GGB
BY TIMKEN

GGB DU® and DU-B

METAL-POLYMER SELF-LUBRICATING BEARING SOLUTIONS

Who we are

GGB helps create a world of motion with minimal frictional loss through plain bearing and surface engineering technologies. With global R&D, testing, and production facilities GGB partners with customers worldwide on customized tribological design solutions that are efficient and environmentally sustainable. GGB's engineers bring their expertise and passion for tribology to a wide range of industries, including automotive, aerospace and industrial manufacturing. To learn more about tribology for surface engineering from GGB, visit **ggbearings.com**.

Our products are used in tens of thousands of critical applications every day on our planet. It is always our goal to provide superior, high-quality solutions for our customers' needs, no matter where those demands take our products. From space vehicles to golf carts and virtually everything in between; we offer the industry's most extensive range of high performance, maintenance-free bearing solutions for a multitude of applications:

Aerospace

Agriculture

Automotive

Construction

E-Mobility

Energy

Exoskeletons

Fluid Power

Industrial

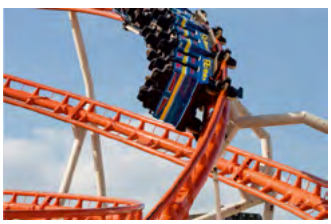
Medical

Mining

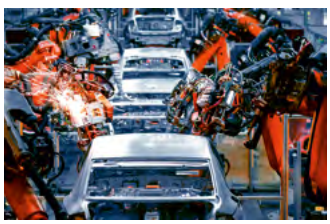
Oil & Gas

Primary Metals

Railway



Recreation



Robotics & Automation

The GGB Advantage

MAINTENANCE-FREE

GGB bearings are self-lubricating, making them ideal for applications requiring long bearing life without continuous lubrication.

LOW FRICTION, HIGH WEAR RESISTANCE

Low coefficients of friction eliminate the need for lubrication, while providing smooth operation, reducing wear and extending service life.

NVH (NOISE, VIBRATION, HARSHNESS)

Plain bearings provide a smooth sliding motion between surfaces and their material properties and simple design reduce noise, vibration and harshness.

LOWER SYSTEM COST

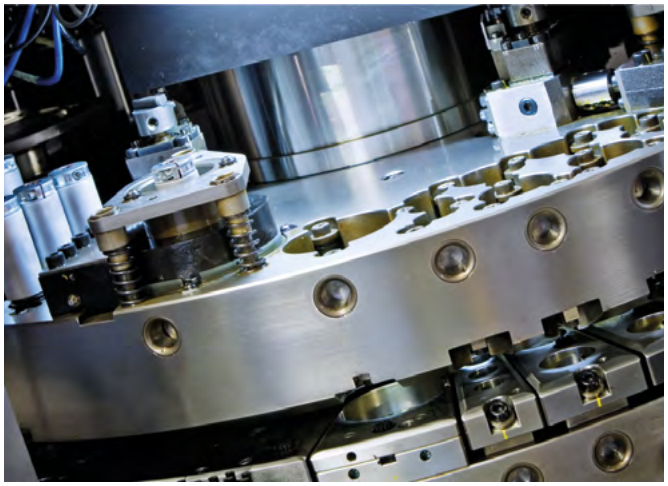
A one-piece design offers space and weight reductions and thanks to the material compositions and self-lubricating properties, less maintenance is needed.

REDUCED CO_2 FOOTPRINT

GGB's flexible and local production platforms assure timely deliveries and reduced CO_2 footprint.

PARTNER SUPPORT

GGB offers tribological, application and design support, and partners with our customers to provide the most efficient solutions.



The Highest Standards in Fabrication

Our world-class manufacturing plants are certified in quality and excellence according to ISO 9001, IATF 16949, ISO 14001 and ISO 45001. This allows us to access the industry's best practices while aligning our management system with global standards.

For a complete listing of our certifications, please visit our website:

ggbearings.com/en/certificates

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1 Introduction

The purpose of this handbook is to provide comprehensive technical information on the characteristics of DU® and DU-B bearings. The information given permits designers to establish the correct size of bearing required and the expected life and performance. GGB Research and Development services are available to assist with unusual design problems.

Complete information on the range of DU® and DU-B standard stock products is given together with details of other DU® and DU-B products.

GGB is continually refining and extending its experimental and theoretical knowledge and, therefore, when using this brochure it is always worthwhile to contact the Company should additional information be required.

As it is impossible to cover all conditions of operation which arise in practice, customers are advised to carry out prototype testing wherever possible.

1.1 APPLICATIONS

DU® and DU-B are suitable for

- rotating,
- oscillating,
- reciprocating and
- sliding movements.

Also available are DU® and DU-B related material compositions for specific applications, for example when increased corrosion resistance of the bearing material is required:

- in the case of more stringent requirements as a result of environmental regulations
- when there is a tendency to fretting corrosion.

1.2 CHARACTERISTICS AND ADVANTAGES

- DU® and DU-B require no lubrication
- Provides maintenance-free operation
- DU® and DU-B have a high PV capability
- DU® and DU-B exhibit low wear rate
- Seizure resistant
- Suitable for temperatures from -200 to +280 °C
- High static and dynamic load capacity
- Good frictional properties with negligible stick-slip
- Resists solvents
- No water absorption and therefore dimensionally stable
- DU® and DU-B are electrically conductive and show no electro-static effects
- DU® and DU-B have good embeddability and are tolerant of dusty environments
- Compact and light
- DU® and DU-B bearings are prefinished and require no machining after assembly

1.3 BASIC FORMS AVAILABLE

Standard Components available from Stock

These products are manufactured to international, national or GGB standard designs.

— Cylindrical Bushes — Flanged Bushes — Thrust Washers — Flanged Washers (metric sizes only) — Plates

Figure 1: Standard components

Non-Standard Components not available from Stock

These products are manufactured to customers' requirements with or without GGB recommendations, and include for example:

— Modified Standard Components — Half Bearings — Flat Components — Deep Drawn Parts — Pressings — Stampings

Figure 7: Non-standard components

2 Material

2.1 STRUCTURE

DU® and DU-B take advantage of the outstanding dry bearing properties of Polytetrafluoroethylene (PTFE) and combine them with strength, stability and good wear resistance, excellent heat conductivity and low thermal expansion.

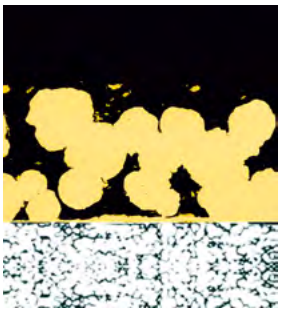


Fig. 3: DU microsection

Fig. 4: DU-B microsection

DU

DU® consists of three bonded layers: a steel backing strip and a porous bronze matrix, impregnated and overlaid with the PTFE/lead bearing material.

DU-B

DU-B also consists of three layers, with a bronze backing replacing the steel backing strip. The structure is otherwise the same as that of DU®.

The bronze backing provides a high corrosion resistance, antimagnetic properties and a good thermal conductivity.

MATERIAL COMPOSITION

MATERIAL	BACKING	BEARING LINING	OPERATING TEMPERATURE [°C]	MAXIMUM LOAD P_{lim} [N/mm²]
DU®	Steel	PTFE+Lead	min -200 / max +280	250
DU-B	Bronze	PTFE+Lead	min -200 / max +280	140

Table 1: Characteristics of DU and DU-B

2.2 DRY WEAR MECHANISM

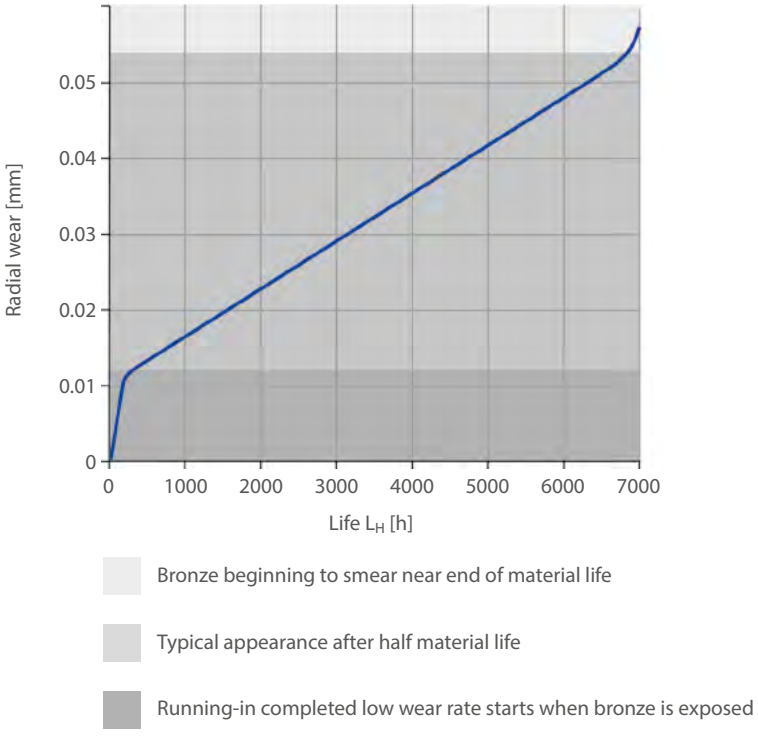


Fig. 5: Effect of wear on the DU bearing surface under dry operating conditions.

Running-in

During normal operation, a DU® bearing quickly beds in and the PTFE/lead overlay material removed during this period, typically 0.015 mm, is transferred to the mating surface and forms a physically bonded lubricant film.

The rubbing surface of the bearing often acquires a grey-green colour and the bronze matrix can be seen exposed over about 10 % of the bearing surface. Any excess of the PTFE/lead surface layer will be shed as fine feathery particles.

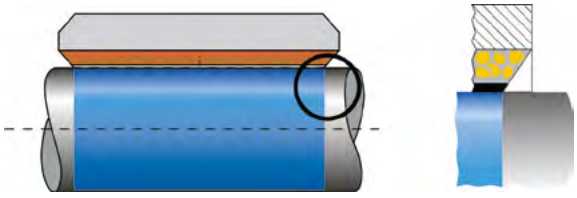


Fig. 6: Running-in

After 50 % of Useful Life

Following the running-in period the wear rate reduces to a minimum and the percentage of bronze exposed gradually increases.

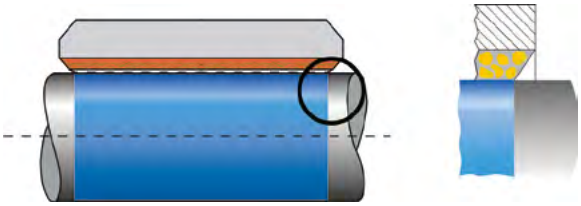


Fig. 7: After 50 % of useful life

End of Useful Life

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 0.06 mm wear will have occurred.

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 or becomes contaminated with abrasive dirt.

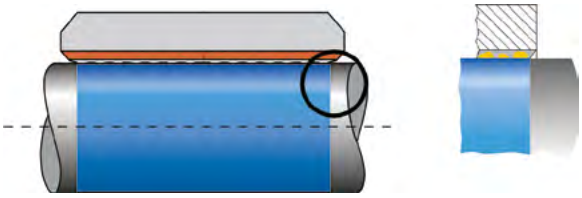


Fig. 8: End of useful life

2.3 PHYSICAL, MECHANICAL AND ELECTRICAL PROPERTIES

BEARING PROPERTIES		SYMBOL	UNIT	VALUE		COMMENTS
				DU®	DU-B	
PHYSICAL PROPERTIES						
Thermal conductivity		λ	W/mK	40	60	after running-in
Coefficient of linear thermal expansion	parallel to surface normal to surface	α_1 α_2	10^{-6}/K	11 30	18 36	measured on strip 1,9 mm thick
Operating temperature		T_{max} T_{min}	°C	+280 - 200	+280 - 200	
MECHANICAL PROPERTIES						
Compressive yield strength		σ_C	N/mm²	350	300	measured on disc Ø 25 mm x 2,45 mm thick
Maximum load	static dynamic	$P_{sta.max}$ $P_{dyn.max}$	N/mm²	250 140	140 140	
ELECTRICAL PROPERTIES						
Surface Resistance		R_{OB}	Ω	1 - 10	1 - 12	depends on applied pressure and contact area
NUCLEAR RADIATION RESISTANCE						
Maximum thermal neutron dose		D_{Nth}	nvt	2×10^{15}	2×10^{15}	nvt = thermal neutron flux
Maximum gamma ray dose		D_Y	Gy = J/kg	10^6	10^6	1 Gray = 1J/kg

Table 2: Properties of DU and DU-B

2 Material

2.4 CHEMICAL PROPERTIES

The following table provides an indication of the chemical resistance of DU® and DU-B to various chemical media.
It is recommended that the chemical resistance is confirmed by testing if possible.

CHEMICAL	%	°C	DU®	DU-B
STRONG ACIDS				
Hydrochloric Acid	5	20	-	-
Nitric Acid	5	20	-	-
Sulfuric Acid	5	20	-	-
WEAK ACIDS				
Acetic Acid	5	20	-	o
Formic Acid	5	20	-	o
BASES				
Ammonia	10	20	o	-
Sodium Hydroxide	5	20	o	o

CHEMICAL	°C	DU®	DU-B
SOLVENTS			
Acetone	20	+	+
Carbon Tetrachloride	20	+	+
LUBRICANTS AND FUELS			
Paraffin	20	+	+
Gasoline	20	+	+
Kerosene	20	+	+
Diesel Fuel	20	+	+
Mineral Oil	70	o	o
HFA-ISO46 High Water Fluid	70	o	o
HFC-Water-Glycol	70	-	-
HFD-Phosphate Ester	70	o	o
Water	20	o	+
Sea Water	20	-	o

Table 3 Chemical resistance of DU and DU-B

+ Satisfactory: Corrosion damage is unlikely to occur

o Acceptable: Some corrosion damage may occur but this will not be sufficient to impair either the structural integrity or the tribological performance of the material

- Unsatisfactory: Corrosion damage will occur and is likely to affect either the structural integrity and/or the tribological performance of the material

Electrochemical Corrosion

DU-B should not be used in conjunction with aluminium housings due to the risk of electrochemical corrosion in the presence of water or moisture.

2.5 FRICTIONAL PROPERTIES

DU® bearings show negligible 'stick-slip' and provide smooth sliding between adjacent surfaces. The coefficient of friction of DU® depends upon:

- The specific load P [N/mm^2]
- The sliding speed V [m/s]
- The roughness of the mating running surface R_a [µm]
- The bearing temperature T [°C].

A typical relationship is shown in Fig. 9, which can be used as a guide to establish the actual friction under clean, dry conditions after running in.

Exact values may vary by ± 20 % depending on operating conditions.

Before running in, the friction may be up to 50 % higher. With frequent starts and stops, the static coefficient of friction is approximately equal to, or even slightly less than the dynamic coefficient of friction.

After progressively longer periods of dwell under load (e.g. hours or days) the static coefficient of friction on the first movement may be between 1,5 and 3 times greater, particularly before running in. Friction increases at bearing temperatures below 0 °C. Where frictional characteristics are critical to a design they should be established by prototype testing.

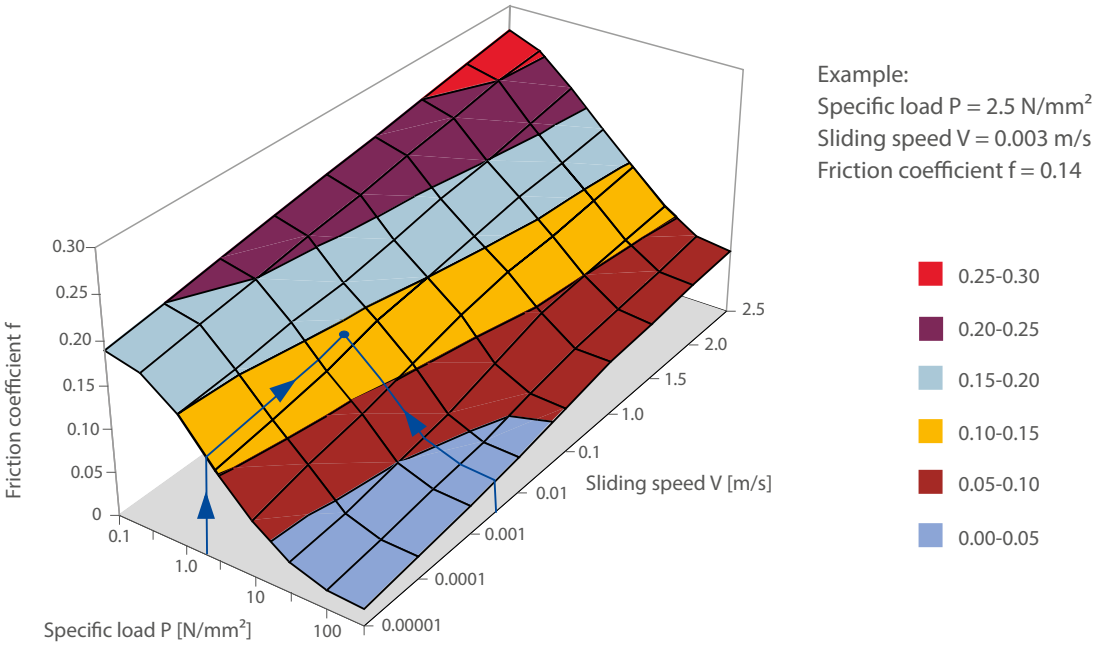


Fig. 9: Variation of friction coefficient f with specific load P and sliding speed V at temperature T = 25 °C

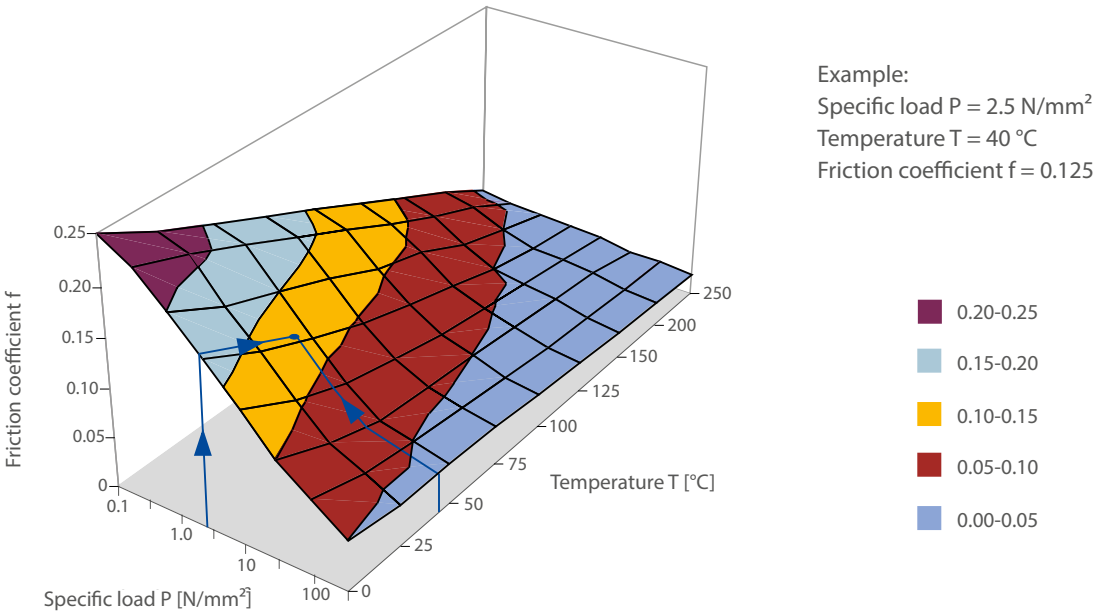


Fig. 10: Variation of friction coefficient f with specific load P and temperature T at sliding speed V = 0,01 m/s

3 Performance

3.1 DESIGN FACTORS

The main parameters when determining the size or calculating the service life for a DU® bearing are:

- Specific load limit P_{lim} [N/mm²]
- PV Factor [N/mm² x m/s]
- Mating surface roughness R_a [µm]
- Mating surface material
- Temperature T [°C]
- Other environmental factors e.g. housing design, dirt, lubrication.

Calculation

Two design procedures are provided as follows:

- A bearing service life calculation based on the permitted bearing dimensions
- A calculation of the necessary bearing dimensions based on the required bearing service life.

3.2 SPECIFIC LOAD P

For the purpose of assessing bearing performance the specific load p is defined as the working load divided by the projected area of the bearing and is expressed in N/mm².

Cylindrical Bush

(3.2.1) [N/mm²]

$$P = \frac{F}{D_i \cdot B}$$

Thrust Washer

(3.2.2) [N/mm²]

$$P = \frac{4F}{\pi \cdot (D_o^2 - D_i^2)}$$

Flanged Bush (Axial Loading)

(3.2.3) [N/mm²]

$$P = \frac{F}{0.04 \cdot (D_{fl}^2 - D_i^2)}$$

Slide Plate

(3.2.4) [MPa]

$$P = \frac{F}{L \cdot W}$$

Permanent deformation of the DU® bearing lining may occur at specific loads above 140 N/mm² and under these conditions DU® should only be used with slow intermittent movements.

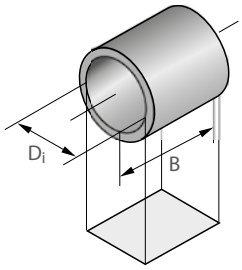
The permissible maximum load on a thrust washer is higher than that on the flange of a flanged bush, and under conditions of high axial loads a thrust washer should be specified.

3.3 SPECIFIC LOAD LIMIT P_{lim}

The maximum load which can be applied to a DU® bearing can be expressed in terms of the Specific Load Limit, which depends on the type of the loading. It is highest under steady loads. Conditions of dynamic load or oscillating movement which produce fatigue stress in the bearing result in a reduction in the permissible Specific Load Limit.

In general the specific load on a DU® bearing should not exceed the Specific Load Limits given in Table 4.

The values of Specific Load Limit specified in Table 4 assume good alignment between the bearing and mating surface (Fig. 29).



Projected area
$A = D_i \cdot B$

Maximum Specific Load P_{lim}

TYPE OF LOADING / P_{lim} [N/mm²]										
Steady load - rotating movement P_{lim}	140									
Steady load - oscillating movement										
P_{lim}	140	140	115	95	85	80	60	44	30	20
Number of movement cycles Q	1000	2000	4000	6000	8000	10^4	10^5	10^6	10^7	10^8
Dynamic load - rotating or oscillating movement										
P_{lim}	60	60	50	46	42	40	30	22	15	10
Number of load cycles Q	1000	2000	4000	6000	8000	10^4	10^5	10^6	10^7	10^8

Table 4: Maximum specific load P_{lim}

3.4 SLIDING SPEED V

The sliding speed V [m/s] is calculated as follows:

CONTINUOUS ROTATION

Cylindrical Bush

(3.4.1) [m/s]

$$V = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3}$$

Thrust Washer

(3.4.2) [m/s]

$$V = \frac{\frac{D_o + D_i}{2} \cdot \pi \cdot N}{60 \cdot 10^3}$$

OSCILLATING MOVEMENT

Cylindrical Bush

(3.4.3) [m/s]

$$V = \frac{D_i \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{OSZ}}{360}$$

Thrust Washer

(3.4.4) [m/s]

$$V = \frac{\frac{D_o + D_i}{2} \cdot \pi}{60 \cdot 10^3} \cdot \frac{4\varphi \cdot N_{OSZ}}{360}$$

3 Performance

3.5 PV FACTOR

The useful operating life of a DU® bearing is governed by the PV factor, the product of the specific load P [N/mm²] and the sliding speed V [m/s].

For thrust washers and flanged bush thrust faces the rubbing velocity at the mean diameter is used.

PV factors up to 3.6 N/mm² x m/s can be accommodated for short periods, whilst for continuous rating.

PV factors up to 1.8 N/mm² x m/s can be used, depending upon the operating life required.

	DU	UNIT
P	140	N/mm²
V	2.5	m/s
PV continuous	1.8	$N/mm^2 \cdot m/s$
PV intermittent	3.6	$N/mm^2 \cdot m/s$

Table 5: Typical data P, V and PV

Calculation of PV Factor

(3.5.1) [$N/mm^2 \cdot m/s$]

$$PV = P \cdot V$$

3.6 APPLICATION FACTORS

Temperature

The useful life of a DU bearing depends upon the operating temperature.

Under dry running conditions frictional heat is generated at the rubbing surface of the bearing dependent on the PV condition. For a given PV factor the operating temperature of the bearing depends upon the temperature of the surrounding environment and the heat dissipation properties of the housing. Intermittent operation affects the heat dissipation from the assembly and hence the operating temperature of the bearing.

The effect of temperature on the operating life of DU bearings is indicated by the factor a_T shown in Table 6.

MODE OF OPERATION	NATURE OF HOUSING	TEMPERATURE OF BEARING ENVIRONMENT T_{amb} [°C] AND TEMPERATURE APPLICATION FACTOR a_T					
		[°C] 25	60	100	150	200	280
Dry continuous operation	Average heat dissipating qualities	1.0	0.8	0.6	0.4	0.2	0.1
Dry continuous operation	Light pressings or isolated housing with poor heat dissipating qualities	0.5	0.4	0.3	0.2	0.1	-
Dry continuous operation	Non-metallic housings with bad heat dissipating qualities	0.3	0.3	0.2	0.1	-	-
Dry intermittent operation (duration less than 2 min, followed by a longer dwell period)	Average heat dissipating qualities	2.0	1.6	1.2	0.8	0.4	0.2
Continuously immersed in water		2.0	1.5	0.6	-	-	-
Alternately immersed in water & dry		0.2	0.1	-	-	-	-
Continuously immersed in non lubricant liquids other than water		1.5	1.2	0.9	0.6	0.3	0.1
Continuously immersed in lubricant		3.0	2.5	2.0	1.5	-	-

Table 6: Temperature application factor a_T

Mating Surface

The effect of the mating surface material type on the operating life of DU® bearings is indicated by the mating surface factor a_M and the life correction constant a_L shown in Table 7.

MATERIAL	a_M	a_L
Steel and Cast Iron		
Steel and Cast Iron	1	200
Carbon Manganese Steel	1	200
Alloy Steel	1	200
Case Hardened Steel	1	200
Nitrided Steel	1	200
Salt bath nitrocarburised	1	200
Stainless Steel (7-10 % Ni, 17-20 % Cr)	2	200
Sprayed Stainless Steel	1	200
Cast Iron (0.3 µm R_a)	1	200
Plated Steel with min. Thickness of Plating 0.013 mm		
Cadmium	0.2	600
Hard Chrome	2.0	600
Lead	1.5	600
Nickel	0.2	600
Phosphated	0.2	300
Tin Nickel	1.2	600
Titanium Nitride	1.0	600
Tungsten Carbide Flame Plated	3.0	600
Zinc	0.2	600
Non Ferrous Metals		
Aluminium Alloys	0.4	200
Bronze and Copper Base Alloys	0.1 - 0.4	200
Hard Anodised Aluminium (0.025 mm thick)	3.0	600

Table 7: Mating surface factor a_M and life correction constant a_L

Note

The factor values given assume a mating surface finish of ≤0.4 µm R_a

- A ground surface is preferred to fine turned
- Surfaces should be cleaned of abrasive particles after polishing
- Cast iron surfaces should be ground to <0,3 µm R_a
- The grinding cut should be in the same direction as the bearing motion relative to the shaft

Bearing Size

The running clearance of a DU® bearing increases with bearing diameter resulting in a proportionally smaller contact area between the shaft and bearing. This reduction in contact area has the effect of increasing the actual unit load and hence PV factor. The bearing size factor (Fig. 13) is used in the design calculations to allow for this effect. The bearing size factor is also applicable to thrust washers, where for other reasons, bearing diameter has an effect on performance.

FIgure 12: Contact area between bearing and shaft

3 Performance

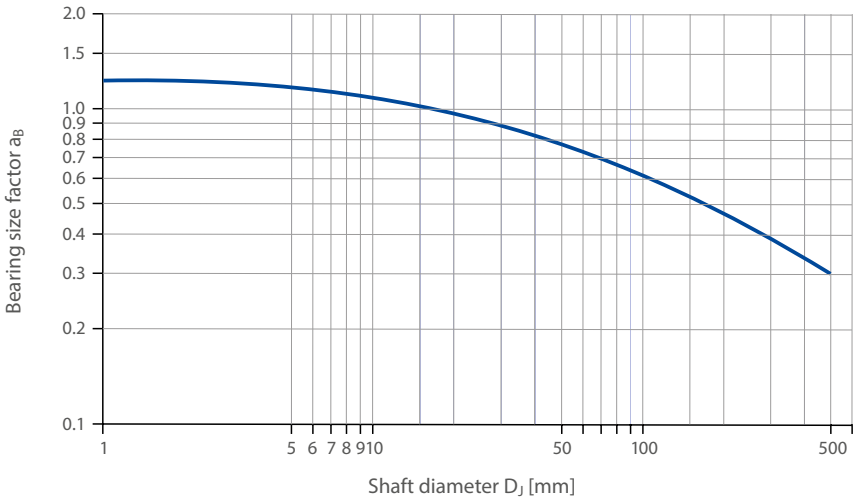


Fig. 13: Bearing size factor a_B

Bore Burnishing

Burnishing or machining the bore of a DU® bearing results in a reduction in the wear performance. The application factor a_C given in Table 8 is used in the design calculations to allow for this effect.

DEGREE OF SIZING	APPLICATION FACTOR a_C	
BURNISHING	0.025 mm	0.8
Excess of burnishing tool diameter over	0.038 mm	0.6
mean bore size	0.050 mm	0.3
BORING	0.025 mm	0.6
Depth of cut	0.038 mm	0.3
	0.050 mm	0.1

Table 8: Bore burnishing or machining application factor a_C

Type of Load

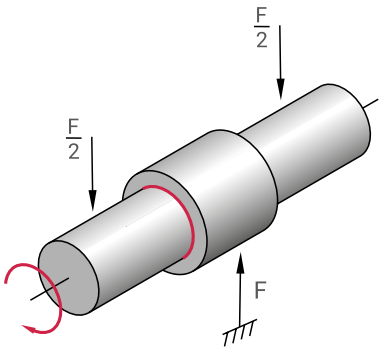


Fig. 14: Steady load, bush stationary, shaft rotating

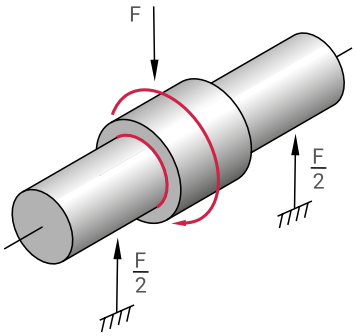


Fig. 15: Rotating load, shaft stationary, bush rotating

3.7 CALCULATION OF BEARING SIZE

In designing all bearings, the shaft diameter is usually determined by considerations of physical stability or stiffness and the main variable to be determined is the length of the bush or the land width of the thrust washer.

The formulae given below enable designers to calculate the length or width necessary to satisfy both the Specific Load Limit and the PV/Life relationship.

If it is found that the total length exceeds twice the diameter of the shaft, this indicates that the conditions envisaged are too severe for DU® material and consideration should be given to repositioning the bearings in order to reduce the load.

Calculation for Bushes

Bush stationary, shaft rotating

(3.7.1) [mm]

$$B = \frac{F \cdot N \cdot (L_H + a_L)}{1.25 \cdot 10^7 \cdot a_T \cdot a_M \cdot a_B} + \frac{F}{P_{lim} \cdot D_i}$$

Bush rotating, shaft stationary

(3.7.2) [mm]

$$B = \frac{F \cdot N \cdot (L_H + a_L)}{2.5 \cdot 10^7 \cdot a_T \cdot a_M \cdot a_B} + \frac{F}{P_{lim} \cdot D_i}$$

Calculation for Thrust Washers

(3.7.3) [mm]

$$D_o - D_i = \frac{F \cdot N \cdot (L_H + a_L)}{1.25 \cdot 10^7 \cdot a_T \cdot a_M \cdot a_B} + \sqrt{D_i^2 + \frac{1.3\,F}{P_{lim}}} - D_i$$

Calculation for Slideways

(3.7.4) [mm²]

$$A = \frac{2.38 \cdot F \cdot U \cdot (L_H + a_L)}{10^3 \cdot a_T \cdot a_M} \cdot \frac{(L + L_S)}{L} + \frac{F}{P_{lim}}$$

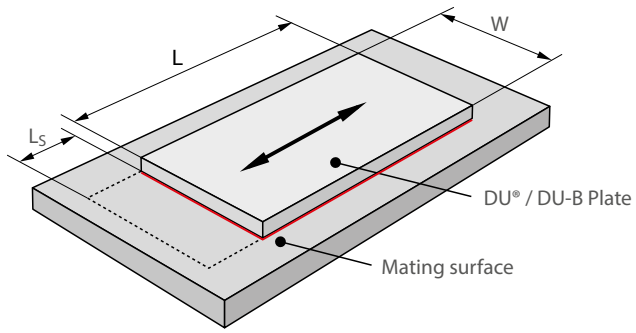


Fig. 16: Slideway

3 Performance

3.8 CALCULATION OF BEARING SERVICE LIFE

Where the size of a bearing is governed largely by the space available the following calculation can be used to determine whether its useful life will satisfy the requirements. If the calculated life is inadequate, a larger bearing should be considered.

Specific load P

Bushes

(3.8.1) [N/mm²]

$$P = \frac{F}{D_i \cdot B}$$

Flanged Bushes

(3.8.2) [N/mm²]

$$P = \frac{4F}{0.04 \cdot (D_{fl}^2 - D_i^2)}$$

Thrust Washers

(3.8.3) [N/mm²]

$$P = \frac{4F}{\pi \cdot (D_o^2 - D_i^2)}$$

high load factor a_e

(3.8.4) [-]

$$a_E = \frac{P_{lim} - P}{P_{lim}}$$

P_{lim} see Table 4 Page 13

Modified PV Factor

Bushes

(3.8.5) [N/mm² · m/s]

$$PV = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B}$$

Flanged Bushes

(3.8.6) [N/mm² · m/s]

$$PV = \frac{6.5 \cdot 10^{-4} F \cdot N}{a_E \cdot (D_{fl} - D_i) \cdot a_T \cdot a_M \cdot a_B}$$

Thrust Washers

(3.8.7) [N/mm² · m/s]

$$PV = \frac{3.34 \cdot 10^{-5} F \cdot N}{a_E \cdot (D_o - D_i) \cdot a_T \cdot a_M \cdot a_B}$$

For oscillating movement, calculate the average rotational speed.

(3.8.8) [1/min]

$$N = \frac{4\varphi \,.\, N_{OSZ}}{360}$$

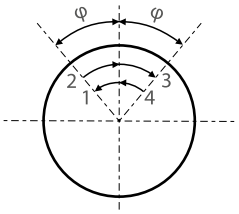


Figure 17: Oscillating cycle φ

Estimation of Bearing Life L_H

Bushes (steady load)

(3.8.9) [h]

$$L_H = \frac{615}{PV} - a_L$$

Bushes (rotating load)

(3.8.10) [h]

$$L_H = \frac{1230}{PV} - a_L$$

Flanged Bushes (axial load)

(3.8.11) [h]

$$L_H = \frac{410}{PV} - a_L$$

Thrust Washers

(3.8.12) [h]

$$L_H = \frac{410}{PV} - a_L$$

Bore Burnishing

If the DU® bush is bore burnished then this must be allowed for in estimating the bearing life by the application factor a_C (Table 8, Page 16).

Estimated Bearing Life

(3.8.13) [h]

$$L_H = L_H \cdot a_C$$

Slideways

Specific Load Factor

(3.8.14) [-]

$$a_{E1} = A - \frac{F}{P_{lim}}$$

If negative, the bearing is overloaded and the bearing area should be increased

Speed Temperature and Material Application Factors

(3.8.15) [-]

$$a_{E2} = \frac{420 \cdot a_T \cdot a_M}{F \cdot V}$$

Relative Contact Area Factor

(3.8.16) [-]

$$a_{E3} = \frac{A}{A_M}$$

Estimated Bearing Life

(3.8.17) [h]

$$L_H = a_{E1} \cdot a_{E2} \cdot a_{E3} - a_L$$

Estimated bearing lives greater than 4000 h are subject to error due to inaccuracies in the extrapolation of test data.

$Z_T = L_H \cdot N_{OSZ} \cdot 60$ (for oscillating movements - 3.8.18)

$Z_T = L_H \cdot C \cdot 60$ (for dynamic load - 3.8.19)

Check that Z_T is less than total number of cycles Q for the operating specific load P (Table 4, Page 13)

For oscillating movements or dynamic load: calculate estimated number of cycles Z_T.

If $Z_T < Q$, L_H will be limited by wear after Z_T cycles.

If $Z_T > Q$, L_H will be limited by fatigue after Q cycles.

3 Performance

3.9 WORKED EXAMPLES

CYLINDRICAL BUSH

Given:			
Load Details	Steady Load Continuous Rotation	Inside Diameter D_i Length B	40 mm 30 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load F Rotational Speed N	5,000 N 50 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit P_{lim}	140 N/mm²	(Table 4, Page 13)
Temperature Application Factor a_T	1.0	(Table 6, Page 14)
Material Application Factor a_M	1.0	(Table 7, Page 15)
Bearing Size Factor a_B	0.85	(Fig. 13, Page 16)
Life Correction Constant a_L	200	(Table 7, Page 15)

Calculation	Ref	Value
Specific Load P [N/mm²]	(3.2.1) Page 12	$P = \frac{F}{D_i \cdot B} = \frac{5{,}000}{40 \cdot 30} = 4.17$
Sliding Speed V [m/s]	(3.4.1) Page 13	$V = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{40 \cdot 3.14 \cdot 50}{60 \cdot 10^3} = 0.105$
PV Factor calculate from Table 5, Page 14	(3.5.1) Page 14	$PV = P \cdot V = 4.17 \cdot 0.105 = 0.438$
High Load Factor a_E [-] must be > 0	(3.8.4) Page 18	$a_E = \frac{P_{lim} - P}{P_{lim}} = \frac{140 - 4.17}{140} = 0.97$
Modified PV Factor [N/mm² · m/s]	(3.8.5) Page 18	$PV = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B} = 0.53$
Life L_H [h]	(3.8.9) Page 19	$L_H = \frac{615}{PV} - a_L = \frac{615}{0.53} - 200 = 960$

CYLINDRICAL BUSH

Given:			
Load Details	Steady Load Continuous Rotation	Inside Diameter D_i Length B	30 mm 30 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load F Rotational Speed N	25,000 N 15 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit P_{lim}	60 N/mm²	(Table 4, Page 13)
Temperature Application Factor a_T	1.0	(Table 6, Page 14)
Material Application Factor a_M	1.0	(Table 7, Page 15)
Bearing Size Factor a_B	1.0	(Fig. 13, Page 16)
Life Correction Constant a_L	200	(Table 7, Page 15)

Calculation	Ref	Value
Specific Load P [N/mm²]	(3.2.1) Page 12	$P = \frac{F}{D_i \cdot B} = \frac{25{,}000}{30 \cdot 30} = 27.78$
Sliding Speed V [m/s]	(3.4.1) Page 13	$V = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{30 \cdot 3.14 \cdot 15}{60 \cdot 10^3} = 0.024$
PV Factor calculate from Table 5, Page 14	(3.5.1) Page 14	$PV = P \cdot V = 27.78 \cdot 0.024 = 0.669$
High Load Factor a_E [-] must be > 0	(3.8.4) Page 18	$a_E = \frac{P_{lim} - P}{P_{lim}} = \frac{60 - 27.78}{60} = 0.54$
Modified PV Factor [N/mm² · m/s]	(3.8.5) Page 18	$PV = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B} = 1.23$
Life L_H [h]	(3.8.9) Page 19	$L_H = \frac{615}{PV} - a_L = \frac{615}{1.23} - 200 = 300$
Calculate Total Load Cycles	Table 4 Page 13	$L_T = 300 \cdot 60 \cdot 60 = 1.08 \cdot 10^6$
Q for 27.78 N/mm² = bearing will fatigue after 10^5 cycles (=28 h)		

CYLINDRICAL BUSH

Given:			
Load Details	Steady Load Continuous Rotation	Inside Diameter D_i Length B	50 mm 50 mm
Shaft	Steel Unlubricated at 100°C	Bearing Load F Rotational Speed N	10,000 N 50 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit P_{lim}	60 N/mm²	(Table 4, Page 13)
Temperature Application Factor a_T	0.6	(Table 6, Page 14)
Material Application Factor a_M	1.0	(Table 7, Page 15)
Bearing Size Factor a_B	0.78	(Fig. 13, Page 16)
Life Correction Constant a_L	200	(Table 7, Page 15)

Calculation	Ref	Value
Specific Load P [N/mm²]	(3.2.1) Page 12	$P = \frac{F}{D_i \cdot B} = \frac{10{,}000}{50 \cdot 50} = 4.0$
Sliding Speed V [m/s]	(3.4.1) Page 13	$V = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{50 \cdot 3.14 \cdot 50}{60 \cdot 10^3} = 0.131$
PV Factor calculate from Table 5, Page 14	(3.5.1) Page 14	$PV = P \cdot V = 4.0 \cdot 0.131 = 0.542$
High Load Factor a_E [-] must be > 0	(3.8.4) Page 18	$a_E = \frac{P_{lim} - P}{P_{lim}} = \frac{60 - 4.17}{60} = 0.93$
Modified PV Factor [N/mm² · m/s]	(3.8.5) Page 18	$PV = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B} = 1.20$
Life L_H [h]	(3.8.9) Page 19	$L_H = \frac{1.230}{PV} - a_L = \frac{1.230}{1.20} - 200 = 825$

CYLINDRICAL BUSH

Given:			
Load Details	Steady Load Oscillating Movement	Inside Diameter D_i Length B	45 mm 40 mm
Shaft	Stainless Steel Unlubricated at 25°C Continuous Operation	Bearing Load F Frequency C Amplitudes ϕ	40,000 150 20°

Calculation Constants and Application Factors		
Specific Load Limit P_{lim}	140 N/mm²	(Table 4, Page 13)
Temperature Application Factor a_T	1.0	(Table 6, Page 14)
Material Application Factor a_M	2.0	(Table 7, Page 15)
Bearing Size Factor a_B	0.81	(Fig. 13, Page 16)
Life Correction Constant a_L	200	(Table 7, Page 15)

Calculation	Ref	Value
Specific Load P [N/mm²]	(3.2.1) Page 12	$P = \frac{F}{D_i \cdot B} = \frac{40{,}000}{45 \cdot 40} = 22.22$
Sliding Speed V [m/s]	(3.4.1) Page 13	$V = \frac{D_i \cdot \pi \cdot N}{60 \cdot 10^3} = \frac{45 \cdot 3.14 \cdot 33.33}{60 \cdot 10^3} = 0.078$
Average Speed N [1/min]	(3.8.8) Page 18	$N = \frac{4\varphi \,.\, N_{OSZ}}{360} = \frac{4 \cdot 20 \cdot 150}{360} = 33.33$
PV Factor calculate from Table 5, Page 14	(3.5.1) Page 14	$PV = P \cdot V = 22.22 \cdot 0.078 = 1.733$
High Load Factor a_E [-] must be > 0	(3.8.4) Page 18	$a_E = \frac{P_{lim} - P}{P_{lim}} = \frac{140 - 22.22}{140} = 0.84$
Modified PV Factor [N/mm² · m/s]	(3.8.5) Page 18	$PV = \frac{5.25 \cdot 10^{-5} F \cdot N}{a_E \cdot B \cdot a_T \cdot a_M \cdot a_B} = 1.29$
Life L_H [h]	(3.8.9) Page 19	$L_H = \frac{615}{PV} - a_L = \frac{615}{1.29} - 200 = 277$
Calculate Total Load Cycles	Table 4 Page 13	$L_T = 277 \cdot 150 \cdot 60 = 2.5 \cdot 10^6$
Q for 22.22 N/mm² = 10^8 bearing o.k.!		

THRUST WASHER

Given:			
Load Details	Axial Load Continuous Rotation	Outside Diameter D_o Inside Diameter D_i	62 mm 38 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load F Rotational Speed N	6,500 N 60 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit P_{lim}	140 N/mm²	(Table 4, Page 13)
Temperature Application Factor a_T	1.0	(Table 6, Page 14)
Material Application Factor a_M	1.0	(Table 7, Page 15)
Bearing Size Factor a_B	0.85	(Fig. 13, Page 16)
Life Correction Constant a_L	200	(Table 7, Page 15)

Calculation	Ref	Value
Specific Load P [N/mm²]	(3.8.3) Page 18	$P = \frac{4 \cdot 6{,}500}{3.14 \cdot (62^2 - 38^2)} = 3.45$
Sliding Speed V [m/s]	(3.4.2) Page 13	$V = \frac{\frac{(62+38)}{2} \cdot 3.14 \cdot 60}{60 \cdot 10^3} = 0.157$
PV Factor calculate from Table 5, Page 14	(3.5.1) Page 14	$PV = P \cdot V = 3.45 \cdot 0.157 = 0.541$
High Load Factor a_E [-] must be > 0	(3.8.4) Page 18	$a_E = \frac{P_{lim} - P}{P_{lim}} = \frac{140 - 3.45}{140} = 0.98$
Modified PV Factor [N/mm² · m/s]	(3.8.7) Page 18	$PV = \frac{3.34 \cdot 10^{-5} \cdot 6{,}500 \cdot 60}{0.87 \cdot (62 - 38) \cdot 1 \cdot 1 \cdot 0.85} = 0.56$
Life L_H [h]	(3.8.12) Page 19	$L_H = \frac{410}{PV} - a_L = \frac{410}{0.65} - 200 = 431$

FLANGED BUSH

Given:			
Load Details	Axial Load Continuous Rotation	Flange Outside Ø D_{fl} Inside Diameter D_i	23 mm 15 mm
Shaft	Steel Unlubricated at 25°C	Bearing Load F Rotational Speed N	250 N 25 · 1/min

Calculation Constants and Application Factors		
Specific Load Limit P_{lim}	140 N/mm²	(Table 4, Page 13)
Temperature Application Factor a_T	1.0	(Table 6, Page 14)
Material Application Factor a_M	1.0	(Table 7, Page 15)
Bearing Size Factor a_B	1.0	(Fig. 13, Page 16)
Life Correction Constant a_L	200	(Table 7, Page 15)

Calculation	Ref	Value
Specific Load P [N/mm²]	(3.2.2) Page 12	$P = \frac{250}{0.04 \cdot (23^2 - 15^2)} = 20.55$
Sliding Speed V [m/s]	(3.4.2) Page 13	$V = \frac{\frac{(23+15)}{2} \cdot 3.14 \cdot 25}{60 \cdot 10^3} = 0.025$
PV Factor calculate from Table 5, Page 14	(3.5.1) Page 14	$PV = P \cdot V = 20.55 \cdot 0.025 = 0.513$
High Load Factor a_E [-] must be > 0	(3.8.4) Page 18	$a_E = \frac{P_{lim} - P}{P_{lim}} = \frac{140 - 20.55}{140} = 0.85$
Modified PV Factor [N/mm² · m/s]	(3.8.6) Page 18	$PV = \frac{6.5 \cdot 10^{-5} \cdot 250 \cdot 50}{0.85 \cdot (23 - 15) \cdot 1 \cdot 1 \cdot 1} = 0.59$
Life L_H [h]	(3.8.11) Page 19	$L_H = \frac{410}{PV} - a_L = \frac{410}{0.59} - 200 = 495$

4 Lubrication

Although DU® was developed as a dry self-lubricating bearing material, DU® also provides excellent performance in lubricated applications.

The following sections describe the basics of lubrication and provide guidance on the application of DU® in such environments.

4.1 LUBRICANTS

DU® can be used with most fluids including:

- water
- lubricating oils
- engine oil
- turbine oil
- hydraulic fluid
- solvent
- refrigerants

In general, the fluid will be acceptable if it does not chemically attack the PTFE/lead overlay or the porous bronze interlayer. Where there is doubt about the suitability of a fluid, a simple test is to submerge a sample of DU® material in the fluid for two to three weeks at 15-20 °C above the operating temperature.

The following will usually indicate that the fluid is not suitable for use with DU®:

- A significant change in the thickness of the DU® material,
- a visible change in the bearing surface other than some discolouration or staining,
- a visible change in the microstructure of the bronze interlayer.

4.2 TRIBOLOGY

There are three modes of lubricated bearing operation which relate to the thickness of the developed lubricant film between the bearing and the mating surface.

These three modes of operation depend upon:

- Bearing dimensions
- Clearance
- Load
- Speed
- Lubricant Viscosity
- Lubricant Flow

HYDRODYNAMIC LUBRICATION

Characterised by:

- Complete separation of the shaft from the bearing by the lubricant film
- Very low friction and no wear of the bearing or shaft since there is no contact.
- Coefficients of friction of 0.001 to 0.01

Hydrodynamic conditions occur when:

(4.3.1) [N/mm²]

$$P \leq \frac{U \cdot \eta}{7.5} \cdot \frac{B}{D_i}$$

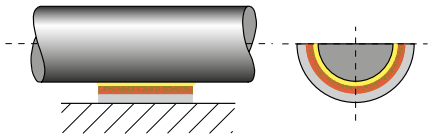


Figure 4: Hydrodynamic lubrication

MIXED FILM LUBRICATION

Characterised by:

- Combination of hydrodynamic and boundary lubrication.
- Part of the load is carried by localised areas of self pressurised lubricant and the remainder supported by boundary lubrication.
- Coefficients of friction of 0.01 to 0.10.
- Friction and wear depend upon the degree of hydrodynamic support developed.
- DX® provides low friction and high wear resistance to support the boundary lubricated element of the load.

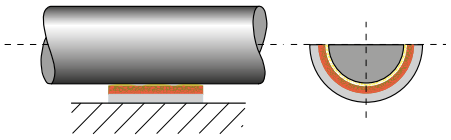


Figure 5: Mixed film lubrication

BOUNDARY LUBRICATION

Characterised by:

- Rubbing of the shaft against the bearing with virtually no lubricant separating the two surfaces.
- Bearing material selection is critical to performance.
- Shaft wear is likely due to contact between bearing and shaft.
- The excellent properties of DX® material minimizes wear under these conditions.
- The dynamic coefficient of friction with DX® is typically 0.02 to 0.1 under boundary lubrication conditions.
- The static coefficient of friction with DX® is typically 0.03 to 0.15 under boundary lubrication conditions.

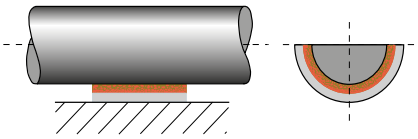


Figure 6: Hydrodynamic lubrication

4.3 CHARACTERISTICS OF LUBRICATED DU® BEARINGS

DU® is particularly effective in the most demanding of lubricated applications where full hydrodynamic operation cannot be maintained, for example:

High load conditions

In highly loaded applications operating under boundary or mixed film conditions DU® shows excellent wear resistance and low friction.

Start up and shut down under load

With insufficient speed to generate a hydrodynamic film the bearing will operate under boundary or mixed film conditions. DU® minimises wear and requires less start up torque than conventional metallic bearings.

Sparse lubrication

Many applications require the bearing to operate with less than the ideal lubricant supply, typically with splash or mist lubrication only. DU® provides excellent self lubricating properties.

Dry operation after running in water

If a DU® bearing is required to run dry after running in water under non hydrodynamic conditions then the wear resistance will be substantially reduced due to an increased amount of bedding in wear.

4 Lubrication

4.4 DESIGN GUIDANCE FOR LUBRICATED APPLICATIONS

Fig. 21 shows the three lubrication regimes discussed above. In order to use Fig. 21, using the formula on page 12 and page 13:

- Calculate the specific load P,
- Calculate the shaft surface speed V.

Using the viscosity temperature relationships presented in Table 9.

- Determine the lubricant viscosity in centipoise, of the lubricant.

If the operating temperature of the fluid is unknown, a provisional temperature of 25 °C above ambient can be used.

Area 1

The bearing will operate with boundary lubrication and PV factor will be the major determinant of bearing life. The DU® bearing performance can be calculated using the method given in Section 3, although the result will probably underestimate the bearing life

Area 2

The bearing will operate with mixed film lubrication and the PV factor is no longer a significant parameter in determining the bearing life. The DU® bearing performance will depend upon the nature of the fluid and the actual service conditions.

Area 3

The bearing will operate with hydrodynamic lubrication. The bearing wear will be determined only by the cleanliness of the lubricant and the frequency of start up and shut down.

Area 4

These are the most demanding operating conditions. The bearing is operated under either high speed or high bearing load to viscosity ratio, or a combination of both. These conditions may cause:

- excessive operating temperature and/or
- high wear rate.

The bearing performance may be improved by adding one or more grooves to the bearing and a shaft surface finish <0.05 µm R_a.

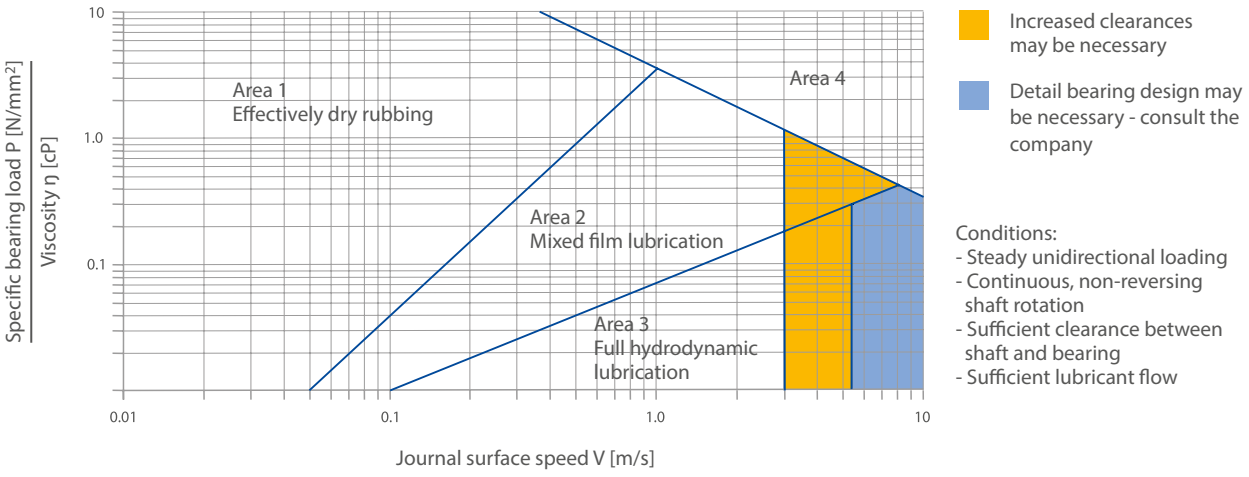


Fig. 21: Design guide for lubricated application

VISCOSITY η [cP]															
TEMPERATURE [°C]	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Lubricant															
ISO VG 32	310	146	77	44	27	18	13	9.3	7.0	5.5	4.4	3.6	3.0	2.5	2.2
ISO VG 46	570	247	121	67	40	25	17	12	9.0	6.9	5.4	4.4	3.6	3.0	2.6
ISO VG 68	940	395	190	102	59	37	24	17	12	9.3	7.2	5.8	4.7	3.9	3.3
ISO VG 100	2110	780	335	164	89	52	33	22	15	11.3	8.6	6.7	5.3	4.3	3.6
ISO VG 150	3600	1290	540	255	134	77	48	31	21	15	11	8.8	7.0	5.6	4.6
Diesel oil	4.6	4.0	3.4	3.0	2.6	2.3	2.0	1.7	1.4	1.1	0.95				
Petrol	0.6	0.56	0.52	0.48	0.44	0.40	0.36	0.33	0.31						
Kerosene	2.0	1.7	1.5	1.3	1.1	0.95	0.85	0.75	0.65	0.60	0.55				
Water	1.79	1.30	1.0	0.84	0.69	0.55	0.48	0.41	0.34	0.32	0.28				

Table 9: Viscosity data

4.5 CLEARANCES FOR LUBRICATED OPERATION

The recommended shaft and housing diameters given for standard DU® bushes will provide sufficient clearance for applications operating with boundary lubrication.

For bearings operating with mixed film or hydrodynamic lubrication it may be necessary to improve the fluid flow through the bearing by reducing the recommended shaft diameter by approximately 0.1 %, particularly when the shaft surface speed exceeds 2.5 m/s.

4.6 MATING SURFACE FINISH FOR LUBRICATED OPERATION

- $R_a \leq 0.4$ µm boundary lubrication
- $R_a = 0.1$ - 0.2 µm mixed film or hydrodynamic conditions
- $R_a \leq 0.05$ µm for the most demanding operating conditions

4.7 GROOVING FOR LUBRICATED OPERATION

In demanding applications an axial oil groove will improve the performance of DU®. Fig. 22 shows the recommended form and location of a single groove with respect to the applied load and the bearing split. GGB can manufacture special DU® bearings with embossed or milled grooves on request.

4.8 GREASE LUBRICATION

DU® is not generally recommended for use with grease lubrication. In particular the following must be avoided:

- Dynamic loads - which can result in erosion of the PTFE/lead bearing surface.
- Greases with EP additives or fillers such as graphite or MoS_2 which can cause rapid wear of DU®.

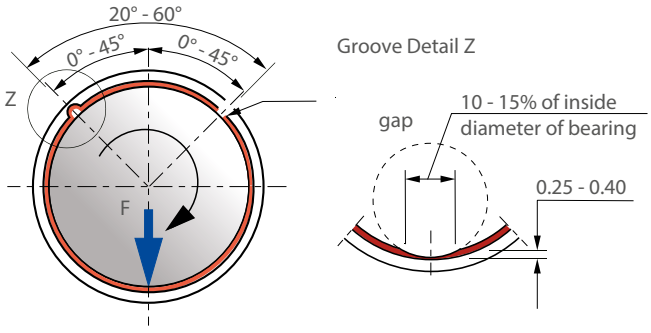


Fig. 22: Location of oil holes and grooves

5 Bearing Assembly

Dimensions and Tolerances

DU® bushes are prefinished in the bore, and except in very exceptional circumstances, must not be burnished, broached or otherwise modified. It is essential that the correct running clearance is used and that both the diameter of the shaft and the bore of the housing are finished to the limits given in the tables. Under dry running conditions any increase in the clearances given will result in a proportional reduction in performance.

If the bearing housing is unusually flexible the bush will not close in by the calculated amount and the running clearance will be more than the optimum. In these circumstances the housing should be bored slightly undersize or the journal diameter increased, the correct size being determined by experiment.

Where free running is essential, or where light loads (less than 0.1 N/mm^2) prevail and the available torque is low, increased clearance is required and it is recommended that the shaft size quoted in the table be reduced by 0.025 mm.

5.1 ALLOWANCE FOR THERMAL EXPANSION

For operation in high temperature environments the clearance should be increased by the amounts indicated by Fig. 23 to compensate for the inward thermal expansion of the bearing lining.

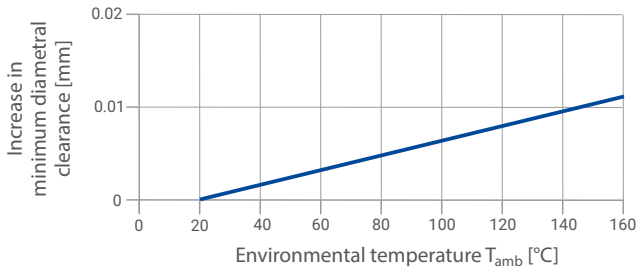


Fig. 23: Increase in diametral clearance

If the housing is non-ferrous then the bore should be reduced by the amounts given in Table 10, in order to give an increased interference fit to the bush, with a similar reduction in the journal diameter additional to that indicated by Fig. 23.

HOUSING MATERIAL	REDUCTION IN HOUSING DIAMETER PER 100°C RISE	REDUCTION IN SHAFT DIAMETER PER100°C RISE
Aluminium alloys	0.1 %	0.1 % + values from Fig. 23
Copper base alloys	0.05 %	0.05 % + values from Fig. 23
Steel and cast iron	-	values from Fig. 23
Zinc base alloys	0.15 %	0.15 % + values from Fig. 23

Table 10: Allowance for high temperature

5.2 TOLERANCES FOR MINIMUM CLEARANCE

Where it is required to keep the variation of assembled clearance to a minimum, closer tolerances can be specified towards the upper end of the journal tolerance and the lower end of the housing tolerance. If housings to H6 tolerance are used, then the journals should be finished to the following limits. The sizes in Table 11 give the following nominal clearance range.

D_i	D_J
< 25 mm	- 0.019 to - 0.029
> 25 mm < 50mm	- 0.021 to - 0.035

Table 11: Shaft tolarances for use with H6 housings

D_i	D_J
10 mm	0.005 to 0.078
50mm	0.005 to 0.130

Table 12: Clearance vs bearing diameter

Sizing

The burnishing or fine boring of the bore of an assembled DU® bush in order to achieve a smaller clearance tolerance is only permissible if a substantial reduction in performance is acceptable. Fig. 24 shows a recommended burnishing tool for the sizing of DU® bushes.

The coining section of the burnishing tool should be case hardened (case depth 0.6 - 1.2 mm, HRC 60±2) and polished ($R_Z \approx 1$ µm).

Note: Ball burnishing of DU® bushes is not recommended.

The values given in Table 13 indicate the dimensions of the burnishing tool required to give specific increases in the bearing bore diameter.

Exact values must be determined by test.

The reduction in bearing performance as a result of burnishing is allowed for in the bearing life calculation by the application factor a_C (Table 8, page 16).

ASSEMBLED BUSH INSIDE Ø	REQUIRED BUSH INSIDE Ø	REQUIRED BURNISHING TOOL Ø DC
$D_{i,a}$	$D_{i,a}$ + 0.025	$D_{i,a}$ + 0.06
$D_{i,a}$	$D_{i,a}$ + 0.038	$D_{i,a}$ + 0.08
$D_{i,a}$	$D_{i,a}$ + 0.050	$D_{i,a}$ + 0.10

Table 13: Burnishing tool tolerances

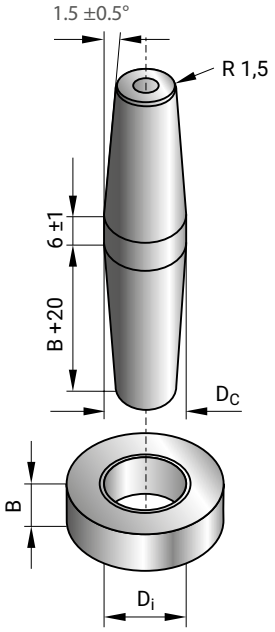


Fig. 24: Burnishing tool

5.3 COUNTERFACE DESIGN

The suitability of mating surface materials and recommendations of mating surface finish for use with DU® are discussed in detail on page 15.

DU® is normally used in conjunction with ferrous journals and thrust faces, but in damp or corrosive surroundings, particularly without the protection of oil or grease, stainless steel, hard chromium plated mild steel, or hard anodised aluminium is recommended. When plated mating surfaces are specified the plating should possess adequate strength and adhesion, particularly if the bearing is to operate with high fluctuating loads.

The shaft or thrust collar used in conjunction with the DU® bush or thrust washer must extend beyond the bearing surface in order to avoid cutting into it. The mating surface must also be free from grooves or flats, the end of the shaft should be given a lead-in chamfer and all sharp edges or projections which may damage the soft overlay of the DU® must be removed.

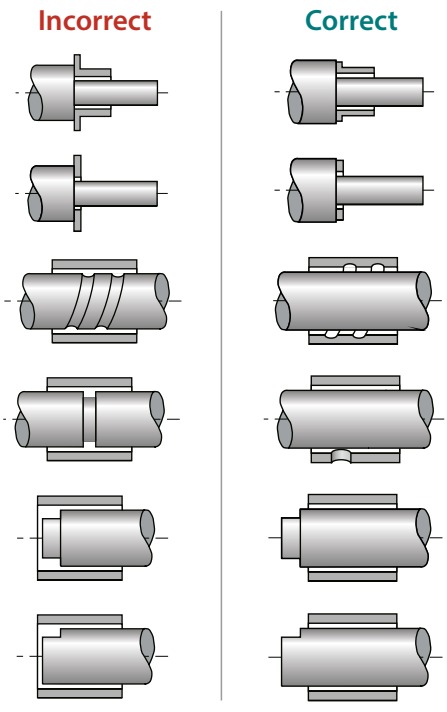


Fig. 25: Counterface design

5 Bearing Assembly

5.4 INSTALLATION

Fitting of Cylindrical Bushes

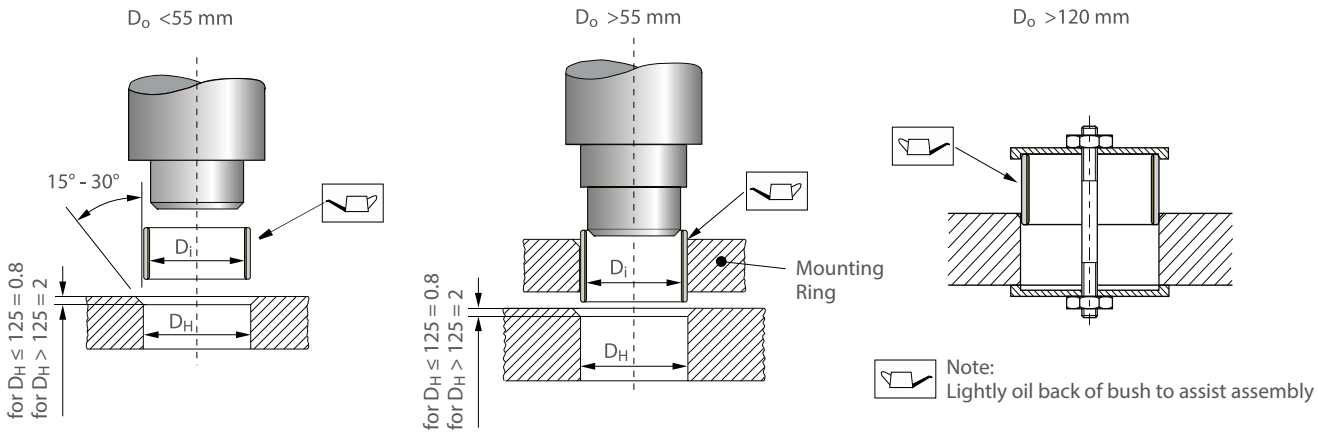


Fig. 26: Fitting of cylindrical bushes

Fitting of Flanged Bushes

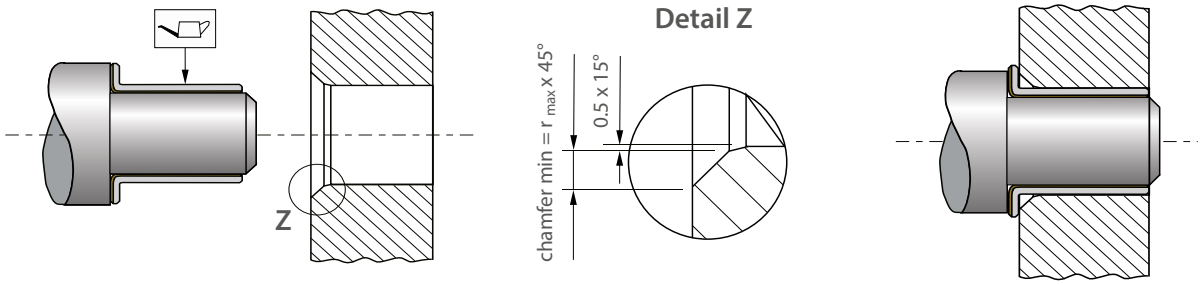


Fig. 27: Fitting of flanged bushes

Insertion Forces

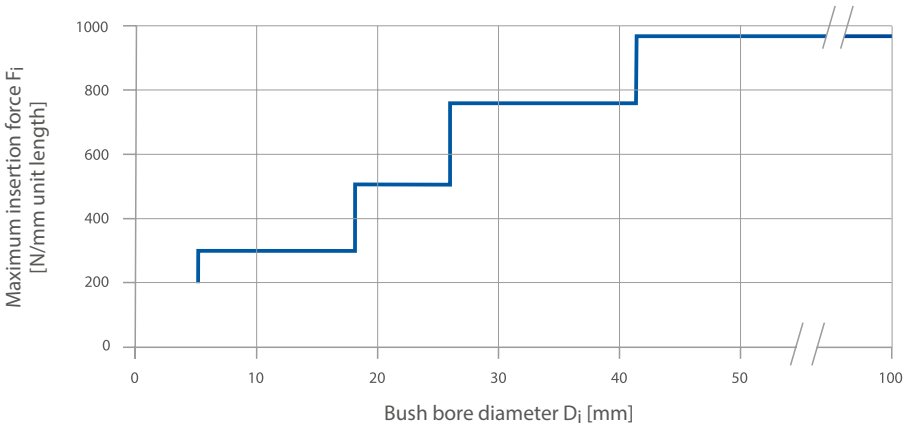


Fig. 28: Maximum Insertion Force F_i

Alignment

Accurate alignment is an important consideration for all bearing assemblies, but is particularly so for dry bearings because there is no lubricant to spread the load. With DU® bearings misalignment over the length of a bush (or pair of bushes), or over the diameter of a thrust washer should not exceed 0.020 mm as illustrated in Fig. 29.

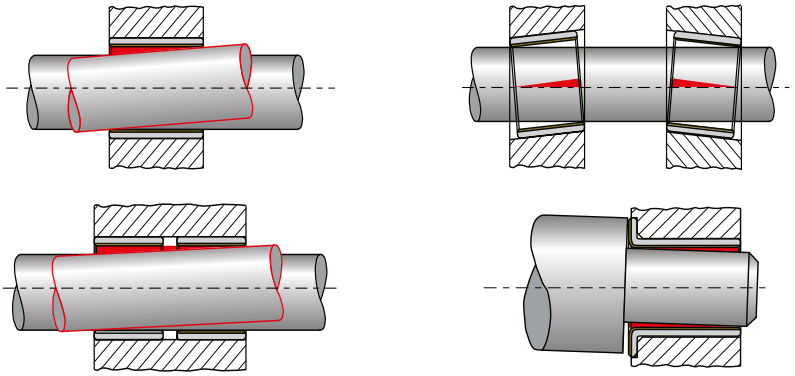


Fig. 29: Alignment

Sealing

While DU® can tolerate the ingress of some contaminant materials into the bearing without loss of performance, where there is the possibility of highly abrasive material entering the bearing, a suitable sealing arrangement, as illustrated in Fig. 30 should be provided.

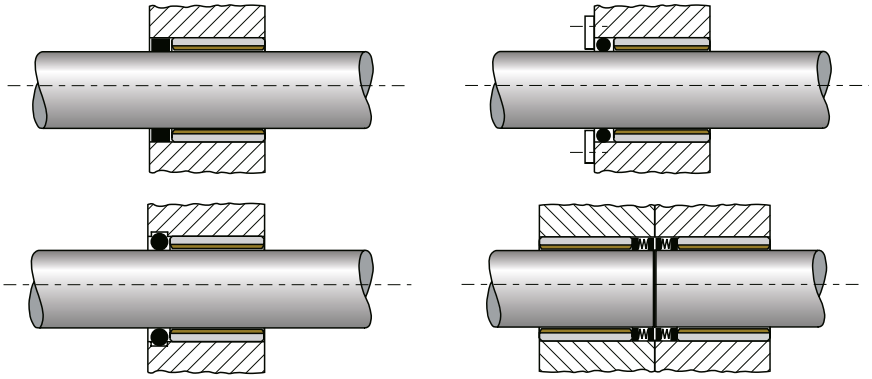


Fig. 30: Recommended sealing arrangements

5.5 AXIAL LOCATION

Where axial location is necessary, it is advisable to fit DU® thrust washers in conjunction with DU® bushes, even when the axial loads are low.

Fitting of Thrust Washers

DU® thrust washers should be located in a recess as shown in Fig. 31. The recess diameter should be 0.125 mm larger than the washer diameter and the depth as given in the product tables. If a recess is not possible one of the following methods may be used:

- Two dowel pins
- Two screws
- Adhesive
- Soldering

5 Bearing Assembly

Important Note

- Ensure the washer ID does not touch the shaft after assembly
- Ensure that the washer is mounted with the steel backing to the housing
- Dowel pins should be recessed 0,25 mm below the bearing surface
- Screws should be countersunk 0,25 mm below the bearing surface
- DU® must not be heated above 320 °C
- Contact adhesive manufacturers for guidance on selection of suitable adhesives
- Protect the bearing surface to prevent contact with adhesive

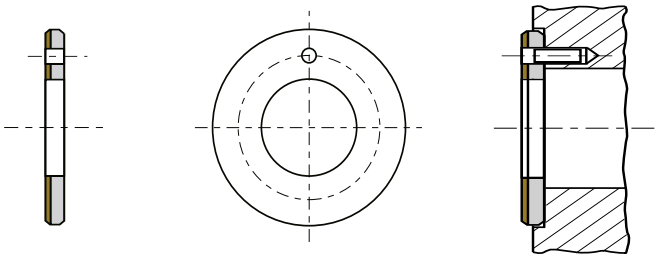


Fig. 31: Installation of thrust washer

Grooves for Wear Debris Removal

Tests with thrust washers have demonstrated that for optimum dry wear performance at specific loads in excess of 35 N/mm², four wear debris removal grooves should be machined in the bearing surface as shown in Fig. 32.

Grooves in bushes have not been found to be beneficial in this respect.

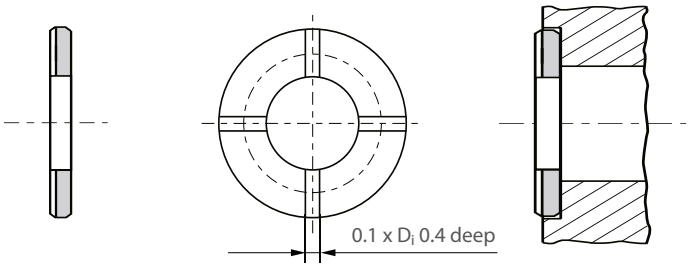


Fig. 32: Debris removal grooves

Slideways

DU® strip material for use as slideway bearings should be installed using one of the following methods:

- Countersunk screws
- Adhesives
- Mechanical location as shown below

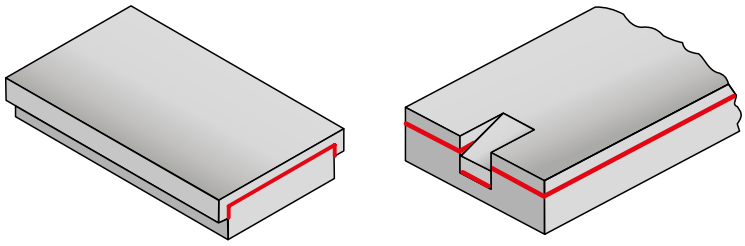


Fig. 33: Mechanical location of DU slideplates

6 Modification

6.1 CUTTING AND MACHINING

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

Drilling Oil Holes

Bushes should be adequately supported during the drilling operation to ensure that no distortion is caused by the drilling pressure.

Cutting Strip Material

DU® strip material may be cut to size by any one of the following methods.

Care must be taken to protect the bearing surface from damage and to ensure that no deformation of the strip occurs:

- Using side and face cutter, or slitting saw, with the strip held flat and securely on a horizontal milling machine.
- Cropping
- Guillotine (For widths less than 90 mm only)
- Water-jet cutting
- Laser cutting (see Health Warning)

6.2 ELECTROPLATING

DU® Components

In order to provide some protection in mildly corrosive environments the steel back and end faces of standard range DU® bearings are tin flashed.

If exposed to corrosive liquids further protection should be provided and in very corrosive conditions DU-B should be considered.

DU® can be electroplated with most of the conventional electroplating metals including the following:

- zinc ISO 2081-2
- cadmium ISO 2081-2
- nickel ISO 1456-8
- hard chromium ISO 1456-8

For the harder materials if the specified plating thickness exceeds approximately 5 µm then the housing diameter should be increased by twice the plating thickness in order to maintain the correct assembled bearing bore size.

With light deposits of materials such as cadmium, no special precautions are necessary. Harder materials such as nickel however, may strike through the PTFE/lead surface layer of DU® and it is advisable to use an appropriate method of masking the bearing surface.

Where electrolytic attack is possible tests should be conducted to ensure that all the materials in the bearing environment are mutually compatible.

Mating Surfaces

DU® can be used against some plated materials as indicated on page 15.

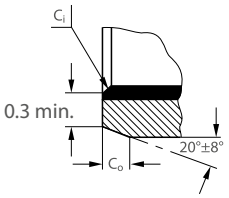
Care should be taken to ensure that the recommended shaft sizes and surface finish are achieved after the plating process.

7 Standard Products

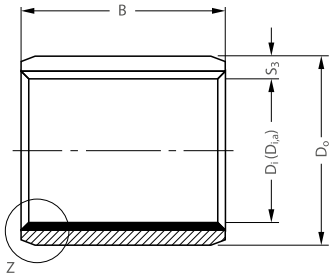
7.1 DU® / DU-B CYLINDRICAL BUSHES - METRIC SIZES

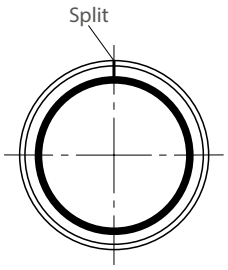
DU®

DU-B



Detail Z





Dimensions and Tolerances according to ISO 3547 and GGB Specifications

OUTSIDE C_o AND INSIDE C_i CHAMFERS

WALL THICKNESS S_3	C_o (a) MACHINED	/ ROLLED	C_i (b)
0.75	0.5 ± 0.3	0.5 ± 0.3	-0.1 to -0.4
1	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.5
1.5	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.7

WALL THICKNESS S_3	C_o (a) MACHINED	/ ROLLED	C_i (b)
2	1.2 ± 0.4	1.0 ± 0.4	-0.1 to -0.7
2.5	1.8 ± 0.6	1.2 ± 0.4	-0.2 to -1.0

(a) = chamfer C_o machined or rolled at the opinion of the manufacturer
(b) = C_i can be a radius or a chamfer in accordance with ISO 13715

TECHNICAL DATA										PART-NO.	
Dimensions				Installation							
Inside Ø D_i	Outside Ø D_o	Wall Thickness S_3 max./min.	Width B max./min.	Shaft Ø D_J [h6, f7, h8] max./min.		Housing Ø D_H [H6, H7] max./min.		Bush Ø $D_{i,a}$ assembly in H6/H7 housing max./min.	Clearance C_D max./min.	DU®	DU-B
2	3.5	0.750 0.730	3.25 / 2.75	h6	2.000 1.994	H6	3.508 3.500	2.048 2.000	0.054 0.000	0203DU	0203DUB
			5.25 / 4.75							0205DU	0205DUB
3	4,5		3.25 / 2.75		3.000 2.994		4.508 4.500	3.048 3.000		0303DU	
			5.25 / 4.75							0305DU	
			6.25 / 5.75							0306DU	0306DUB
4	5,5		3.25 / 2.75		4.000 3.992		5.508 5.500	4,048 4,000	0.056 0.000	0403DU	
			4.25 / 3.75							0404DU	0404DUB
			6.25 / 5.75							0406DU	0406DUB
			10.25 / 9.75							0410DU	
5	7	1.005 0.980	5.25 / 4.75	f7	4.990 4.978	H7	7.015 7.000	5.055 4.990	0.077 0.000	0505DU	0505DUB
			8.25 / 7.75							0508DU	
			10.25 / 9.75							0510DU	0510DUB
6	8		4.25 / 3.75		5.990 5.978		8.015 8.000	6.055 5.990		0604DU	
			6.25 / 5.75							0606DU	0606DUB
			8.25 / 7.75							0608DU	0608DUB
			10.25 / 9.75							0610DU	0610DUB
7	9		5.25 / 4.75		6.987 6.972		9.015 9.000	7.055 6.990	0.083 0.003	0705DU	
			10.25 / 9.75							0710DU	
8	10		6.25 /5.75		7.987 7.972		10.015 10.000	8.055 7.990		0806DU	
			8.25 / 7.75							0808DU	0808DUB
			10.25 / 9.75							0810DU	0810DUB
			12.25 / 11.75							0812DU	0812DUB
10	12		6.25 / 5.75		9.987 9.972		12.018 12.000	10.058 9.990	0.086 0.003	1006DU	
			8.25 / 7.75							1008DU	
			10.25 / 9.75							1010DU	1010DUB
			12.25 / 11.75							1012DU	
			15.25 / 14.75							1015DU	1015DUB
			20.25 / 19.75							1020DU	

All dimensions in mm.

TECHNICAL DATA									PART-NO.	
Dimensions				Installation						
Inside Ø D_i	Outside Ø D_o	Wall Thickness S_3 max./min.	Width B max./min.	Shaft Ø D_J [h6, f7, h8] max./min.		Housing Ø D_H [H6, H7] max./min.		Bush Ø $D_{i,a}$ assembly in H6/H7 housing max./min.	Clearance C_D max./min.	DU®	DU-B
12	14	1.005 0.980	8.25 / 7.75	f7	11.984 11.966	H7	14.018 14.000	12.058 11.990	0.092 0.006	1208DU	1208DUB
			10.25 / 9.75							1210DU	1210DUB
			12,25 / 11.75							1212DU	1212DUB
			15.25 / 14.75							1215DU	1215DUB
			20.25 / 19.75							1220DU	
			25.25 / 24.75							1225DU	
13	15		10.25 / 9.75		12.984 12.966		15.018 15.000	13.058 12.990		1310DU	
			20.25 / 19.75							1320DU	
14	16		5.25 / 4.75		13.984 13.966		16.018 16.000	14.058 13.990		1405DU	
			10.25 / 9.75							1410DU	1410DUB
			12,25 / 11.75							1412DU	
			15.25 / 14.75							1415DU	1415DUB
			20.25 / 19.75							1420DU	
			25.25 / 24.75							1425DU	
15	17		10.25 / 9.75		14.984 14.966		17.018 17.000	15.058 14.990		1510DU	
			12,25 / 11.75							1512DU	
			15.25 / 14.75							1515DU	1515DUB
			20.25 / 19.75							1520DU	
			25.25 / 24.75							1525DU	1525DUB
16	18		10.25 / 9.75		15.984 15.966		18.018 18.000	16.058 15.990		1610DU	
			12,25 / 11.75							1612DU	
			15.25 / 14.75							1615DU	1615DUB
			20.25 / 19.75							1620DU	
			25.25 / 24.75							1625DU	1625DUB
17	19		20.25 / 19.75		16.984 / 16.966		19.021 / 19.000	17.061 / 16.990		1720DU	
18	20		10.25 / 9.75		17.984 17.966		20.021 20.000	18.061 17.990	0.095 0.006	1810DU	
			15.25 / 14.75							1815DU	
			20.25 / 19.75							1820DU	1820DUB
			25.25 / 24.75							1825DU	1825DUB
20	23	1.505 1.475	10.25 / 9.75		19.980 19.959		23.021 23.000	20.071 19.990	0.112 0.010	2010DU	
			15.25 / 14.75							2015DU	2015DUB
			20.25 / 19.75							2020DU	2020DUB
			25.25 / 24.75							2025DU	2025DUB
			30.25 / 29.75							2030DU	2030DUB
22	25		15.25 / 14.75		21.980 21.959		25.021 25.000	22.071 21.990		2215DU	2215DU
			20.25 / 19.75							2220DU	2220DU
			25.25 / 24.75							2225DU	2225DU
			30.25 / 29.75							2230DU	
24	27		15.25 / 14.75		23.980 23.959		27.021 27.000	24.071 23.990		2415DU	
			20.25 / 19.75							2420DU	
			25.25 / 24.75							2425DU	
			30.25 / 29.75							2430DU	
25	28		15.25 / 14.75		24.980 24.959		28.021 28.000	25.071 24.990		2515DU	2515DUB
			20.25 / 19.75							2520DU	
			25.25 / 24.75							2525DU	2525DUB
			30.25 / 29.75							2530DU	
			50.25 / 49.75							2550DU	
28	32	2.005 1.970	15.25 / 14.75		27.980 27.959		32.025 32.000	28.085 27.990	0.126 0.010	2815DU	
			20.25 / 19.75							2820DU	
			25.25 / 24.75							2825DU	
			30.25 / 29.75							2830DU	2830DUB
30	34		10.25 / 9.75		29.980 29.959		34.025 34.000	30.085 29.990		3010DU	
			15.25 / 14.75							3015DU	
			20.25 / 19.75							3020DU	3020DUB
			25.25 / 24.75							3025DU	
			30.25 / 29.75							3030DU	3030DUB
			40.25 / 39.75							3040DU	3040DUB

All dimensions in mm.

7 Standard Products

TECHNICAL DATA									PART-NO.	
Dimensions				Installation						
Inside Ø D_i	Outside Ø D_o	Wall Thickness S_3 max./min.	Width B max./min.	Shaft Ø D_J [h6. f7. h8] max./min.		Housing Ø D_H [H6. H7] max./min.		Bush Ø $D_{i,a}$ assembly in H6/H7 housing max./min.	Clearance C_D max./min.	DU®	DU-B
32	36	2.005 1.970	20.25 / 19.75	f7	31.975 31.950	H7	36.025 36.000	32.085 31.990	0.135 0.015	3220DU	
			30.25 / 29.75							3230DU	
			40.25 / 39.75							3240DU	
35	39		20.25 / 19.75		34.975 34.950		39.025 39.000	35.085 34.990		3520DU	3520DUB
			30.25 / 29.75							3530DU	3530DUB
			35.25 / 34.75							3535DU	
			40.25 / 39.75							3540DU	
			50.25 / 49.75							3550DU	
37	41		20.25 / 19.75		36.975 / 36.950		41.025 / 41.000	37.085 / 36.990		3720DU	
40	44		20.25 / 19.75		39.975 39.950		44.025 44.000	40.085 39.990		4020DU	
			30.25 / 29.75							4030DU	4030DUB
			40.25 / 39.75							4040DU	
			50.25 / 49.75							4050DU	4050DUB
45	50	2.505 2.460	20.25 / 19.75		50.025 50.000		50.025 50.000	45.105 44.990	0.155 0.015	4520DU	
			30.25 / 29.75							4530DU	4530DUB
			40.25 / 39.75							4540DU	
			45.25 / 44.75							4545DU	
			50.25 / 49.75							4550DU	4550DUB
50	55		20.25 / 19.75		49.975 49.950		55.030 55.000	50.110 49.990	0.160 0.015	5020DU	
			30.25 / 29.75							5030DU	
			40.25 / 39.75							5040DU	5040DUB
			50.25 / 49.75							5050DU	
			60.25 / 59.75							5060DU	5060DUB
55	60		20.25 / 19.75		54.970 54.940		60.030 60.000	55.110 54.990		5520DU	
			25.25 / 24.75							5525DU	
			30.25 / 29.75							5530DU	
			40.25 / 39.75							5540DU	5540DUB
			50.25 / 49.75							5550DU	
			55.25 / 54.75							5555DU	
			60.25 / 59.75							5560DU	
60	65		20.25 / 19.75		59.970 59.940		65.030 65.000	60.110 59.990	0.170 0.020	6020DU	
			30.25 / 29.75							6030DU	
			40.25 / 39.75							6040DU	6040DUB
			50.25 / 49.75							6050DU	6050DUB
			60.25 / 59.75							6060DU	6060DUB
			70.25 / 69.75							6070DU	6070DUB
65	70		30.25 / 29.75		64.970 64.940		70.030 70.000	65.110 64.990		6530DU	
			50.25 / 49.75							6550DU	
			70.25 / 69.75							6570DU	6570DUB
70	75		40.25 / 39.75		69.970 69.940		75.030 75.000	70.110 69.990		7040DU	
			50.25 / 49.75							7050DU	7050DUB
			70.25 / 69.75							7070DU	7070DUB
75	80		60.25 / 59.75		74.970 74.940		80.030 80.000	75.110 74.990		7560DU	
			80.25 / 79.75							7580DU	7580DUB
80	85	2.490 2.440	40.50 / 39.50	h8	80.000 79.946		85.035 85.000	80.155 80.020	0.209 0.020	8040DU	
			60.50 / 59.50							8060DU	8060DUB
			80.50/ 79.50							8080Du	
			100.50 / 99.50							80100DU	80100DUB
85	90		30.50 / 29.50		85.000 84.946		90.035 90.000	85.155 85.020		8530DU	
			60.50 / 59.50							8560DU	
			100.50 / 99.50							85100DU	85100DUB
90	95		60.50 / 59.50		90.000 89.946		95.035 95.000	90.155 95.020		9060DU	9060DUB
			100.50 / 99.50							90100DU	90100DUB
95	100		60.50 / 59.50		95.000 94.946		100.035 100.000	95.155 95.020		9560DU	
			100.50 / 99.50							95100DU	95100DUB

All dimensions in mm.

TECHNICAL DATA										PART-NO.	
Dimensions				Installation							
Inside Ø D_i	Outside Ø D_o	Wall Thickness S_3 max./min.	Width B max./min.	Shaft Ø D_J [h6. f7. h8] max./min.		Housing Ø D_H [H6. H7] max./min.		Bush Ø $D_{i,a}$ assembly in H6/H7 housing max./min.	Clearance C_D max./min.	DU®	DU-B
100	105	2.465 2.415	50.50 / 49.50	h8	100.000 99.946	H7	105.035 105.000	100.155 100.020	0.209 0.220	10050DU	
			60.50 / 59.50							10060DU	10060DUB
			115.50 / 114.50							100115DU	100115DUB
105	110		60.50 / 59.50		105.000 104.946		110.035 110.000	105.155 105.020		10560DU	
			115.50 / 114.50							105115DU	105115DUB
110	115		60.50 / 59.50		110.000 109.946		115.035 115.000	110.155 110.020		11060DU	
			115.50 / 114.50							110115DU	110115DUB
115	120		50.50 / 49.50		115.000 114.946		120.035 120.000	115.155 115.020		11550DU	
			70.50 / 69.50							11570DU	
120	125		50.50 / 49.50		120.000 119.946		125.040 125.000	120.210 120.070	0.264 0.070	12050DU	
			60.50 / 59.50							12060DU	
			100.50 / 99.50							120100DU	
125	130		100.50 / 99.50		125.000 124.937		130.040 130.000	125.210 125.070		125100DU	
130	135		60.50 / 59.50		130.000 129.937		135.040 135.000	130.210 130.070		13060DU	
			100.50 / 99.50							130100DU	
135	140		60.50 / 59.50		135.000 134.937		140.040 140.000	135.210 135.070		13560DU	
			80.50 / 79.50							13580DU	
140	145		60.50 / 59.50		140.000 139.937		145.040 145.000	140.210 140.070	0.273 0.070	14060DU	
			100.50 / 99.50							140100DU	
150	155		60.50 / 59.50		150.000 149.937		155.040 155.000	150.210 150.070		15060DU	
			80.50 / 79.50							15080DU	
			100.50 / 99.50							150100DU	
160	165		80.50 / 79.50		160.000 159.937		165.040 165.000	160.210 160.070		16080DU	
			100.50 / 99.50							160100DU	
180	185		100.50 / 99.50		180.000 179.937		185.046 185.000	180.216 180.070	0.279 0.070	180100DU	
200	205				200.000 199.928		205.046 205.000	200.216 200.070	0.288 0.070	200100DU	
210	215				210.000 209.928		215.046 215.000	210.216 210.070		210100DU	
220	225				220.000 219.928		225.046 225.000	220.216 220.070		220100DU	
250	255				250.000 249.928		255.052 255.000	250.222 250.070	0.294 0.070	250100DU	
300	305				300.000 299.919		305.052 305.000	300.222 300.070	0.303 0.070	300100DU	

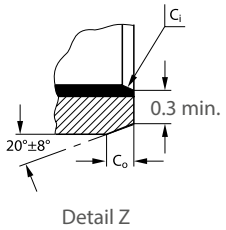
All dimensions in mm.

7 Standard Products

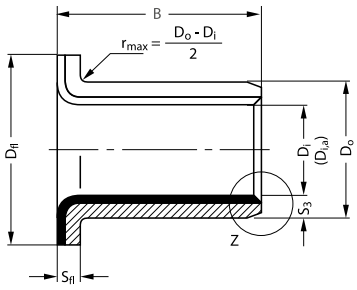
7.2 DU® / DU-B FLANGED BUSHES - METRIC SIZES

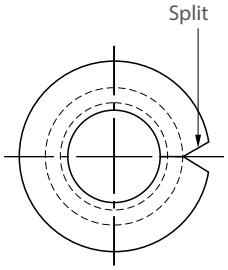
DU®

DU-B



Detail Z





Dimensions and Tolerances according to ISO 3547 and GGB Specifications

OUTSIDE C_o AND INSIDE C_i CHAMFERS

WALL THICKNESS S_3	C_o (a) MACHINED	/ ROLLED	C_i (b)
0.75	0.5 ± 0.3	0.5 ± 0.3	-0.1 to -0.4
1	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.5
1.5	0.6 ± 0.4	0.6 ± 0.4	-0.1 to -0.7

WALL THICKNESS S_3	C_o (a) MACHINED	/ ROLLED	C_i (b)
2	1.2 ± 0.4	1.0 ± 0.4	-0.1 to -0.7
2.5	1.8 ± 0.6	1.2 ± 0.4	-0.2 to -1.0

(a) = chamfer C_o machined or rolled at the opinion of the manufacturer
(b) = C_i can be a radius or a chamfer in accordance with ISO 13715

TECHNICAL DATA												PART-NO.	
Dimensions						Installation							
Inside Ø D_i	Outside Ø D_o	Wall Thickness S_3 max./min.	Flange-Thickness S_{fl} max./min.	Flange Ø D_{fl} max./min.	Width B max./min.	Shaft Ø D_J [h6. f7. h8] max./min.		Housing Ø D_H [H6. H7] max./min.		Bush Ø $D_{i,a}$* max./min.	Clearance C_D max./min.	DU®	DU-B
3	4,5	0.750 0.730	0.80 0.70	7.50 6.50	4.25 3.75	h6	3.000 2.994	H6	4.508 4.500	3.048 3.000	0.054 0.000	BB0304DU	BB0304DUB
4	5,5			9.50 8.50	4.25 3.75		4.000 3.992		5.508 4.500	4.048 4.000	0.056 0.000	BB0404DU	BB0404DUB
5	7	1.005 0.980	1.05 0.80	10.50 9.50	5.25 4.75	f7	4.990 4.978	H7	7.015 7.000	5.055 4.990	0.077 0.000	BB0505DU	BB0505DUB
6	8			12.50 11.50	4.25 3.75		5.990 5.978		8.015 8.000	6.055 5.990	0.077 0.000	BB0604DU	BB0604DUB
					8.25 7.75							BB0608DU	BB0608DUB
8	10			15.50 14.50	5.75 5.25		7.987 7.972		10.015 10.000	8.055 7.990	0.083 0.003	BB0806DU	BB0806DUB
					7.75 7.25							BB0808DU	
					9.75 9.25							BB0810DU	BB0810DUB
10	12			18.50 17.50	7.75 7.25		9.987 9.972		12.018 12.000	10.058 9.990	0.086 0.003	BB1007DU	BB1007DUB
					9.75 9.25							BB1009DU	
					12.25 11.75							BB1012DU	BB1012DUB
					17.25 16.75							BB1017DU	
12	14			20.50 19.50	7.75 7.25		11.984 11.966		14.018 14.000	12.058 11.990	0.092 0.006	BB1207DU	BB1207DUB
					9.75 9.25							BB1209DU	BB1209DUB
					12.25 11.75							BB1212DU	BB1212DUB
					17.25 16.75							BB1217DU	

All dimensions in mm.

* assembly in H6/H7 housing

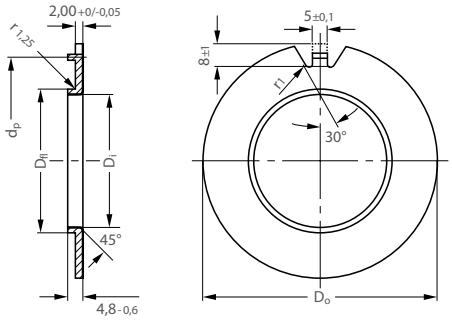
TECHNICAL DATA											PART-NO.	
Dimensions						Installation						
Inside Ø D_i	Outside Ø D_o	Wall Thickness S_3 max./min.	Flange-Thickness S_{fl} max./min.	Flange Ø D_{fl} max./min.	Width B max./min.	Shaft Ø D_J [h6. f7. h8] max./min.		Housing Ø D_H [H6. H7] max./min.		Bush Ø $D_{i,a}$* max./min.	Clearance C_D max./min.	DU®	DU-B
14	16	1.005 0.980	1.05 0.80	22.50 21.50	12.25 11.75	f7	13.984 13.966	H7	16.018 16.000	14.058 13.990	0.092 0.006	BB1412DU	
					17.25 16.75							BB1417DU	BB1417DUB
15	17			23.50 22.50	9.75 9.25		14.984 14.966		17.018 17.000	15.058 14.990		BB1509DU	
					12.25 11.75							BB1512DU	BB1512DUB
					17.25 16.75							BB1517DU	BB1517DUB
16	18			24.50 23.50	12.25 11.75		15.984 15.966		18.018 18.000	16.058 15.990		BB1612DU	BB1612DUB
					17.25 16.75							BB1617DU	BB1617DUB
18	20			26.50 25.50	12.25 11.75		17.984 17.966		20.021 20.000	18.061 17.990	0.095 0.006	BB1812DU	BB1812DUB
					17.25 16.75							BB1817DU	
					22.25 21.75							BB1822DU	BB1822DUB
20	23	1.505 1.475	1.60 1.30	30.50 29.50	11.75 11.25		19.980 19.959		23.021 23.000	20.071 19.990	0.112 0.110	BB2012DU	BB2012DUB
					16.75 16.25							BB2017DU	BB2017DUB
					21.75 21.25							BB2022DU	
25	28			35.50 34.50	11.75 11.25		24.980 24.959		28.021 28.000	25.071 24.990		BB2512DU	BB2512DUB
					16.75 16.25							BB2517DU	
					21.75 21.25							BB2522DU	BB2522DUB
30	34	2.005 1.970	2.10 1.80	42.50 41.50	16.25 15.75		29.980 29.959		34.025 34.000	30.085 29.990	0.126 0.010	BB3016DU	BB3016DUB
					26.25 25.75							BB3026DU	BB3026DUB
35	39			47.50 46.50	16.25 15.75		34.975 34.950		39.025 39.000	35.085 34.990	0.135 0.115	BB3516DU	
					26.25 25.75							BB3526DU	BB3526DUB
40	44			53.50 52.50	16.25 15.75		39.975 39.950		44.025 44.000	40.085 39.990		BB4016DU	
					26.25 25.75							BB4026DU	BB4026DUB
45	50	2.505 2.460	2.60 2.30	58.50 57.50	16.25 15.75		44.975 44.950		50.025 50.000	45.105 44.990	0.155 0.015	BB4516DU	
					26.25 25.75							BB4526DU	BB4526DUB

All dimensions in mm.

* assembly in H6/H7 housing

7 Standard Products

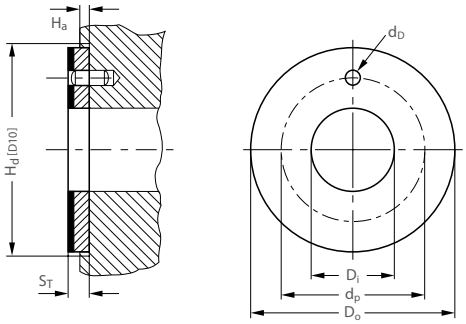
7.3 DU® FLANGED WASHERS - METRIC SIZES



PART-NO.	INSIDE Ø D_i max. / min.	OUTSIDE Ø D_o max. / min.	FLANGE Ø D_{fl} max. / min.	LOCATION Ø d_p max. / min.
BS40DU	40.7 / 40.2	75.0 / 74.5	44.00 / 43.90	65.0 / 64.5
BS50DU	51.5 / 51.0	85.0 / 84.5	55.00 / 54.88	75.0 / 74.5
BS60DU	61.5 / 61.0	95.0 / 94.5	65.00 / 64.88	85.0 / 84.5
BS70DU	71.5 / 71.0	110.0 / 109.5	75.00 / 74.88	100.0 / 99.5
BS80DU	81.5 / 81.0	120.0 / 119.5	85.00 / 84.86	110.0 / 109.5
BS90DU	91.5 / 91.0	130.0 / 129.5	95.00 / 94.86	120.0 / 119.5
BS100DU	101.5 / 101.0	140.0 / 139.5	105.00 / 104.86	130.0 / 129.5

All dimensions in mm. Dimensions and Tolerances according to ISO 3547 and GGB Specifications

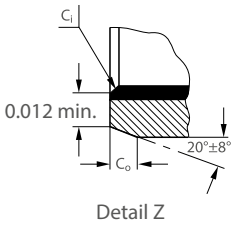
7.4 DU® THRUST WASHERS - METRIC SIZES

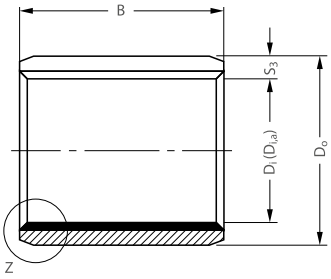


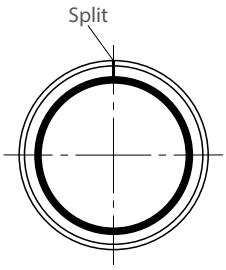
PART-NO.	INSIDE Ø D_i max. / min.	OUTSIDE Ø D_o max. / min.	THICKNESS S_T max. / min.	DOWEL HOLE Ø d_D max. / min.	DOWEL HOLE PCD Ø d_p max. / min.	RECESS DEPTH H_a max. / min.
WC08DU	10.25 / 10.00	20.00 / 19.75	1.50 / 1.45	No Hole	No Hole	1.20 / 0.95
WC10DU	12.25 / 12.00	24.00 / 23.75		1.875 / 1.625	18.12 / 17.88	
WC12DU	14.25 / 14.00	26.00 / 25.75		2.375 / 2.125	20.12 / 19.88	
WC14DU	16.25 / 16.00	30.00 / 29.75			22.12 / 21.88	
WC16DU	16.25 / 16.00	32.00 / 31.75			25.12 / 24.88	
WC18DU	20.25 /20.00	36.00 / 35.75		3.375 / 3.125	28.12 / 27.88	
WC20DU	22.25 / 22.00	38.00 / 37.75			30.12 / 29.88	
WC22DU	24.25 / 24.00	42.00 / 41.75			33.12 / 32.88	
WC24DU	26.25 / 26.00	44.00 / 43.75			35.12 / 34.88	
WC25DU	28.25 / 28.00	48.00 / 47.75		4.375 / 4.125	38.12/ 37.88	
WC30DU	32.25 / 32.00	54.00 / 53.75			43.12 / 42.88	
WC35DU	38.25 / 38.00	62.00 / 61.75			50.12 / 49.88	
WC40DU	42.25 / 42.00	66.00 / 65.75			54.12 / 53.88	
WC45DU	48.25 / 48.00	74.00 / 73.75	2.00 / 1.95		61.12 / 60.88	1.70 / 1.45
WC50DU	52.25 / 52.00	78.00 / 77.75			65.12 / 64.88	
WC60DU	62.25 / 62.00	90.00 / 89.75			76.12 / 75.88	

All dimensions in mm. Dimensions and Tolerances according to ISO 3547 and GGB Specifications

7.5 DU® CYLINDRICAL BUSHES - INCH SIZES







OUTSIDE C_o AND INSIDE C_i CHAMFERS

D_i	C_o	α	C_i	β
1/8" - 5/16"	0.008" - 0.024"	30° - 40°	0.004" - 0.012"	30° - 45°
3/8" - 11/16"	0.020" - 0.040"	20° - 30°	0.005" - 0.025"	40° - 55°
3/4" - 7"	0.020" - 0.040"	15° - 25°	0.005" - 0.025"	40° - 50°

PART-NO.	TECHNICAL DATA								
	Dimensions					Installation			
	Inside Ø D_i	Outside Ø D_o	Width B	Wall Thickness S_3 max. / min.	Width B max. / min.	Shaft Ø D_J max. / min.	Housing Ø D_H max. / min.	Bush Ø $D_{i,a}$* max. / min.	Clearance C_D max. / min.
02DU02	1/8	3/16	1/8	0.0315 0.0305	0.1350 0.1150	0.1243 0.1236	0.1878 0.1873	0.1268 0.1243	0.0032 0.0000
02DU03			3/16		0.1975 0.1775				
025DU025	5/32	7/32	5/32		0.16625 0.14265	0.1554 0.1547	0.2191 0.2186	0.1581 0.1556	0.0034 0.0002
025DU04			1/4		0.2600 0.2400				
03DU03	3/16	1/4	3/16		0.1975 0.1775	0.1865 0.1858	0.2503 0.2497	0.1893 0.1867	0.0035 0.0002
03DU04			1/4		0.2600 0.2400				
03DU06			3/8		0.3850 0.3650				
04DU04	1/4	5/16	1/4		0.2600 0.2400	0.2490 0.2481	0.3128 0.3122	0.2518 0.2492	0.0037 0.0002
04DU06			3/8		0.3850 0.3650				
05DU06	5/16	3/8	3/8		0.3850 0.3650	0.3115 0.3106	0.3753 0.3747	0.3143 0.3117	
05DU08			1/2		0.5100 0.4900				
06DU06	3/8	15/32	3/8	0.0471 0.0461	0.3850 0.3650	0.3740 0.3731	0.4691 0.4684	0.3769 0.3742	0.0038 0.0002
06DU08			1/2		0.5100 0.4900				
06DU12			3/4		0.7600 0.7400				
07DU08	7/16	17/32	1/2		0.5100 0.4900	0.4365 0.4355	0.5316 0.5309	0.4394 0.4367	0.0039 0.0002
07DU12			3/4		0.7600 0.7400				
08DU06	1/2	19/32	3/8		0.3850 0.3650	0.4990 0.4980	0.5941 0.5934	0.5019 0.4992	
08DU08			1/2		0.5100 0.4900				
08DU10			5/8		0.6350 0.6150				
08DU12			7/8		0.8850 0.8650				
09DU08	9/16	21/32	1/2		0.5100 0.4900	0.5615 0.5605	0.6566 0.6559	0.5644 0.5617	
09DU12			3/4		0.7600 0.7400				

All dimensions in inches.

* assembly in D_H housing

7 Standard Products

PART-NO.	TECHNICAL DATA								
	Dimensions					Installation			
	Inside Ø D_i	Outside Ø D_o	Width B	Wall Thickness S_3 max. / min.	Width B max. / min.	Shaft Ø D_J max. / min.	Housing Ø D_H max. / min.	Bush Ø $D_{i,a}$* max. / min.	Clearance C_D max. / min.
10DU08	5/8	23/32	1/2	0.0471 0.0461	0.5100 0.4900	0.6240 0.6230	0.7192 0.7184	0.6270 0.6242	0.0040 0.0002
10DU10			5/8		0.6350 0.6150				
10DU12			3/4		0.7600 0.7400				
10DU14			7/8		0.8850 0.8650				
11DU14	11/16	25/32	7/8		0.8850 0.8650	0.6865 0.6855	0.7817 0.7809	0.6895 0.6867	
12DU08	3/4	7/8	1/2	0.0627 0.0615	0.5100 0.4900	0.7491 0.7479	0.8755 0.8747	0.7525 0.7493	0.0046 0.0002
12DU12			3/4		0.7600 0.7400				
12DU16			1		1.0100 0.9900				
14DU12	7/8	1	3/4		0.7600 0.7400	0.8741 0.8729	1.0005 0.9997	0.8775 0.8743	
14DU14			7/8		0.8850 0.8650				
14DU16			1		1.0100 0.9900				
16DU12	1	1 1/8	3/4		0.7600 0.7400	0.9991 0.9979	1.1256 1.1246	1.0026 0.9992	0.0047 0.0001
16DU16			1		1.0100 0.9900				
16DU24			1 1/2		1.5100 1.4900				
18DU12	1 1/8	1 9/32	3/4	0.0784 0.0770	0.7600 0.7400	1.1238 1.1226	1.2818 1.2808	1.1278 1.1240	0.0052 0.0002
18DU16			1		1.0100 0.9900				
20DU12	1 1/4	1 13/32	3/4		0.7600 0.7400	1.2488 1.2472	1.4068 1.4058	1.2528 1.2490	0.0056 0.0002
20DU16			1		1.0100 0.9900				
20DU20			1 1/4		1.2600 1.2400				
20DU28			1 3/4		1.7600 1.7400				
22DU16	1 3/8	1 17/32	1		1.0100 0.9900	1.3738 1.3722	1.5318 1.5308	1.3778 1.3740	
22DU22			1 3/8		1.3850 1.3650				
22DU28			1 3/4		1.7600 1.7400				
24DU16	1 1/2	1 21/32	1		1.0100 0.9900	1.4988 1.4972	1.6568 1.6558	1.5028 1.4990	
24DU20			1 1/4		1.2600 1.2400				
24DU24			1 1/2		1.5100 1.4900				
24DU32			2		2.0100 1.9900				
26DU16	1 5/8	1 25/32	1		1.0100 0.9900	1.6238 1.6222	1.7818 1.7808	1.6278 1.6240	0.0056 0.0002
26DU24			1 1/2		1.5100 1.4900				
28DU16	1 3/4	1 15/16	1	0.0941 0.0923	1.0100 0.9900	1.7487 1.7471	1.9381 1.9371	1.7535 1.7489	0.0064 0.0002
28DU24			1 1/2		1.5100 1.4900				
28DU28			1 3/4		1.7600 1.7400				
28DU32			2		2.0100 1.9900				
30DU16	1 7/8	2 1/16	1		1.0100 0.9900	1.8737 1.8721	2.0633 2.0621	1.8787 1.8739	0.0066 0.0002
30DU30			1 7/8		1.8850 1.8650				
30DU36			2 1/4		2.2600 2.2400				

All dimensions in inches.

* assembly in D_H housing

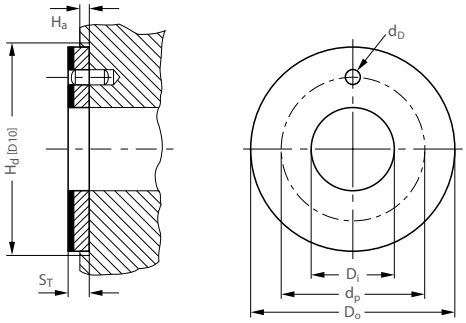
PART-NO.	TECHNICAL DATA								
	Dimensions					Installation			
	Inside Ø D_i	Outside Ø D_o	Width B	Wall Thickness S_3 max. / min.	Width B max. / min.	Shaft Ø D_J max. / min.	Housing Ø D_H max. / min.	Bush Ø $D_{i,a}$* max. / min.	Clearance C_D max. / min.
32DU16	2	2 3/16	1	0.0941 0.0923	1.0100 0.9900	1.9987 1.9969	2.1883 2.1871	2.0037 1.9989	0.0068 0.0002
32DU24			1 1/2		1.5100 1.4900				
32DU32			2		2.0100 1.9900				
32DU40			2 1/2		2.5100 2.4900				
36DU32	2 1/4	2 7/16	2		2.0100 1.4900	2.2507 2.2489	2.4377 2.4365	2.2573 2.2509	
36DU36			2 1/4		2.2600 2.2400				
36DU40			2 1/2		2.5100 2.4900				
36DU48			3		3.0100 2.9900				
40DU32	2 1/2	2 11/16	2		2.0100 1.9900	2.5011 2.4993	2.6881 2.6869	2.5077 2.5013	0.0084 0.0002
40DU40			2 1/2		2.5100 2.4900				
40DU48			3		3.0100 2.9900				
40DU56			3 1/2		3.5100 3.4900				
44DU32	2 3/4	2 15/16	2		2.0100 1.9900	2.7500 2.7482	2.9370 2.9358	2.7566 2.7502	
44DU40			2 1/2		2.5100 2.4900				
44DU48			3		3.0100 2.9900				
44DU56			3 1/2		3.5100 3.4900				
48DU32	3	3 3/16	2	0.0928 0.0902	2.5100 2.4900	3.0000 2.9982	3.1872 3.1858	3.0068 3.0002	0.0086 0.0002
48DU48			3		3.0100 2.9900				
48DU60			3 3/4		3.7600 3.7400				
56DU40	3 1/2	3 11/16	2 1/2		2.5100 2.4900	3.5000 3.4978	3.6872 3.6858	3.5068 3.5002	0.0090 0.0002
56DU48			3		3.0100 2.9900				
56DU60			3 3/4		3.7600 3.7400				
64DU48	4	4 3/16	3		3.0100 2.9900	4.0000 3.9978	4.1872 4.1858	4.0068 4.0002	
64DU60			3 3/4		3.7600 3.7400				
64DU76			4 3/4		4.7600 4.7400				
80DU48	5	5 3/16	3		3.0100 2.9900	4.9986 4.9961	5.1860 5.1844	5.0056 4.9988	0.0095 0.0002
80DU60			3 3/4		3.7600 3.7400				
96DU48	6	6 3/16	3		3.0100 2.9900	6.0000 5.9975	6.1874 6.1858	6.0070 6.0002	
96DU60			3 3/4		3.7600 3.7400				
112DU60	7	7 3/16	3 3/4		3.7600 3.7400	6.9954 6.9929	7.1830 7.1812	7.0026 6.9956	0.0097 0.0002

All dimensions in inches.

* assembly in D_H housing

7 Standard Products

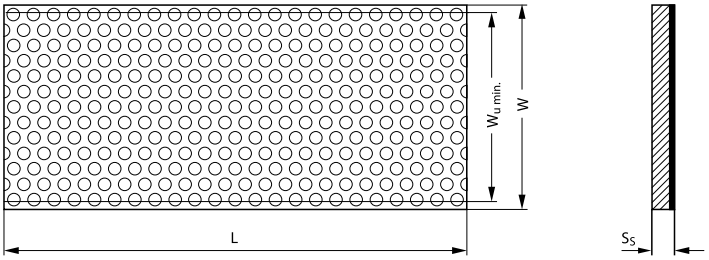
7.6 DU® THRUST WASHERS - INCH SIZES



PART-NO.	INSIDE Ø D_i max. / min.	OUTSIDE Ø D_o max. / min.	THICKNESS S_T max. / min.	DOWEL HOLE Ø d_D max. / min.	DOWEL HOLE PCD Ø d_p max. / min.	RECESS DEPTH H_a max. / min.
DU06	0.510 / 0.500	0.875 / 0.865	0.063 / 0.061	0.077 / 0.067	0.692 / 0.682	0.050 / 0.040
DU07	0.572 / 0.562	1.000 / 0.990			0.786 / 0.776	
DU08	0.635 / 0.625	1.125 /1.115		0.109 / 0.099	0.880 / 0.870	
DU09	0.697 / 0.687	1.187 /1.177			0.942 / 0.932	
DU10	0.760 / 0.750	1.250 / 1.240			1.005 / 0.995	
DU11	0.822 /0.812	1.375 / 1.365			1.099 / 1.089	
DU12	0.885 /0.875	1.500 / 1.490		0.140 / 0.130	1.192 / 1.182	
DU14	1.010 /1.000	1.750 / 1.740			1.380 / 1.370	
DU16	1.135 / 1.125	2.000 / 1.990		0.171 / 0.161	1.567 / 1.557	
DU18	1.260 / 1.250	2.125 / 2.115			1.692 / 1.682	
DU20	1.385 / 1.375	2.250 / 2.240			1.817 / 1.807	
DU22	1.510 / 1.500	2.500 / 2.490		0.202 / 0.192	2.005 / 1.995	
DU24	1.635 / 1.625	2.625 / 2.615			2.130 / 2.120	
DU26	1.760 / 1.750	2.750 / 2.740			2.255 / 2.245	
DU28	2.010 / 2.000	3.000 / 2.990	0.093 / 0.091		2.505 / 2.495	0.080 / 0.070
DU30	2.135 / 2.125	3.125 / 3.115			2.630 / 2.620	
DU32	2.260 / 2.250	3.250 / 3.240			2.755 / 2.745	

All dimensions in inches.

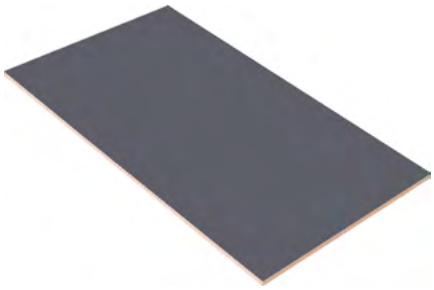
7.7 DU® PLATES - METRIC SIZES



PART NO.	LENGTH L max. min.	TOTAL WIDTH W	USABLE WIDTH $W_{U\,min}$	THICKNESS S_S max. min.
S07190DU	503 500	200	190	0.74 0.70
S10190DU				1.01 0.97
S15190DU				1.52 1.48
S20190DU				2.00 1.96
S25190DU				2.50 2.46
S30190DU				3.06 3.02

All dimensions in mm

7.8 DU-B PLATES - METRIC SIZES



PART NO.	LENGTH L max. min.	TOTAL WIDTH W	USABLE WIDTH $W_{U\,min}$	THICKNESS S_S max. min.
S07085DUB	503 500	95	85	0.74 0.70
S10180DUB		193	180	1.01 0.97
S15180DUB				1.52 1.48
S20180DUB				2.00 1.96
S25180DUB				2.50 2.46

All dimensions in mm

7.9 DU® PLATES - INCH SIZES

DU® Plate inch sizes are available as non-Standard products, on request.

8 Test Methods

8.1 MEASUREMENT OF WRAPPED BUSHES

It is not possible to accurately measure the external and internal diameters of a wrapped bush in the free condition. In its free state a wrapped bush will not be perfectly cylindrical and the butt joint may be open. When correctly installed in a housing the butt joint will be tightly closed and the bush will conform to the housing. For this reason the external diameter and internal diameter of a wrapped bush can only be checked with special gauges and test equipment.

The checking methods are defined in ISO 3547 Parts 1 to 7.

TEST A OF ISO 3547 PART 2

Checking the external diameter in a test machine with checking blocks and adjusting mandrel.

TEST A OF ISO 3547 PART 2 ON 2015DU	
Checking block and setting mandrel $d_{ch,1}$	23.062 mm
Test force F_{ch}	4500 N
Limits for Δz	0 and -0.065 mm
Bush Outside diameter D_o	23.035 to 23.075 mm

Table 14 : Test A of ISO 3547 Part 2

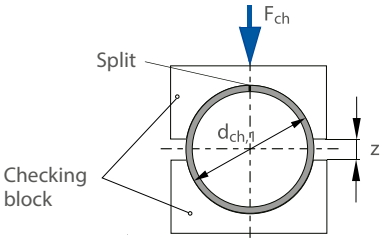


Fig. 34: Test A, data for drawing

TEST B (ALTERNATIVELY TO TEST A)

Check external diameter with GO and NO GO ring gauges.

TEST C

Checking the internal diameter of a bush pressed into a ring gauge, which nominal diameter corresponds to the dimension specified in table 6 of ISO 3547 Part 2 (Example D_i = 20 mm).

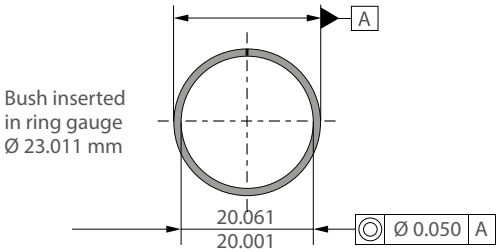


Fig. 35: Test C, data for drawing

MEASUREMENT OF WALL THICKNESS (ALTERNATIVELY TO TEST C)

The wall thickness is measured at one, two or three positions axially according to the bearing dimensions.

B [mm]	X [MM]	MEASUREMENT POSITION
≤15	B/2	1
>15 ≤50	4	2
>50 ≤90	6 and B/2	3
>90	8 and B/2	3

Table 15 : Measurement position

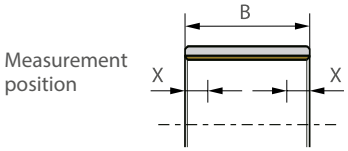


Fig. 36: Test C, measurement position

TEST D

Check external diameter by precision measuring tape.

Formula Symbols and Designations

SYMBOL	UNIT	DESIGNATION
A	mm^2	Surface area of DU® bearing
A_M	mm^2	Surface area of mating surface in contact with DU® bearing (slideway)
a_B	-	Bearing size factor
a_C	-	Application factor for bore burnishing or machining
a_E	-	High load factor
a_{E1}	-	Specific load factor (slideways)
a_{E2}	-	Speed, temperature and material factor (slideways)
a_{E3}	-	Relative contact area factor (slideways)
a_L	-	Life correction constant
a_M	-	Mating surface material factor
a_T	-	Temperature application factor
B	mm	Nominal bush length
C	1/min	Dynamic load frequency
C_D	mm	Installed diametrical clearance
C_i	mm	ID chamfer length
C_o	mm	OD chamfer length
C_T	-	Total number of dynamic load cycles
D_C	mm	Diameter of burnishing tool
D_{fl}	mm	Nominal bush flange OD
D_H	mm	Housing Diameter
D_i	mm	Nominal bush and thrust washer ID
$D_{i,a}$	mm	Bush ID when assembled in housing
D_J	mm	Shaft diameter
D_{Nth}	nvt	Max. thermal neutron dose
D_o	mm	Nominal bush and thrust washer OD
D_Y	Gy	Max. Gamma radiation dose
d_D	mm	Dowel hole diameter
d_L	mm	Oil hole diameter
d_p	mm	Pitch circle diameter for dowel hole
F	N	Bearing load
F_{ch}	N	Test force
F_i	N	Insertion force
f	-	Coefficient of friction

SYMBOL	UNIT	DESIGNATION
H_a	mm	Depth of housing recess (e.g. for thrust washers)
H_d	mm	Diameter of housing recess (e.g. for thrust washers)
L	mm	Plate length
L_H	h	Bearing service life
L_S	mm	Length of stroke (slideway)
N	1/min	Oscillating movement frequency
N_{osz}	1/min	Specific load
P	MPa	Specific load limit
P_{lim}	MPa	Maximum static load
$P_{sta,max}$	MPa	Maximum dynamic load
$P_{dyn,max}$	MPa	Permissible number of cycles
Q	-	Rotational speed
R_a	µm	Surface roughness (DIN 4768, ISO/DIN 4287/1)
R_{OB}	Ω	Electrical resistance
S_3	mm	Bush wall thickness
S_{fl}	mm	Flange thickness
S_S	mm	Plate thickness
S_T	mm	Thrust washer thickness
T	°C	Temperature
T_{amb}	°C	Ambient temperature
T_{max}	°C	Maximum temperature
T_{min}	°C	Minimum temperature
V	m/s	Sliding speed
W	mm	Plate width
$W_{U\ min}$	mm	Minimum usable strip width
Z_T	-	Total number of cycles
α_1	$1/10^6K$	Coefficient of linear thermal expansion parallel to surface
α_2	$1/10^6K$	Coefficient of linear thermal expansion normal to surface
σ_c	MPa	Compressive yield strength
λ	W/mK	Thermal conductivity
φ	°	Angular displacement
η	Ns/mm^2	Dynamic viscosity

9 Bearing Application Data Sheet

Please complete the form below and share it with your sales engineer.

DATA FOR BEARING DESIGN CALCULATION

Application: _____

_____

Project/No.: _____ Quantity: _____ ☐ New Design ☐ Existing Design

☐ Steady Load ☐ Rotating Load ☐ Rotational Movement ☐ Oscillating Movement ☐ Linear Movement

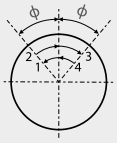
DIMENSIONS [MM]

Inside diameter	D_i	
Outside diameter	D_o	
Length	B	
Flange diameter	D_{fl}	
Flange thickness	B_{fl}	
Wall thickness	S_T	
Length of slideplate	L	
Width of slideplate	W	
Thickness of slideplate	S_S	

LOAD

☐ Static load		
☐ Dynamic load		
Axial load F	[N]	
Radial load F	[N]	

MOVEMENT

Rotational speed	N [1/min]	
Speed	V [m/s]	
Length of stroke	L_S [mm]	
Frequence of stroke	[1/min]	
Oscillating cycle 	ϕ[°]	
Osc. frequence	N_{osz} [1/min]	

MATING SURFACE

Material		
Hardness	HB/HRC	
Surface finish	R_a [µm]	

FITS & TOLERANCES

Shaft	D_J	
Bearing housing	D_H	

OPERATING ENVIRONMENT

Ambient temperature T_{amb} [°]	
Bearing housing material	

☐ Housing with good heating transfer properties

☐ Light pressing or insulated housing with poor heat transfer properties

☐ Non metal housing with poor heat transfer properties

☐ Alternate operation in water and dry

OPERATING ENVIRONMENT

☐ Dry
☐ Continuous lubrication
☐ Process fluid lubrication
☐ Initial lubrication only
☐ Hydrodynamic conditions

Process fluid	
Lubricant	
Dynamic viscosity η[mPas]	

SERVICE HOURS PER DAY

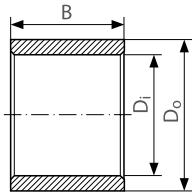
Continuous operation	
Intermittent operation	
Operating time	
Days per year	

SERVICE LIFE

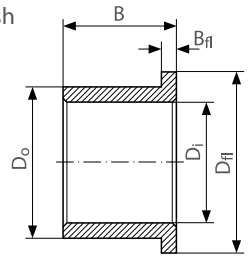
Required service life	L_H [h]	

BEARING TYPE

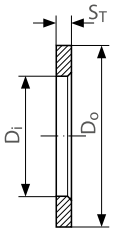
☐ Cylindrical bush



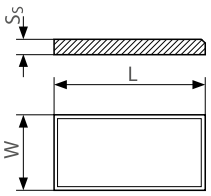
☐ Flanged bush



☐ Thrust washer



☐ Slide plate



☐ Special parts (sketch)

CUSTOMER INFORMATION

Company _____

Street _____

City / State / Province / Post Code _____

Telephone _____ Fax _____

Name _____

Email Address _____ Date _____

Product Information

This document is provided to give you the analysis tools or information to assist you in product selection. Product performance is affected by many factors beyond the control of GGB. Therefore, you must validate the suitability and feasibility of all product selections for your applications.

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Each of our global locations has management systems in place that adhere to IATF 16949, ISO 9001, ISO 14001 and ISO 45001 quality regulations. Our certificates can be found here: **ggbearings.com/en/certificates**.

A detailed explanation of our commitment to REACH and RoHS directives can be found at **ggbearings.com/en/reach-rohs.**

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