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NLGI

Grease Glossary

Definitions of Terms Relating to the Lubricating Grease Industry

Additive – Any substance added to a lubricant to modify its properties. Typical examples are anti-oxidants, corrosion inhibitors, antiwear (AW), and extreme pressure (EP) additives.

Adhesion – The force or forces between two materials in contact, such as lubricating grease and a metal substrate, that causes them to stick together.

Age Hardening – Increase in consistency (hardness) of a lubricating grease during storage.

Anhydrous – Without water, for example, a lubricating grease in which no water is detected by ASTM D128. Calcium 12-hydroxystearate grease is called anhydrous calcium soap grease.

Anti-oxidant (Oxidation inhibitor) – An additive used to slow the degradation of lubricants by oxidation. Oxidation is degradation caused by chemical reactions of the lubricant with oxygen. These reactions change the chemical composition, alter the properties and shorten the service life of a lubricant.

Antiwear (AW) Additive – An additive used to protect lubricated surfaces from contacting one another under moderate loads. Antiwear additives function by forming a surface layer on metal parts, thus keeping the surfaces separated. For more highly loaded applications, extreme pressure (EP) additives are required.

Apparent Viscosity – The apparent viscosity of grease is the ratio of shear stress to shear rate as measured by ASTM D1092 or other techniques. It is a function of temperature and shear rate. A graph of apparent viscosity versus shear is used to predict the pressure drop in a grease distribution system under steady-state flow conditions at constant temperature.

Appearance – Characteristics of a lubricating grease that are observed by visual inspection: bloom, bulk appearance, color, luster and texture.

ASTM D02.G0 – ASTM International (formerly the American Society for Testing and Materials) is an international standards organization. Committee D02 covers petroleum products, liquid fuels, and lubricants. Subcommittee D02.G0 covers lubricating grease.

API Groups I-V – The lubricating fluid in a grease can be a mineral oil (derived from petroleum), a synthetic fluid, or a vegetable-based fluid. Lubricant base fluids are divided into five groups defined by the American Petroleum Institute (API) as follows:

Group I – Paraffinic mineral oil, typically produced from petroleum by solvent extraction processes, with a sulfur content of >0.03% and/or saturates <90%. The viscosity index (VI) ranges from 80 to 120.

Group II – Paraffinic mineral oil, typically produced from petroleum by a combination of solvent extraction and catalytic processes, with a sulfur content of <0.03% and saturates >90%. The viscosity index is in the range from 80 to 120.

Group III – Paraffinic oil produced from petroleum by severe hydrocracking processes, with a sulfur content of <0.03% and saturates >90%. The viscosity index is >120. Group

III oils are widely (but not universally) considered to be synthetic. Gas-to-liquid (GTL) base oils are classified as Group III.

Group IV – Polyalphaolefin (PAO) fluids are the sole member of Group IV. PAOs are synthetic lubricant base stocks that are synthesized by the polymerization of linear alpha-olefins.

Group V – This Group includes all base stocks not covered elsewhere. It includes all synthetic fluids other than PAOs. Group V includes naphthenic mineral oils, natural esters (vegetable oils), synthetic esters, silicone oils, and all other synthetic hydrocarbons (other than polyalphaolefins).

In Europe, ATIEL defines similar categories to the API Groups, but in addition has classified poly(internal olefins), i.e., PIOs, as Group VI.

Applied Shear Stress – The force applied per unit area of fluid to sustain flow.

Asperity – An asperity is a microscopic "bump" or "peak" on a solid surface. Asperities are present on virtually every solid surface due to the machining processes used to make bearings, gears, etc.

ATIEL – The Technical Association of the European Lubricants Industry, ATIEL is a nonprofit association that represents leading European and international engine oil manufacturers and marketers. ATIEL promotes consensus on key technical, product stewardship and sustainability issues. A major focus is the performance of engine oils including wear protection, deposit control, fuel economy and CO_2 emissions.

Biodegradable – Biodegradable lubricants rapidly decompose to water, carbon dioxide, and minerals due to the action of naturally-occurring microorganisms or enzymes present in soil or groundwater. Readily biodegradable lubricants undergo ≥60% decomposition by mass, and inherently biodegradable lubricants undergo somewhat less (between 20 and 60%), in OECD 301 testing. They are typically used in environmentally sensitive applications.

Bleeding – The separation of liquid from a lubricating grease, also referred to as "oil separation."

Blending – The process of mixing components to produce a mixture with desired properties.

Bloom – The surface color (usually blue or green) of a lubricating oil or grease when viewed by daylight reflected at an angle of approximately 45 degrees from the surface. Bloom is associated with the absorption of ultraviolet light in the oil and may not be visible if the sample is viewed using artificial light.

Boundary Lubrication – See Lubrication.

Bulk Appearance – Visual appearance of grease when the undisturbed surface is viewed in an opaque container. See also Texture. Bulk Appearance is typically described in the following terms:

Bleeding - Free oil on the surface or in the cracks of grease.

Cracked - Surface cracks.

Grainy - Small granules or lumps of thickener or additive particles.

Rough - Many small irregularities.

Smooth - Relatively free of irregularities.

Cavitation – Formation of voids due to reduced pressure in lubricating grease or oil. Cavitation of a lubricating grease in a dispensing system can prevent the grease from flowing.

Certification Marks – See NLGI Certification Marks.

Certified Lubricating Grease Specialist (CLGS) – Certification an a CLGS indicates that an individual possesses a defined level of expertise in the field of lubricating grease as defined by NLGI. Certification is awarded after an individual passes a two-hour exam that consists of 120 questions about lubrication fundamentals and grease types, selection, manufacturing, applications, maintenance, testing, etc.

Channeling – The tendency (usually desirable) of a channel to form when grease is worked in a bearing, leaving shoulders of unworked grease that serve as a seal and a reservoir of oil. Also the tendency of liquid lubricants and certain lubricating greases to form a plastic structure sufficiently strong to resist flow under gravitational forces at low temperatures. Similar, but not identical to, the pour point of liquid lubricants, channeling is measured with empirical tests such as Method 3456.2 in Federal Test Method Standard No. 791 (D).

Coefficient Of Friction (Static) – The static coefficient of friction (COF) is the ratio of the tangential force that is needed to start relative motion between two contacting surfaces to the perpendicular force (applied load) holding them in contact.

Coefficient Of Friction (Dynamic) – The dynamic COF is the ratio of the tangential force that is needed to maintain relative motion between two contacting surfaces to the perpendicular force (applied load) holding them in contact.

Cohesion – Attractive forces between molecules in a substance. For example, cohesion between molecules in grease contributes to its resistance to flow.

Cold SETT – See Sett.

Colloid – A substance that consists of microscopically dispersed insoluble particles that are suspended throughout another substance, typically in a fluid. Lubricating grease is a colloidal system of thickener particles or fibers in oil. See Thickener.

Color (of lubricating grease) – The shade and intensity observed when lubricating grease is viewed under conditions that eliminate bloom. For example, lubricating grease in an opaque container such as a metal package can be observed under reflected light from a position approximately perpendicular to the surface. Grease color can also be observed with transmitted light by placing the sample on a transparent plate. It is important to indicate the method used to determine the color of grease. Colors of lubricating greases are best described in terms of the predominant hue such as amber, brown (or perhaps green, red, or blue for dyed grease) with a qualifying adjective describing intensity in terms of light, medium, or dark.

Color (of lubricating oil) – That shade observed when viewed under transmitted light only. Usually lubricating oil colors are obtained by viewing under specified conditions in test equipment. Several such methods are available, the most widely used being ASTM D1500, which describes the colors in terms of numbers.

Complex Soap – A soap thickener wherein the soap crystals or fibers are formed by co-crystallization of two or more compounds, i.e., the primary soap and complexing agents such as metal salts of organic acids or inorganic salts. The complexing agent modifies the grease characteristics and usually increases the dropping point.

Cone Penetrometer – A device described in ASTM D217 and D1403 (ISO 2137) that measures the consistency (hardness) of lubricating grease. The device consists of a freely moving cone and shaft assembly, a pedestal for placing the grease sample below the cone, a locking device to stop the motion of the cone and shaft, and a scale for measuring the depth to which the cone penetrates the grease.

Consistency (hardness) – The resistance of a lubricating grease to deformation under the application of force. Consistency characterizes the plasticity of a solid in much the same way that viscosity characterizes a fluid. Grease consistency is measured by cone penetration according to ASTM D217 (ISO 2137).

Corrosion – The gradual destruction and/or pitting of a metal surface due to chemical reactions. The most common form of corrosion is caused by the oxidation of metal, i.e., electrochemical reactions of metal with oxygen and/or aggressive ions. (See Fretting).

Corrosion Inhibitor – An additive used in grease to prevent metal corrosion. Test methods for corrosion prevention properties of grease include D1743, D5969, and D6138 for ferrous metals and D4048 for copper. Different chemistries are used to protect different types of metals.

DIN – Deutsches Institut für Normung e. V., the German Institute for Standardization, is a nonprofit organization that develops and publishes standards on a wide variety of topics. Headquartered in Berlin, Germany, DIN is Germany's national standards organization. DIN standards are synchronized with the rest of the world.

Dispensability – The ease with which grease may be transferred from its container to its point of application. Mostly used in discussion of grease dispensing systems, where it includes both the properties of pumpability and feedability.

Dropping Point – Refers to the temperature observed in a laboratory test where a small quantity of lubricating grease is heated until a drop of material separates from the grease. That temperature is adjusted according to ASTM D 2265. The dropping point is not the melting point of lubricating grease. Dropping point is used in many grease specifications. However, this test has very limited relevance to service performance. Dropping point should not be used to determine the upper operating temperature of a grease. To estimate how grease performs at high temperature, certain bearing life tests may be helpful.

Dry Film Lubricant – Dry or solid lubricants form films that reduce friction without oil. Dry lubricants are often used in locks, certain bearings, and applications at high temperatures or oxidizing conditions. Examples include graphite, molybdenum disulfide, boron nitride, PTFE (polytetrafluoroethylene) and certain soaps.

Dynamic Friction – Also called kinetic friction, the resistance to motion of contacting bodies as they move relative to one another.

Dynamic Viscosity – The ratio between the applied shear stress and rate of shear of a liquid. The dynamic viscosity can be measured by placing the liquid between two parallel plates and measuring the force required to move one plate while holding the other plate fixed.

Elastohydrodynamic Lubrication – See Lubrication.

Environmentally Acceptable Lubricant or Environmentally Advantaged Lubricant (EAL) – A lubricant meeting application or regulatory requirements on toxicity, bioaccumulation, biodegradability, and, in certain circumstances, renewable content.

Evaporation Loss – That portion of a lubricant that volatilizes in use or in storage. Typical test methods are ASTM D972 and D2595.

Extreme Pressure (EP) Additive – Extreme pressure (EP) additives enhance the load carrying capacity of a grease under boundary lubrication conditions. EP additives chemically react with the metal surface under conditions of high load and elevated temperature, forming a chemically bonded lubricating film.

Extreme Pressure Property (EP) – The ability of a lubricant to reduce scuffing, scoring, and seizure that can occur when highly-loaded moving surfaces are in contact. Commonly used laboratory test measurements of the EP level of greases are the Timken OK Load (ASTM D2509, 4-Ball Weld and Load Wear Index (ASTM D2596), and EP by SRV Step Load (ASTM D5706)

False Brinelling – Localized fretting that occurs when the rolling elements of a bearing vibrate or oscillate with a small amplitude while pressed against the bearing race. The mechanism proceeds in stages: 1) asperities weld, separate, and form wear particles, which may then be oxidized; 2) the wear particles cause abrasive wear. The resulting wear is in the form of depressions that appear similar to Brinell depressions obtained with static overloading. (See also Fretting). ~~Note: Asperities are microscopic "bumps" or "peaks" on surfaces.~~

Fatigue – Fatigue refers to the initiation and growth of cracks due to cyclic loading.

Feedability – The ability of lubricating grease to flow under suction in a dispensing pump at a rate at least equal to the pump delivery capacity. When the feed of grease is not satisfactory, cavitation can occur at the inlet to the dispensing pump. In such cases, feedability can often be improved by the use of follower plates.

Fiber – Soap thickeners are chemicals that form microscopic fibers during the production of lubricating grease. Some soaps crystallize in the form of threads, which are 20 or more times as long as they are thick. Most soap fibers are microscopic in size, so that the grease appears smooth to the unaided eye. Some greases have a fibrous appearance when fiber bundles are large enough to be seen by the unaided eye. The most common fibrous lubricating greases contain sodium soap thickeners, although not all sodium base greases are fibrous. (See Appearance and Texture).

Fibril – An extremely small fiber, barely visible even at maximum magnification of an electron microscope. Fibrils may collect in bundles to form larger fibers.

Filler – A material added to a grease to increase bulk or density. Examples of fillers are talc, pigments, and carbon black.

Film Strength – The ability of a film of lubricant to resist rupture due to load, speed, and temperature.

Follower Plate – A plate fitted to the top surface of lubricating grease in a container and designed to assist delivery of grease to the inlet of the dispensing system.

Food Grade – A term used casually to refer to lubricants certified by NSF International for use primarily in food and beverage, personal care product, and pharmaceutical processing applications. .

Food Machinery Lubricant – Any lubricant that has received H1designation from NSF for use "above the line" in manufacturing and packaging food, beverage, personal care, and pharmaceutical products

Four-Ball Weld Point – In ASTM D2596, refers to the applied load at which the lubricant no longer prevents metal-to-metal contact, and the standard steel balls used in the test undergo welding.

Fretting Wear – A form of wear caused by vibratory or oscillatory motion of limited amplitude and characterized by the removal of fine particles from the rubbing surfaces. Fretting wear is often followed by localized oxidation, hence the term Friction Oxidation. (See also False Brinelling and Fretting Corrosion).

Fretting Corrosion – Under conditions of fretting wear, fretting corrosion occurs between a bearing inner ring and shaft or an outer ring and housing. The corrosion occurs at points where the fit is too loose. When the fit is too loose, the metal oxide film can be worn away, allowing oxygen to attack the underlying metal. The build-up of corrosion products can cause severe bearing damage, including cracking of bearing rings.

Friction – The force resisting relative motion between two surfaces that are in contact.

Friction Oxidation – See Fretting Wear.

Gas to Liquids (GTL) – Refers to the conversion of gaseous hydrocarbons, such as natural gas, to liquid synthetic fuels and lubricant base stocks. The GTL lubricant base stocks are classified as API Group III.

Gel – An elastic, jelly-like material that resembles a solid but flows like a liquid. Most gels are dispersions of liquids in networks of colloidal particles or polymers.

Grease – See Lubricating Grease.

Grease Worker – A standard laboratory-scale device used to apply shear to a grease. The grease worker consists of a metal cup of standard dimensions, a cover fitted with a handle, and a shaft attached to a metal plate drilled with 61 x ¼-inch holes. The cup is filled with grease, the cover is closed, and the plate is pushed through the grease sample. The device can be manually or mechanically driven. For ½-scale and ¼-scale penetrations, the equipment is progressively smaller. The equipment details can be found in ASTM D217 (full-scale) and ASTM D1403 (small-scale) and ISO 2137.

Grease Worker Cup – A machined metal cup that holds grease for working. It is also the cup that is used to hold the grease for penetration measurements. A full-scale worker cup holds about one pound (~450 grams) of grease. See ASTM D217 for the details of the cup dimensions. Smaller scale (½- and ¼-scale) worker cups are described in ASTM D1403.

H1/H2/H3/3H/HX1 – Designations defined by NSF International (Ann Arbor, Michigan) for finished lubricants and components used in food-processing applications. H1 lubricants must be colorless, odorless, tasteless, non-toxic and meet other criteria; they are certified for incidental food contact. H2 lubricants may be used in food processing but only in situations where food contact cannot occur. H3, also known as soluble or edible oils, are used to clean and prevent rust on hooks, trolleys, and similar equipment. 3H lubricants are allowed to be in direct contact with food. HX1 ingredients must be used to formulate H1 lubricants.

Herschel-Bulkley – A rheological model describing the relationship between applied shear stress and shear rate for a non-Newtonian fluid such as lubricating grease.

Homogenization – The process of very thoroughly mixing the components in a mixture and applying intensive shear to improve their dispersion. Grease is homogenized to disperse the thickener, improve the bulk appearance, improve the yield, and reduce the cost of the product.

Hybrid Thickener – A grease thickener where a metallic soap is used with a non-soap thickener. Examples include urea complex thickener where a urea and a calcium complex soap are used together and calcium sulfonate complex where a fatty acid is reacted with residual lime to form a mixed calcium sulfonate-soap grease.

Hydrated Soap – A soap that has water associated with its structure. A typical example is a water-stabilized calcium soap grease, which owes its stability to hydrated calcium soap.

Hydrodynamic Lubrication – See Lubrication.

Hydrophilic – Having an affinity for water; capable of uniting with or dissolving in water.

Hydrophobic – Repelling water, incapable of uniting with or dissolving in water.

Hydrostatic Lubrication – See Lubrication.

Incidental Food Contact – Incidental food contact refers to unintended contact by small amounts of NSF H1 lubricants that may splash, drip, etc. onto products such as food, beverages, and personal care products during processing or related operations. The concentration of H1 lubricants in food and beverages is limited to 10 parts per million (ppm).

Incompatibility – Two lubricating greases are incompatible when a mixture of the products has physical or performance properties that are inferior to those of the individual greases. Physical or performance properties inferior to one of the products and superior to the other may be due to simple mixing and would not be considered as evidence of incompatibility.

Induction Period (Grease Oxidation) – A period of time during which oxidation occurs at a relatively slow rate. At the end of the induction period, the oxidation rate may become more rapid. Methods of measurement of induction time include ASTM D942 and D5483.

Inorganic Acid – An acid that does not contain a carbon chain. Inorganic acids, such as boric acid, are sometimes used as complexing agents in complex soap greases. Contrast with Organic Acid.

Inorganic Salt – The reaction product of an alkali with an inorganic acid. Inorganic salts, such as lithium borate, are sometimes found in complex soap greases.

Inorganic Thickener – See Non-Soap Thickener.

Insolubles – Components of a lubricating grease that are insoluble in the prescribed solvents in an analytical procedure such as ASTM D128. The analytical procedure should be indicated when specifying insolubles. Additional identifying analytical tests are required to determine the nature and composition of insolubles, which may consist of fillers, additives, certain types of thickeners, or impurities.

ISO - The International Organization for Standardization, a non-governmental, independent organization with a membership of 166 national standards bodies, is based in Geneva, Switzerland. It has developed and published more than 24,000 international standards covering almost all aspects of technology and manufacturing.

Kinematic Viscosity – The resistance of a liquid to flow under gravity. Kinematic viscosity can be measured directly, as in ASTM D445, where it is measured by the time required for a volume of liquid to flow under gravity through a calibrated glass capillary tube referred to as a viscometer. Standard temperatures of 40°C and 100°C are typically used. Kinematic viscosity can also be calculated as the ratio of the dynamic viscosity to the density of the liquid.

Load Wear Index – An index of the ability of a lubricant to minimize wear at applied loads in the 4-Ball EP Test (ASTM D2596). The applied load is increased step-wise until welding (seizure) occurs. The load wear index is calculated based on the wear scars of the 10 highest non-seizure loads.

Lubricant – Any material that is used or applied to surfaces in order to reduce friction and/or wear that can occur when two surfaces are in contact and undergo relative motion. Lubricants are available in various forms: liquids, greases, dry films, and coatings.

Lubricating Grease – A lubricant that is a solid to semi-fluid dispersion of a thickening agent (thickener) in a liquid. A lubricating grease may be formulated with additives that impart special properties such as

resistance to oxidation or wear. An alternative definition (Vold and Vold, 1952) states, "A grease is a lubricant that has been thickened in order that it remain in contact with the moving surfaces and not leak out under gravity or centrifugal action, or be squeezed out under pressure."

Lubricating Grease Structure – The physical arrangement of thickener particles or fibers in a grease. The nature, form, and stability of this structure determine the appearance, texture, and physical properties of the grease.

Lubrication – The use or application of a material (lubricant) to reduce friction and/or wear that can occur when two surfaces undergo relative motion while in contact under an applied load. Friction and lubrication performance depend upon the relative speed of the surfaces, the lubricant viscosity, and the applied load.

There are five major lubrication regimes or types of behavior.

Boundary Lubrication – The lubricant film is too thin to form a fluid layer that completely separates two surfaces. Asperities on the surfaces collide. Friction and wear depend upon the presence of chemical additives that adsorb and form molecular layers on the surfaces.

Elastohydrodynamic Lubrication – Elastohydrodynamic or EHD occurs in rolling element bearings and certain gears when very high loads are concentrated on small surface areas. Under these conditions, the surfaces deform elastically or flatten to increase the surface area that bears the load. Lubricant is trapped between the surfaces, and its viscosity increases under the pressure. As a result, the lubricant is able to form a hydrodynamic film and separate the surfaces.

Hydrodynamic Lubrication – Under appropriate conditions, the relative motion of two sliding surfaces causes a continuous fluid film to form and completely separate the surfaces. This requires a balance between the sliding speed, the applied load, and the lubricant viscosity. Fluid Film Lubrication is another name for this type of lubrication.

Mixed Lubrication – A lubrication regime where the load is supported partially by a fluid film and partially by the surfaces in contact.

Hydrostatic Lubrication – Lubricant is supplied under pressure to a plain bearing. This applied pressure forces the lubricant to form a continuous fluid film that completely separates the surfaces. Hydrostatic lubrication occurs typically during start-up of plain bearings. Hydrodynamic lubrication becomes effective when plain bearings are in motion.

Luster – The intensity of light reflected by lubricating grease, i.e., its sheen or brilliance. Luster is described as follows:

Bright – Reflects light with a relatively strong intensity.

Dull – Reflects light with a relatively weak intensity. Some greases with a high water content may have a dull luster. Certain thickeners and fillers give a grease a characteristic dull luster.

Macroscopic – Visible to the unaided human eye, where the particles are at least 40 μm or 0.0015 in. in size.

Mechanical Stability – See Shear Stability.

Metallic Soaps – Metallic soaps are the most common thickeners used in lubricating greases. Materials such as NaOH (sodium hydroxide), LIOH (lithium hydroxide), $Ca(OH)_2$ (calcium hydroxide), and $Al(OH)_3$ (aluminum hydroxide) contain basic or alkaline hydroxide groups (OH^-). These materials are mixed with organic fatty acids in oil and heated to prepare grease. The OH^- groups react with acidic H^+ ions

on fatty acids such as stearic acid. This reaction produces thickener fibers plus water as a by-product. This reaction is known as saponification.

Microscopic – Not visible to the unaided human eye, smaller than 40 μm or 0.0015 in.

Newtonian Behavior – Simple liquids are said to be Newtonian when the applied shear stress is directly proportional to the shear rate. In other words, the viscosity (applied shear stress/shear rate) of a Newtonian fluid is constant and does not depend on the shear stress or shear rate at constant temperature.

NLGI Certification Marks –NLGI licenses certification marks for use on labels of products that satisfy performance criteria and pass laboratory evaluations managed by NLGI. In 1989, GC/LB Certification Marks were designed and standardized by NLGI and ASTM (D4950) to meet requirements for lubrication of automotive wheel bearings and chasses and then written into many original equipment manufacturer (OEM) specifications. Chassis lubricants are designated L, and wheel bearing lubricants are designated G. There are two performance classifications for chassis greases (LA and LB), and three for wheel bearing greases (GA, GB, and GC). The automotive industry is in general agreement that the highest performance classifications (LB and GC) are suitable for service relubrication of vehicles. In 2020, NLGI introduced the HPM (High Performance Multiuse) Certification Marks. In addition to the general HPM Certification Mark, there are additional specifications and Marks for lubricating greases with enhanced water resistance (WR), corrosion resistance (CR), load carrying ability (HL), and low temperature performance (LT).

NLGI Grade – A numerical scale for classifying the consistency of lubricating greases that is based on the ASTM D217 worked penetration at 25°C (77°F). NLGI Grades are also referred to as NLGI Consistency Numbers or NLGI Numbers. In order of increasing consistency (hardness):

NLGI Grade	Worked Penetration Range, 25 °C (77 °F)
000	445-475
00	400-430
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	185-115

Some grease suppliers use descriptions such as NLGI Grade 1.5, which indicates that the grease consistency is between that of NLGI Grades 1 and 2.

Non-Newtonian Behavior – Some fluids and many plastic solids, including lubricating greases, exhibit non-Newtonian behavior. In other words, the viscosity (applied shear stress/ shear rate) is not constant; instead, it depends on the shear stress and shear rate at a given temperature. Thus, non-Newtonian fluids are described by their apparent viscosity. Conventional types of viscometers with uncontrolled shear rates are not suitable for measuring the viscosity of non-Newtonian materials.

Non-Soap Thickener – Any of several specially treated naturally occurring or synthetic materials, excepting the metallic soaps, which can be either thermally or mechanically dispersed in liquid lubricants to form lubricating grease. Sometimes called Synthetic Thickener, Inorganic Thickener, or Organic Thickener. Examples include polyurea, calcium sulfonate, bentonite, and silica-thickened greases.

OECD – The Organization for Economic Co-operation and Development (OECD) is an intergovernmental organization of 38 developed member countries describing themselves as committed to democracy and a market economy; it seeks to stimulate economic progress and world trade by providing a platform to compare policy experiences, seek answers to common problems, identify good practices and coordinate domestic and international policies of its members.

OECD 301 – Test No. 301: Ready Biodegradability covers six methods that permit the screening of chemicals for ready biodegradability in an aerobic aqueous medium. In general, **a** solution or suspension of the test substance in a mineral medium is inoculated and incubated, normally for 28 days, under aerobic conditions in the dark or in diffuse light. Degradation is monitored by the determination of parameters such as dissolved organic carbon (DOC), CO_2 production and oxygen uptake and compared with standard thresholds for biodegradability.

Oiliness Agent – A material that reduces friction by formation of an adsorbed film.

OK Load – The OK load or the Timken OK load describes the load-carrying capacity of a lubricant. The OK load is measured in a standard test (ASTM D2509). In this test, a bearing ring rotates against a stationary steel block under an applied load. The OK load is the maximum load that can be applied without scuffing or seizure of the steel block. It is used to characterize the extreme pressure performance of greases and lubricants. The test in named for the Timken Company, which developed this test machine.

Oleate – An oleate is a salt or ester of oleic acid. Oleic acid is an unsaturated fatty acid with chemical formula $C_{18}H_{34}O_2$ or CH_3-$[CH_2]_7$-CH=CH-$[CH_2]_7$-COOH. Oleate greases are made by reacting oleic acid with an inorganic base to form a salt, i.e., soap thickener.

Operating Temperature – The operating temperature of a grease is the range between the lowest temperature where a lubricated device can be started up in an acceptable manner and the highest temperature where lubrication is adequate. The operating temperature of a grease depends on its formulation (base fluid, thickener, additives). In this context, temperature is measured in the general vicinity of the lubricated contact and not between the loaded surfaces. Low-temperature bearing or flow tests are used often to determine the minimum operating temperature. High-temperature bearing tests are used typically to determine the maximum operating temperature. Dropping point alone is not sufficient to determine the maximum operating temperature of a grease.

Organic Acid – In general, organic acids are organic chemicals with acidic properties. Organic compounds contain primarily carbon (C) and hydrogen (H), and may contain smaller amounts of nitrogen (N), oxygen (O), sulfur (S), etc. Acidic molecules tend to release H^+ ions by reacting with basic molecules or dissociating in polar solvents. Most organic acids contain a -COOH or carboxyl group that can release an H^+ ion.

Organic Soap – An organic soap is an organic molecule that is formed by the chemical reaction of an acid and a base. Many grease thickeners are organic soaps formed by reactions of organic acids with inorganic bases. For example, grease can be prepared by reacting 12-hydroxystearic acid and lime (calcium hydroxide) in base fluid to form calcium 12-hydroxystearate soap, which thickens the fluid to form grease.

Organic Thickener – See Non-Soap Thickener.

Oxidation Stability – The resistance of lubricants to chemical reactions with oxygen. The absorption and reaction of oxygen may lead to degradation of lubricants. Several test methods are in use, including ASTM D942 (IP 142) and D5483. Elevated temperature bearing test methods such as the Ball

Bearing Grease Life Test (ASTM D3336), the Wheel Bearing Grease Life Test (ASTM D3527) and the FE9 (DIN 51281) are also used.

PAO – Polyalphaolefins (PAOs) are hydrocarbon oils that are synthesized by polymerizing α-olefins. PAOs are API Group IV base oils. They are noted for their chemical purity, consistent molecular weight distribution, and high viscosity index, and they can be used over a wide range of temperatures.

PIO – Poly(internal olefins) (PIOs) are hydrocarbon oils that are synthesized by dehydrochlorination or chlorination of linear paraffins. They have high viscosity indices and low pour points, and they are used in engine oils, compressor lubricants, and other applications.

Penetration – An arbitrary standard measure of consistency (hardness) based on ASTM D217 (ISO 2137). The softer the consistency, the higher the penetration number.

The ASTM definitions are:

Penetration – The depth that a standard cone penetrates a sample of lubricating grease under prescribed conditions of cone weight, time and temperature. Penetration is measured in tenths of a millimeter, sometimes abbreviated as dmm.

Undisturbed Penetration – The penetration of a sample of lubricating grease that has not been stirred or disturbed, measured at 25 °C (77 °F).

Unworked Penetration – The penetration at 25 °C (77 °F) of a sample of lubricating grease that has received only minimum disturbance in transferring to a grease worker cup or dimensionally equivalent container.

Worked Penetration – The penetration at 25 °C (77 °F) of a sample of lubricating grease immediately after it has been subjected to 60 double strokes in a standard grease worker.

Prolonged Worked Penetration – The penetration at 25 °C (77 °F) of a sample of lubricating grease that has been subjected to more than 60 double strokes in a standard grease worker at a temperature of 15–30 °C (59–86 °F). Typical numbers of double strokes used for prolonged working are 10,000 and 100,000. After the prescribed number of double strokes, the sample is brought to 25 °C (77 °F), and worked an additional 60 double strokes, and penetration is then measured without delay.

Block Penetration – The penetration at 25 °C (77 °F) of a sample of lubricating grease that is sufficiently hard to hold its shape, determined on the freshly prepared face of a cube cut from a block of grease.

Penetrometer – See Cone Penetrometer.

Plasticity – The property of an apparently solid material that enables it to be permanently deformed, without rupture, under the application of force. Plastic flow differs from fluid flow in that the shearing stress must exceed a yield point before any flow occurs.

Pumpability – The ability of a lubricating grease to flow under pressure through the lines, nozzles, and fittings of a grease dispensing system. Pumpability is best indicated by the apparent viscosity at moderate shear rate. See ASTM D1092 and the NLGI publication, NLGI Steady Flow Charts for Grease.

Reversibility – The ability of a grease to return to its normal consistency after temporary excursions at temperatures near or above the dropping point of that grease. Aluminum complex greases are known to have this property.

Rheology – The study of the deformation and flow of matter in terms of stress, strain, temperature and time.

Rheopectic Grease – A lubricating grease that hardens when it is subjected to shear.

Rolling Contact Fatigue (RCF) – The breaking-up of a bearing surface due to fatigue process leading to failure. Pitting, spalling, and micropitting are all manifestations of rolling contact fatigue.

Roll Stability – The ability of a grease to maintain its consistency when subjected to shear in a rolling steel cylinder containing a cylindrical heavy weight as described in ASTM D1831.

Saponification – The chemical reaction of fatty acids, fats or esters with an alkali metal base to form a metallic salt. This salt is commonly called a soap.

Scoring – A form of abrasive wear that resembles scratches along the direction of motion of sliding surfaces. Causes include contaminated or insufficient lubrication, excessive loads, vibration and lack of antiwear or extreme pressure additives in the lubricant.

Scuffing – A form of adhesive wear that produces a dull or matte area on sliding surfaces. Causes include contaminated or insufficient lubrication, excessive loads, vibration and lack of antiwear or extreme pressure additives in the lubricant.

Seizure – A type of damage that occurs when rolling surfaces overheat suddenly or rapidly, and metal surfaces such as bearings and raceways soften, melt and deform to weld. Causes include inadequate lubrication or contaminated lubricant, excessive speed or load, and inadequate clearance.

Set – In manufacture of a lubricating grease, the change from a fluid to a semi-fluid or plastic state.

SETT – The word "SETT" is uniquely applied to a particular type of product, i.e., Cold Sett greases, which change from a fluid to a semi-fluid or plastic state after component combination and often after packaging.

Shearing – Slipping or sliding of one part of a substance relative to an adjacent part. In a solid, such action involves cutting or breaking of the crystal structure, but in a fluid or plastic material, shearing does not necessarily destroy the continuous nature of the substance.

Shear Rate – The rate of a slip within a substance engaging in flow. The average or mean shear rate in a pipe or tube is proportional to the average velocity divided by the radius of the tube. Therefore, shear has the dimensions of the reciprocal of the time and is usually expressed in the unit of reciprocal seconds (sec^{-1}). The mean shear rate is reported in the determination of apparent viscosity in ASTM D1092.

Shear Stability – The ability of a lubricating grease to resist changes in consistency during mechanical working. Working may be in any of several types of laboratory machines or may be in actual service. This may also be called Mechanical Stability.

Shear Stress – The force per unit area causing shearing in a substance. In fluids, the ratio of the shear stress to the shear rate is the viscosity of the substance.

Simple Soap – Simple soaps are grease thickeners that are prepared by reacting a single organic acid with one or more inorganic bases. Complex soaps are prepared from two or more organic acids.

Slumpability – See Feedability.

Soap – See Soap Thickener; Complex Soap; Saponification.

Soap Crystal – See Soap Thickener

Soap Thickener – Many greases are prepared by reacting organic acid(s) and inorganic base(s) in base fluid to form salt crystals. These crystals are partially soluble in base fluid and form colloidal particles or

fibers dispersed in the fluid. These particles or fibers are responsible for the semi-solid consistency of grease, and they are referred to as soap thickeners.

Sol – A suspension of particles of colloidal dimensions in a liquid. These systems possess the gross properties of a liquid.

Squeeze Film Lubrication – A lubrication state in which surfaces that are thickly coated or flooded with lubricant move toward each other at sufficient speed to develop fluid pressure to briefly support a load. Because of its viscosity (or apparent viscosity), the lubricant cannot immediately flow away from the area of contact. Squeeze film lubrication occurs, for example, between gear teeth and between wrist pins and their bushings.

SRV – Schwingung (Oscillating) Reibung (Friction) Verschleiz (Wear). A SRV machine is used to evaluate the friction and wear properties of liquid lubricants and lubricating greases in a variety of contacts. SRV tests measure interactions between a lubricant and two specimens in a loaded contact undergoing rotational or sliding oscillatory motion. Two of a number of standard tests that use an SRV machine are ASTM D5707 (friction and wear) and ASTM D5706 (step-wise EP).

Static Friction – Resistance to motion as contacting bodies begin to move from rest.

Steady-State Flow – A fluid is described as undergoing steady-state flow when its properties at any given condition are unchanging, which is the case during laminar flow.

Stearate – A stearate is a salt or ester of stearic acid. Stearic acid is a fatty acid with chemical formula $C_{18}H_{36}O_2$ or CH_3-$[CH_2]_{16}$-COOH. Stearate greases are made by reacting stearic acid with an inorganic base to form a salt, i.e., a soap thickener.

Stringiness – A term that is used casually to refer to a qualitative visual assessment of the ability of a grease to form thread-like "strings". (See Tackiness)

Syneresis – Loss of liquid lubricant from a lubricating grease due to shrinkage or rearrangement of the structure. The shrinkage may be due to either physical or chemical changes in the thickener. Syneresis is a form of oil separation.

Synthetic Grease – A grease composition in which the liquid lubricant is other than mineral or vegetable oil.

Tackiness – The adhesive-cohesive property of a grease, i.e., how well a grease adheres to the surface that it lubricates. In the adhesive industry, tackiness was defined as the force applied to separate two solid surfaces joined by an adhesive layer in its liquid state. In the grease industry, tackiness is qualitatively considered as the ability of a grease to form threads as it is being pulled apart, e.g., when a small amount of grease is held between the thumb and forefinger of an operator, and the operator increases the gap between their thumb and forefinger. Research is underway to develop a formal definition and quantitative test method to measure tackiness and adhesion of grease.

Texture – Properties of lubricating greases that are observed visually when handling grease. Texture is described in the following terms:

Brittle – Has a tendency to rupture or crumble when compressed.

Buttery – Separates in short peaks with no visible fibers.

Long Fibers – Shows tendency to stretch or form a string consisting of a single bundle of fibers.

Resilient – Capable of withstanding moderate compression without permanent deformation or rupture.

Short Fibers – Shows short break-off with evidence of fibers.

Stringy – Stretching into long fine threads with no visible evidence of fiber structure.

Tacky – Having adhesiveness, especially to metal surfaces. Greases with polymers tend to be tacky.

Other terms, such as *Smooth*, *Rough*, *Grainy*, etc., are defined under Bulk Appearance.

Thickener – The solid particles that are relatively uniformly dispersed in a liquid lubricant to form the structure of lubricating grease. The solid particles may be fibers, platelets, amorphous particles, or polymers.

Thixotropy – Decrease in grease consistency (softening) as a result of shearing, followed by an increase in consistency (hardening) after shearing is stopped. Thixotropic age hardening is a relatively prolonged process proportional to aging time and is seldom, if ever, complete. In contrast, the apparent viscosity increase in non-Newtonian systems with decreasing shear rate is instantaneous and fully reversible. Lubricating grease is both thixotropic and non-Newtonian.

Timken OK Load – See OK Load.

Translatory – A synonym for translation or linear motion in DIN (Deutsches Institut für Normung e. V.) and other European specifications and standards.

Viscosity – The absolute or dynamic viscosity (η) in centipoise (cP) is a measure of the internal resistance of a fluid to flow. Absolute viscosity is typically measured with a rotational viscometer. Lubricants and base oils are usually described in terms of their kinematic viscosity (ν) in centistokes (cSt), which is defined as the ratio of the kinematic viscosity to the density of a fluid. Kinematic viscosity is typically measured with a flow-type viscometer; an operator measures the length of time that it takes for a fluid to flow through a capillary tube. Thus, kinematic viscosity corresponds to the speed at which a fluid flows under the application of a certain force, typically gravity. The terms "heavier" and "lighter" are used casually to refer to oils and lubricants that have higher and lower viscosities, respectively.

Viscosity Index – The viscosity index (VI) of a base oil or lubricant describes its change in viscosity with temperature. The VI value is usually obtained according to ASTM D2270 from a calculation based on data for the kinematic viscosity at 40 and 100°C.

Water Resistance – The ability of lubricating grease to withstand the addition of water to the lubricant system without adverse effects. Water resistance is considered to be made up of four components as listed below:

Water Washout Resistance – The ability of a lubricating grease to resist being removed from a bearing when operated with exposure to water. Generally measured by ASTM D1264 or ISO 11009.

Water Absorption – The characteristics of a lubricating grease when water is added:

Water Soluble – The lubricating grease absorbs the water and then becomes semi-fluid.
Water Absorbent – The lubricating grease absorbs relatively large quantities of water with little or no change in consistency and without a separate phase of free water.
Water Resistant – The lubricating grease does not absorb more than small amounts of water, does not change appreciably in consistency, and most of the added water is a separate second phase.

Water Corrosion Resistance – The ability of a lubricating grease to prevent corrosion of metal surfaces in the presence of water. May be measured either statically by standard tests or dynamically by

operation of bearings with water added to the lubricant reservoir, as in ASTM D1743, D5969, D6138 and ISO 11007.

Water Spray Resistance – The ability of a grease to resist displacement from a surface by the impact of a water spray. The test method used is ASTM D4049.

Lubricating greases for various types of service may not need any of the water resistance properties described above. They are not measures of quality except for specific situations where water resistance is required.

Wear – Damage that involves the cumulative and gradual removal of material from surfaces. Several types of wear are described below:

Abrasive Wear – Damage that occurs when surfaces are in contact and undergo relative motion, and cutting or abrasion by hard particles removes material from the surfaces.

Adhesive Wear – Damage that occurs when two surfaces are in contact and undergo relative motion, and high loads and/or temperatures cause asperities to weld and then immediately separate, removing material from one or both surfaces. Adhesive wear can be mild (frosting), moderate (scuffing), or severe (galling, scoring, seizing).

Corrosive Wear – Damage that occurs when chemical or electrochemical reactions at a surface result in the removal of material. Corrosion can be localized (e.g., pitting) or general.

Electrical Discharge Wear – Removal of material from solid surfaced due to sparks or high-amperage electrical discharge.

Erosive Wear – Progressive loss of material from the surface or edge of a solid component when a liquid or a large number of solid particles impinge upon it..

Fatigue Wear – Wear of a solid surface that is caused by fatigue, i.e., repeated heavy loading that causes dents, cracks, fracture and removal of fragments from a metal surface.

Fretting Wear – Wear that occurs as a result of fretting, i.e., small amplitude oscillations or vibrations between two solid surfaces that are in contact.

Polishing Wear – Occurs when very fine hard particles in a lubricant remove material from a solid surface, producing a brightly polished surface.

White Etch Cracking – Bearing failure characterized by the appearance of white cracks on the surface of the bearing. White etch cracks are typically found in high-stress applications such as wind turbine gearbox bearings. In-situ hydrogen generation by corrosion or other causes and stray electrical currents have been implicated as factors leading to white etch cracking.

Working – The subjection of lubricating grease to any form of agitation or shearing action beyond simple transfer to any test apparatus, package, or application.

Yield – The amount of grease of a given consistency that may be made with a specific amount of thickening agent. As the yield increases, percent thickener by weight decreases.

Yield Stress – (Yield value or yield point) – The minimum shear stress required to produce flow of a plastic material. It can be estimated by the intercept on the shear stress axis of a shear stress-shear rate curve by extrapolation of the straight portion of the curve. (See Apparent Viscosity)