Standard Terminology for Rolling Element Bearings

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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.

2. Terminology

2.1 Definitions:

absolute viscosity ($\eta$), $n$—(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.

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

ball gage deviation ($\Delta S$), $n$—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.

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.

centistoke, $n$—unit of kinematic viscosity.

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 \((\rho)\) is \(1 \text{ g/cm}^3\), and the SI unit of density is \(1 \text{ kg/m}^3\). 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 \((\Delta R_w)\), \( n \)—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 polyl 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 \((10^{-6} \text{ kg})\) 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 \(\text{cSt}\) and the SI unit is \(\text{m}^2/\text{s}\). 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 \(k_s\) depending on the roller element bearing type:

\[ k_s = 1 \text{ for deep groove ball bearings, angular contact ball bearings, self-aligning ball bearings, radially loaded cylindrical roller bearings, and thrust ball bearings; } \]

\[ k_s = 2 \text{ for spherical roller bearings, taper roller bearings, and needle roller bearings; } \]

\[ k_s = 3 \text{ for axially loaded cylindrical roller bearings and full complement roller bearings. } \]

The factor \(k_s\) 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:

M81793/XX-XXXXXXXXX

**Passivation,** $n$—treatment for corrosion-resistant steel to eliminate corrodeable 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 inerterness, 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), $\eta$, on pressure, $p$, can be expressed by the equation:

$$\eta = \eta_0 \exp(\alpha p)$$  \hspace{1cm} (1)

where:

- $\eta$ = absolute viscosity at pressure, $p$,
- $\eta_0$ = absolute viscosity at one atmosphere, and
- $\alpha$ = 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 $\eta_0$ and the corresponding equation is that the measurements of $\eta_0$ 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,** $(\eta_r)$, $n$—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** ($D_{ws}$), $n$—distance between two parallel planes tangent to the surface of the ball.

**Stepped inner ring,** $n$—inner ring of a groove ball bearing with one shoulder completely or partially removed.

**Surface energy/surface tension,** $n$—a fundamental property of liquids is the existence of a free energy at the surface. A consequence of this free energy is the property that a liquid spontaneously contracts to the smallest possible area. For example, liquid droplets assume a spherical shape if no outside forces are acting on the droplet. To deform the droplet from its spherical shape, a definite amount of work must be done. This work (or energy expended) when
normalized per unit area is called surface tension and has the unit mN/m (formally dyne/cm). Surface tension is dependent upon temperature but not upon pressure. The surface tension is a measure for the wetting of a bearing surface and for the creeping (spreading) property of a lubricant. Fluids with low surface tensions like dimethylsilicones show improved wetting but increased creeping (migration) tendency.

swelling properties, n—swelling of natural rubber and elastomers under the influence of lubricants.

synthetic fluids, n—lubricating fluids produced by chemical synthesis.

Discussion—The synthetic route to lubricants allows the manufacturer to introduce those chemical structures into the lubricant molecule that will impart specific properties into the resultant fluid such as very low pour point, good viscosity-temperature relationship, low evaporation loss, long lubricating lifetime, and so forth.

viscosity, n—see absolute viscosity.

viscosity index (VI), n—indicates the range of change in viscosity of a lubricating fluid within a given temperature range. With an increase in the viscosity index, the fluid becomes less sensitive to temperature, that is, a low-viscosity index signifies a relatively large change, whereas a high-viscosity index relates to a relatively small change in viscosity with temperature.

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

2.2 Acronyms:
ABEC, n—Annular Bearing Engineer’s Committee of the American Bearing Manufacturers Association (ABMA). The ABEC establishes bearing tolerance classes. Precision bearings are ABEC 5P and ABEC-5T and higher.

VIMVAR, n—vacuum induction melt-vacuum arc remelt.

3. Keywords
3.1 ball bearing; lubricant; rolling element bearings