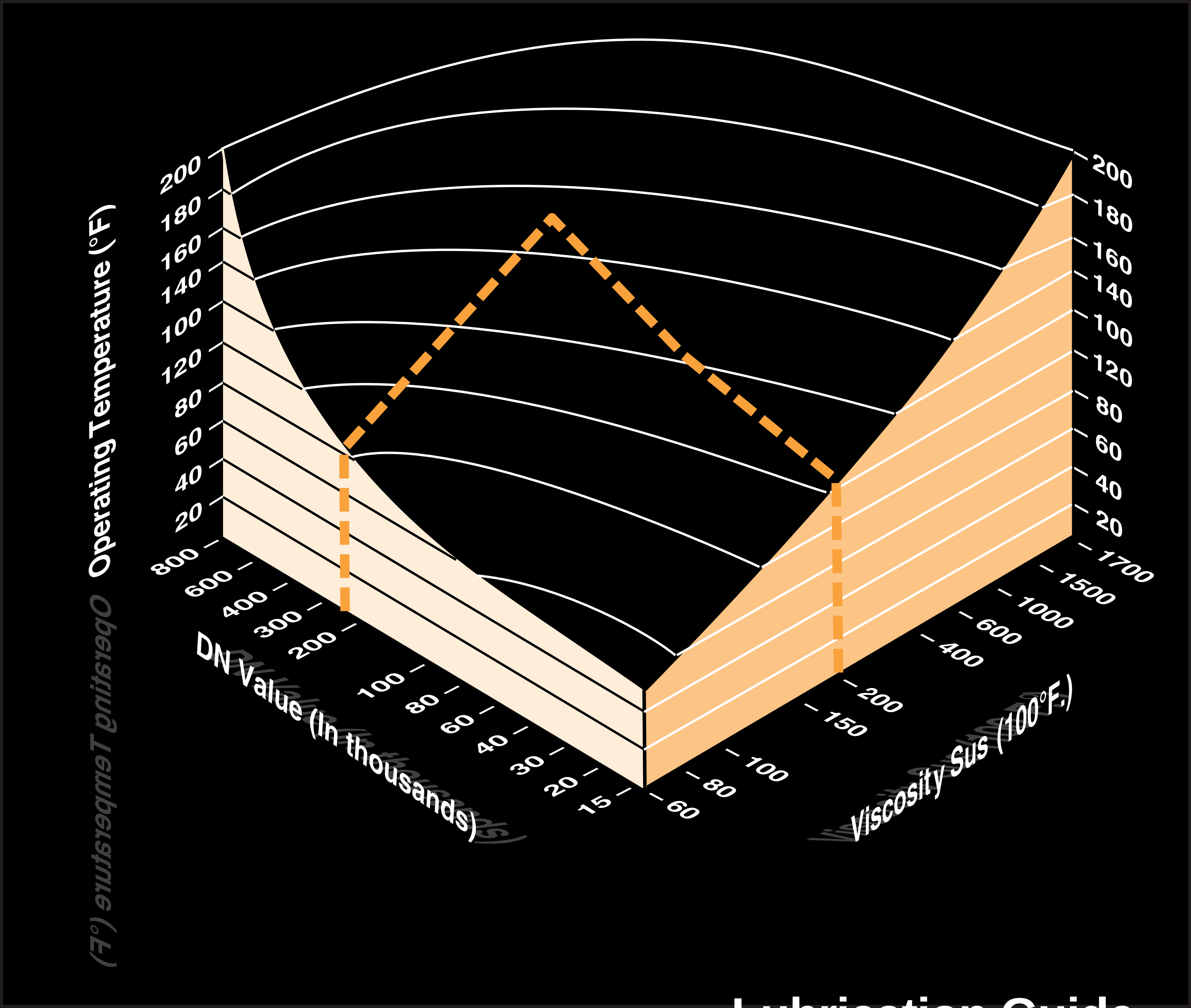
TIMKEN®

Torrington® Fafnir®



Lubrication Guide

TIMKEN®

Lubrication Guide

Introduction

Lubrication Information

Lubricant Selection

The purpose of this guide is to help you to recognize the relationship of bearings and proper lubrication. Selection of the proper lubricant is an important design function in the use of bearings, since lubricant affects bearing life and operation. The major functions of lubrication in bearing application are:

- to minimize friction at points of contact within the bearing
- to protect the precision finishes on bearing surfaces from becoming corroded
- to dissipate heat generated within the bearing
- to remove or prevent the entry of foreign matter within the bearing

The Timken Company hopes that this guide will help you to identify lubrication problems and take corrective and preventive measures to keep them from recurring.

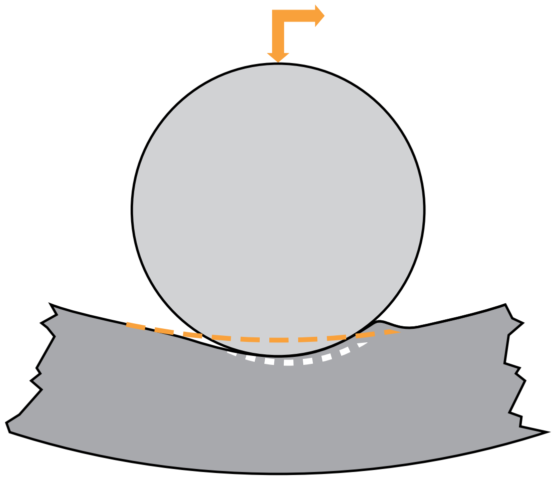
Mechanical Forces Within the Rolling Bearings

A major source of the frictional resistance in a ball bearing is sliding between the balls, the races, and the retainer. Additional frictional resistance occurs between the rotating parts and the lubricant.

A third factor contributing to frictional resistance is the deformation of the bearing parts under load. When a ball in a bearing is subjected to load, a deformation of both the ball and the race results. This deformation causes an elliptical area of contact between the ball and the race. The amount of deformation is a function of the elasticity of the materials used, the ball size, race geometry, and the magnitude and direction of the applied load.

Rolling Ball Under Vertical and Tangential Load

When a ball is motionless, the load is distributed symmetrically on the ball and the race within the contact area. When a tangential load is applied, causing the ball to roll, the material in the race bulges in front of the ball and flattens out behind the ball. The ball flattens out in the lower front quadrant and bulges in the lower rear quadrant.



Rolling Ball Under Vertical and Tangential Load

Contact Ellipse Formed by Ball and Race

One part of the resistance to rolling is accounted for by this elastic deformation of the rolling elements and the races. Another source of energy loss is the actual slippage within the contact areas of the ball and the races. As shown, all points in the contact area are at different distances from the axis of rotation of the ball and rotate at different velocities. However, two points, **A** and **B**, roll true and form a line parallel to the axis of rotation and perpendicular to the direction of rolling. All other points in the **contact ellipse** slide to varying degrees.

The retainer is another source of sliding friction. Depending upon the bearing design, the retainer may be ball or ring piloted. In both cases, sliding friction will occur between the balls and the ball pockets.

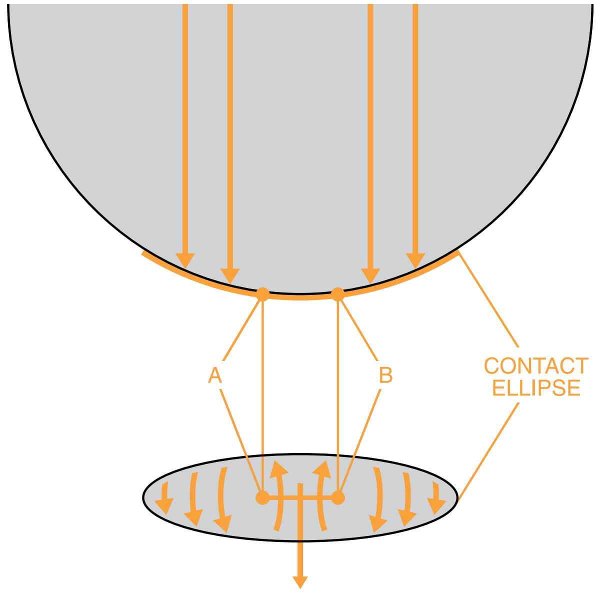
Sliding friction also occurs between the retainer and the controlling ring in the ring piloted retainer. The heat generated within the bearing is a consequence of the frictional resistance of the bearing as well as other effects enumerated above.

High pressures exist in the area of contact. In the absence of lubricant, metal to metal pick-up or welding between the balls and the races can occur. High temperatures due to sliding friction between the balls, races and retainer may also cause surface damage.

To prevent these actions from occurring, lubricants having adequate film strength are required. Insufficient film strength allows metal to metal contact within the contact areas. The hydrodynamics of the lubricant may reduce the stresses in the contact area. This is significant because the amount of deformation of the ball and the race bears a direct relationship to frictional resistance and the fatigue life of the bearing.

In both the ball to race contact area and the retainer rubbing areas, sufficient lubricant flow or movement must be maintained to prevent localized heat build-up in the bearing.

Fluid friction, friction within the lubricant itself, is a function of the chemical and physical composition of the lubricant. Friction between the lubricant and the bearing components is a function of the characteristics of the lubricant and the design of the bearing. All of these factors contribute significantly to the frictional resistance of the bearing and must be considered when selecting the proper lubricant. Of equal importance when selecting a lubricant for a specific application, are the actual operating conditions in addition to the bearing's characteristics.



Contact Ellipse Formed by Ball and Race

Lubricant Types

Two basic types of lubricants–oils and greases–are used with anti-friction bearings. Each has its advantages and limitations.

As a liquid, oil lubricates all the surfaces and is able to dissipate heat from these surfaces more readily. Oil retains its physical characteristics over a wide range of temperatures, making it ideal for high speed and high temperature applications. The quantity of oil supplied to the bearing may be controlled accurately allowing for better circulation, cleansing and cooling.

As a thicker substance, grease can seal a bearing better than oil, while allowing seal design simplification. It can be confined easily in the bearing housing, and permits prelubrication of sealed or shielded bearings.

Advantages of Oil and Grease

Oil

- Better for high speed operation. Easier dispersion over bearing surfaces. Diffuses heat quicker because of viscosity.
- Easier to handle and control amount of lubricant reaching the bearing.
- Variety of ways to deliver oil (drip, wick, circulation, batch, air-oil mist) make it easier to introduce into bearing.
- Easier to keep clean for recirculating systems.
- Easily controlled lubrication. Carries away moisture and particulate matter.

Grease

- Clings to surfaces better. Is squeezed out of roller path to lesser extent.
- Easier to retain in bearing. Lubricant loss is lower than oil loss. Generally requires less frequent lubrication.
- Lasts longer and protects better than oil.
- Acts as an efficient bearing sealant. Allows seal design simplification.
- Easily confined in housing, an important plus in food, textile and chemical industries.

Coatings and Surface Treatments

Coatings and surface treatments specifically developed to protect bearings from rusting, reduce wear, increase hardness and lubricity are available. Among them:

Electro-Plating

The coating of metal parts with another metal by means of ionic bonding, through the introduction of electric charges in the presence of a chemical agent.

Electroless-Plating

The coating of metal parts with another metal by means of ionic bonding, through the application of heat and chemical agents.

PVD (Physical Vapor Deposition)

The coating of metal surfaces with low temperature plasma coatings.

CVD (Chemical Vapor Deposition)

The coating of metal with alloys similar to electroless plating.

Solid Lubricants

Coatings and treatments at area of surface-to-surface interface which intentionally wear onto surfaces to ease interaction and contact.

Examples of these coatings are Fafnir TDC™ (Thin Dense Chrome) Electro-less Nickel, Cadmium Plating, Molybnium Disulfide, Titanium Nitride, gold/silver/brass flake and Teflon®/Nomex®.

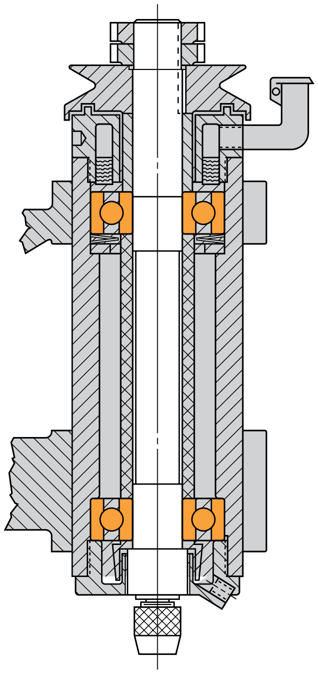
Lubrication Delivery Systems

Oil-Bath Lubrication

The conventional oil-bath system for lubricating bearings is satisfactory for low to moderately high speed applications. Because this type of system is non-circulating, the static oil-level should never be higher than the center of the lowest positioned rolling element in the bearing being lubricated. A greater amount of oil can cause churning, increase the fluid friction within the bearing and result in excessive operating temperatures.

Unless the running level of the oil is known, oil level should be checked only when equipment is shut down as the running level can drop considerably below the static level depending on the speed of the application.

Because speed, sealing effectiveness, temperature and type of oil are factors that influence the refilling cycle, regular inspection is necessary to determine the frequency of refilling. Applications of this type generally employ sight gages to facilitate inspection.



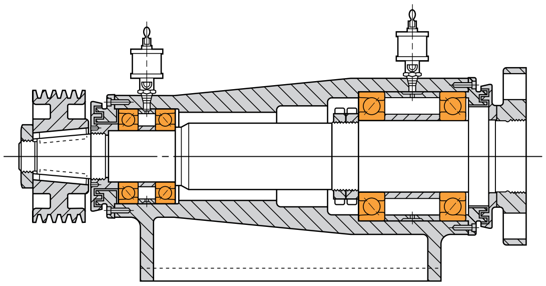
Wick-Feed Lubrication

Wick-Feed Lubrication

Wick-feed oilers, one of the older methods of applying oil to bearings, still enjoy a certain popularity. Properly designed, applied and maintained, then are effective and inexpensive.

Functioning as a filter and quantity regulator, the wick employs either capillary action, or gravity (see illustration) to transfer the oil from the reservoir to bearing.

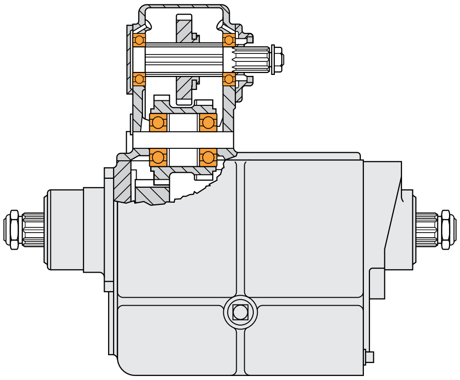
Paraffinic lubricating oils may also be used with this type oiler although they have a tendency to deposit wax crystals on the wick fibers, destroying the effectiveness of the wick. Because napathetic and synthetic oils do not exhibit this tendency, they are preferred for wick oilers.



Drip-Feed Lubrication

Drip-Feed Lubrication

Another one of the older methods of lubrication of oiling bearings is the drip-feed system. This system has been applied successfully to applications where moderate loads and speeds are encountered. The oil introduced through a filter-type, sight feed oiler, has a controllable flow rate which is determined by the operating temperature of the particular application.



Oil-Splash Lubrication

Oil -Splash Lubrication

This system of lubrication is used primarily in gear cases where the bearing and gear lubricant is common. The lubrication of bearings in a gearbox, other than one of slow speed, is usually not critical as the oil splash from gear teeth is sufficient to lubricate the bearings.

Because of the constant problem of the oil carrying wear debris, the use of filters and magnetic drain plugs is helpful in reducing the possibility of wear debris contaminating the bearings.

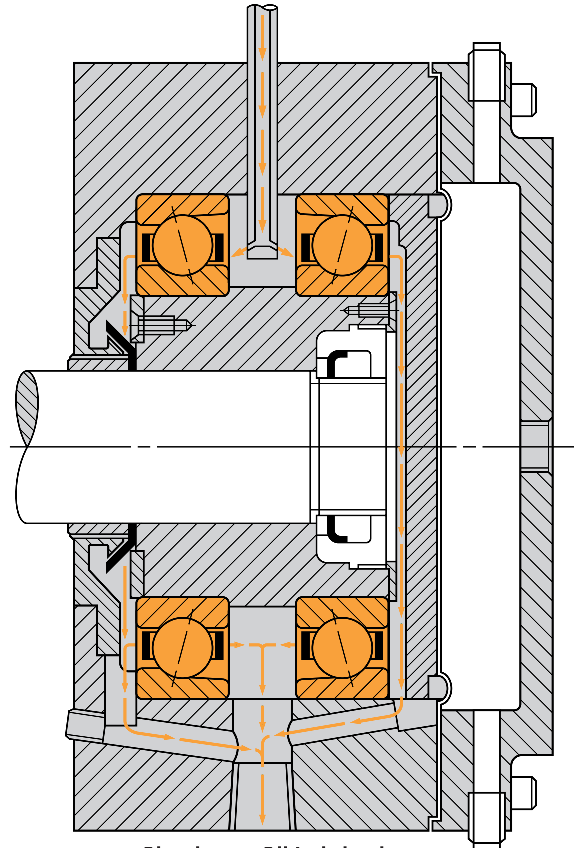
In applications where heavy oil flow or splash is encountered, bearings equipped with shields to reduce the quantity of oil reaching the bearings are sometimes necessary to prevent overheating caused by fluid friction where the bearing is flooded.

In systems where normal splash or washdown is expected to be marginal, oil feeder trails should be designed into the case to direct case washdown into the bearings.

Lubrication Delivery Systems

Circulating-Oil Lubrication

This type of system utilizes a circulating pump to assure a positive supply of lubricant to the bearing and can be used for low to moderately high speed and high temperature power transmission applications.The flow path of the oil in this system is important because bearing churning in a captive amount of oil can generate temperatures capable of causing lubricant breakdown and bearing damage. Due to the inherent possibility of contamination from wear debris in heavy duty applications, suitable oil filters and magnetic drain plugs are necessary to prevent damage to the bearings.



Circulatory-Oil Lubrication

Oil-Jet Lubrication

In applications where a bearing is heavily loaded and operating at high speed and temperatures, a sophisticated variation of circulating oil lubrication, called oil-jet lubrication, may be required. In such cases, it is necessary to lubricate each bearing location individually, under pressure, and to provide adequately large scavenging drains to prevent the accumulation of oil after passage through the bearing. In certain high speed applications where the bearing itself creates a pumping action, the flow of oil must be adjusted to assure passage through the bearing. This is extremely important where the flow of oil from the jet opposes the pumping action within the bearing.

Oil-Mist Lubrication

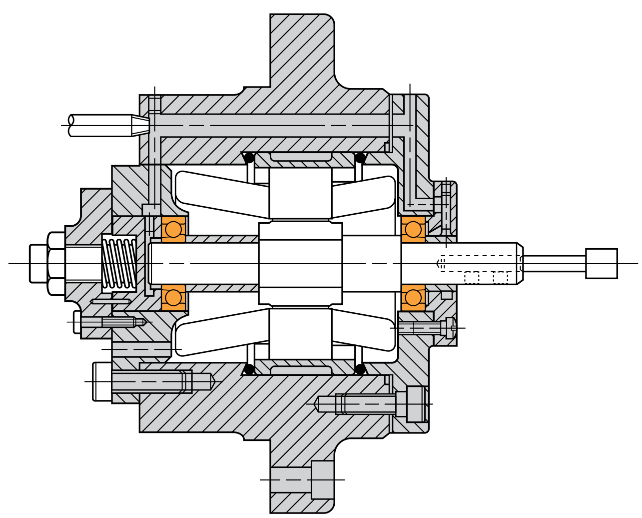
Oil-Mist Lubrication systems are used in high-speed, continuous operation applications. This system permits close control of the amount of lubricant reaching the bearing. The oil may be metered, atomized by compressed air and mixed with air, or it may be picked up from a reservoir using a venturi effect. In either case, the air is filtered and supplied under sufficient pressure to assure adequate lubrication of the bearings. Control of this type of lubricating system is accomplished by monitoring the operating temperatures of the bearings being lubricated.

The continuous passage of the pressurized air and oil through the labyrinth seals used in the system prevents the entrance of contaminants from the atmosphere into the system.

To insure “wetting” of the bearings and to prevent possible damage to the rolling elements and races, it is imperative that the oil-mist system be turned on for several minutes before the equipment is started. The importance of the “wetting” the bearings before starting cannot be overstressed and has particular significance for equipment that has been idle for extended periods of time.

The successful operation of this type of system is based upon the following factors:

- proper location of the lubricant entry ports in relation to the bearings being lubricated
- avoidance of excessive pressure drops across void systems within the system
- the proper air pressure and oil quantity ratios to suit the particular application
- the adequate exhaust of the air-oil mist after lubrication has been accomplished



Air-Oil-Mist

Lubrication Delivery Systems

Oil Quantity

Normally, not more than a thin film of oil is required to lubricate a bearing. Experience has shown that when the oil quantity is increased to more than just enough to form a film on the bearings, fluid friction and friction torque will increase. In applications where generated heat is a critical factor, increased quantities of oil are used as a heat transfer medium.

Pre-Packed Bearings

Bearings which are utilized in moderately high speed applications are supplied with the proper amount and type of grease pre-packed in the bearing. Prelubricated Timken® Torrington® bearings are prepacked with greases which have chemical and mechanical stability and that have demonstrated long-life characteristics in rotating bearings. Greases are filtered several times to remove all harmful material and accurately metered so that each bearing receives the proper amount of grease.

Prelubricated shielded and sealed bearings are extensively used with much success on applications where:

- Grease might be injurious to other parts of the mechanism
- Costs and space limitations preclude the use of a grease-filled housing
- Housings cannot be kept free of grit, water or other contaminants
- Relubrication is impossible or would be a hazard to satisfactory use

Housed Bearings

Applications utilizing grease lubrication should have a grease fitting and vent on opposite sides of the housing near the top. A drain plug should be located near the bottom of the housing to allow purging of the old grease from the bearing.

Relubricate at regular intervals to prevent damage to the bearing. Relubrication intervals are very difficult to determine. If plant practice or experience with other applications is not available, consult your lubricant supplier or a Timken sales engineer.

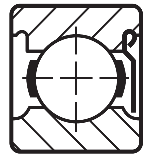
Grease Quantity

There is no set formula to determine the exact amount of grease necessary to lubricate a bearing because the quantity is directly dependent upon such factors as the application, the bearing and retainer design and the type of grease used. Certain bearings of the high precision types used in high speed applications may have as little as 20 percent of the bearing void filled with grease. Other bearings of the types used in low speed applications may have as much as 80 percent of the bearing void filled with grease. Aircraft bearings of the oscillating types may be 100 percent filled with grease. Even within the limits of a given application, the quantity of grease may be dependent upon the type of grease selected. For example, two different grades of grease, one a NLGI Grade #1 and the other a NLGI Grade #4, have proved to be suitable lubricants for machine tool spindle bearings. However, because the Grade #1 grease has a tendency to churn, a lesser amount must be used in a given bearing as compared to the amount of a Grade #4 grease is a channeling type which does not churn; consequently, the amount used in the bearing is less critical. Overgreasing may cause a rapid temperature rise in the bearing that can damage both the lubricant and the bearing.

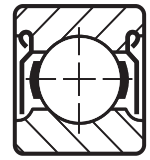
Shields

Shields, D-Type

Bearings are available with one shield (D-Type), or two shields (DD-Type). A shield on one side provides protection against the entrance of coarse dirt or chips and makes it possible to relubricate the bearing from the open side. Double shielded bearings are prelubricated with the correct amount of Timken® Fafnir® approved ball bearing grease and are designed for applications where relubrication is not required.



One Shield D

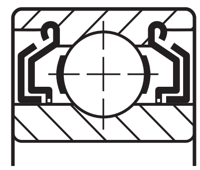


Two Shields DD

Seals

Labyrinth or Mechani-Seals, L-Type

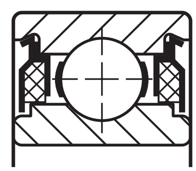
The Mechani-Seal was developed by The Timken Company to provide a frictionless seal for effective grease retention and exclusion of foreign matter. Basically it consists of two "dished" steel plates. The inner member is fixed securely in the outer ring of the bearing and provides an ample grease chamber plus effective grease retention. The outer member is pressed on the outside diameter of the inner ring and rotates as a slinger to throw off contaminants. Close running clearance between the inner and outer members assures effective sealing under extremely severe operating conditions. This seal configuration is very effective at high speeds, because it is virtually frictionless and utilizes slinger action. Mechani-Seal bearings are very popular in high speed pneumatic tools, small electric motors, pumps, domestic appliances and similar high speed applications.



Mechani-Seals LL

Felt Seals, T-Type

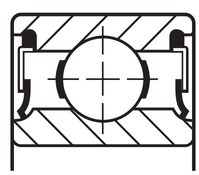
The felt seal consists of two metal plates fixed in the outer ring of the bearing which enclose a felt washer. This felt washer, which is saturated with oil before assembly in the bearing, contacts the ground outside of the inner ring to provide sealing with minimum friction drag.



Two Felt Seals TT

Rubber Seals, P-Type

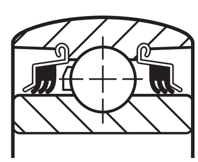
The P-Type design is a positive contact seal using a molded synthetic rubber. Firmly fixed to the outer ring, the seal flares outward and rides on the rabbet radius of the inner ring. The flareout of the seal against the inner rabbet radius assures constant positive contact to provide an effective barrier against the entrance of contamination or loss of lubricant.



Two Rubber Seals PP

Tri-Ply Seals

Tri-Ply seals are designed for bearing applications involving exceptionally severe contamination or abrasive environment. Each Tri-Ply seal consists of a triple lip nitrile seal molded to a heavy metal shroud cap. All three seal lips have heavy flare-out contact with the inner ring outside diameter and provide exceptionally effective protection against the loss of lubricant and the entrance of wet or abrasive contaminants. The shroud cap, which nests closely with the outside seal lip helps protect the rubber seal members from wrap and abrasion.



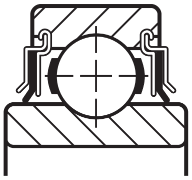
Tri-Ply Seal

Seals

Rubber Seals, R-Type

One of the most advanced sealing designs is the Timken Fafnir R-Type rubber seal. This is a positive contact seal of three-piece construction utilizing a synthetic rubber seal retained by two steel caps. The seal flares outward and rides or wipes on the ground land of the inner ring. In this design, the rubber sealing element is completely protected by a loosely-fitting outer cap or shroud, which nests tightly against the seal member following its flared-out shape at the inner ring outside diameter. The innermost member is crimped into a groove in the outer ring and encapsulates the seal and outside shroud. Besides providing firm seal contact, the back-up plate of the seal assembly has a close clearance with the outside diameter of the inner ring thus preventing the seal from being pushed inward by external forces.

The "R" seal provides improved lubricant retention and greater protection against contaminants, the shroud design guards the rubber seal against abrasive damage by dirt and fiber wrap which may be prevalent in agriculture and textile applications.



R-Type Seal

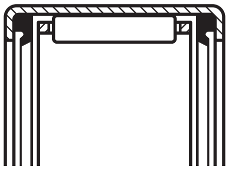
Sealed Bearings

Torrington drawn cup caged needle roller bearings are offered with integral seals. Lip contact seals limit the bearing operating temperature between –25°F and +225°F (–30°C and +110°C). The seal lip design achieves a light and constant contact with the shaft throughout the range of mounting bearing clearances thereby ensuring positive sealing and low frictional drag.

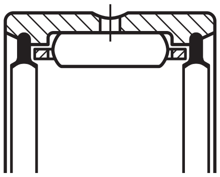
Sealed drawn cup bearings are intended to retain grease or non-pressurized oil within a bearing while also preventing contaminants entering the raceway area. These seals are not intended to withstand a pressure differential exceeding 2 psi (14kPa).

The standard lip contact seals are compatible with lubricating oils and petroleum based fuels, but they are adversely affected by certain fire-resistant hydraulic fluids and most common solvents.

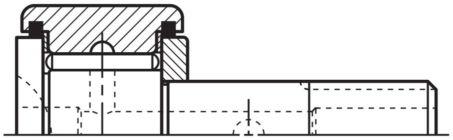
If the operating temperature must be outside of the above range or if the seals are exposed to unusual fluids please consult your nearest Timken sales associate.



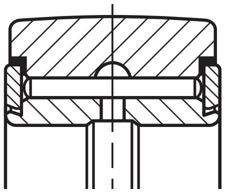
Drawn Cup
JTT



Heavy Duty
HJ-2RS



Track Roller/Cam Follower
CRS



Airframe
ATF

Compatibility of Seals and Lubricants

Buna N

Buna N is also known as Acrylonitrile which is often shortened to Nitrile. Buna N has greater resistance to petroleum oils, fuels and solvents at higher temperatures than Neoprene. Its compatibility with diester fluids and diester fluid greases made Buna N rubber an immediate success for bearing seals. The changeover from Neoprene to Buna N Ply-Seals began in early 1946. Because of its compatibility with fuels and lubricants, its excellent wear characteristics, easy moldability and low cost, Buna N has been and still is the most widely used seal material.

Buna N becomes stiff and brittle with extended exposure at 250°F so it is generally limited to service below that temperature.

Polyacrylic

Polyacrylic, also referred to as PA, is a copolymer of ethyl acrylate and chlorethylvinyl ether. Polyacrylic has excellent wear characteristics, petroleum oil and fuel compatibility and is capable of withstanding temperatures up to 320°F. Polyacrylic seals are not compatible with diester oils or greases.

Fluoro-Elastomer

The increased demand for equipment to operate at higher temperatures has led to the development of the Fluoro-Elastomer type seals. This group includes materials such as the fluorinated hydro-carbons which are copolymers of vinylidine fluoride and hexafluoropropylene (Viton) and also fluorinated silicone which, as the name implies, is a fluorine containing silicone elastomer. This family is noted for its exceptional heat resistance and compatibility with various fluids, especially petroleum products at higher temperatures than the other elastomers discussed.

This family of elastomers includes many trade names such as Viton, Teflon, Kel F, and Fluorothene. Although some of these are more correctly classified as plastics, they are used as sealing materials. Of this group only Viton and Teflon have been used in any quantity for bearing seals.

The cost of these materials is sufficiently higher than other elastomers so that very special applications are required to justify their use. Temperature range is –65°F to +450°F

Bonded Teflon Seals

Teflon or polytetrafluoroethylene (PTFE) is a relatively soft, white, waxy, inert non-toxic resin closely resembling a thermoplastic.

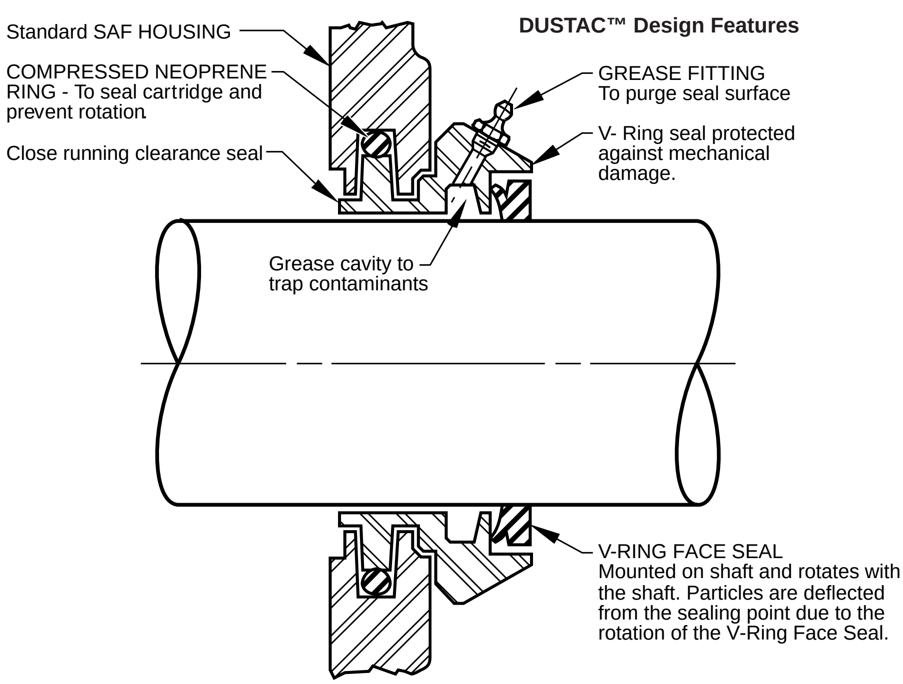
PTFE is used as bearing seal material because of its chemical inertness and wide thermal range (–125°F to +500°F). PTFE is a less effective seal material than elastomers primarily because it lacks wear or abrasion resistance.

Pillow Block Seal

The Dustac™ Shaft seal is for extremely contaminated environments, such as might be encountered by roller bearing pillow blocks located in taconite mines.

A Dustac seal shuts out residual and air-borne contaminants even better than the triple ring labyrinth shaft seal.

The Dustac shaft seal is a patented device utilizing a V-shaped nitrile ring which rotates with the shaft and applies pressure to the cartridge face to exclude contaminants. The geometry of this seal also enhances the excluding effect of centrifugal force.



Properties of Seal Materials

Property	Type of Material Base				
	Nitrile (Buna N)	Poly-acrylic	Viton	Teflon	Neoprene
Tear Resistance	Fair	Good	Good	Good	Good
Abrasion Resistance	Good	Good	Good	Poor	Excellent
Aging					
Sunlight	Poor	Good	Excellent	Excellent	Excellent
Oxidation	Fair	Excellent	Excellent	Excellent	Good
Heat (max. temp.)	250°F	350°F	400°F	500°F	225°F
Static (shelf)	Good	Good	Good	Excellent	Good
Flex Cracking Resistance	Good	Good	Good	Good	Excellent
Compression Set Resistance	Good	Good	Excellent	Poor	Excellent
Lubricant Resistance					
Low Aniline Mineral Oil	Excellent	Excellent	Excellent	Excellent	Fair
High Aniline Mineral Oil	Excellent	Excellent	Excellent	Excellent	Good
Silicones	Fair	Good	Excellent	Excellent	Fair
Diesters	Fair	Poor	Good	Excellent	Poor
Phosphate Esters	Poor	Poor	Good	Excellent	Poor
Silicate Esters	Fair	Poor	Good	Excellent	Poor
Solvent Resistance					
Aliphatic Hydrocarbon	Good	Excellent	Excellent	Excellent	Fair
Aromatic Hydrocarbon	Fair	Poor	Excellent	Excellent	Poor
Halogenated Solvent	Poor	Poor	Good	Excellent	Poor
Keytones	Poor	Poor	Poor	Excellent	Poor
Gasoline Resistance					
Aromatic	Good	Good	Excellent	Excellent	Poor
Non-Aromatic	Excellent	Good	Excellent	Excellent	Good
Acid Resistance					
Dilute (under 10%)	Good	Poor	Good	Excellent	Fair
Concentrated	Poor	Poor	Good	Excellent	Poor
Alkali Resistance					
Dilute (under 10%)	Good	Poor	Good	Excellent	Good
Concentrated	Fair	Poor	Poor	Excellent	Poor
Low Temperature Flexibility (max.)	–65°F	–55°F	–65°F	–125°F	–65°F
Resistance to Gas Permeation	Fair	Good	Good	Excellent	Good
Water Resistance	Good	Poor	Good	Excellent	Fair
Resilience	Fair	Fair	Good	Fair	Good

Lubricant Selection

The successful application of lubricating fluids in bearings depends on the physical and chemical properties of the lubricant as they pertain to the bearing, its application, installation and general environmental factors.

Viscosity

Generally, the most important single property of a lubricating fluid is its viscosity. Viscosity is the measure of the relative resistance of a fluid to flow.

The measurement of viscosity can be made by any of a number of different instruments called viscosimeters. A common unit of measure is the Saybolt Universal Second (SUS). This is the time, in seconds, required for 60 c.c. of a fluid to flow through a standardized orifice under a standard head, at a given temperature. The common temperatures for reporting viscosity are 100°F to 210°F. The higher the viscosity number, the greater the resistance to flow.

Experience indicates that a lubricating fluid with a viscosity of at least 100 SUS at the operating temperature of the application will be adequate for normal lubrication of bearings.

Viscosity Index

The ideal oil (as far as viscosity is concerned) would be the same viscosity at all temperatures. All oils become less viscous (thin-out) when heated and more viscous (thicken) when cooled.

However, all oils do not vary in viscosity to the same extent. Some thicken more rapidly or thin more rapidly than others.

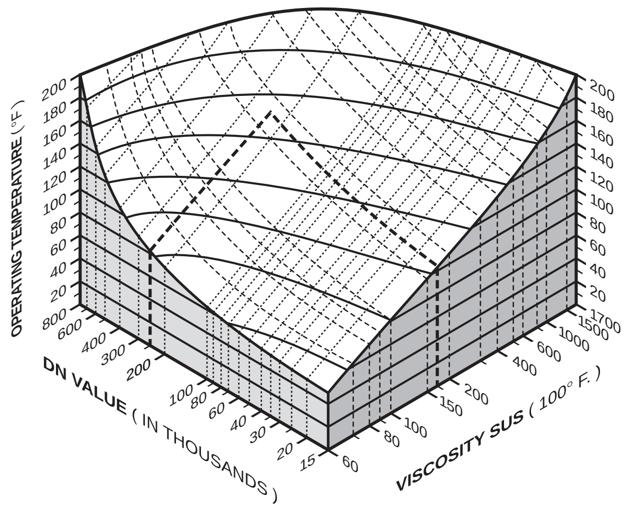
The term “viscosity index” or VI is used to rate oils according to their temperature-viscosity behavior.

Oils with the highest viscosity index are more resistant to changes in viscosity with changes in temperature than lower viscosity index oils. Obviously high viscosity index lubricants are most suitable for bearing applications experiencing wide temperature variations.

NLGI Grease Grades	Penetration Number
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

Pour Point

The pour point is the lowest temperature at which a fluid will flow or can be poured. It is important in applications exposed to low temperatures that the lubricating fluid selected has a pour point lower than the minimum ambient temperature.



The Oil Viscosity Selection Chart may be used to approximate the proper oil viscosity for all bearing applications.
To use the chart proceed as follows:

1. Determine the DN value – Multiply the bore diameter of the bearing, measured in millimeters, by the speed of the shaft, measured in revolutions per minute.

2. Select the proper temperature – The operating temperature of the bearing may run several degrees higher than the ambient temperature depending upon the application. The temperature scale of this chart reflects the operating temperature of the bearing.

3. Enter the DN value in the DN scale on the chart.

4. Follow or parallel the “DOTTED” line to the point where it intersects the selected “SOLID” temperature line.

5. At this point follow or parallel the nearest “DASHED” line downward and to the right to the viscosity scale.

6. Read off the approximate viscosity value – expressed in Saybolt Universal Seconds at 100°F

Lubricant Selection

Oxidation Resistance

The most important property of an oil, from a quality standpoint, is its chemical or oxidation stability.

All lubricating fluids are subject to a continual chemical combination with oxygen to form a multitude of compounds. The initial reaction generally results in the formation of unstable hydroperoxides which react to form such compounds as alcohols, aldehydes, keytones, acids and oxyacids. Subsequently, through polymerization and condensation reactions, oil in soluble gum, sludge and varnish will be formed. This can reduce bearing clearances, plug lines, increase operating temperature and further accelerate lubricant deterioration which will end with bearing failure.

Lubricating fluids vary in ability to resist oxidation effects. Oxidation stability is dependent upon the fluid type, refining methods and whether or not, oxidation inhibitors are present. In a circulating or splash system the oxidation rate is not only a function of the oil, but also of the operating conditions. Temperature, contaminants, water, metal surfaces and agitation all favor oxidation and all are present in lubrication systems.

Temperature Impact on Lubricant

Temperature is primarily an accelerator of oil oxidation. The rate of any chemical reaction including the oxidation of hydrocarbons will double for every 18°F increase in temperature. It is estimated that the life of an oil be decreased 50% for every 18°F temperature rise above 140°F and increased 50% for reductions in temperature of 18° below 140°F.

Metal Effect on Lubricant

Metal, particularly copper, and copper containing alloys are known catalysts for oil oxidation and their catalytic effect is greatly enhanced by water or water containing contaminants.

Additives to Lubricants

Present day lubricating fluids are formulated with chemical additives to increase the viscosity index, increase oxidation resistance, provide detergent properties, resist corrosion, provide extreme pressure properties and lower the pour point.

Grease Selection

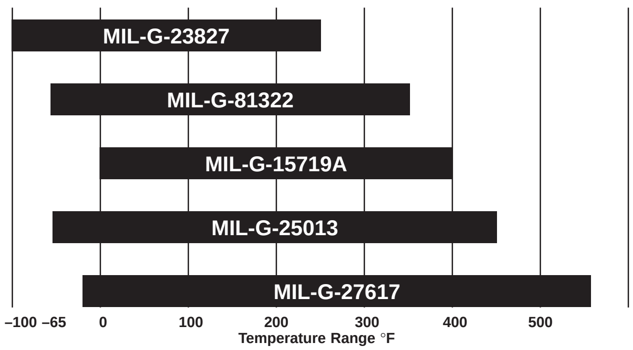
Sodium, lithium and polyurea base greases are normally preferred for general purpose bearing lubrication. Lime base greases are advantageous for high moisture applications but should not be operated above 150°F. Lithium complex greases have good water resistant characteristics and may be operated through the same temperature range as sodium base greases. Polyurea greases have excellent water resistance and can be used at higher temperatures.

The grease must be carefully selected with regard to its consistency at operating temperature. It should not exhibit thickening, separation of oil, acid formation or hardening to any marked degree. It should be smooth, non-fibrous and entirely free from chemically active ingredients. Its melting point should be considerably higher than the operating temperature of the bearing.

Frictional torque is influenced by the quantity and quality of lubricant present. Excessive quantities of grease causes churning. This results in excessive temperatures, separation of the grease components and break-down in lubricating valves. On normal speed applications the housings should be kept approximately one-third to one-half full.

Only on low speed applications may the housing be entirely filled with grease. This method of lubrication is a safeguard against the entry of foreign matter, where sealing provisions are inadequate for exclusion of contaminants or moisture.

During periods of non-operation, it is often wise to completely fill the housings with grease to protect the bearings surfaces. Prior to subsequent operation, the excess grease should be removed and the proper level restored.



Lubricating Grease Temperature Ranges

Thickener	Typical Dropping PT F	C	Usable* Temp. F	C	Typical Water Resistance
Sodium Soap	500+	260+	250	121	Poor
Lithium Soap	380	193	220	104	Good
Polyurea	460	238	300	149	Excellent
Lithium Complex Soap	500+	260+	250	121	Good

* Continuous operation with no relubrication. Depending on the formulation, the service limits may vary. The usable limit can be extended significantly with relubrication.

Note: The properties of a grease may vary considerably depending on the particular oil, thickener and additives used in the formulation.

By expanding the formula:

Fluids + Thickening Agents + Special Ingredients = Lubricating Grease

it is possible to show the combinations possible for formulating greases to meet a wide range of operating conditions.

Fluids	+	Thickening Agents	+	Special Ingredients	=	Lubricating Grease
Mineral Oils		Soaps		Oxidation Inhibitors		
Esters		Lithium, Sodium		Rust Inhibitors		
Organic Esters		Barium, Calcium		VI Improver		
Glycols		Strontium		Tackiness		
Silicones		Non-Soap (Inorganic)		Perfumes		
		Microgel (Clay)		Dyes		
		Carbon Black		Metal Deactivator		
		Silica-gel				
		Non-Soap (Organic)				
		Urea compounds				
		Terepthlamate				
		Organic Dyes				

Lubrication Terms

Additive	A chemical compound or compounds added to a lubricant for the purpose of imparting new properties or of enhancing those properties which the lubricant already has.
Channeling	The tendency of grease to form an unobstructed path or channel following the movement of the rolling elements in a bearing.
CVD – Chemical Vapor Deposition	A method of thin coating (3-5 microns) metal parts with metallic alloys through a gaseous medium. The coating adds to the hardness while reducing wear and increasing lubricity of base metal.
EP (Extreme Pressure) Lubricants	Lubricants which impart to rubbing surfaces the ability of carrying appreciably greater loads than would be possible with ordinary lubricants without excessive wear or damage.
Fiber Grease	Grease having a distinctly fibrous structure which is noticeable when a sample of the grease is pulled apart. Greases having this fibrous structure tend to resist being thrown off gears and out of bearings.
Flash Point (Cleveland Open Cup)	The temperature to which a combustible liquid must be heated to give off sufficient vapor to form momentarily a flammable mixture with air when a small flame is applied under conditions. (ASTM Designation D 92-57).
Grease	A lubricant composed of an oil or oils thickened with a soap, soaps or other thickener to a semi-solid or solid consistency.
Lime Base Grease	A grease prepared from a lubricating oil and a calcium soap.
Lithium Base Grease	A grease prepared from a lubricating oil and a lithium soap.
Lubricant	Any substance interposed between two surfaces in relative motion for the purpose of reducing the friction and/or wear between them.
NLGI	National Lubricating Grease Institute
Oil	A viscous, unctuous liquid of vegetable, animal, mineral, or synthetic origin.
Penetration or Penetration Number	The depth, in tenths of a millimeter, that a standard cone penetrates a semi-solid sample under specified conditions (ASTM Designation D 217-60T.) (See Worked Penetration.)
Polyurea Base Grease	A grease prepared from a lubricating oil and a polyurea thickener.
Pour Point	The pour point is the lowest temperature at which a fluid will flow or can be poured.
PVD – Physical Vapor Deposition	A thin metal-plasma coating (2-5 microns) that is applied in a low heat temperature environment (350°F to 600°F) which can be applied to standard metal surfaces to help resist wear while increasing lubricity and hardness.
SAE Numbers – **SAE Viscosity Classification.**	Numbers applied to crankcase, transmission and rear axle lubricants to indicate their viscosity range.

Lubrication Terms

Saybolt Universal Viscosity, SUV (or Saybolt Universal Seconds, SUS)	The time in seconds required for 60 cubic centimeters of a fluid to flow through the orifice of the Standard Saybolt Universal Viscometer at a given temperature under specified conditions. (ASTM Designation D 88-56.)
Soda-Base Grease	A grease prepared from lubricating oil and sodium soap.
Thixotrophy	The characteristic of grease to soften under shear and return to original state when shearing force is removed.
Viscosity	That property of a fluid, semi-fluid or semi-solid substance which causes it to resist flow. It is defined as the shear stress on a fluid element divided by the rate of shear. The standard unit of viscosity in the English system is the dyne which has units of 16 sec/in^2. The standard unit of viscosity in the CGS. system is the poise which has the units of dyne sec/cm. 1 dyne = 6.895 x 10^4 poises.
Viscosity Index (VI)	A commonly used measure of a fluid's change of viscosity with temperature. The higher the viscosity index the smaller the relative change in viscosity temperature.
"**Wetting" Bearings**	The pre-lubrication of bearing surfaces prior to starting a machine that has been idle for an extended period of time. Prevention of possible brinel damage to bearing components upon sudden dry start of a machine.
Worked Penetration	The penetration of a sample of lubricating grease immediately after it has been brought to 77° F and then subjected to 60 strokes in a standard grease worker. (ASTM Designation D217-60T).

Newton's Law

$$\text{Force} = \text{dynamic viscosity} \times \text{area} \times \frac{\text{velocity}}{\text{film thickness}}$$

$$F = \eta \cdot A \cdot \frac{V}{h}$$

F = Force, Newton (N)

η = dynamic viscosity

A = area, square meters (m^2)

V = velocity, meters per second ($m \cdot s^{-1}$)

h = film thickness, meter (m)

Dynamic Viscosity

$$\eta = \frac{F}{A} \cdot \frac{h}{V}$$

$\frac{F}{A}$ = consists of units of pressure $\frac{N}{m^2}$ or pascal (Pa) -SI System.

$\frac{h}{V}$ = consists of units of time $\frac{m}{m \cdot s^{-1}}$ or seconds (s) -SI System.

therefore:

dynamic viscosity, η = pascal seconds, Pa · s.

or

cgs system unit of dynamic viscosity - poise (P)

for convenience both systems can be related as follows:
1 millipacal second = 1 centipoise
or
1 mPa • s = 1 cP

Kinematic Viscosity

$$\text{Kinematic viscosity} = \frac{\text{dynamic viscosity}}{\text{density}}$$

or

$$v = \frac{\eta}{p}$$

v = kinematic viscosity

η = dynamic viscosity, $Pa \cdot s = \frac{kg}{m \cdot s}$ (in base units)

p = density, $\frac{kg}{m^3}$

Conversion of Pa • s to $\frac{kg}{m \cdot s}$

$$Pa = \frac{N}{m^2} \quad \text{by definition}$$

$$N = \frac{kg \cdot m}{s^2} \quad \text{by definition}$$

therefore:

$$Pa \cdot s = \frac{N \cdot s}{m^2} = \frac{kg \cdot m \cdot s}{m^2 \cdot s^2} = \frac{kg}{m \cdot s}$$

therefore:

$$v = \frac{\eta}{p} = \frac{kg}{m \cdot s} \cdot \frac{m^3}{kg} = \frac{m^2}{s} \quad \text{(square meters per second)}$$

In the cgs system, v = stoke (st)

For most common uses units are related in lower common denominators:

1 millimeter squared per second = 1 centistoke

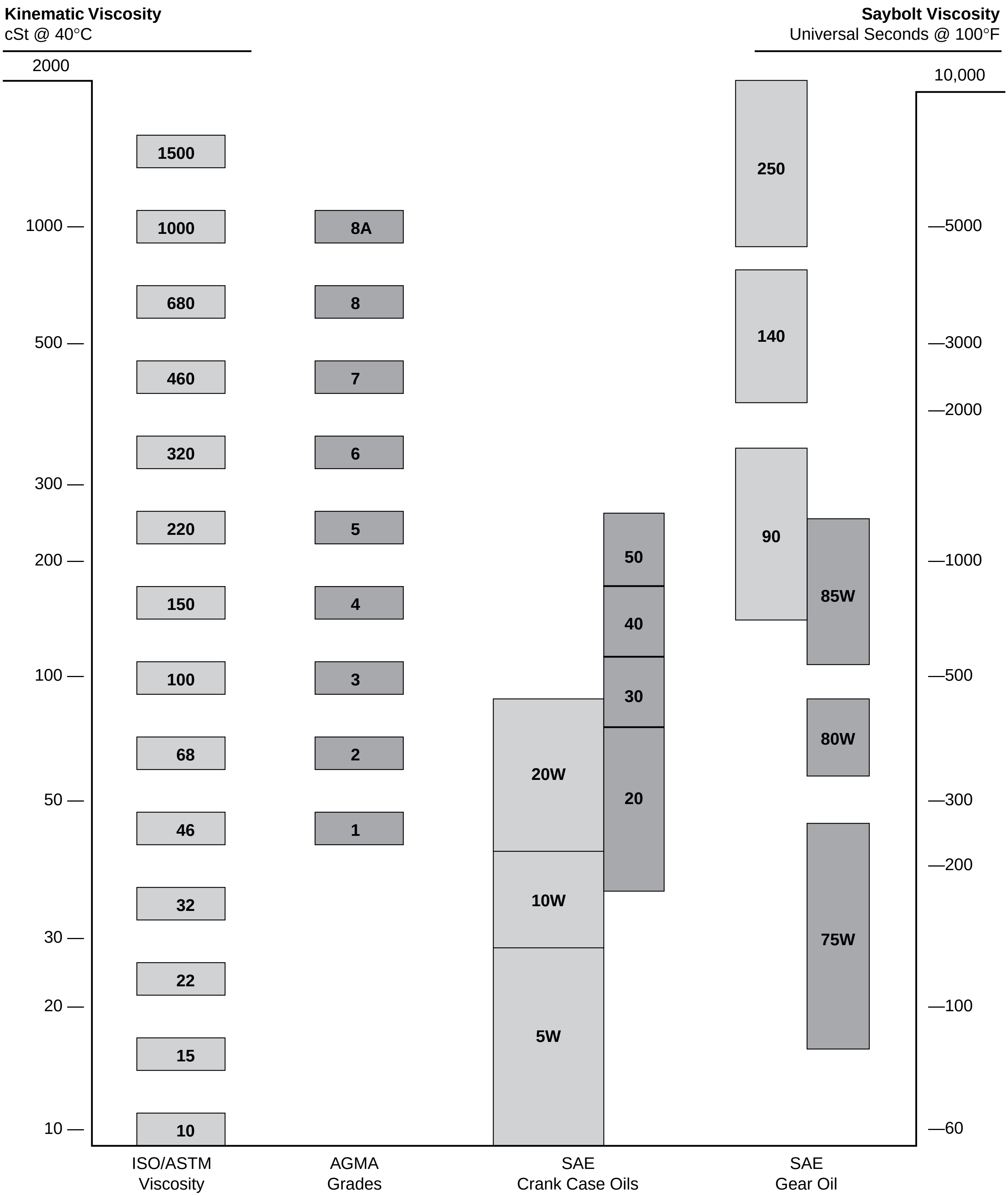
$$1 \ \frac{mm^2}{s} = 1 \ cSt$$

Examples of Viscosity

Examples of the viscosities in the SI units of lubricating mineral oils are shown in the table.

Oil	Viscosity			
	Dynamic m Pa · s		Kinematic $mm^2 \cdot s^{-1}$	
	40°C	100°C	40°C	100°C
Light	7.9	2.1	9.2	2.5
Heavy	1065	50.8	1162	55.4

Viscosity Grade Comparisons



Conversion Tables

TO CONVERT FROM	TO		MULTIPLY BY
	Acceleration		
foot/second^2	meter/second^2	m/s^2	0.3048
inch/second^2	meter/second^2	m/s^2	0.0254
	Area		
foot^2	meter^2	m^2	0.09290304
inch^2	meter^2	m^2	0.00064516
inch^2	millimeter^2	mm^2	645.16
yard^2	meter^2	m^2	0.836127
mile^2 (U S. statute)	meter^2	m^2	2589988
	Bending Moment or Torque		
dyne-centimeter	newton-meter	N • m	0.0000001
kilogram-force-meter	newton-meter	N • m	9.806650
pound-force-inch	newton-meter	N • m	0.1129848
pound-force-foot	newton-meter	N • m	1.355818
	Energy		
B.T.U. (International Table)	joule	J	1055.056
foot-pound-force	joule	J	1.355818
kilowatt-hour	megajoule	MJ	3.6
	Force		
kilogram-force	newton	N	9.806650
kilopond-force	newton	N	9.806650
pound-force (lbf avoirdupois)	newton	N	4.448222
	Length		
fathom	meter	m	1.8288
foot	meter	m	0.3048
inch	millimeter	mm	25.4
microinch	micrometer	um	0.0254
micron (μn)	millimeter	mm	0.0010
mile (U.S. statute)	meter	m	1609.344
yard	meter	m	0.9144
nautical mile (UK)	meter	m	1853.18
	Mass		
kilogram-force-second^2/meter (mass)	kilogram	kg	9.806650
kilogram-mass	kilogram	kg	1.0
pound-mass (Ibm avoirdupois)	kilogram	kg	0.4535924
ton (long, 2240 Ibm)	kilogram	kg	1016.047
ton (short, 2000 Ibm)	kilogram	kg	907.1847
tonne	kilogram	kg	1000.000
	Power		
BTU (International Table)/hour	watt	W	0.293071
8TU (International Table)/minute	watt	W	17.58426
horsepower (550 ft lbf/s)	kilowatt	kW	0.745700
BTU (therrnochemical)/minute	watt	W	17.57250
	Pressure or Stress (Force/Area)		
newton/meter^2	pascal	Pa	1 .0000
kilogram-force/centimeter^2	pascal	Pa	98066.50
kilogram-force/meter^2	pascal	Pa	9.806650
kilogram-force/millirneter^2	pascal	Pa	9806650
pound-force/foot^2	pascal	Pa	47.88026
pound-force/inch^2 (psi)	megapascal	MPa	0.006894757
	Temperature		
degree Celsius	degree Kelvin	°K	$t_k = t_c + 273.15$
degree Fahrenheit	degree Kelvin	°K	$k = \frac{5}{9} (t_f + 459.67)$
degree Fahrenheit	degree Celsius	°C	$t_c = \frac{5}{9} (t_f - 32)$
	Velocity		
foot/minute	meter/second	m/s	0.00508
foot/second	meter/second	m/s	0.3048
inch/second	meter/second	m/s	0.0254
kilometer/hour	meter/second	m/s	0.27778
mile/hour (U.S. statute)	meter/second	m/s	0.44704
mile/hour (U.S. statute)	kilometer/hour	km/h	1.609344
	Volume		
foot^3	meter^3	m^3	0.02831685
gallon (U.S. liquid)	liter	***l***	3.785412
liter	meter^3	m^3	0.001
inch^3	meter^3	m^3	0.00001638706
inch^3	centimeter^3	cm^3	16.38706
inch^3	millimeter^3	mm^3	16387.06
ounce (U.S. fluid)	centimeter^3	cm^3	29.57353
yard^3	meter^3	m^3	0.7645549

VISCOSITY CONVERSION TABLE

SUS Saybolt (sec.)	R' Redwood (sec.)	E Engler (deg.)	cSt Centistokes
35	32.2	1.18	2.7
40	36.2	1.32	4.3
45	40.6	1.46	5.9
50	44.9	1.60	7.4
55	49.1	1.75	8.9
60	53.5	1.88	10.4
65	57.9	2.02	11.8
70	62.3	2.15	13.1
75	67.6	2.31	14.5
80	71.0	2.42	15.8
85	75.1	2.55	17.0
90	79.6	2.68	18.2
95	84.2	2.81	19.4
100	88.4	2.95	20.6
110	97.1	3.21	23.0
120	105.9	3.49	25.0
130	114.8	3.77	27.5
140	123.6	4.04	29.8
150	132.4	4.32	32.1
160	141.1	4.59	34.3
170	150.0	4.88	36.5
180	158.8	5.15	38.8
190	167.5	5.44	41.0
200	176.4	5.72	43.2
220	194.0	6.28	47.5
240	212	6.85	51.9
260	229	7.38	56.5
280	247	7.95	60.5
300	265	8.51	64.9
325	287	9.24	70.3
350	309	9.95	75.8
375	331	10.7	81.2
400	353	11.4	86.8
425	375	12.1	92.0
450	397	12.8	97.4
475	419	13.5	103
500	441	14.2	108
550	485	15.6	119
600	529	17.0	130
650	573	18.5	141
700	617	19.9	152
750	661	21.3	163
800	705	22.7	173
850	749	24.2	184
900	793	25.6	195
950	837	27.0	206
1000	882	28.4	217
1200	1058	34.1	260
1400	1234	39.8	302
1600	1411	45.5	347
1800	1587	51	390
2000	1763	57	433
2500	2204	71	542
3000	2646	85	650
3500	3087	99	758
4000	3526	114	867
4500	3967	128	974
5000	4408	142	1082
5500	4849	156	1150
6000	5290	170	1300
6500	5730	185	1400
7000	6171	199	1510
7500	6612	213	1630
8000	7053	227	1740
8500	7494	242	1850
9000	7934	256	1960
9500	8375	270	2070
10000	8816	284	2200

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