Technical manual

deva .metal®

Your challenges are our fascination.

Self-lubricating sliding bearings

Contemporary designs pose a major challenge to modern sliding materials. Maintenance-free operation is often expected even under difficult operating conditions with extremely high loads. Constant cost pressure forces increasing availability of machines and systems, even though no restrictions can be accepted with regard to their reliability.

With maintenance-free, self-lubricating high-performance sliding materials from the DEVA® product range, it is now possible to implement sliding bearing concepts that operate reliably over long periods of time. 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 equally suitable for small movements. The type of movement, whether translatory, rotatory, angular or a combination of several, is irrelevant.

In addition, the deva.metal® range of materials is characterized by the following properties:
- High wear resistance
- Resistant to rough operating and environmental influences, both mechanical and chemical in nature

We support you with the
- Selection of sliding materials
- Design and individual adaptation to your requirements
- Estimation of bearing life
- Simulation of your sliding bearing application on our test rigs
- Assembly

Maintenance-free,
self-lubricating
sliding bearings

Of course maintenance-free. Sliding bearings from DEVA®.

The deva.metal® range of materials offers the designer a wide spectrum of possible applications wherever environmentally conscious handling of lubricants is desired or required, or conventional lubrication is not possible.

Typical applications for deva.metal® sliding bearings can be found in these industries:

- Iron and steel industry
- Hydro-Civil Engineering
- Bridges and steel construction
- Mechanical engineering
- Injection molding and tire molding
- Food and packaging machines
- Shipbuilding and offshore industry
- Onshore and offshore wind turbines
- Railway vehicles
- Gas and steam turbines
- Agricultural and construction machines

Technical manual deva.metal®

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deva.metal® sliding bearings

Material properties

Maintenance-free and self-lubricating sintered sliding materials

deva.metal® is a high performance dry sliding bearing material. The powder metallurgically produced deva.metal® system is based on four main groups – bronze, iron, nickel and stainless steel. These contain solid lubricants, like graphite, which are uniformly embedded in the metal structure. As a material produced by powder metallurgy, deva.metal® is not ductile. However, the special sintering processes enable a very high physical resistance, especially under pressure load.

The application-specific requirements determine the percentage, type and form of the solid lubricant. The sliding speed, the specific load, the temperature and other application-specific influences are relevant. Thus, defined tribological properties can be created.

Performance promise Our deva.metal®

- Enables maintenance-free operation without lubrication
- Has a high static and dynamic load capacity
- Has very good sliding properties in dry running
- Suitable for dusty and dirty environments
- Offers a wide temperature range from −200 °C to +800 °C, depending on the alloy
- Can be used in corrosive environments
- Does not absorb water and is therefore well suited for use in seawater and many industrial liquids where high dimensional stability is required
- Suitable for radioactive environments depending on the alloy
- Is electrically conductive. There are no electrostatic charging effects
- Is suitable for translatory, rotatory, oscillatory movements with cylindrical guide or also as a sliding plate. These movements can occur individually or in combination
- Provides emergency running properties in insufficiently lubricated applications

Made to fit you

deva.metal® sliding bearings are available in standard dimensions and as customized special parts.

Customer benefit from our many years of experience in various applications and our technical support in the area of material selection and design for special sliding bearings.

deva.metal® sliding bearings

Sliding bearing materials

Sintered metal alloys with homogeneous solid lubricant distribution

The dry-running principle, which allows our alloys to work without conventional lubricants, is the same for all metal structures and solid lubricants within the deva.metal® system.
All deva.metal® alloys have a uniformly distributed solid lubricant embedded in the basic metal structure. The solid lubricants have a lamellar structure with low interfacial shear strength compared to the adjacent intermolecular layers in the material.

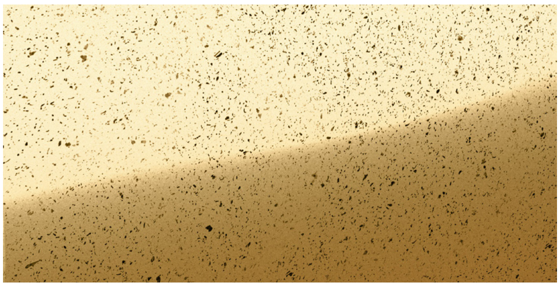
Due to the relative movement between the mating material and the deva.metal® bearing the preloaded solid lubricant is released by micro-wear. Interactions and the defined surface roughness of the mating material, which enables mechanical bonding of the solid lubricants, lead to the build-up of a solid lubricant film on the sliding partners. This so-called transfer film has a lower shear strength and reduces friction and wear of the bearing system.

The continuous micro-wear ensures that new lubricant is fed into the system.
This results in a maintenance-free operation in many applications.

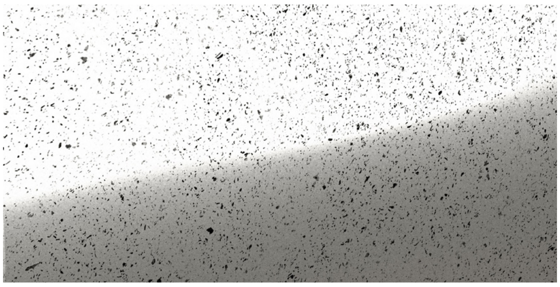
2.1 Microstructure and texture

The composition of the metallic structure determines the physical, mechanical and chemical properties of an alloy and is therefore the basis for the selection of materials for a specific application. There are four main groups, bronze-, iron-, nickel- and stainless steel-based.

The 4 deva.metal® main groups

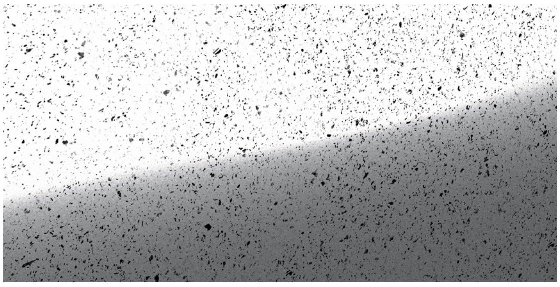


Bronze base



Iron base

Nickel base



Stainless steel base

The proportion and properties of the solid lubricant have a fundamental influence on the sliding behavior of a deva.metal® alloy. Within the four main groups the following solid lubricants are used:

- Graphite – C
- Molybdenum disulphide – MoS_2
- Manganese sulphide – MnS

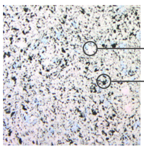
Graphite is the most commonly used solid lubricant, either as finely dispersed or agglomerated particles in the metallic microstructure, depending on the operating application.

The following microstructure images show deva.metal® solid lubricant distribution structures which are used depending on the application-specific requirements.
In addition to the lubricant distribution, the lubricant quantity also plays a role in the load and sliding properties. The properties of the distribution structures (Table 2.1.1) are based on the assumption of equal solid lubricant quantities.

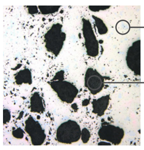
The 3 deva.metal® microstructures

The grouping is only valid under the condition of equal solid lubricant concentrations

Fine distribution
- Basic material
- High loads, very low sliding movements and sliding speeds
- High static loads
- Low loads, very high speeds


(1)
(2)

Mean distribution
- Medium dynamic loads and higher sliding speeds
- Good wear resistance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Rough distribution
- High dynamic loads and higher sliding speeds
- Very good wear resistance

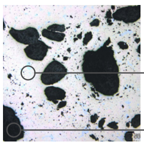

(1)
(2)

Figure 2.1.1

Properties of solid lubricants

	Graphite	MoS_2
Crystalline structure	hexagonal	none
Specific gravity [g/cm³]	2.25	4.7
Coefficient of friction in air	0.1 – 0.18	0.08 – 0.12
Temperature application range	– 120 °C to 600 °C	– 100 °C to 400 °C
Chemical resistance	very good	good
Corrosion resistance	good	conditionally suitable
Resistance to radioactive radiation	very good	good
Use in air	very good	good
Use in water	very good	conditionally suitable
Use in vacuum	Not suitable	good

Table 2.1.1

(1) Metal sintering matrix (2) Solid lubricant

2.2 Overview of selected materials

The deva.metal® sliding bearing family consists of more than 60 alloy variants. An overview of the common alloys is shown in table 2.2.1. Our application engineers will be pleased to select the most suitable alloy for your application.
The standard temperature range of bronze materials is up to +150 °C. In order to ensure the dimensional stability of bronze alloys in continuous operation even at higher temperatures, the material can be subjected to an additional heat treatment. The upper operating temperature limit is then +350 °C. At operating temperatures above 350°C, the heat-treated bronze alloys are replaced by iron alloys. deva.metal® iron or iron/nickel-based alloys are used instead of the heat-treated bronze alloys. deva.metal® nickel alloys or stainless steel alloys are generally used where high chemical and corrosion resistance is required.

		Physical properties			Mechanical properties		Maximum load			Storage properties			
	deva.metal®	Density ρ | [g/cm³]	Hardness [HB_{min}]	Linear coefficient of thermal expansion α | [10^{-6}/K]	Compressive strength σ_M | [MPa]	Modulus of elasticity (E-modulus) E | [MPa]	Static load $\bar{p}_{stat/max}$ | [MPa]	Dynamic load $\bar{p}_{dyn/max}$ | [MPa]	Maximum pU value dry $\bar{p}U_{max}$ | [MPa × m/s]	Temperature application range T | [°C]	Friction coefficient (dry) μ	Friction coefficient (water) μ	Minimum hardness of shaft
Bronze-based alloys													
	**101**	6.8	40	18.0	300	52000	200	100	1.5	−100 to 150	0.13 to 0.18	0.11 to 0.16	180 HB
	103	6.4	50	18.0	250	53000	180	90	1.5	−100 to 150	0.11 to 0.16	0.10 to 0.13	220 HB
	105	6.6	65	18.0	340	53000	230	115	1.5	−100 to 150	0.13 to 0.18	0.12 to 0.16	270 HB
	157	6.3	50	18.0	220	43000	180	70	1.5	−100 to 150	0.10 to 0.15	0.09 to 0.12	220 HB
	172	7.2	60	18.0	400	59000	260	130	1.5	−100 to 150	0.15 to 0.22	0.12 to 0.20	180 HB
	179	7.1	80	18.0	390	50000	200	80	1.5	−100 to 150	0.18 to 0.26	0.16 to 0.24	35 HRC
	Pro	5.2	35	18.4	170	24000	130	70	1.5	−100 to 150	0.07 to 0.40	0.07 to 0.40	180 HB
Bronze-based alloys (heat-treated)													
	**108**	6.3	35	18.0	250	41000	170	85	1.5	−100 to 350	0.12 to 0.18	0.11 to 0.16	180 HB
	110	6.4	50	18.0	250	43000	170	85	1.5	−100 to 350	0.11 to 0.16	0.10 to 0.13	220 HB
	112	6.4	40	18.0	320	46000	220	110	1.5	−100 to 350	0.11 to 0.20	0.10 to 0.18	270 HB
	113	6.3	50	18.0	220	44000	200	100	1.5	−100 to 350	0.10 to 0.15	0.09 to 0.12	220 HB
	162	6.6	50	18.0	340	49000	230	115	1.5	−100 to 350	0.13 to 0.22	0.12 to 0.20	270 HB
	175	6.8	60	18.0	360	49000	250	120	1.5	−100 to 350	0.15 to 0.22	0.13 to 0.20	180 HB
	Pro HT	5.2	35	18.4	170	24000	130	70	1.5	−100 to 350	0.07 to 0.40	0.07 to 0.40	180 HB

Table 2.2.1

deva.metal®		Physical properties			Mechanical properties		Maximum load			Storage properties			
		Density ρ | [g/cm³]	Hardness $[HB_{min}]$	Linear coefficient of thermal expansion α | $[10^{-6}/K]$	Compressive strength σ_M | [MPa]	Modulus of elasticity (E-modulus) E | [MPa]	Static load $\bar{p}_{stat/max}$ | [MPa]	Dynamic load $\bar{p}_{dyn/max}$ | [MPa]	Maximum pU value dry $\bar{p}U_{max}$ | [MPa × m/s]	Temperature application range T | [°C]	Friction coefficient (dry) μ	Friction coefficient (water) μ	Minimum hardness of shaft
Iron and iron-based alloys													
	118	6.0	80	13.0	550	61000	150	60	1.0	to 600	0.30 to 0.45	–	45 HRC
	120	6.0	120	12.0	460	–	70	30	1.0	to 600	0.25 to 0.43	–	45 HRC
	121	6.4	50	12.0	180	–	70	30	1.0	280 to 450	0.30 to 0.45	–	45 HRC
	122	5.9	50	13.0	180	–	70	30	1.0	280 to 450	0.30 to 0.45	–	45 HRC
	123	5.7	140	13.0	400	–	70	30	1.0	to 600	0.28 to 0.45	–	45 HRC
Nickel and nickel-based alloys													
	124	6.4	45	15.0	400	–	100	50	0.8	−200 to 200	0.30 to 0.45	–	45 HRC
	126	6.4	45	15.0	400	–	100	50	0.8	−200 to 600	0.30 to 0.45	–	45 HRC
	127	6.4	45	15.0	400	–	150	50	0.8	−200 to 600	0.30 to 0.45	–	45 HRC
	233	6.2	40	16.0	380	–	120	50	0.8	280 to 450	0.30 to 0.45	–	45 HRC
Stainless steel base alloys													
	128	5.8	55	14.4	180	–	150	–	0.5	−100 to 750	0.35 to 0.49	–	60 HRC
	129	5.8	75	15.4	760	–	150	–	0.5	350 to 800	0.20 to 0.60	–	200 HB

Table 2.2.1

2.3 Material selection

The following is a decision-making aid for the selection of the most appropriate deva.metal® alloys under certain operating conditions.

Scheme material selection deva.metal®

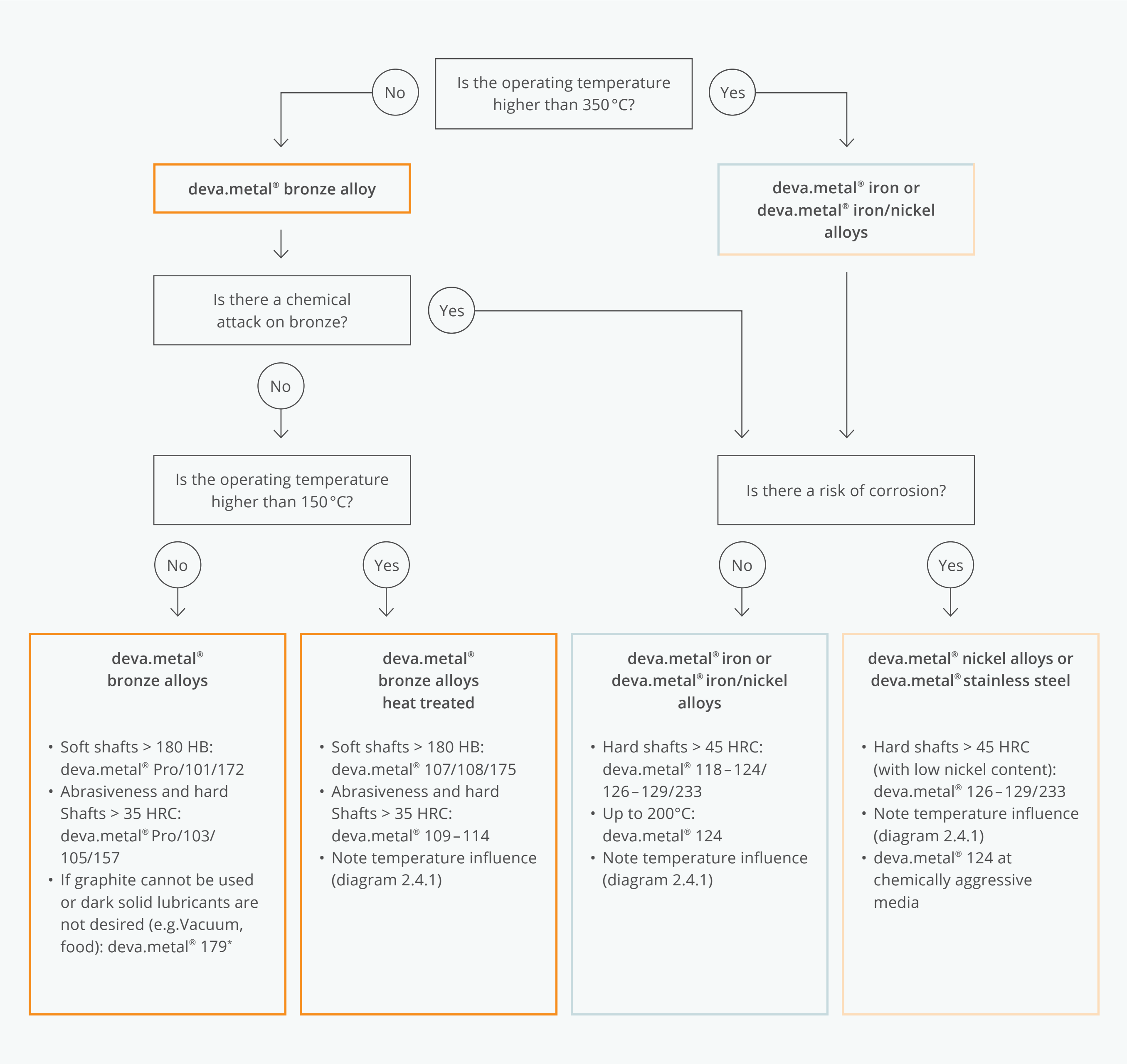


Figure 2.3.1

* A suitability check by our technicians is recommended

Typical applications of individual deva.metal® alloys

deva.metal® alloy	Areas of application	Features
101 / 103	General	Standard material for most applications
Pro	General	Highly wear resistant
111 / 112	Rolling Mills / Smelter Industry	When high abrasiveness occurs
113 / 114	Oven construction	Temperature
101 / 172*	Hydraulic steelwork	High static load, corrosion resistant
105	Rolling Mills / Smelter Industry, Brakes	Very good braking properties
117 / 163	Heavy industry	High load / abrasivity
Pro HT	Steam and gas turbines, incinerators	High abrasion resistance
118	Oven construction	Temperature
233 / 126	Flue gas / flue gas dampers	Temperature and corrosion
128 / 129	Hot valves, furnace construction	Very high temperature
179	Food industry, vacuum	Graphite-free

Table 2.3.1

* Lead-free replacement for deva.metal® 115

2.4 Temperature influence

The maximum specific load to which a deva.metal® bearing can be subjected, decreases with increasing temperature.

Temperature influence on the static permanent load bearing capacity of deva.metal®

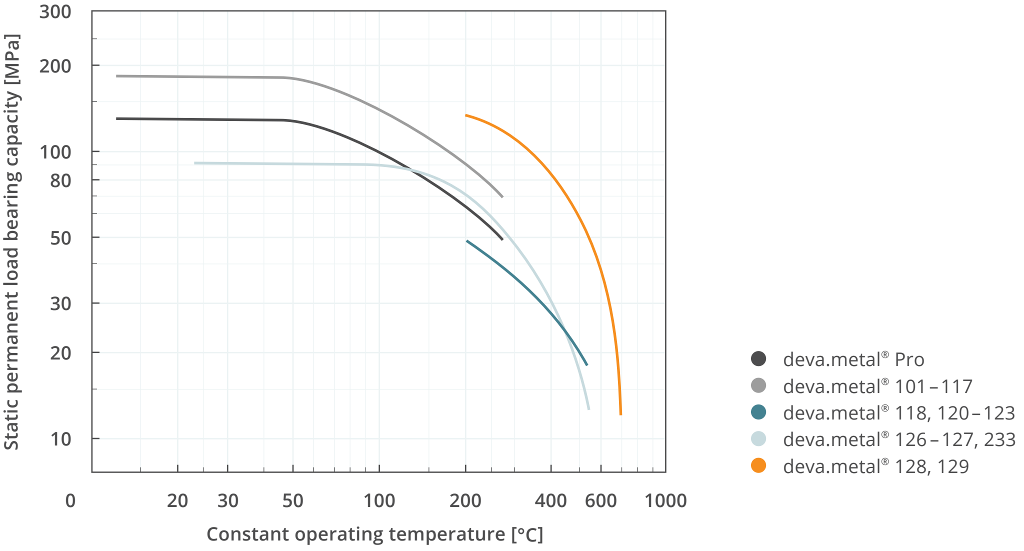


Diagram 2.4.1

2.5 Specific wear

The effect of the pU value on the specific wear rate of deva.metal®
Alloy systems are shown in Figure 2.5.1..

Specific wear rate of deva.metal® alloys

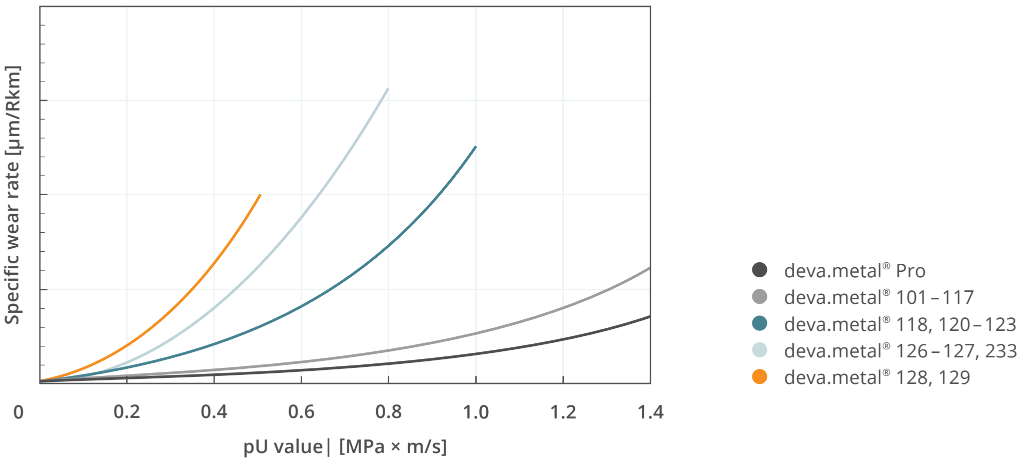


Diagram 2.5.1

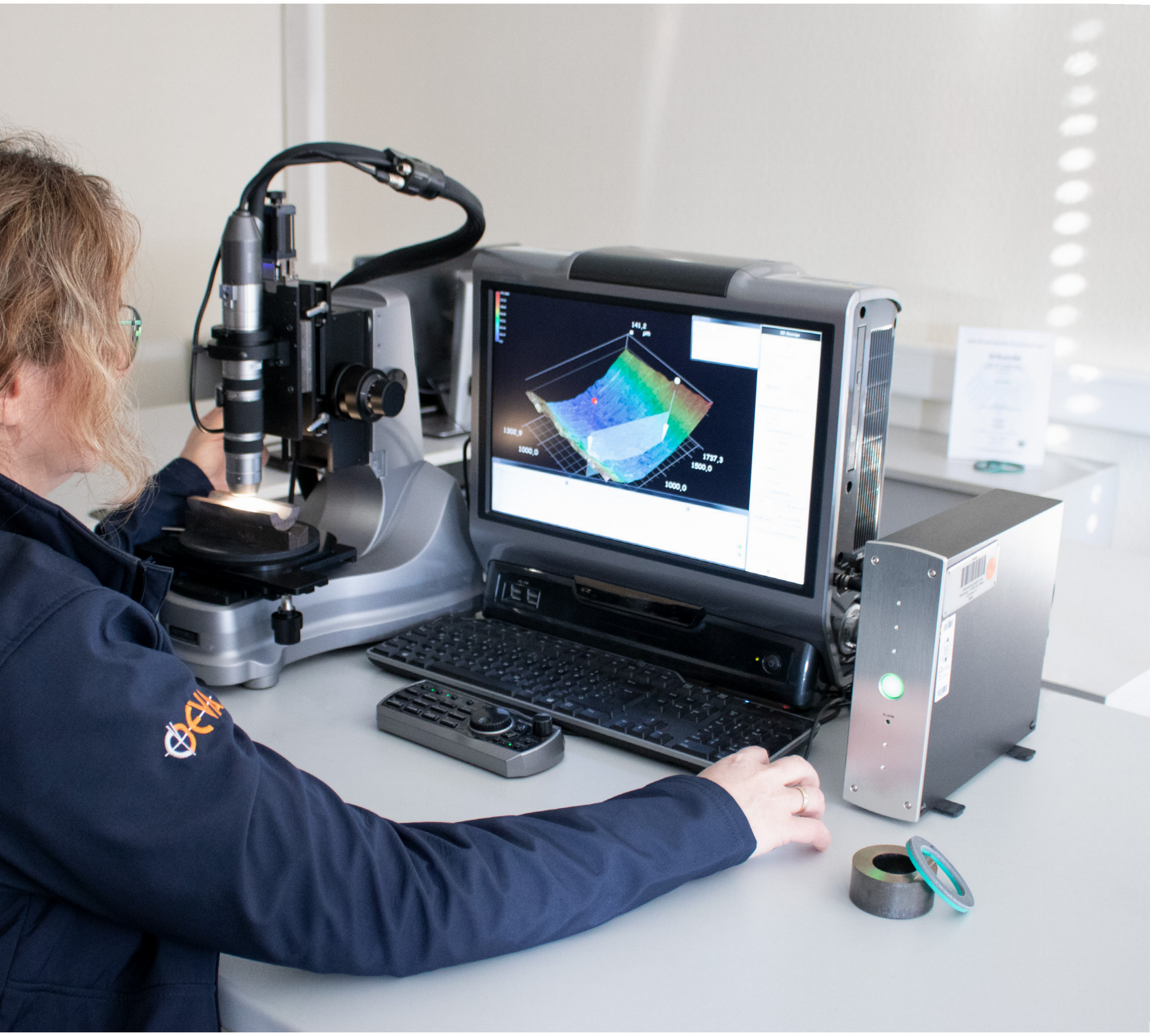
deva.metal® sliding bearings

Quality and certificates

Environmental protection and production safety

We attach great importance to qualitative, environmentally conscious and safe production. We are committed to this through the application of a variety of internationally recognized standards for quality assurance, emission control and workplace safety.

- RoHS and REACH compliant
- Certificate of origin
- Acceptance test certificates DIN EN 10204–2.1; 2.2; 3.1 and 3.2
- Certified according to ISO 9001; ISO 14001 and ISO 45001



deva.metal® sliding bearings

Load cases

The four cases of bearing load

DEVA® differentiates between four load cases. We do this to take into account the fatigue influences under dynamic load. The percentage values refer to the limit values given in the material data sheets and technical manuals.

The specifications should be understood as guide values. With alternation of loads in particular, the frequency and the number of cycles need to be considered with regard to the fatigue properties. Please contact us for a detailed analysis in a personal discussion.

Load case 0

The acting normal force is constant or can be assumed to be constant without frequent or rapid load changes or load alternations. There is no sliding movement.

Permissible limit load: 100 % of the max. permissible static load according to material data sheet

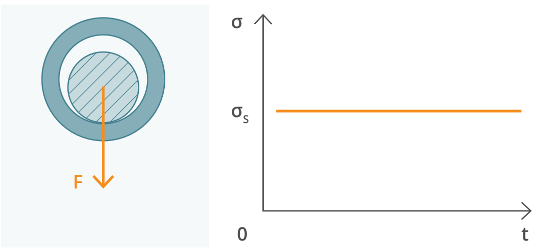


Diagram 4.1.1

Load case 1

The acting normal force changes frequently or quickly or oscillates strongly around a nominal force. There is no sliding movement.

Permissible limit load: 80 % of the max. permissible static load according to material data sheet

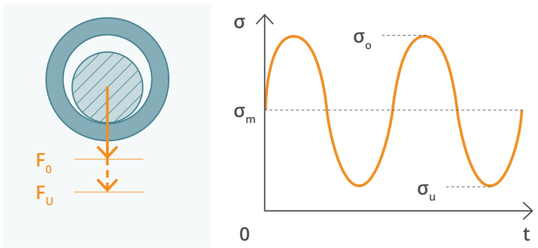


Diagram 4.1.2

Load case 2

The acting normal force is constant or can be assumed to be constant without frequent or rapid load changes or load alternations. In addition, a sliding movement takes place.

Permissible limit load: 100 % of the max. permissible dynamic load according to the material data sheet or 50 % of the static limit load if the dynamic load is unknown

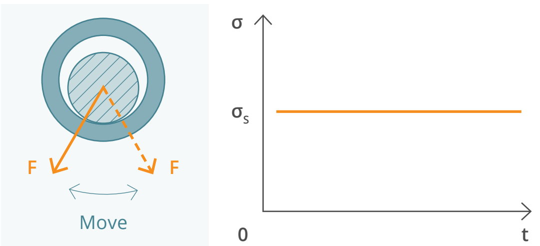


Diagram 4.1.3

Load case 3

The acting normal force changes frequently or quickly or oscillates strongly around a nominal force. In addition, a sliding movement takes place.

Permissible limit load: 100 % of the max. permissible dynamic load according to the material data sheet or 50 % of the static limit load if the dynamic load is unknown

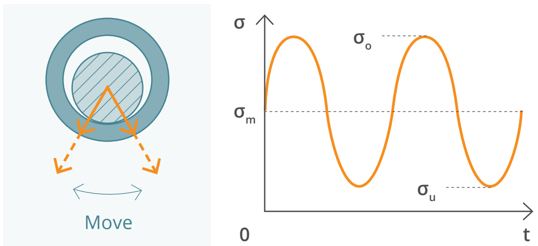


Diagram 4.1.4

deva.metal® sliding bearings

Mating materials

Roughness and surface finish

The deva.metal® sliding materials require the use of a mating material with a minimum hardness of 180 HB. If the bearing is additionally lubricated, hardness values of >130 HB can also be permitted. In case of high sliding distances or abrasion from the environment, a hardened surface of 35 HRC/45 HRC should be used. The surface roughness when using deva.metal® is ideally Ra = 0.2 bis 0.8 µm produced by grinding. Depending on the operating conditions, greater surface roughness can also be accepted.

Normally, shafts and end faces that run against deva.metal® are made of steel. For humid and corrosive environments, the use of stainless steel is recommended. For repairs or reduction of costs, the use of running sleeves with the appropriate hardness is possible. Also hardfaced coatings or other protective coatings (hard chrome-plated, electroless nickel, ...) can be used to a certain extent. The corrosion requirements to be met by the mating material are to be determined on the basis of the respective operating conditions.

Roughness of the mating materials

Influence of the surface roughness of the mating material on the microwear of the sliding material
(Model representation from various investigations)

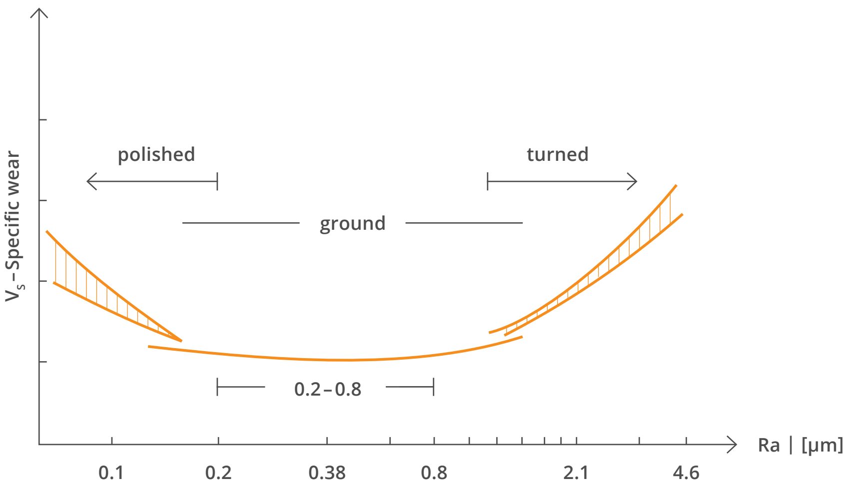


Diagram 5.1.1

Constructive design of the mating surface

Shaft and end faces in use against deva.metal® sliding bearings or thrust washers must be wider or have a larger diameter (Fig. 5.1.1) than the bearing to prevent running-in. Grooves and flat spots in the shafts must be avoided. The shaft ends must be chamfered. All sharp edges or protrusions that could damage the bearing must be removed.

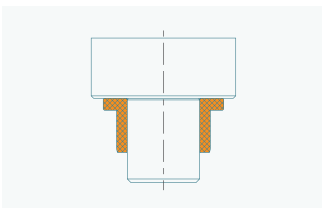


Figure 5.1.1

Suggested materials

The following table gives an overview of some possible mating materials.

Material number	DIN designation	Comparable standards		
		USA–ANSI	GB–BS 970	F–AFNOR
Mating materials for normal applications				
1.0543	ZSt 60-2	Grade 65	55C	A60-2
1.0503	C45	1045	080M46	CC45
1.7225	42CrMo4	4140	708M40	42CD4

Table 5.1.1

Mating materials for corrosive environment

1.4021	X20Cr13	420	420S37	Z20C13
1.4057	X17CrNi-16-2	431	432S29	Z15CN16.02
1.4112	X90CrMoV18	440B	–	(Z70CV17)
1.4122	X35CrMo17	–	–	–
1.4418	X4CrNiMo16-5-1	S165M	–	Z6CND16-05-01

Table 5.1.2

Mating materials for use in seawater

1.4462	X2CrNiMoN22-5-3	UNS531803	318513	Z3CND24-08
1.4501	X2CrNiMoCuWN25-7-4	UNSS32760	–	Z3CND25.06Az
2.4856	Inconel 625	–	–	–

Table 5.1.3

deva.metal® sliding bearings

Cylindrical sliding bearings

Manufacturing process

deva.metal® alloys are produced using powder metallurgy processes. This results in manufacturing restrictions with regard to the individual component length and the width/diameter ratio [B_1/D_2]. In practice, the following values B_1/D_2 of 0.5 to 1.0 have proved successful. If edge loads occur, a ratio greater than 1 is not advisable. Sliding bearings with a width/diameter ratio >1.5 are not recommended.

6.1 Recommended standard dimensions – cylindrical bushings

The maximum available inner diameter for cylindrical sliding bearing bushes made of deva.metal® is 560 mm and the outer diameter 600 mm. Table 6.1.1 shows typical bearing dimensions based on production capability. Other sizes are available on request.

Recommendation
Recommended and producible tolerances see page 22 and 23

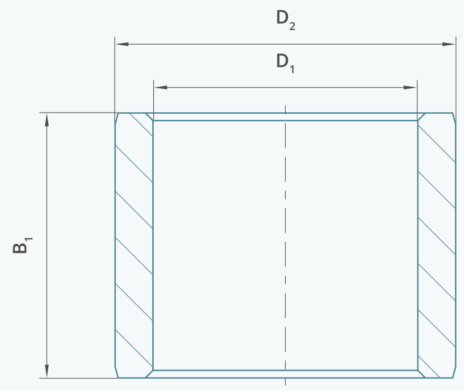


Figure 6.1.1

B_1 – Bearing width D_1 – Inner diameter D_2 – Outer diameter

Dimension table

Selection of the min. outer diameter $D_{2\,min}$ and the maximum producible length B_{max} of deva.metal® bushings depending on the specific surface load p and the alloy. For longer bearings, a multi-part solution of 2 or more bushings is possible

	$D_{2\,min}$				B_{max}			
D_1	P < 10 MPa	P= 10–25 MPa	P= 26–50 MPa	p > 50 MPa	101/108/172/175	118	103/105/110/112/113/120/123/124/126/127/128/129/157/162/179/233	Pro/Pro HT
8	12	12	13	14	60	60	60	57
10	14	15	16	16	60	60	60	57
12	17	17	18	19	60	60	60	57
14	19	20	21	21	60	60	60	57
15	20	21	22	23	60	60	60	57
16	22	22	23	24	60	60	60	57
18	24	25	26	26	60	60	60	57
20	26	27	28	29	80	80	60	57
22	29	29	30	31	80	80	60	57
25	32	33	34	35	80	80	60	57
28	35	36	37	39	80	80	60	57
30	38	38	40	41	80	80	60	57
32	40	41	42	43	80	80	60	57
35	43	44	46	47	80	80	60	57
36	44	45	47	48	80	80	60	57
38	47	48	49	50	80	80	60	57
40	49	50	51	53	80	80	60	57
42	51	52	54	55	80	80	60	57
45	54	55	57	58	80	80	60	57
48	58	59	60	62	80	80	60	57
50	60	61	63	64	80	80	60	57
55	65	66	68	70	80	80	60	57
60	71	72	74	75	80	80	60	57
65	76	77	79	81	80	80	60	57
70	82	83	85	87	100	80	76	57
75	87	88	90	92	100	80	76	57
80	93	94	96	98	100	80	76	57
85	98	99	101	103	100	80	76	57
90	103	105	107	109	100	80	76	70
100	114	115	118	120	100	100	76	70
105	119	121	123	125	110	100	76	70
110	125	126	129	131	100	100	76	70
120	135	137	140	142	100	100	76	70
130	146	148	150	153	100	100	76	70
140	157	158	161	164	100	100	76	70
150	167	169	172	174	100	100	76	70
160	178	180	183	185	100	100	76	70
170	188	190	193	196	100	100	76	–
180	199	201	204	207	100	100	76	57
190	209	211	215	218	100	100	76	57
200	220	222	225	228	100	80	76	70
210	230	232	236	239	100	80	76	57
220	241	243	247	250	80	80	76	75
230	251	253	257	260	100	80	76	57
240	262	264	268	271	60	60	60	57
250	272	274	278	282	60	60	60	54
260	283	285	289	292	60	60	60	57
270	293	295	299	303	60	60	60	–
280	304	306	310	313	60	60	60	–
290	314	316	320	324	60	60	60	–
300	324	327	331	335	60	60	60	–
310	335	337	341	345	60	60	60	–
320	345	348	352	356	60	60	60	–
330	356	358	362	366	80	80	60	–
340	366	369	373	377	80	80	60	–
350	376	379	383	387	80	80	60	–
360	387	389	394	398	80	80	60	–
370	397	400	404	408	60	60	60	–
380	408	410	415	419	60	60	60	–
390	418	421	425	429	60	60	60	–
Up to 560	Custom designed on request							

Table 6.1.1

Table 6.1.1

– Bearings not producible in this dimension

6.2 Recommended standard dimensions – flanged bushings

Recommendation
Recommended and producible tolerances see page 22 and 23

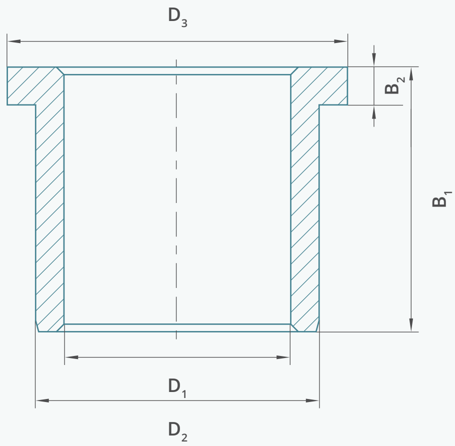


Figure 6.2.1

Table 6.2.1

Dimension table

Selection of the minimum outside diameter $D_{2\,min}$ and the maximum producible length B_{max} of deva.metal® flanged bushings depending on the specific surface load p and the alloy

D_1	$D_{2\,min}$				$D_{3\,max}$	Flange width B_2	B_{max}			
	P < 10 MPa	P= 10 – 25 MPa	P= 26 – 50 MPa	p > 50 MPa			101/108/172/175	118	103/105/110/112/ 113/120/123/124/ 126/127/128/129/ 157/162/179/233	Pro/Pro HT
8	12	12	13	14	16	3	60	60	60	57
10	14	15	16	16	18	3	60	60	60	57
12	17	17	18	19	24	3	60	60	60	57
14	19	20	21	21	26	3	60	60	60	57
15	20	21	22	23	27	3	60	60	60	57
16	22	22	23	24	28	5	60	60	60	57
18	24	25	26	26	30	5	60	60	60	57
20	26	27	28	29	32	5	80	80	60	57
22	29	29	30	31	34	5	80	80	60	57
25	32	33	34	35	39	5	80	80	60	57
28	35	36	37	39	44	5	80	80	60	57
30	38	38	40	41	46	5	80	80	60	57
32	40	41	42	43	48	5	80	80	60	57
35	43	44	46	47	55	7	80	80	60	57
36	44	45	47	48	57	7	80	80	60	57
38	47	48	49	50	58	7	80	80	60	57
40	49	50	51	53	60	7	80	80	60	57
42	51	52	54	55	62	7	80	80	60	57
45	54	55	57	58	65	7	80	80	60	57
48	58	59	60	62	68	7	80	80	60	57
50	60	61	63	64	75	10	80	80	60	57
55	65	66	68	70	80	10	80	80	60	57
60	71	72	74	75	95	10	80	80	60	57
65	76	77	79	81	100	10	80	80	60	57
70	82	83	85	87	105	10	100	80	75	57
75	87	88	90	92	110	10	100	80	75	57
80	93	94	96	98	120	10	100	80	75	57
85	98	99	101	103	125	10	100	80	75	57

Table 6.2.1

D_1	$D_{2\,min}$				$D_{3\,max}$	Flange width B_2	B_{max}			
	P < 10 MPa	P= 10 – 25 MPa	P= 26 – 50 MPa	p > 50 MPa			101/108/172/175	118	103/105/110/112/ 113/120/123/124/ 126/127/128/129/ 157/162/179/233	Pro/Pro HT
90	103	105	107	109	130	10	100	80	75	57
100	114	115	118	120	150	15	100	80	75	70
105	119	121	123	125	155	15	80	80	60	60
110	125	126	129	131	160	15	80	80	60	60
120	135	137	140	142	165	15	100	80	75	70
130	146	148	150	153	175	15	100	80	75	70
140	157	158	161	164	180	15	100	80	75	70
150	167	169	172	174	210	15	100	100	75	–
160	178	180	183	185	225	15	100	100	75	–
170	188	190	193	196	225	15	80	80	60	–
180	199	201	204	207	240	15	100	80	60	–
190	209	211	215	218	255	15	60	60	60	–
200	220	222	225	228	260	15	60	60	60	57
210	230	232	236	239	270	15	60	60	60	57
220	241	243	247	250	270	15	60	60	60	57
230	251	253	257	260	280	15	60	60	60	57
240	262	264	268	271	280	15	60	60	60	57
250	272	274	278	282	300	15	60	60	60	55
260	283	285	289	292	300	15	60	60	60	55
270	293	295	299	303	335	15	60	60	60	–
280	304	306	310	313	335	15	60	60	60	–
290	314	316	320	324	335	15	60	60	60	–
					Up to 600	Custom designed on request				

Table 6.2.1

B_2 – Flange height

D_3 – Flange diameter

6.3 Fits and surfaces

deva.metal® sliding bearings are pressed in with interference fit between the housing inside diameter and bearing outside diameter. Bearing outside, bearing inside, shaft and housing inside diameters must be manufactured within the recommended tolerances to ensure trouble-free operation.

Permissible fit and tolerance ranges

Figure 6.3.1 and Table 6.3.1 show the recommended fits and tolerance options. To create more accurate fits after assembly (IT7 or better), finish machining should be done after installation. For this purpose, deva.metal® can be produced with a machining allowance of 0.15 - 0.2 mm. The adaptation of the bearing tolerances to deviating shaft tolerances is possible on request.

Surface finish of deva.metal®

According to DIN 30910 for sintered metals, roughness specifications according to DIN 4768 or DIN 4771 are not possible due to the low residual porosity and the solid lubricant deposits. Specifications on our drawings are only for orientation and for setting process parameters in production, but are not guaranteed values.

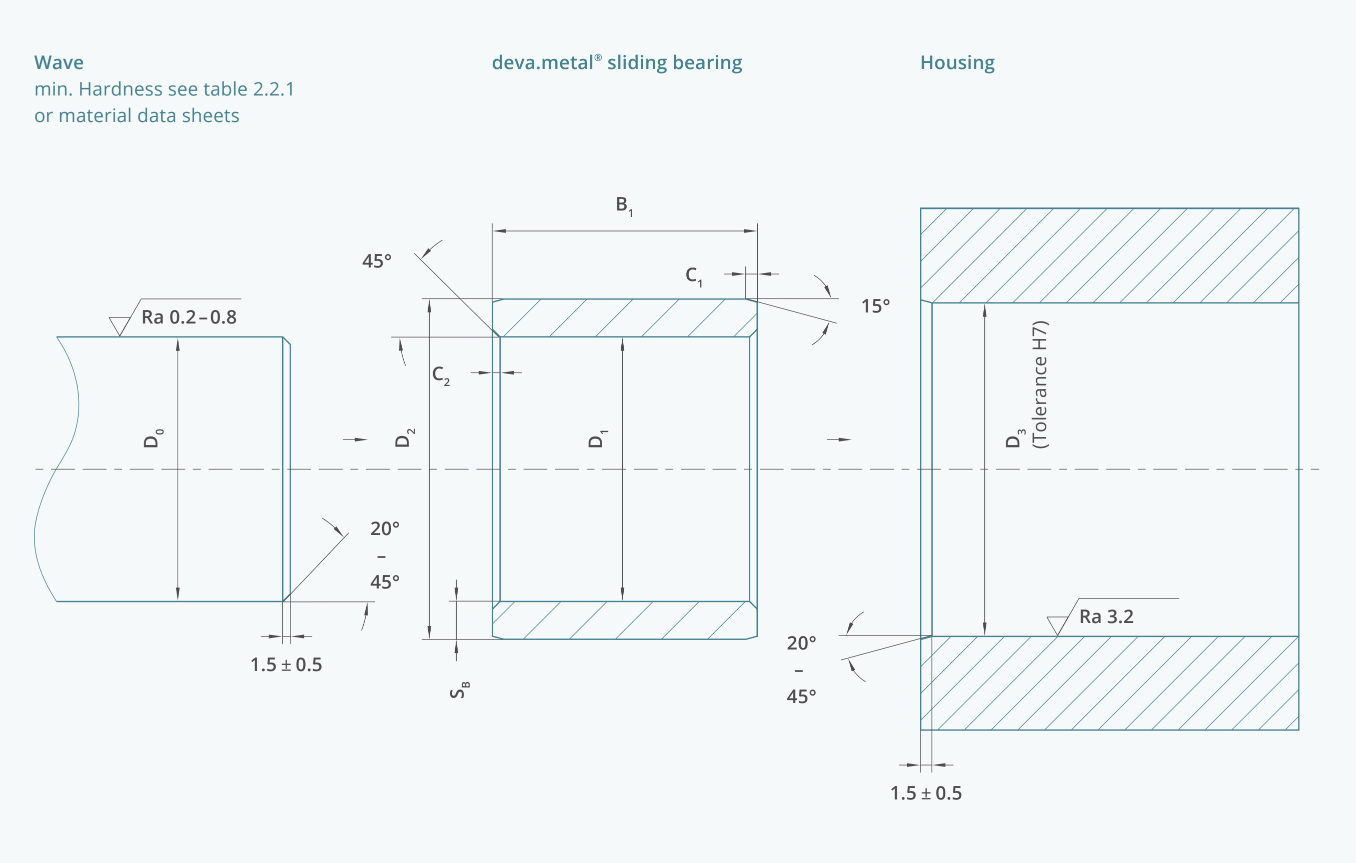


Figure 6.3.1

B_1 – Bearing width

C_1 – Chamfer outer diameter
C_2 – Chamfer inner diameter

D_0 – Shaft outer diameter
D_1 – Bearing inner diameter
D_2 – Bearing outer diameter

S_B – Wall thickness

Recommended fit and tolerance ranges

The adaptation of the bearing tolerances to deviating shaft tolerances is possible on request.

	Operating temperature < 100°C		Operating temperature > 100°C
	Standard	Precision*	Cus-tomised
Bearing outer diameter	r6 (u6**)	r6 (u6**)	r6 (u6**)
Bearing bore (before installation)	C7	D7	To be determined
Bearing bore (after installation)	D8	E8	To be determined
Shaft (D_0)	h7	h7	To be determined

Tabelle 6.3.1

Design recommendations for customized deva.metal® bushings

The bearing wall thickness must correspond to the manufacturing possibilities.
On the one hand, the dimension lists in chapter 6.1 and 6.2 are a help, on the other hand, table 6.3.2 shows the recommended minimum wall thickness for deva.metal® bearings taking into account the specific load and the inner bearing diameter.
For the inner chamfer C_2 the following generally applies: $C_2 = S_B / 5$
Table 6.3.3 shows the recommended lengths of the installation chamfers on the outside diameter.

Wall thickness deva.metal® sliding bearing

Specific load [MPa]	Recommended minimum wall thickness [mm]
< 10	$\sqrt{0.5\,D_1}$
10–25	$\sqrt{0.6\,D_1}$
> 25–50	$\sqrt{0.8\,D_1}$
> 50	$\sqrt{D_1}$

Table 6.3.2

Recommendation length of Fase C_1

Bearing width B_1 [mm]	Chamfer C_1 [mm]
< 10	1.0
10–25	1.5
> 25–50	2.0
> 50–80	3.0
> 80	4.0

Table 6.3.3

deva.metal® flanged sliding bearing

For deva.metal® flanged sliding bearings, the transition radius between the back of the flange and the outer diameter of the radial sliding bearing must be taken into account by means of a undercut on the housing.

* For reduced operating clearance ** For deva.metal® Pro and Pro HT

Operating clearance and press fit

The required operating clearance for deva.metal® bearings in dry-running conditions is determined by the specific operating temperature and must be strictly adhered to in order to ensure safe operation. Dry-running bearings generally require a slightly larger running clearance than externally lubricated bearings. The bearing inner diameter is manufactured with finished dimensions. It should be noted that the inner diameter of the bearing decreases when it is pressed into the housing. Pressing the bearing into the housing reduces the inner diameter of the bearing by approx. 75 % to 95 % of the actual interference fit on the outer diameter. deva.metal® bearings are manufactured in such a way that finishing is not necessary for normal installation after mounting. The narrowing that occurs is already taken into account during manufacture.

The adequate tight fit of a bearing depends on its wall thickness and the operating conditions. For continuous operation above 150 °C or when absorbing axial forces, the bearings must be additionally secured mechanically against displacement or rotation (see figure 6.4.1).

Determination of the running clearance above 100 °C

For the design of the running clearance above 100°C, please contact our technical advisors. Please provide the following information:

- Housing material
- Shaft material
- Operating temperature (constant or changing)

Thermal expansion

Many deva.metal® applications are in the range of higher temperatures. When designing above 100 °C, the following must therefore be taken into account

- Thermal expansion of the enclosure
- Thermal expansion of the deva.metal® bearing
- Thermal expansion of the shaft, the resulting influences on the tight fit of the bearings in the housing and the clearance between bearing and shaft
- Potential grain growth

Mechanical protection of deva.metal® Sliding bearings for > 150°C

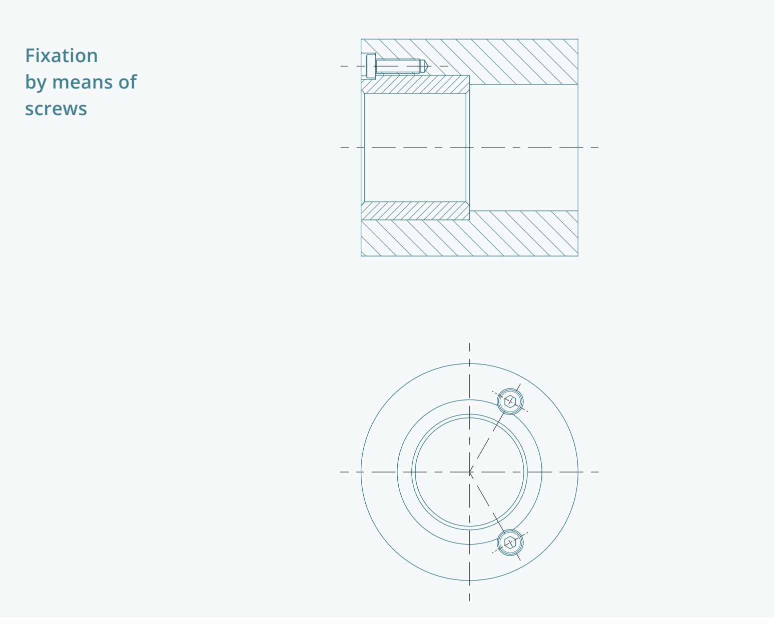


Figure 6.4.1

6.4 Post-processing

deva.metal® sliding bearings are supplied as finished machined parts. The standard tolerances are sufficient for most applications. In cases where a required accuracy can only be achieved by machining in the installed condition, deva.metal® sliding bearings can be reworked mechanically. This also applies to the insertion of retaining grooves or similar. Guidelines for machining deva.metal® materials are laid down in the DEVA® works standard DN 0.37 and will be sent on request. Due to its composition, deva.metal® is classified as a hazardous material. The legal regulations must be observed during machining. For details, see also the section on machining.

6.5 Installation by means of press-fitting

Press-fit is a universally applicable installation method for deva.metal® bushings. deva.metal® radial sliding bearings can be mounted with a screw press or a hydraulic press. It is important to ensure that the mounting force is applied centrically.
It is recommended to use a press-in mandrel as installation support for installation by press fitting (see figure below).

Installation using an impact tool (hammer) is not permissible, as this can lead to damage to the sliding bearing.

Installation description

- A light oiling of the housing bore supports the installation and protects the components from seizure
- Insert the press-in mandrel into the bushing and position it on the housing bore
- The force must be applied evenly to the slide bearing via the press-in mandrel to avoid tilting

We will be happy to provide you with further information and documentation relating to sliding bearing assembly. Please contact us!

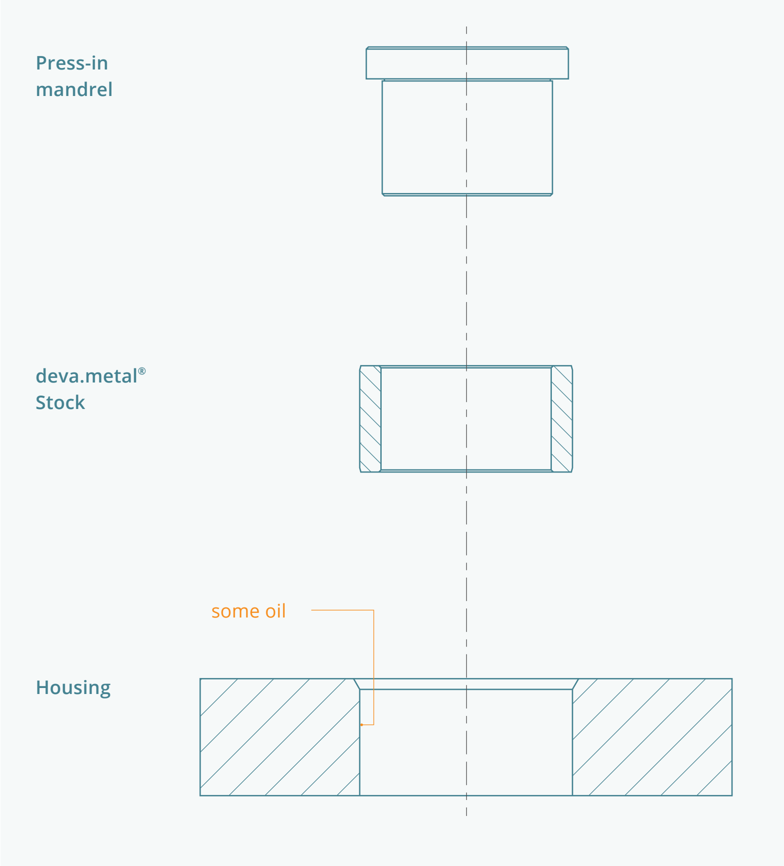


Figure 6.5.1

6.6 Installation by supercooling (bronze alloys only)

The supercooling installation method is only permissible for deva.metal® bronze alloys. For all other deva.metal® alloys, supercooling can lead to structural changes that affect the dimensional stability or change the material behaviour. To check whether supercooling the bearing is the correct installation method, the shrinkage dimension (s) must be calculated. It is calculated according to the following equation:

$$s = n \times \alpha_1 \times \Delta T \times D \text{ mm}$$

Determination of α_1

α_1 (for dry ice) = $0.83 \times \alpha$

α_1 (for nitrogen) = $0.77 \times \alpha$

Shrink dimensions

The following diagram serves for a quick estimation of the shrinkage depending on the cooling medium. The curves apply to a coefficient of thermal expansion of $\alpha = 18 \times 10^{-6}$ 1/K

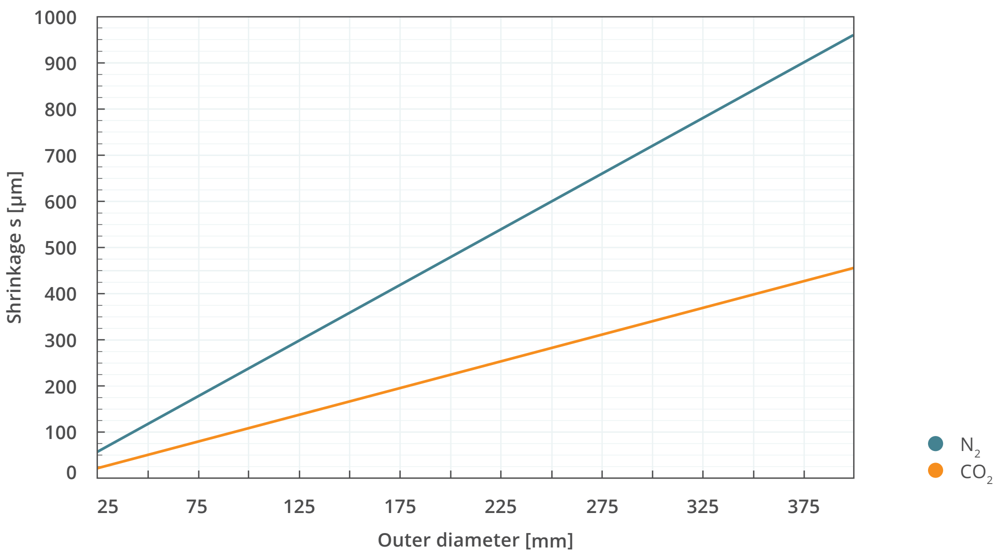


Diagram 6.6.1

The supercooling parts can be inserted into the mounting hole without any effort. Especially in the case of large parts, make sure that the parts to be mounted are neatly aligned during assembly.

Dry ice and liquid nitrogen are classified as hazardous substances. In this context, we expressly point out the handling of hazardous materials. To achieve uniform cooling, dry ice should be crushed to about the size of a walnut. When using liquid nitrogen, the bearings should be completely immersed. The time required for complete cooling of the bearings is between 0.5 and 2 hours, depending on the volume of the parts to be cooled and the cooling medium.

ΔT = Temperature difference [K]
s = shrinkage dimension [mm]
D = outer diameter of the bearing [mm]

α = Coefficient of linear thermal expansion [1/K]
α_1 = Linear coefficient of thermal expansion for low temperature [1/K]
n = 0.8 is an empirical value for the consideration of heat transfer and the heating of the bearing during handling

deva.metal® sliding bearings

Sliding plates and segments

7.1 Possible dimensions deva.metal® sliding plugs and plates

deva.metal® can be produced in almost any shape. Nevertheless, as a sintered material it is subject to manufacturing limitations. The recommended maximum sizes for cylindrical plugs are 280 mm diameter and 100 mm length, for plates 125 mm width, 220 mm length and 55 mm thickness. Exact dimensions on request.

7.2 Installation of sliding plates, segments and thrust washers in general

deva.metal® sliding plates, segments and thrust washers should, if possible, be fixed by means of a mechanical fastening, e.g. chambering (Fig. 7.2.3). In case that no housing rotation or housing chambering is possible, alternative fastening methods can be used.

Alternative fastening options

- Retaining pins
- Standard screws
- With DEVA® special screws
- Gluing
- Soldering

Note

- Position the retaining pins deep enough away from the tread so that no contact can take place until the wear limit is reached
- Make countersinks for retaining screws deep enough so that no contact can take place up to the wear limit
- Cover the running surface during the gluing process to avoid soiling by the adhesive. In this case, it is essential to follow the instructions of the adhesive manufacturer
- Make sure that the inner diameter of the thrust washer does not touch the shaft after mounting
- When using deva.metal® plates in sliding guides at elevated temperatures, the higher coefficient of expansion of deva.metal® compared to steel must be taken into account. The running clearance must be dimensioned accordingly

Fastening deva.metal® thrust washers

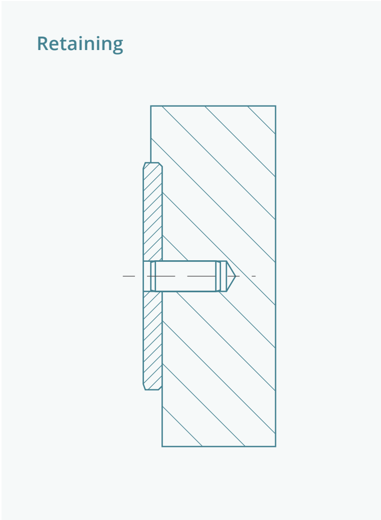


Figure 7.2.1

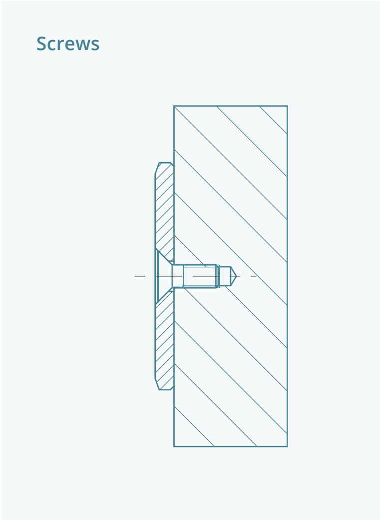


Figure 7.2.2

Chambering

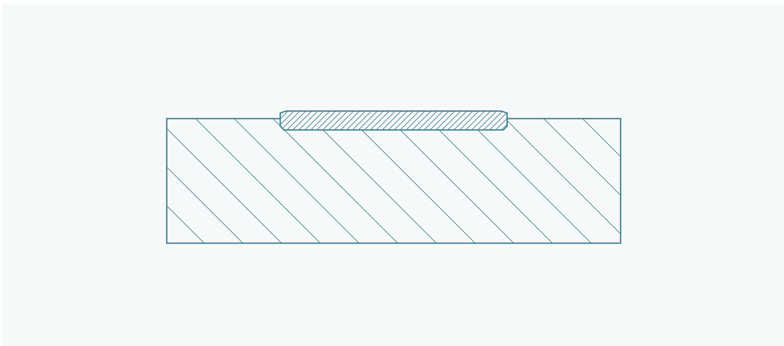


Figure 7.2.3

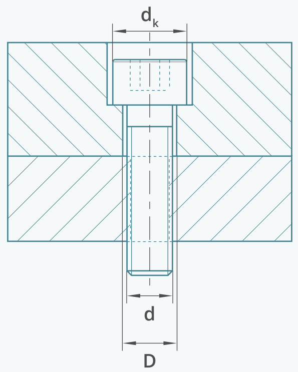
7.3 Installation of sliding plates using standard screws

Taking into consideration the maximum static load capacity p − stat / max of the respective deva.metal® material, the maximum permissible surface pressure under the screw head or washer can be calculated according to the formula below.

$$MA/max = p_{stat/max} \times A_{Kontakt} \times (0.16 \times P + \mu_{ges} \times 1.5\, d_2)$$

Example 1

Screw connection deva.metal with M8 screw according to DIN 912 / ISO 4762

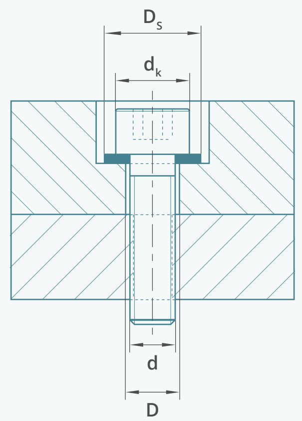


d_k = 13 mm
d_2 = 7.19 mm
P = 1.5 mm
D = 9 mm
$A_{Contact}$ = $(d_K - D^2)\ \pi/4 = (13^2 - 9^2)^*\ \pi/4 = 69\ mm^2$
$p_{stat/max}$ = 200 N/mm^2 (for deva.metal® 101)
μ_{ges} = 0.1
$M_{A/max}$ = $(p_{stat/max} \times A_{Contact}) \times (0.16 \times P + \mu_{ges} \times 1.5\ d_2)$
= $(200\ N/mm^2 \times 69\ mm^2) \times (0.16 \times 1.5\ mm + 0.1 \times 1.5 \times 7.19\ mm)$ = 18.195 Nmm
= **18.2 Nm**

Figure 7.3.1

Example 2

Screw connection deva.metal® with M8 and washer according to DIN125 / ISO 1789



D_s = 16 mm
d_2 = 7.19 mm
P = 1.5 mm
D = 9 mm
$A_{Contact}$ = $(D_S^2 - D^2)\ \pi/4 = (16^2 - 9^2)^*\ \pi/4 = 137\ mm^2$
$p_{stat/max}$ = 200 N/mm^2 (for deva.metal® 101)
μ_{ges} = 0.1
$M_{A/max}$ = $(p_{stat/max} \times A_{Contact}) \times (0.16 \times P + \mu_{ges} \times 1.5\ d_2)$
= $(200\ N/mm^2 \times 137\ mm^2) \times (0.16 \times 1.5\ mm + 0.1 \times 1.5 \times 7.19\ mm)$ = 36168 Nmm
= **36.2 Nm**

Figure 7.3.2

Screw connection

We recommend securing the screws with “Loctite 243” for medium-strength or “Loctite 278” for high-strength screw locking. The temperature limits and processing instructions of the manufacturer must be observed.

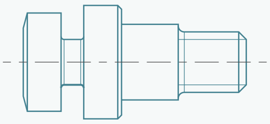
$M_{A/max}$ max. permissible screw tightening torque [Nm]
$p_{stat/max}$ max. stat. load capacity of the selected [N / mm²]
$A_{Contact}$ Contact area between screw head support and deva.metal® component [mm²]
μ_{ges} Total coefficient of friction (thread and screw head on deva.metal® = 0.1)

d – Screw diameter
d_K – Screw head diameter
d_2 – Thread flank diameter [mm]
P – Thread pitch [mm]
D_S – Diameter washer
D – Hole in deva.metal®

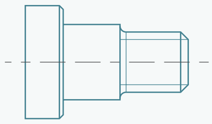
7.4 Installation of sliding plates by means of special screws

Installation is carried out using DEVA® special screws in accordance with DEVA® works standard DN 0.34.
Special screws are available in M8, M10 and M12.
The connection between deva.metal® and the supporting part must be made in one clamping operation. For more information, please contact our technicians

DEVA® special screw before assembly



DEVA® special screw after assembly



DEVA® special screw after assembly

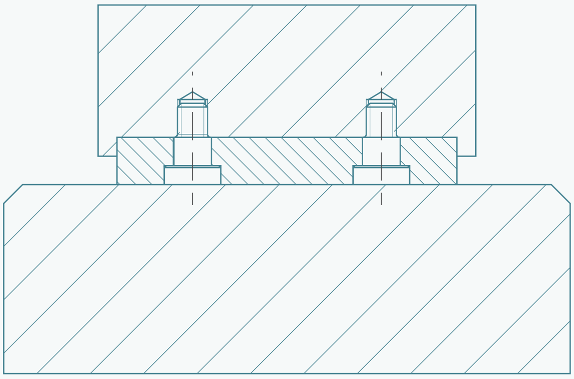


Figure 7.4.1

deva.metal® sliding bearings

Chemical resistance

deva.metal® and various media

The following table provides information on the chemical resistance of deva.metal® alloys. It is recommended that the actual behaviour of a selected deva.metal® alloy should be verified by in-service tests.

Medium / chemical substance	Concentration [%]	Temperature [°C]	deva.metal® bronze alloy	deva.metal® iron alloy			deva.metal® nickel alloys			deva.metal® stainless steel	
			101–117	118/119	120/121	122/123	124	126/233	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	×	●	●	●	●	●	●	●	●
Potassium hydroxide	5	20	●	●	●	●	●	●	●	●	●
Sodium hydroxide	5	20	●	●	●	●	●	●	●	●	●
Solvent											
Acetone		20	●	●	●	●	●	●	●	●	●
Carbon tetrachloride		20	●	●	●	●	●	●	●	●	●
Ethyl alcohol		20	●	●	●	●	●	●	●	●	●
Ethyl acetate		20	●	●	●	●	●	●	●	●	●
Ethyl chloride		20	●	×	×	×	●	●	●	●	●
Glycerine		20	●	●	●	●	●	●	●	●	●
Salts											
Ammonium nitrate			×	○	○	○	●	×	●	●	●
Calcium chloride			●	●	●	●	●	●	●	●	●
Magnesium chloride			●	○	○	○	●	○	○	●	●
Magnesium sulfate			●	○	○	○	●	○	○	●	●
Sodium chloride			●	○	○	○	●	●	●	●	●
Sodium nitrate			●	●	●	●	●	●	●	●	●
Zinc chloride			×	×	×	×	●	×	○	●	●
Zinc sulfate			●	○	○	○	●	×	○	●	●

Table 8.1.1

Medium/ chemical substance	Concentration [%]	Temperature [°C]	deva.metal® bronze alloy	deva.metal® iron alloy			deva.metal® nickel alloys			deva.metal® stainless steel	
			101 – 117	118/119	120/121	122/123	124	126/233	127	128	129
Gases											
Ammonia gas			○	●	●	●	×	○	○	●	●
Chlorine gas			×	×	×	×	⁄	○	×	×	×
Carbon dioxide			●	○	○	○	○	×	○	●	●
Fluorine			×	○	○	○	●	●	●	●	●
Sulphur dioxide			●	×	×	×	○	○	○	●	●
Hydrogen sulfide			○	×	×	×	○	●	○	●	●
Nitrogen			●	●	●	●	●	●	●	●	●
Hydrogen			●	●	●	●	●	●	●	●	●
Lubricants / Fuels											
Paraffin		20	●	●	●	●	●	●	●	●	●
Petrol		20	●	●	●	●	●	●	●	●	●
Heating oil		20	●	●	●	●	●	●	●	●	●
Diesel		20	●	●	●	●	●	●	●	●	●
Mineral oil		70	●	●	●	●	●	●	●	●	●
HFA ISO46 Oil Water Emulsion		70	●	●	●	●	●	●	●	●	●
HFC Water Ethylene		70	●	●	●	●	●	●	●	●	●
HFD Phosphate ester		70	●	●	●	●	●	●	●	●	●
Other											
Water		20	●	●	×	×	●	●	●	●	●
Seawater		20	●	×	×	×	●	●	●	●	●
Resin			●	●	●	●	●	●	●	●	●
Hydrocarbon			●	●	●	●	●	●	●	●	●

Table 8.1.1

● Resistant

○ Conditionally resistant, depending on environmental conditions

× Not recommended

⁄ No data available

deva.metal® sliding bearings

Design examples and applications

9.1 Grooves

The dry-running behaviour of deva.metal® is improved by grooves in the sliding surface. They guide operational wear particles and dirt away from the bearing point. The drawings below show two possible designs.

deva.metal® spirally arranged cleaning grooves

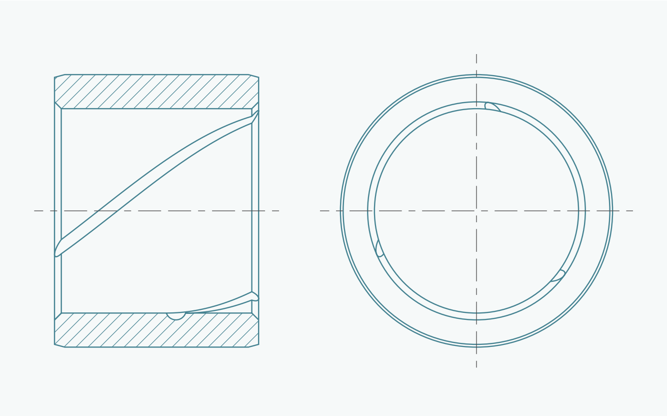


Figure 9.1.1

deva.metal® diamond-shaped cleaning grooves

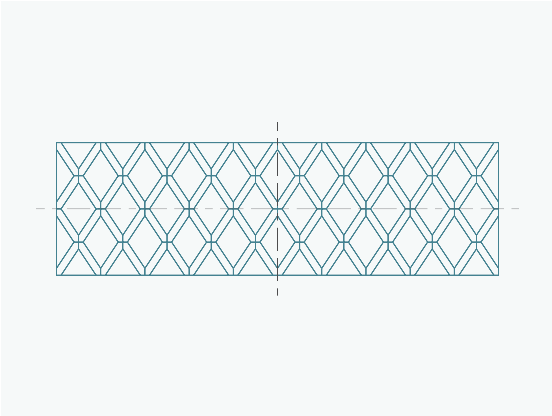


Figure 9.1.2

9.2 Examples of special constructions

deva.metal® centre bearing for screw conveyor

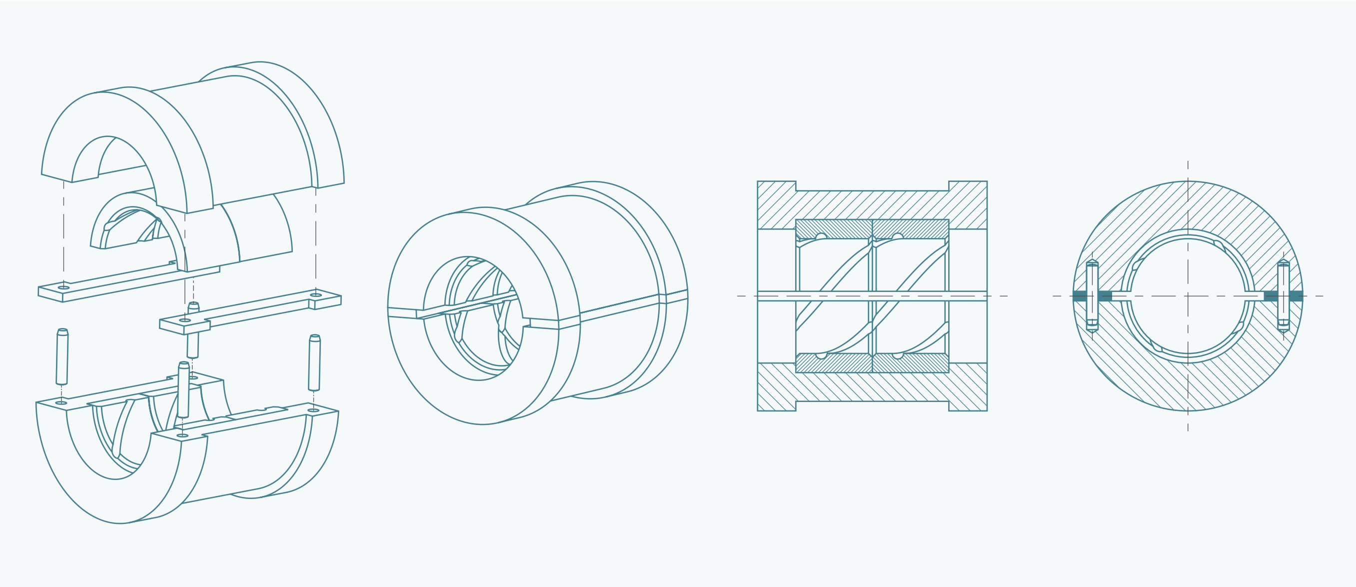


Figure 9.1.3

deva.metal® sliding strip

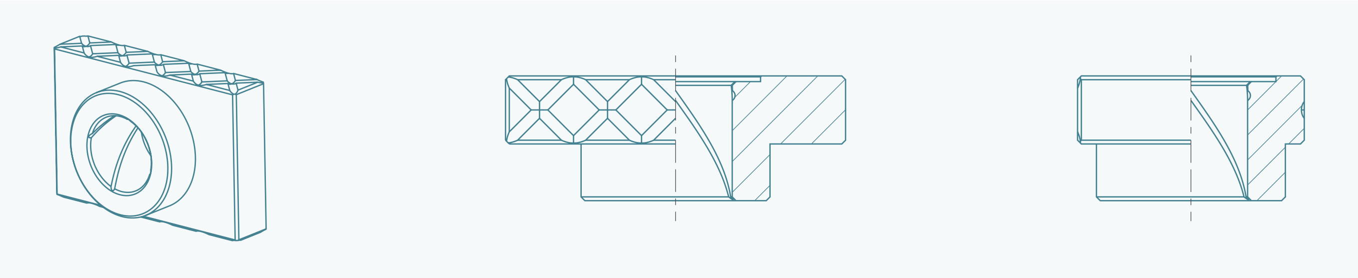


Figure 9.1.4

deva.metal® sliding strip

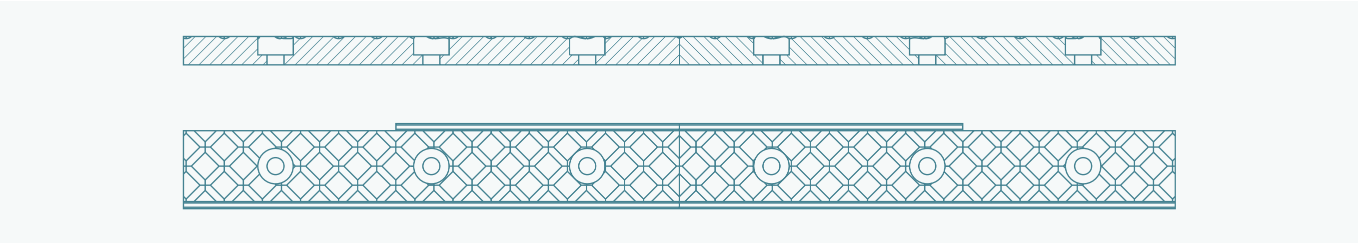


Figure 9.1.5

deva.metal® angle compensator

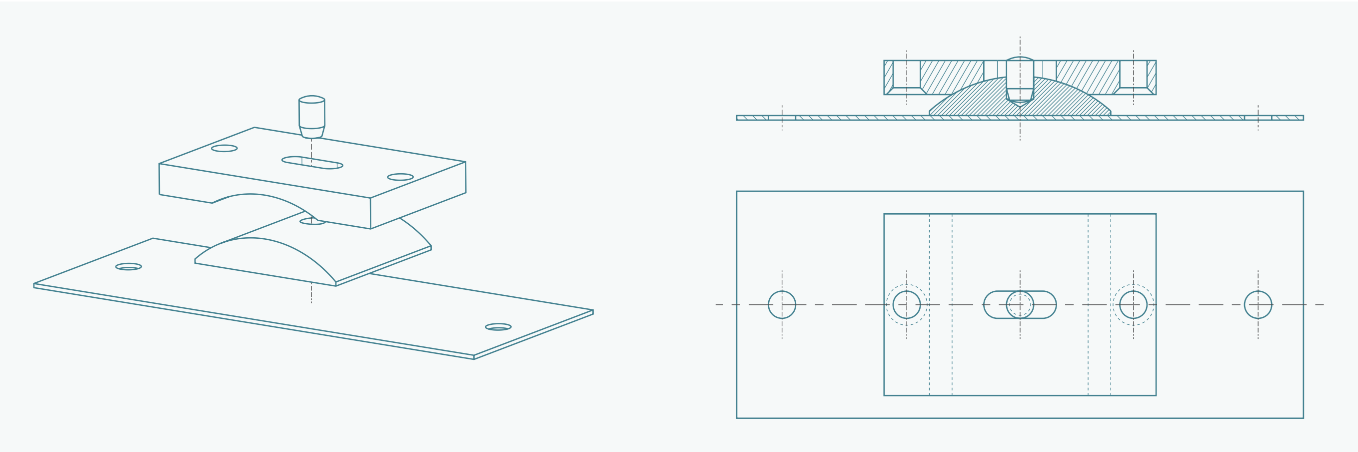


Figure 9.1.6

deva.metal® sliding bearings

Data for the design of DEVA® sliding bearings

Personal data

Company name

Project number

Address

Contact person

Phone

Fax

Mobile phone

Email

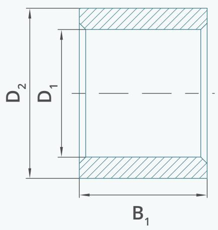
Description of the application

- ○ New design
- ○ Existing design
- ○ Steel industry
- ○ Wind energy
- ○ Rubber and plastics industry
- ○ Steam and Gas Turbines
- ○ Offshore and Marine
- ○ Heavy-duty Vehicles
- ○ Railway
- ○ Hydro Power
- ○ Other

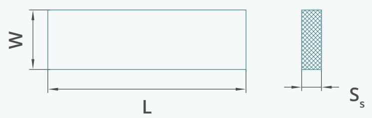
Bearing type

- ○ Shaft rotates
- ○ Bearing rotates
- ○ Angular motion
- ○ Axial motion

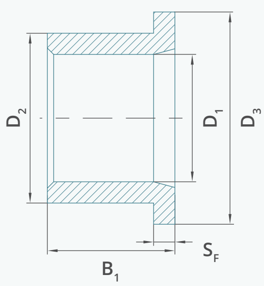
○ Bushing



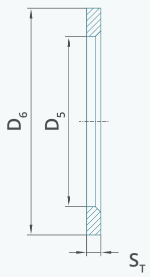
○ Sliding plate



○ Flanged bushing bearing

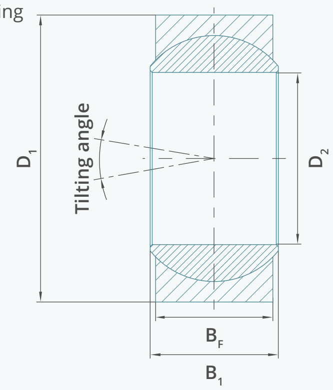


○ Thrust washer



○ Spherical bearing

- ○ Floating bearing
- ○ Fixed bearing



	Pos. 1	Pos. 2	Pos. 3
Quantity			

Dimensions [mm]	Pos. 1	Pos. 2	Pos. 3
Inner diameter D_1 (D_5)			
Outer diameter D_2 (D_6)			
Bearing width B_1			
Outer ring width B_F			
Flange outer diameter D_3			
Flange thickness S_F			
Wall thickness S_T			
Plate length L			
Panel width W			
Plate thickness S_S			

Load	Pos. 1	Pos. 2	Pos. 3
Static	○	○	○
Dynamic	○	○	○
Alternating	○	○	○
Shock loads	○	○	○
Radial load **[kN]**			
Axial load **[kN]**			
Surface pressure			
Radial **[MPa]**			
Axial **[MPa]**			

Mating material	Pos. 1	Pos. 2	Pos. 3
Material no./type			
Hardness **[HB/HRC]**			
Roughness R_a **[μm]**			

Housing material	Pos. 1	Pos. 2	Pos. 3
Material no./type			

Lubrication	Pos. 1	Pos. 2	Pos. 3
Dry run	○	○	○
Permanent lubrication	○	○	○
Medium lubrication	○	○	○
Medium			
Lubricant			
Initial lubrication	○	○	○
Hydrodynamic lubrication	○	○	○
Dynamic viscosity			

Move	Pos. 1	Pos. 2	Pos. 3
Speed **[rpm]**			
Sliding speed **[m/s]**			
Stroke length **[mm]**			
Double strokes **[/min]**			
Rotation angle **[°]**			
Frequency **[n/min]**			
Tilt angle (spherical bearing) **[°]**			

Operating time	Pos. 1	Pos. 2	Pos. 3
Continuous operation			
Intermittent operation			
Duty operation **[%/h]**			
Days/Year			
Frictional distance **[km]**			

Fits/Tolerances	Pos. 1	Pos. 2	Pos. 3
Shaft			
Bearing housing			

Environmental conditions	Pos. 1	Pos. 2	Pos. 3
Temperature at bearing			
Contact medium			
Other influences			

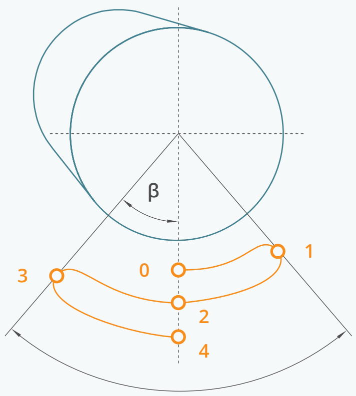
Lifetime	Pos. 1	Pos. 2	Pos. 3
Desired operating time **[h]**			
Permissible wear **[mm]**			

Comments

- ○ Certificate required (e.g., 3.1)
- ○ Acceptance procedure (e.g., 3.2)

Angle
The angle β is defined by the movement from the middle position to one end point.

Cycle
A cycle is four times the angle β. The calculation of the expected friction distance is based on this.



Example
Bushing $D_1 = 50$ mm and angle $\beta = 5°$
1 cycle shows a friction distance of 8.73 mm

Disclaimer

The present technical documentation has been prepared with care and all the information verified for its correctness. No liability, however, can be accepted for any incorrect or incomplete information. The data given in the documentation 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 sliding friction and wear values stated by us or appearing in catalogues and other technical documentation do not constitute a guarantee of the specified properties. They have been determined in our test facilities under conditions that do not necessarily reflect the actual application of our products and their service environment or permit comprehensive simulation in relation to them.

We provide guarantees only after written agreement of the test procedures and parameters and of all the relevant characteristics which the product is required to have. All transactions conducted by DEVA® are subject, in principle, to our terms of sale and delivery as indicated in our offers, product brochures and price lists. Copies are available upon 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 prior notice.

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