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Standard Terminology for Rolling Element Bearings[1]

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1. Scope

1.1 This terminology covers terms and their definitions relevant to the materials and processes associated with rolling element bearings.

1.2 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions:*

absolute viscosity (η), *n*—(sometimes called **dynamic viscosity** or just **viscosity**)—a measure of the tendency of the fluid to resist shear.

acid number, *n*—measure of the quality of a lubricant. High acid numbers (much higher than the fresh oil) are an indication of lubricant oxidation/degradation.

DISCUSSION—Oils with high acid numbers should not be used. Acid number is measured as milligrams of KOH needed to neutralize 1 g of oil.

additive, *n*—any chemical compound added to a lubricant to improve or meet special needs necessary for service (formulated lubricants). The most important additives are antioxidants, rust, and corrosion inhibitors, and extreme pressure (EP) and antiwear (AW) additives.

antioxidants (oxidation inhibitors), *n*— chemical compounds used to improve the oxidation stability and subsequent deterioration of lubricants.

average life (L_{50}), *n*—for a radial roller bearing, the number of revolutions that 50 % of a group of bearings will complete or exceed before the first evidence of fatigue develops.

DISCUSSION—The average life maybe as much as five times the rating life.

ball gage (*S*), *n*— prescribed small amount by which the lot mean diameter should differ from nominal diameter, this amount being one of an established series of amounts.

DISCUSSION—A ball gage, in combination with the ball grade and nominal ball diameter, should be considered as the most exact ball size specification to be used by a customer for ordering purposes.

ball gage deviation (Δ*S*), *n*—difference between the lot mean diameter and the sum of the nominal diameter and the ball gage.

ball grade (*G*), *n*—specific combination of dimensional form and surface roughness tolerances. A ball grade is designated by a grade number followed by the letter "C" indicating silicon nitride ceramic.

boundary lubrication, *n*—condition of lubrication in which the friction between two surfaces in relative motion is determined by the roughness of the surfaces and by the properties of the lubricant other than viscosity.

DISCUSSION—Antiwear and extreme pressure additives reduce the wear of components operating under this regime.

case depth, *n*—thickness, measured radially from the surface of the hardened case to a point at which carbon content or hardness becomes the same as the ball core.

centipoise, *n*—unit of dynamic viscosity.

DISCUSSION—The unit in the cgs system is 1 centipoise (cP). The SI unit of dynamic viscosity is 1 Pa-s and equivalent to 10^3 cP.

centistoke, *n*—unit of kinematic viscosity.

DISCUSSION—The unit in the cgs system is 1 centistoke (cSt). The SI unit of kinematic viscosity is 1 m^2/s and is equivalent to 10^6 cSt.

compatibility, *n*—measure of the ability of a lubricant to be mixed with other lubricants or bearing preservatives (fluids that form films on metal surfaces to prevent corrosion during storage) to form a uniform mixture without causing any resultant reaction or precipitation of material. Compatibility is also a measure of the ability of a lubricant not to cause any detrimental effect to metal, plastic, or elastomer materials.

DISCUSSION—It is recommended that any preservative material be removed from bearings before lubrication.

contamination, *n*—*(1)* presence of mostly solid foreign materials like sand, grinding powder, dust, and so forth, in a lubricant that might cause an increase in wear, torque, and noise and result in reduced bearing life; and *(2)* presence of

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fluids like water, solvents, and other oils that might cause accelerated oxidation, washout, rusting, or crystallization of the additives and other phenomena that reduce a bearing's life.

corrosion, *n*—gradual destruction of a metal surface as a result of chemical attack caused by polar or acidic agents like humidity (water), compounds formed by lubricant deterioration, or contaminants from the environment.

corrosion inhibitors, *n*—corrosion inhibitors protect metal surfaces against corrosion or rust by forming a protective coating or by deactivation of corrosive compounds formed during the operation of a bearing.

density, *n*—mass per unit volume of a substance.

DISCUSSION—The cgs unit of density (ρ) is 1 g/cm^3, and the SI unit of density is 1 kg/m^3. Density depends on the chemical composition and in itself is no criterion of quality. It is a weak function of temperature and pressure for liquids and solids.

deviation from spherical form (Δ*Rw*) , *n*—greatest radial distance in any radial plane between a sphere circumscribed around the ball surface and any point on the ball surface.

***DN* value,** *n*— product of the bearing bore diameter in millimetres multiplied by the speed in revolutions per minute (compare to nD_m value).

dynamic viscosity, *n*—another name for **absolute viscosity**.

EP lubricants (extreme pressure lubricants), *n*—lubricants (oil or greases) that contain extreme pressure additives to protect the bearings against wear and welding (scoring).

esters, *n*—esters are formed from the reaction of acids and alcohols. Esters form a class of synthetic lubricants.

DISCUSSION—Esters of higher alcohols with divalent fatty acids form diester lubricants while esters of polyhydric alcohols are called the polyol ester lubricants. These latter esters have higher viscosity and are more heat resistant than diesters.

evaporation loss, *n*—lubrication fluid losses occurring at higher temperatures or under vacuum, or both, as a result of evaporation.

DISCUSSION—This can lead to an increase in lubricant consumption and also to an alteration of the fluid properties of a lubricant (especially an increase in the viscosity of blended lubricants). The evaporation loss is expressed as a weight loss in milligrams (10^{-6} kg) or wt %.

fire point, *n*—lowest temperature at which the vapor or a lubrication fluid ignites under specified test conditions and continues to burn for at least 5 s without the benefit of an outside flame. The fire point is a temperature above the flash point.

DISCUSSION—Perfluoropolyethers have no fire point.

flash point, *n*—lowest temperature of a lubrication fluid at which the fluid gives off vapors that will ignite when a small flame is periodically passed over the liquid surface under specified test conditions.

DISCUSSION—The flash and fire points provide a rough characterization of the flammable nature of lubrication fluids. Perfluoropolyethers have no flash point.

fretting corrosion, *n*—special type of wear produced on materials in intimate contact that are subjected to the combined action of oscillatory motions of small amplitudes and high frequencies. Fretting corrosion appears similar to atmospheric corrosion (rust) as a reddish-brown layer on steel surfaces.

interfacial tension, *n*—when two immiscible liquids are in contact, their interface has many characteristics in common with a gas-liquid surface. This interface possesses interfacial free energy because of the unbalanced attractive forces exerted on the molecules at the interface by the molecules within the separate phases. This free energy is called the interfacial tension.

kinematic viscosity, *n*—ratio of absolute viscosity to fluid density.

DISCUSSION—This ratio arises frequently in lubrication analyses, and thus, kinematic viscosity has become a separate term describing the viscosity of a fluid. Many experimental measurements of viscosity of fluids result in a measure of kinematic viscosity from which absolute viscosity is calculated. See **absolute viscosity**. The cgs unit of kinematic viscosity is cSt and the SI unit is m^2/s. The viscosity of a PREB oil is a major factor in lubricant selection. The viscosity is directly involved in frictional, thermal, and fluid film conditions that reflect the influence of load, speed, temperature, and design characteristics of the bearing being lubricated.

marking increments, *n*—standard unit steps to express the specific diameter.

mineral oil, *n*—oils based on petroleum stocks. These oils come in two types, naphthenic and paraffinic. The naphthenic oils contain unsaturated hydrocarbons, usually in the form of aromatic species. The paraffinic oils are primarily saturated hydrocarbons with only low levels of unsaturation.

***nD$_m$* value (index),** *n—also called speed index*—relative indicator of the lubricant stress imposed by a bearing rotating at a given speed, where *n* is the rotational speed of the rolling element bearing in revolutions per minute and D_m is the mean diameter in millimetres (arithmetic mean of bore diameter *d* and outside diameter *D*).

DISCUSSION—The speed index is multiplied by a factor k_a depending on the roller element bearing type:

k_a = 1 for deep groove ball bearings, angular contact ball bearings, self-aligning ball bearings, radially loaded cylindrical roller bearings, and thrust ball bearings;

k_a = 2 for spherical roller bearings, taper roller bearings, and needle roller bearings; and

k_a = 3 for axially loaded cylindrical roller bearings and full complement roller bearings.

The factor k_a takes into account the various rates of sliding friction that usually occurs during the operation of a rolling element bearing. The nD_m value is an aid in choosing a suitable lubricant viscosity for a given bearing speed and is particularly applicable to grease-lubricated bearings.

neutralization number, *n*—measure of the acidity or alkalinity of a lubricating fluid. The test determines the quantity of base (milligrams of potassium hydroxide) or acid (also expressed as milligrams of potassium hydroxide) needed to neutralize the acidic or alkaline compounds present in a lubricating fluid.

DISCUSSION—Actually, the neutralization number is not one number but several numbers: strong acid number, total acid number, strong base number, and total base number. The neutralization number is used for quality control and to determine changes that occur in a lubricant in service.

oxidation stability, *n*—stability of a lubricant in the presence of air or oxygen is an important chemical property.

DISCUSSION—Oxidation stability has a strong influence on numerous physical properties of a lubricant. These properties include the change of viscosity under static conditions for long periods of time (storage) or when exposed to temperatures high above room temperature, or both. The slow chemical reaction of fluid (base oil) and oxygen (air) is called oxidation. Inhibitors (see **antioxidants**) are used to improve the oxidation stability of the lubricants. Synthetic fluids, especially perfluoropolyethers and silicones, are much more resistant to oxidation than mineral oils.

part number, *n*—part number is developed by selecting a characteristic from each of the tables in a specification sheet, for example:

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passivation, *n*—treatment for corrosion-resistant steel to eliminate corrodible surface impurities and provide a protective film.

perfluoropolyethers (PFPE or PFAE), *n*— fully fluorinated long-chain aliphatic ethers.

DISCUSSION—The perfluoropolyethers show some extraordinary properties like chemical inertness, nonflammability, high thermal and oxidative resistance, very good viscosity-temperature characteristics, and compatibility with a wide range of materials, including metals and plastics. The perfluoropolyethers, however, are not suitable for use with aluminum, magnesium, and titanium alloys. The perfluoropolyethers are not compatible with other types of synthetic fluids and mineral oils and cannot dissolve common lubricant additives.

pH value, *n*—scale for measuring the acidity or alkalinity of a product. Zero pH is very acid, 7 is neutral, and 14 is very alkaline.

poise (*P*), *n*— see **centipoise** (cP).

pour point, *n—of a lubricating fluid* , the lowest temperature at which the lubricating fluid will pour, or flow.

pressure-viscosity coefficient, *n*—dynamic viscosity of a fluid increases with increasing pressure.

DISCUSSION—The dependence of viscosity (absolute), η, on pressure, *p*, can be expressed by the equation:

$$\eta = \eta_0 \exp(\alpha p) \quad (1)$$

where:

η = absolute viscosity at pressure, p,
η_0 = absolute viscosity at one atmosphere, and
α = the pressure-viscosity coefficient.

The pressure-viscosity coefficient is very small and varies with the chemical composition of the fluid.

One limitation of the use of η_0 and the corresponding equation is that the measurements of η_0 are made under static conditions where the pressure is held constant while the viscosity attains a steady-state value. In actual bearing operations, the lubricant may see high pressure in the contact zone for only a few milliseconds and the viscosity changes as a result of this high pressure may not reach steady-state values.

rated viscosity, (ν_1), *n*— kinematic viscosity attributed to a defined lubricating condition of a rolling element bearing. The rated viscosity is a function of the speed and can be determined by the mean bearing diameter in millimetres (10^{-3} m) and the rotational speed (rpm).

rating life (L_{10}), *n—for a radial roller bearing*, the number of revolutions that 90 % of a group of bearings will complete or exceed before the first evidence of fatigue develops

repeatability, *n*—criterion for judging the acceptability of test results. Repeatability is the difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on identical test material.

DISCUSSION—Repeatability is usually reported as a range of values that would, in the normal and correct operation of the test method, encompass two standard deviations from the median value of the test.

reproducibility, *n*—criterion for judging the acceptability of test results. Reproducibility is the difference between two single and independent results obtained by different operators working with identical test material.

DISCUSSION—This difference, in the long run and under normal and correct operation of the test method, would not exceed a specified value.

saponification number, *n*—measure of the amount of constituents of a lubrication fluid that will easily saponify under test conditions. The saponification number is expressed in milligrams of potassium hydroxide that are required to neutralize the free and bonded acids contained in 1 g of lubricating fluid. The saponification number is a measure of fatty acids compounded in an oil and a measure of the state of oil deterioration.

saponify, *v*—to hydrolyze an ester and to convert the free acid into soap.

seal compatibility, *n*—extent of the reaction of sealing materials with lubricating oils, greases, and other fluids.

DISCUSSION—The reaction can result in swelling, shrinking, plasticizing, embrittlement, or even dissolution. Operating temperatures and lubricant composition are dominant factors influencing the extent of the interaction between the sealing material and the lubricating fluid.

setting point, *n—of a lubricating fluid* , the temperature at which the fluid ceases to flow when cooled under specified conditions. The low-temperature behavior of the fluid slightly above the setting point may be unsatisfactory and, therefore, this behavior should be determined by measuring the low-temperature kinematic or absolute viscosity.

silicone oils, *n*—synthetic fluids composed of organic esters of long chain complex silicic acids.

DISCUSSION—Silicone oils have better physical properties than mineral oils. However, silicone oils have poorer lubrication properties, lower load-carrying capacity, and a strong tendency to spread on surfaces (see **surface tension**). To prevent this spreading, the use of barrier films is necessary.

single diameter of a ball (*Dws*), *n*—distance between two parallel planes tangent to the surface of the ball.