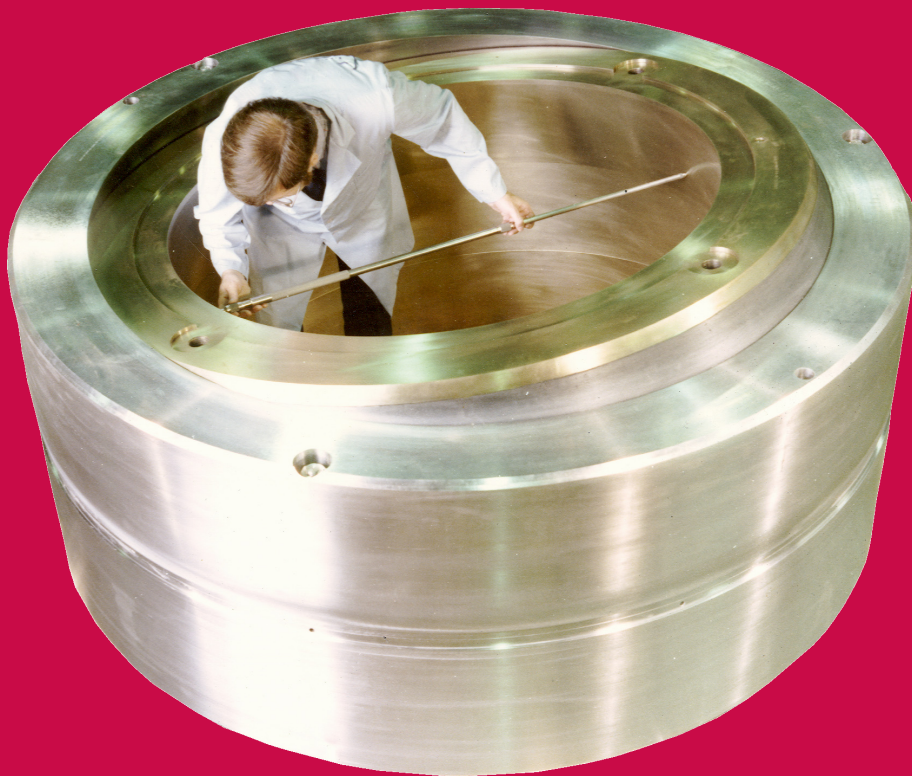


LUBRITE

The world's most experienced self-lubricating bearings, bushings, washers and expansion plates.



LUBRITE® TECHNOLOGIES



LUBRITE® : THE WORLD'S MOST EXPERIENCED SELF-LUBRICATING BEARING.

When Lubrite® bearings were introduced in 1897 they were the first permanent self-lubricated bearings in the world. As time passed, they were found to be ideal for a wide variety of applications, and especially well suited to heavy-duty applications such as the trunnion bearings found in the gates of hydroelectric plants. From that point Lubrite quickly expanded to many other areas where the need existed for supporting heavy and medium loads at slow-to-medium speeds. The permanent self-lubricating nature of Lubrite bearings also contributed to this early growth by eliminating the need for bearing maintenance, a very desirable feature in applications where bearings were located in difficult or impossible to reach locations.

Today, Lubrite bearings can be found in bridges, offshore equipment, hydroelectric installations, nuclear power plants, buildings, transportation vehicles, heavy industrial equipment, and process plant machinery, to name just a few.

Lubrite bearings feature:

- Complete self lubrication.
- Capacity to carry extremely heavy dynamic and static loads.
- Elimination of supplementary lubrication.
- Ability to operate dry or immersed.
- Low coefficient of friction.
- Elimination of maintenance.
- Prevention of galling, scoring and seizing.
- High and low-temperature operation.
- Design that prevents foreign matter contamination of bearing surfaces.
- Choice of lubricant and bearing materials to minimize corrosion in hostile environments.



Thames Flood Barrier in London, England



LOOK AT THE CAPABILITY THAT BACKS UP EVERY LUBRITE® PRODUCT

Design Engineering

A bearing is only as good as the engineering and manufacturing skills that go into it. Lubrite's® capability is evidenced by the long and successful experience of our engineering staff. The group has at its disposal a comprehensive databank on bearing design and performance. This knowledge is the result of experience in a wide variety of applications, and is supplemented by our computer assisted design and engineering programs. In addition, Lubrite Engineers always stand ready to provide you with the full benefit of this experience – from preliminary design assistance through field engineering. More than 100 years of research, engineering and manufacturing know how stand behind every Lubrite bearing.

Metallurgy

A bearing consists of two basic components – the bearing metal and lubricant. This makes detailed knowledge on the application of bearing materials extremely important. Lubrite maintains a comprehensively equipped metallurgical laboratory to provide the required expertise.

The materials selected for a bearing system can vary considerably based on the application. Bronze is commonly used, but in unusual environments other materials ranging from stainless steel and nodular iron to tool steel can be employed. Lubrite's metallurgical skills and experience assure you of proper selection and maximum bearing life.

Lubricants

Lubricants used in Lubrite products are solid, permanent, and completely self-lubricating. They do not require any form of supplementary lubrication. Years of research has been put into developing Lubrite lubricants and they are constantly evaluated both in our laboratories and in the field to ensure performance, or to refine as necessary. A number of lubricants have been developed to meet the specific needs of a wide variety of applications. One of these lubricants will provide the operating characteristics needed for your application.

Meadville Plant

Testing Laboratory

Lubrite maintains a sophisticated in-house testing laboratory for research and development as well as production testing. If required, new designs can be tested under simulated field operating conditions to ensure successful performance. Precise load, speed, and environmental conditions can be simulated.





Bearing Assemblies

Lubrite® has the in-plant capability to manufacture extremely large self-lubricating bearings and accompanying assemblies -- such as the 30,000 lb. bearings used in the Thames Flood Defense Project in London, England.

Lubrite generally supplies all the peripheral parts needed to complete a bearing assembly, including support systems, structural components, mating pins, housings, and any other special requirements. The combination of our metallurgical skills with an in-house foundry and state-of-the-art welding capability facilitates manufacturing even the largest assembly parts. Assemblies as large as 35 tons have been built in our Meadville, PA plant.

It is recommended that complete bearing assemblies (including pins, shafts, and all related steel components) be designed and manufactured by Lubrite. This approach assures perfect mating fits of system components, a fast efficient installation, and superior bearing performance.

Foundry

Our foundry produces an impressive array of bronze, stainless steel, and aluminum castings. Our unique method of centrifugal and static casting produces the highest quality parts available. The foundry has over 100 years of experience in pouring all varieties of bronze alloys and other ferrous and nonferrous metals. The foundry pours a tremendous range of sand and centrifugal castings, ranging from a few pounds up to 35,000 pounds. Centrifugal castings are poured up to an outside diameter of 124 inches. A sophisticated chemical and physical testing laboratory and stringent quality control assures that you will receive a casting which is the very foundation of a quality self lubricated bearing.

Machining

Lubrite's modern machine shop with CNC capability performs all of the machining operations required in manufacturing Lubrite products, assuring consistent quality and on-time deliveries.



Welding

Superior welding skills are required to produce mating surfaces of unusual metals. One example is the use of submerged arc welding techniques by Lubrite® welders to overlay surfaces with materials such as Inconel 625, Monel, and stainless steel.

Lubrite welders are qualified to meet the requirements of the AWS structural welding code and AASHTO.

Quality Assurance and Control

The first and most important step in quality control is quality assurance. Once product specifications are established, quality assurance develops step-by-step manufacturing guidelines to ensure the finished product will meet your requirements. Each stage in the production process is then monitored by quality control personnel to be certain of adherence to the guidelines. A reporting system that documents every interval of the manufacturing process and provides complete traceability is an important part of the program.

Lubrite Technology Service

Lubrite's philosophy is one of involvement and commitment. Our personnel are always available to work closely with your own staff. Your customer service contact will help you establish the original design concept, and then follow through to delivery of the bearing to your site. Arranging field inspections, handling expediting requests, providing test and certification documentation, and supplying any other information you may need are all part of your customer service representative's role in assuring you of superior service. If you have a special requirement, such as field engineering assistance after installation, this can also be easily arranged.

Before, during, and after start-up of your projects, you always have the assurance of knowing Lubrite's complete capability is always available.



Applications

Lubrite® bearings are being used to support medium-to-heavy loads at slow-to-medium speeds in a wide variety of applications.

Bridges

Bridges develop considerable stresses on various component members due to temperature variation, dead and live loads, and wind. Maintaining stress at a minimum (or relieving it entirely) by permitting controlled movement has been a job performed by Lubrite bearings for more than 80 years. The lubricants provide a low coefficient of friction and are capable of withstanding extremely heavy static loads over long periods of time. Lubrite bearings offer the ultimate in ease of installation and economy of operation, and in many installations have proven that they are capable of outlasting the bridge itself.

Hydroelectric

Bearing systems in a hydroelectric facility must be able to withstand high static loads for prolonged periods while partially or completely submerged. The installation environment is frequently subjected to icing, silt, and erosion – factors encouraging corrosive and galvanic action. Often the bearing's inaccessibility and association with massive pieces of equipment necessitate a product that will provide trouble-free operation throughout its service life. And, under all these conditions, the bearing must perform the function for which it was designed – providing free movement of extreme loads at moderate speeds.

Lubrite provides bearings for all of the gate applications encountered in hydroelectric plants. Other areas with similar problems that utilize bearings to permit relative motion between two components are: penstock supports, sheaves, linkages, dogging devices, floating mooring bits, valves, and lifting mechanisms.



Itaipu Dam - Brazil

The specific requirements of a given application may indicate the use of any of a number of available alloys. However, special attention should be given to the high-strength manganese and aluminum bronzes. The inherent properties of these materials have generally supported their suitability for extreme hydroelectric operating conditions.

Lubricants have been specially formulated by our research department for use in underwater applications and where electrolysis is a concern. None of the ingredients compounded to form these lubricants will promote galvanic action or act as a catalyst in promoting electrolysis between dissimilar adjacent materials. Specially compounded lubricants may be required in installations where a grease system provides supplementary or emergency lubrication. These lubricants have been designed to be used with grease or where there is a possibility of grease contamination. Please consult Lubrite's engineering department before specification to be assured of proper application and satisfactory performance. When needed, compatibility tests can be conducted on grease lubricants (or other substances) to determine their suitability for use in a Lubrite® bearing system. Additional lubricants have been developed to satisfy applications where erosion from water flow is a consideration. These lubricants do not contain graphite or other ingredients which could promote electrolysis.

The selection of materials for abutting structures such as housing and shafts is extremely important, as deterioration will adversely affect bearing operation. It is preferable that the metal opposing the Lubrite bearing be either corrosion-resistant or protected with a corrosion-resistant surface.

As in all other Lubrite application areas, our engineering department is available to assist you, and will apply their combined experience, creativity, and research capability to help satisfy your hydroelectric bearing requirements.

Offshore

Lubrite® bearings were originally developed for use in marine environments. When offshore energy exploration became a reality, Lubrite's experience working in the highly corrosive marine environment became extremely valuable. Lubrite offshore products range from highly complex self-aligning bearing assemblies to basic pins and shafts using corrosion resistant materials such as Inconel 625, 17-4 PH stainless steel and Monel.

Today, Lubrite bearings are being utilized in a variety of applications on offshore energy exploration equipment – from the decks of ships and drilling platforms – right down to the mud line. Some typical applications include fairleads, rudder post bearings, mooring mechanisms, cranes, chain guides, cardan joints, flare structures and many others.

The major problem encountered in offshore installations is corrosion. Since performing maintenance on or servicing many of these bearings is virtually impossible, the ability to function for years with zero maintenance is a necessity. Lubrite bearings have proven their ability to satisfy these demands in a long list of successful installations.

Minimizing the corrosion problems in offshore installations demands specialized knowledge. Temperature, compatibility of adjacent materials, and velocity of the surrounding media are only a few of the many factors that influence the rate of corrosion. Although corrosion cannot be totally eliminated, its effects can be substantially reduced with proper engineering. Lubrite's production

facility permits the manufacture of component parts in just about any material needed to combat the detrimental effects of corrosion. Sophisticated welding techniques permit overlaying with corrosion resistant metals such as Inconel 625 or stainless steel on component parts. Lubrite's long experience in working with corrosive environments assures you of the best possible solution to your corrosive environment problem.



Industrial

Lubrite® bearings offer industry self-lubricating, maintenance-free performance resulting in overall cost savings and operational safety. Lubrite bearings span an “industrial gap” of operation outside the range of rolling element and other types of bearings. More strenuous demands on both industry and industrial equipment coupled with spiraling maintenance costs necessitated the development of a maintenance-free self-lubricating bearing system. Lubrite bearings meet this demand.

Eighty years of manufacturing experience and performance data combined with a contemporary research and development program have resulted in proven solutions to many unusual bearing problems. Since there is no “best” bearing for all applications, and the best effort of the designer is often a compromise, each bearing should be evaluated on its own merits for each application.

The various types of bearings can be examined from the standpoints of the more common selection criteria: load capacity, friction, space requirements, accuracy, noise, cost, and operating conditions.

Industrial applications involving ambient temperatures in excess of 250°F (121°C) require critical analysis of both the overall design and individual bearing system components. High temperatures significantly alter the physical properties of bearing materials and can lead to stress cracking and geometric changes that significantly reduce bearing life.

When temperatures reach the point that bronze alloys cannot be used due to loss of strength and other required bearing characteristics, a high quality cast iron may provide the solution. When designing bearings for high-temperature applications it is very important to discuss all of the operating parameters with your Lubrite engineering representative to assure selection of the best possible combination of metals and lubricants to meet your needs.

Structural

Stresses that develop in the structural members of buildings (and any other allied applications) can be effectively relieved with Lubrite bearings. Both the internal stress of component members and the magnitude of the forces transmitted to the supporting structure itself can be minimized. This basic principle applies to a variety of structure types such as: pollution-control precipitators, rotary bridges, vessel supports, auditoriums, stadiums, shopping centers, and many others.



Radio Telescope, West Virginia



Petronas Towers, Malaysia

Lubrite self-lubricating bearings provide a positive and proven means of permitting relative motion between structural members that result from such factors as wind, temperature, and load variations. Simplicity of design makes incorporating these bearings into almost any support assembly an easy task. It also allows the designer maximum freedom in architectural expression without compromise in the areas of function and safety.

Lubrite bearings can be found in nuclear power plants, where trouble-free performance is a must.

Nuclear

Lubrite® has been a primary source for the development and manufacture of structural bearings and associated components for atomic energy applications since the inception of the nuclear reactor.

Some of the areas in which Lubrite bearings are being used in nuclear facilities are: main reactor vessel supports, steam generators, pumps, gas coolers, shutdown-cooling blowers, boilers, heat exchangers, suction headers, nozzle and pipe supports, sheaves, jousting mechanisms, manipulation pivots, safety-door hangers and blast-door trucks.

Radiation, temperature extremes, potential contamination, and a number of other difficult conditions present a unique challenge to bearing systems in nuclear applications. Maintenance-free bearings are especially important in this environment due to the presence of radiation, making the bearings inaccessible for service.

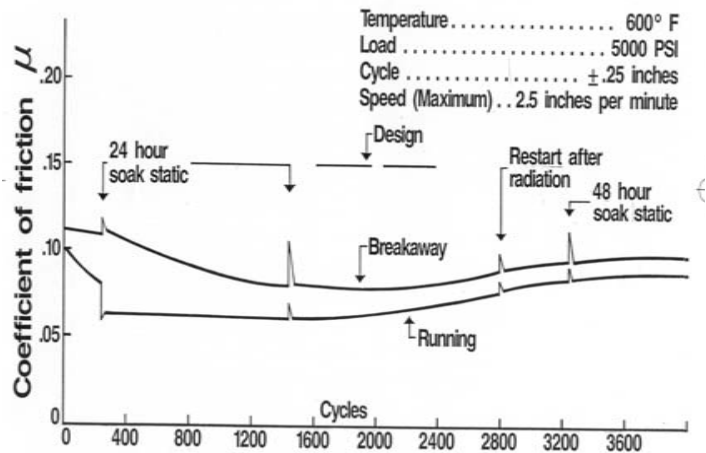
Extremely high temperatures are another aspect of a traditional problem that has been solved with improved standard (and occasionally exotic) materials.

Radiation, however, proves a more stubborn problem, as it tends to polymerize organic lubricants and cause bearing failure. Because of this, use of halogens, sulfur, lead, and other materials are severely restricted in the presence of nuclear radiation.

The wide range of operating parameters and applications occurring with a nuclear facility cannot be bridged by a single lubricant or bearing system. Each system and lubricant must be designed to meet the specific conditions encountered in order to supply maximum lubricity, durability, and the lowest coefficient of friction.

Special applications

Lubrite self-lubricating bearings can be utilized in almost any application where heavy loads must be supported at relatively low to medium speeds, or where fabrication from unusual materials is required. Our engineering department has developed a large databank of design information on a wide range of special applications. We invite you to take advantage of this experience by contacting your Lubrite engineering representative for assistance on any unusual application you may be considering.

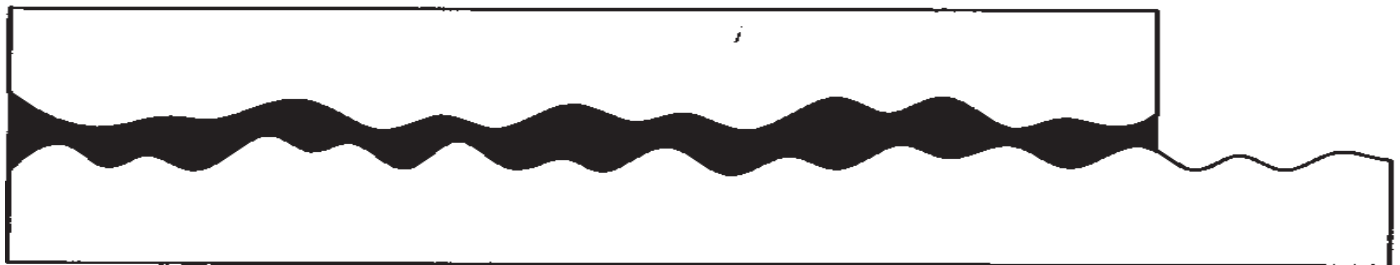
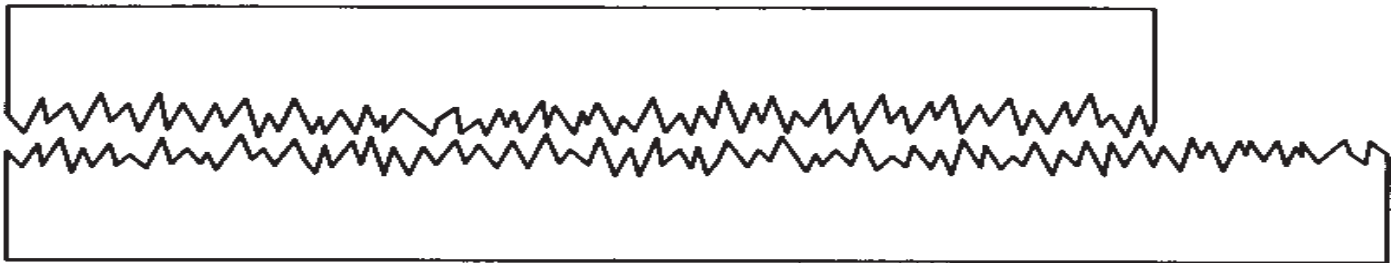


Bearings, Lubricants and Friction

Friction is defined as the resistance to sliding motion between two surfaces. The smoother the surfaces, the lower the resistance. Even finely finished metal surfaces still have some surface roughness caused by microscopic “peaks and valleys” called “asperities”. The major cause of friction (and resistance to movement) is the interlocking action of these asperities. The heavier the load, the greater the tendency for the asperities to interlock and resist movement. The stronger the material the greater the resistance, since the asperities must shear off to permit movement. In an unlubricated system of different materials the softer material wears when motion takes place. Under extreme circumstances, galling, fretting, and even cold-pressure welding can occur and result in bearing seizure.

The purpose of a lubricant is twofold. First, it should minimize or eliminate actual contact between the two adjoining surfaces. Second, the lubricating material should have a low shear strength to facilitate movement. To perform efficiently the lubricant must be capable of providing a complete lubricating film between the adjoining surfaces under all expected load conditions. Unfortunately, traditional lubricants do not meet these requirements.

Asperities interlock experienced in unlubricated machined surfaces.



Lubrite® covers asperities and provides low shear-strength lubricating film between opposing surfaces.

Lubricants in action

Lubricants utilized in Lubrite® bearings are of a permanent, dry, solid, thick-film nature that will function for long periods under heavy loads. The proprietary lubricant formulas are custom compounded. The unique laminar-lattice crystalline structure of these mastic lubricants provides very low resistance to shear and makes possible the self-regenerating quality of the lubricating film. The action occurring in the lubricant is very similar to what happens when you subject a deck of playing cards to horizontal motion. Any movement is accompanied by a sliding action between the crystallographic planes (the cards). The fact that the interatomic forces of the lubricant plane are much greater than the external interplanar forces means that any movement taking place will be

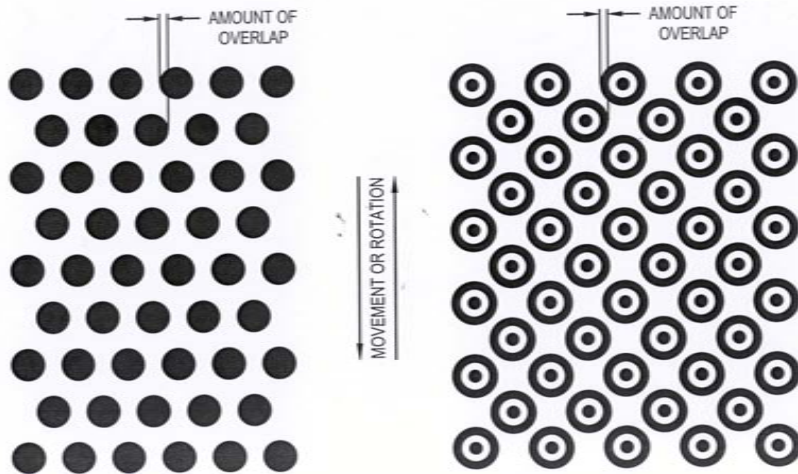
a sliding action between planes. Since the molecular forces in each plane are sufficient to protect it from destruction by pressure or heat, motion between planes only is assured.

The lubricant is densified into trepanned recesses in the bearing by an extrusion process. The size, spacing, and pattern of these recesses are computer designed for every bearing that we manufacture to provide optimum lubrication coverage for the application involved.

The manufacturing procedure results in a lubricant surface that projects above the bearing surface.

Since the recesses overlap in the direction of movement, any motion between bearing surfaces will cause the lubricant to spread, distributing a thick, friction-reducing film on the bearing surface between lubricant recesses. The lubricant also fills surface asperities, effectively “sealing” the surface and preventing asperity interlock. In operation, both surfaces burnish quickly and result in a highly polished bearing surface capable of withstanding extreme pressures. Since Lubrite products are completely self-lubricating, they require no maintenance for the design life of the product, eliminating the need for supplementary lubrication and maintenance. The unique formulation of Lubrite makes it ideal for applications where extremely heavy loads are involved or where static loads must be maintained indefinitely without lubrication breakdown.

A variety of lubricants have been developed to accommodate the needs of a wide range of applications. All have proven themselves in years of service, thereby ensuring superior performance in your application. Lubricants are available for products that will be immersed in sea water, superheated steam, and solvent solutions; or used in corrosive atmospheres, at subzero and above 250°F temperatures, in conjunction with petroleum based products, and under exposure to radiation. Lubrite has already taken on just about any application challenge you can imagine.



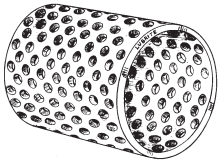
The Lubrite® Product Line

Lubrite bearings are available in the following configurations:

- | | |
|------------------------------------|------------------------|
| 1. One-piece bushings | 7. Liners |
| 2. Split bushings | 8. Flat plates |
| 3. Two-piece bushings | 9. Radialube® |
| 4. Flanged bushings | 10. Spherilube® plates |
| 5. Self-aligning spherical bushing | 11. Special shapes |
| 6. Thrust and expansion washers | |

One-piece bushings

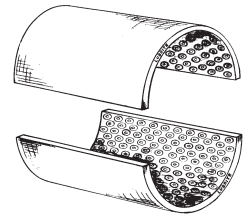
The one-piece bushing is essentially a sleeve bearing used in a wide variety of both general machinery and heavy-duty applications. Depending on size and application a variety of lubricating patterns are available to accommodate all types of linear and rotary motion.



In situations where very heavy loading is encountered, one-piece bushings with lubricating recesses extending partially through the wall are recommended.

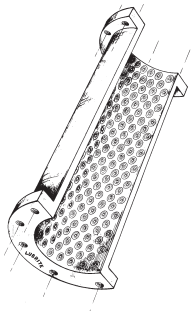
Split bushings

A split bushing is cast and machined as a single unit and then split. This approach results in less than perfect half-bearings due to the gap created by the cutting process. It is recommended that where the shaft rotates, the load should not be applied directly on the split line. If required, shims can be used to provide a full 360° surface.



Two-piece bushings

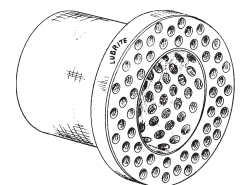
Two-piece bushings are used when installation requirements (or the future need for disassembly and reassembly) prevent use of a one-piece or split bushing. This product provides a full 360° of bearing surface. The halves are match marked for proper assembly so as to assure complete concentricity when installed. These bushings are normally supplied with standard lubricating patterns but utilize recesses on internal surfaces only.



Another form of two-piece bushing is a half bearing, also called a perfect half-bearing. Perfect half-bearings should only be specified when the bearing centerline is extremely critical.

Flanged bushings

One- and two-piece bushings can be provided with flanges on one or both ends. The flanges can be lubricated for applications where end-thrust must be accommodated, or provided without lubrication to function as a spacer or holding flange. The flange thickness is normally the same thickness as the wall but can be supplied in a different thickness if desired. It is usually more economical to utilize integral flanges on the bushing itself as opposed to purchasing separate washers.



Thrust and expansion washers

Thrust washers are used to accommodate rotational end thrust, serve as a spacer, or substitute for a flange on the end of a sleeve bearing. Washers may be lubricated on one or both sides.

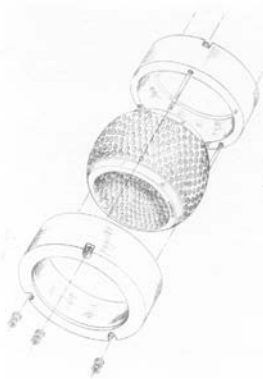
Expansion washers are used where motion takes place radially across the axis of the washer. All washers usually require the same dimensions as bearing walls. Consult the wall thickness chart for correct washer thickness using washer outside diameter as the controlling parameter.



Self-aligning spherical bushings

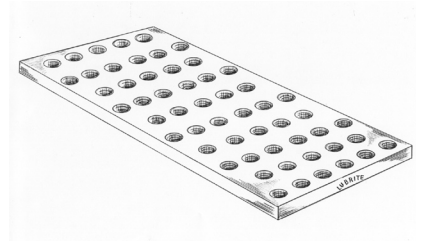
Spherical bushing assemblies will support various combinations of both radial and axial loads in addition to accommodating articulation and rotation. The bushings consist of an inner and outer ring with curved mating surfaces. Either or both surfaces can be lubricated.

A number of factors must be considered before a spherical bushing design can be formulated. Foremost are the magnitude and variety of directions from which load will be exerted, and environmental conditions, operating temperatures, etc. Careful evaluation of the combination of these factors is critical to the proper selection of bushing materials and lubricants. Since spherical bushing design is complicated by the large number of interdependent variables involved, we suggest you contact your Lubrite® engineering representative for information regarding your application.



Liners

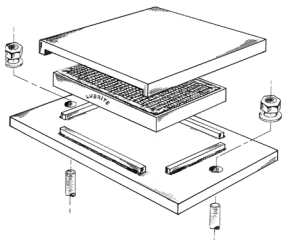
Lubrite liners are specifically designed for applications where motion will take place only on the longitudinal axis. The length-to-width ratio (and the resulting lubricating pattern) of a liner is not sufficient to permit its use as an expansion plate.



Flat plates

Flat plates can be designed to accommodate both longitudinal and transverse motion. Flat plates feature a higher width-to-length ratio than liners and utilize the trepanned lubricating pattern which provides maximum lubrication. Generally the flat Lubrite plate is installed by affixing it to the base plate with machine screws or by constructing a nest on the base plate into which the plate can be lowered. If a nest is used, openings should be left at the corners to permit drainage, and they should be machined flat within the area contacted by the Lubrite plate.

Care should be exercised to make sure the mating plate is large enough to completely cover the Lubrite plate during all anticipated movement. Failure to do this will expose the Lubrite plate to the possibility of contamination and resultant increase wear. The mating plate must be machined to a surface finish of 125 rms or better on the face contacting the Lubrite bearing.



The entire assembly should be installed in such a manner as to insure uniform distribution of loading over the entire surface of the Lubrite plate. Where eccentric forces are found there is a tendency for edge concentration of loading to develop, and this should be compensated for by the inclusion of some type of self-aligning mechanism. Where required, guide bars can be incorporated into the assembly to control the direction of movement and resist transverse forces.

Materials typically used for base and sole plates would be structural steel, although the operating environment may suggest the use of other materials. In some applications facing the sole plate with stainless steel can extend service life dramatically.

A plate thickness of 1/2" minimum is required.

Radialube®

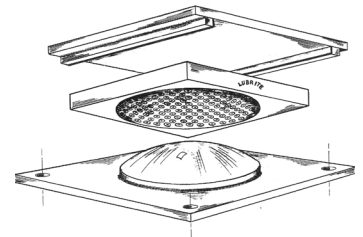
The Radialube plate is similar to the flat plate except that it has both a curved and flat surface. Either or both surfaces can be lubricated, and the curved surface can be either concave or convex. The flat side of the Radialube design accommodates longitudinal movement caused by expansion and contraction of structural members, while the curved side permits rotational movement arising from member deflection. Rotation is accommodated by installing a matching curved plate that mates with the Radialube surface.

Guide bars can be installed to control the direction of movement and resist transverse forces. Radialube assemblies utilizing a curved surface on both faces (with perpendicular axes) provide complete self-alignment while permitting longitudinal and transverse expansion and rotation. Materials are generally the same as used for the flat plate assembly. Minimum plate thickness of 3/4 inches is required.

Spherilube®

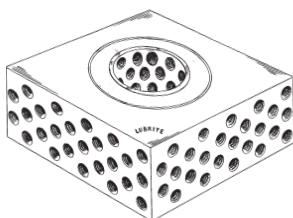
Spherilube plates accommodate omnidirectional rotation as well as contraction and expansion. This plate has both a curved and flat surface, and either or both surfaces can be lubricated. The spherical surface can also be either concave or convex.

Spherilube plates are excellent for applications where structural irregularities may be encountered since the bearings "ball-joint" design can help compensate for such factors. This can be accomplished without the vertical deflection that is present in other types of bearing systems, and which introduces an additional stress into the structure. The spherical design offers the additional advantages of maintaining uniform load distribution in situations where forces are variable in both magnitude and direction, and accommodating lack of parallelism and changes in structural geometry. Material and plate thickness requirements are similar to the Radialube design.



Special shaped bearings

Lubrite bearings are manufactured in a wide range of shapes and sizes. Some typical examples are: segments of bushings or washers, cut away bushings, or washers, cut away bushings, spherically lubricated surfaces, eccentric and oscillating blocks, self-aligning bearings, and many others. Surfaces of specially designed bearings can be lubricated to accommodate the requirements of the application. Lubricated surfaces can also be provided to handle rotating, oscillating, sliding, and eccentric forms of motion.



DESIGN GUIDE FOR LUBRITE® BEARINGS

This section describes the fundamental design considerations involved in specifying Lubrite® bearings. It will help you specify a bearing to meet the requirements of your application. We strongly urge you, however, to consult with our engineers before finalizing your design, since small changes in application parameters and bearing specifications can significantly affect performance. Often-times, our engineering expertise can help you improve results at little or no additional costs.

Design factors

The basic design of a Lubrite bearing is governed by the following factors:

1. Magnitude and direction of load or loads
2. Surface speed
3. Operating temperature
4. Operating environment
5. Frequency
6. Life expectancy
7. Type and magnitude of movement

The detail design work on a bearing consists of utilizing the above information to specify:

1. Bearing dimensions
2. Bearing material
3. Lubricant type
4. Operating clearance (bushings)
5. Mounting method

Dimensioning

The following information is intended primarily for use in the design of Lubrite bushings. The data is generally applicable to all Lubrite products, but we suggest you verify all specifications with your Lubrite engineering representative before proceeding to a final design.

Outside diameter

To determine the outside diameter of a bushing, add twice the recommended wall thickness (see chart) to the specified inside diameter, and then round out the total to a figure compatible with containment restrictions.

Inside diameter

Optimum mechanical efficiency is obtained when a bushing combines the smallest possible inside diameter with a shaft of sufficient strength and rigidity. When the design load requires additional bearing area it is best to increase the bearing length (wherever possible) rather than increasing shaft diameter. This approach will result in the lowest possible frictional resistance and power loss.

Length

Copley Place, Boston, Massachusetts

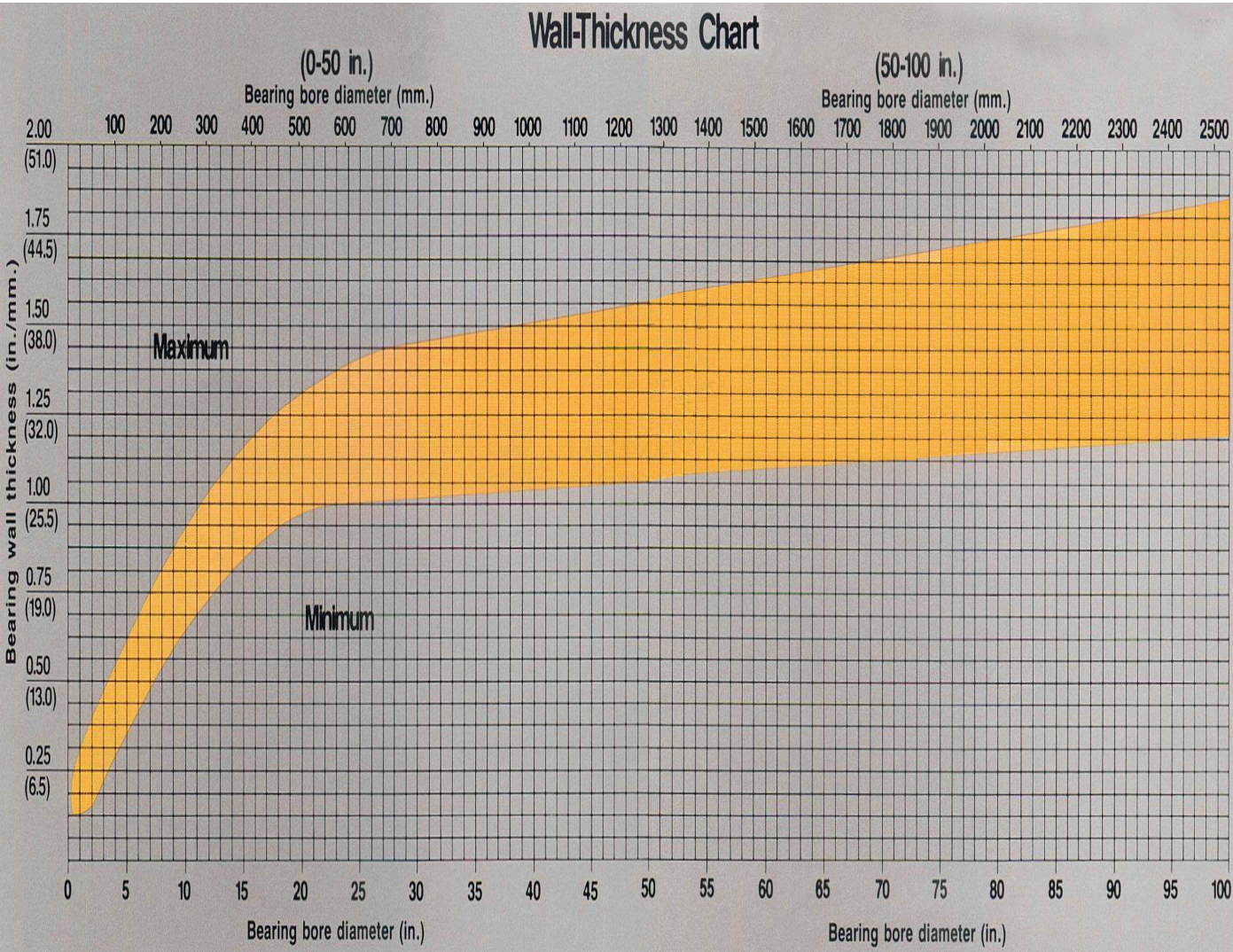


It is desirable that the length-to-diameter (L/D) ratio range of a bushing be 1.0 to 2.0. These are general guides however. We suggest you contact Lubrite’s engineering staff to confirm the best approach for your particular application.

Wall thickness

Lubrite® sleeve bearings are normally contained within a housing. The bearing wall thickness selected (in combination with the housing) must be of sufficient strength to support the load while minimizing elastic or thermal distortion which could alter bearing geometry. Thin wall bearings should be avoided as they may impede heat transfer during bearing operation. There is also a tendency to reduced retention and increased susceptibility to distortion due to thermal growth and mechanical distortion during machining. Heavy wall bearings are recommended if severe wear of the bearing is permissible and expected.

Large temperature variations and different coefficients of thermal expansion in the bearing, shaft and housing materials combine to produce distortions that make bearing dimensions and fits difficult to maintain. A varying clearance within the bearing can result.



Bearing Metals

Lubrite alloy number	CDA alloy number * H	UNS designation * I	Maximum recommended values up to 250°F * D			Minimum mechanical properties per ASTM * A				Brinell Hardness				
			Dynamic load (psi)	Constant speed (sfm)	Limiting continuous PV (pressure x velocity)	Compressive strength .001" SET (ksi)	Tensile strength (ksi)	Yield strength (ksi)	Elongation (% in 2")					
										500 kg or 3,000 kg	Maximum operating temperature (°F)	Coefficient of thermal expansion (in/in/°F) 10 ⁶	ASTM specification	Generic name
305	937 ^F	C93700	^B 1000	250	30,000	(13)	30	12	15	60	450	10.3	B22-C93700 B584-C93700	Hi lead tin bronze
315	932 ^F	C93200	1000	250	20,000	(14)	30	14	15	65	450	10.0	B584-C93200	Hi lead tin bronze
237	924 ^F	C92400	2000	250	30,000	(15)	40	18	20	75	550	11.0	B22-C90500M B584-C90500M	^C Leaded bronze
196	911	C91100	^{BG} 2500	50	30,000	18	(35)	(25)	(2)	135	250		B22- C91100	Hi tin bronze
194	913	C91300	^B 3000	50	30,000	24	(35)	(30)	(0.5)	160	250		B22- C91300	Hi tin bronze
417	954 ^F	C95400	3500	100	50,000	(22)	75	30	12	150	500	9.0	B148-C95400	Aluminum bronze
418	955 ^F	C95500	5000	100	70,000	(28)	90	40	6	190	600	9.0	B148-C95500	Ni aluminum bronze
	958 ^F	C95800	5000	100	70,000	(30)	85	35	15	160	600	9.0	B148-C95800	Alpha Ni Al bronze
423	862 ^F	C86200	8000	25	70,000	(50)	90	45	18	180	650	12.0	B584-C86200	Manganese bronze
424	863 ^F	C86300	^B 8000	25	70,000	55	110	60	12	223	650	12.0	B22- C86300 B584-C86300	Manganese bronze
GA50	-	F13501	8000	25	70,000	(180)	50	-	-	220	1000	7.2	A48-Class 50	^E GA50 Meehanite

A Typical values not specified by ASTM are shown in parentheses for information only **B** Specified by ASTM B22
C Modified with up to 2 1/2% lead allowed **D** The physical strength of materials is reduced at elevated temperatures. Refer to section on "high-temperature applications" **E** For use in "high-temperature applications" and/or where copper base materials cannot be tolerated. GA50 Meehanite also meets the requirements of ASTM A278 - A319 - A438
F When applicable these alloys may be centrifugal cast to ASTM B271 **G** Specified by AASHTO
H Copper Development Association **I** Unified Numbering System

Loads and speeds

Lubrite® bearings are primarily designed for medium and heavy loads at slow and medium speeds. Maximum load carrying capacity is governed by the bearing material itself. The overall design must take into consideration the speed of operation, unit loading, temperature, and any other special considerations to which the bearing is subjected, such as hostile environments.

PV (pressure x velocity) calculation

The PV factor is a tool that permits defining the operating capability of any type of bearing. The acceptable PV value for a given application is a function of loading, substrate material, lubricant, temperature, service environment, and any other pertinent factors. A general guide to the relationship of PV and materials is provided in the materials chart.

P (pressure) is the force (in pounds per square inch) being applied on the bearing surface. The area of a sleeve bushing is defined as the diameter X the length. For thrust washers and plates simply use the surface area of the bearing.

$$P = \frac{\text{Total applied load}}{\text{Area}} \quad (\text{psi})$$

V (velocity) is the movement in surface-feet-per-minute on the bearing surface. The velocity for sleeve bushings and thrust washers can be determined by the following formulas.

Sleeve bushings
 $V = \text{RPM} \times .262 \times \text{diameter}$

Thrust Washers
$$V = \text{RPM} \times \frac{.262 \times \text{ID} + \text{OD}}{2}$$

Sample calculation
4" dia. shaft rotating at 6 RPM; bushing length 5"; total load 60 KIP
$$P = \frac{60,000 \text{ lbs}}{4" \text{ dia.} \times 5" \text{ length}} = 3,000 \text{ psi}$$
$$V = 6 \text{ RPM} \times .262 \times 4" \text{ dia.} = 6.288 \text{ SFM}$$
$$PV = 3,000 \text{ psi} \times 6.288 \text{ SFM} = 18,864 \text{ psi-SFM}$$

For flat plates the velocity is the linear speed of the sliding surface.

The materials chart provides normal design limits for a variety of bearing materials operating at temperatures under 250°F. Before committing to your design however, please verify all design parameters with Lubrite's engineering department to ensure satisfactory performance.

Coefficient of friction

Lubrite bearings specified for use within the recommended PV range will function at a coefficient of friction between 0.04 and 0.09, depending on the lubricant and operating parameters of the bearing. A maximum design coefficient of 0.10 should therefore be considered unless field service substantiates lower values. For high temperature service, a design coefficient of 0.15 is suggested.

Applications necessitating lower coefficients can often be satisfied through the special design efforts of our engineering department.

Bearing metals

Ideally, the bearing and its mating surface should always be separated by a film of lubricant. Over a period of time however, specified conditions may vary due to wear, contamination, or elastic or thermal distortion and result in mating surface contact.

Normally bronze is used as the base material for Lubrite bearings. Applications involving extreme temperatures, environments corrosive to bronze, and loads exceeding the compressive strength of bronze will require the physical and chemical characteristics of other materials. Substrate materials range from stainless steel and nodular iron to tool steels. Selection of the proper bearing and mating surface materials and lubricants is extremely important to obtain both long bearing life and maintenance free operation.

The material chart shows a few of the common bearing alloys along with the selected physical properties. Other materials can be used where the application is of an unusual nature, but we suggest that you contact our engineering department for recommendations on your particular application.

Although the physical data shown are of prime importance in selecting materials, the following factors should be considered and evaluated by the design engineer for the specific application under consideration.

Score resistance	Corrosion resistance
Hardness difference	Shear strength
Compressive strength	Compatibility
Fatigue strength	Environmental effect
Deformability	

These factors should be evaluated in regard to all bearing system components.

Clearances

Lubrite® bearings are supplied completely finished with proper clearance and tolerances, and are ready for installation. Boring, reaming, or other operations prior to or after assembly are not necessary and should be avoided as they could impair operating efficiency and service life.

Diametral allowance (operating clearance) is the amount by which the inside diameter of a bearing exceeds the journal diameter after “press-fit” closure allowance. This measurement is expressed in thousandths of an inch. Diametral clearance is an essential consideration in any bearing design, and selection of the correct clearance is a significant factor in bearing performance. For special or severe operating conditions the diametral clearances are designed using computer assisted techniques which take into consideration such factors as Hertz contact stresses, mechanical properties and lubrication.

Since the lubricant in a Lubrite bearing coats the mating surfaces with a thick film of lubrication, greater clearances are required than in bearings utilizing thin-film lubrication. These clearances do not indicate any looseness however. The lubricant coats both the journal and bearing walls and fills the clearance, thereby providing the assembly with a satisfactory fit.

Clearance must of necessity vary with operating conditions. Factors such as speed, load, temperature, size, and type of application must be considered. The graphs will serve as a guide in the selection of correct clearances for the majority of applications. For special or unusual conditions please contact our engineering department for recommendations.



Typical design clearances between shaft and inside diameter of bushing(0-25 in.)

Lubricants

A wide range of lubrication materials are offered for Lubrite® bearings. Most of these lubricants are proprietary formulations developed by Lubrite through years of intensive research and field testing. Although no single lubricant fulfills all service conditions, each will satisfy a range of operating conditions under which it supplies maximum lubricity, durability, and the lowest possible coefficient of friction. New lubricating materials are constantly under development in Lubrite's research facilities. These, along with the most advanced lubricating materials produced by industry are incorporated into Lubrite bearing lubricant formulations as soon as improved performance can be demonstrated.

Lubricating pattern

The recesses for Lubrite bearings are designed for lubricant retention and replenishment, and may be round or trepanned holes cast or machined into the metal substrate. The size, proper spacing, and correct percentage of recess area over a given bearing surface must be carefully engineered to ensure sufficient lubrication during the functional life of the bearing. Whenever possible we recommend using trepanned recesses. Trepanned recesses were developed by Lubrite through years of research and development to provide the optimum lubrication track pattern. This pattern assures continuous lubrication replenishment between mating surfaces for the life of the bearing.

The size, shape, and geometric location of the recesses will be determined by the size and shape of the bearing and the operational parameters to which it is subjected. Plate type configurations (flat, Radialube, Spherilube) will have blind recesses on all lubricated surfaces. Thrust or expansion washers may have recesses on one or both faces or "through holes" as required.

Surface finish

The peak surface variation in bearing and journal surfaces should be less than the thickness of the minimum lubrication film expected during operation. When surface roughness exceeds the lubricating film, peaks on the journal surface contact peaks on the bearing surface and result in

Standard lubricants	
Type	Description
G1	General Duty. Temperature from minus 100 to 250°F. Atmospheric exposure. Mild contaminants.
G2	Temperature from minus 100 to 500°F. Occasional contamination from petroleum base products and mild solvents.
G4	Temperature from minus 100 to 350°F. Will not promote electrolysis in salt water and other corrosive media.
G10	Temperature from minus 100°F to 400°F. Epoxy base graphite-free lubricant. Less prone to attack by certain acids and petroleum-based products.
G12	Temperature from minum 100°F to 400°F. Epoxy base graphite-free lubricant. Will not promote electrolysis in seawater. Excellent wear resistance, compatible with most petroleum base products. Capable of carrying high unit-loads. For use in high cycle applications.
T1	Temperature 250 to 550°F.
T7	Temperatures up to 1,200°F.
AE1	Temperature 100 to 300°F. Tested up to 1×10^7 rads, gamma and 6×10^{13} nvt, fast neutron radiation.
AE6	Temperature 550 to 1,000°F. Tested up to 2.2×10^9 rads, gamma and 1×10^{18} nvt, fast neutron radiation. Excellent high unit-load carrying capabilities.
AE7	Temperature up to 700°F. Tested up to 2.2×10^9 rads, gamma and 1×10^{18} nvt, fast neutron radiation.

The above list is only a fraction of the available lubricants. Many other lubricant systems can be formulated to meet the requirements of particular applications.

increased friction and accelerated wear. Since the journal is harder and has a higher shear value than the bearing material, its surface finish should be smoother than that of the bearing. Under slow moving and static conditions the Lubrite® film remains thicker than in high-speed applications, and surface finishes better than 63-125 rms are not required. In general, smoother finishes are required for harder materials, higher loads, and higher surface velocities.

Installation guidelines

Several different methods may be used to retain a bearing in its housing. The best method will depend on the particular application. The designer should keep in mind that the bearing/housing assembly should always be designed to permit convenient installation.

The most frequently used retaining method is to press the bearing into the housing with an interference fit. Shrink fits are not normally recommended and should only be considered when a press fit is not feasible. Please consult Lubrite's engineering department before attempting a shrink fit as this method could loosen or damage the lubricant. Fits recommended for general applications are listed below.

For high temperature applications and where thin wall bushings are required, fits must be adjusted to avoid yielding of the bearing material or housing.

When a Lubrite bearing is pressed into the housing the driving force should be uniformly applied to the end of the bearing. The bearings are provided with a chamfer on the outside diameter to help facilitate alignment and to permit the "rounding out" of any ovality in the bearing. Some ovality will be present due to the turning, drilling and high hydraulic pressures required in the manufacture of the bearing. This should not cause concern, however, as the bearing will conform to the roundness of its housing when installed.

Typical surface roughness values

micro-inches (μ -IN)	micro-meters (μ -M)
16	0.4
32	0.8
63	1.6
125	3.2
250	6.3

Recommended tolerances for nominal housing bores using press fits*

(Dimensions in parentheses indicate millimeters)

Nominal housing bore	Tolerance on nominal housing bore	Range of interference fit
0 to 1 (0 - 25.4)	+0.0005 / -0.0000 (+0,013 - -0,000)	0.0005 - 0.0020 (0,013 - 0,051)
OVER 1 to 2 (25.4 - 50.8)	+0.0010 / -0.000 (+0,025 / - 0,000)	0.0010 - 0.0030 (0,025 - 0,076)
OVER 2 to 3 (50.8 - 76.2)	+0.0010 / -0.0000 (+0,025 / -0,000)	0.0010 - 0.0040 (0,025 - 0,102)
OVER 3 to 5 (76.2 - 127)	+0.0010 / -0.0000 (+0,025 / -0,000)	0.0020 - 0.0050 (0,051 - 0,127)
OVER 5 to 9 (127 - 228.6)	+0.0015 / -0.000 (+0,038 / -0,000)	0.0020 - 0.0060 (0,051 - 0,152)
OVER 9 to 20 (228.6 - 508)	+0.0020 / -0.0000 (+0,051 / -0,000)	0.0020 - 0.0070 (0,051 - 0,178)
OVER 20 to 36 (508 - 914.4)	+0.0030 / 0.0000 (+0,076 / -0,000)	0.0020 - 0.0080 (0,051 - 0,203)
OVER 36 (-914.4)	Note: Above 36 inch housing bore a press fit is not recommended. A transitional-to-clearance fit should be designed. Consult Lubrite engineering department for appropriate recommendations.	

Press fitting sleeve bearings can cause difficulties in assembly due to "close-in" of the bore when the bearing is installed in the housing. It is extremely difficult to predict the amount of closure with any degree of accuracy. In general, it is best to adopt a design policy of compensating the bore decrease by 100 percent to determine the final clearance after press fit.

Other methods of bearing retention noted below may be employed, but as Lubrite® bearings should NOT be machined after assembly, care must be taken to prevent distortion or deformation caused by the keying methods.

1. Set screws
2. Dowel pins
3. Bolted bearing flanges
4. Housing caps

Bearing and journal hardness

In general, the journal should be made harder than the bearing material. Although this is a conservative design practice, it assures that if wear ever should occur, it will primarily affect the more easily replaced bearing surface as opposed to the more expensive journal. For the best wear characteristics it is recommended that the journal be 100 points harder than the bearing material.

As the hardness of the bearing material increases so will the heat output generated when the bearing touches the shaft. Also, abrasive matter contamination is not as easily imbedded into hard materials, so greater care must be taken to keep mating surfaces clean. The performance and service life of any bearing, however, is obviously dependent on cleanliness.

High temperature applications

With correct design and material selection Lubrite can provide lubrication to prevent seizing and galling at temperature extremes. However, applications involving environments of 250°F and above require critical engineering. Bearing materials have drastically altered creep rates and strengths at elevated temperatures, and differences in thermal expansion of the bearing, housing and journal must be carefully calculated to ensure satisfactory performance. Conservative engineering will eliminate problems such as surface cracks and small geometric changes assuring you of optimum bearing life. Refinement in surface finishes of both the Lubrite bearing and the opposing face becomes more critical as temperatures increase. It is important that our engineering department advise on all high-temperature bearing applications.





1. Dams

Radial gate trunnions
Dogging devices
Cranes
Turbines
Floating mooring-bits
Valves
Vertical lift crest
gates
Roller chains
Fixed wheel gates
Sheaves
Flap gates
Slide gates
Mitre gates
Sector gates
Penstocks
Wicket gates

2. Bridges

Plate girder
Truss
Arch
Suspension
Cable stayed
Movable

3. Offshore

Fairleads
Cardan joints
Bow thrusters
Mooring yoke
Boom equalizer
Crane pivot
Flare boom
Rotating head
Stinger
Platforms
Turntables

4. Structural

Buildings
Shopping centers
Auditoriums
Gymnasiums
Churches
Pipe supports
Vessel supports
Oil and chemical
refinery equipment
Hangar bearings
Heat exchangers

Pipelines

Airport hangars

Condensers

Stadiums

Jacking devices

Regenerator supports

5. Nuclear

Reactor supports

Steam generator supports

Missile barriers

Blast doors

Pump & equipment supports

Fuel transfer systems

Valves

Torus supports

6. Industrial

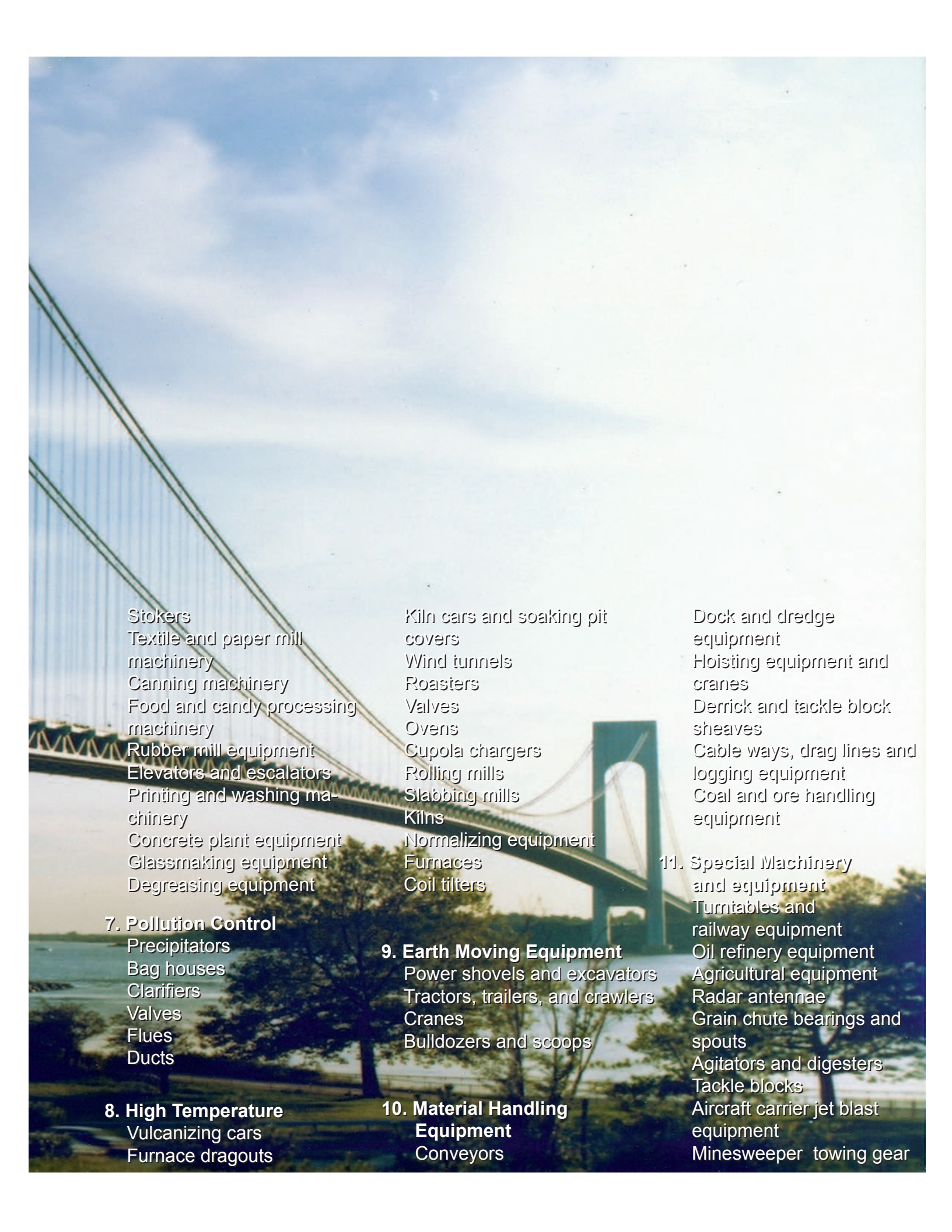
Idler gears

Mixers, grinders
and pulverizers

Foundry equipment

Clutches

Coke plant equipment



Stokers
Textile and paper mill
machinery
Canning machinery
Food and candy processing
machinery
Rubber mill equipment
Elevators and escalators
Printing and washing ma-
chinery
Concrete plant equipment
Glassmaking equipment
Degreasing equipment

7. Pollution Control

Precipitators
Bag houses
Clarifiers
Valves
Flues
Ducts

8. High Temperature

Vulcanizing cars
Furnace dragouts

Kiln cars and soaking pit
covers
Wind tunnels
Roasters
Valves
Ovens
Cupola chargers
Rolling mills
Slabbing mills
Kilns
Normalizing equipment
Furnaces
Coil tilters

9. Earth Moving Equipment

Power shovels and excavators
Tractors, trailers, and crawlers
Cranes
Bulldozers and scoops

**10. Material Handling
Equipment**

Conveyors

Dock and dredge
equipment
Hoisting equipment and
cranes
Derrick and tackle block
sheaves
Cable ways, drag lines and
logging equipment
Coal and ore handling
equipment

**11. Special Machinery
and equipment**

Turntables and
railway equipment
Oil refinery equipment
Agricultural equipment
Radar antennae
Grain chute bearings and
spouts
Agitators and digesters
Tackle blocks
Aircraft carrier jet blast
equipment
Minesweeper towing gear



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