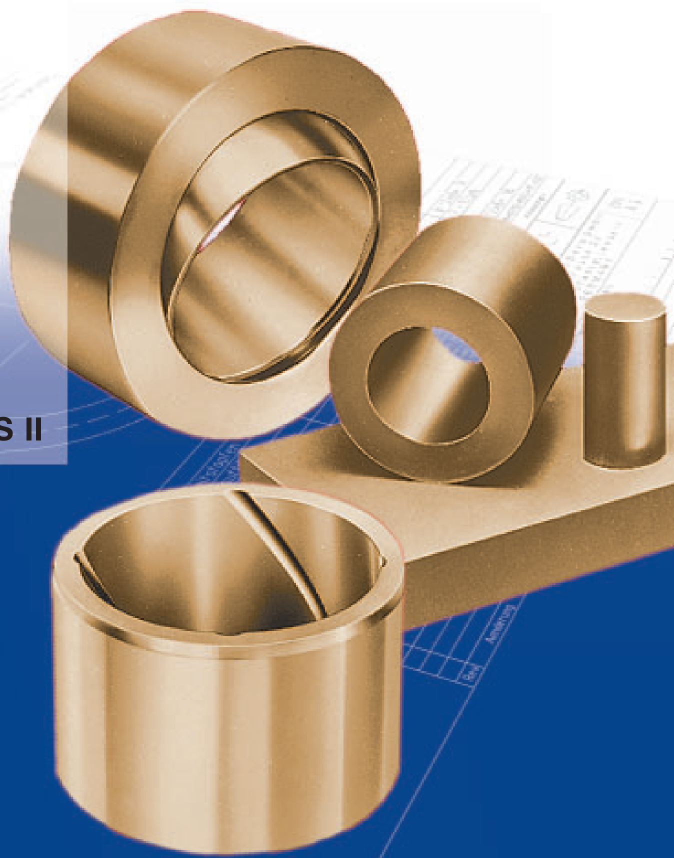
deva.metal®

Maintenance-free, self-lubricating bearings

Engineering Services

DEVA® – more than just bearings

- Benefit from more than **60 years of experience** with self lubricating bearings
- Use our **extensive material and application knowledge** in all industrial areas
- Let the **DEVA® application engineering team assist you** with:
  - Material selection
  - Design, standard or according to your individual needs
  - Assembly
  - Calculation of estimated life time
- Make use of the latest **material developments** supported by modern **test facilities**
- Ask for simulation of **your bearing application on our test rigs**
- Let us **analyse your bearing problem by FEM**
- Expect the highest quality standards, certified by **DIN ISO 9001:2000, ISO/TS 16949:2002, ISO 14001/EMAS II**



DEVA® – Your partner for plain bearing applications.

Technical manual deva.metal® – Contents

Introduction

Modern designs place huge demands on today‘s bearing materials, requiring zero maintenance even under severe to extreme operating conditions and maximum loads. Moreover, the permanent cost pressure calls for increasing uptime availability of machines and plants and uncompromising standards of operational reliability. With the **DEVA**® range of maintenance-free, self-lubricating, heavy-duty friction materials it is possible to produce self-lubricating bearings with guaranteed long-term reliability.

deva.metal® materials are suitable for applications with high static and dynamic loads. Due to the micro-distribution of the lubricant, all **deva.metal**® materials are also equally suitable for small movements.

At the same time the form of movement, whether translational, rotational or a combination of both, is insignificant. The **deva.metal**® material range is also characterised by the following properties:

- high wear resistance
- insensitive to impact stress
- resistant to harsh operational and ambient conditions of mechanical or chemical nature

The **deva.metal**® material range provides the design engineer with countless opportunities wherever environmentally-friendly lubrication is either desired or required, or where conventional lubrication is not possible.

1 Material properties

deva.metal® is a family of high performance, self-lubricating bearing materials. The **deva.metal**® system is based on four main groups – bronze, iron, nickel and stainless steel – each containing dry solid lubricant, most commonly graphite, uniformly dispersed within the metal matrix.
Important selection criteria are the sliding speed, specific load, temperature and other application-specific influences.
deva.metal®
- normally requires no lubrication.
- provides maintenance free operation.
- has high static and dynamic load capacity.
- has good frictional properties with negligible stick-slip.
- can be used in dusty environments.
- can be used dependent on alloy in a temperature range of -200 °C to +800 °C.
- grades may be selected to tolerate corrosive applications.
- has no water absorption and is therefore dimensionally stable, suitable for use in sea water and many commercial liquids.
- alloys are available for use in radioactive environments.
- is electrically conductive. No signs of electrostatic charging occur.
- is suitable for translatory, rotational and oscillating movements with cylindrical guide or also for direct surface use. These movements can occur individually or in combination.
- is used where conventional lubrication is not possible.
- offers advantages for low-cost lubrication in comparison to conventional bearing materials.
- can be used as back-up bearing for hydrodynamic lubrication.
- can be used with hydrodynamic water lubrication.

2 Material structure

2.1 Alloys

All **deva.metal**® alloys share a common metallurgical microstructure of a solid lubricant uniformly distributed throughout a metal matrix.
The properties of the metal matrix determine the general physical, mechanical and chemical properties of the material and are the basis on which an initial alloy selection is made for a specific application.
A selection of four main groups is available: bronze base, iron base, nickel base and stainless-steel base.

2.2 Solid lubricants

deva.metal® solid lubricant distribution structures show the following microstructures, which are used according to the application-specific requirement.

These different structures and distributions can be used in all three main groups (Tab. 2.2.1).

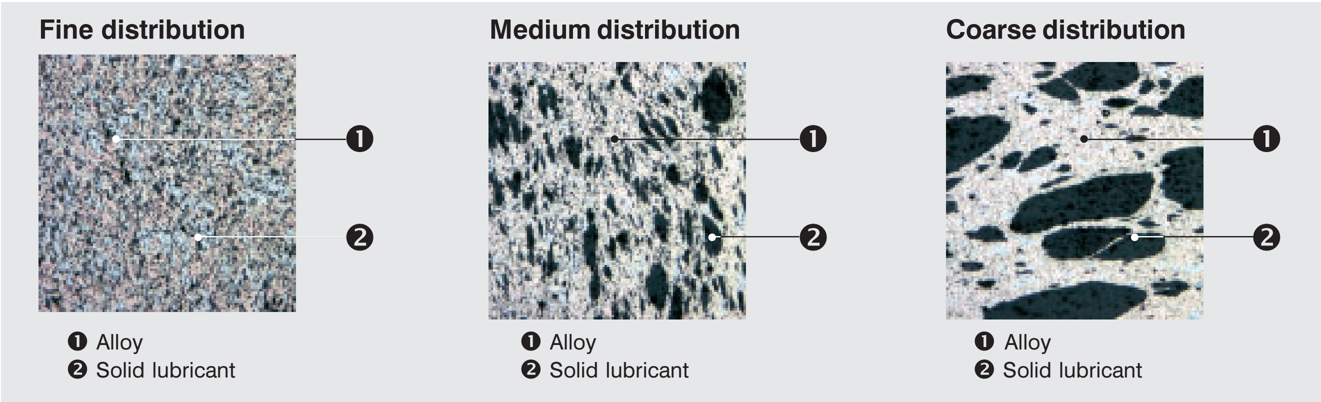


Fig. 2.2.1 – Solid lubricant distribution structures of different deva.metal® alloys

Solid lubricants
The amount and characteristics of the solid lubricant largely determine the bearing properties of a particular **deva.metal**® alloy composition within each of the four metal matrix types.
The solid lubricants are:

Graphite C
Molybdenum Disulphide MoS_2
Tungsten Disulphide WS_2

Graphite is the most frequently used solid lubricant and may occur as fine or agglomerated particles within the metal matrix according to the requirements of the application.

Property	Graphite	MoS_2	WS_2
Crystal structure	hexagonal	hexagonal	hexagonal
Specific gravity	2.25	4.7	7.5
Coefficient of friction in air	0.1 to 0.18	0.08 to 0.12	0.09 to 0.17
Operating temp. range	-120 °C to +600 °C	-100 °C to +400 °C	-180 °C to +600 °C
Chemical resistance	very good	good	good
Corrosive resistance	good	limited	limited
Nuclear radiation resist.	very good	good	good
Performance in air	very good	good	very good
Performance in water	very good	limited	limited
Performance in vacuum	not suitable	good	very good

Table 2.2.1 – Solid lubrications

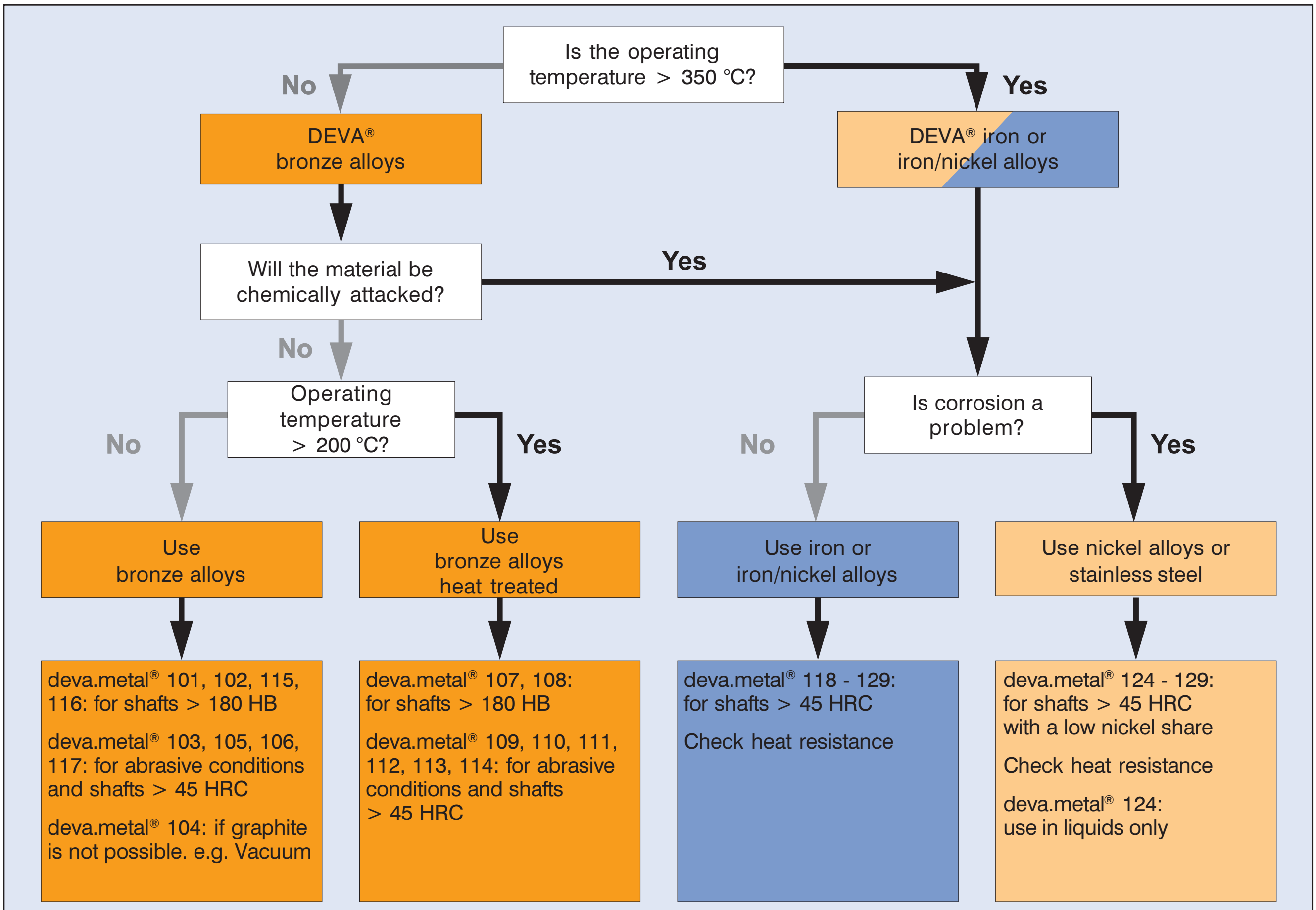
The dry wear mechanism that enables **deva.metal**® alloys to operate satisfactorily in the absence of conventional lubricants is the same for each of the metal matrix and solid lubricant materials of the **deva.metal**® system.
All solid lubricants have a lamella structure characterised by a low interfacial shear strength between adjacent intermolecular layers within the material.

The preloaded solid lubricant is released by the relative movement between the running surface and the **deva.metal**® bearing and is deposited mechanically in the running surface. A solid lubricant film is formed on the sliding partners with low coefficients of friction. The micro-wear of the bearing during relative movement continually releases new lubricant and thus ensures a sustained supply of new lubricant to the system. This enables many applications to be free of maintenance.

3 Materials

3.1 Material selection

The following decision chart provides guidance on the selection of the appropriate **deva.metal®** alloy according to the environmental conditions of the application.



NOTE: For your assurance we recommend to consult our application engineers.

Figure 3.1.1 – Scheme material selection deva.metal®

Typical applications for some deva.metal® alloys

Metal alloy	Application	Characteristic
deva.metal® 101	General	Standard material for most applications
deva.metal® 111/112	Iron and steel industry	High abrasion
deva.metal® 113/114	Furnace construction	Temperature
deva.metal® 115	Hydro-mechanical applications	High load, corrosion-resistant/sea water
deva.metal® 116	Bottle cleaning/filling machines	High speed
deva.metal® 117	Heavy industry	High load/abrasion
deva.metal® 118	Furnace construction	Temperature
deva.metal® 125/126	Exhaust/flue gas register	Temperature and corrosion
deva.metal® 128	Hot valves	Very high temperature

Table 3.1.1 – Typical applications

3.2 Properties

The **deva.metal**® bronze and lead bronze alloys are the most widely used of the **DEVA**® materials and are particularly suitable for water lubrication. They are also suitable for elevated temperature applications, however due to problems of dimensional stability the bronze alloys are generally limited to a maximum service temperature of about 200 °C. For prolonged use at temperatures above 200 °C it is necessary to

deva.metal®	Properties [1]							
Alloys	**Physical properties**			**Mechanical properties**			**Max. static load**	
	Density	Hardness	Coefficient of linear thermal expansion	Tensile strength	Compressive strength	Young's modulus	stat. [4]	dyn. [4]
Symbol	γ		α_l	δ_T	δ_C	E	$\bar{p}_{stat/max}$	$\bar{p}_{dyn/max}$
Unit	g/cm³	HBmin	10^{-6}/K	MPa	MPa	MPa	MPa	MPa
Bronze alloys								
deva.metal® 101	6.8	40	18	50	300	52000	200	100
deva.metal® 102	6.0	50	18	35	180	42000	140	70
deva.metal® 103	6.4	50	18	55	250	53000	180	90
deva.metal® 104	7.6	45	18	20	230	24000	150	75
deva.metal® 105	6.6	65	18	85	340	53000	230	115
deva.metal® 106	6.1	45	18	50	240	49000	160	80
Bronze alloys (heat treated)								
deva.metal® 107	6.3	35	18	57	250	43000	170	85
deva.metal® 108	6.3	35	18	57	250	43000	170	85
deva.metal® 109	6.4	50	18	55	250	43000	170	85
deva.metal® 110	6.4	50	18	55	250	43000	170	85
deva.metal® 111	6.4	40	18	65	320	46000	220	110
deva.metal® 112	6.4	40	18	65	320	46000	220	110
deva.metal® 113	6.3	50	18	40	220	44000	200	100
deva.metal® 114	6.3	50	18	40	220	44000	200	100
Lead bronze alloys [2]								
deva.metal® 115	7.2	50	18	85	380	57000	260	130
deva.metal® 116	5.8	50	18	30	220	26000	150	75
deva.metal® 117	6.6	65	18	85	340	48000	230	115
Iron alloys								
deva.metal® 118	6.0	80	13	80	550		150	60
deva.metal® 119 [3]	6.7	70	16	45	350		70	30
deva.metal® 120	6.0	120	12	100	460	73000	70	30
deva.metal® 121	6.4	50	12	50	180		70	30
deva.metal® 122	5.9	50	13	50	180		70	30
deva.metal® 123	5.7	140	13	60	400		70	30
Nickel alloys								
deva.metal® 124	6.4	45	15	60	400		100	50
Nickel/copper alloys								
deva.metal® 125	6.2	40	16	70	380		100	50
deva.metal® 126	6.2	65		30	300			
Nickel/iron alloys								
deva.metal® 127	6.0	45	12.5	50	240		100	50
Stainless steel								
deva.metal® 128	5.8	55	13	120	180		150	70
deva.metal® 129	5.8	75	13	130			50	10/1 [5]

[1] Current properties and values are listed in the DEVA® material sheets. These are provided on request.
[2] For bearings containing lead please refer to our DEVA® standards sheet DN 0.14
[3] Special material not for new design
[4] For minimum permissible temperature
[5] 10 at 550 °C
1 at 800 °C

Table 3.2.1 – Properties of deva.metal®

stabilise the material by an additional heat treatment process, after which the heat treated bronze materials may be used at temperatures up to 350 °C.

The **deva.metal®** nickel based alloys are generally used in those applications requiring the highest resistance to corrosion.

deva.metal®	Bearing properties							
Alloys	Max. sliding velocity	Max. $\bar{p}U$ factor	Temperature range		Coefficient of friction 1) 4)		Min. shaft hardness	Shaft surface finish
	dry	dry	max.	min.	dry	in water		optimum
Symbol	U_{max}	$\bar{p}U_{max}$	T_{max}	T_{min}	f	f		R_a
Unit	m/s	MPa × $\frac{m}{s}$	°C	°C			HB/HRC	µm
Bronze alloys								
deva.metal® 101	0.3	1.5	200	-50	0.13 – 0.18	0.11 – 0.16	>180HB	0.2 – 0.8
deva.metal® 102	0.4	1.5	200	-50	0.10 – 0.15	0.09 – 0.12	>180HB	0.2 – 0.8
deva.metal® 103	0.3	1.5	200	-50	0.11 – 0.16	0.10 – 0.13	>35HRC	0.2 – 0.8
deva.metal® 104	0.2	1.2	240	-100	0.15 – 0.22	0.13 – 0.20	>45HRC	0.2 – 0.8
deva.metal® 105	0.3	1.5	200	-50	0.13 – 0.18	0.11 – 0.16	>45HRC	0.2 – 0.8
deva.metal® 106	0.4	1.5	200	-50	0.10 – 0.15	0.09 – 0.12	>45HRC	0.2 – 0.8
Bronze alloys (heat treated)								
deva.metal® 107	0.3	1.5	350	-100	0.13 – 0.18	0.11 – 0.16	>180HB	0.2 – 0.8
deva.metal® 108	0.3	1.5	350	-100	0.13 – 0.18	0.11 – 0.16	>180HB	0.2 – 0.8
deva.metal® 109	0.4	1.5	350	-100	0.11 – 0.16	0.10 – 0.13	>35HRC	0.2 – 0.8
deva.metal® 110	0.4	1.5	350	-100	0.11 – 0.16	0.10 – 0.13	>35HRC	0.2 – 0.8
deva.metal® 111	0.3	1.5	350	-100	0.11 – 0.16	0.10 – 0.13	>45HRC	0.2 – 0.8
deva.metal® 112	0.3	1.5	350	-100	0.11 – 0.16	0.10 – 0.13	>45HRC	0.2 – 0.8
deva.metal® 113	0.4	1.5	350	-100	0.10 – 0.15	0.09 – 0.12	>35HRC	0.2 – 0.8
deva.metal® 114	0.3	1.5	350	-100	0.10 – 0.15	0.09 – 0.12	>35HRC	0.2 – 0.8
Lead bronze alloys 2)								
deva.metal® 115	0.3	1.5	200	-50	0.15 – 0.22	0.13 – 0.18	>180HB	0.2 – 0.8
deva.metal® 116	0.3	1.5	200	-50	0.13 – 0.18	0.11 – 0.16	>180HB	0.2 – 0.8
deva.metal® 117	0.3	1.5	200	-50	0.13 – 0.18	0.11 – 0.16	>45HRC	0.2 – 0.8
Iron alloys								
deva.metal® 118	0.2	1.0	600	0	0.30 – 0.45		>45HRC	0.2 – 0.8
deva.metal® 119 3)	0.2	1.0	500	0	0.25 – 0.35		>45HRC	0.2 – 0.8
deva.metal® 120	0.2	1.0	600	0	0.25 – 0.43		>45HRC	0.2 – 0.8
deva.metal® 121	0.2	1.0	450	280	0.30 – 0.45		>45HRC	0.2 – 0.8
deva.metal® 122	0.2	1.0	450	280	0.30 – 0.45		>45HRC	0.2 – 0.8
deva.metal® 123	0.2	1.0	600	0	0.28 – 0.45		>45HRC	0.2 – 0.8
Nickel alloys								
deva.metal® 124	0.2	0.8	200	-200	0.30 – 0.45		>45HRC	0.2 – 0.8
Nickel/copper alloys								
deva.metal® 125	0.2	0.8	450	-200	0.30 – 0.45		>45HRC	0.2 – 0.8
deva.metal® 126	0.2	0.8	450	-200	0.30 – 0.45		>45HRC	0.2 – 0.8
Nickel/iron alloys								
deva.metal® 127	0.2	0.8	650 3)	-200	0.25 – 0.43		>45HRC	0.2 – 0.8
Stainless steel								
deva.metal® 128	0.2	0.5	750	-100	0.35 – 0.49		>45HRC	0.2 – 0.8
deva.metal® 129	0.05	0.5	800	350	0.40 2)		>200HB	0.2 – 0.8

1) Remark: Friction decreases at operating temperature
2) Fluctuates according to temperature
3) In a hot steam environment: < 450 °C

4) The coefficients of friction cited are not guaranteed properties. They have been ascertained on our test benches using practical parameters. These do not have to coincide with the immediate application of our products and their application environment. We can offer customer-specific friction and wear tests on request

Table 3.2.2 – Bearing properties of deva.metal®

3.3 Chemical resistance

The following table indicates the chemical resistance of the **deva.metal**® bronze alloys to various chemical media. It is recommended that the chemical resistance of the selected **deva.metal**® alloy is confirmed by testing.

Definitions:

- ✚ Resistant
- ⋆ Resistant depending on concentration, oxygen content, temperature, etc.
- ○ Not recommendable
- □ No data available

Chemical substance	Conc. in %	Temp. in °C	Bronze all. deva.metal®	Iron alloys deva.metal®			Nickel alloys deva.metal®			Stainless steel deva.metal®
			101-117	118-119	120-121	122-123	124	125-126	127	128-129
Strong acids										
Hydrochloric acid	5	20	⋆	○	⋆	○	○	⋆	○	○
Hydrofluoric acid	5	20	⋆	⋆	○	○	✚	✚	⋆	○
Nitric acid	5	20	○	○	○	○	○	○	○	○
Sulphuric acid	5	20	✚	○	⋆	○	⋆	✚	○	○
Phosphoric acid	5	20	✚	○	○	○	✚	⋆	⋆	⋆
Weak acids										
Acetic acid	5	20	✚	○	○	○	⋆	✚	✚	✚
Formic acid	5	20	✚	○	○	○	⋆	✚	✚	✚
Boric acid	5	20	✚	○	○	○	✚	✚	✚	✚
Citric acid	5	20	✚	⋆	⋆	⋆	✚	✚	✚	✚
Bases										
Ammonia	10	20	○	✚	✚	✚	✚	✚	✚	✚
Sodium hydroxide	5	20	✚	✚	✚	✚	✚	✚	✚	⋆
Potassium hydroxide	5	20	✚	✚	✚	✚	✚	✚	✚	⋆
Solvents										
Acetone		20	✚	✚	✚	✚	✚	✚	✚	✚
Carbon tetrachloride		20	✚	✚	✚	✚	✚	✚	✚	✚
Ethanol		20	✚	✚	✚	✚	✚	✚	✚	✚
Ethyl acetate		20	✚	✚	✚	✚	✚	✚	✚	✚
Ethyl chloride		20	✚	○	○	○	✚	✚	✚	✚
Glycerin		20	✚	✚	✚	✚	✚	✚	✚	✚
Salts										
Ammonium nitrate			○	⋆	⋆	⋆	✚	○	✚	✚
Calcium chloride			✚	✚	✚	✚	✚	✚	✚	○
Magnesium chloride			✚	⋆	⋆	⋆	✚	⋆	⋆	○
Magnesium sulfate			✚	⋆	⋆	⋆	✚	⋆	⋆	✚
Sodium chloride			✚	⋆	⋆	⋆	✚	✚	✚	○
Sodium nitrate			✚	✚	✚	✚	✚	✚	✚	✚
Zinc chloride			○	○	○	○	✚	○	⋆	○
Zinc sulphate			✚	⋆	⋆	⋆	✚	○	⋆	⋆
Gases										
Ammonia			⋆	✚	✚	✚	○	⋆	⋆	✚
Chlorine			○	○	○	○	□	⋆	○	○
Carbon dioxide			✚	⋆	⋆	⋆	⋆	○	⋆	✚
Fluorine			○	⋆	⋆	⋆	✚	✚	✚	✚
Sulphur dioxide			✚	○	○	○	⋆	⋆	⋆	✚
Hydrogen sulphide			⋆	○	○	○	⋆	✚	⋆	✚
Nitrogen			✚	✚	✚	✚	✚	✚	✚	✚
Hydrogen			✚	✚	✚	✚	✚	✚	✚	✚
Lubricants and fuels										
Paraffin		20	✚	✚	✚	✚	✚	✚	✚	✚
Gasolene		20	✚	✚	✚	✚	✚	✚	✚	✚
Kerosene		20	✚	✚	✚	✚	✚	✚	✚	✚
Diesel fuel		20	✚	✚	✚	✚	✚	✚	✚	✚
Mineral oil		70	✚	✚	✚	✚	✚	✚	✚	✚
HFA - ISO46 water-in-oil emul.		70	✚	✚	✚	✚	✚	✚	✚	✚
HFC - water-glycol		70	✚	✚	✚	✚	✚	✚	✚	✚
HFD - phosphate ester		70	✚	✚	✚	✚	✚	✚	✚	✚
Others										
Water		20	✚	✚	○	○	✚	✚	✚	✚
Seawater		20	✚	○	○	○	✚	✚	✚	✚
Resin			✚	✚	✚	✚	✚	✚	✚	✚
Hydrocarbon			✚	✚	✚	✚	✚	✚	✚	✚

Table 3.3.1 – Chemical properties of deva.metal® alloys

3.4 Effect of temperature

The maximum specific load which can be supported by **deva.metal**® alloys decreases with temperature.

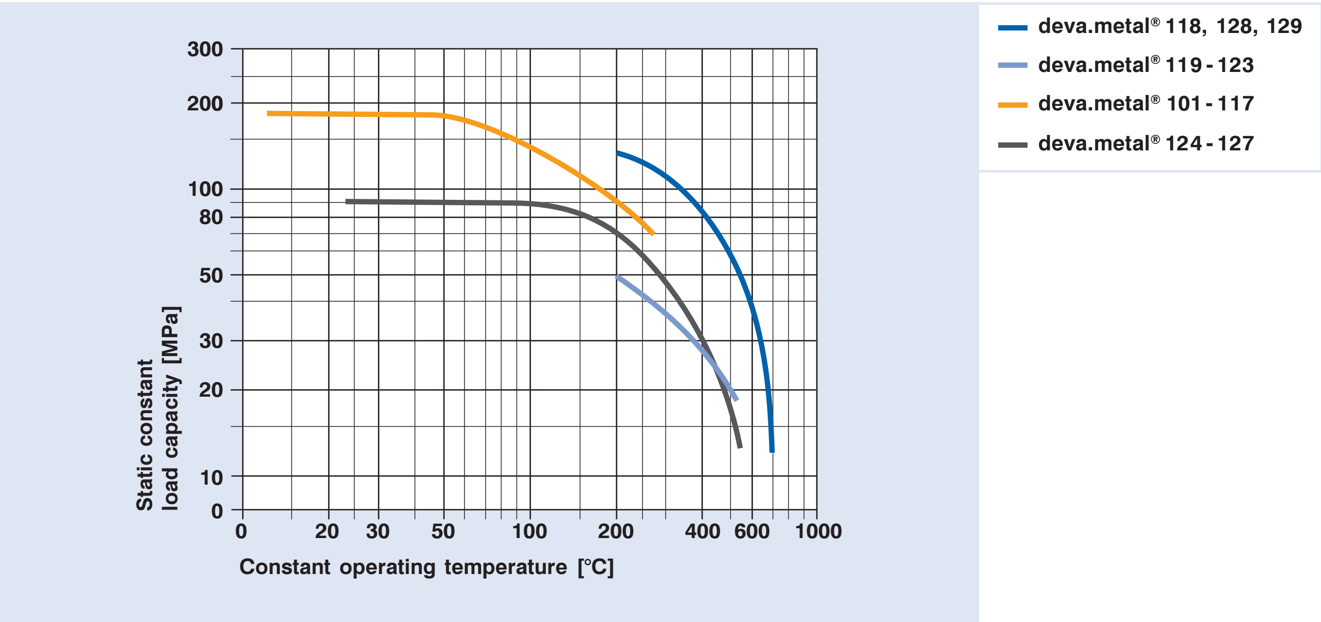


Figure 3.4.1 – Effect of temperature on the specific load capacity of deva.metal®

3.5 Specific wear rate

The effect of p̄U-factor on the specific wear rate (ΔS_h) for each of the three **deva.metal**® alloy groups is shown in figure 3.5.1.

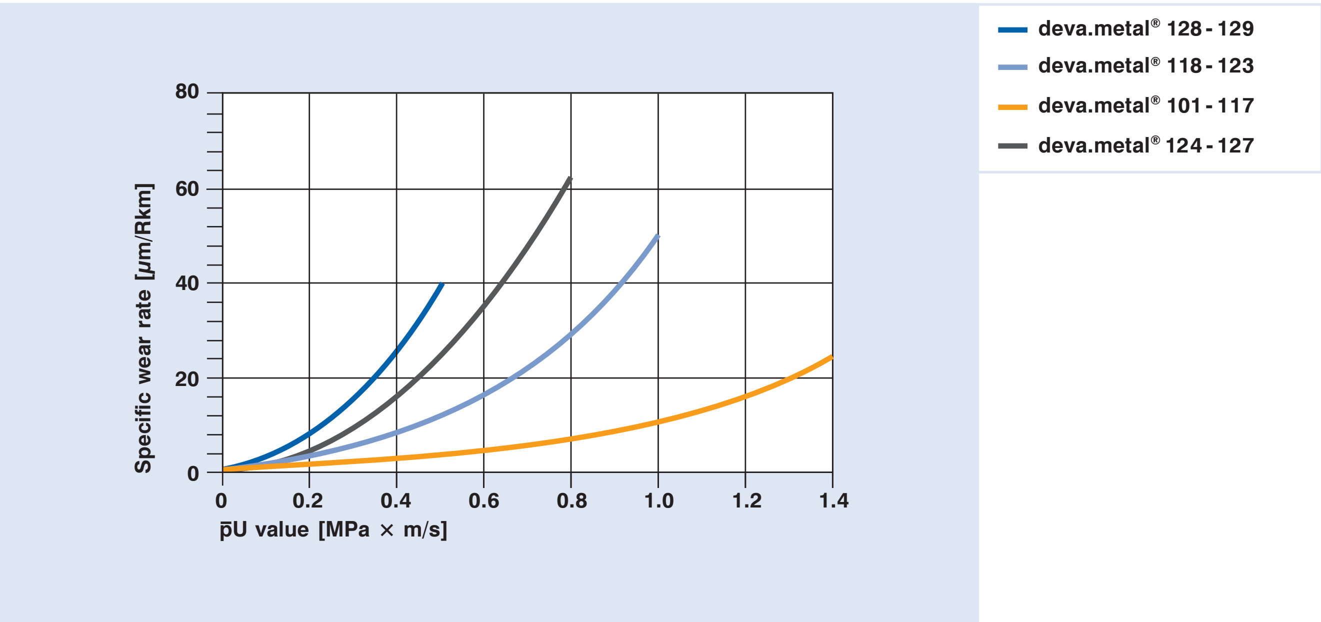


Figure 3.5.1 – Specific wear rate of deva.metal® alloys

4 Counter materials

The **deva.metal**® sliding materials can only be used with counter material hardness of at least 180 HB. If an additional lubricant is introduced into the sliding contact, hardness values of >130 HB are also admissible. In abrasive environments, a hardened 35 HRC/45 HRC surface should be used. The ideal mating surface roughness for **deva.metal**® is $R_a = 0.2$ to $0.8\,\mu m$ (obtained by grinding). Rougher surfaces are also acceptable depending on the operating conditions. To obtain the right surface roughness, it is also possible to use bushings of a suitable hardness. Hard-faced layers or galvanised protective layers (normally coated, hard-chrome and nickel-plated) can be used to a limited extent. The corrosion criteria for the counter materials should be determined on the basis of the relevant operating conditions. The adjacent table provides an overview of some of the possible counter materials.

Counter materials

Counter materials for normal applications

Material No.	DIN designation	Comparable standards		
		USA AISI	GB B.S. 9 70	F AFNOR
1.0543	ZSt 60-2	Grade 65	55C	A60-2
1.0503	C45	1045	080M46	CC45
1.7225	42CrMo4	4140	708M40	42CD4

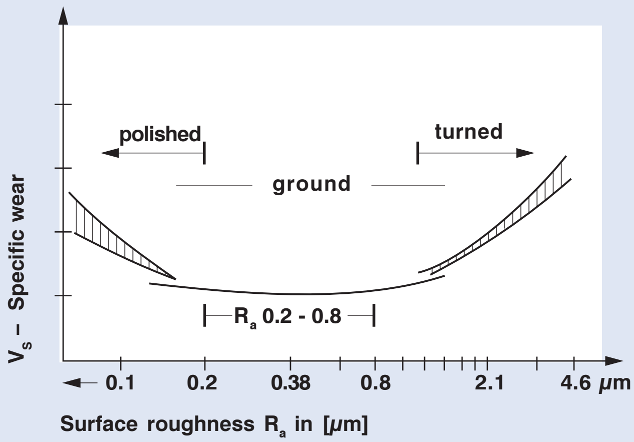
Counter material for corrosive applications

Material No.	DIN designation	Comparable standards		
		USA AISI	GB B.S. 9 70	F AFNOR
1.4021	X 20Cr13	420	420S37	Z20C13
1.4057	X 17CrNi16-2	431	432S29	Z15CN16.02
1.4112	X 90CrMoV18	440B		(Z70CV17)
1.4122	X 39CrMo17-1			

Counter materials for use in sea water

Material No.	DIN-designation	Comparable standards		
		USA AISI	GB B.S. 9 70	F AFNOR
1.4460	X 8CrNiMo27-5-2			
1.4462	X2CrNiMoN22-5-3	UNS531803	318513	Z3CND24-08
2.4856	Inconel 625			

Table 4.1 – Main possible counter materials



Model representation (refering to different examinations)

Figure 4.1 – Effect on counter material surface roughness on micro wear of composite

5 Fits and tolerances

In order to ensure satisfactory performance, the bearing outside diameter, bearing bore, shaft diameter and the bore of the housing should be finished to the recommended limits.

Interference fit
deva.metal® bearings should be installed into the housing with an interference fit between the outside diameter of the bush and the bore of the housing.

Housing bore
The housing bore should be finished to H7 tolerance with a maximum surface finish of $R_a = 3.2\,\mu m$.

Outer diameter of bearing
Sufficient close fitting of a bearing depends on its wall thickness and the operating conditions. Table 5.1 shows recommended tolerances for the outer diameter of **deva.metal®** bearings.
Additionally the bearings must be mechanically protected against displacement or rotation, if they operate continuously at temperatures above 150 °C or if they have to absorb axial loads (see Fig. 5.1).

Clearance
The required assembled clearance for **deva.metal®** bearings operating under dry conditions depends upon the bearing load and the operating temperature. In order to ensure satisfactory operation it is essential that the correct running clearance is used. Under dry running conditions any increase in the clearance recommended will result in a proportional reduction in performance.
Bearing bores are manufactured pre-finished. Consider the contraction of the bearing bore when the bearing is installed into the housing.

Application	Tolerance bearing outer-Ø
Normal load in range < 50 MPa	r6
High load in range > 50 MPa	s6

Table 5.1 – Tolerances

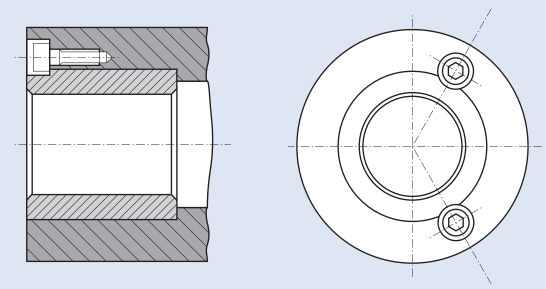


Fig. 5.1 – Mechanical fixation of deva.metal® bushings

The inner diameter of the bearing is reduced by approx. 75 to 95 % of the actual excess dimension by press fitting the bearing into the housing. **deva.metal®** sliding bearings are manufactured in such a way that finishing work is not necessary for normal installation after assembly. The resulting contraction is already taken into consideration during production.
Recommended installation clearances for **deva.metal®** bearings and values for the inner diameter reduction during assembly are given in Table 5.2: tolerance H7 for inner diameter of housing and tolerance r6 for outer diameter of bearing.

Application	Operating conditions	Shaft tol.	Bearing inner-Ø: Tolerance machined before installation	Bearing inner-Ø: Tolerance machined after installation
Mechanical equipment	Normal op.: Temp. < 100 °C	h7	C7	D8
	100 °C < Temp. < 130 °C	h8	B7	C9
	> 130 °C	sep. det.	separate determination	separate determination
	High specific load	h8	B7	C9
	Precision allowances	h6	D7	E8
Steel works equipm.	Normal operation	h8	B7	C9

Table 5.2 – Tolerances deva.metal®

Machining allowance for precision bearings

Precision bearings with an assembled bore tolerance of IT7 or IT6 are obtained by finish machining the bearing bore after assembly in the housing. In this case a machining allowance of 0.15 - 0.2 mm is recommended.

Wall thickness

The bearing wall thickness must be sufficient to meet both the manufacturing and application strength requirements. Table 5.3 gives the recommended minimum wall thickness for **deva.metal®** bearings according to the specific load and bearing diameter.

Specific load (MPa)	Recommended minimum wall thickness
< 10	$\sqrt{0.5\ D_1}$
10 - 25	$\sqrt{0.6\ D_1}$
25 - 50	$\sqrt{0.8\ D_1}$
> 50	$\sqrt{D_1}$
D_1 = Bearing inner diameter	

Table 5.3 – Wall thickness of deva.metal® bearings

Chamfers

In order to facilitate the installation of **deva.metal®** bearings both the housing bore and the bush outside diameter should be provided with chamfers as indicated in Fig. 5.2.
For all diameters: $C_2 = S_B/5$
Housing bore chamfer: 1 × 15° - 20°

B_1	C_1
< 10	1
10 - 25	1.5
25 - 50	2
50 - 80	3
> 80	4

Table 5.4 – Chamfers

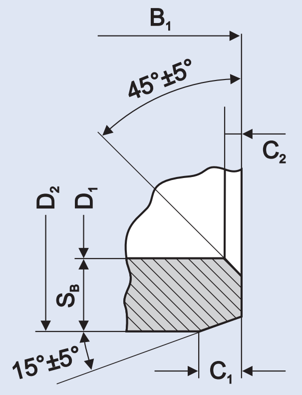


Fig. 5.2 – Chamfers

Bearing width

deva.metal® alloys are manufactured using powder metallurgy methods.
Resulting manufacturing restrictions in relation to the width/diameter ratios [$B_1 : D_2$].
Practical values $B_1 : D_2$ have proven to be from 0.5 to 1.0. Difficulties on account of edge loading are to be expected for ratios greater than 1, sliding bearings with a width/diameter ratio >1.5 are not recommended.

Allowances for thermal expansion

Many **deva.metal®** applications operate at high temperatures, in which case the following factors must be considered at the design stage:

a) thermal expansion of the housing
b) thermal expansion of the **deva.metal®** bearing
c) thermal expansion of the shaft, the consequential effects on the interference fit of the bush in the housing and the clearance of the bush on the shaft.

The following formulae allow the designer to calculate the required manufactured bearing clearance to ensure that the correct running clearance is maintained at the anticipated operating temperature of the application.

Example:
Calculation of bearing installation clearance at increased temperatures

The condition is typical of many furnace and oven conveyer applications.

$$C_{DM} = C_D + [D_J \times \Delta T\,(\alpha_J + \alpha_D - \alpha_G)]$$

where:

C_{DM} = manufactured clearance
C_D = required operating clearance
D_J = shaft diameter
ΔT = operating temperature – ambient temperature
α_J = linear coefficient of thermal expansion of shaft material
α_D = linear coefficient of thermal expansion of **deva.metal®** alloy
α_G = linear coefficient of thermal expansion of housing material

If the bearing arrangement is subject to changing temperatures please contact our application engineers.

6 Design

6.1 Design of sliding surfaces

Experience has shown that the dry wear performance of **deva.metal**® is improved by grooves in the bearing surface to assist in the removal of wear debris and dirt from the bearing. The drawings below show two possible designs.

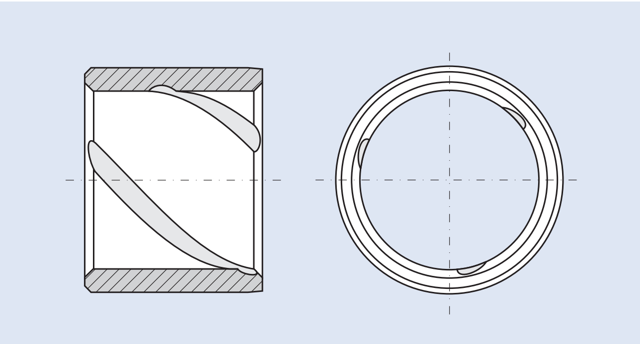


Fig. 6.1.1 – Helical cleaning grooves

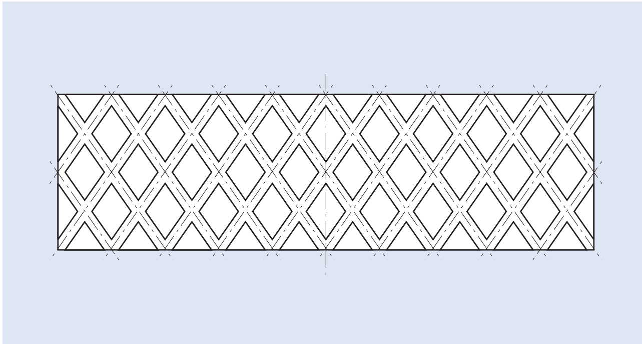


Fig. 6.1.2 – Cleaning grooves in diamond pattern

6.2 Examples

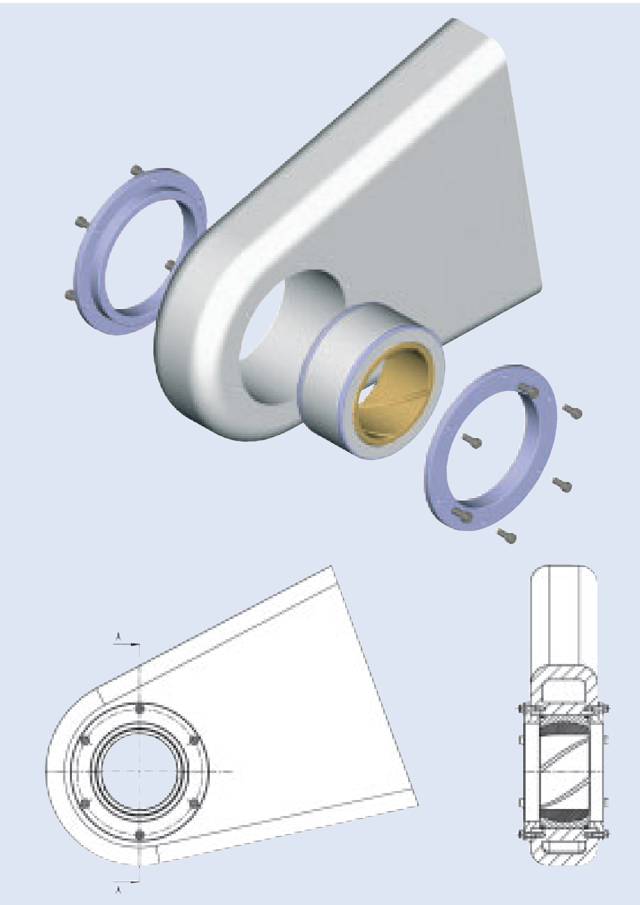


Fig. 6.2.1 – Bracket bearing

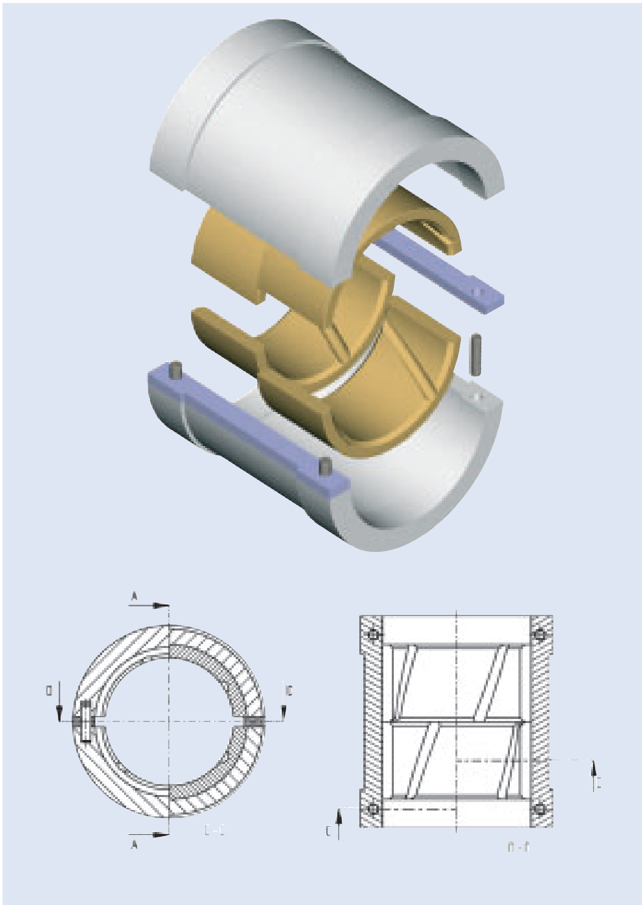


Fig. 6.2.2 – Middle bearing for conveyor worm

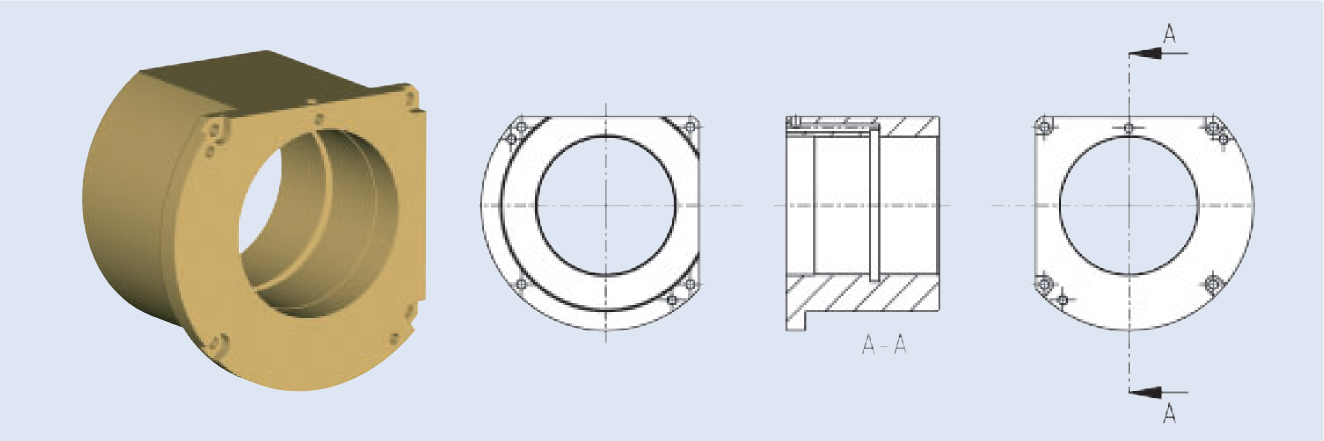


Fig. 6.2.3 – Flanged bearing

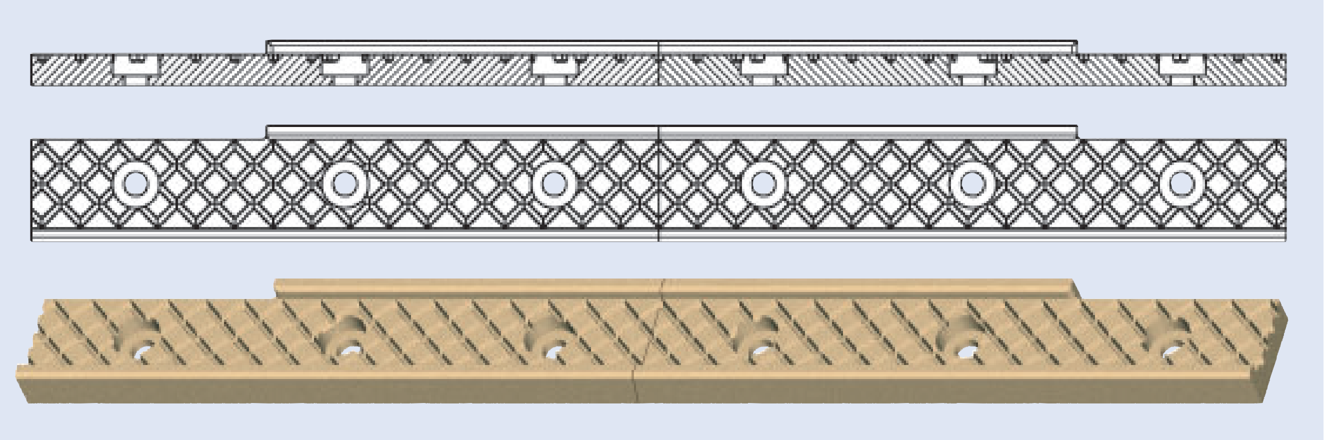


Fig. 6.2.4 – Sliding bar

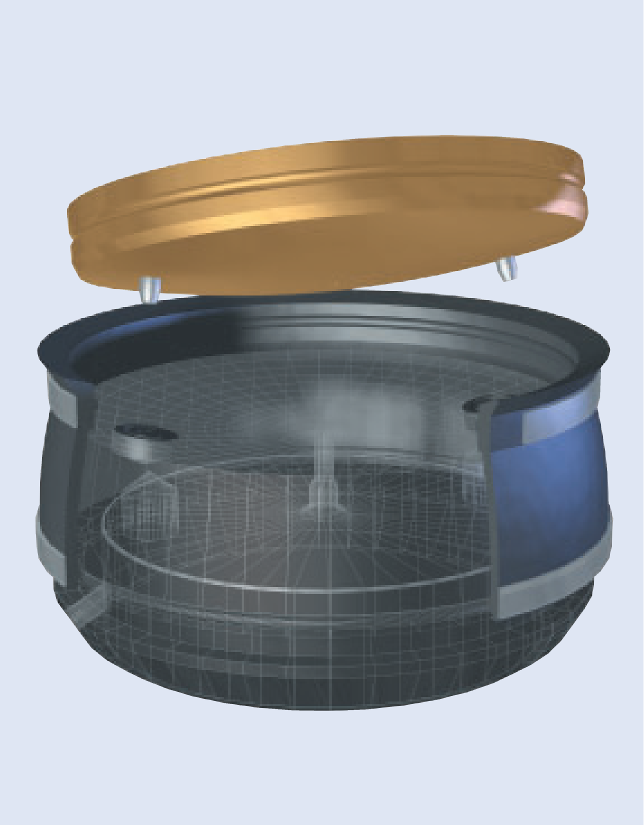


Fig. 6.2.5 – DEVA® Turret bearing

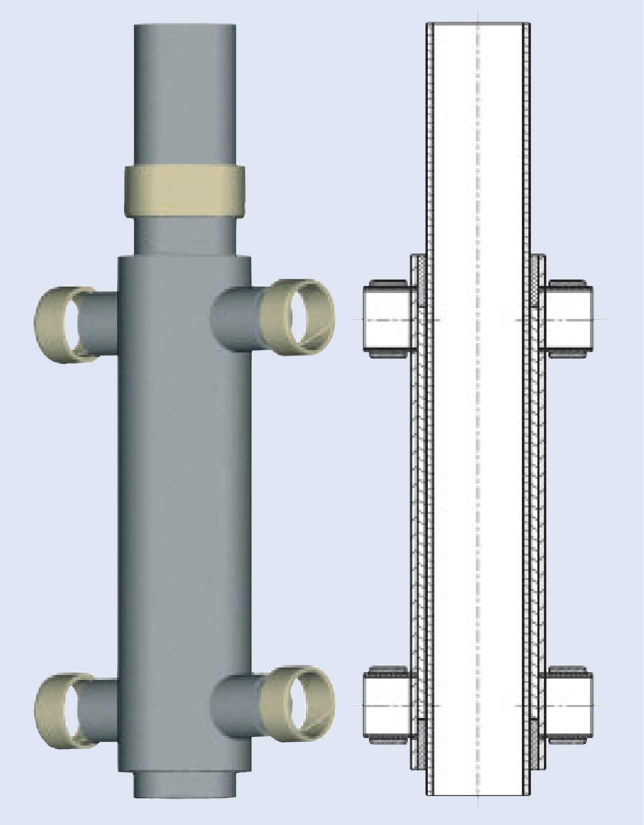


Fig. 6.2.6 – Piston guide rod with balance bearings

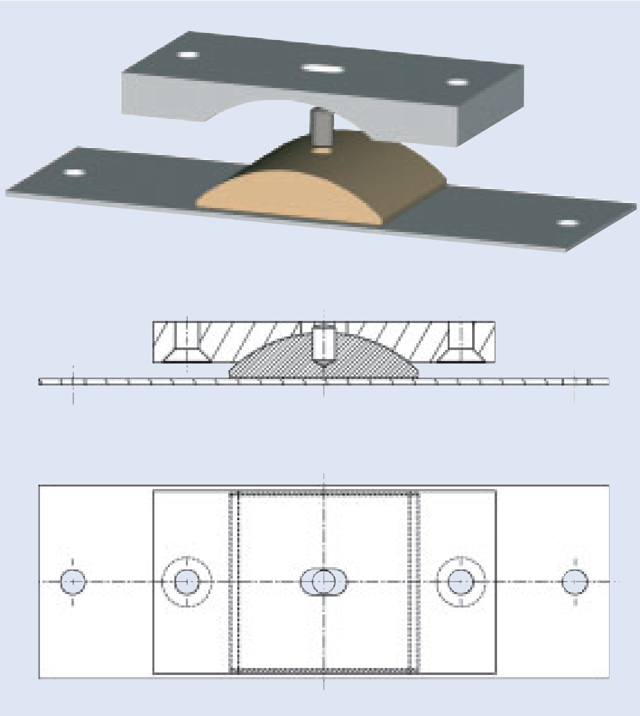


Fig. 6.2.7 – Angle compensation piece

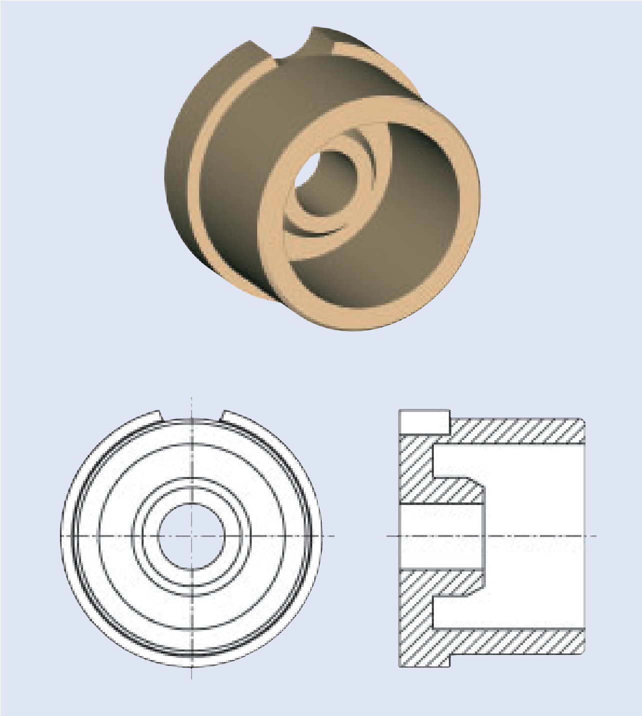


Fig. 6.2.8 – Guide bearing

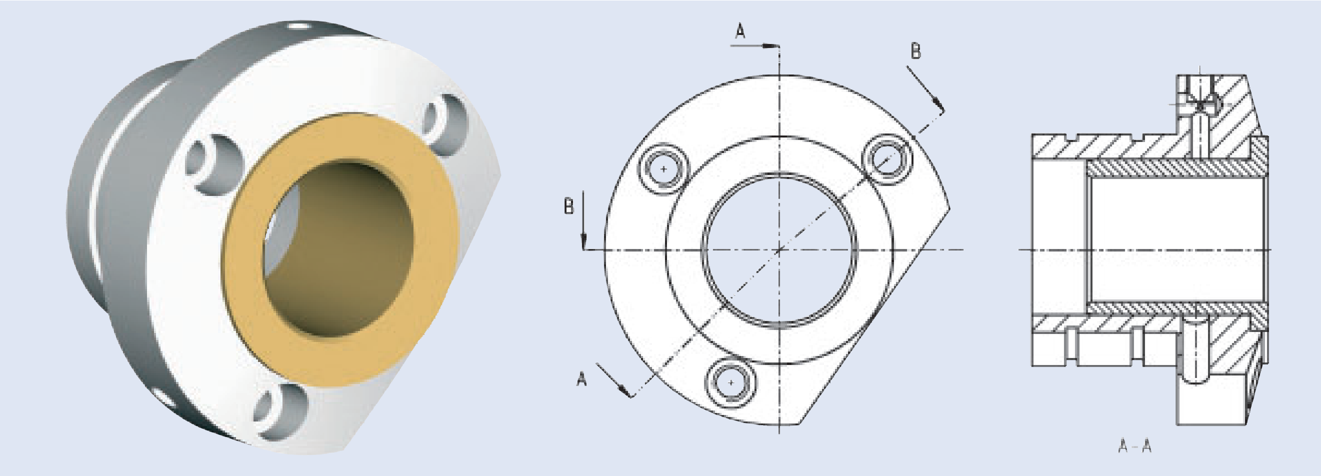


Fig. 6.2.9 – Flanged bearing

6.3 Design considerations of running surfaces

Shafts and counter faces which run against **deva.metal**® are normally produced from steel. It is recommended to use stainless steel or hard-chrome plated steel as counter materials for damp and corrosive environments – particularly if neither oil nor grease are available as basic protection. The determination of the counter material surface qualities and hardness has already been discussed in Chapter 4.
Shafts and counter surfaces operating against the **deva.metal**® bearings or thrust washers 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 **deva.metal**® bearing must be removed.

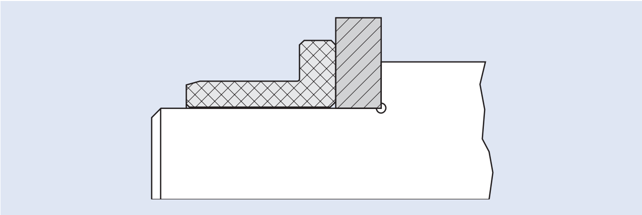


Fig 6.3.1 – Design considerations of running surfaces

7 Installation

7.1 Installation of deva.metal® radial bearings

Press fitting

Press fitting is a universally applicable installation method for all **deva.metal®** materials.

deva.metal® radial bearings can be installed with a screw press or hydraulic press. It is important to ensure that the mounting force is applied centrically. See also figure 7.1.1, installation by press fitting.

Driving in using a hammer is not permitted, as this can result in damage to the **deva.metal®** material.

For **deva.metal®** flanged bearings the transition radius between the flange rear and outer diameter of the radial bearing must be taken into consideration by machining a small chamfer. See also figure 7.1.1.

Supercooling (only bronze alloys)

The supercooling installation method is only permitted for **deva.metal®** bronze alloys.

To all other **deva.metal®** alloys supercooling can cause structural changes which affect the dimensional stability or alter the material behaviour.

To check whether supercooling the bearing is the correct installation method, the shrinkage allowance (s) must be calculated. This can be calculated according to the following equation:

$$s = 0.8 \times \alpha_1 \times \Delta T \times D_2 \ (\text{mm})$$

where:

α = linear coefficient of thermal expansion [1/K]
  = 18×10^{-6} 1/K for bronze alloys

The media used most frequently for supercooling are dry ice and liquid nitrogen. Both substances are classified as hazardous substances.

We expressly draw attention to dealing with hazardous substances. Safety data sheets are available on request.

To achieve a uniform supercooling, the dry ice should be crushed to about the size of a walnut. The sliding bearings should be completely immersed when using liquid nitrogen. The time required for complete supercooling of the bearings is between 0.5 to 2 hours depending on the volumes of the parts to be cooled.

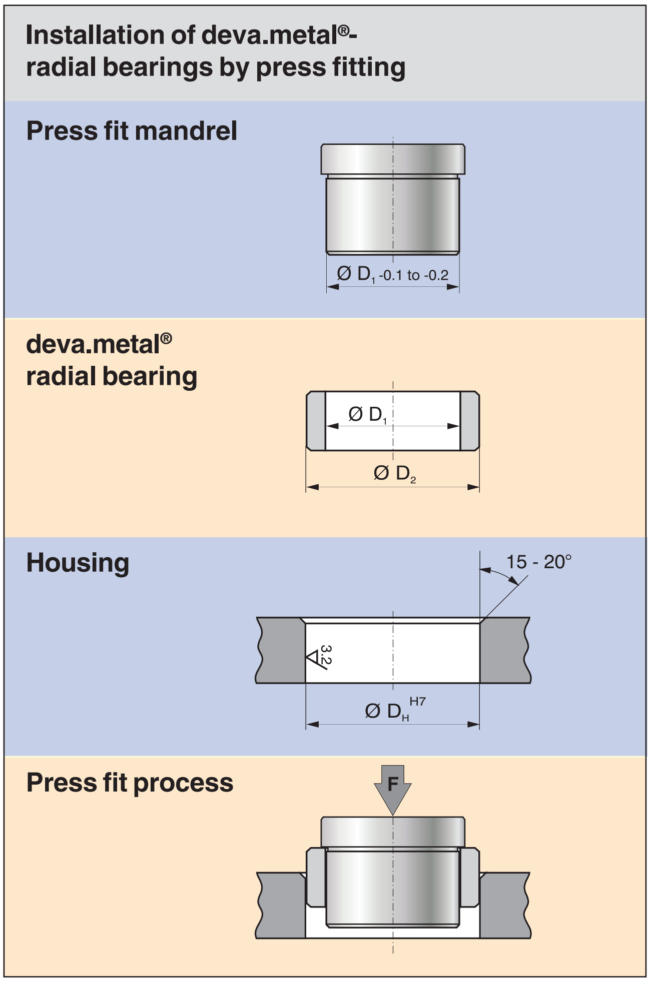


Fig. 7.1.1 – Installation by press fitting

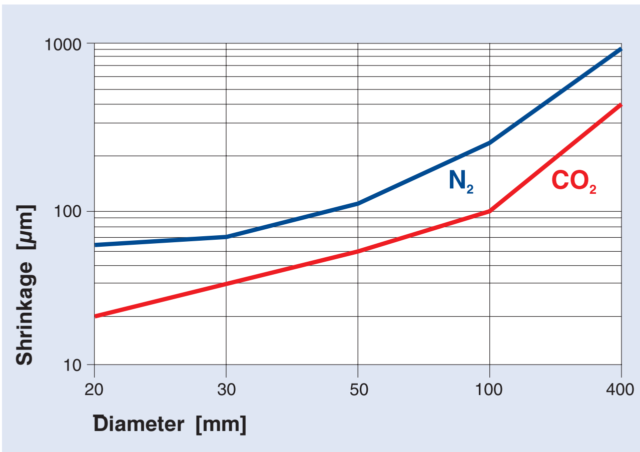


Fig. 7.1.2 – Shrinkage of deva.metal® dependent on outer diameter

The supercooled parts can be inserted without effort into the housing bore. Ensure that the parts to be mounted are correctly aligned, especially where large parts are involved.

Sliding bearings can be cemented in the housing as an additional protection against rotation or displacement during operation. The instructions of the adhesive manufacturer must be followed.

7.2 Installation of thrust washers

deva.metal® thrust washers should be located on the outside diameter in a recess as shown in Fig. 7.3.1.
If there is no recess for the thrust washer one of the following methods of fixing may be used:
- Two locking pins
- Two screws
- Adhesive
- Soldering

Important note:
- Locking pins must be recessed below the bearing surface sufficient to allow for the anticipated wear of the **deva.metal**® washer.
- Screws must be countersunk below the bearing surface sufficiently to allow for the anticipated wear of the **deva.metal**® thrust washer.
- Contact adhesive manufacturer for selection of suitable adhesives.
- Protect the bearing surface to prevent contact with adhesive.
- Ensure the washer ID does not touch the shaft after assembly.

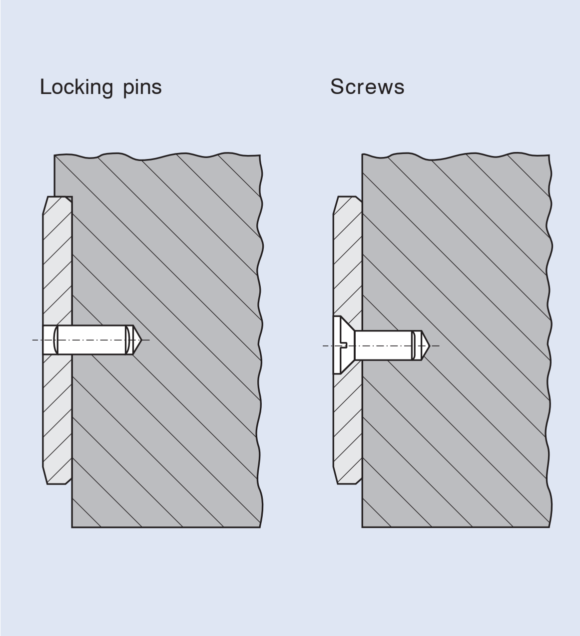


Fig. 7.2.1 – Locating thrust washers

7.3 Installation of sliding plates

deva.metal® sliding plates should be mounted as follows:
- With **DEVA**® special bolts in accordance with **DEVA**® works standard DN 0.34 (Abb. 7.3.1)
- Through mechanical fixing, e.g. form fit (Fig. 7.3.1)
- By adhesion

The higher expansion coefficient of **deva.metal**® in comparison to steel must be observed when using **deva.metal**® sliding plates at increased temperatures. The running clearance must be selected accordingly.

Adhesion:
Sliding bearings can be cemented in the housing as an additional protection against displacement during operation. The instructions for use of the adhesive manufacturer must be followed in this case.

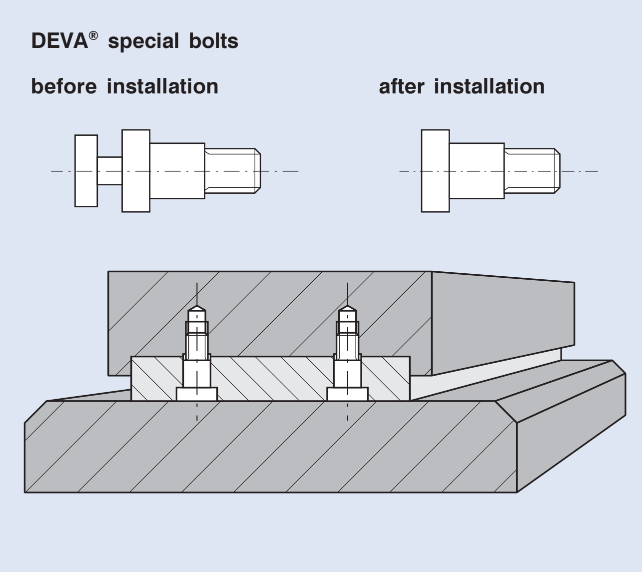


Fig 7.3.1 – Installation of a deva.metal® sliding plate with DEVA® special bolts

8 Finishing

General

deva.metal® sliding bearings are supplied as finished parts. The standard tolerances are sufficient for most applications. In cases where a sufficient accuracy can only be attained by finishing work after installation, **deva.metal**® sliding bearings can be mechanically finished. This also applies for mounting holding grooves or similar.

The guidelines for working with **deva.metal**® materials are set out in the **DEVA**® works standard DN 0.37 and can be supplied on request. **deva.metal**® is classified as a hazardous substance on account of its composition. The legal requirements must be adhered to during the work. For details see also the chapter on machining work.

Machining work

Carbide tipped tools in accordance with ISO-Norm K10 are recommended. The cutting edges must always be kept sharp in order to attain an optimum surface smoothness. Recommended surface quality: $R_a = 1.2\,\mu m$. Please consult our application engineers when working with thick-walled workpieces. Thin-walled workpieces which tend to twist during machining or treatment, should be worked with a lower cut depth and a lower feed.

deva.metal® can be machined like grey cast iron. Health and work safety regulations must always be observed. Machining work – except grinding – is carried out dry (without coolant). The air must be permanently extracted in accordance with regulations (keep inhaled air clean). The air speed at the suction point should be 20 m/s.

Turning

A three or four jaw chuck can be used for preliminary machining at wall thicknesses > 10 mm. Collet chucks or bushings must be used for thin-walled bearings and finishing work in order to prevent deformations resulting from restraint pressure.
The workpieces must be removed from the clamping chucks before finishing work so that potential deformations can relax again.

Grinding

The sliding surfaces should not be ground, as abrasion particles could be pressed into the running surface causing damage during operation. If grinding is absolutely necessary it must be carried out with 5CG 10C 80/100JT 12 V82 (Dilumit) grinding discs or similar. Vacuum plates can be used for fixing.

Drilling

HSS drills are recommended at a cutting speed of 15 - 26 m per minute and a feed of 0.05 - 0.1 mm per cut. Reduce the feed before boring through in order to prevent damage to the **deva.metal**® workpiece.

Surface roughness

An average roughness R_a of approx. $1.2\,\mu m$ should be attained with the above mentioned methods.

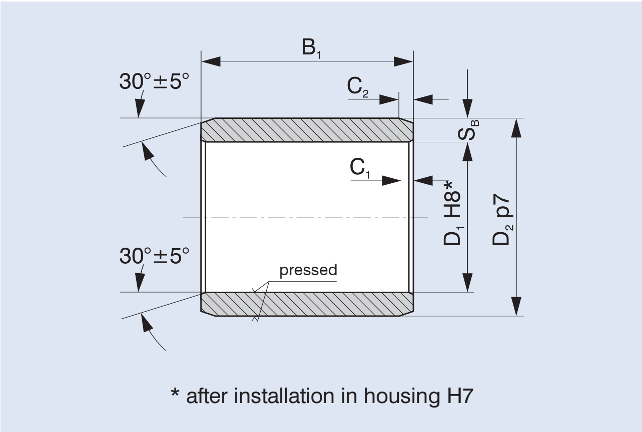
Milling

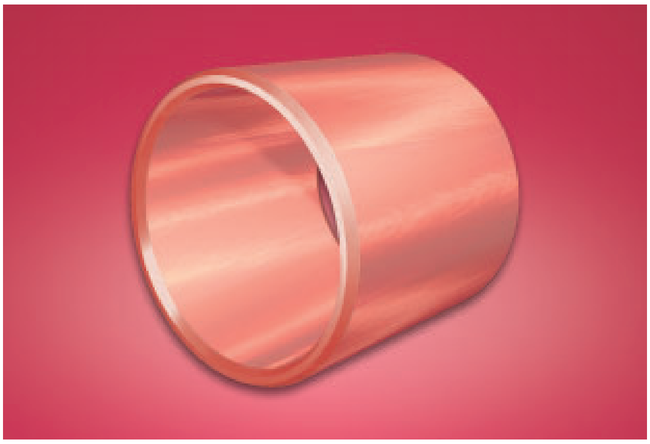
The same cutting tool requirements apply as for machining. It is important to adhere to the tool angle in order to prevent edge chipping on the **deva.metal**® workpiece if the milling cutter reaches the material edge.

9 Available dimensions

Most of the radial bearings supplied by **DEVA®** have diameters or lengths ranging from 1 mm to 3500 mm in all common tolerances. The application examples shown in chapter 6.2 should be taken as suggestions. Feel free to ask us. We shall be delighted to answer your queries. Besides this, a range of finished, cold-pressed radial bearings in accordance with **DEVA®** works standard DN 0.42 is also available.

9.1 Size table for deva.metal® radial bearings, ready for installation in accordance with DEVA® works standard DN 0.42 (formerly DN 2.27)





We only stock these sliding bearings for **deva.metal® 116**. You can obtain further alloys, dimensions and designs on request.

B_1	Dimensions																
	D_1	3	4	5	6	8	10	12	14	15	16	18	20	22	25	28	30
	D_2	5	6	8	9	11	14	16	18	20	20	22	25	26	30	34	36
	S_B	1.0		1.5			2.0			2.5	2.0		2.5	2.0	2.5	3.0	
3	Width $B_1 \leq 10 \pm 0.25$ mm	○	○	○	○												
3.5			○	○	○												
4			○	○	○	○											
4.5				○	○	○											
5				○	○	○	○										
6					○	○	○	○									
7.5						○	○	○	○	○							
8						○	○	○	○	○	○						
9							○	○	○	○	○	○					
10							○	○	○	○	○	○	○				
12								○	○	○	○	○	○	○			
14	Width $B_1 > 10 \pm 0.40$ mm								○	○	○	○	○	○	○	○	
15										○	○	○	○	○	○	○	○
16											○	○	○	○	○	○	○
18												○	○	○	○	○	○
20													○	○	○	○	○
22														○	○	○	○
24															○	○	○
25															○	○	○
26																○	○
28																○	○
30																	○

○ = recommended dimensions

Further dimensions on request.

Table 9.1.1 – Dimensions deva.metal® radial bearings (all dimensions in mm)

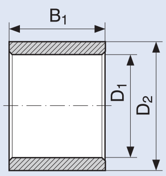
10 Relevant design data for DEVA® sliding bearings

Description of application: ____

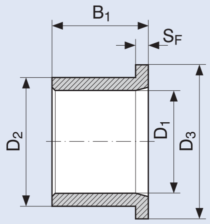
____

____

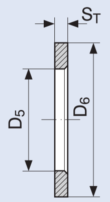
Project / no.: ______________________ ☐ **New design** ☐ **Existing design**



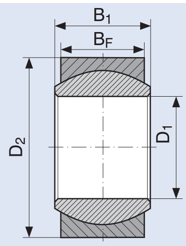
☐ Plain bearing



☐ Flanged bearing

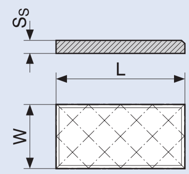


☐ Thrust washer



Spherical bearing

☐ Floating bearing ☐ Fixed bearing



☐ Sliding plate

☐ Shaft rotates ☐ Bearing rotates ☐ Angular motion ☐ Axial motion

	Item 1	Item 2	Item 3
Quantity			

Dimensions (in mm)	Item 1	Item 2	Item 3
Inner Ø D_1 (D_5)			
Outer Ø D_2 (D_6)			
Bearing width B_1			
Outer ring width B_F			
Flange outer Ø D_3			
Flange thickness S_F			
Wall thickness S_T			
Plate length L			
Plate width W			
Plate thickness S_S			

Load	Item 1	Item 2	Item 3
Static	☐	☐	☐
Dynamic	☐	☐	☐
Alternating	☐	☐	☐
Impact	☐	☐	☐
Radial load in kN			
Axial load in kN			
Surface pressure			
Radial in MPa			
Axial in MPa			

Counter material	Item 1	Item 2	Item 3
Material no./type			
Hardness in HB/HRC			
Roughness R_a in μm			

Lubrication	Item 1	Item 2	Item 3
Dry running	☐	☐	☐
Permanent lubrication	☐	☐	☐
Proven fluid lubrication	☐	☐	☐
Proven fluid			
Lubricant			
Initial lubrication	☐	☐	☐
Hydrodyn. lubrication	☐	☐	☐
Dyn. viscosity			

Motion	Item 1	Item 2	Item 3
Speed in rpm			
Sliding speed in m/s			
Stroke length in mm			
Double strokes/min			
Angle $\measuredangle \alpha^0$			
Frequency in n/min			

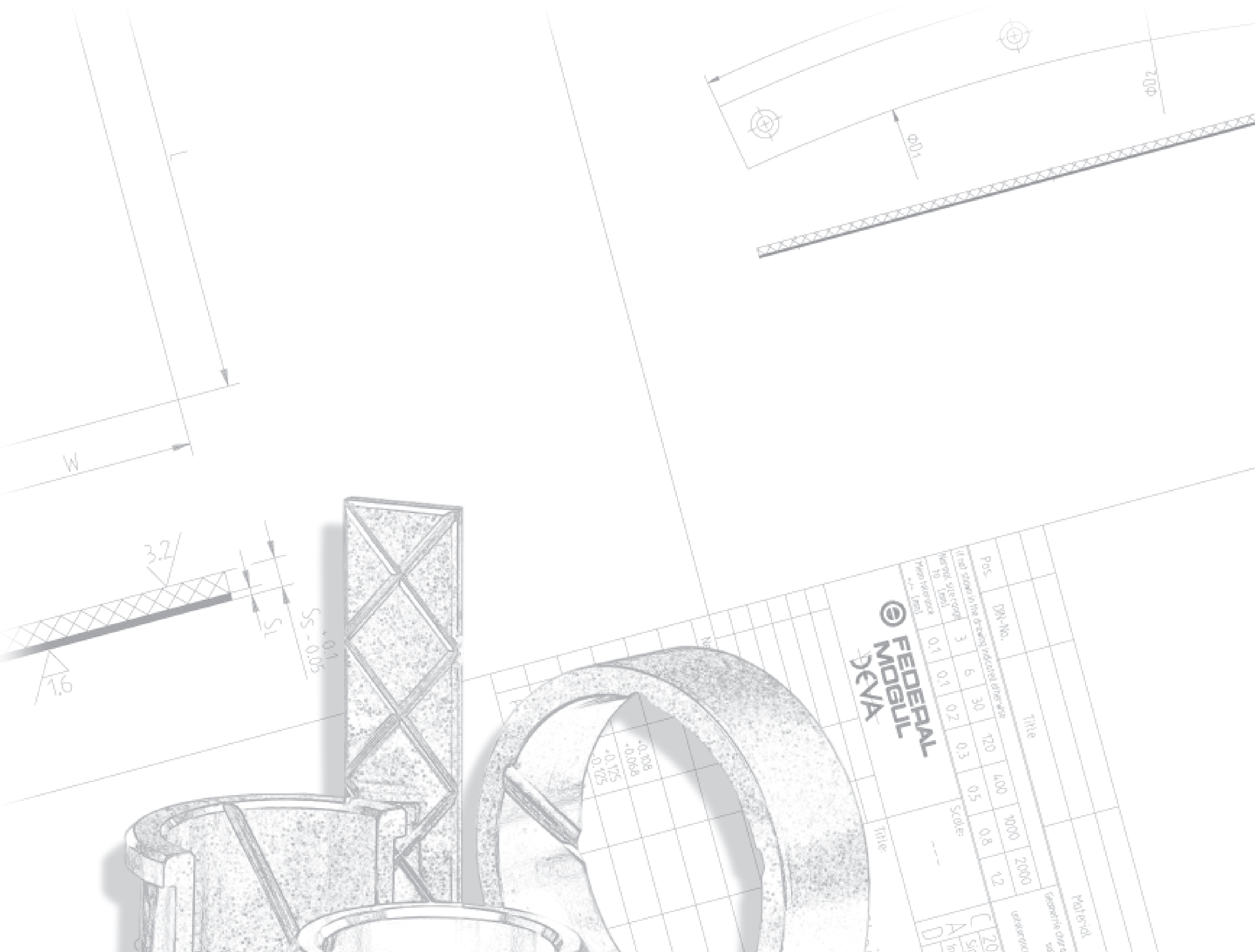
Operating time	Item 1	Item 2	Item 3
Continuous operation			
Temporary operation			
Duty cycle	%/h	%/h	%/h
Days/year			
Frictional distance in km			

Fits & tolerances	Item 1	Item 2	Item 3
Shaft			
Bearing housing			

Environmental cond.	Item 1	Item 2	Item 3
Temperature at bearing	°C	°C	°C
Contact medium			
Other influences			

Lifetime	Item 1	Item 2	Item 3
Desired operating time	h	h	h
Permissible wear	mm	mm	mm

Company address / contact



For more information about DEVA® and its products, please visit our website www.deva.de

This technical documentation was checked carefully. However we can not take any liability for mistakes or incomplete information. The data given in the document are intended as an aid for assessing the suitability of the material. They are derived from our own research as well as generally accessible publications.

The coefficients of friction and wear rates mentioned and also indicated in our catalogues or other technical literatures are no assured properties. These values resulted from tests carried out on our test rigs under conditions not matching exactly the operating and environmental conditions of the application of our products involved. Hence the real occurring operating conditions cannot be extensively simulated. Guarantees can only be given upon written agreement on all decisive product features, test procedures and parameter required.

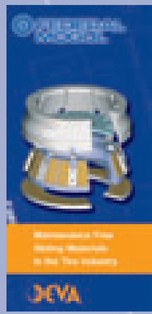
All transactions conducted by DEVA® are subject to our terms of sale and delivery as indicated in our offers, product brochures and price lists. Copies are available on request. Our products are subject to a constant process of development. DEVA® reserves the right to amend the specification or improve the technological data without notice.

Further information about our products:

Technical manual
deva.bm®

Technical manual
deva.glide®

Technical manual
deva.tex®



DEVA®-Materials
in the tire industry

Technical manual
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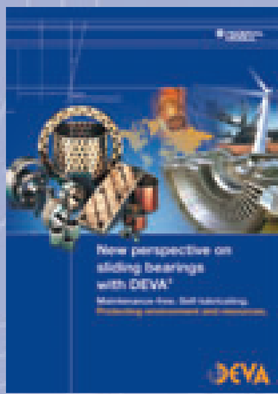
DEVA® Product range



New bearing perspective
with DEVA®

DEVA®-Materials
in the steel industry

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Metal-EN/03/2004/Rev.00/3000
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