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Garlock Bearings LLC

BFGoodrich

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DU®
DX™

Self-Lubricating Bearings
Prelubricated Bearings

Garlock Bearings LLC
700 Mid Atlantic Parkway, P.O. Box 189, Thorofare, New Jersey 08086
Phone 1-800-222-0147 • Fax 856-848-5115 • www.garlockbearings.com

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Other Self-lubricating Bearings from Garlock Bearings

In addition to the DU and DX bearings described in this catalog, Garlock Bearings also offers a wide range of other self-lubricating bearings, including:

GAR-MAX® impact resistant bearings combine a rugged filament wound glass-epoxy backing with a surface of wound PTFE and polyester fibers for low friction.

GAR-FIL® filament wound bearings with a filled PTFE tape bearing surface for long life without lubrication.

MULTIFIL™ 426 bearing tape for remarkable performance with or without lubrication in machine tool ways, gibs and other sliding applications.

MULTILUBE® bearings which combine the convenience, economy and flexibility of injection molding with outstanding friction and wear properties.

Garlock Bearings also offers filled PTFE bearings, integral lip seal bushings and a variety of other types of self-lubricating bearing materials to meet specialized application needs.

Your inquiry is invited on any of these bearings.

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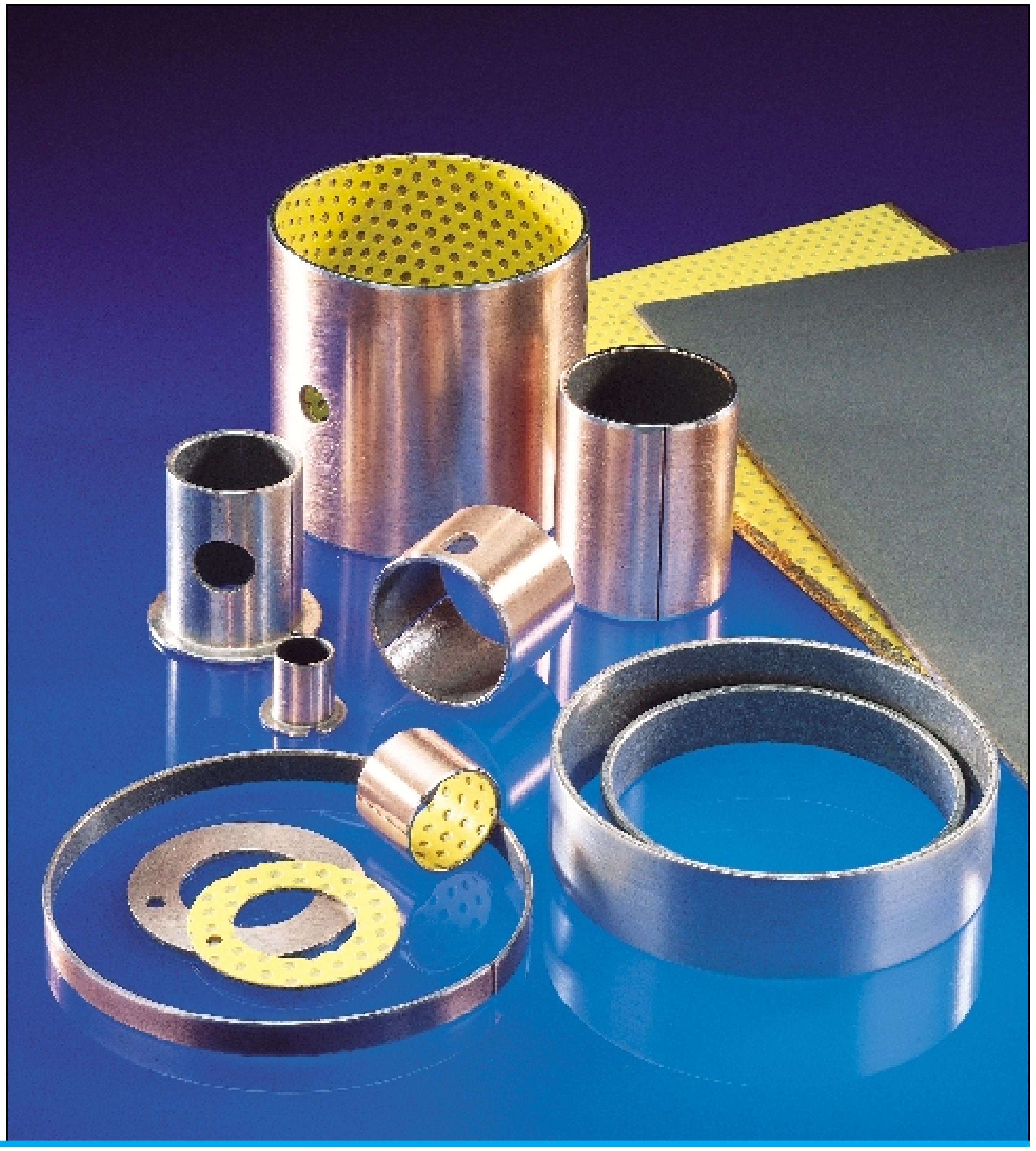

INTRODUCTION

Garlock Bearings LLC
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__DU®__ is the highest performance self-lubricating bearing material available anywhere. It offers a combination of properties and capabilities unmatched by any other self-lubricating bearing material and, consequently, has the broadest application range.

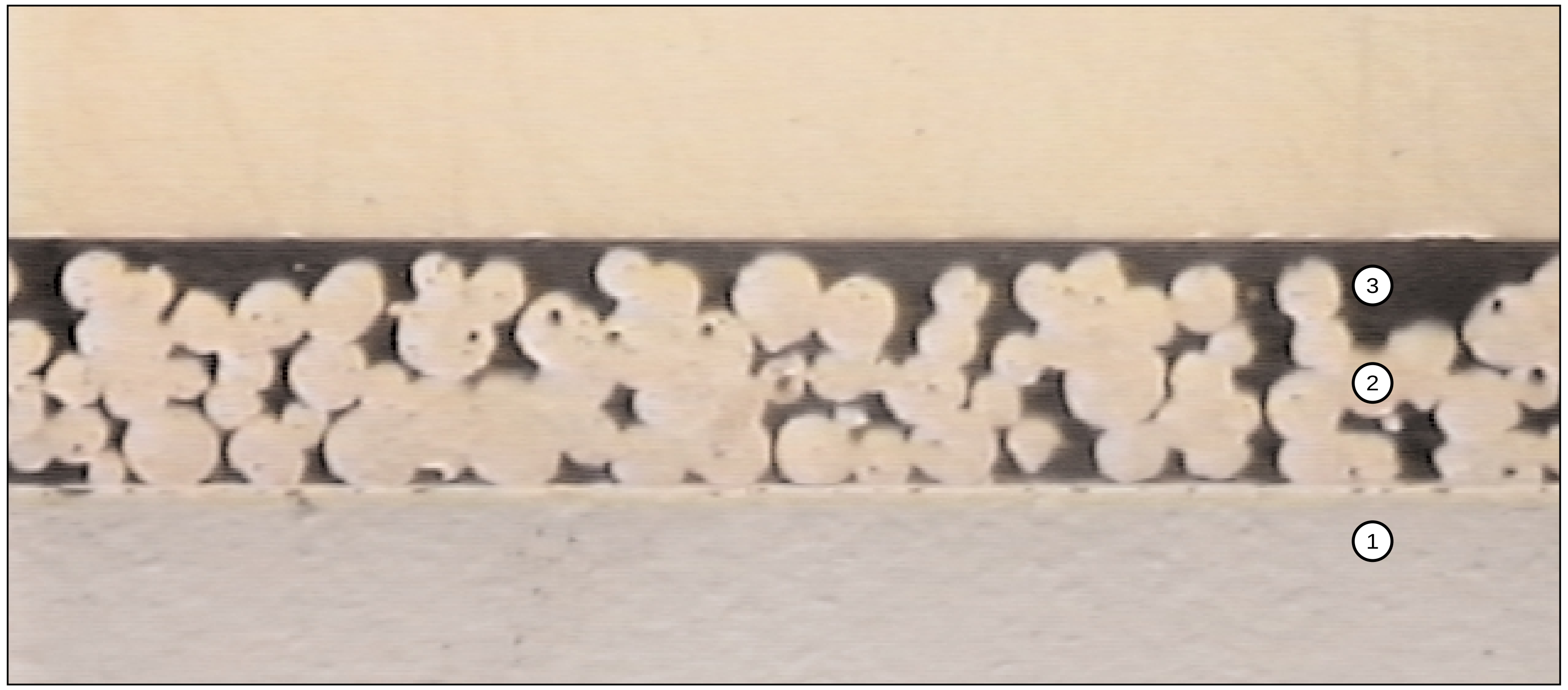

Figure 1-1. DU Photomicrograph Cross Section

DU®...the high performance self-lubricating bearing material

DU bearings combine the advantages of many conventionally lubricated, metallic plain bearings—particularly high load capacity and dimensional rigidity—with the design freedoms of self-lubricating materials, including the ability to operate successfully well beyond the scope of conventional lubricants.

The material: a steel backed composite

The key to the remarkable performance capabilities of DU is its unique method of manufacture. By employing the unique method of sintering and mechanical interlocking by impregnation, DU bearings eliminate the problems of temperature and aging faced by bonded films and fabrics. In addition, the polymeric self-lubricating material in the DU structure does not have to provide structural support. Furthermore, the metal components provide maximum heat dissipation. The photomicrograph above (Figure 1-1) shows the three main elements that make up this composite:

1. Steel backing

This steel backing gives DU its exceptionally high load carrying capacity; thin, compact design; excellent heat dissipation; and dimensional and structural rigidity.

2. Porous bronze innerstructure

This comprises a nominal 0.010 inch (0.25 mm) thick layer of carefully sized bearing quality bronze powder which is sintered onto the steel backing. This porous structure is impregnated with a homogeneous mixture of PTFE (polytetra-fluoroethylene) and lead. In addition to providing maximum thermal conductivity away from the bearing surface, this unique bronze innerstructure also serves as a reservoir for the PTFE-lead mixture.

3. PTFE-lead overlay

This low friction overlay, approximately 0.001 inch (0.025 mm) thick, provides an excellent initial transfer film which effectively coats the mating surface of the bearing assembly, forming an oxide type solid lubricant film. As this film is depleted, the relative motion of the mating surface continues to draw material from the porous bronze layer.

When conditions are severe, the feed of lubrication is increased. The peaks of porous bronze coming in contact with the mating surface generate localized heat and, due to the high thermal expansion rate of the PTFE, force additional lubricant to the bearing surface. The relative motion of the mating parts wipes the lubricant over the interface, continuously restoring the low friction surface film.

The limits: beyond any self-lubricating bearing material

DU bearings—including plain bearings, thrust washers, flanged bearings and slides—offer these remarkable operating parameters:

Loads – P

Dynamic pressures up to 20,000 psi (140 N/mm^2) and compressive yield strength of 44,000 psi (310 N/mm^2), assuring high load carrying capacity and excellent resistance to shock loading.

Speeds – V

Speeds up to 1000 fpm (5 m/s) without lubrication; 2000 fpm (10 m/s) with lubrication.

Performance – PV

PVs to 50,000 psi-fpm (1.75 N/mm^2 x m/s) for continuous operation, 100,000 psi-fpm (3.50 N/mm^2 x m/s) for short-term use. In actual operation, DU bearings have been successfully used at levels which approach 3,000,000 psi-fpm (105 N/mm^2 x m/s) lubricated.

Temperatures

From -328 to +536ºF (-200 to +280ºC), making it suitable for use in applications well beyond the scope of most liquid lubricants.

Motion

Ideal for all types of rotating, oscillating, and sliding motion, and both radial and thrust loading.

Lubrication

Can be used totally dry, fully lubricated, or with intermittent lubrication and can be used in the presence of many industrial liquids.

Introduction

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DU®

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Introduction
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DX™

DX™ bearings offer extraordinary operating advantages and a wide range of design possibilities. In slow speed, oscillatory applications, or wherever conditions of intermittent operation or boundary lubrication exist, DX prelubricated bearings have opened a new dimension in performance capabilities for design engineers.

DX™...the bearings that can do more

The key to the superior performance capabilities of DX bearings is their unique construction incorporating a highly effective grease retention system.

The bearings exhibit extremely low friction during operation and are highly resistant to wear. By taking advantage of the low friction and longer service life provided by DX bearings, designers now have the opportunity to improve the performance of their product while increasing its effective operating life. The designer can also be assured that frequency of maintenance is minimized due to the greatly extended lubrication cycle of DX bearings.

DX prelubricated bearings effectively fill the gap between fully lubricated bearings and dry bearings. They are referred to as "prelubricated" because they require only a trace of lubricant to operate satisfactorily and will, therefore, run for very long periods by drawing only upon the lubricant introduced on initial assembly.

DX is a steel-backed material from which bearings, thrust washers, and other shapes can be made. The DX material can be sized in place by boring, reaming, etc. This ability to resize the DX is of particular value in the control of initial starting clearance and the correction of misalignment. The wall thickness of DX bearings is held to close limits so that machining should be unnecessary for most applications.

DX is recommended for conditions of intermittent operation or boundary lubrication, and for situations in which lubricant cannot be supplied continuously or repeatedly. The time during which a DX bearing will operate without further lubrication will depend on operating conditions.

A unique, composite bearing material

DX, shown in magnified cross section in Figure 1-2, is a composite strip material made up of three layers: steel, porous bronze, and acetal resin polymer:

1. Steel backing

(Full depth not shown.) This steel backing is the key to the exceptional strength; thin, compact design; excellent heat dissipation; and dimensional and structural rigidity of DX bearings. This rugged, copper-plated steel backing also provides a good interference fit in metallic housings throughout the temperature range for the bearing.

2. Porous bronze innerstructure

This comprises a nominal 0.010 inch (0.25 mm) layer of carefully sized, bearing quality bronze powder sintered onto the steel backing. This porous bronze innerlayer is impregnated with the acetal resin and is securely sintered to the steel. The bronze also serves as an effective heat conductive path which minimizes undue temperature rise at the bearing surface and provides dimensional stability.

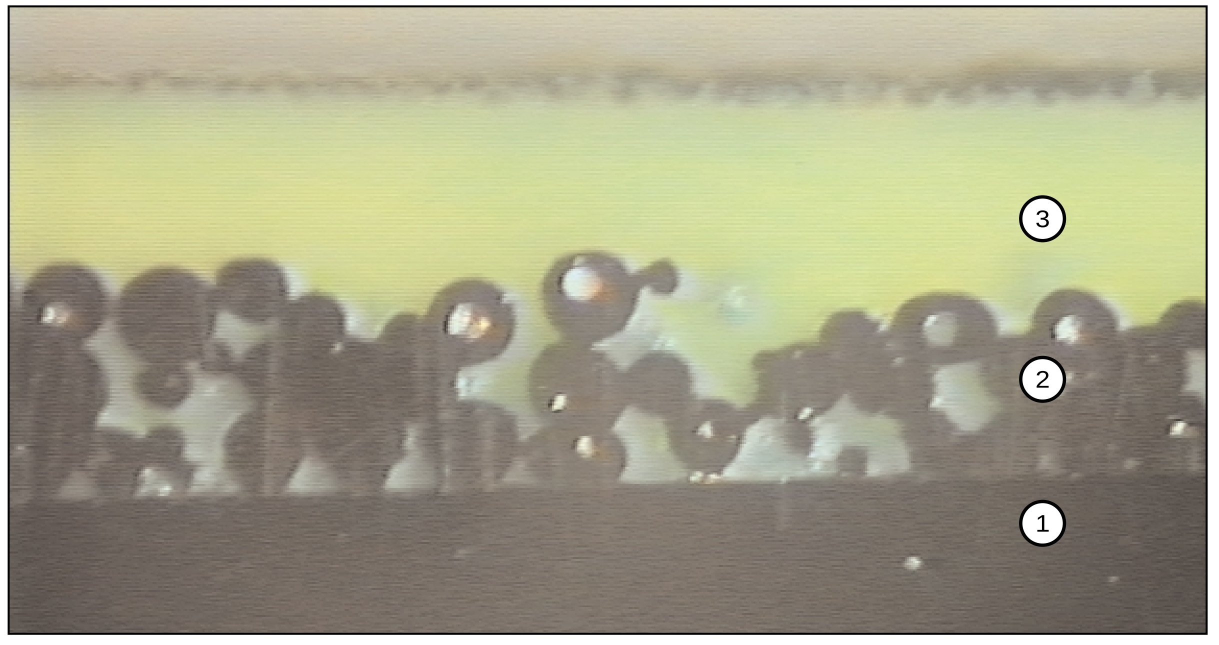

Figure 1-2. DX Photomicrograph Cross Section

3. Acetal resin liner

The acetal resin forms a nominal 0.010 inch thick (0.25 mm) liner that gives the DX bearing its distinctive yellow color. This acetal resin has the outstanding property of high wear resistance and low friction even when only minute quantities of lubricant are supplied to the polymer surface. Although DX bearings only have moderate performance in the complete absence of lubricant, the response of the polymer provides superior bearing performance in the presence of even a trace of conventional oil or grease. Under conditions of marginal lubrication or those which do not favor the formation of a complete oil film—oscillating or fretting conditions, high loads, low speeds, frequent stop/start or starting under load—DX is the preferred material.

The standard DX bearing surface carries a pattern of circular indents which should be filled with grease on assembly of the bearing. The pattern is so designed that every point on the bearing surface is supplied with lubricant from an indent by the rotation of the mating surface. There may be occasions when non-indented or grooved bearing bores are required. These are available as nonstandard items.

Grease pockets must be filled with a suitable lubricant before assembly. See page 5-9 for a discussion on grease lubrication.

DX is available in bearings, thrust washers, and strip. Furthermore, DX is also available, on special order, with a non-indented bearing surface.

The following is a summary of DX performance capabilities:

Loads – P
Dynamic pressures up to 20,000 psi (140 N/mm²) assuring high load carrying capacity and resistance to shock loading.

Speeds – V
Speeds up to 500 fpm (2.5 m/s) with grease lubrication.

Performance – PV
PVs to 80,000 psi-fpm (2.8 N/mm² x m/s) for continuous operation.

Temperatures
From -40 to +210ºF (-40 to +100ºC) continuous and up to 260ºF (125ºC) for short periods.

Motion
Ideal for all types of rotating, oscillating, and sliding motion, and both radial and thrust loading.

Lubrication
Typically grease lubricated. Can also be lubricated with oil, other lubricants, and can be used in the presence of many industrial liquids. DX is not recommended for dry applications; instead we recommend DU.

Frictional properties
The dynamic coefficient of friction is very low, between 0.01 and 0.1, depending on speed, load, and lubrication conditions. The coefficient of static friction of DX bearings ranges from about 0.015 to 0.15.

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Properties of DU® and DX™ Compared

Properties	DU Bearing Material	DX Bearing Material
Construction		
Backing	Steel	Steel
Innerstructure	Porous copper-tin bronze	Porous copper-tin bronze
Bearing Surface	PTFE / Lead	Acetal with pin indentations
Lubrication	Not required	Initial prelubrication at assembly required
Load Capacity		
Compressive Strength	44,000 psi (310 N/mm²)	44,000 psi (310 N/mm²)
Static Load Capacity	36,000 psi (250 N/mm²)	36,000 psi (250 N/mm²)
Dynamic Load Capacity	20,000 psi (140 N/mm²)	20,000 psi (140 N/mm²)
Speeds	1,000 fpm (5 m/s), dry 2,000 fpm (10 m/s), (lubricated)	100 fpm (0.5 m/s), greased 500 fpm (2.5 m/s), in oil
PV Limits		
Continuous	50,000 psi-fpm (1.75 N/mm² x m/s)	80,000 psi-fpm (2.8 N/mm² x m/s)
Intermittent	100,000 psi-fpm (3.50 N/mm² x m/s)	
Temperature Range	-328 to +536ºF (-200 to +280ºC)	-40 to +210ºF (-40 to +100ºC) intermittent to +260ºF (+125ºC)
Coefficient of Friction		
Static*	0.02 – 0.20	0.015 – 0.15
Dynamic	0.02 – 0.20	0.01 – 0.10
Standard Products	Refer to pages 3-2 to 3-11	Refer to pages 3-12 to 3-13
Sleeve Bearings	Inch and Metric Sizes	Inch (metrics on special order)
Thrust Washers	Inch and Metric Sizes	Inch (metrics on special order)
Flanged Bearings	Inch and Metric Sizes	Not available
Flat Strip	Inch, 18 inch and 8 foot lengths	Inch, 18 inch and 8 foot lengths
Sizing Bearing ID at Assembly	Burnishing	Boring, turning, reaming, broaching

*Static coefficient of friction of the first movement may be greater for a long dwell period under load. Refer to page 4-4.

Table 1-1

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APPLICATIONS

DU® bearings provide economical solutions to many bearing problems, making them ideal for a wide variety of applications.

DU® gives you the widest application range of any self-lubricating bearing

Because of the unique combination of properties and performance capabilities noted on page 1-3 and detailed in later sections, DU bearings have a far greater application range than any other self-lubricating bearing. In fact, in some applications, DU is the only bearing material that can meet the demanding criteria for long life and trouble-free performance, with or without lubrication.

For decades, DU bearings have proven to be the economical solution to a wide range of bearing problems. In many cases, DU bearings completely eliminate the need for lubrication, as well as maintenance, while extending the life of the assembly. These superior bearings can also eliminate the need for hardened shafts and other expensive surface preparation, further reducing the total cost of the bearing assembly. In lubricated applications, DU bearings provide a margin of safety—particularly during start-up, in the event of interruption of lubrication feed, and in highly loaded applications.

Millions of DU bearings are purchased annually for applications as diverse as low speed, high load pivots to high speed, low load gear pump bearings, and virtually everything in between. These are just a few of the reasons why design engineers throughout the world specify DU bearings for their applications:

DU with or without lubrication

DU's unique PTFE-based bearing surface permits smooth, low friction operation with no lubrication, no maintenance, no costly lubrication systems. Where permissible, lubrication further improves the performance of these bearings.

DU bearings are convenient to use

The prefinished surface of DU bearings requires no machining. These thin, compact bearings require minimum space and are located within the housing by interference fit. DU bearings are supplied from stock in a wide range of inch and metric sizes, as outlined on pages 3-2 through 3-11. And these superior bearings are readily available worldwide through an extensive network of distributors and licensees. Special sizes are also available upon request.

DU bearings provide highest performance

As noted on page 1-3, DU bearings take PVs to 100,000 psi-fpm (3.50 N/mm^2 x m/s) or more, operate at temperatures from -328 to +536°F (-200 to +280°C), can be used with fully rotational, oscillatory, and axial sliding motion, take both radial and thrust loads, and resist shock loadings.

DU bearings are reliable

The performance capabilities and predictable wear patterns of DU bearings have been more thoroughly documented, both in the field and in the laboratory, than any other self-lubricating bearing. These bearings are noted for their long, trouble-free life, their tolerance of dusty, dirty environments, and their ability to withstand operating extremes and perform in the presence of most solvents and industrial fluids.

Applications
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DU®

Typical DU® bearing applications

The following list covers some of the many types of successful DU bearing applications, as well as some of the special problems solved by this unique bearing material.

Agricultural equipment

A wide range of agricultural vehicles and implements such as tractors, combines, crop sprayers, tillers, harvesters, grain dryers, etc. use DU bearings to eliminate lubrication points. Specific applications include clutches, governor linkage, brake pedals, control pivots, cross shaft linkage, and parking brakes.

Off-highway, truck, and automotive

Typical applications in these areas include earth-movers, graders and other construc-tional and off-the-highway equipment, trucks, and autos. Specific uses include power steering cylinders, steering gear thrust washers, disc brakes, calipers and pistons, shock absorbers, governor linkage (diesel), windshield wiper motor/trans-missions, tilt gear assemblies, hydraulic steering mechanisms, shifter linkage, brake pedal pivots, clutch cross shafts, steering shaft universal joints, throttle bodies, tachometers, fuel pumps, roof actuators, steering pivot tubes, kingpin assemblies, suspension and steering ball joints, yoke assemblies, steering idler arms, torsional supports, and many more. DU bearings are chosen to minimize the need for lubrication and servicing, and for their high reliability even in dirty environments.

Aviation

Aircraft engines, controls, landing gears, sliding wing supports, linkages, brakes, etc. DU bearings are particularly ideal for applications where parts requiring lubrication or servicing are inaccessible, and for their indifference to extremely low temperatures, tolerance of airborne dirt, and ability to operate in the vacuum of outer space.

Business machines

Photocopy machines, typewriters, mail sorters, postage meter systems, computer terminal printers and peripheral equipment, automatic printing devices, mail processing machinery, electric staplers, high speed business machines, photo processing machines, etc.

Garden, lawn, and outdoor equipment

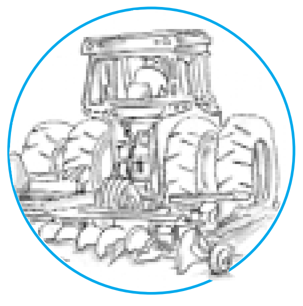
Lawnmowers, garden tractors, fairway mowers, chain saws. Specific applications include starter mechanisms, drive shafts, gears, front mounts, and clutches.

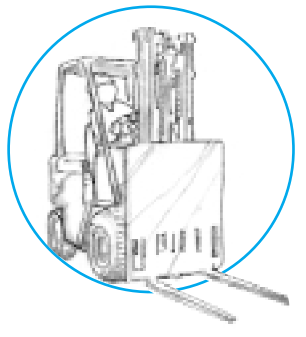
Hydraulics and valves

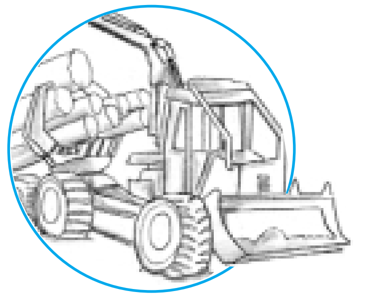
Pumps, including gear, rotary, water, axial piston, and other types; ball, butterfly, poppet steam, check and other valves and valve trunnions; pump pressure and thrust plates, reciprocating air compressors, hydraulic actuators, centrifugal compressors, water hydrants, air regulator lever points, bellows compressors, etc. Several of these applications dramatically demonstrate the unrivaled capabilities of DU bearings. In one gear pump application, for example, PV values approaching 3,000,000 psi-fpm are achieved under fully lubricated (hydrodynamic) conditions, with no bearing failure or premature wear. Although these levels are not maintained for long periods of time, they indicate the fail-safe capabilities of DU bearings under extreme operating conditions.

Home appliances and consumer goods

Tape recorders, refrigerators, air conditioners, cleaners, polishers, sewing machines, ovens, dishwashers, clothes washing machines, and other appliances. Even "domestic" applications like these can destroy ordinary self-lubricating bearings. In the case of the washing machines, DU bearings were the only units which could withstand the punishment of combined rotating and reciprocating motion.







DU®

Applications
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Materials handling
Liquid filling equipment, side loader roller assemblies, power take-off units, variable speed sheaves, marine winches, hoists, coal mine roll conveyors, forklift truck safety rollers, canning line chains, oil skimmer conveyors, screw conveyor systems and components, hydraulic lifts, scissors lifts, filling and bagging machines, weighing equipment, etc. The rugged durability of DU bearings is particularly useful in these applications, many of which are subjected to shock loadings.

Medical and dental
Dental chair lifts, base rotation pads, stop plunger mechanisms, guide rollers and attachments; X-ray machine radial arm swivels and scissors mounts; hospital beds; sterilizer casters and operating tables. DU bearings are ideal where cleanliness and reliability are important.

Marine
Marine engine gearcases, steer axis stern drive pivots, sailboat winches, anchors and chain winches, hatch covers, hoist pivots, submersible pumps.

Packaging
Glass packaging and processing machinery, glass container equipment, coin wrapping machines, packaging system tie bar bearings, bookbinding equipment, camshaft heated wrapping machines.

Recreational vehicles
Snowmobile clutches, transmissions for four-wheel drive vehicles, mobile home brakes, outboard motors, steering columns, shifter pivots.

Railway equipment
Railway side bearings, switch gears, level crossing gates, detector boxes, automatic door closing mechanisms, semaphore signal arms, etc.; trolley wheels and chains, trolley car door mechanisms.

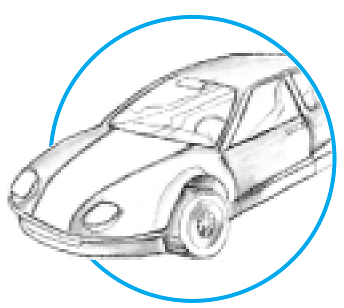
Textile equipment
Spinning, weaving, tufting, and finishing machinery, rotating bobbins, etc. In these applications, DU bearings offer exceptional cleanliness, freedom from the effects of static electricity and fire hazards, tolerance of "fly" and other airborne dirt, elimination of complex lubrication systems, and smooth running with no-stick slip.

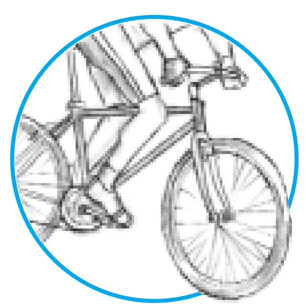
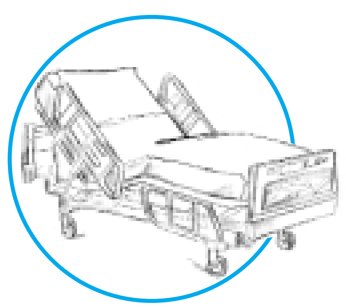
Tools
Shears, hand tools, reaming tools, crimping tools, reciprocating saws, cutting torches, arbors, etc.

Other diverse applications benefiting from the unique advantages of DU include machine tools, gymnasium equipment, compound bows, telescope mounts, couplings, paper making machinery, shell making machines, hydraulic door closers, surgical equipment, measuring instruments, wind direction indicators, car wash side brush rollers, safe hinges, switchgears, concrete mixers, gas meters, expansion sliding bearings for bridges, heavy plants and buildings … and much more.

For further information on these and other applications, please consult our Applications Engineering staff.

Note: Because of the lead content, DU bearings should not be used in contact with food or pharmaceutical products.



Applications
Prelubricated Bearings

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DX™

DX™ prelubricated bearings give you the widest application range

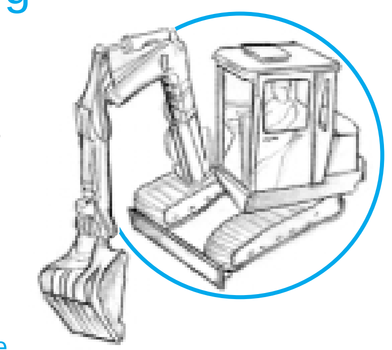
DX bearings are recommended for applications involving intermittent operation or boundary lubrication. As a result of the unique lubrication-retaining pockets on the surface, DX bearings are especially well-suited for applications where lubricant cannot be supplied continuously or repeatedly. The length of time that a DX bearing will operate without further lubrication depends on the interaction of the load, surface speed, and temperature encountered in specific operation conditions. With proper lubrication and relubrication at appropriate intervals, DX bearings can last indefinitely, as suggested by Figure 5-1.

Oscillating applications
DX bearings should be considered for any application where the bearing is used primarily as a pivot and where, because of small movements and heavy loading, fretting might occur with some other type of bearing. Applications of this type include suspension and steering linkages in trucks and earth-moving equipment.

Full rotating service
Lubricated upon assembly, DX bearings operate very satisfactorily under full rotating conditions. They are particularly recommended for applications involving splash lubrication, as in gearboxes, where conventional plain bearings would require full oil lubrication. Such higher speed applications require additional clearance for oil lubrication. Contact our Engineering Department for a suitable recommendation.

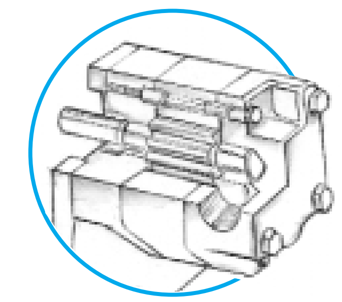
Thrust washers
Made of DX material will give satisfactory operation under conditions of marginal lubrication. DX thrust washers are particularly recommended where the loads are too high, the speeds too low, or the quantity of lubrication insufficient to maintain the hydrodynamic film required by most metallic bearing materials.

Typical DX™ bearing applications

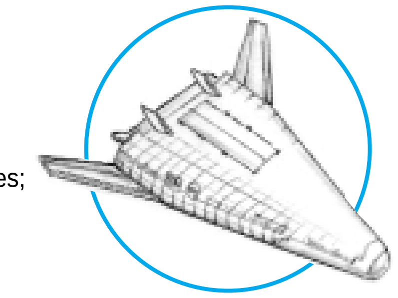


Agricultural equipment
Gearbox, clutch, bale trips and wheel caster swivels for bale accumulators; front axle pivot bearings, steering idler box bearings and kingpin bearings for harvesters; tractor attachments including implement lifting gears, rollers, seeding equipment, etc.

Off-highway, truck, and automotive
Suspension joints, kingpin assemblies and stub axles of trucks; automobile driving joint hinges, steering and other linkages; steering and articulation joints, rear chassis hinges, fairleader rollers, suspension system, locking links on the grapple, and brake and accelerator pedal shafts for log skidders and loaders.

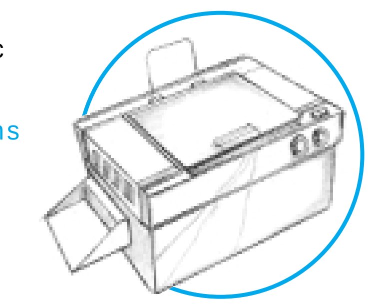


Handling and lifting equipment
Vertical guide rollers for garage car lifts; transfer gearbox for forklift trucks; gearbox and in idler chain sprockets for crane transmissions; worm drive gear, winding drum supports and rope pulleys for lift hoists; car conveyors; main swivel arms for aircraft loading equipment; pulley sheaves for support cable pile drivers; and drive assembly unit and platform lift arm assembly for walkie pallet trucks.



Machine tool building industry
Spindles in drill, grinding, and milling machines; ram guide plates in multiram presses; and eccentric drive unit in precision grinding machines.

Hydraulics
Support bearings in rotary actuators; support bearings for nose piece in hydraulic rams; variable swashplate trunnion bearings in hydraulic pumps; piston rod guide in hydraulic and pneumatic cylinders; oil gear pumps.



Engineering and general applications
Pivot linkages of the gutter brush assembly in road sweepers; trolley casters, industrial and medical; right ascension axis and declination axis shafts of an astronomical telescope.

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DU® and DX™ Bearings Application Data Sheet

Name ____________ Date ____________
Company ____________
Address ____________
City ____________ State ____________ Zip ____________
Telephone ____________ Fax ____________
Bearing to be used for ____________ ☐ New Design ☐ Existing Design

If not new, what type of bearing has been used? ____________
Part Number ____________ I.D. ____________ O.D. ____________ Length ____________
Was it satisfactory? ____________ If not, why not? ____________

Service Conditions

Speeds (Max., Min., Average RPM or Cycles per minute) ____________

Loads (lbs. or psi) Radial ____________ Axial ____________
Constant ____________ Fluctuating ____________
Shock ____________ Vibratory ____________

Motion ☐ Rotating shaft with unidirectional load ☐ Rotating load with Stationary shaft
☐ Oscillating shaft Angle ____________ ☐ Reciprocating Stroke ____________

Shaft Drawing Number ____________ ☐ Horizontal ☐ Vertical
Diameter ____________ Misalignment anticipated ____________
Material ____________ Hardness ____________ Surface Finish ____________

Housing Length ____________ I.D. ____________ O.D. ____________ Material ____________
Construction: ☐ Light ☐ Heavy

Service Life Required

Total Life (operating hours) ____________ Total Allowable Wear (inches) ____________
☐ Continuous
☐ Intermittent (describe) ____________

Environmental Conditions

☐ Air ☐ Clean ☐ Contaminated–Type ____________
☐ Gas ☐ Clean ☐ Contaminated–Type ____________
☐ Liquid–Type ____________ Concentration ____________
Lubricating properties ____________
Is sealing available? ____________ Type ____________

Environmental Temperature

Maximum ____________ Minimum ____________ Normal ____________
Quantity required per year? ____________

Table 2-1

Garlock Bearings LLC
700 Mid Atlantic Parkway, P.O. Box 189, Thorofare, New Jersey 08086
Phone 1-800-222-0147 • Fax 856-848-5115 • www.garlockbearings.com

SIZES and ORDERING

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Sizes and Ordering: Inch Sizes
Self-Lubricating Bearings
Garlock Bearings LLC
700 Mid Atlantic Parkway, P.O. Box 189, Thorofare, New Jersey 08086
Phone 1-800-222-0147 • Fax 856-848-5115 • www.garlockbearings.com
DU®

DU® Bearings Inch Sizes

Ordering Information

To determine Part Number, read down the first column to find the desired Bearing Bore, and across to the desired Bearing Length in a tinted column; the Part Number is shown to the right. Part Numbers are expressed in 1/16 inch increments, bore x length.

For example:
12DU16 = 3/4 inch bore x 1 inch length.

Length Tolerances

Up to and including 3/8 inch I.D. or length — ±0.015 inch.

Above 3/8 inch I.D. or length — ±0.010 inch.

Chamfers

Bearings between 3/8 inch and 2 inches in diameter and lengths of 3/8 inch or more are normally furnished with 0.015/0.047 inch x 12º/28º chamfers. All other bearings will have deburred edges, unless otherwise specified.

Special Bearings

Special Lengths
In addition to the lengths listed, DU bearings of over 2 inch I.D. or larger can be supplied in any desired length from 0.5 to 6 inches.

Special Diameters
DU bearings can be produced in any diameter 1/8 inch and over, and up to 6 inches in length. In addition, DU bearings with heavier or thinner walls than shown can be furnished.

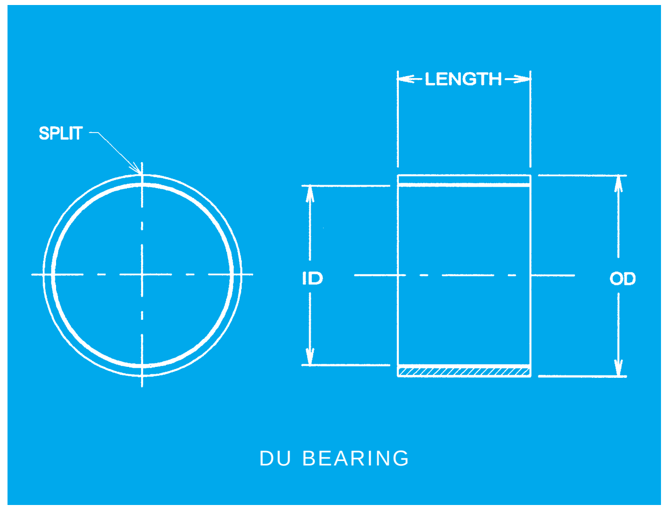
Please consult the Garlock Bearings Marketing Department about special bearings and any partial tooling charges that may be required.

DU® Bearings Inch Sizes Up to 2"

Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.*	Bearing Length and Part Number				Bearing Length and Part Number							
1/8	.1243 .1236	.1873 .1878	.1243 .1268	1/8	02DU02	3/16	02DU03								
5/32	.1554 .1547	.2186 .2191	.1556 .1581	5/32	025DU025	1/4	025DU04								
3/16	.1865 .1858	.2497 .2503	.1867 .1893	3/16	03DU03	1/4	03DU04	3/8	03DU06						
1/4	.2490 .2481	.3122 .3128	.2492 .2518	1/4	04DU04	3/8	04DU06								
5/16	.3115 .3106	.3747 .3753	.3117 .3143	3/8	05DU06	1/2	05DU08								
3/8	.3740 .3731	.4684 .4691	.3742 .3769	3/16	06DU03	1/4	06DU04	3/8	06DU06	1/2	06DU08	5/8	06DU10	3/4	06DU12
7/16	.4365 .4355	.5309 .5316	.4367 .4394	1/2	07DU08	3/4	07DU12								
1/2	.4990 .4980	.5934 .5941	.4992 .5019	1/4	08DU04	3/8	08DU06	1/2	08DU08	5/8	08DU10	3/4	08DU12	7/8	08DU14
9/16	.5615 .5605	.6559 .6566	.5617 .5644	3/8	09DU06	1/2	09DU08	5/8	09DU10	3/4	09DU12				
5/8	.6240 .6230	.7184 .7192	.6242 .6270	1/4	10DU04	1/2	10DU08	5/8	10DU10	3/4	10DU12	7/8	10DU14	1	10DU16
11/16	.6865 .6855	.7809 .7817	.6867 .6895	7/8	11DU14										
3/4	.7491 .7479	.8747 .8755	.7493 .7525	1/4	12DU04	3/8	12DU06	1/2	12DU08	5/8	12DU10	3/4	12DU12	1	12DU16
13/16	.8116 .8104	.9372 .9380	.8118 .8150	3/4	13DU12	1 1/8	13DU18								
7/8	.8741 .8729	.9997 1.0005	.8743 .8775	1/4	14DU04	3/8	14DU06	3/4	14DU12	1	14DU16	1 1/4	14DU20		
1	.9991 .9979	1.1247 1.1255	.9993 1.0025	3/8	16DU06	1/2	16DU08	3/4	16DU12	1	16DU16	1 1/4	16DU20	1 1/2	16DU24
1 1/8	1.1238 1.1226	1.2808 1.2818	1.1240 1.1278	3/8	18DU06	5/8	18DU10	3/4	18DU12	1	18DU16				
1 1/4	1.2488 1.2472	1.4058 1.4068	1.2490 1.2528	3/8	20DU06	3/4	20DU12	7/8	20DU14	1	20DU16	1 1/4	20DU20	1 3/4	20DU28
1 3/8	1.3738 1.3722	1.5308 1.5318	1.3740 1.3778	3/4	22DU12	1	22DU16	1 1/2	22DU24	1 3/4	22DU28				
1 1/2	1.4988 1.4972	1.6558 1.6568	1.4990 1.5028	1/2	24DU08	1	24DU16	1 1/8	24DU18	1 1/4	24DU20	1 1/2	24DU24	2	24DU32
1 5/8	1.6238 1.6222	1.7808 1.7818	1.6240 1.6278	1	26DU16	1 1/2	26DU24								
1 3/4	1.7487 1.7471	1.9371 1.9381	1.7489 1.7535	1	28DU16	1 1/2	28DU24	2	28DU32						
1 7/8	1.8737 1.8721	2.0621 2.0633	1.8739 1.8787	3/4	30DU12	1	30DU16	2 1/4	30DU36						
2	1.9987 1.9969	2.1871 2.1883	1.9989 2.0037	1/2	32DU08	1	32DU16	1 1/2	32DU24	1 3/4	32DU28	2	32DU32	2 1/2	32DU40

*When installed in a rigid steel or cast-iron housing. See page 6-2.

*When installed in a rigid steel or cast-iron housing. See page 6-2.



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DU®

DU® Bearings Inch Sizes Over 2"

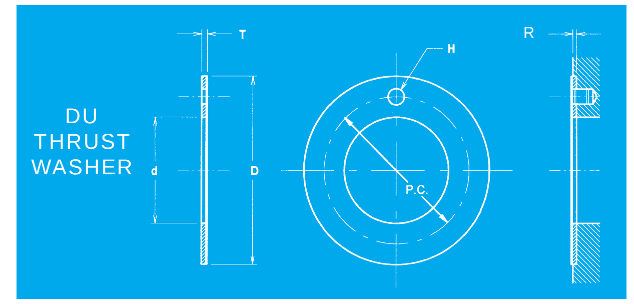
Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.*	Bearing Length and Part Number																			
2 1/8	2.1257 2.1239	2.3118 2.3130	2.1262 2.1326	3	34DU48																		
2 1/4	2.2507 2.2489	2.4365 2.4377	2.2509 2.2573	1 3/4	36DU28	2	36DU32	2 1/2	36DU40	3	36DU48	3 1/2	36DU56	3 3/4	36DU60	4	36DU64	4 1/2	36DU72				
2 1/2	2.5011 2.4993	2.6869 2.6881	2.5013 2.5077	1	40DU16	1 5/8	40DU26	2	40DU32	2 1/2	40DU40	3	40DU48	3 1/2	40DU56	3 3/4	40DU60	4	40DU64	4 1/2	40DU72	4 3/4	40DU76
2 3/4	2.7500 2.7482	2.9358 2.9370	2.7502 2.7566	2	44DU32	2 1/4	44DU36	2 1/2	44DU40	3	44DU48	3 1/2	44DU56	3 3/4	44DU60	4	44DU64	4 1/2	44DU72	4 3/4	44DU76	5	44DU80
2 7/8	2.8752 2.8734	3.0610 3.0623	2.8754 2.8819	2	46DU32	2 1/4	46DU36	2 1/2	46DU40	3	46DU48	3 1/2	46DU56	3 3/4	46DU60	4	46DU64	4 1/2	46DU72	4 3/4	46DU76	5	46DU80
3	3.0000 2.9982	3.1858 3.1872	3.0002 3.0068	2	48DU32	2 1/4	48DU36	2 1/2	48DU40	3	48DU48	3 1/2	48DU56	3 3/4	48DU60	4	48DU64	4 1/2	48DU72	4 3/4	48DU76	5	48DU80
3 1/4	3.2500 3.2480	3.4358 3.4372	3.2502 3.2568	2	52DU32	2 3/8	52DU38	2 1/2	52DU40	3	52DU48	3 1/2	52DU56	3 3/4	52DU60	4	52DU64	4 1/2	52DU72	4 3/4	52DU76	5	52DU80
3 1/2	3.5000 3.4978	3.6858 3.6872	3.5002 3.5068	2	56DU32	2 3/8	56DU38	2 1/2	56DU40	3	56DU48	3 1/2	56DU56	3 3/4	56DU60	4	56DU64	4 1/2	56DU72	4 3/4	56DU76	5	56DU80
3 5/8	3.6250 3.6228	3.8108 3.8122	3.6252 3.6318	2	58DU32	2 1/4	58DU36	2 1/2	58DU40	3	58DU48	3 1/2	58DU56	3 3/4	58DU60	4	58DU64	4 1/2	58DU72	4 3/4	58DU76	5	58DU80
3 3/4	3.7500 3.7478	3.9358 3.9372	3.7502 3.7568	2	60DU32	2 1/4	60DU36	2 1/2	60DU40	3	60DU48	3 1/2	60DU56	3 3/4	60DU60	4	60DU64	4 1/2	60DU72	4 3/4	60DU76	5	60DU80
4	4.0000 3.9978	4.1858 4.1872	4.0002 4.0068	2	64DU32	2 1/4	64DU36	2 1/2	64DU40	3	64DU48	3 1/2	64DU56	3 3/4	64DU60	4	64DU64	4 1/2	64DU72	4 3/4	64DU76	5	64DU80
4 1/4	4.2500 4.2478	4.4358 4.4372	4.2502 4.2568	2	68DU32	2 1/4	68DU36	2 1/2	68DU40	3	68DU48	3 1/2	68DU56	3 3/4	68DU60	4	68DU64	4 1/2	68DU72	4 3/4	68DU76	5	68DU80
4 3/8	4.3750 4.3728	4.5608 4.5622	4.3752 4.3818	2	70DU32	2 1/4	70DU36	2 1/2	70DU40	3	70DU48	3 1/2	70DU56	3 3/4	70DU60	4	70DU64	4 1/2	70DU72	4 3/4	70DU76	5	70DU80
4 1/2	4.5000 4.4978	4.6858 4.6872	4.5002 4.5068	2	72DU32	2 1/4	72DU36	2 1/2	72DU40	3	72DU48	3 1/2	72DU56	3 3/4	72DU60	4	72DU64	4 1/2	72DU72	4 3/4	72DU76	5	72DU80
4 3/4	4.7500 4.7475	4.9358 4.9374	4.7502 4.7572	2	76DU32	2 1/4	76DU36	2 1/2	76DU40	3	76DU48	3 1/2	76DU56	3 3/4	76DU60	4	76DU64	4 1/2	76DU72	4 3/4	76DU76	5	76DU80
5	4.9986 4.9961	5.1844 5.1860	4.9988 5.0056	2	80DU32	2 1/4	80DU36	2 1/2	80DU40	3	80DU48	3 1/2	80DU56	3 3/4	80DU60	4	80DU64	4 1/2	80DU72	4 3/4	80DU76	5	80DU80
5 1/4	5.2500 5.2475	5.4358 5.4374	5.2502 5.2570	2	84DU32	2 1/4	84DU36	2 1/2	84DU40	3	84DU48	3 1/2	84DU56	3 3/4	84DU60	4	84DU64	4 1/2	84DU72	4 3/4	84DU76	5	84DU80
5 1/2	5.5000 4.4975	5.6858 5.6874	5.5002 5.5070	2	88DU32	2 1/4	88DU36	2 1/2	88DU40	3	88DU48	3 1/2	88DU56	3 3/4	88DU60	4	88DU64	4 1/2	88DU72	4 3/4	88DU76	5	88DU80
5 3/4	5.7500 5.7475	5.9358 5.9374	5.7502 5.7570	2	92DU32	2 1/4	92DU36	2 1/2	92DU40	3	92DU48	3 1/2	92DU56	3 3/4	92DU60	4	92DU64	4 1/2	92DU72	4 3/4	92DU76	5	92DU80
6	6.0000 5.9975	6.1858 6.1874	6.0002 6.0070	2	96DU32	2 1/4	96DU36	2 1/2	96DU40	3	96DU48	3 1/2	96DU56	3 3/4	96DU60	4	96DU64	4 1/2	96DU72	4 3/4	96DU76	5	96DU80
6 1/4	6.2500 6.2475	6.4358 6.4374	6.2502 6.2570	2	100DU32	2 1/4	100DU36	2 1/2	100DU40	3	100DU48	3 1/2	100DU56	3 3/4	100DU60	4	100DU64	4 1/2	100DU72	4 3/4	100DU76	5	100DU80
6 1/2	6.5000 6.4975	6.6858 6.6874	6.5002 6.5070	2	104DU32	2 1/4	104DU36	2 1/2	104DU40	3	104DU48	3 1/2	104DU56	3 3/4	104DU60	4	104DU64	4 1/2	104DU72	4 3/4	104DU76	5	104DU80
6 3/4	6.7500 6.7475	6.9358 6.9374	6.7502 6.7570	2	108DU32	2 1/4	108DU36	2 1/2	108DU40	3	108DU48	3 1/2	108DU56	3 3/4	108DU60	4	108DU64	4 1/2	108DU72	4 3/4	108DU76	5	108DU80
7	6.9954 6.9929	7.1812 7.1830	6.9956 7.0026	2	112DU32	2 1/4	112DU36	2 1/2	112DU40	3	112DU48	3 1/2	112DU56	3 3/4	112DU60	4	112DU64	4 1/2	112DU72	4 3/4	112DU76	5	112DU80

*When installed in a rigid steel or cast-iron housing. See page 6-2.

*When installed in a rigid steel or cast-iron housing. See page 6-2.

DU® Thrust Washers Inch Sizes

Part Number	Inside Dia. +.010 d	Outside Dia. −.010 D	Thickness +.0020 T	Dowel Hole Dia. +.010 H	Dowel Hole Pitch Circle Dia. −.010 P.C.	Housing Recess Depth +.010 R
G06DU	.500	.875	.0585	.067	.692	.040
G07DU	.562	1.000	.0585	.067	.786	.040
G08DU	.625	1.125	.0585	.099	.880	.040
G09DU	.687	1.187	.0585	.099	.942	.040
G10DU	.750	1.250	.0585	.099	1.005	.040
G11DU	.812	1.375	.0585	.099	1.099	.040
G12DU	.875	1.500	.0585	.130	1.192	.040
G13DU	.937	1.625	.0585	.130	1.286	.040
G14DU	1.000	1.750	.0585	.130	1.380	.040
G16DU	1.125	2.000	.0585	.161	1.567	.040
G18DU	1.250	2.125	.0585	.161	1.692	.040
G20DU	1.375	2.250	.0585	.161	1.817	.040
G22DU	1.500	2.500	.0585	.192	2.005	.040
G24DU	1.625	2.625	.0585	.192	2.130	.040
G26DU	1.750	2.750	.0585	.192	2.255	.040
G28DU	2.000	3.000	.0895	.192	2.505	.070
G30DU	2.125	3.125	.0895	.192	2.630	.070
G32DU	2.250	3.250	.0895	.192	2.755	.070



DU® Flat Strip Material Inch Sizes

Group	Thickness	Usable Width	Approx. Lbs. Per Ft.
0	.0276/.0296	4 5/8	.50
1	.0430/.0450	5 1/8	.83
2	.0585/.0605	5	1.06
3	.0738/.0758	5	1.33
4	.0895/.0915	5	1.61
5	.1190/.1210	5 1/2	2.36

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DU®

DU® Bearings Metric Sizes

Ordering Information

To determine Part Number, read down the first column to find the desired Bearing Bore, and across to the desired Bearing Length in a tinted column; the Part Number is shown to the right. Part Numbers are expressed in millimeters, bore x length.

For example:
MB0608DU = 6 mm bore x
8 mm length.

Length Tolerances

Up to and including 10 mm I.D. or length — ±0.38 mm.

Above 10 mm I.D. or length — ±0.25 mm.

Chamfers

Bearings between 10 mm and 50 mm diameter and lengths of 10 mm or more are normally furnished with 0.38/1.19 mm x 12º/28º chamfers. All other bearings will have deburred edges, unless otherwise specified.

Special Bearings

Special Lengths
In addition to the lengths listed, DU bearings over 50 mm I.D. or larger can be supplied in any desired length from 13 to 150 mm.

Special Diameters
DU bearings can be produced in any diameter from 3 mm and over, and up to 150 mm in length. In addition, DU bearings with heavier or thinner walls than shown can be furnished.

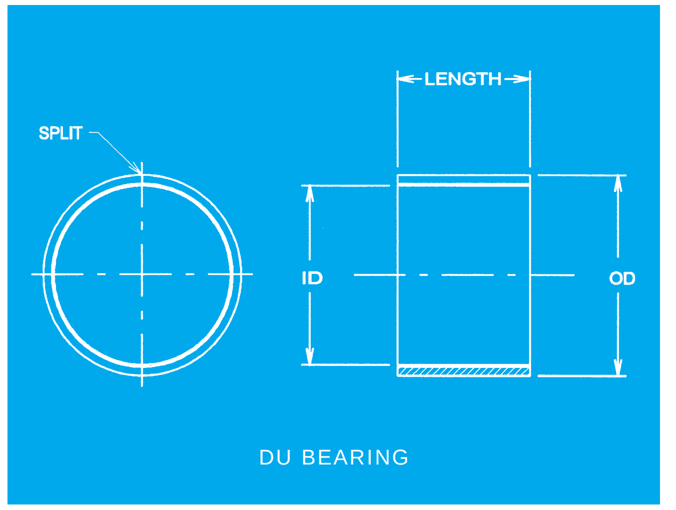
Please consult the Garlock Bearings Marketing Department about special bearings and any partial tooling charges that may be required.

DU® Bearings Metric Sizes Up to 45 mm

Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.*	Bearing Length and Part Number						Bearing Length and Part Number					
2	2.000 1.994	3.500 3.508	2.000 2.048	3	MB 0203DU	5	MB 0205DU								
3	3.000 2.994	4.500 4.508	3.000 3.048	3	MB 0303DU	5	MB 0305DU	6	MB 0306DU						
4	4.000 3.992	5.500 5.508	4.000 4.048	3	MB 0403DU	4	MB 0404DU	6	MB 0406DU	10	MB 0410DU				
5	4.990 4.978	7.000 7.015	4.990 5.055	5	MB 0505DU	8	MB 0508DU	10	MB 0510DU						
6	5.990 5.978	8.000 8.015	5.990 6.055	6	MB 0606DU	8	MB 0608DU	10	MB 0610DU						
7	6.987 6.972	9.000 9.015	6.990 7.055	10	MB 0710DU										
8	7.987 7.972	10.000 10.015	7.990 8.055	8	MB 0808DU	10	MB 0810DU	12	MB 0812DU						
10	9.987 9.972	12.000 12.018	9.990 10.058	8	MB 1008DU	10	MB 1010DU	12	MB 1012DU	15	MB 1015DU	20	MB 1020DU		
12	11.984 11.966	14.000 14.018	11.990 12.058	8	MB 1208DU	10	MB 1210DU	12	MB 1212DU	15	MB 1215DU	20	MB 1220DU	25	MB 1225DU
13	12.984 12.966	15.000 15.018	12.990 13.058	10	MB 1310DU	20	MB 1320DU								
14	13.984 13.966	16.000 16.018	13.990 14.058	5	MB 1405DU	10	MB 1410DU	12	MB 1412DU	15	MB 1415DU	20	MB 1420DU	25	MB 1425DU
15	14.984 14.966	17.000 17.018	14.990 15.058	10	MB 1510DU	12	MB 1512DU	15	MB 1515DU	20	MB 1520DU	25	MB 1525DU		
16	15.984 15.966	18.000 18.018	15.990 16.058	10	MB 1610DU	12	MB 1612DU	15	MB 1615DU	20	MB 1620DU	25	MB 1625DU		
17	16.984 16.966	19.000 19.021	16.990 17.061	20	MB 1720DU										
18	17.984 17.966	20.000 20.021	17.990 18.061	15	MB 1815DU	20	MB 1820DU	25	MB 1825DU						
20	19.980 19.959	23.000 23.021	19.990 20.062	10	MB 2010DU	15	MB 2015DU	20	MB 2020DU	25	MB 2025DU	30	MB 2030DU		
22	21.980 21.959	25.000 25.021	21.990 22.071	15	MB 2215DU	20	MB 2220DU	25	MB 2225DU	30	MB 2230DU				
24	23.980 23.959	27.000 27.021	23.990 24.071	15	MB 2415DU	20	MB 2420DU	25	MB 2425DU	30	MB 2430DU				
25	24.980 24.959	28.000 28.021	24.990 25.071	15	MB 2515DU	20	MB 2520DU	25	MB 2525DU	30	MB 2530DU	50	MB 2550DU		
28	27.980 27.959	32.000 32.025	27.990 28.085	15	MB 2815DU	20	MB 2820DU	25	MB 2825DU	30	MB 2830DU				
30	29.980 29.959	34.000 34.025	29.990 30.085	15	MB 3015DU	20	MB 3020DU	25	MB 3025DU	30	MB 3030DU	40	MB 3040DU		
32	31.975 31.950	36.000 36.025	31.990 32.085	20	MB 3220DU	30	MB 3230DU	40	MB 3240DU						
35	34.975 34.950	39.000 39.025	34.990 35.085	20	MB 3520DU	30	MB 3530DU	35	MB 3535DU	40	MB 3540DU	50	MB 3550DU		
37	36.975 36.950	41.000 41.025	36.990 37.085	20	MB 3720DU										
40	39.975 39.950	44.000 44.025	39.990 40.085	20	MB 4020DU	30	MB 4030DU	40	MB 4040DU	50	MB 4050DU				
45	44.975 44.950	50.000 50.025	44.990 45.105	20	MB 4520DU	30	MB 4530DU	40	MB 4540DU	45	MB 4545DU	50	MB 4550DU		

*When installed in a rigid steel or cast-iron housing. See page 6-2.

*When installed in a rigid steel or cast-iron housing. See page 6-2.



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DU®

DU® Bearings
Metric Sizes Over 45 mm

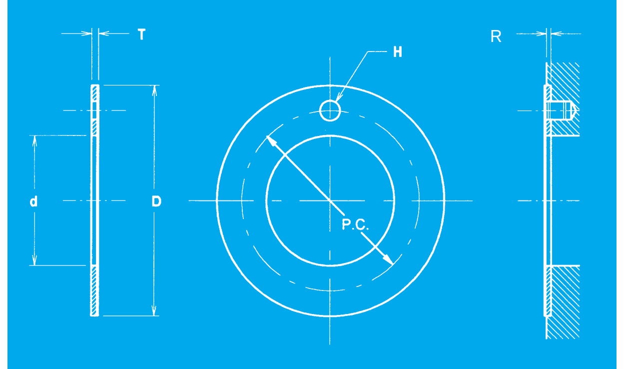
Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.*	Bearing Length and Part Number									
50	49.975 49.950	55.000 55.030	49.990 50.110	20	MB 5020DU	30	MB 5030DU	40	MB 5040DU	50	MB 5050DU	60	MB 5060DU
55	54.970 54.940	60.000 60.030	54.990 55.110	20	MB 5520DU	30	MB 5530DU	40	MB 5540DU	55	MB 5555DU	60	MB 5560DU
60	59.970 59.940	65.000 65.030	59.990 60.110	20	MB 6020DU	30	MB 6030DU	40	MB 6040DU	60	MB 6060DU	70	MB 6070DU
65	64.970 64.940	70.000 70.030	64.990 65.110	30	MB 6530DU	50	MB 6550DU	70	MB 6570DU				
70	69.970 69.940	75.000 75.030	69.990 70.110	40	MB 7040DU	50	MB 7050DU	70	MB 7070DU				
75	74.970 74.940	80.000 80.030	74.990 75.110	60	MB 7560DU	80	MB 7580DU						
80	80.000 79.954	85.000 85.035	80.010 80.145	60	MB 8060DU	100	MB 80100DU						
85	85.000 84.946	90.000 90.035	85.010 85.145	30	MB 8530DU	60	MB 8560DU	100	MB 85100DU				
90	90.000 89.946	95.000 95.035	90.010 90.145	60	MB 9060DU	100	MB 90100DU						
95	95.000 94.946	100.000 100.035	95.010 95.145	60	MB 9560DU	100	MB 95100DU						
100	100.000 99.946	105.000 105.035	100.010 100.145	60	MB 10060DU	115	MB 100115DU						
105	105.000 104.946	110.000 110.035	105.010 105.145	60	MB 10560DU	115	MB 105115DU						
110	110.000 109.946	115.000 115.035	110.010 110.145	60	MB 11060DU	115	MB 110115DU						
115	115.000 114.946	120.000 120.035	115.010 115.145	50	MB 11550DU	70	MB 11570DU						
120	120.000 119.946	125.000 125.040	120.048 120.220	50	MB 12050DU	60	MB 12060DU	100	MB 120100DU				
125	125.000 124.937	130.000 130.040	125.048 125.220	100	MB 125100DU								
130	130.000 129.937	135.000 135.040	130.048 130.220	60	MB 13060DU	100	MB 130100DU						
135	135.000 134.937	140.000 140.040	135.048 135.220	60	MB 13560DU	80	MB 13580DU						
140	140.000 139.937	145.000 145.040	140.048 140.220	60	MB 14060DU	100	MB 140100DU						
150	150.000 149.937	155.000 155.040	150.048 150.220	60	MB 15060DU	80	MB 15080DU	100	MB 150100DU				
160	160.000 159.937	165.000 165.040	160.048 160.220	80	MB 16080DU	100	MB 160100DU						
180	180.000 179.937	185.000 185.046	180.048 180.226	100	MB 180100DU								
200	200.000 199.928	205.000 205.046	200.048 200.226	100	MB 200100DU								
210	210.000 209.928	215.000 215.046	210.048 210.226	100	MB 210100DU								
220	220.000 219.928	225.000 225.046	220.048 220.226	100	MB 220100DU								
250	250.000 249.928	255.000 255.052	250.048 250.232	100	MB 250100DU								
300	300.000 299.919	305.000 305.052	300.048 300.232	100	MB 300100DU								

*When installed in a rigid steel or cast-iron housing. See page 6-2.

*When installed in a rigid steel or cast-iron housing. See page 6-2.

DU® Thrust Washers
Metric Sizes

Part Number	Inside Dia. +.25 d	Outside Dia. −.25 D	Thickness +.05 T	Dowel Hole Dia. +.25 H	Dowel Hole Pitch Circle Dia. −.24 P.C.	Housing Recess Depth +.25 R
WC08DU	10.00	20.00	1.45	—	—	.95
WC10DU	12.00	24.00	1.45	1.625	18.12	.95
WC12DU	14.00	26.00	1.45	2.125	20.12	.95
WC14DU	16.00	30.00	1.45	2.125	22.12	.95
WC16DU	18.00	32.00	1.45	2.125	25.12	.95
WC18DU	20.00	36.00	1.45	3.125	28.12	.95
WC20DU	22.00	38.00	1.45	3.125	30.12	.95
WC22DU	24.00	42.00	1.45	3.125	33.12	.95
WC24DU	26.00	44.00	1.45	3.125	35.12	.95
WC25DU	28.00	48.00	1.45	4.125	38.12	.95
WC30DU	32.00	54.00	1.45	4.125	43.12	.95
WC35DU	38.00	62.00	1.45	4.125	50.12	.95
WC40DU	42.00	66.00	1.45	4.125	54.12	.95
WC45DU	48.00	74.00	1.95	4.125	61.12	1.45
WC50DU	52.00	78.00	1.95	4.125	65.12	1.45
WC60DU	62.00	90.00	1.95	4.125	76.12	1.45



DU THRUST WASHER

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DU® Flanged Bearings Inch and Metric Sizes

Ordering Information

To determine Part Number, read down the first column to find the desired Bearing Bore, and across to the desired Bearing Length in a tinted column; the Part Number is shown to the right. Part Numbers are expressed in 1/16 inch increments (inch series) or in 1 millimeter increments (metric series), bore x length.

For example:
12FDU08 = 3/4 inch bore x 1/2 inch length.
or
FMB1512DU = 15 mm bore x 12 mm length.

Length Tolerances

+0.010 inch (0.25 mm) / -0.020 inch (0.50 mm).

Flange O.D. Tolerances

Up to and including 1 inch or 25 mm nominal bearing I.D. — ±0.020 inch (±0.50 mm).

Over 1 inch or 25 mm nominal bearing I.D. — ±0.030 inch (±0.75 mm).

Chamfers

Standard flanged DU bearings are supplied with 0.015/0.047 inch (0.38/1.19 mm) x 12º/28º chamfers.

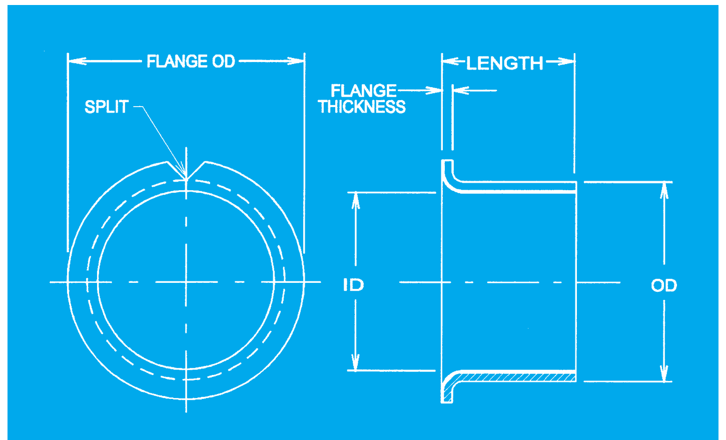
Special Bearings

Please consult the Garlock Bearings Marketing Department about special bearings and any partial tooling charges that may be required.

DU® Flanged Bearings Inch Sizes

Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.*	Nominal Flange O.D.	Flange Thick-ness	Bearing Length and Part Number							
3/8	.3750 .3740	.4684 .4691	.3752 .3779	11/16	.052 .044	1/4	06FDU04	3/8	06FDU06	1/2	06FDU08	3/4	06FDU12
1/2	.5000 .4990	.5934 .5941	.5002 .5029	13/16	.052 .044	1/4	08FDU04	3/8	08FDU06	1/2	08FDU08	3/4	08FDU12
5/8	.6250 .6240	.7184 .7192	.6252 .6280	15/16	.052 .044	3/8	10FDU06	1/2	10FDU08	5/8	10FDU10	3/4	10FDU12
3/4	.7500 .7488	.8747 .8755	.7502 .7534	1 1/8	.068 .060	3/8	12FDU06	1/2	12FDU08	3/4	12FDU12	1	12FDU16
7/8	.8750 .8738	0.9997 1.0005	.8752 .8784	1 1/4	.068 .060	1/2	14FDU08	3/4	14FDU12	1	14FDU16	1 1/4	14FDU20
1	1.0000 0.9988	1.1247 1.1255	1.0002 1.0034	1 3/8	.068 .060	1/2	16FDU08	3/4	16FDU12	1	16FDU16	1 1/4	16FDU20
1 1/4	1.2500 1.2484	1.4058 1.4068	1.2502 1.2540	1 3/4	.083 .075	1	20FDU16	1 1/4	20FDU20	1 1/2	20FDU24		
1 1/2	1.5000 1.4984	1.6558 1.6568	1.5002 1.5040	2	.083 .075	1	24FDU16	1 1/2	24FDU24	2	24FDU32		
1 3/4	1.7500 1.7484	1.9371 1.9381	1.7502 1.7548	2 3/8	.098 .090	1	28FDU16	1 1/2	28FDU24	2	28FDU32		

*When installed in a rigid steel or cast-iron housing. See page 6-2.



DU FLANGED BEARING

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DU® Flanged Bearings Metric Sizes

Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.*	Nominal Flange O.D.	Flange Thick-ness	Bearing Length and Part Number							
6	5.990 5.978	8.000 8.015	5.990 6.055	12	1.00 .80	4	FMB 0604DU	8	FMB 0608DU				
8	7.987 7.972	10.000 10.015	7.990 8.055	15	1.00 .80	5.5	FMB 0805.5DU	7.5	FMB 0807.5DU	9.5	FMB 0809.5DU		
10	9.987 9.972	12.000 12.018	9.990 10.058	18	1.00 .80	7	FMB 1007DU	9	FMB 1009DU	12	FMB 1012DU	17	FMB 1017DU
12	11.984 11.966	14.000 14.018	11.990 12.058	20	1.00 .80	7	FMB 1207DU	9	FMB 1209DU	12	FMB 1212DU	17	FMB 1217DU
14	13.984 13.966	16.000 16.018	13.990 14.058	22	1.00 .80	12	FMB 1412DU	17	FMB 1417DU				
15	14.984 14.966	17.000 17.018	14.990 15.058	23	1.00 .80	9	FMB 1509DU	12	FMB 1512DU	17	FMB 1517DU		
16	15.984 15.966	18.000 18.018	15.990 16.058	24	1.00 .80	12	FMB 1612DU	17	FMB 1617DU				
18	17.984 17.966	20.000 20.021	17.990 18.061	26	1.00 .80	12	FMB 1812DU	17	FMB 1817DU	22	FMB 1822DU		
20	19.980 19.959	23.000 23.021	19.990 20.062	30	1.50 1.30	11.5	FMB 2011.5DU	16.5	FMB 2016.5DU	21.5	FMB 2021.5DU		
25	24.980 24.959	28.000 28.021	24.990 25.071	35	1.50 1.30	11.5	FMB 2511.5DU	16.5	FMB 2516.5DU	21.5	FMB 2521.5DU		
30	29.980 29.959	34.000 34.025	29.990 30.085	42	2.00 1.80	16	FMB 3016DU	26	FMB 3026DU				
35	34.975 34.950	39.000 39.025	34.990 35.085	47	2.00 1.80	16	FMB 3516DU	26	FMB 3526DU				
40	39.975 39.950	44.000 44.025	39.990 40.085	52	2.00 1.80	16	FMB 4016DU	26	FMB 4026DU				

*When installed in a rigid steel or cast-iron housing. See page 6-2.

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DX™ Bearings Inch Sizes

Ordering Information

To determine Part Number, read down the first column to find the desired Bearing Bore and across to the desired Bearing Length in a tinted column; the Part Number is shown to the right. Part Numbers are expressed in 1/16 inch increments, bore x length.

For example:
012DXR016 = 3/4 inch bore x 1 inch length.

Length Tolerances

The length tolerance for all DX bearings is ±0.010 inch.

Special Diameters and Lengths

DX bearings can be produced in any diameter from 1/2 inch to 30 inches or more, and up to 5 inches in length. Consult Garlock Bearings for details.

Chamfers

DX bearings between 1/2 inch and 2 inches in diameter and lengths of 3/8 to 3 inches are normally furnished with 0.015/0.047 inch x 12º/28º machine chamfers. All other DX bearings will have deburred edges, unless otherwise specified.

Metric Sizes

Metric sizes are available by special order.

DX™ Bearings Inch Sizes

Nominal Bearing Bore	Recommended Shaft Dia.	Recommended Housing Bore	Installed Bearing I.D.	Bearing Length ±0.010" and Part Number							
1/2	.5000 .4990	.6345 .6352	.5007 .5038	3/8	008DXR006	1/2	008DXR008				
5/8	.6250 .6240	.7596 .7604	.6258 .6290	5/8	010DXR010	3/4	010DXR012				
3/4	.7500 .7488	.8846 .8854	.7508 .7540	3/4	012DXR012	1	012DXR016				
7/8	.8750 .8738	1.0097 1.0105	.8759 .8791	3/4	014DXR012	1	014DXR016				
1	1.0000 0.9988	1.1348 1.1356	1.0010 1.0042	3/4	016DXR012	1	016DXR016				
1 1/8	1.1250 1.1238	1.2598 1.2606	1.1260 1.1292	3/4	018DXR012	1	018DXR016				
1 1/4	1.2500 1.2484	1.4160 1.4170	1.2512 1.2550	3/4	020DXR012	1	020DXR016				
1 3/8	1.3750 1.3734	1.5410 1.5420	1.3762 1.3800	1	022DXR016	1 1/2	022DXR024				
1 1/2	1.5000 1.4984	1.6660 1.6670	1.5012 1.5050	1	024DXR016	1 1/2	024DXR024	2	024DXR032		
1 5/8	1.6250 1.6234	1.7910 1.7920	1.6262 1.6300	1	026DXR016	1 1/2	026DXR024	2	026DXR032		
1 3/4	1.7500 1.7484	1.9371 1.9381	1.7515 1.7577	1	028DXR016	1 1/2	028DXR024	2	028DXR032		
1 7/8	1.8750 1.8734	2.0621 2.0633	1.8765 1.8829	1	030DXR016	1 1/2	030DXR024	2	030DXR032	2 1/4	030DXR036
2	2.0000 1.9982	2.1871 2.1883	2.0015 2.0079	1	032DXR016	1 1/2	032DXR024	2	032DXR032		
2 1/2	2.5000 2.4982	2.6871 2.6883	2.5015 2.5079	1 1/2	040DXR024	2	040DXR032	2 1/2	040DXR040		
3	3.0000 2.9982	3.1875 3.1889	3.0019 3.0085	1 1/2	048DXR024	2	048DXR032	2 1/2	048DXR040	3	048DXR048

Lubrication Holes: 016DXR and larger have a 5/16" diameter hole; all others have a 5/32" diameter hole.

Sizes and Ordering: Inch Sizes
Prelubricated Bearings
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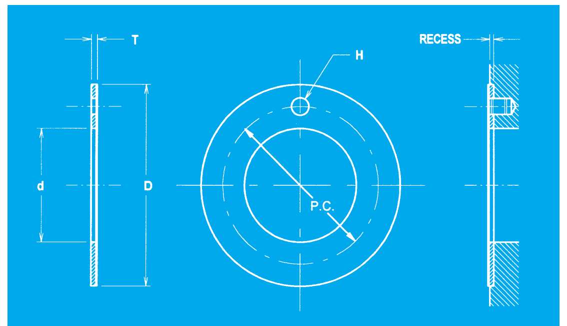
DX™

DX™ Thrust Washers Inch Sizes

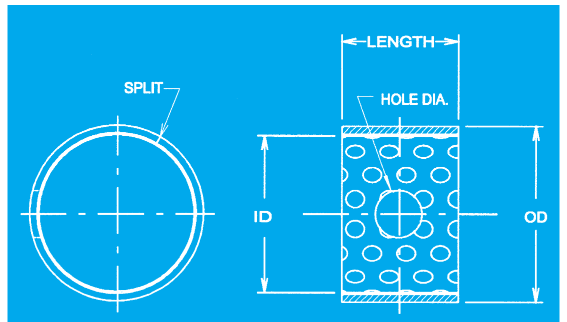
Part Number	Inside Diameter d	Outside Diameter D	Effective Wall Thickness T	Dowel Hole Diameter H	Dowel Hole Pitch Circle Diameter P.C.	Housing Recess Depth R
G08DXR	.625 .635	1.125 1.115	.0660 .0625	.099 .109	.870 .880	.040 .050
G10DXR	.750 .760	1.250 1.240	.0660 .0625	.099 .109	.995 1.005	.040 .050
G12DXR	.875 .885	1.500 1.490	.0660 .0625	.130 .140	1.182 1.192	.040 .050
G14DXR	1.000 1.010	1.750 1.740	.0660 .0625	.130 .140	1.370 1.380	.040 .050
G16DXR	1.125 1.135	2.000 1.990	.0660 .0625	.161 .171	1.557 1.567	.040 .050
G18DXR	1.250 1.260	2.125 2.115	.0660 .0625	.161 .171	1.682 1.692	.040 .050
G20DXR	1.375 1.385	2.250 2.240	.0660 .0625	.161 .171	1.807 1.817	.040 .050
G22DXR	1.500 1.510	2.500 2.490	.0660 .0625	.192 .202	1.995 2.005	.040 .050
G24DXR	1.625 1.635	2.625 2.615	.0660 .0625	.192 .202	2.120 2.130	.040 .050
G26DXR	1.750 1.760	2.750 2.740	.0660 .0625	.192 .202	2.245 2.255	.040 .050
G28DXR	2.000 2.010	3.000 2.990	.0930 .0895	.192 .202	2.495 2.505	.070 .080
G30DXR	2.125 2.135	3.125 3.115	.0930 .0895	.192 .202	2.620 2.630	.070 .080
G32DXR	2.250 2.260	3.250 3.240	.0930 .0895	.192 .202	2.745 2.755	.070 .080



DX THRUST WASHER

DX™ Flat Strip Material Inch Sizes

Group	Thickness	Usable Width	Approx. Lbs.Per Ft.
7	.0625/.0660	4 3/4	0.94
8	.0780/.0815	5	1.23
9	.0895/.0930	5	1.41



DX BEARING

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Notes

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DU® DATA for DESIGNERS

The information in this catalog enables the design engineer to establish parameters for maximum performance in the application and to estimate the expected life of the product.

Our Applications Engineers will provide additional technical service to assist with unusual design problems. Garlock Bearings can provide a computer program to assist you in the analysis and specification of DU bearings. Contact the Applications Engineering Department for details.

Technical Information

Thermal properties

DU bearings can be used in ambient temperatures between -328°F and +536°F (-200 and +280°C). As the operating temperature increases, the wear life of the bearing is decreased, but the reliability of the product is maintained.

Heat is generated in all bearings even when lightly loaded. Without lubrication, this heat must be transmitted through the bearing and dissipated by the housing. The DU composite structure provides both high thermal conductivity and the thermal expansion rate of steel.

The poor heat conductivity of solid plastic bearings or bearing housings is the main factor limiting their use for self-lubricated bearing assemblies. When heat is not dissipated rapidly, high thermal expansion rates can cause the bearing to close in and seize on the shaft. With a plastic bearing in a metal housing, heat will affect the plastic material in such a way that housing retention is lost.

Table 4-1: Physical Properties of DU Bearing Material

Yield strength in compression as measured on a 1 inch (25.4 mm) diameter disc	Approximately 44,000 psi (300 N/mm^2)
Coefficient of linear expansion parallel to surface	6 x 10^{-6}/°F (11 x 10^{-6}/°C)
Coefficient of linear expansion at right angles to surface on 0.075 inch (1.91 mm) strip	17 x 10^{-6}/°F (30 x 10^{-6}/°C)
Thermal conductivity after bedding-in measured at right angles to surface	288 BTU/(hr.)(ft.^{2})(°F/in.) (40 W/m K)

Corrosion protection

The exposed backing and end faces of standard DU bearings and thrust washers are tin flashed for protection in mildly corrosive surroundings. If exposed to corrosive liquids, further protection should be provided by electroplating with corrosion-resistant metals. In very corrosive conditions where plating is inadequate, DU material can be furnished with a bronze backing, DU(B). Consult our Applications Engineering Department regarding corrosion preventive coatings or DU(B).

Zinc-chromate plating is beneficial in applications where the bearings will be exposed to outdoor conditions.

When electrolytic (galvanic) corrosion is possible, tests should be conducted to ensure that all materials in the bearing environment are mutually compatible.

Electrical resistance

Unlike solid plastic bearing materials, DU is a good conductor of electricity. The electrical resistance of a DU bearing assembly will depend upon the bearing pressure and contact area. In general, it is in the region of 6 to 60 ohms/inch^2 (1 to 10 ohms/cm^2) of contact area.

No static electricity phenomena have been observed with DU bearing material.

DU® Data for Designers
Self-Lubricating Bearings
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DU®

Wear pattern of DU®

During normal operation, a DU bearing quickly beds in and the overlay material removed during this period—an average of 0.0005 inch (0.013 mm) thick—is transferred to the mating surface and forms a physically bonded lubricant film. The rubbing surface of the bearing often acquires a grey-green color, and the bronze matrix is exposed over at least 10% of the bearing surface. Any excess of the PTFE-lead surface layer will be shed as fine, feathery particles.

Following the bedding-in period, the wear rate becomes extremely low and the percentage of bronze exposed gradually increases. After an extended period of operation, the wear rate increases as the component approaches the end of its useful life as a self-lubricating bearing. At this stage, at least 70% of the bearing surface will be exposed bronze, and approximately 0.002 inch (0.05 mm) additional radial wear will have occurred (Figure 4-1).

Wear of mating surfaces

There is no measurable wear of mating surfaces made from recommended materials unless a DU bearing is operated beyond its useful life span or becomes seriously contaminated with abrasive particles.

Effect of contamination

Generally, DU bearings are more tolerant of dirt-laden environments than lubricated bearings since there is no capillary action to entrain abrasive particles.

Dirt is, of course, undesirable in any bearing, and the longest life and most satisfactory performance will be achieved if abrasive particles are, as far as possible, prevented from reaching the bearing surfaces. This can often be achieved by suitable design of the housing or by the provision of a simple seal or shield.

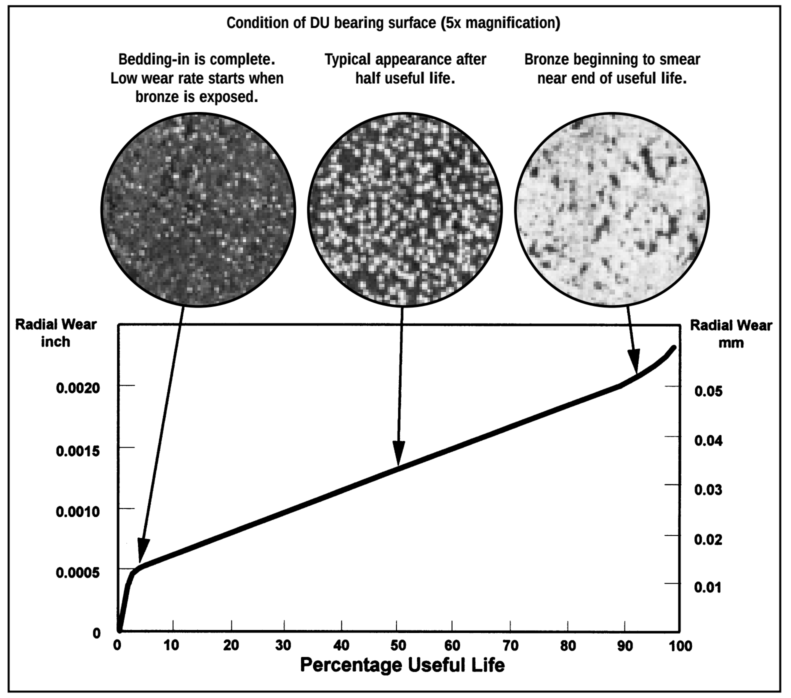

Figure 4-1. Effect of Wear on DU Bearing Surface

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Fretting corrosion

The type of rapid wear known as “fretting corrosion” often encountered under heavy load and slight relative motion, does not occur with bearings made from DU when used with recommended mating surface materials.

Frictional properties

DU bearings are generally free from “stick-slip” and provide smooth sliding between adjacent surfaces. The coefficient of friction varies in relation to the specific load, velocity, and surface area. A typical relationship is shown in Figure 4-2, which can be used as a guide to establish the actual coefficient of friction under clean, dry conditions after running-in. Exact values of the coefficient of friction, µ, may vary by ±20%, depending on operating conditions, and should be established by test. Before bedding-in, the coefficient of friction may be up to 50% higher.

The coefficient of friction of DU material has also been shown to vary with temperature. For example, experiments under constant conditions of load and speed in vacuum have shown that the coefficient of friction doubles as the temperature is reduced from 140 to -4ºF (60 to -20ºC.)

With frequent starts and stops, the static coefficient of friction is approximately equal to or slightly less than the dynamic coefficient of friction. After progressively longer periods of dwell under load (e.g., of hours or days), the static coefficient of friction of the first movement has been measured to be 50%-200% higher, particularly before bedding-in. This phenomenon must be considered when designing long dwell applications.

Table 4-2: Wear Performance Comparisons

This is a guide to the relative service performance of DU bearings and other bearings intended for use without regular lubrication. These were thrust washer tests operating under the conditions described.

Bearing material tested against mild steel with surface finish of 16 microinches (0.4 micrometers) PV value 16,000 psi-fpm (0.56 N/mm²)	Testing Time Hours	Wear at End of Test, Inches
DU (PTFE-lead in porous bronze)	1,000.0	Less than 0.002
100% PTFE without lead in porous bronze	213.0	0.005
Graphite and lead bronze	158.0	0.010
PTFE + 25% graphite	134.0	0.005
Oil-impregnated porous bronze	105.0	0.010
Phenolic resin + MoS_2	73.0	0.005
PTFE + 25% glass fiber	48.0	0.005
MoS_2-treated steel	26.0	(Seized)
Graphite, bearing grade	24.0	0.005
Porous bronze + 25% MoS_2	17.0	0.005
Asbestos + resin + MoS_2	0.8	0.005
Nylon	0.3	0.010

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DU®

Effect of liquids and lubricants

The presence of clean liquids in and around DU bearings will generally reduce the rate of wear and thus increase their useful life by removing heat from the bearing surface. When loads and speeds are such that a hydrodynamic lubricating film is established, even liquids without normal lubricating properties, such as water, will improve bearing life substantially. Additional benefits gained by the use of DU in many lubricated applications have been the elimination of shaft galling and lower torque values at start up. Refer to section on “Lubricated Environments” on pages 4-11 to 4-14 for details.

The use of oil or grease should be avoided under conditions of severe cyclic loading during which the bearing and mating surface frequently become separated. Their presence in these circumstances may lead to cavitation erosion of the PTFE.

Grease packing on assembly, without subsequent replenishment, is not recommended.

DU bearings can be used in alternately wet and dry conditions, but their life in such environments will be shorter than when completely dry or fully lubricated. With alternating conditions, there is a greater amount of bedding-in occurring which substantially reduces the dry wear resistance.

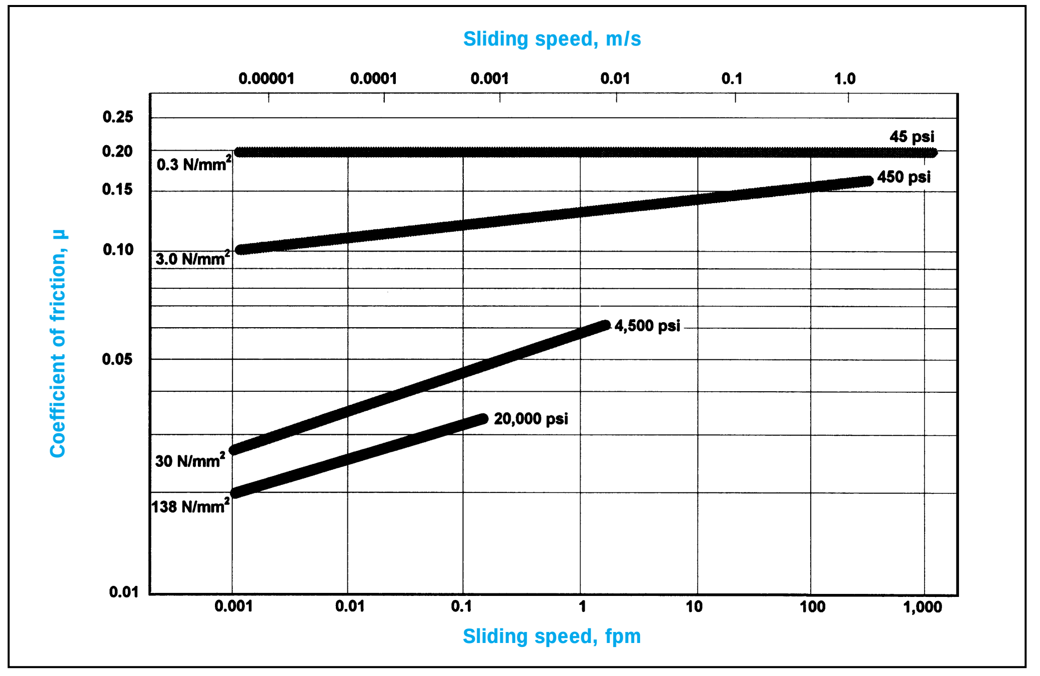

Figure 4-2. Friction vs. Velocity for Various Loads

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Design Factors

Bearing pressure – P

For the purpose of assessing bearing performance, bearing pressure P is defined as the working load divided by the projected area and is expressed as psi (N/mm²). Table 4-4 on page 4-7 lists common DU bearing configurations and their respective bearing pressure formulas.

The maximum pressure which can be supported by a DU bearing will depend upon the type of loading. It will be highest under steady loads whereas dynamic loads or oscillating motions, which produce fatigue stress on the bearings, will result in a reduction in load capacity (Table 4-3).

Surface velocity – V

DU has been particularly successful in applications where the motion will not allow formation of a conventional liquid lubricant film between the mating surfaces. DU can be designed for use at surface velocities up to 1,000 fpm (5 m/s), depending upon the operating life required. Refer to Table 4-4 on page 4-7 for velocity calculations.

PV factor

PV factor is used as a guide to the useful operating life of a DU bearing. PV is the product of the bearing pressure P and the surface velocity V. PV is expressed as psi-fpm (N/mm²-m/s). At extreme values, each parameter must be considered individually as well as together.

PV factors of up to 100,000 psi-fpm (3.5 N/mm²-m/s) can be accommodated for short periods, while for continuous rating, PV factors up to 50,000 psi-fpm (1.75 N/mm²-m/s) can be used, depending upon the operating life required. For lubricated applications, PV factors greater than 3,000,000 psi-fpm (105 N/mm²-m/s) are possible. Refer to section "DU in Lubricated Environments" on page 4-11.

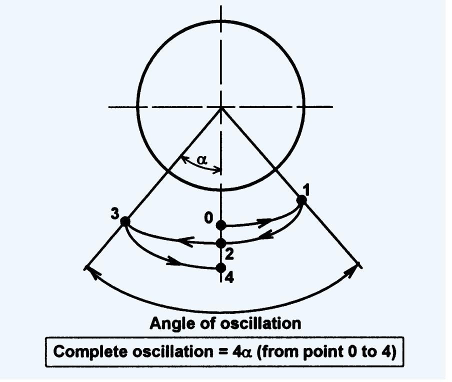

Figure 4-3. Oscillation Angle

Effective PV – EPV factor

The EPV factor takes into account the effect of high load and is used to estimate DU bearing life. Table 4-3 shows the maximum bearing pressure, U, for various operating conditions. If referring to Figure 4-4 for a U value, choose a corresponding U value based upon the desired bearing cycles L_Q.

Once the value for U is selected, the EPV can be calculated as follows:

$$EPV = \frac{U}{U - P} \times P \times V$$

Refer to pages 4-8 to 4-9 for the method of estimating DU bearing life.

Table 4-3:
Maximum Pressure, U Factors

Type of Loading	Maximum Pressure, U
Steady unidirectional loads relative to the bearing surface, with rotation in one direction only.	20,000 psi
Steady unidirectional loads with oscillating motion (cycles in Figure 4-4 refer to oscillating motion).	See Curve 1, Fig. 4-4
Dynamic loads, rotating, alternating or fluctuating, with steady or oscillating motion (cycles in Figure 4-4 refer to load cycles).	See Curve 2, Fig. 4-4
Flanged DU bearing thrust surface. Steady unidirectional load with rotation in one direction.	2,000 psi (14 N/mm²)
Static capacity— non-rotating.	36,000 psi (250 N/mm²)

The loads specified in Table 4-3 and Figure 4-4 assume good alignment between the bearing and the mating surface— better than 0.0008 inch (0.020 mm) over the length of the bearing.

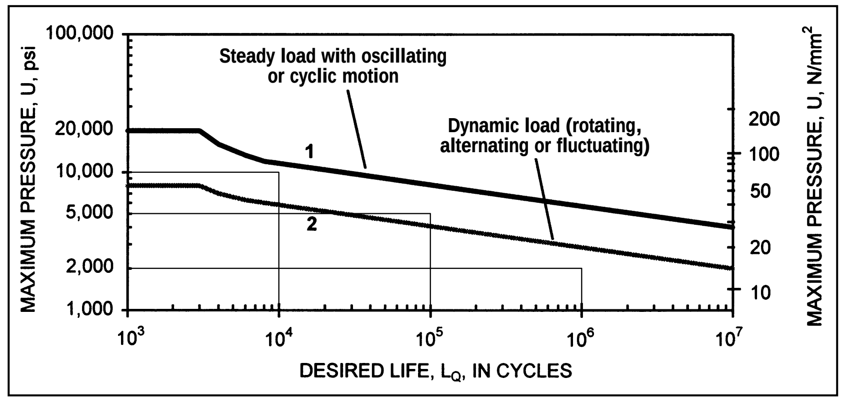

Figure 4-4. DU Maximum Pressure for Cyclic Applications

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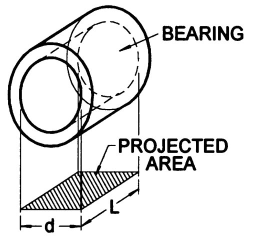
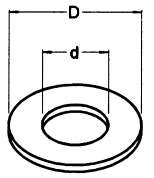
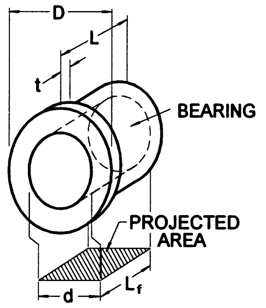
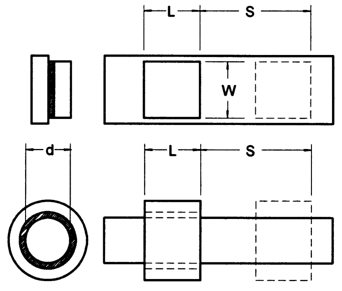
DU

BEARING	PRESSURE, P	VELOCITY, V
Sleeve Bearing 	Radial Load: $P = \frac{F_r}{Ld}$	Rotation: V (fpm) = 0.262 dn V (m/s) = 5.24 x 10^{-5}dn Oscillation: V (fpm) = 2.91 x 10^{-3} dcα V (m/s) = 5.82 x 10^{-7} dcα
Thrust Washer 	Thrust Load: $P = \frac{1.273F_t}{D^2 - d^2}$	Rotation: V (fpm) = 0.131 (D + d)n V (m/s) = 2.62 x 10^{-5} (D + d)n Oscillation: V (fpm) = 1.46 x 10^{-3} (D + d)cα V (m/s) = 2.91 x 10^{-7} (D + d)cα
Flanged Bearing 	Radial Load: $P = \frac{F_r}{L_f d}$ Thrust Load: $P = \frac{2.546F_t}{D^2 - d^2}$	Shaft Speed: Use formulas for sleeve bearing. Flange Face Speed: Use formulas for thrust washer.
Slideway and Linear Bearing 	Slideway: $P = \frac{F_s}{LW}$ Linear Bearing: $P = \frac{F_r}{Ld}$	Slideway/Linear Bearing Speed: V (fpm) = 0.166 cS V (m/s) = 3.33 x 10^{-5} cS

KEY

d = bearing/thrust washer ID
D = thrust washer/flange OD
L = bearing/slide pad length
L_f (inch) = L – t – 0.060
L_f (mm) = L – t – 1.5
t = flange thickness
W = slide pad width
S = bearing/slide pad stroke

P = calculated bearing pressure in psi (Newtons/mm²)
F_r = radial load in pounds (Newtons)
F_t = thrust load in pounds (Newtons)
F_S = slideway load in pounds (Newtons)

V = relative surface velocity in feet per minute (fpm) or meters per second (m/s)
n = rotation speed, revs per minute
c = cycling rate, cycles per minute
α = angle of oscillation, degrees, refer to Figure 4-3.

Dimensions in inches (millimeters)

Table 4-4: DU Design Factors

Calculating DU® bearing life

A useful approximation of actual performance in a specific application can be made by making allowance for the effect of the most important variables including operating temperature, heat dissipation, mating materials, and bearing size proportions. This section covers the method of estimating bearing life.

Figure 4-5 shows the basic service life in hours, assuming normal room temperature conditions, normal running clearances, and good heat dissipation of a well-proportioned bearing operating against low carbon steel with a surface finish of 16 microinches (0.4 micrometers). The following graphs and tables describe major factors affecting DU bearing life.

Accounting for all the variables in a specific application is difficult, but the following recommended approach will provide a useful guide for the designer.

The calculated EPV factor, as described on page 4-6, is used to determine the basic DU bearing service life L_b. The estimated bearing life L_{DU} is calculated by applying various service factors to the basic service life L_b. Refer to Figure 4-5 and select the type of bearing, and then read the basic service life based on the calculated EPV. Now you can estimate DU bearing life.

Garlock Bearings offers a computer program that will assist in calculating DU bearing life. Contact our Applications Engineering Department for a copy of this program.

Note: Estimated bearing lives greater than 4,000 hours are subject to error due to inaccuracies in the extrapolation of test data.

The formula for DU bearing life is:

$$L_{DU} = L_b \times H \times M \times B - A$$

Where:

L_{DU}	=	DU bearing life, hours
L_b	=	DU basic service life, hours, Figure 4-5
H	=	Heat dissipation factor, Figures 4-6 and 4-7
M	=	Mating surface factor, see Table 4-5
B	=	Bearing size factor, Figure 4-8
A	=	Life adjustment factor, hours, Table 4-5

For linear sleeve bearings or slideways (see page 4-7), the above equation is modified as follows:

$$L_{DU} = \frac{L}{L+S} \times L_b \times H \times M \times B - A$$

Where:

L_b	=	for linear sleeve bearings use stationary bearing, rotating shaft basic service life, Figure 4-5; for linear slideways use thrust washer basic service life, Figure 4-5
L	=	bearing length, inches (mm)
S	=	bearing stroke, inches (mm)

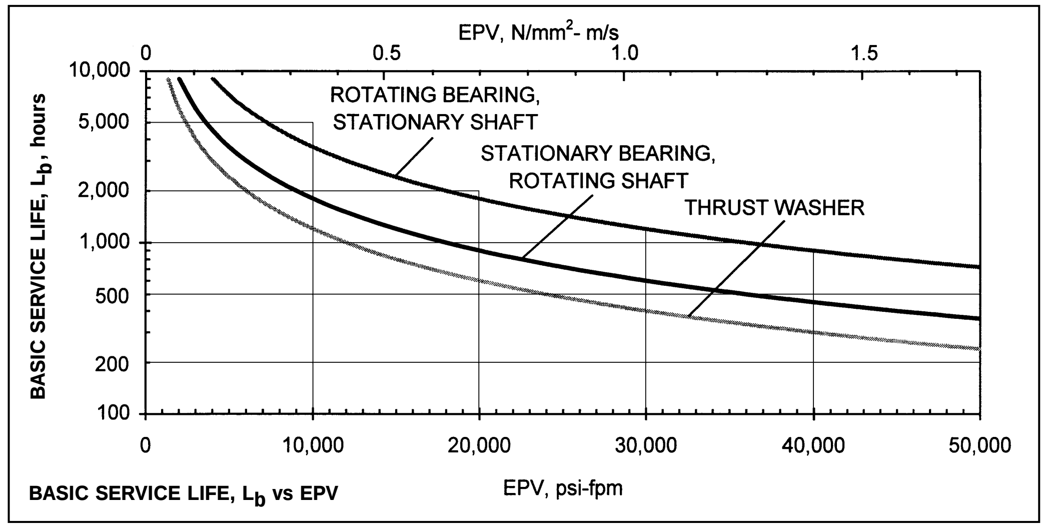


Figure 4-5. DU Basic Service Life in Hours

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DU®

Oscillating, cyclical, and linear motion/fluctuating loads

These conditions require special consideration when calculating bearing life. The maximum bearing pressure, U, is a function of the desired bearing life, L_Q, expressed in cycles. Figure 4-4, page 4-6, shows the U factor as a function of cycles. Bearing life, L_{DU} in hours, can be estimated by using the previously described method. Bearing life is converted into equivalent cycles by the equation:

$$L_Z = 60 \times L_{DU} \times c$$

Where:

L_Q	=	desired bearing life in cycles
L_Z	=	DU bearing life in cycles
L_{DU}	=	DU bearing life, hours
c	=	cycling rate in cycles per minute

If the calculated life cycles, L_Z, are less than the desired L_Q cycles used to select the U value, bearing life will be limited by wear after L_Z cycles. If L_Z cycles are greater than the desired L_Q cycles, bearing life will be limited by fatigue after L_Q cycles for oscillating, cyclic, linear, and highly dynamic load situations.

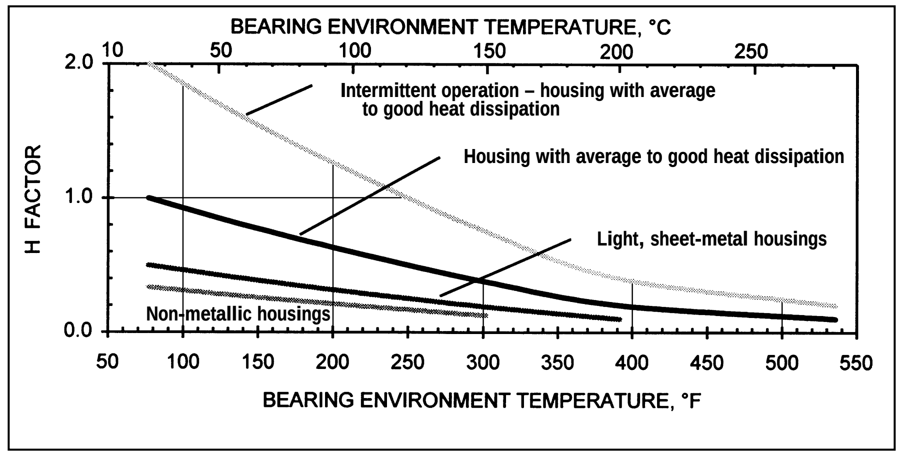

Figure 4-6. DU Heat Dissipation Factor – H for Dry Applications

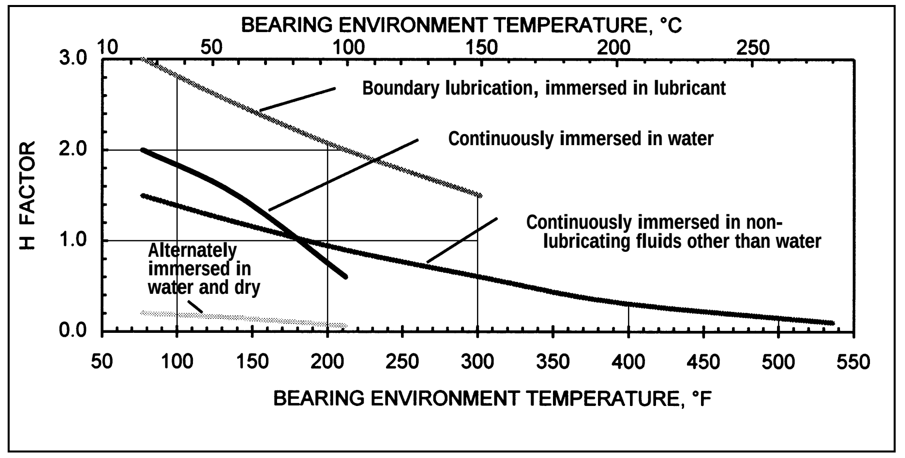

Figure 4-7. DU Heat Dissipation Factor – H for Fluid Applications

Heat dissipation factor – H

In the early stages of design, steps should be taken to obtain maximum heat dissipation, thereby allowing the bearing surface to operate at the lowest possible temperature.

Liquids may substantially improve bearing performance if hydrodynamic conditions are established. Boundary lubrication performance will depend upon the nature of the liquid and testing should be conducted. In the absence of test data, the values in Figure 4-6 may be used. DU in lubricated environments is covered in detail on pages 4-11 to 4-13.

If the bearing is required to operate dry subsequent to running in water under boundary conditions, the dry wear resistance of DU material may be substantially reduced. This is because of the greater amount of bedding-in wear which occurs under these conditions. In the absence of specific test data, use an H factor of not greater than 0.2.

Mating surface factor – M
Life adjustment factor – A

The mating surface factors for common mating materials and platings are listed in Table 4-5. This factor applies for a mating surface finish of 16 microinches (0.4 micrometers) or better. To assure maximum operating life, the surface finish should be ground to better than 16 microinches (0.4 micrometers). Above 32 microinches (0.8 micrometers), bearing life is reduced by more than 50%. Refer to page 4-14 for shaft selection details.

Table 4-5 also lists the life adjustment factor, A. For unplated materials, this factor is 200 hours; for plated shafting, the factor is typically 600 hours.

Table 4-5: Mating Surface Life Adjustment Factors

Material	Mating Surface Factor—M	Life Adjustment Factor—A, Hours
Steel and Cast Iron		
Case-hardened steel	1.0	200
Cast iron-12 microinches (0.3 micrometers)	1.0	200
Mild steel	1.0	200
Nitrided steel	1.0	200
Sprayed stainless steel	1.0	200
Stainless steel	2.0	200
Plated Steel with 0.0005 inch (0.013 mm) minimum plating thickness		
Hard chrome	2.0	600
Nickel	0.2	600
Phosphated	0.2	300
Tin nickel	1.2	600
Tungsten carbide flame	3.0	600
Zinc	0.2	600
Non-Ferrous Metals		
Anodized aluminum (decorative)	0.4	200
Bronze and copper base alloys	0.1–0.4	200
Hard anodized aluminum, 0.001 inch (0.025 mm) thick	3.0	600

Bearing size factor – B

As the bearing size increases, there is a relatively larger running clearance which results in proportionately smaller contact area. This reduction in contact area has the effect of increasing the actual unit load. A size factor (B) must then be considered, as in Figure 4-8.

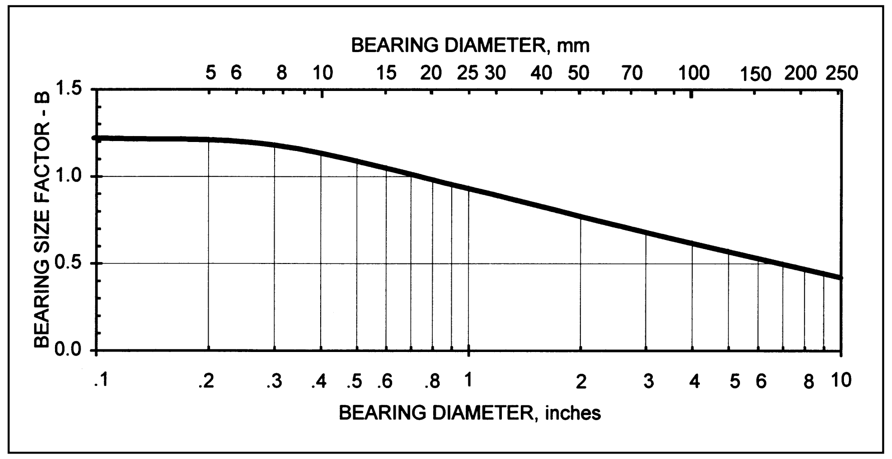

Figure 4-8. DU Bearing Size Factor – B

Bearing length

In designing bearings, the shaft diameter is usually determined by the need for physical stability or stiffness and the main size variable to be determined is the length of the bearing or the width of a thrust washer.

Short or narrow bearings will have reduced wear life, and the design length to diameter ratio should be high, up to a maximum of 2:1. Longer bearings are not recommended as they can be subject to shaft deflection problems. They are also more difficult to manufacture and install.

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Lubricated Environments

Although DU material was developed for use as a dry, self-lubricating bearing material, engineers and designers have discovered many years ago that DU also provides excellent performance for lubricated applications. DU bearings are being used successfully in engines, compressors, pumps, transmissions, and countless other demanding applications where conventional bearing materials often fail. DU's unique combination of properties provides a greater margin of safety for use in lubricated environments. This translates into higher capacity, longer service intervals, less maintenance and improved performance for your application. This section will cover the basics of lubrication and how to design and specify DU bearings for your lubricated applications.

Lubrication basics for DU® bearings

Theoretically, there are three basic types of lubricated bearing operation which relate to how well the lubricant or liquid develops a separating film between the shaft and the bearing. These three types of operation depend largely on the overall bearing dimensions, the clearance between the shaft and bearing, shaft speed, bearing load, and the type and quantity of liquid supplied to the bearing. The three types of bearing lubrication can be summarized as follows:

Hydrodynamic lubrication

occurs where there is a complete separation of the shaft from the bearing by a thin film of liquid. Hydrodynamic lubrication is characterized by very low friction and no wearing of the bearing or shaft since there is no contact. The film thickness can range from 0.0001 inch (0.003 mm) or less to 10 or 20 times that amount depending on bearing parameters. Coefficients of friction of 0.001 to 0.01 are typical for hydrodynamic lubrication.

Boundary lubrication

is the rubbing of the shaft on the bearing with virtually no lubricant separating the two surfaces. In this regime, bearing material selection is very important to bearing performance. For example, conventional bearings operating under boundary lubrication typically have a coefficient of friction of 0.08 to 0.15. However, DU's coefficient of friction is usually between 0.02 and 0.06 in boundary lubrication. Since there is intimate contact between the shaft and bearing, wear is inevitable in conventional plain bearings. The inherent self-lubricating properties of DU material minimize wear under boundary lubrication, and in many cases, the wear pattern resembles a burnished surface.

Mixed film lubrication

is a combination of hydrodynamic and boundary lubrication. Part of the load will be carried by localized areas of self-pressurized lubricant and the remaining part of the load supported by boundary lubrication. Bearing friction and wear depend on the degree of hydrodynamic forces developed. Here too, DU materials provide a low friction, long wearing bearing surface required to carry the boundary lubrication portion of the load.

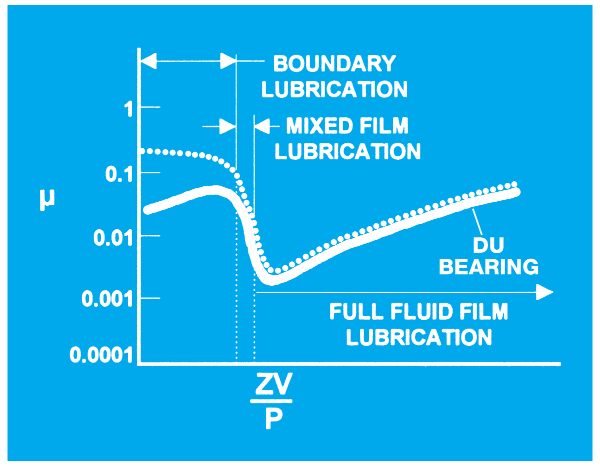

Figure 4-9. Frictional Characteristics of Lubricated DU Bearings

Figure 4-9 illustrates the relationship of the coefficient of friction and lubrication regime for a given sleeve bearing/shaft combination plotted as a function of fluid viscosity (Z), bearing pressure (P) and shaft speed (V). Plotted in dotted line is the classical lubrication curve based on conventional plain bearing materials such as bronze or babbitt; the blue curve is DU material. For boundary and part of mixed film lubrication regimes, DU is lower in friction than conventional bearing materials because of its low-friction PTFE/lead surface. The two curves are essentially the same under full film hydrodynamic lubrication and mixed film lubrication where a substantial part of the load is carried by a hydrodynamic fluid film.

As can be seen in Figure 4-9, DU material is particularly effective in the most demanding lubricated applications because of its inherent low friction and excellent wear resistance without lubrication. The following is a summary of application parameters where DU has successfully replaced conventional bearing materials and improved performance.

Highly loaded applications

DU bearings are specified in numerous applications where the loads substantially exceed the ability of the bearings to develop a hydrodynamic film. Extensive testing has proven its superior wear resistance and low friction in highly loaded applications where the bearing is subjected primarily to boundary and mixed film lubrication.

Start-up and shutdown under load

Since there will be insufficient speed to generate a hydrodynamic film under start-up or shutdown, the bearing will operate under boundary and mixed film conditions. In equipment where such conditions are a frequent occurrence, premature bearing failure can be experienced even though the bearing normally operates with a fully hydrodynamic film. DU minimizes wear and requires less start-up torque than conventional plain bearing materials.

Sparse lubrication

Many applications require the bearing to operate with less than ideal lubricant supply, typically a splash or mist lubrication system in which only trace amounts ever reach the bearing surface. The self-lubricating properties of DU material permit successful operation in sparsely lubricated environments which will cause other bearing materials to overheat and fail.

Non-lubricating fluids

Although a hydrodynamic film can be developed using any fluid, successful boundary or mixed film applications require a fluid with some lubricating properties. DU bearings have been used successfully in applications using non-lubricating fluids such as water because DU's naturally self-lubricating bearing surface can effectively overcome the fluid's inability to lubricate the bearing.

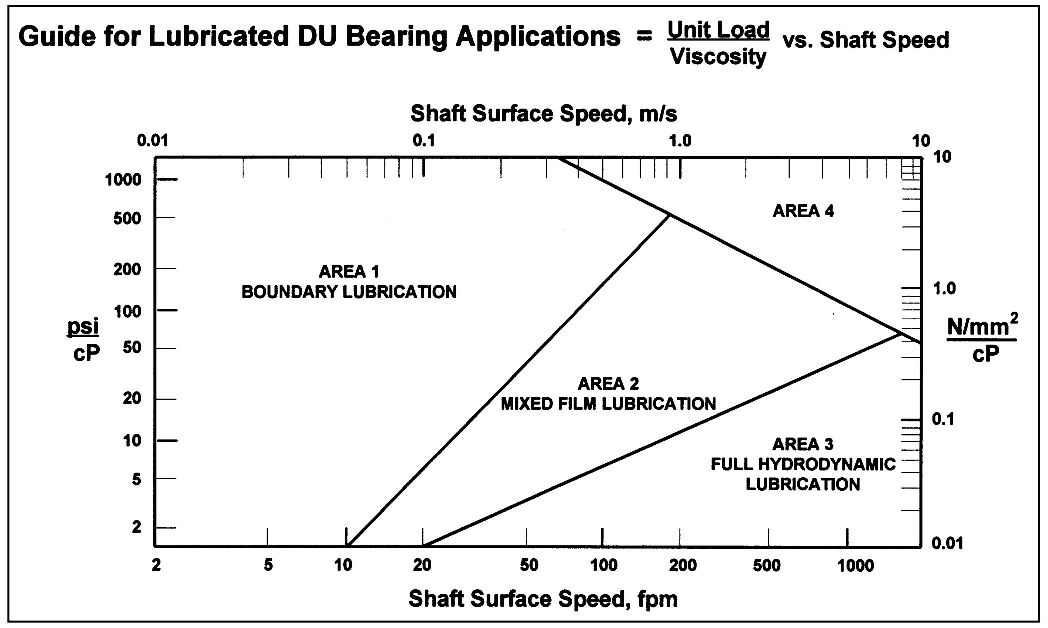

Figure 4-10. Guide for Lubricated DU Bearing Applications

Designing lubricated applications with DU® bearings

Figure 4-10 shows the three lubrication regimes as areas plotted on a graph of surface speed vs. the ratio of unit load to lubricant viscosity. This illustration is useful in the preliminary analysis of the application to determine in which regime the bearing is operating. The graph is based on steady, unidirectional loading; continuous, non-reversing shaft rotation; sufficient clearance between shaft and bearing; and, an adequate supply of lubricant.

In order to use Figure 4-10, first calculate the bearing pressure P and shaft surface speed V using the formulae on page 4-7. Next, determine the viscosity, in centipoise, of the lubricant used. Viscosity is a function of operating temperature. The viscosity-temperature relationships of several liquids are presented in Figure 4-11. If the operating temperature of the fluid is unknown, a provisional temperature of 50ºF (25ºC) above ambient can be used.

Referring to Area 1, (boundary lubrication) in Figure 4-10, PV is the major consideration since there will be no lubricating film to separate the shaft and bearing. DU bearing life can be calculated using the technique given in pages 4-8 to 4-9, with an H factor (Figure 4-7) for bearings continuously immersed in liquids, although this method will probably underestimate bearing life.

In Area 2, (mixed film lubrication), the fluid film generated will be sufficient to permit partial separation of the shaft and bearing surfaces. The PV factor is no longer a significant parameter in determining bearing life. Bearing performance will depend on the nature of the fluid and actual service conditions.

In Area 3, (full hydrodynamic lubrication), the shaft and bearing will be completely separated by a fluid film. Provided the fluid is clean and there are no start-ups and shutdowns, the bearing will last indefinitely. For bearings operating at speeds in excess of 1000 fpm (5 m/s), there is a potential for shaft instability (shaft whirl) and/or excessive operating fluid temperatures to occur. Consult Garlock Bearings LLC for additional advice.

Area 4, which is in the upper right hand corner of Figure 4-10, represents the most demanding operating conditions. In this area, the bearing is subjected to either high speed, high bearing load to viscosity ratio, or, a combination of both. These conditions may cause excessive operating temperature and/or a high wear rate which may result in rapidly deteriorating bearing performance. Although DU bearings are better suited to Area 4 than conventional bearing materials, the addition of one or more groove(s) to the bearing, and specification of a superfinished (1 to 2 microinch [0.02 to 0.05 micrometer]) shaft may be required to achieve satisfactory performance.

Lubricants

DU bearings can be used with most fluids including water, lubricating oils, engine oil, turbine oil, hydraulic fluids, ethylene glycol solutions, solvents, fuels, and refrigerants. In general, the fluid will be acceptable if it does not chemically attack the porous bronze innerstructure or PTFE/lead overlay. Acid and alkaline solutions should be avoided as well as some lubricants that contain sulfur as an extreme pressure (EP) additive. Where there is any doubt about the suitability of a fluid, a simple test is to submerge a sample of DU material in the fluid for 2 to 3 weeks at 10 to 20ºF (5 to 10ºC) above the operating temperature. Any change in thickness and/or weight of the DU material, a visible change in the surface other than some discoloration or staining, or a visible change in the bronze innerstructure will usually indicate that the fluid is not suitable for use with DU bearings.

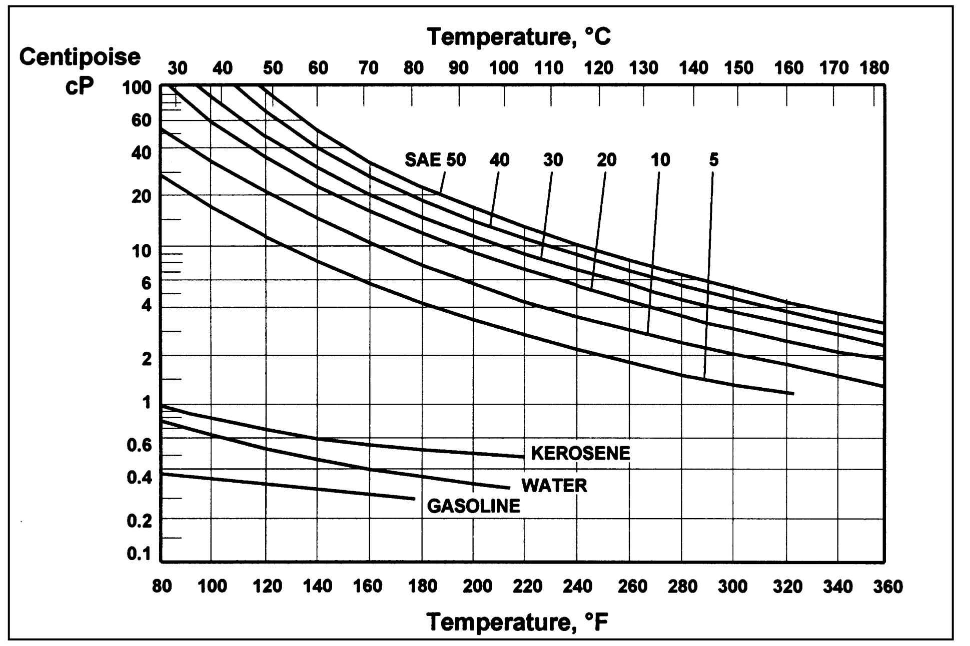

Figure 4-11. Viscosity vs. Temperature

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Clearance

The recommended shaft and housing bore diameters given for standard DU bearings will provide sufficient clearance for applications operating under boundary lubrication, Area 1 in Figure 4-10. For bearings operating under mixed film or hydrodynamic lubrication regimes (Areas 2 and 3), the recommended shaft diameter should be reduced by approximately 0.1%, particularly when surface speed exceeds 500 fpm (2.5 m/s). The additional clearance will permit the generation of a fluid film and provide enough clearance for the flow of fluid through the bearing.

In certain applications, the maximum clearance associated with standard DU bearings may result in reduced performance. There are two methods of reducing the clearance range of standard DU bearings: specifying tighter tolerances for the shaft and housing; and, final sizing of the bearing after installation in the housing. Final sizing can be done preferably by burnishing the bearing ID. This method will not remove the overlay from the bearing surface. Refer to page 6-6 for burnishing tool design. Certain specific applications may require closer-tolerance bearings. Garlock Bearings can manufacture these on special order. Please contact Garlock Bearings Applications Engineering Department for details.

Shaft finish

A shaft finish of up to 16 microinches (0.4 micrometers) is acceptable for bearings operating exclusively under boundary lubrication. For applications where there will be mixed film or hydrodynamic lubrication, a surface finish of 2 to 8 microinches (0.05 to 0.20 micrometers) is required to achieve optimum performance.

Grooving

Grooves used alone or in combination with a hole will help guarantee an adequate supply of lubricant to the bearing. In most cases, a simple groove extending across the width of the bearing is effective. Figure 4-12 shows the recommended location of the oil groove with respect to the bearing load zone and bearing split. Figure 4-12 shows two different groove profiles that can be simply milled or broached in the bearing. The leading and trailing edges of the groove should be tapered which will help develop a lubricating film. Garlock can furnish special DU bearings with embossed or milled grooves on request. Consult the Garlock Bearings Applications Engineering Department for details.

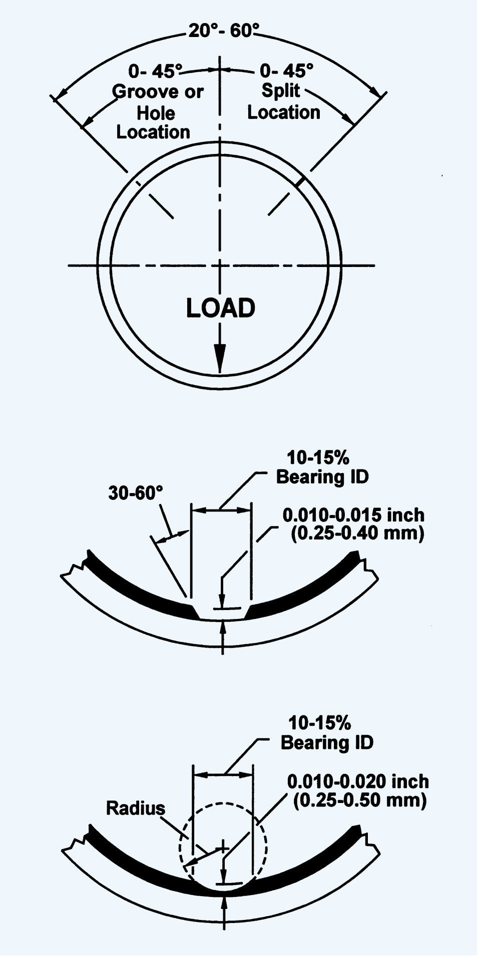

Figure 4-12.
Oil Grooves for DU Bearings

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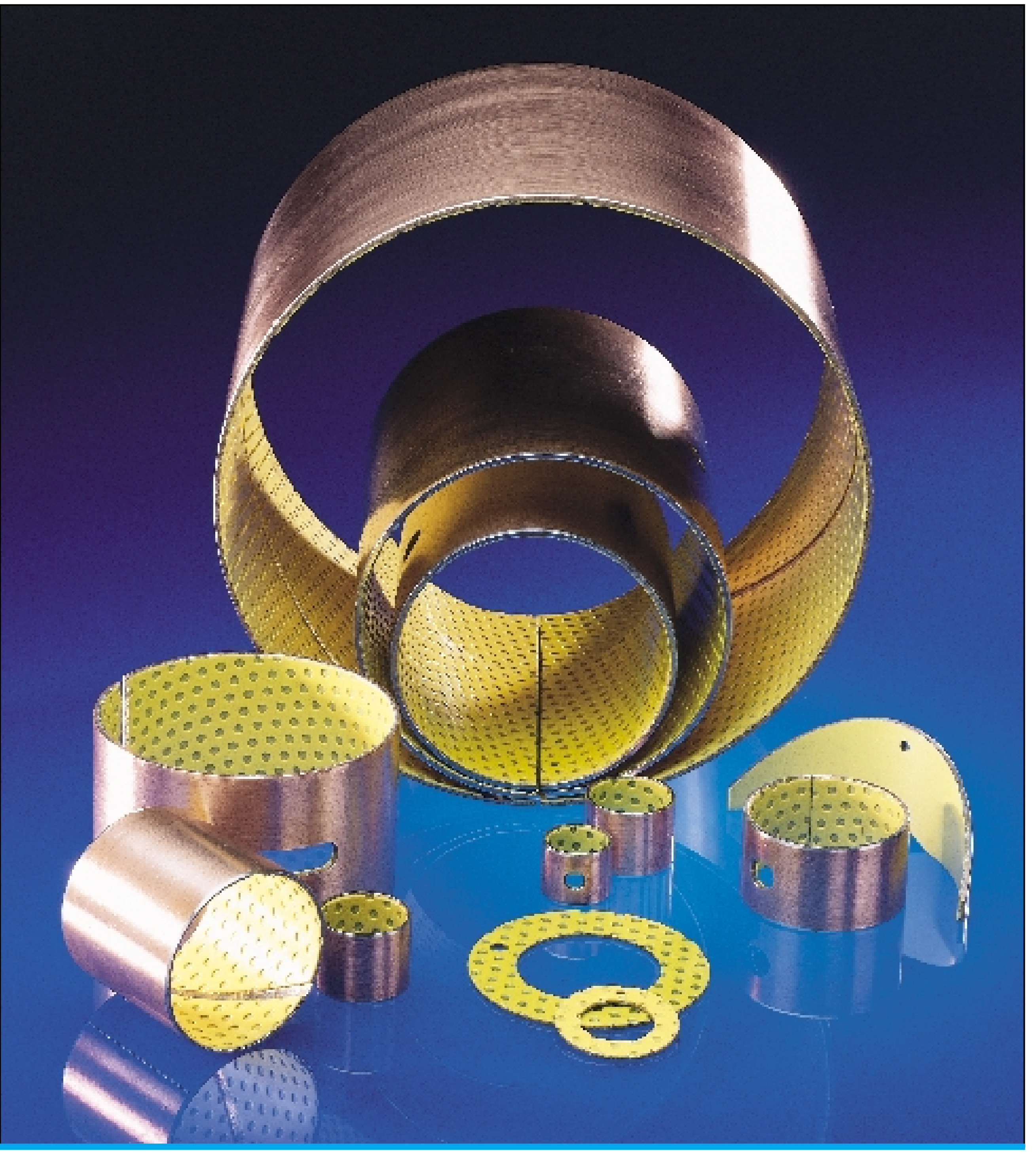

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The information in this catalog enables the design engineer to establish parameters for maximum performance in the application and to estimate the expected life of the product.

Our Applications Engineers will provide additional technical service to assist with unusual design problems.

Technical Information

Frictional properties

When DX bearings are used with steel mating surfaces, the dynamic coefficient of friction is very low, varying normally between 0.01 and 0.1 depending on speed, load, and lubrication conditions. Under conditions of boundary lubrication, DX bearings will operate with less friction and wear than bronze-surfaced bearings. The corresponding coefficient of static friction of DX bearings ranges from about 0.015 to 0.15.

Thermal properties

Using a suitable lubricant, DX bearings can be used continuously at temperatures up to 210ºF (100ºC), or down to -40ºF (-40ºC). They can be used at intermittent temperatures up to 260ºF (125ºC). DX bearings can be used at the full calculated load capacity at temperatures up to 100ºF (40ºC). However, at temperatures above 100ºF (40ºC), the load carrying capacity gradually diminishes to about half of the load limit values.

Effect of contamination

DX bearings can tolerate more dirt between the rubbing surfaces than either conventionally lubricated or dry bearings. With all bearings, it is always desirable to minimize intrusion of dirt by using a suitable seal.

Bearing clearance

Experience has shown that DX bearings should be given more diametrical clearance than conventional plain bearings to allow for the small thermal expansion of the lining when at operating temperature. For slow speed, oscillatory motion, clearance can be at a minimum where the shaft-to-bearing fit will be assembled snug for excellent bearing-to-shaft conformity. When shaft surface speeds exceed 50 fpm (0.25 m/s), additional clearance will be required.

Unlike many synthetic materials, the amount of moisture absorbed and consequent swelling of DX material is extremely small. As a result, there is no danger of a DX bearing seizing or even tightening on the shaft when water is present.

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DX™

Wear rate and relubrication

DX bearings exhibit an exceptionally low wear rate. Even during the initial stages of use, the bedding-in wear for these lubricated bearings is only about 0.0001 inch (0.003 mm) when the load is less than 14,500 psi (100 N/mm^2). Subsequent wear is usually inconsequential as long as there is sufficient amount of lubricant present.

Under bearing pressure above 14,500 psi (100 N/mm^2), the initial bedding-in wear is greater, about 0.001 inch (0.025 mm), followed by a decreasing wear rate until the bearing exhibits a similar wear/life relationship to that shown in Figure 5-1.

If the bearing is regreased before the rate of wear starts to increase rapidly, the material will continue to function satisfactorily with little wear. Figure 5-1 shows the typical wear pattern and the concept of the DX bearing relubrication.

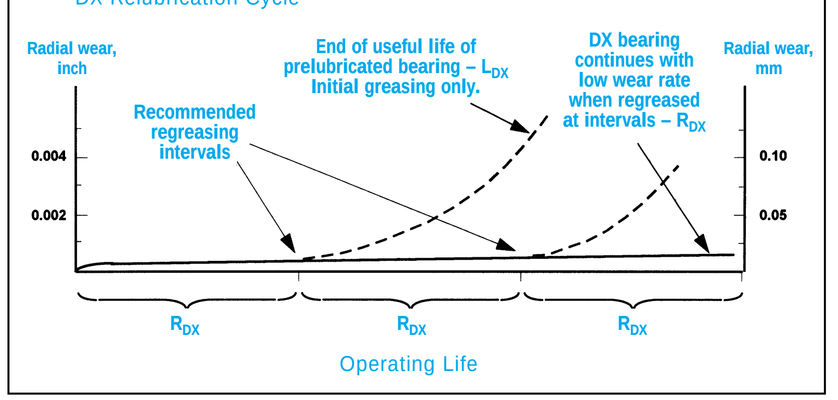

Figure 5-1. DX Relubrication Cycle

The lubricant film that the bearing surface is able to maintain during long periods of sliding contact with a shaft or flat surface ensures negligible wear. Should the bearing be allowed to run after the film of lubricant has disappeared, some wear will occur; but there will be no damage to the mating surface until the bronze substrate surface is exposed.

For assistance in calculating the appropriate relubrication interval for your various applications, please refer to the technical discussion on this subject on page 5-6.

Static electricity

DX bearing material has not exhibited static electricity phenomena.

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Design Factors

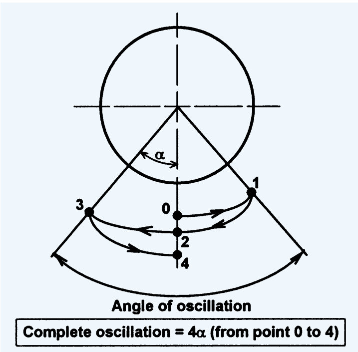

Figure 5-2. Oscillation Angle

Bearing pressure – P

For the purpose of assessing bearing performance, bearing pressure P is defined as the working load divided by the projected area and is expressed as psi (N/mm^2). Table 5-2 lists common DX bearing configurations and their respective bearing pressure formulas.

The maximum pressure which can be supported by a DX bearing will depend upon the type of loading. It will be highest under steady loads whereas dynamic loads or oscillating motions, which produce fatigue stress on the bearings, will result in a reduction in load capacity (Table 5-1).

Surface velocity – V

Standard DX bearings can be used up to 50 fpm (0.25 m/s). When speeds exceed this value and approach 100 fpm (0.5 m/s) then additional diametrical clearance will be required to accommodate the thermal expansion caused by surface heat generation. Refer to Table 5-2 for velocity calculations.

PV factor

PV factor is used as a guide to the useful operating life of a DX bearing and the relubrication interval. PV is the product of the bearing pressure P and the surface velocity V. PV is expressed as psi-fpm (N/mm^2-m/s). At extreme values, each parameter must be considered individually as well as together.

PV factors of up to 80,000 psi-fpm (2.8 N/mm^2-m/s) can be accommodated at speeds up to 5 fpm (0.025 m/s), while for speeds between 5 to 100 fpm (0.025 to 0.5 m/s), PV factors up to 20,000 psi-fpm (0.7 N/mm^2-m/s) can be used.

Effective PV – EPV factor

The EPV factor takes into account the effect of high load and is used to estimate DX bearing life. Table 5-1 shows the maximum bearing pressure, U, for various operating conditions. If referring to Figure 5-3 for a U value, choose a corresponding U value based upon the desired bearing cycles life, L_Q.

Once the value for U is selected, the EPV can be calculated as follows:

$$EPV = \frac{U}{U-P} \times P \times V$$

Refer to pages 5-6 to 5-9 for the method of estimating DX bearing life and regreasing interval.

Table 5-1: Maximum Pressure – U

Load	Operating Condition	Lubrication	Maximum Pressure, U
Steady	Little or very slow continuous motion	Grease	20,000 psi (140 N/mm^2)
Steady	Continuous rotation	Grease (Boundary lubrication)	10,000 psi (80 N/mm^2)
Steady	Oscillating motion	Grease	Refer to Figure 5-3
Dynamic	Continuous rotation	Grease (Boundary lubrication)	Refer to Figure 5-3

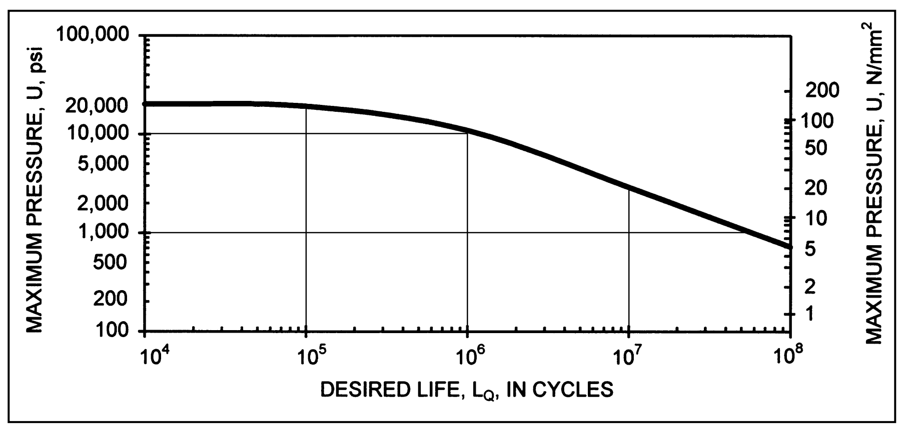

Figure 5-3. DX Maximum Pressure for Cyclic Applications

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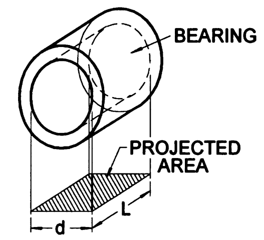
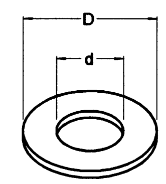
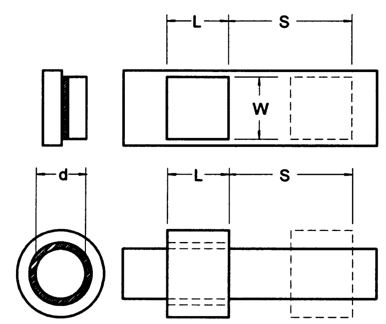
DX™

BEARING	PRESSURE, P	VELOCITY, V
Sleeve Bearing 	Radial Load: $P = \frac{F_r}{Ld}$	Rotation: V (fpm) = 0.262 dn; V (m/s) = 5.24 x 10^{-5} dn. Oscillation: V (fpm) = 2.91 x 10^{-3} dcα; V (m/s) = 5.82 x 10^{-7} dcα
Thrust Washer 	Thrust Load: $P = \frac{1.273 F_t}{D^2 - d^2}$	Rotation: V (fpm) = 0.131 (D + d)n; V (m/s) = 2.62 x 10^{-5} (D + d)n. Oscillation: V (fpm) = 1.46 x 10^{-3} (D + d)cα; V (m/s) = 2.91 x 10^{-7} (D + d)cα
Slideway and Linear Bearing 	Slideway: $P = \frac{F_s}{LW}$ Linear Bearing: $P = \frac{F_r}{Ld}$	Slideway/Linear Bearing Speed: V (fpm) = 0.166 cS; V (m/s) = 3.33 x 10^{-5} cS

KEY

d = bearing/thrust washer ID
D = thrust washer OD
L = bearing/slide pad length
W = slide pad width
S = bearing/slide pad stroke

P = calculated bearing pressure in psi (Newtons/mm^2)
F_r = radial load in pounds (Newtons)
F_t = thrust load in pounds (Newtons)
F_s = slideway load in pounds (Newtons)

V = relative surface velocity in feet per minute (fpm) or meters per second (m/s)
n = rotation speed, revs per minute
c = cycling rate, cycles per minute
α = angle of oscillation, degrees, refer to Figure 5-2.

Dimensions in inches (millimeters)

Table 5-2: DX Design Factors

Calculating DX™ bearing life

A useful approximation of actual performance in a specific application can be made by making allowance for the effect of the most important variables including speed, mating surface, operating temperature, and bearing size proportions. This section covers the method of estimating DX bearing life and regreasing interval.

Figure 5-4 shows the basic service life, L_b, in hours assuming normal room temperature conditions, normal running clearances, and good heat dissipation of a well-proportioned bearing operating against low carbon steel with a surface finish of 16 microinches (0.4 micrometers). The following graphs and tables describe major factors affecting DX bearing life.

Accounting for all the variables in a specific application is difficult, but the following recommended approach will provide a useful guide for the designer.

The calculated EPV factor, as described on page 5-4, is used to determine the basic DX bearing service life L_b. The estimated bearing life, L_{DX}, is calculated by applying various service factors to the basic service life L_b. Refer to Figure 5-4 and read the basic service life based on the calculated EPV.

Garlock Bearings offers a computer program that will assist in calculating DX bearing life. Contact our Applications Engineering Department for a copy of this program.

The formula for DX bearing life is:

$$L_{DX} = L_b \times r \times s \times t \times b$$

The formula for DX regreasing interval is:

$$R_{DX} = \frac{L_{DX}}{2}$$

Where:

L_{DX}	=	DX bearing life, hours
R_{DX}	=	regreasing interval, hours
L_b	=	DX basic service life, hours, see Figure 5-4
r	=	surface speed factor, Table 5-3
s	=	mating surface factor, Figure 5-5
t	=	operating temperature factor, Figure 5-6
b	=	bearing size factor, Figure 5-7

For linear sleeve bearings or slideway (see page 5-5), the above equation is modified as follows:

$$L_{DX} = \frac{L}{L+S} \times L_b \times r \times s \times t \times b$$

Where:

L_b	=	sleeve bearing basic service life, Figure 5-4
L	=	bearing length, inches (mm)
S	=	bearing stroke, inches (mm)

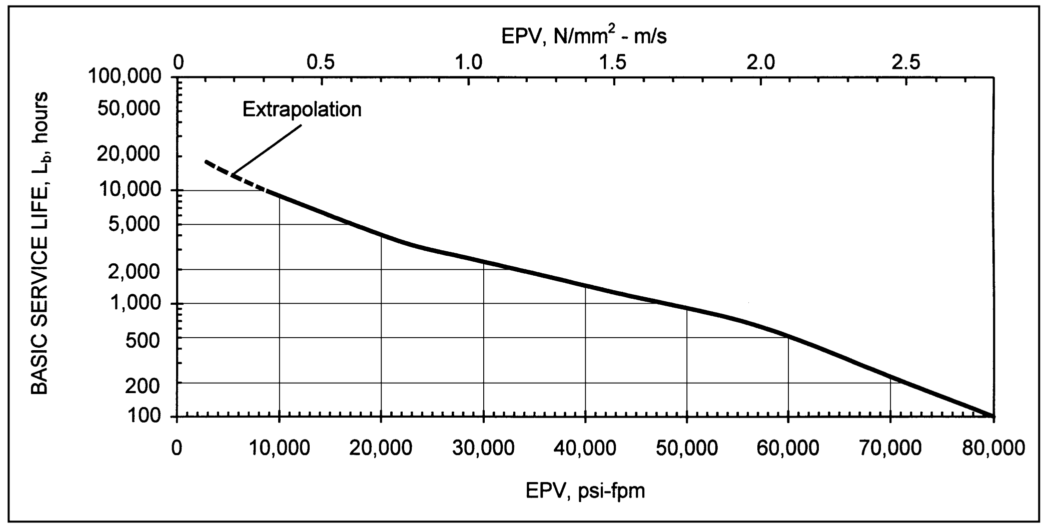


Figure 5-4. DX Basic Service Life, L_b, vs. EPV

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Oscillating, cyclical, and linear motion/fluctuating loads

These conditions require special consideration when calculating bearing life. The maximum bearing pressure, U, is a function of the desired bearing life, L_Q, expressed in cycles. Figure 5-3, page 5-4, shows the U factor as a function of cycles. Bearing life, L_{DX} in hours, can be estimated by using the previously described method. Bearing life is converted into equivalent cycles by the equation:

$$L_Z = 60 \times L_{DX} \times c$$

Where:

L_Q	=	desired bearing life in cycles
L_Z	=	DX bearing life in cycles
L_{DX}	=	DX bearing life, hours
c	=	cycling rate in cycles per minute

If the calculated life cycles, L_Z, are less than the desired L_Q cycles used to select the U value, bearing life will be limited by wear after L_Z cycles. If L_Z cycles are greater than the desired L_Q cycles, bearing life will be limited by fatigue after L_Q cycles for oscillating, cyclic, linear, and highly dynamic load situations.

To minimize wear and extend bearing life, regreasing, if possible, should be at intervals 0.5 x L_Z or 0.5 x L_Q, whichever is less.

Table 5-3: Surface Speed Factor – r

		Surface Speed		
	fpm **m/s**	**up to 5** **up to 0.025**	**5 to 50** **0.025 to 0.25**	**50 to 100** **0.25 to 0.5**
Maximum permissible PV factor for grease lubrication	psi-fpm N/mm²-m/s	80,000 2.8	20,000 0.7	20,000 0.7
DX bearings – steady load vertically downwards (lubricant draining towards load area)	unmachined machined	4 3.6	3 2.7	2 1.8
DX bearings – steady load not downwards (lubricant draining away from load area) or dynamic load	unmachined machined	1.6 1.4	1.3 1.1	1.1 1
DX bearings rotating load	unmachined	4	3	3
	machined	3.4	2.75	2.75
DX thrust washer		2	1	1

Surface speed – r

The effect of the surface speed is shown by the application factor, r, as shown in Table 5-3. Standard DX bearings can be used up to 50 fpm (0.25 m/s). When speeds exceed this value and approach 100 fpm (0.5 m/s), then additional bearing clearance will be required to accommodate the thermal expansions caused by surface heat generation.

Mating surfaces – s

DX bearings may be used with all conventional shaft materials. A ground finish of better than 16 microinches (0.4 micrometers) is recommended. Hardening of steel shafts is not essential unless abrasive dirt is present, in which case a shaft hardness of at least Rc40 is recommended. Figure 5-5 shows the relationship of application factor, s, for various surface finishes.

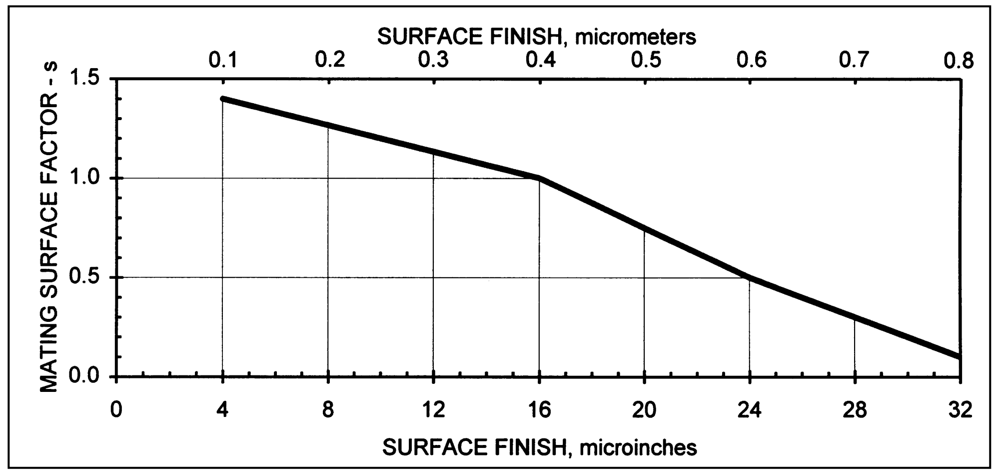

Figure 5-5. DX Mating Surface Factor – s

Operating temperature – t

The effect of environmental temperature and basic type of grease lubricant is shown by application factor, t, as shown in Figure 5-6. The heat dissipating properties of the housing, especially if the bearing is mounted in an area close to an engine or other heat generating unit, affect bearing surface temperature and are particularly important at high PV values. When the temperature approaches the top limit of 260ºF (125ºC), consult our Application Engineering Department.

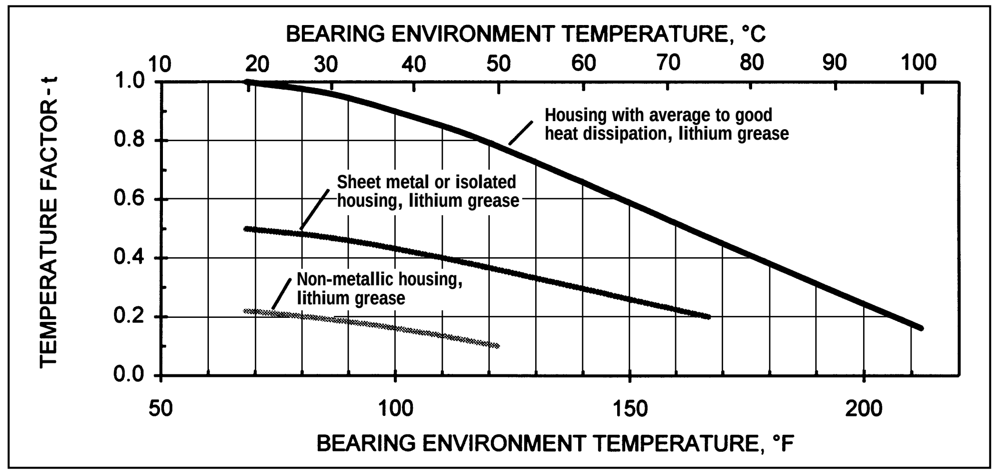

Figure 5-6. DX Environmental Temperature Factor – t

Bearing size factor – b

Frictional heat is generated at the bearing surface during operation and is dissipated through the shaft and housing. The heat generated depends both on the operating conditions (i.e., PV factor) and the bearing size. For a given PV condition, a large bearing will run hotter than a smaller bearing due to a proportionately smaller contact area.

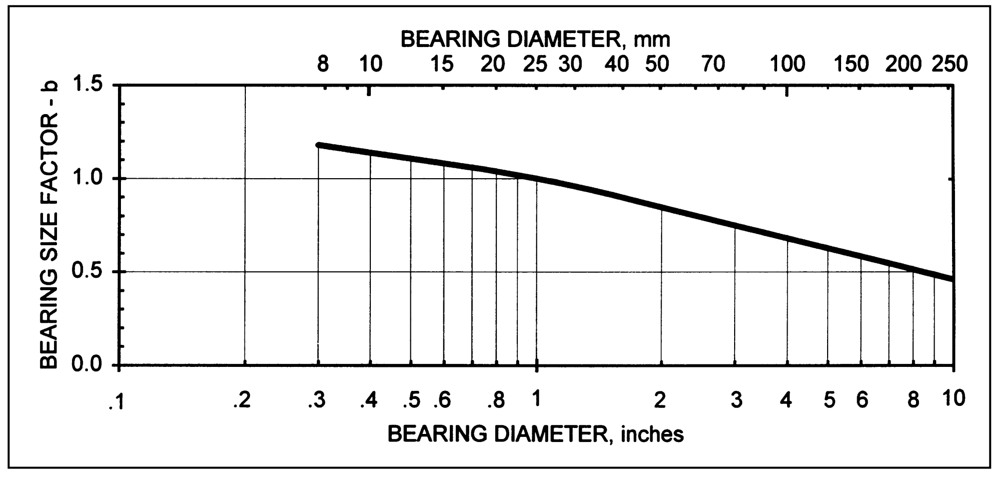

Figure 5-7. DX Bearing Size Factor – b

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Choice of lubricants for DX™ bearings

The choice of lubricant will depend primarily upon three factors: the maximum temperature expected; the stability of the lubricant in the environmental conditions; and the degree of contamination. When the lubricant is applied on the initial assembly only, a grease is recommended. For temperatures between 160ºF and 210ºF (70ºC and 100ºC), the grease, or in some cases oil, should contain an antioxidant, while for temperatures between 210ºF (100ºC) and the maximum permissible temperature of 260ºF (125ºC), a silicone grease is preferred. DX bearings are only suitable for operation in water when the load and speed conditions permit a hydrodynamic film to be established, or alternatively when the PV factor is less than 1,000 psi-fpm (0.04 N/mm²). The degree of contamination is a very important factor. In contaminated applications, with or without seals, a grease should be used rather than any type of oil to purge the bearing clean.

Table 5-4 shows relative ratings which are based on performance, or likely performance, of a DX bearing initially lubricated with a grease. The table is not relevant to characteristics of greases other than their direct effect on DX bearing performance. Greases in the "Not Recommended" category can be used because of some desirable property other than the direct beneficial effect on life. Life may nevertheless be adequate provided the application is not very severe.

Where there is any doubt, the suitability of a lubricant should be determined by testing, particularly if the environmental temperature exceeds 150ºF (65ºC). A severe, but relatively easy test is to immerse the DX bearing sample in the lubricant for 2-3 weeks at 40º/50ºF (20º/25ºC) above the anticipated environmental or operational temperature. If there is a reduction in the wall thickness of the bearing, or if the lining is visibly affected, as indicated by a change of the bearing surface from polished to matte, that particular lubricant will not be suitable for use with the DX bearing material.

Table 5-4: Greases

GREASES RECOMMENDED

TYPE OF GREASE	DESCRIPTION
Premium Quality, Multi-Purpose	Stabilized, Antioxidant Lithium Base* Lithium Base with 3% Molybdenum Disulfide, High Drop Point*
Multi-Purpose	Calcium Based, for General Automotive and Industrial Use Calcium Grease, Water Stabilized, High Drop Point
Anti-Friction Bearing	Calcium Based with EP Additives Lithium Based Sodium Based
Extreme Pressure (EP)	Lithium Based with EP Additives Calcium Based with EP Additives
High Temperature	Modified Sodium Based, High Drop Point*
Transmission	Semi-Fluid, Calcium Based
Molybdenum Filled	Lithium Based with 2% Molybdenum Disulfide*
Graphite Filled	Sodium Based with 2% Graphite
Block Grease	Sodium Based Solid Grease
White Grease	Aluminum Complex Based with Antioxidant & Rust Inhibitors & Zinc Oxide Additives
Silicone	Lithium Based with Silicone Oil Lubricant

*Especially recommended

GREASES NOT RECOMMENDED

TYPE OF GREASE	DESCRIPTION
Cup Grease	Light Service Calcium or Sodium Based Grease
Graphite Filled	Greases with More than 10% Graphite
Molybdenum Filled	Greases with More than 10% Molybdenum Disulfide
Fluorocarbon	Low Molecular Weight Chlorofluoroethylene Polymer with Inert Thickeners
White Grease	Calcium Based, Zinc Oxide Filled

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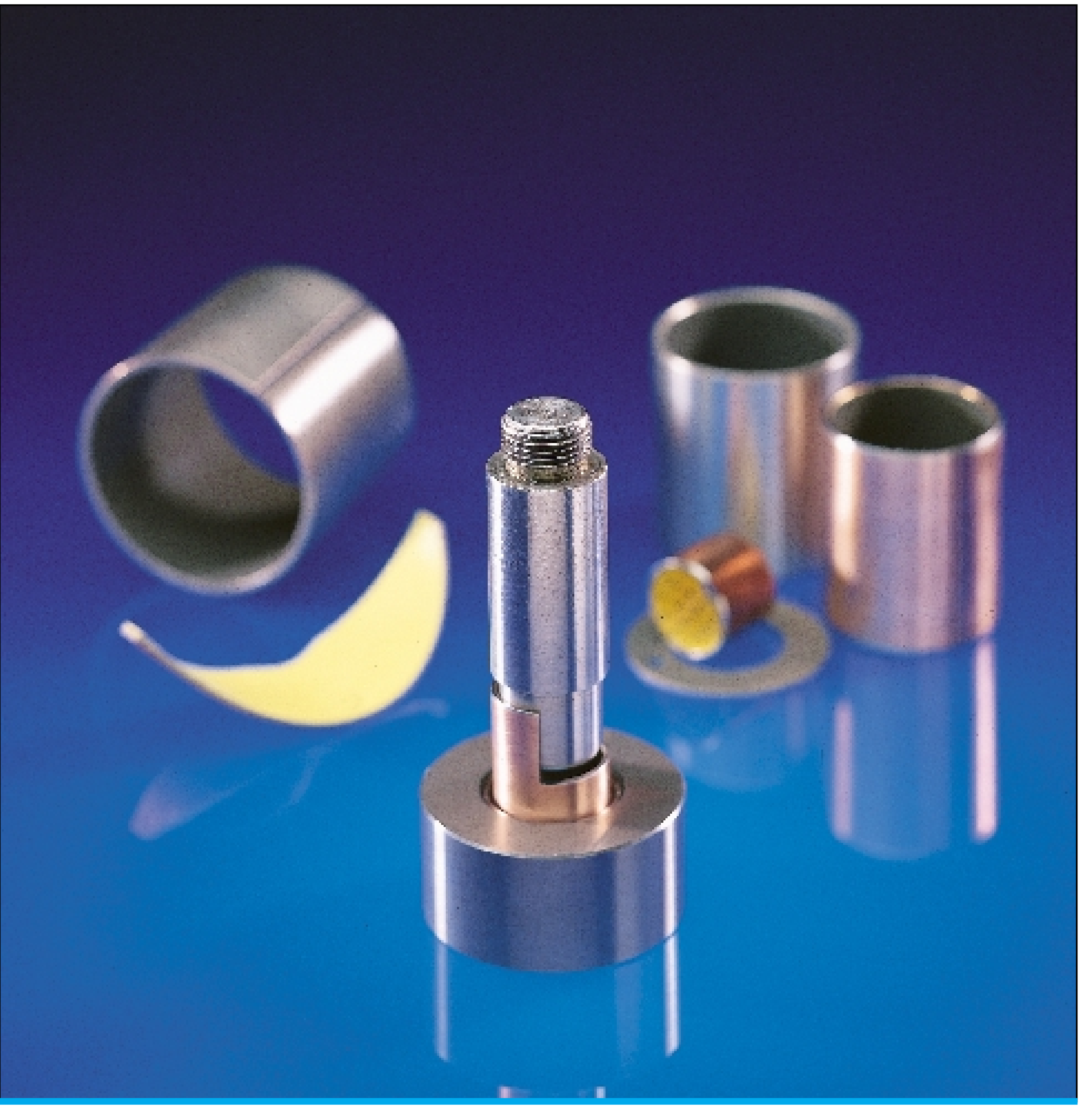

INSTALLATION and FABRICATION

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Installation Guidelines

*The success of a **DU**® or **DX**™ application depends, in part, on the proper installation of the bearing or thrust washer. The following pages show how to best install and modify DU and DX bearings.*

Sizing DU and DX bearings

DU bearings do not require sizing in the bore and, except in unusual circumstances, should not be roller burnished, broached, or machined. DU bearings can be sized by burnishing, although this may lead to reduced bearing life depending upon the amount of burnishing. Refer to Figure 6-3 for burnishing tool recommendations and Table 6-2 for DU bearing life modification factor.

DX bearings have a nominal 0.010 inch (0.25 mm) acetal layer and can be sized at assembly by boring, broaching, or reaming the bore.

If DU or DX bearings are not to be sized at assembly, it is important that both the shaft diameter and housing bore are finished to the sizes listed in the standard bearing tables. Any increase in clearance may result in a reduction in performance.

Assembly in a rigid steel or cast-iron housing will produce the calculated close-in and proper running clearances. With thin-walled housings or housings made from less rigid materials, such as aluminum or plastic, the clearances will be increased. In these circumstances, the housing should be bored slightly undersize or the shaft diameter increased—the correct size being determined by experiment.

When free-running is essential, or where lighter loads prevail (less than 15 psi [0.1 N/mm^2]) and the available torque is low, increased clearance is required, and it is recommended that the shaft diameter shown in the standard product tables be reduced by 0.001 inch (0.025 mm).

Tolerance for minimum clearance

When it is necessary to keep the variation of assembled clearance to a minimum, closer tolerances can be specified at the lower end of the housing tolerance and/or at the upper end of the shaft tolerance. It is not possible to reduce the lower housing limit or the upper shaft limit without running the risk of the shaft interference in the assembled bearing.

Normally, it is recommended that the housing and shaft be finished to the limits given in the standard product tables. With these sizes, the following are examples of the diametral clearance range created on assembly:

DU Bearings
0.0002 to 0.0034 inch for a 0.5 inch bore
0.0002 to 0.0068 inch for a 2.0 inch bore

DX Bearings
0.0007 to 0.0048 inch for a 0.5 inch bore
0.0015 to 0.0097 inch for a 2.0 inch bore

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Alignment

Accurate alignment is a primary design consideration in all bearing applications but is particularly important with DU bearings because there are no lubricants to spread the load. To maximize bearing life of DU bearings, misalignment over the length of a bearing (or pair of bearings in tandem), or over the diameter of a thrust washer should not exceed 0.0008 inch (0.020 mm). For DX bearings, misalignment should not exceed 0.002 inch (0.05 mm).

Axial location

Where axial location is necessary, it is advisable to use DU or DX thrust washers in conjunction with DU or DX bearings, even when the axial loads are light. Alternatively, for DU applications, flanged DU bearings should also be considered. Experience has indicated that fretting debris from mating thrust surfaces without a thrust bearing between them can enter an adjacent bearing and adversely affect the bearing life and performance.

Allowance for high temperature

When a DU or DX bearing is subjected to elevated temperatures, the diameter of the shaft should be reduced by 0.0002 inch per 100ºF (0.010 mm per 100ºC) for a DU bearing or 0.0005 inch per 100ºF (0.025 mm per 100ºC) for a DX bearing above normal room temperature. If the housing is a bronze-, zinc-, or aluminum-based alloy, its bore should be reduced by the amount shown in Table 6-1 to give an increased interference fit to the bearing. The shaft diameter should be reduced by this same amount in addition to previously mentioned shaft diameter reduction.

Table 6-1: High Temperature Allowance

Housing Material	Reduction in Housing and Shaft Diameter
Steel and Cast Iron	Nil
Brass or other Copper Alloys	0.025% per 100ºF (0.05% per 100ºC)
Aluminum Alloys	0.05% per 100ºF (0.10% per 100ºC)
Zinc Base Alloys	0.08% per 100ºF (0.15% per 100ºC)

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Bearing installation

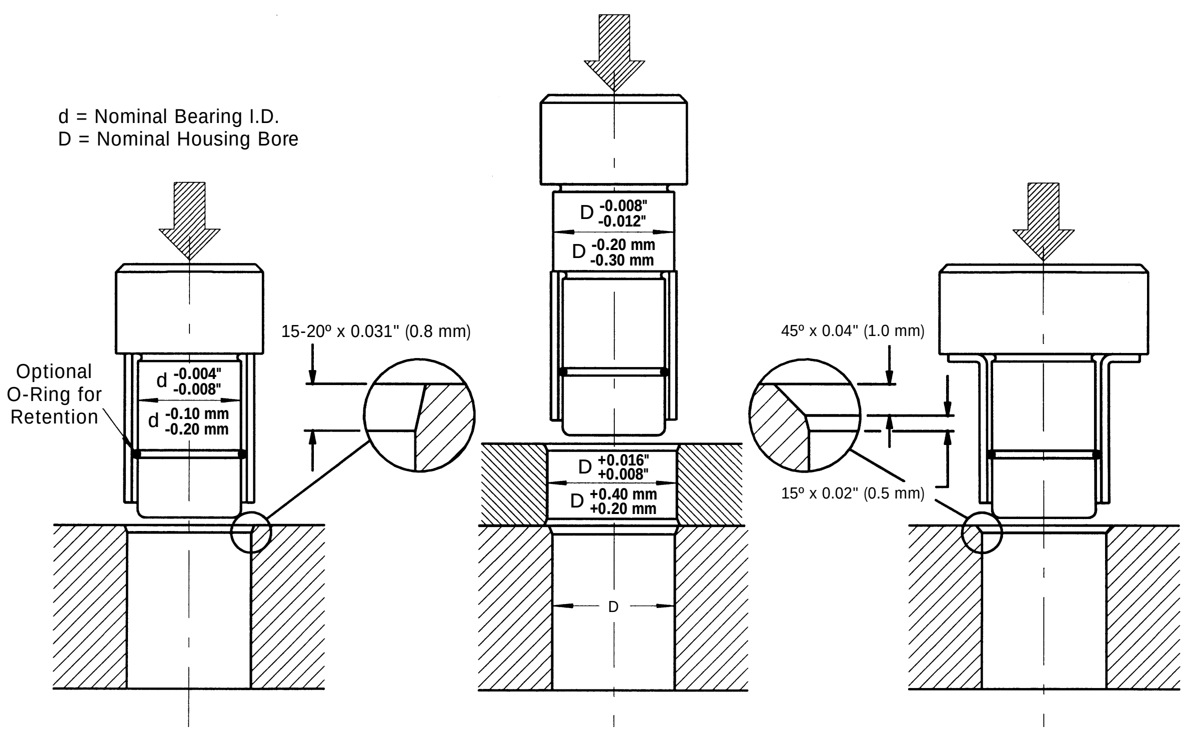
As illustrated by Figure 6-1, the bearing is inserted into its housing with the aid of a conventional stepped mandrel, preferably made from case-hardened mild steel and free of burrs and sharp edges.

Care must be taken to insert the bearing squarely into the housing to avoid damage to the lining material. A slight lead-in chamfer should be machined in the housing and a smear of oil may be applied to the housing bore to assist the fitting operation. Installation can be further improved by using an installation ring as shown on Figure 6-1. This approach is helpful for installing large diameter bearings. Figure 6-1 shows the recommended housing bore chamfer for flanged DU bearings. Recommended arbor and chamfer dimensions are given in the accompanying illustrations. Housing and shaft sizes are given in the standard product tables.

When the use of a mandrel for large bearings becomes impractical, other methods can be used, provided care is taken to protect the edge of the bearing from being damaged. Steps must be taken to maintain the alignment of the bearing split during assembly.

Note: Even though bearing surfaces of DU and DX materials are extremely durable when rubbing against a suitable shaft or thrust face, care must be taken to ensure that the bearing material is not scratched or otherwise damaged by sharp projections before or during installation.

Figure 6-1. Installing DU and DX Bearings



Standard Bearing Installation | Installation with Sizing Ring | Flanged Bearing Installation

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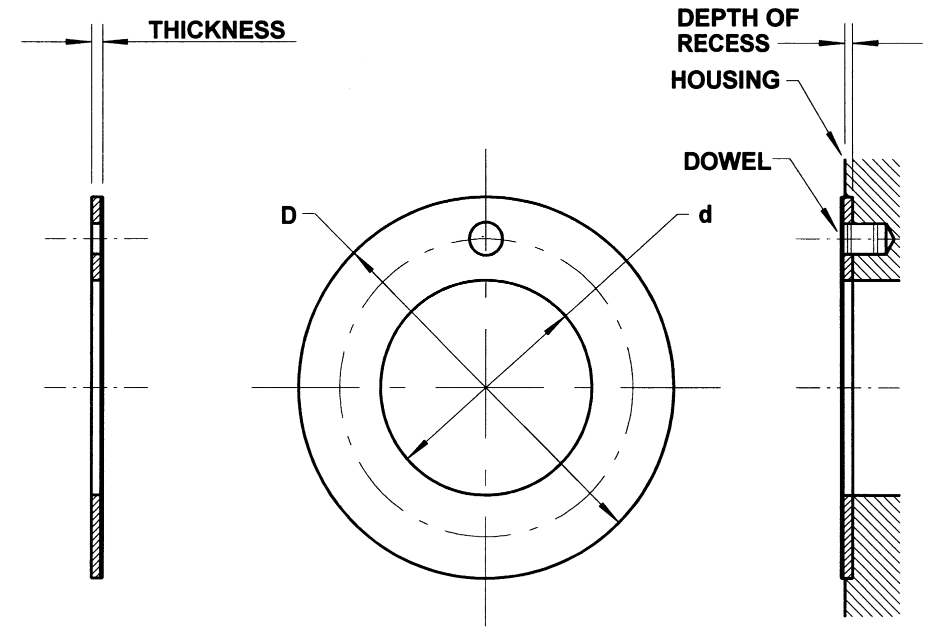

Figure 6-2. Installing a Thrust Washer

Thrust washer installation

As illustrated in Figure 6-2, thrust washers should be located on the outside diameter in a recess. The inside diameter must be clear of the shaft to prevent the steel backing from rubbing on the journal surface. The recess diameters should be 0.005 inch (0.13 mm) larger than the washer diameter.

A dowel or countersunk screw should be used to prevent rotation, but the head must be recessed at least 0.010 inch (0.25 mm) below the bearing surface. The size and position of the dowel hole provided for this purpose can also be found in the tables of standard sizes. Where a housing recess cannot be provided, two dowels or screws or a suitable adhesive may be used. When the use of screws or dowels is not convenient, solder or a synthetic resin adhesive may be used. Care must be taken not to heat the bearing above the maximum recommended operating temperature to avoid damage to the bearing material. Advice on the use of an adhesive should be obtained from the adhesive manufacturer.

Electroplating

The back and edges of DU can be electroplated with most conventional metals. With light deposits of materials such as tin, no special precautions are necessary. Since harder materials (e.g., chromium) or heavier deposits may bond to or strike through the surface layer, it is advisable to use an appropriate method of masking the bearing surface. Refer to Corrosion Protection on page 4-2.

Typically, DX bearings do not require plating since they are subsequently lubricated with grease or oil.

Length shortening, drilling

The modification of DU and DX bearing components requires no special procedures. In general, it is more satisfactory to perform machining or drilling operations from the bearing surface side in order to avoid burrs. When cutting is done from the steel side, minimum cutting pressure should be used. Remove all burrs and steel or bronze particles protruding into the remaining bearing material.

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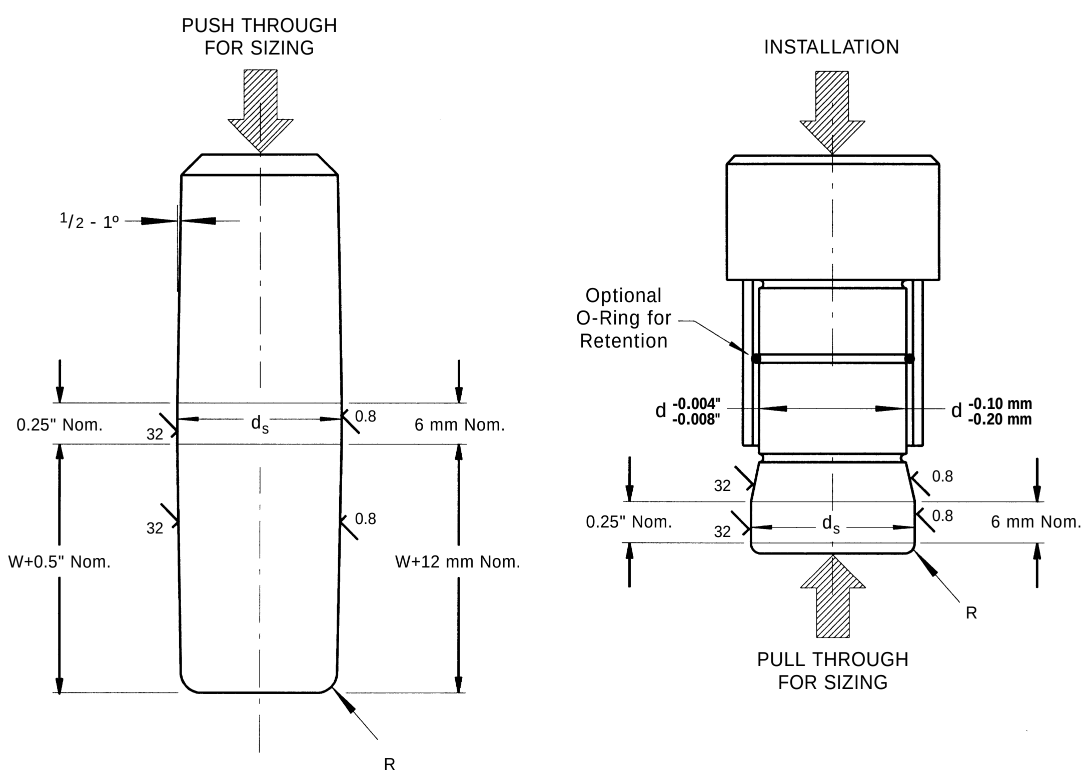
Burnishing DU® bearings

DU bearings can be sized at assembly by burnishing the bearing I.D. using tools as shown in Figure 6-3. This method of sizing DU is used to help control the assembled bearing clearance. However, burnishing will reduce dry bearing life. Table 6-2 lists a factor, based on the degree of burnishing, to be used when estimating DU bearing life. Multiply the bearing size factor B (Figure 4-8, page 4-10) by the factor in Table 6-2. For full hydrodynamic applications, burnishing will not affect bearing life except during starting and stopping. Roller burnishing is not recommended since the bronze innerstructure may be damaged.

Table 6-2: Burnishing Factor

Excess of burnishing tool diameter, d_s, over mean installed bearing I.D.	Burnishing Factor
0.001 inch (0.025 mm)	0.8
0.0015 inch (0.038 mm)	0.6
0.002 inch (0.05 mm)	0.3

Figure 6-3. Burnishing Tools



L = bearing length
d = shaft diameter

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DU® DX™

Boring DX™ bearings

Acetal resin has good general machining characteristics and can be treated as a free cutting brass in most respects. The pattern of indents applied to DX bearings makes certain machining procedures necessary. To obtain good results, we suggest use of a tool made from high speed steel or tungsten carbide.

Cutting speed should be high, the optimum lying between 400 and 900 fpm (2.0 to 4.5 m/s). The feed should be low, in the range of 0.002/0.001 inch (0.05/0.03 mm). For cuts of 0.005 inch (0.13 mm), the lower feeds should be used with the higher speed value.

Care should be taken with the final cut to make sure that the acetal bearing material does not smear into the indentations.

Also, machining may lead to the formation of burrs or whiskers due to the resilience of the DX lining. This can be avoided by using machining methods which remove the lining in a broad ribbon, rather than a narrow thread. Satisfactory finishes can usually be obtained machining dry, but should difficulty be met, a coolant can be used.

It is recommended that not more than 0.005 inch (0.13 mm) cut should be removed from the thickness of the DX lining, in order to ensure that the lubricant capability of the indent remaining after machining is not seriously reduced.

Reaming DX bearings

DX bearings can be reamed satisfactorily by hand with a straight-fluted expanding reamer. For best results, the reamer should be sharp, the cut 0.001 to 0.002 inch (0.03 to 0.05 mm), and the feed slow.

Where hand reaming is not desired, machining speeds of about 10 fpm (0.05 m/s) are recommended with the cuts and feed as for boring.

Broaching DX bearings

Broaches are suitable for finishing grooved or indented DX bearings. The broach should be used dry, at a speed of 20 fpm (0.1 m/s).

A single-tooth broach should be used where the bearing is less than 1 inch (25 mm) long, and a multiple tooth broach, for longer bearings or for bearings mounted in tandem.

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