1](#).

**BLOW-BY** - that portion of the combustion reactants and unburned air-fuel mixture which leaks into the engine crankcase during engine operation. Most blow-by gasses are scavenged by the Positive Crankcase Ventilation system, but some condense and mix with the oil.

**BORON** - is a chemical element with atomic number 5 and the chemical symbol B. Boron is a trivalent metalloid element which occurs abundantly in the evaporite ores borax and ulexite. Boron is never found as a free element on Earth. It can be used in various compounds as an antiwear additive in oil.

**BOUNDARY LUBRICATION** - form of lubrication between two rubbing surfaces without development of a full-fluid lubricating film. Boundary lubrication can be made more effective by including additives in the lubricating oil that provide a stronger oil film, thus preventing excessive friction and possible scoring. There are varying degrees of boundary lubrication, depending on the severity of service. For mild conditions, oiliness agents may be used; these are polar compounds that have exceptionally high affinity for metal surfaces. By plating out on these surfaces in a thin but durable film, oiliness agents prevent scoring under some conditions that are too severe for a straight mineral oil. Compounded oils, which are formulated with polar fatty oils, are sometimes used for this purpose. Anti-wear additives are commonly used in more severe boundary lubrication applications. High-quality motor oils contain anti-wear additives to protect heavily-loaded engine components, such as the valve train. The more severe the cases of boundary lubrication are defined as extreme pressure conditions; they are met with lubricants containing EP additives that prevent sliding surfaces from fusing together at high local temperatures and pressures. See [HYDRODYNAMIC LUBRICATION](#), [STRIBECK CURVE](#), [TB11 pg.2](#).

**BRIGHT STOCK** - high viscosity oil, highly refined and dewaxed, produced from residual stocks or bottoms. Named for their SUS viscosity at 210°F, having viscosities ranging from about 500 to 1100 cSt at 40°C. They are HVI oils refined to clear products of good color. Used for blending with lower viscosity oils.

**BROOKFIELD VISCOSITY** - apparent viscosity of an oil, as determined under ASTM D2983. Since the apparent viscosity of a non-Newtonian fluid holds only for the shear rate (as well as temperature) at which it is determined, the Brookfield viscometer provides a known rate of shear by means of a spindle of specified configuration that rotates at a known constant speed in the fluid. The torque imposed by fluid friction can be converted to absolute viscosity units (centipoises) by a multiplication factor. The viscosities of certain petroleum waxes and wax-polymer blends in the molten state can also be determined by the Brookfield test method ASTM D2669. See [VISCOSITY](#), [SHEAR STRESS](#).

## - C -

**CALORIE** - term applicable either to the gram calorie or the kilocalorie. The gram calorie is defined as the amount of heat required at a pressure of one atmosphere to raise the temperature of one gram of water one degree Celsius at 15°C. The kilocalorie is the unit used to express the energy value of food; it is defined as the amount of heat required at a pressure of one atmosphere to raise the temperature of one kilogram of water one degree Celsius; it is equal to 1000 gram calories.

**CARBONACEOUS DEPOSIT** - a firm deposit composed primarily of carbon and organic residue most readily definable by thickness or volume and texture. Such deposits will be found primarily on surfaces operating above engine bulk temperature but below the ashing point.

**CARBURETOR** - device in an internal combustion engine that atomizes and mixes fuel with air in the proper proportion for efficient combustion at all engine speeds, and controls the engine's power output by throttling, or metering the air-fuel mixture admitted to the cylinders. The automobile carburetor is a complex mechanism designed to compensate for many variables over a wide range of speeds and loads. Intake air is drawn through the venturi, a constricted throat in the air passage that causes a pressure reduction in the air stream, which draws fuel from the carburetor bowl through either the main jet or the idle jet. The fuel is atomized by the high velocity air, and the resulting air-fuel mixture is piped through the intake manifold to the individual cylinders, where it is burned. A throttle plate between the venturi and the cylinders control power and speed by controlling the volume of air-fuel mixture reaching the cylinders. In most carburetors, closing of this (venturi) throttle valve shuts down the main jet and activates the idle jet, which provides the fuel-rich mixture that idling requires. An accelerator pump in the carburetor provides momentary fuel enrichment when the accelerator pedal is depressed rapidly, to compensate for the sudden influx of air. During cold starting, a choke (or butterfly valve) restricts airflow to the carburetor, thus enriching the mixture for faster starting. The choke on most automotive engine carburetors is operated automatically by a thermostatic spring, which opens the choke as the engine warms up. See [FUEL INJECTION](#).

**CATALYTIC CONVERTER** - an emissions control device incorporated into an automobile's exhaust system containing catalysts, such as platinum, palladium, or rhodium. Catalytic converters reduce the levels of hydrocarbons (HC), carbon monoxide (CO) and, in more recent designs, nitrogen oxides (NO<sub>x</sub>) emitted to the air. In the catalytic converter, HC and CO are oxidized to form carbon dioxide (CO<sub>2</sub>) and NO<sub>x</sub>, which are reduced to nitrogen and oxygen. Three-way catalytic converters that control all three substances require associated electronic controls for precise regulation of oxygen levels in the exhaust gas. Catalytic converters are also effective in removing PNA (polynuclear aromatic) hydrocarbons. Cars equipped with catalytic converters require unleaded gasoline, since the lead in tetraethyl lead (an anti-knock compound), is a catalyst "poison." See [EMISSIONS](#), [HYDROCARBON \(HC\) EMISSIONS](#), [LEAD ALKYL](#), [TB1 pg.1](#).

**CATALYTIC CRACKING** - in refining, the breaking down at elevated temperatures of large, high-boiling hydrocarbon molecules into smaller molecules in the presence of a catalyst. The principal application of catalytic cracking is the production of high-octane gasoline, to supplement the gasoline produced by distillation and other processes. Catalytic cracking also produces heating oil components and hydrocarbon feedstocks, such as propylene and butylene, for polymerization, alkylation, and petrochemical operations. See [TB10 pg.4](#).

**CETANE** - colorless liquid hydrocarbon, C<sub>15</sub>H<sub>34</sub>, used as a standard in determining diesel fuel ignition performance.

**CETANE NUMBER TESTING** - using ASTM D613, a measured value indicating the ignition quality of diesel fuel.

**CLOSED CUP** - method for determining the flash point of fuels, solvents, and cutback asphalts, utilizing a covered container in which the test sample is heated and periodically exposed to a small flame introduced through a shuttered opening. The lowest temperature at which the vapors above the sample briefly ignite is the flash point.

**CLOUD POINT TESTING** - using ASTM D2500, the temperature at which haze appears in an oil sample.

**COASTAL OIL** - common term for any predominately naphthenic crude oil derived from the fields in the Texas Gulf Coast area.

**COLD CRANKING SIMULATOR (CCS)** - an intermediate shear rate viscometer that predicts the ability of an oil to produce satisfactory cranking speed in a cold engine.

**COLD-FLOW IMPROVER** - additive to improve flow of diesel fuel in cold weather. In some instances, a cold-flow improver may improve operability by modifying the size and structure of the wax crystals that precipitate out of the fuels at low temperatures, permitting their passage through the fuel filter. In most cases, the additive depresses the pour point, which delays agglomeration of the wax crystals, but usually has no significant effect on diesel engine performance. Another means of improving cold flow is to blend kerosene with diesel fuel, which lowers the wax appearance point by about 1°C (2°F) for each 10% increment of kerosene added.

**COMBUSTION** - rapid oxidation of a fuel (burning). The products of an ideal combustion process are water (H<sub>2</sub>O) and carbon dioxide (CO<sub>2</sub>); if combustion is incomplete, some carbon is not fully oxidized, yielding carbon monoxide (CO). A stoichiometric combustible mixture contains the exact quantities of air (oxygen) and fuel required for complete combustion. For gasoline, this air-fuel ratio is about 14.7:1 by weight. For propane it is about 15.6:1. If the fuel concentration is too rich or too lean relative to the oxygen in the mixture, combustion cannot take place.

**COMPRESSION-IGNITION ENGINE** - diesel engine. See [INTERNAL COMBUSTION ENGINE](#).

**COMPRESSION RATIO** - in an internal combustion engine, the ratio of the volume of the combustion space in the cylinder at the bottom of the piston stroke to the volume at the top of the stroke. High-compression ratio gasoline engines require high octane fuels. Not to be confused with the pressure ratio of a compressor.

**CONDENSATE** - in refining, the liquid produced when hydrocarbon vapors are cooled. In oil and gas production, the term applies to hydrocarbons that exist in gaseous form under reservoir conditions, but condense to a liquid when brought to the surface.

**COPOLYMER** - See [POLYMER](#).

**COPPER STRIP CORROSION** - the tendency of a petroleum product to corrode cuprous metals, as determined by ASTM D130; the corrosion stains in a test copper strip are matched against standardized corroded strips.

**CORROSION** - any observed chemical attack on metal parts. Rust is a special case of the corrosion of iron.

**CORROSION INHIBITOR** - additive for protecting lubricated metal surfaces against chemical attack by water or other contaminants. There are several types of corrosion inhibitors. Polar compounds wet the metal surface preferentially, protecting it with a film of oil. Other compounds may absorb water by incorporating it in a water-in-oil emulsion so that only the oil touches the metal surface. Another type of corrosion inhibitor combines chemically with the metal to present a non-reactive surface. See [RUST INHIBITOR](#), [TB12 pg.1](#).

**CORROSIVE WEAR** - progressive removal of material from rubbing surface caused by a combination of chemical attack and mechanical action.

**CRACKING** - petroleum refining in which large-molecule liquid hydrocarbons are converted to small-molecule, lower-boiling point liquids or gases; the liquids leave the reaction vessel as unfinished gasoline, kerosene, and gas oils. At the same time, certain unstable, more reactive molecules combine into larger molecules to form tar or coke bottoms. The cracking reaction may be carried out under heat and pressure alone (thermal cracking), or in the presence of a catalyst (catalytic cracking). See [TB10 pg.3](#).

**CRUDE OIL** - the mixture of petroleum liquids and gases (together with associated impurities) pumped out of the ground by oil wells. It is described by the location of its origin (e.g., "western Texas" or "Brent") and often by its relative weight or viscosity (light, intermediate, or heavy). It may also be referred to as "sweet," which means it contains relatively little sulfur (in the form of the gas H<sub>2</sub>S) and requires less refining, or "sour," which means it contains substantial sulfur and requires more refining. The presence of H<sub>2</sub>S also adds considerably to the production costs as this highly toxic gas cannot simply be emitted into the atmosphere. Usually, it is either stored and then disposed of, or pumped back in the top of the oil reservoir where it expands and helps "push" remaining oil towards producing wells (this is referred to as gas reinjection). Crude oil, like coal and natural gas, is generally held to be the product of compression of ancient vegetation

over geological time scales. It is generally classified by the predominate type of hydrocarbon present, crudes are classified as paraffinic, naphthenic, asphaltic (naphthenic/aromatic) and mixed base (paraffinic/naphthenic/aromatic).

**CUT** - segregated part or fraction separated from crude in the distillation process. See [DISTILLATION](#).

## - D -

**DEMULSIBILITY** - ability of an oil to separate from water, as determined by ASTM D1401 or D2711. Demulsibility is an important consideration in lubricant maintenance in many circulating lubrication systems.

**DEMULSIFIER** - additive that promotes oil-water separation in lubricants exposed to water or steam.

**DENSITY** - See [SPECIFIC GRAVITY](#).

**DESMODROMIC** - is used to refer to mechanisms that have different controls for their actuation in different directions. Specifically applied to internal combustion engine valve trains, it refers to a compound follower arrangement on a camshaft where a different follower handles the opening of a valve than the closing. In this setup, either very minimal or no valve return springs are necessary. Some desmodromic valve systems use a different cam lobe for each follower, but in either case, there are independent cam followers for the opening and closing action.

**DETERGENT** - important component of engine oils that helps control varnish, ring zone deposits, and rust by keeping insoluble particles in colloidal suspension and in some cases, by neutralizing acids. A detergent is usually a metallic (commonly barium, calcium, or magnesium) compound, such as sulfonates, phosphonate, thiophosphonate, phenate, or salicylate. Because of its metallic composition, a detergent leaves a slight ash when the oil is burned. A detergent is normally used in conjunction with a dispersant. See [ASH](#).

**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.

**DETONATION** - sometimes called engine knock, is the uncontrolled supersonic explosion of the fuel-air charge in reciprocating engines. It occurs independently of spark plug ignition, and may be caused by excessively high combustion chamber temperatures. It may occur prior to the firing of the spark plug in Otto-cycle engines. High compression ratios or high temperatures can cause the flame speed of combustion to exceed the sound barrier, resulting in an explosion or detonation and a pressure shock wave. Detonations are extremely destructive to common piston engines, and may result in mechanical deformation of the cylinder walls, piston rings, holes blown through the top of pistons, or cracks in cylinder heads. Detonation can also burn out a spark plug, reducing or eliminating its ability to produce a spark. Detonation is most destructive if it occurs during times in which the explosion forces the piston downwards while it is traveling upwards, which relates to ignition timing. High-octane gasolines resist detonation. Also called knock. See [OCTANE NUMBER](#), [PRE-IGNITION](#).

**DEWAXING** - removal of paraffin wax from lubricating oils to improve low temperature properties, especially to lower the cloud points and pour point. See [TB10 pg.3](#).

**DIBASIC ACID ESTER** - also referred to as diester, is a synthetic lubricant base; an organic ester, formed by reacting a dicarboxylic acid and an alcohol; properties include a high viscosity index (VI) and low volatility. With the addition of specific additives, it may be used as a lubricant in compressors, hydraulic systems, and internal combustion engines.

**DILUTION** - the process of making a solution weaker or less concentrated. For oil additives, the process of diluting the additive with oil to decrease its concentration. See [TB7 pg.1](#).

**DISPERSANT** - engine oil additive that helps prevent sludge, varnish, and other engine deposits by keeping particles suspended in a colloidal state. Dispersants are normally used in conjunction with detergents. A dispersant is commonly distinguished from a detergent in that the former is non-metallic and, thus, does not leave an ash when the oil is burned; hence, the term ash less dispersant. Also, a dispersant can keep appreciable larger quantities of contaminants in suspension than a detergent.

**DISTILLATE** - any of a wide range of petroleum products produced by distillation, as distinct from bottoms, cracked stock, and natural gas liquids. In fuels, a term referring specifically to those products in the mid-boiling range, which include kerosene, turbo fuel, and heating oil, also called middle distillates and distillate fuels. In lubricating oils, lube distillate is the term applied to the various fractions separated under vacuum in a distillation tower for further processing. See [CRACKING](#).

**DISTILLATION** - the primary refining step also referred to as fractionation, in which crude is separated into fractions, or components, in a distillation tower, or pipe still. Heat is usually applied at the bottom of the tower and causes the oil vapors to rise through progressively cooler levels of the tower. Higher in the tower these vapors condense into plates and are drawn off in order of their respective condensation temperatures (or boiling points). The lighter-weight, lower-boiling-point fractions exit higher in the tower. The primary fractions, from low to high boiling point are: hydrocarbon gases (e.g., ethane, propane); naphtha (e.g., gasoline); kerosene, diesel fuels (heating oil); and heavy gas for cracking. Heavy materials remaining at the bottom are called the bottoms or residuum, and include such components as heavy fuel oil and asphaltic substances. Those fractions taken in liquid form from any level other than the very top or bottom are called overhead product. Distillation may take place in two stages: first, the lighter fractions: gases, naphtha, and kerosene, are recovered at essentially atmospheric pressure; next, the remaining crude is distilled at reduced pressure in a vacuum tower. This causes the heavy lube fractions to distill at much lower temperatures than possible at atmospheric pressure, permitting more lube to be distilled without molecular cracking that can occur at extensively high temperatures. See [TB10 pg.3](#).

**DISTILLATION TEST** - method for determining the full range of volatility characteristics of a hydrocarbon liquid by progressively boiling off (evaporating) a sample under controlled heating. Initial boiling point (IBP) is the fluid temperature at which the first drop falls into a graduated cylinder after being condensed in a condenser connected to a distillation flask. Mid-boiling point (MBP) is the temperature at which 50% of the fluid has collected in the cylinder. Dry point is the temperature at which the last drop of fluid disappears from the bottom of the distillation flask. Final boiling point (FBP) is the highest temperature observed. Front-end volatility and tail-end volatility are the amounts of test sample that evaporate, respectively, at the low and high temperature ranges. If the boiling range is small, the fluid is said to be narrow cut, that is, having components with similar volatilities; if the boiling range is wide, the fluid is termed wide cut. Distillation may be carried out by several methods, including ASTM D86, D850, D1078, and D1160.

## - E -

**ELASTO-HYDRODYNAMIC (EHD) LUBRICATION** - the lubrication phenomenon occurring during elastic deformation of two non-conforming surfaces under high load. A high load carried by a small area (as between the ball and race of a rolling contact bearing) causes a temporary increase in lubrication viscosity as the lubricant is momentarily trapped between slightly deformed opposing surfaces. See [TB11 pg.8](#).

**ELASTOMETER** - rubber or rubber-like material, both natural and synthetic, used in making a wide variety of products, such as tires, seals, hose, belting, and footwear. In oil seals, an elastometer's chemical composition is a factor in determining its compatibility with a lubricant, particularly a synthetic lubricant.

**EMISSIONS** - the three major pollutant emissions for which gasoline-powered vehicles are controlled are: unburned hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NO<sub>x</sub>). Diesel-powered vehicles primarily emit NO<sub>x</sub> and particulates. Motor vehicles contribute only a small percentage of total man-made emissions of other atmospheric pollutants, such as sulfur oxides. Evaporative HC emissions from the fuel tank and carburetor are absorbed by activated carbon contained in a canister installed on the vehicle. Blow-by HC emissions from the crankcase are controlled by positive crankcase ventilation (PCV). Exhaust emissions of HC, CO, and NO<sub>x</sub> (the products of incomplete combustion) are controlled primarily by a catalytic converter in conjunction with exhaust gas recirculation. The automotive industry is implementing increasingly sophisticated technology for improving combustion efficiency, including electronic emission controls. See [HYDROCARBON \(HC\) EMISSIONS](#).

**EMULSIFIER** - additive that promotes the formation of a stable mixture or emulsion of oil and water. Common emulsifiers are: metallic soaps, certain animal and vegetable oils, and various polar compounds (having molecules that are water-soluble at one extremity of their structures and oil-soluble at the other).

**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. Water from condensation of combustion products, carbon, residues from fuel or lubricating oil additives, dust metal particles also contribute. Engine deposits can impair engine performance and damage engine components by causing valve and ring sticking, clogging of the oil screen and oil passages, and excessive wear of pistons and cylinders. Hot, glowing deposits in the combustion chamber can also cause pre-ignition of the air-fuel mix. Engine deposits are increased by short trips in cold weather, high-temperature operation, heavy loads (such as pulling a trailer), and over-extended oil drain intervals.

**ENGINE OIL** - oil carried in crankcase, sump, or oil pan of a reciprocating internal combustion engine to lubricate all major engine parts; also used in reciprocating compressors and in steam engines of crankcase design. In automotive applications, it is the function of the engine oil not only to lubricate, but to cool hot engine parts, keep the engine free of rust and deposits, and seal the rings and valves against leakage of combustion gases. Oil-feed to the engine parts is generally under pressure developed by a gear pump (forced feed). The oil circulates through passages formed by tubing and drilling (rifling) through the engine parts, and through an oil filter to remove metallic contaminants and other foreign particles. In some engines, lubrication may also be accomplished in part by splashing resulting from the rotation of the crankshaft in the oil in the sump. Modern engine oils are formulated with additives to improve performance. Additive content in a single-viscosity-grade oil is typically around 15 mass percent, and in a multi-grade oil, 20 percent or more. See [TB11 pg.1](#).

**ENGINE OIL SUPPLEMENT (EOS)** - a engine break-in supplement manufactured for General Motors containing the anti-wear agent ZDDP and detergents. See [TB1 pg.2](#).

**ENVIRONMENTAL PROTECTION AGENCY (EPA)** - a United States Governmental agency. The mission of the EPA is to protect human health and the environment. To this end, the United States Congress has empowered the EPA with the setting and enforcement of regulations pertaining to pollution from consumer and industrial sources.

**EXTREME PRESSURE (EP) ADDITIVE** - a 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. Reactive compounds of sulfur, chlorine, or phosphorus are used to form these inorganic films.

**EROSION** - mechanical removal of material by impingement of high velocity fluid with or without entrained particles.

**ESTER** - chemical compound formed by the reaction of an organic or inorganic acid with an alcohol or with another organic compound containing the hydroxyl (-OH) radical. The reaction involves replacement of the hydrogen of the acid with a hydrocarbon group. The name of the ester indicates its derivation; e.g., the ester resulting from the reaction of ethyl alcohol and asceic acid is called ethyl acetate. Esters have important uses in the formulation of some petroleum additives and synthetic lubricants. See [DIBASIC ACID ESTER](#), [PHOSPHATE ESTER](#).

**ETHANOL** - also known as ethyl alcohol (C<sub>2</sub>H<sub>5</sub>OH). Obtained principally from the fermentation of grains or blackstrap molasses; also obtained from ethylene, by absorption in sulfuric acid and hydrolyzing with water. Widely used as an industrial solvent, extraction medium, chemical intermediate, and in many proprietary products; a component of gasohol.

**ETHYLENE** - flammable gas (C<sub>2</sub>H<sub>4</sub>) derived from natural gas and petroleum; the lowest molecular weight member of the generic family of olefins. Ethylene is widely used as a feedstock in the manufacture of petrochemicals, including polyethylene and other plastics.

**EXHAUST GAS RECIRCULATION (EGR)** - system designed to reduce automotive exhaust emissions of nitrogen oxides (NO<sub>x</sub>). The system routes exhaust gases into the carburetor or intake manifold; the gases dilute the air-fuel mixture. See [COMBUSTION](#).

**EXTRACTION** - use of a solvent to remove edible and commercial oils and seeds (e.g., soybeans), or oils and fats from meat scraps; also, the removal of reactive components from lube distillates. See [SOLVENT EXTRACTION](#).

## - F -

**FATTY ACID** - any monobasic (one displaceable hydrogen atom per molecule) organic acid having the general formula  $(C_nH_2)_{n+1}COOH$ . Fatty acids derived from natural fats and oils are used to make soaps used in the manufacture of greases and other lubricants. See [GREASE](#).

**FILM STRENGTH** - See [LUBRICITY](#).

**FIRE POINT** - temperature at which the vapor concentration of combustible liquid is sufficient to sustain combustion, as determined by ASTM D92, Cleveland Open Cup method.

**FLASH POINT** - the temperature at which a product's vapor can be ignited momentarily by a flame, using ASTM D92 Cleveland Open Cup (preferred for engine oils), D56 Tag Closed Tester, D93 Pensky-Martens Closed Tester or D1310 Tag Open Cup methods.

**FLAT-TAPPET** - a plain (non-roller) camshaft follower. Wear of flat cam followers has become a source of significant concern as ZDDP levels are slowly decreased in modern oils, starting with API SL rated oil. In order to deal with the decreased ZDDP levels, manufacturers have redesigned engines with roller followers. See [TAPPET](#), [TB11 pg.9](#).

**FLOC POINT** - temperature at which waxy materials in a lubricating oil separate from a mixture of oil and Freon (Registered trademark of E.I. Dupont de Nemours, Inc.) R-12 refrigerant, giving a cloudy appearance to the mixture; also called Freon floc point. Generally used to evaluate the tendency of refrigeration oils to plug expansion valves or capillaries in refrigerant systems. Not to be confused with cloud point, the temperature at which wax precipitates from an undiluted oil.

**FLUID FRICTION** - See [FRICTION](#).

**FOAMING** - occurrence of frothy mixture of air and petroleum product (e.g., lubricant, fuel oil) that can reduce the effectiveness of the product. The film strength of oil in a hydrodynamic lubrication mode is greatly reduced by the presence of foam, due to the displacement of oil by air. Foaming can result from excessive agitation, improper fluid levels, air leaks, cavitation, or contamination with water or other foreign materials. Some oil additives which contain long-chain polymers will increase foaming in oil. Foaming can be inhibited with an anti-foam agent. The foaming characteristics of a lubricating oil can be determined by blowing air through a sample at a specified temperature and measuring the volume of foam, as described in ASTM D892. See [TB12 pg.11](#).

**FRETTING** - wear occurring on mating surfaces due to slight relative motion resulting from dynamic stresses.

**FRICTION** - resistance to the motion of one surface over 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. Friction between unlubricated solid bodies is independent of speed and area. The coefficient of friction is obtained by dividing the force required to move one body over a horizontal surface at a constant speed, by the weight of the body. Coefficients of rolling friction (e.g., the motion of a tire or ball bearing) are much less than the coefficient of sliding friction (back and forth motion over two flat surfaces). Sliding friction is thus more wasteful of energy and can cause more wear. Fluid friction occurs between the molecules of a gas or liquid in motion, and is expressed as shear stress. Unlike solid friction, fluid friction varies with speed and area. In general, lubrication is the substitution of low fluid friction in place of high solid-to-solid friction. See [TRIBOLOGY](#).

**FEDERAL TEST METHOD (FTM)** - a system of standards and measurement methods maintained by the United States Federal Government.

**FUEL ECONOMY OIL** - engine oil specially formulated to increase fuel efficiency. A fuel-economy of oil works by reducing the friction between moving engine parts that wastefully consumes fuel energy. There are two known means of accomplishing this goal: (1) by reducing the viscosity of the oil to decrease fluid friction and (2) by using friction-reducing additives in the oil to prevent metal-to-metal contact or rubbing friction between surfaces. See [TB6 pg.1](#).

**FUEL INJECTION** - method of introducing fuel under pressure through a small nozzle into the intake system or cylinders

of an engine. Fuel injection is essential to the diesel cycle, and an alternative to conventional carburetion in the gasoline engine. In some designs, each cylinder has a cam-operated injector, which is a plunger pump that delivers precisely metered quantities of fuel at precise intervals. The fuel is injected in a minutely divided spray at high discharge. The amount of the charge is controlled by the throttle pedal. A combination of fuel injection and carburetion is used in advanced emission-control systems, involving fuel injection into the throttle body of the carburetor. Fuel injection offers certain advantages over carburetion including: (1) more balanced fuel distribution in the cylinders for improved combustion, (2) more positive delivery of fuel to the cylinder (hence, easier starting and faster acceleration), and (3) higher power output because of improved volumetric efficiency. See [CARBURETOR](#).

**FULL-FLUID-FILM LUBRICATION** - See [HYDRODYNAMIC LUBRICATION](#).

## - G -

**GAS ENGINE** - internal combustion engine, either two or four stroke cylinder, powered by natural gas or LPG. Commonly used to drive compressors on gas pipelines, utilizing as fuel a portion of the gas being compressed.

**GASOHOL** - blend of 10% volume anhydrous ethanol (ethyl alcohol) and 90% unleaded gasoline.

**GASOLINE** - blend of light hydrocarbon fractions of relatively high anti-knock value. Finished motor and aviation gasolines may consist of the following components; straight-run naphthas, obtained by primary distillation of crude oil; natural gasoline which is "stripped" or condensed out of natural gas; cracked naphthas or reformed naphthas; and alkylate. A high-quality gasoline has the following properties (1) proper volatility to ensure easy starting and rapid warm-up; (2) clean-burning characteristics to prevent harmful engine deposits; (3) additives to prevent rust, oxidation, and carburetor icing; and (4) sufficiently high octane number to prevent engine knock. See [CATALYTIC CRACKING](#).

**GEAR OIL** - long-life oil of relatively high viscosity for the lubrication of rear axles and some manual transmissions. Most final drives and many accessories in agricultural and construction equipment also require gear oils. Straight (non-additive) mineral gear oils are suitable for most spiral-bevel rear axles and for some manual transmissions. Use of such oils is declining, however, in favor of EP (extreme pressure) gear oils suitable for both hypoid gears and for all straight mineral oil applications. An EP oil is also appropriate for off-highway and other automotive applications for which the lubricant must meet the requirements of Military Specification MIL-L-2105C.

**GRAVITY** - See [SPECIFIC GRAVITY](#).

**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. Soap thickeners are formed by reacting (saponifying) a metallic hydroxide or other alkali with a fat, fatty acid, or ester. The type of soap used depends on the grease properties desired. Calcium (lime) soap greases are highly resistant to water, but unstable at high temperatures. Sodium soap greases are stable at high temperatures, but wash out in moist conditions. Lithium soap greases resist both heat and moisture. A mixed-base soap is a combination of soaps, offering some of the advantages of each type. A complex soap is formed by the reaction of an alkali with a high-molecular-weight fat or fatty acid to form a soap, and the simultaneous reaction of the alkali with a short-chain organic or inorganic acid to form a metallic salt (the complexing agent). Complexing agents usually increase the dropping point of grease. Lithium, calcium, and aluminum greases are common alkalis in complex-soap greases. Non-soap thickeners, such as clays, silica gels, carbon black, and various synthetic organic materials are also used in grease manufacture. A multi-purpose grease is designed to provide resistance to heat as well as water, and may contain additives to increase load-carrying ability and inhibit rust.

## - H -

**HEAVY ENDS** - highest boiling portion in a distilled petroleum fraction or finished product. In motor gasoline, the heavy ends do not fully volatilize until the engine has warmed. See [LIGHT ENDS](#).

**HYDROCARBON** - chemical compound of hydrogen and carbon; also called organic compound. Hydrogen and carbon atoms can be combined in virtually countless ways to make a diversity of products. Carbon atoms form the skeleton of the hydrocarbon molecule, and may be arranged in chains (aliphatic) or rings (cyclic). There are three principal types of hydrocarbons that occur naturally in petroleum: paraffins, naphthenes, and aromatics, each with distinctive properties. Paraffins are aliphatic, the others cyclic. Paraffins and naphthenes are saturated; that is, they have a full complement of hydrogen atoms and, thus, only single bonds between carbon atoms. Aromatics are unsaturated, and have as part of the molecular structure at least one benzene ring, i.e., six carbon atoms in a ring configuration with alternating single and double bonds. Because of these double bonds, aromatics are usually more reactive than paraffins and naphthenes, and are therefore prime carbons for chemical synthesis. Other types of hydrocarbons are formed during the petroleum refining process. Important among these are olefins and acetylenes. Olefins are unsaturated hydrocarbons with at least one double bond in the molecular structure, which may be in either an open chain or ring configuration; olefins are highly reactive. Acetylenes are also unsaturated and contain at least triple bond in the molecule. See [SATURATED HYDROCARBON](#), [UNSATURATED HYDROCARBON](#).

**HYDROCARBON (HC) EMISSIONS** - substances considered to be atmospheric pollutants because the more reactive hydrocarbons (e.g., aromatics) undergo a photochemical reaction with nitrogen oxides (NO<sub>x</sub>) to form oxidants, components of smog that can cause eye irritation and respiratory problems. Motor vehicles account for about one-third of man-made hydrocarbon emissions, although automotive emission controls are reducing this amount. The greatest portion of total atmospheric hydrocarbons is from natural sources, such as pine trees. See [CATALYTIC CONVERTER, EMISSIONS](#).

**HYDROCRACKING** - refining process in which the middle and heavy distillate fractions are cracked (broken into smaller molecules) in the presence of hydrogen at high pressure and moderate temperature to produce high-octane gasoline, turbine fuel components, and middle distillates with good flow characteristics and cetane ratings. The process is a combination of hydrogenation and cracking.

**HYDRODYNAMIC LUBRICATION** - presence of a continuous lubricating film sufficient to completely separate two surfaces, as distinct from boundary lubrication. Hydrodynamic lubrication is a form of full-fluid-film lubrication, whereby the oil adheres to the moving part and is drawn into the area between the sliding surfaces, where it forms a pressure or hydrodynamic wedge. See [STRIBECK CURVE](#), [TB11 pg.2](#).

**HYDROFINISHING** - form of hydrogen treating in which refinery distillate, lube, and wax streams are treated with hydrogen at elevated temperatures and moderate pressures in the presence of a catalyst, to improve color and stability, and reduce sulfur content.

**HYDROFORMING** - a dehydrogenation process in which naphthas are passed over a solid catalyst at elevated temperatures and moderate pressures in the presence of hydrogen to form high-octane motor gasoline, high-grade aviation gasoline, or aromatic solvents. This process is a net producer of hydrogen.

**HYDROGENATION** - in refining, the chemical addition of hydrogen to a hydrocarbon in the presence of a catalyst, a severe form of hydrogen treating. Hydrogenation may be either destructive or non-destructive. In the former case, hydrocarbon chains are ruptured (cracked) and hydrogen is added where the breaks have occurred. In the latter, hydrogen is added to a molecule that is unsaturated with respect to hydrogen. In either case, the resulting molecules are highly stable. Temperature and pressures in the hydrogenation process are usually greater than hydrofinishing. See [UNSATURATED HYDROCARBON](#).

**HYDROTREATING** - refining process in which hydrocarbons are treated with hydrogen in the presence of a catalyst at relatively low temperatures to remove mercaptans and other sulfur compounds, and improve color and stability. See [HYDROFINISHING](#).

**HYDROPHILIC** - also hydroscopic, having an affinity for water. Some polar compounds are simultaneously hydrophilic and oil soluble, or oliophilic.

**HYDROPHOBIC** - the opposite of hydrophilic.

**HYDROSTATIC LUBRICATION** - a less common form of full-fluid-lubrication is hydrostatic lubrication, wherein the oil is supplied to the bearing area under sufficient external pressure to separate the sliding surfaces.

**HYDROSCOPIC** - See [HYDROPHILIC](#).

- / -

**INITIAL BOILING POINT (IBP)** - the temperature at which vapor bubbles are generated in a liquid. See [DISTILLATION TEST](#).

**INDUCTIVELY COUPLED PLASMA (ICP)** - a way of magnetically exciting atoms to emit their characteristic energy which is then analyzed, and the elemental makeup identified. Commonly used in analytical instrument that measures elements in lubricating additives. See [TB4 pg.2](#).

**INHIBITOR** - additive that improves the performance of a petroleum product through the control of undesirable chemical reactions. See [CORROSION INHIBITOR](#), [OXIDATION INHIBITOR](#), [RUST INHIBITOR](#).

**INSOLUBLES TESTING** - using ASTM D893, material not soluble in pentane or toluene, with or without the use of a coagulant.

**INTERFACIAL TENSION (IFT)** - the force required to rupture the interface between two liquid phases. The interfacial tension between water and a petroleum oil can be determined by measuring the force required to move a platinum ring upward through the interface, under conditions specified by ASTM D971. Since the interface can be weakened by oxidation products in the oil, this measurement may be evidence of oil deterioration. The lower the surface tension below the original value, the greater the extent of oxidation. ASTM D971 is not widely used with additive-containing oils, since additives may affect surface tension, thus reducing the reliability of the test as an indicator of oxidation.

**INTERNAL COMBUSTION ENGINE** - heat engine driven directly by the expansion of combustion gases, rather than by an externally produced medium, such as steam. Basic versions of the internal combustion engine are: gasoline engine and gas engine (spark ignition), diesel engine (compression ignition), and gas turbine (continuous combustion). Diesel compression-ignition engines are more fuel-efficient than gasoline engines because compression ratios are higher, and because the absence of air throttling improves volumetric efficiency.

Gasoline, gas (natural gas, propane), and diesel engines operate either on a four-stroke cycle (Otto cycle) or a two-stroke cycle. Most gasoline engines are of the four-stroke type, with operation as follows: (1) intake (piston moves down the cylinder, drawing in a fuel-air mixture through the intake valve); (2) compression (all valves closed, piston moves up, compressing the fuel-air mixture, and spark ignites mixture near top of stroke); (3) power (rapid expansion of heat combustion drives piston down, all valves remain closed); and (4) exhaust (exhaust valves open and piston returns, forcing out spent gases).

The diesel four-stroke cycle differs in that only air is admitted on the intake stroke, fuel is injected at the top of the compression stroke, and the fuel-air mixture is ignited by the heat of compression rather than by an electric spark. The four-stroke cycle engine has certain advantages over a two-stroke, which include: higher piston speeds, wider variation in speed and load, cooler pistons, no fuel lost through exhaust, and lower fuel consumption.

The two-stroke cycle eliminates the intake and exhaust strokes of the four-stroke cycle. As the piston ascends, it compresses the charge in the cylinder, while simultaneously drawing a new fuel-air charge into the crankcase, which is air-tight. (In the diesel two-stroke cycle, only air is drawn in; the fuel is injected at the top of the compression stroke.) After ignition, the piston descends on the power stroke, simultaneously compressing the fresh charge in the crankcase. Toward the end of the power stroke, intake ports in the piston skirt admit a new fuel-air charge that sweeps exhaust products from the cylinder through exhaust ports; this means of flushing out exhaust gases is called "scavenging." Because the crankcase is needed to contain the intake charge, it cannot double as an oil reservoir. Therefore, lubrication is generally supplied by oil that is pre-mixed with the fuel. An important advantage of the two-stroke cycle engine is that it offers twice as many power strokes per cycle and, thus, greater output for the same displacement and speed. Because two-stroke engines are light in relation to their output, they are frequently used where small engines are desirable, as in chain saws, outboard motors, and lawn mowers. Many commercial, industrial, and railroad diesel engines are also two-stroke.

Gas turbines differ from conventional internal combustion engines in that a continuous stream of hot gases is directed at the blades of a rotor. A compressor section supplies air to a combustion chamber into which fuel is sprayed, maintaining continuous combustion. The resulting hot gases expand through the turbine unit, turning the rotor and driveshaft.

See [TB11 pg.1](#), [TB12 pg.2](#).

**ION** - electrically charged atom, or group of atoms, that has lost or gained electrons. Electron loss makes the resulting particle positive, while electron gain makes the particle negative.

**ISOMER** - a molecule having the same molecular formula as another molecule, but having a different structure and, therefore, different properties. As the carbon atoms in a molecule increase, the number of possible combinations, or isomers, increases sharply. For example octane (an 8-carbon-atom molecule) has 18 isomers; decane (a 10-carbon-atom molecule) has 75 isomers.

**ISOOCTANE** - an isomer of octane (C<sub>8</sub>H<sub>18</sub>) having very good anti-knock properties. With a designated octane number of 100, isooctane is used as a standard for determining the octane number of gasolines.

**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. For example, a lubricant with an ISO grade of 32 has a viscosity within the range of 28.8 - 35.2 cSt, the mid-point of which is 32.

## - J -

**JOURNAL** - that part of a shaft or axle which rotates in or against a bearing. See [TB11 pg.2](#).

## - K -

**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 ASTM D445. To determine kinetic viscosity, a fixed volume of the test fluid is allowed to flow through a calibrated capillary tube (viscometer) that is held at a closely controlled temperature. The kinematic viscosity in centistokes (cSt) is the product of the measured flow time in seconds and the calibration constant of the viscometer. See [VISCOSITY](#), [TB10 pg.6](#).

**KNOCK** - See [DETONATION](#).

## - L -

**LACQUER** - a thin varnish-like deposit composed primarily of organic residue most readily definable by color. It is resistant to saturated solvents (e.g., petroleum naphtha) but is soluble in other solvents (e.g., benzene, chloroform, ketones) and similar compounds classed as "lacquer solvents." Most often association with diesel engines.

**LEAD ALKYL** - any of several lead compounds used to improve octane number in a gasoline. The best known is tetraethyl lead (TEL), Pb (C<sub>2</sub>H<sub>5</sub>)<sub>4</sub>. Another is tetramethyl lead (TML), Pb (CH<sub>3</sub>)<sub>4</sub>. Other compounds have varying proportions of methyl radicals (CH<sub>3</sub>) and ethyl radicals (C<sub>2</sub>H<sub>5</sub>). Use of lead compounds in motor gasoline has been phased out for environmental reasons. Beginning with the 1980-model year, all new U.S. and foreign-made cars sold in the U.S. require unleaded gasoline.

**LEAN AND RICH OCTANE NUMBER** - expression of the anti-knock value of an aviation gasoline at lean air-fuel mixtures (relatively low concentration of fuel) and rich air-fuel mixtures, respectively. A grade designation of 80/87 means that at lean mixtures the fuel performs like an 80-octane gasoline and at rich mixtures, like an 87-octane gasoline.

**LIGHT ENDS** - low-boiling-point hydrocarbons in gasoline having up to five carbon atoms, e.g., butanes, butenes, pentanes, pentenes, etc. Also, any extraneous low-boiling fraction in a refinery process stream.

**LIQUEFIED PETROLEUM GAS (LPG)** - propane or (less commonly) butane, obtained by extraction from natural gas or from refinery processes. LPG has a vapor pressure sufficiently low to permit compression and storage in a liquid state at moderate pressures and normal ambient temperatures. Pressurized in metal bottles or tanks, LPG is easily handled and readily lends itself to a variety of applications as a fuel, refrigerant, and propellant in packaged aerosols. LPG is also called LP gas and bottled gas. See [NATURAL GAS LIQUIDS](#).

**LOAD WEAR INDEX (LWI)** - 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. Formerly called mean Hertz load.

**LUBRICATING OIL** - compounded or finished oil consisting of base stocks and the additives necessary for providing the required performance.

**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. For principles of lubrication, see [BOUNDARY LUBRICATION](#), [HYDRODYNAMIC LUBRICATION](#), [ELASTO-HYDRODYNAMIC \(EHD\) LUBRICATION](#), [STRIBECK CURVE](#), [TB10 pg.1](#), [TB11](#).

**LUBRICITY** - ability of an oil or grease to lubricate; also, called film strength. Lubricity can be enhanced by additive treatment. See [POLAR COMPOUND](#), [TB10 pg.6](#).

## **- M -**

**MASS SPECTROMETER** - apparatus for rapid quantitative and qualitative analysis of hydrocarbon compounds in a petroleum sample. It utilizes the principle of accelerating molecules in a circular path in an electrical field. The compounds are separated by centrifugal force, with the molecules having a greater mass (weight) being thrown to the outer periphery of the path. Quantitative measurements are accomplished by use of either a photographic plate or electronic determination of the relative proportions of each type of particle of a given mass.

**MEAN HERTZ LOAD** - See [LOAD WEAR INDEX](#).

**MERCAPTAN** - any of a generic series of malodorous, toxic sulfur compounds occurring in crude oil. Mercaptans are removed from most petroleum products by refining, but may be added to natural gas and LPG in very low concentrations to give a distinctive warning odor.

**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. See [TB10 pg.4](#).

**MISCIBLE** - capable of being mixed in any concentration without separation of phases; e.g., water and ethyl alcohol are miscible.

**MOLYBDENUM DISULFIDE** - a black, lustrous powder ( $\text{MoS}_2$ ) that serves as a dry-film lubricant in certain high-temperature and high-vacuum applications. It is also used in the form of pastes to prevent scoring when assembling press-fit parts, and as an additive to impart residual lubrication properties to oils and greases. Molybdenum disulfide is often called moly or molydisulfide.

**MOTOR OIL** - See [ENGINE OIL](#).

**MULTI-GRADE OIL** - engine oil that meets the requirements of more than one SAE (Society of Automotive Engineers) viscosity grade classification, and may therefore be suitable for use over a wider-temperature range than a single-grade oil. Multi-grade oils have two viscosity grade numbers indicating their lowest and highest classification, e.g., SAE 10W-40. The lower grade number indicates the relative fluidity of the oil in cold weather for easy starting and immediate oil flow. The higher grade number indicates the relative viscosity of the oil at high operating temperatures for adequate wear

protection. The “W” means “winter” grade. Multi-grade oils generally contain viscosity improvers that reduce the tendency of an oil to lose viscosity, or thin out at high temperatures.

## - 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. See [HYDROCARBON](#), [SATURATED HYDROCARBON](#).

**NATURAL GAS** - naturally occurring mixture of gaseous saturated hydrocarbons, consisting of 80-95% methane ( $CH_4$ ), lesser amounts of propane, ethane and butane, and small quantities of non-hydrocarbon gases (e.g., nitrogen, helium). Natural gas is found in sandstone, limestone, and other porous rocks beneath the earth's surface, often in association with crude oil. Because of its high heating value and clean-burning characteristics, natural gas is widely used as a fuel. The heavier hydrocarbons in natural gas can be extracted, through compression or absorption processes, to yield LPG (propane or butane), natural gasoline, and raw materials for petrochemical manufacture.

**NATURAL GAS LIQUIDS** - hydrocarbons extracted from natural gas: primarily LPG (propane or butane) and natural gasoline, the latter being commonly blended with crude-derivative gasoline to improve volatility. Natural gas liquids can be separated from the lighter hydrocarbons of natural gas by compression (the gas is compressed and cooled until the heavier hydrocarbons liquefy) or by absorption (the gas is mixed with a petroleum distillate, such as kerosene, which absorbs, or dissolves, the heavier hydrocarbons).

**NEUTRAL OIL** - lubricant base stocks which are light overhead cuts from vacuum distillation units. Named for their SUS viscosity at 100°F, having viscosities ranging from about 13 to 130 cSt at 40°C. They are usually solvent or clay treated, but not refined with acid or alkali. Most commonly used to formulate automotive and commercial crankcase lubricants.

**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 ASTM D664 (potentiometric method) or ASTM D974 (colorimetric method). Strong acid number is the weight in milligrams of base required to titrate a one-gram sample up to a pH of 4; total acid number is the weight in milligrams of base required to neutralize all acidic constituents. Strong base number is the quantity of acid, expressed in terms of the equivalent number of milligrams of KOH, required to titrate a one-gram sample to a pH of 11; total base number is the milligrams of acid, expressed in equivalent milligrams of KOH, to neutralize all basic constituents. If the neutralization number indicates increased acidity (i.e., high acid number) of a used oil, this may indicate that oil oxidation, additive depletion, or a change in the oil's operating environment has occurred.

**NEWTONIAN FLUID** - fluid, such as a straight mineral oil, whose viscosity does not change with rate of flow. See [SHEAR STRESS](#).

**NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)** - known between 1901 and 1988 as the National Bureau of Standards (NBS), is a measurement standards laboratory which is a non-regulatory agency of the United States Department of Commerce. The institute's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life.

**NITROGEN OXIDES (NO<sub>x</sub>)** - emissions, from man-made and natural sources, of nitric oxide (NO), with minor amounts of nitrogen dioxide (NO<sub>2</sub>). NO<sub>x</sub> are formed whenever fuel is burned at high temperatures in air, from nitrogen in the air as well as in the fuel. Motor vehicles and stationary combustion sources (furnaces and boilers) are the primary man-made sources, although automotive emission controls are reducing the automobile's contribution. Natural emissions of NO<sub>x</sub> arise from bacterial action in the soil. NO<sub>x</sub> can react with hydrocarbons to produce smog. See [CATALYTIC CONVERTER](#), [EMISSION](#), [HYDROCARBON \(HC\) EMISSIONS](#).

**NATIONAL LUBRICATING GREASE INSTITUTE (NLGI)** - a trade association whose main interest is grease and grease technology. The NLGI is best known for its system of rating greases by penetration.

**NON-NEWTONIAN FLUID** - fluid, such as a grease or a polymer containing oil (e.g., multi-grade oil), in which shear stress is not proportional to shear rate. See [BROOKFIELD VISCOSITY](#).

**NORMAL PARAFFIN** - hydrocarbon consisting of unbranched molecules in which any carbon atom is attached to no more than two other carbon atoms; also called straight chain paraffin and linear paraffin.

## - O -

**OCTANE NUMBER** - expression of the anti-knock 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. Both the RON and MON tests are conducted in the same laboratory engine, but RON is determined under less severe conditions, and is therefore numerically greater than MON for the same fuel. The average of the two numbers (RON + MON)/2 is commonly used as the indicator of a gasoline's road anti-knock performance. The gasoline being tested is run in a special single-cylinder engine, whose compression ratio can be varied (the higher the compression ratio, the higher the octane requirement). The knock intensity of the test fuel, as measured by a knockmeter, is compared with the knock intensities of blends of isooctane (assigned a knock rating of 100) and heptane (with a knock rating of zero), measured under the same conditions as the test fuel. The percentage, by volume, of the isooctane in the blend that matches the characteristics of the fuel test is designated as the octane number of the fuel. For example, if the matching blend contained 90% isooctane, the octane number of the test fuel would be 90. In addition to the laboratory tests for RON and MON, there is a third method, Road Octane Number, which is conducted in a specially equipped test car by individuals trained to hear trace levels of engine knock.

**ORIGINAL EQUIPMENT MANUFACTURER (OEM)** - the definition of OEM in the automobile industry constitutes a federally licensed entity required to warrant and/or guarantee their products, unlike "aftermarket" which is not legally bound to a government-dictated level of liability.

**OXIDATION** - occurs when oxygen attacks petroleum fluids. The process is accelerated by heat, light, metal catalysts and the presence of water, acids, or solid contaminants. It leads to increased viscosity and deposit formation.

**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 anti-oxidant. An oxidation inhibitor may work in one of these ways: (1) by combining with and modifying peroxides (initial oxidation products) to render them harmless, (2) by decomposing the peroxides, or (3) by rendering an oxidation catalyst inert. ZDDP was one of the first and still most often specified anti-oxidant for oils and greases. See [TB12 pg.1](#).

## - P -

**PARAFFIN** - hydrocarbon identified by saturated straight (normal or branched {iso}) carbon chains. The generalized paraffinic molecule can be symbolized by the formula  $CH_2$ . Paraffins are relatively non-reactive and have excellent oxidation stability. In contrast to naphthenic oils, paraffinic lube oils have relatively high wax content and pour point, and generally have a high viscosity index (VI). Paraffinic solvents are generally lower in solvency than naphthenic or aromatic solvents. See [HYDROCARBON](#), [SATURATED HYDROCARBON](#), [TB10 pg.4](#).

**PASSENGER CAR ENGINE OIL (PCEO)** - See [ENGINE OIL](#).

**PASSENGER CAR MOTOR OIL (PCMO)** - See [ENGINE OIL](#).

**PERMANENT VISCOSITY LOSS (PVL)** - measure of difference between viscosities of fresh oil and same oil after engine operation or special test conditions of polymer degradation. May be determined under conditions of low or high shear. See [TB10 pg.6](#).

**PETROCHEMICAL** - any chemical derived from crude oil, crude products, or natural gas. A petrochemical is basically

a compound of carbon and hydrogen, but may incorporate many other elements. Petrochemical are used in the manufacture of numerous products, such as synthetic rubber, synthetic fibers (e.g., nylon and polyester), plastics, fertilizers, paints, detergents, and pesticides.

**pH** - the measure of acidity or alkalinity of an aqueous solution. The pH scale ranges from 0 (very acidic) to 14 (very alkaline), with a pH of 7 indicating a neutral solution equivalent to the pH of distilled water. See [NEUTRALIZATION NUMBER](#).

**PHOSPHORUS** - the chemical element that has the symbol P and atomic number 15. The name comes from the Greek "light" and "bearer," due to the greenish glow it gives off as it slowly burns in the presence of oxygen. Due to its high reactivity, phosphorus is never found as a free element in nature on Earth. A multivalent nonmetal of the nitrogen group, phosphorus is commonly found in inorganic phosphate rocks. It is commonly used in antiwear additives like ZDDP. See [ZDDP](#).

**PHOSPHATE ESTER** - any of a group of synthetic lubricants having superior fire resistance. A phosphate ester generally has poor hydrolytic stability, poor compatibility with mineral oil, and a relatively low viscosity index (VI). It is used as a fire-resistant hydraulic fluid in high-temperature applications.

**POLAR COMPOUND** - a chemical compound whose molecules exhibit electrically positive characteristics at one extremity and negative characteristics at the other. Polar compounds are used as additives in many petroleum products. Polarity gives certain molecules a strong affinity for solid surfaces; as lubricant additives (oiliness agents), such molecules plate out to form a tenacious, friction-reducing film. Some polar molecules are oil-soluble at one end and water-soluble at the other end; in lubricants, they act as emulsifiers, helping to form stable oil-water emulsions. Such lubricants are said to have good metal-wetting properties. Polar compounds with a strong attraction for solid contaminants act as detergents in engine oils by keeping contaminants finely dispersed. See [TB10 pg.6](#), [TB11 pg.4](#).

**POLYGLYCOLS** - polymers of ethylene or propylene oxides used as a synthetic lubricant base. Properties include very good hydrolytic stability, high viscosity index (VI), and low volatility. Used particularly in water emulsion fluids.

**POLYMER** - substance formed by the linkage (polymerization) of two or more simple, unsaturated molecules called monomers, to form a single heavier molecule having the same elements in the same proportions as the original monomers; i.e., each monomer retains its structural identity. A polymer may be liquid or solid; solid polymers may consist of millions of repeated linked units. A polymer made from two or more dissimilar monomers is called a copolymer; a copolymer composed of three different types of monomers is a terpolymer. Natural rubber and synthetic rubbers are polymers.

**POLYMERIZATION** - in petroleum refining, polymerization refers to the combination of light, gaseous hydrocarbons, usually olefins, into high-molecular-weight hydrocarbons that are used in manufacturing motor gasoline and aviation fuel. The product formed by combining two identical olefin molecules is called a dimer, and by three such molecules, a trimer. See [POLYMER](#).

**POLYOLEFIN** - polymer derived by polymerization of relatively simple olefins. Polyethylene and polyisoprene are important polyolefins.

**POLYOL ESTER** - synthetic lubricant base, formed by reacting fatty acids with a polyol (such as a glycol) derived from petroleum. Properties include good oxidation stability at high temperatures and low volatility. Used in formulating lubricants for turbines, compressors, jet engines, and automotive engines. See [TB10 pg.5](#).

**POUR POINT** - using ASTM D97, the lowest temperature at which the oil can be poured. Also, using FTM 203, the stable pour point is the lowest temperature at which an oil will remain fluid after being subjected to a cyclic temperature variation for six days. See [TB10 pg.7](#).

**POUR POINT DEPRESSANT** - additive used to lower the pour point of a petroleum product.

**PARTS PER BILLION (PPB)** - one part per billion is 1 part in 1,000,000,000 or 0.0000001%.

**PARTS PER MILLION (PPM)** - one part per million is 1 part in 1,000,000, or 0.0001%.

**PRE-IGNITION** - ignition of a fuel-air mixture in an internal combustion engine (gasoline) before the spark plug fires. It can be caused by a hot spot in the combustion chamber or a very high compression ratio. Pre-ignition reduces power and can damage the engine.

**PUMPABILITY** - the low temperature, low shear, stress-shear rate viscosity characteristics of an oil that permit satisfactory flow to and from the engine oil pump and subsequent lubrication of moving components. Measured in the mini-rotary viscometer, ASTM D4684, and referred to as the borderline pumping temperature.

## - Q -

**QUALITATIVE TEST** - a test to determine the nature of a compound or mixture or the identity of each constituent present.

**QUANTITATIVE TEST** - a test to show the amount of each constituent present in a compound or mixture.

## - R -

**RAFFINATE** - in solvent extraction, that portion of the oil which remains undissolved and is not removed by the selective solvent.

**RATE OF SHEAR** - See [SHEAR RATE](#), [TB11 pg.7](#).

**REACTION DILUENT** - a material (usually a light saturated hydrocarbon; e.g., pentane, hexane) that is used as a carrier for the polymerization catalyst in the manufacture of polyolefins. The material must be very pure, since impurities "poison" the catalyst or hinder the polymerization by reacting with the olefins.

**RECLAIMING** - process of restoring used lubricating oils by filtration, clay absorption, and/or chemical treatment to a condition similar to virgin stocks. This is not to be confused with re-refining operations in which the used oil is vacuum distilled and chemically treated to return it to a state similar to its virgin condition.

**REFINING** - series of processes for converting crude oil and its fractions to finished petroleum products. Following distillation, a petroleum fraction may undergo one or more additional steps to purify or modify it. These refining steps include: thermal cracking, catalytic cracking, hydroforming, hydrogenation, hydrogen treating, hydrofinishing, solvent extraction, dewaxing, de-oiling, acid treating, clay filtration, and de-asphalting. Refined lube oils may be blended with other lube stocks, and additives may be incorporated, to impart special properties; refined naphthas may be blended with alkylates, cracked stock or reformates to improve octane number and other properties of gasolines. See [TB10 pg.3](#).

**REFORMING** - thermal or catalytic refining process in which the hydrocarbon molecules of a naphtha are rearranged to improve its octane number; the resulting product is used in blending high-octane gasoline.

**RE-REFINING** - a process of reclaiming used lube oils and restoring them to a condition similar to virgin stocks by filtration, clay absorption or more elaborate methods.

**REPEATABILITY** - in testing, the ability to perform the same measurement of test in the same lab using all the same materials and personnel. See [TB4 pg.3](#).

**REPRODUCIBILITY** - in testing, the ability to obtain the same results in a different laboratory using the same procedures and materials. See [TB4 pg.3](#).

**RESEARCH OCTANE NUMBER (RON)** - See [OCTANE NUMBER](#).

**RESINS** - solid or semi-solid materials, light yellow to dark brown, composed of carbon, hydrogen, and oxygen. Resins

occur naturally in plants, and are common in pines and firs, often appearing as globules on the bark. Synthetic resins, such as polystyrene, polyesters, and acrylics, are derived primarily from petroleum. Resins are widely used in the manufacture of lacquers, varnishes, plastics, adhesives, and rubber.

**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.

**RUST INHIBITOR** - type of corrosion inhibitor used in lubricants to protect the lubricated surfaces against rusting.

**RUST PREVENTIVE** - compound for coating metal surfaces with a film that protects against rust; commonly used for the preservation of equipment in storage. The base material of a rust preventive may be a petroleum oil, solvent, wax, or asphalt, to which a rust inhibitor is added. A formulation consisting largely of a solvent and additives is commonly called a thin-film rust preventive because of the thin coating that remains after evaporation of the solvent. Rust preventives are formulated for a variety of conditions of exposure; e.g., short-time "in-process" protection, indoor storage, exposed outdoor storage, etc.

## - S -

**SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)** - organization responsible for the establishment of many U.S. automotive and aviation standards, including the viscosity classifications of engine oils and gear oils.

**SATURATED HYDROCARBON** - hydrocarbon with the basic formula  $C_nH_{2n+2}$ ; it is saturated with respect to hydrogen and cannot combine with the atoms of other elements without giving up hydrogen. Saturates are more chemically stable than unsaturated hydrocarbons. See [TB10 pg.5](#).

**SAYBOLT UNIVERSAL SECONDS (SUS)** - the efflux time in seconds required for 60 milliliters of a petroleum product to flow through the calibrated orifice of a Saybolt Universal viscosimeter, under carefully controlled temperature, as prescribed by ASTM D88. This method has largely been supplanted by the kinematic viscosity method.

**SCAVENGER** - a component of lead anti-knock compounds that reacts with the lead radical to form volatile lead compounds that can be easily scavenged from the engine through the exhaust system. Also, an individual who collects used lubricating oils for some secondary use.

**SCORING** - mechanical disturbance of a rubbing surface with definite surface roughness in line with motion, and characterized by the transfer of metal by dragging which results in progressive deterioration.

**SCRATCHING** - mechanical disturbance of a rubbing surface with definite surface roughness in line with motion, but no progressive surface deterioration due to debris.

**SCUFFING** - mechanical disturbance of a rubbing surface with no appreciable surface roughness to feel.

**SEAL SWELL** - swelling of rubber (or other elastomer) gaskets, or seals, when exposed to petroleum, synthetic lubricants, or hydraulic fluids. Seal materials vary widely in their resistance to the effect of such fluids. Some seals are designed so that a moderate amount of swelling improves sealing action. See [TB10 pg.4](#).

**SEIZING** - sticking together of two surfaces characterized by the presence of small particles of material which have become welded to the surface.

**SERIES 3** - obsolete specification for heavy-duty engine oils used in Caterpillar Tractor Company diesel engines. Caterpillar now specifies that the oil for its engines comply with Military Specification MIL-L-2104C or API Engine Service Category CD.

**SHEAR RATE** - rate at which adjacent layers of fluid move with respect to each other, usually expressed as reciprocal seconds. See [SHEAR STRESS](#), [TB11 pg.7](#).

**SHEAR INDEX (SI)** - the measure of an oil's percentage viscosity loss.

**SHEAR STABILITY INDEX (SSI)** - the measure of the VI improver's contribution to an oil's percentage kinematic viscosity loss.

**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. The higher the viscosity of a Newtonian fluid, the greater the shear stress as a function of rate of shear. In a non-Newtonian, fluid such as a grease or a polymer-containing oil (e.g., multi-grade oil), shear stress is not proportional to the rate of shear. A non-Newtonian fluid may be said to have an apparent viscosity, a viscosity that holds only for the shear rate (and temperature) at which the viscosity is determined. See [BROOKFIELD VISCOSITY, TB11 pg.7.](#)

**SINGLE-GRADE OIL** - engine oil that meets the requirements of a single SAE viscosity grade classification.

**SLUDGE** - a deposit, principally composed of engine oil and fuel debris, which does not drain from engine parts but can be removed by wiping with a soft cloth.

**SOLUBLE OILS** - oils which, following the addition of emulsifiers and stabilizers, are readily capable of mixing with water. They are used as drilling, cutting and cooling oils in metalworking.

**SOLVENT** - compound with a strong capability to dissolve a given substance. The most common petroleum solvents are mineral spirits, xylene, toluene, hexane, heptane, and naphthas. Aromatic-type solvents have the highest solvency for organic chemical materials, followed by naphthenes and paraffins. In most applications the solvent disappears, usually by evaporation, after it has served its purpose. The evaporation rate of a solvent is very important in manufacture: rubber cements often require a fast-drying solvent, whereas rubber goods that must remain tacky during processing require a slower-drying solvent. Solvents have a wide variety of industrial applications, including the manufacture of paints, inks, cleaning products, adhesives, and petrochemicals. Other types of solvents have important applications in refining.

**SOLVENT EXTRACTION** - refining process used to separate reactive components (unsaturated hydrocarbons) from lube distillates in order to improve the oil's oxidation stability, viscosity index (VI), and response to additives. Commonly used extraction media (solvents) are: phenol, N-methylpyrrolidone (NMP), furfural, liquid sulfur dioxide, and nitrobenzene. The oil and solvent are mixed in an extraction tower, resulting in the formation of two liquid phases: a heavy phase consisting of the undesirable unsaturates dissolved in the solvent, and a light phase consisting of high-quality oil with some solvent dissolved in it. The phases are separated and the solvent recovered from each by distillation. The unsaturates portion, while undesirable in lubricating oils, is useful in other applications such as rubber extender oils. See [TB10 pg.3.](#)

**SOLVENT NEUTRAL** - high-quality paraffin-base oil refined by solvent extraction.

**SOUR CRUDE** - crude oil containing appreciable quantities of hydrogen sulfide or other sulfur compounds, as contrasted to sweet crude. See [SWEET CRUDE.](#)

**SPALLING** - surface disintegration associated with loss of particles from the surface and associated with adhesion.

**SPARK-IGNITION ENGINE** - see [INTERNAL COMBUSTION ENGINE.](#)

**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 ASTM D1298: the higher the specific gravity, the heavier the product. Specific gravity of a liquid can be determined by means of a hydrometer, a graduated float weighted at one end, which provides a direct reading to which it sinks in the liquid. A related measurement is density, an absolute unit defined as mass per unit volume, usually expressed as kilograms per cubic meter (kg/m<sup>3</sup>).

**STICK-SLIP MOTION** - erratic, noisy motion characteristic of some machine ways, due to the starting friction encountered by a machine part at each end of its back-and-forth (reciprocating) movement. This undesirable effect can be overcome with a way lubricant, which reduces starting friction.

**STOICHIOMETRIC** - the exact proportion of two or more substances that will permit a chemical reaction with none of the individual reactants left over. See [COMBUSTION](#).

**STRAIGHT MINERAL OIL** - petroleum oil containing no additives. Straight mineral oils include such diverse products as low-cost once-through lubricants and thoroughly refined white oils. Most high-quality lubricants, however, do contain additives. See [MINERAL OIL](#).

**STRIBECK CURVE** - named for German scientist Richard Stribeck (1861-1950), general graphic representation of the equation:  $C = (f) ZN/P$ , where C (the coefficient of friction in a journal bearing) is a function (f) of the dimensionless parameter ZN/P, (viscosity x speed/pressure). This is the fundamental lubrication equation, in which the coefficient of friction is the friction per unit load, Z the viscosity of the lubricating oil, N the rpm of the journal, and P the pressure (load per unit area) on the bearing. The Stribeck, or ZN/P curve illustrates the effects of the three variables (viscosity, speed, and load) on friction and, hence, on lubrication. See [BOUNDARY LUBRICATION](#), [HYDRODYNAMIC LUBRICATION](#), [ELASTO-HYDRODYNAMIC \(EHD\) LUBRICATION](#), [TB11 pg.2](#).

**STUCK LIFTER** - one that does not return to its original position by its own force upon removal from the engine.

**SULFATED ASH** - using ASTM D874, the ash that remains after the sample has been carbonized and the residue subsequently treated with sulfuric acid and heated to constant weight. See [ASH](#).

**SURFACTANT** - surface-active agent that reduces interfacial tension of a liquid. A surfactant used in a petroleum oil may increase the oil's affinity for metals and other materials.

**SWEET CRUDE** - crude oil containing little or no sulfur. See [SOUR CRUDE](#).

**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. Synthetic lubricants are derived wholly or primarily from petrochemicals; other synthetic lubricant raw materials are derived from coal and oil shale, or are lipochemicals (from animal and vegetable oils). Synthetic lubricants may be superior to petroleum oils in specific performance areas. Many exhibit higher viscosity index (VI), better thermal stability and oxidation stability, and low volatility (which reduces oil consumption).

Individual synthetic lubricants offer specific outstanding properties: phosphate esters, for example, are fire resistant, diesters have good oxidation stability and lubricity, and silicones offer exceptionally high VI. Most synthetic lubricants can be converted to grease by adding thickeners. Because synthetic lubricants are higher in cost than petroleum oils, they are used selectively where performance or safety requirements may exceed the capabilities of a conventional oil. The following is a list of the principal classes of synthetic lubricants: alkylated aromatics (organic hydrocarbon), olefin oligomers (organic hydrocarbon), dibasic acid esters (organic ester), polyol esters (organic ester), polyglycols, phosphate esters, silicones, silicate esters, and halogenated hydrocarbons. See [TB10 pp.4, 5, and 8](#).

## - T -

**TACKINESS AGENT** - additive used to increase the adhesive properties of a lubricant, improve retention, and prevent dripping and splattering.

**TAPPET** - strictly speaking in mechanical terms, a projection of a mechanism which pushes or "taps" another. In an internal combustion engine, the term is commonly applied to the cam follower or lifter. Traditionally these were flat, or slightly radiused on the end which contacted the cam. This type is referred to as flat-tappets. More recently engines are being designed with roller-tappets or followers to reduced the need for anti-wear agents in oil and reduce frictional power losses. See [TB2 pg.1](#), [TB11 pg.9](#).

**TETRA ETHYL LEAD (TEL)** - See [LEAD ALKYL](#).

**TEMPORARY VISCOSITY LOSS (TVL)** - measure of decrease in dynamic viscosity under high shear rates compared to dynamic viscosity under low shear. May be applied to fresh oil or used oil.

**THERMAL CRACKING** - in refining, the breaking down of large, high-boiling hydrocarbon molecules into smaller molecules in the presence of heat and pressure. See [CRACKING](#).

**THIXOTROPY** - tendency of grease or other material to soften or flow when subjected to shearing action. Grease will usually return to its normal consistency when the action stops. The phenomenon is the opposite of that which occurs with rheopectic grease. Thixotropy is also an important characteristic of drilling fluids, which must thicken when not in motion so that the cuttings in the fluid will remain in suspension.

**TIMKEN EP TEST** - measure of the extreme pressure properties of a lubricant following ASTM D2509 for greases and D2782 for oils. The test utilizes a Timken machine, which consists of a stationary block pushed upward, by means of a lever arm system, against the rotating outer race of a roller bearing, which is lubricated by the product under test. The test continues under increasing load (pressure) until a measurable wear scar is formed on the block. Timken OK load is the heaviest load that a lubricant can withstand before the block is scored. See [SCORING](#).

**TORQUE FLUID** - lubricating and power-transfer medium for commercial automotive torque converters and transmissions. It possesses the low viscosity necessary for torque transmission, the lubricating properties required for associated gear assemblies, and compatibility with seal materials.

**TOTAL ACID NUMBER (TAN)** - using ASTM D664, the quantity of base, expressed in milligrams of potassium hydroxide, that is required to neutralize all acidic constituents present in one gram of sample. See [NEUTRALIZATION NUMBER](#).

**TOTAL BASE NUMBER (TBN)** - using ASTM D2896, the quantity of perchloric acid, expressed in terms of the equivalent number of milligrams of potassium hydroxide that is required to neutralize all basic constituents present in one gram of sample. Also, TBN can be determined using ASTM D664 with hydrochloric acid. See [NEUTRALIZATION NUMBER](#).

**TRIBOLOGY** - science of 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. Tribological research on friction reduction has important energy conservation applications, since friction increases energy consumption. See [FRICTION](#).

**TWO-STROKE CYCLE** - See [INTERNAL COMBUSTION ENGINE](#).

## - U -

**ULTRAVIOLET ABSORBANCE** - measurement of the ultraviolet absorption of petroleum products, determined by standardized tests, such as ASTM D2008. Aromatics absorb more ultraviolet light than do naphthenes and paraffins, and the amount of absorbance can be used as an indication of the amount of aromatics in a product. Certain polynuclear aromatics (PNAs) are known carcinogens (cancer-causing substances), with peaks of absorbance generally between 280 and 400 millimicrons. The Food and Drug Administration (FDA) has therefore imposed limits on the amount of ultraviolet absorbance at these wavelengths for materials classified as food additives. However, not all materials with ultraviolet absorbance at these wavelengths are carcinogenic.

**UNLEADED GASOLINE** - gasoline that derives its anti-knock properties from high-octane hydrocarbons or from non-lead anti-knock compounds, rather than from a lead additive. See [LEAD ALKYL](#).

**UNSATURATED HYDROCARBON** - hydrocarbon lacking a full complement of hydrogen atoms, and thus characterized by one or more double or triple bonds between carbon atoms. Hydrocarbons having only one double bond between adjacent carbon atoms in the molecule are called olefins; those having two double bonds in the molecule are diolefins. Hydrocarbons having alternating single and double bonds between adjacent carbon atoms in a benzene-ring configuration are called aromatics. Hydrocarbons with a triple bond between carbon atoms are called acetylenes. Unsaturated hydrocarbons readily attract additional hydrogen, oxygen, or other atoms, and are therefore highly reactive. See [HYDROCARBON](#), [SATURATED HYDROCARBON](#), [HYDROGENATION](#).

**USED OIL ANALYSIS (UOA)** - the testing or test reports of used oil. See [TB4 pg.1](#).

**- V -**

**VACUUM TOWER** - See [DISTILLATION](#).

**VALVE BEAT-IN** - wear on the valve face or valve seat in internal combustion engines resulting from the pounding of the valve on the seat. Also called valve sink or valve recession.

**VALVE LIFTER** - mechanical or hydraulic device for opening and closing valves by transmitting cam rotation to vertical valve movement. See [TAPPET](#), [TB11 pg.9](#).

**VAPOR LOCK** - disruption of fuel movement to a gasoline engine carburetor caused by excessive vaporization of gasoline. Vapor lock occurs when the fuel pump, which is designed to pump liquid, loses suction as it tries to pump fuel vapor. The engine will usually stall, but in less severe cases may accelerate sluggishly or knock due to an excessively lean fuel mixture. Automotive engines are more likely to experience vapor lock during and acceleration that follows a short shutdown period. Vapor lock problems are most likely to occur in the late spring on unseasonably warm days, before the more volatile winter grades of gasoline have been replaced by the less volatile spring and summer grades. Vapor lock can also occur in other types of pumping systems where volatile liquids are being handled. See [VOLATILITY](#).

**VAPOR PRESSURE** - pressure of confined vapor in equilibrium with its liquid at a specified temperature; thus, a measure of a liquid's volatility. Vapor pressure of gasoline and other volatile petroleum products is commonly measured in accordance with ASTM D323 (Reid vapor pressure). The apparatus is essentially a double-chambered bomb. One chamber, fitted with a pressure gauge, contains air at atmospheric pressure; the other chamber is filled with the liquid sample. The bomb is immersed in a 37.8°C (100°F) bath, and the resulting vapor pressure of the sample is recorded in pounds per square inch (psi). Reid vapor pressure is useful in predicting seasonal gasoline performance (e.g., higher volatility is needed in cold weather, and lower volatility in hot weather), as well as the tendencies of gasolines, solvents, and other volatile petroleum products toward evaporative loss and fire hazard.

**VARNISH** - hard, dry, generally lustrous oil insoluble deposit which cannot be removed by wiping with a soft cloth. Generally associated with gasoline engines.

**VERY HIGH VISCOSITY INDEX (VHVI)** - referring to an extremely refined Group III base stock oil with a VI over 140. Some of these oils are now being marketed as "synthetic" due to the decision reached in the 1999 case of Mobil vs. Castrol. See [SYNTHETIC LUBRICANT](#), [TB10 pp.3, and 8](#).

**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. For convenience, the centipoise (cp), one one-hundredth of a poise, is the unit customarily used. Laboratory measurements of viscosity normally use the force of gravity to produce flow through a capillary tube (viscometer) at a controlled temperature. The measurement is called kinematic viscosity. The unit of kinematic viscosity is the stoke, expressed in square centimeters per second. The more customary unit is the centistoke (cSt), one one-hundredth of a stoke. Kinematic viscosity can be related to absolute viscosity by the equation:  $cSt = cp / \text{fluid density}$ . In addition to kinematic viscosity, there are other methods for determining viscosity, including Saybolt Universal viscosity, Saybolt Furol viscosity, Engler viscosity, and Redwood viscosity. Since viscosity varies inversely with temperature, its value is meaningless unless the temperature at which it is determined is reported. See [TB10 pg.6](#), [TB11 pg.4](#).

**VISCOSITY INDEX (VI)** - 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 VI of an oil, the lower its tendency to change viscosity with temperature. The VI of an oil, with known viscosity at 40°C and at 100°C, is determined by comparing the oil with two standard oils having an arbitrary VI of 0 and 100, respectively, and both having the same viscosity at 100°C as the test oil. The following formula is used, in accordance with ASTM D2270, where L is the viscosity at 40°C of the 0-VI oil, H is the viscosity at 40°C of the 100-VI oil, and U is the viscosity at 40°C of the test oil. There is an alternative calculation, also in ASTM D2270, for oils with VI's above 100. The VI of paraffinic oils is inherently high, but VI is low in naphthenic oils, and even lower in aromatic oils (often below 0). The VI of any petroleum oil can be increased by adding a viscosity index improver. High-VI lubricants are needed wherever relatively constant viscosity is required at widely varying temperatures. In an automobile, for example, an engine oil must flow freely enough to permit

cold starting, but must be viscous enough after warm-up to provide full lubrication. Similarly, in an aircraft hydraulic system, which may be exposed to temperatures above 38°C at ground level and temperatures below -54°C at high altitudes, consistent hydraulic fluid performance requires a high viscosity index. See [TB10 pg.6](#).

**VISCOSITY INDEX (VI) IMPROVER** - lubricant additive, usually a high-molecular-weight polymer, that reduces the tendency of an oil to change viscosity with temperature. The polymer molecules swell with increasing temperature, offsetting the base oil thinning, and shrink at lower temperatures, offsetting the oil's thickening. Multi-grade oils, which provide effective lubrication over a broad temperature range, usually contain VI improvers. See [VISCOSITY INDEX](#).

**VISCOSITY-TEMPERATURE RELATIONSHIP** - the manner in which the viscosity of a given fluid varies inversely with temperature. Because of the mathematical relationship that exists between these two variables, it is possible to predict graphically the viscosity of a petroleum fluid at any temperature within a limited range if the viscosities at two other temperatures are known. The charts used for this purpose are the ASTM Standard Viscosity-Temperature Charts for Liquid Petroleum Products, available in 6 ranges. If two known viscosity-temperature points of a fluid are located on the chart and a straight line drawn through them, other viscosity-temperature values of the fluid will fall on this line; however, values near or below the cloud point of the oil may deviate from the straight-line relationship. See [VISCOSITY INDEX](#).

**VIRGIN OIL ANALYSIS (VOA)** - the testing or test reports of unused oils.

**VOLATILITY** - expression of evaporation tendency. The more volatile a petroleum liquid, the lower its boiling point and the greater its flammability. The volatility of a petroleum product can be precisely determined by tests for evaporation rate; also, it can be estimated by tests for flash point and vapor pressure, and by distillation tests.

## - W -

**WEAR** - the loss or relocation of material from two or more surfaces in relative motion.

**WELD POINT** - the lowest applied load in kilograms at which the rotating ball in the Four Ball EP test either seizes and welds to the three stationary balls, or at which extreme scoring of the three balls results.

**WHITE OIL** - highly refined straight mineral oil, essentially colorless, odorless, and tasteless. White oils have a high degree of chemical stability. The highest purity white oils are free of unsaturated components and meet the standards of the United States Pharmacopoeia (USP) for food, medicinal, and cosmetic applications. White oils not intended for medicinal use are known as technical white oils and have many industrial applications including textile, chemical, and plastics manufacture, where their good color, nonstaining properties, and chemical inertness are highly desirable.

## - X - Y - Z -

**ZINC DIALKYL DITHIOPHOSPHATE or ZINC DIARYL DITHIOPHOSPHATE (ZDDP)** - widely used as an anti-wear agent in motor oils to protect heavily loaded parts, particularly the valve train mechanisms (such as the camshaft and cam followers) from excessive wear. There are many different formulations of ZDDP specifically engineered for different purposes. ZDDP is also used as an anti-wear agent in hydraulic fluids and certain other products. ZDDP is also an effective oxidation inhibitor. Oils containing ZDDP should not be used in engines that employ silver alloy bearings. All car manufacturers now recommend the use of dialkyl ZDDP in motor oils for passenger car service. See [TB1-TB12](#).

**ZINC** - a metallic chemical element with the symbol Zn and atomic number 30. It is a first-row transition metal of the group 12 of the periodic table. It is a moderately reactive metal that is covered by a protective thin layer of basic carbonate in air, which tarnishes in moist air. It can also burn in air with a bright bluish-green flame, giving off fumes of zinc oxide. Zinc reacts with acids, alkalis and other non-metals. It is a constituent atom of the antiwear compound ZDDP. See [ZDDP](#).

**ZN/P CURVE** - See [STRIBECK CURVE](#).

Entries in this glossary were obtained from the following sources:

ZPlus, LLC, 2609 Tucker Street, Burlington, NC 27215

Syntol Racing Lubricants, Box 244, Office 6, Slington House, Rankine Road, Basingstoke RG24 8PH, UK

Noria Corporation, 1328 E. 43rd Court, Tulsa, OK 74105

www.Wikipedia.org and then thoroughly checked!