

Metal bellows coupling for

*Servo drives
Machine tools
Packaging machines
Printing machines*



ROBA[®]-DX

*Positively welded
torsionally rigid shaft coupling*

- *reliable torque transmission*
- *quick and easy installation*
- *high balancing quality*
- *low restoring forces*

K.931.05.GB

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transmission

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Why use ROBA[®]-DX-couplings ?

The success of the servomotor and its increasing application in drives of all kinds, also set new requirements for couplings. In a majority of the applications the coupling must provide a torsional rigid and backlash-free connection between motor shaft and output shaft, for example ball screw drives.

There is a coupling especially designed for these requirements and is, therefore, the ideal coupling for your servodrive.

■ Misalignment-capability

The ROBA[®]-DX compensates axial, radial and angular shaft misalignments caused by tolerances and outer influences, such as pressure or heat. This eliminates bearing failures due to any preload that is caused by using rigid connection.

■ Backlash-free torque transmission

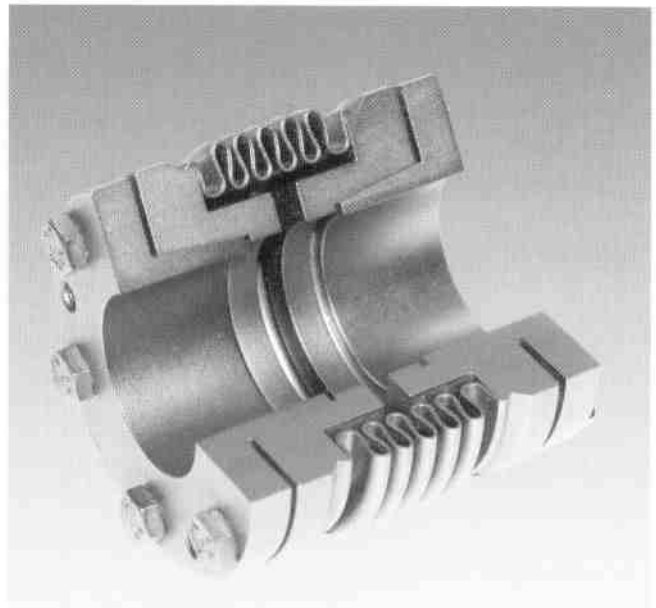
The ROBA[®]-DX coupling guarantees a backlash-free torque transmission between input to output shaft. The different structural shapes with taper bushings, clamping hubs and tapered designs provide a backlash-free shaft to hub connection.

■ Low inertia

The high requirements for the dynamic properties of a drive system can only be met with a low inertia coupling. The small outside dimensions and the advantages of light metal bellows offer extremely low inertia.

■ High torsional stiffness

The ROBA[®]-DX coupling utilizes a special bellow manufacture technique that provides an extreme stiffness and simultaneously low restoring forces.



■ Temperatures

ROBA[®]-DX couplings are insensible to temperatures up to 250° C.

■ High speed performance

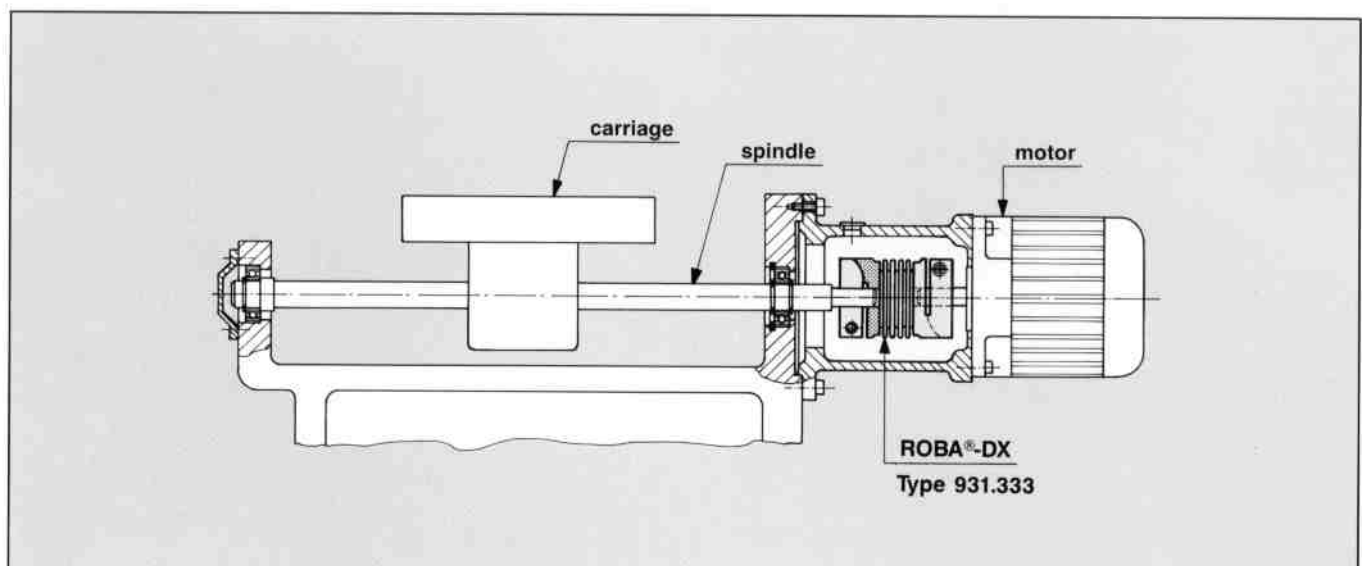
The ROBA[®]-DX coupling can be used up to extremely high speeds and is ideal for high speed machining applications. Due to the excellent true running accuracy the coupling provides a safe and reliable torque transmission.

■ Time saving assemblies

The simple and fast assembly and disassembly saves time when fitting the drive components even with difficult mounting conditions.

■ Maintenance free

After assembly of the components the coupling needs no further maintenance. Considering all the application conditions the ROBA[®]-DX couplings offer a long service life.



Contents

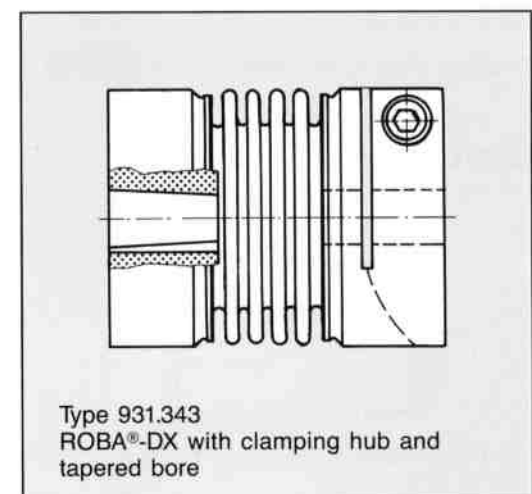
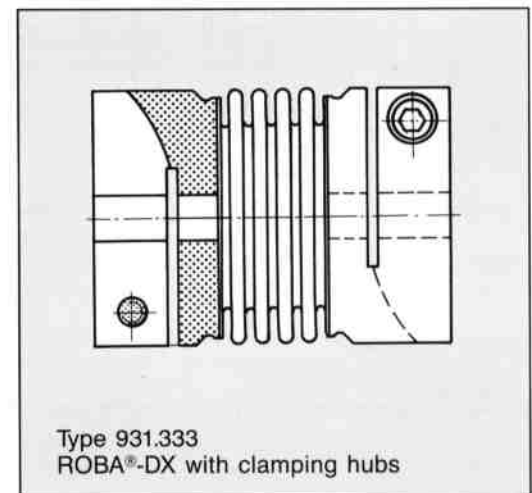
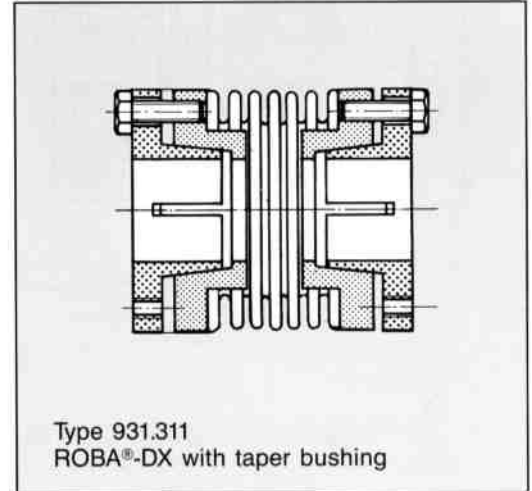
Why use ROBA®-DX	page 2
Structural shapes/ROBA®-DX means	page 3
Technical data	page 4
Mounting instructions/ Mounting examples	page 6
Selection	page 8

ROBA®-DX means:

- Compensation of axial, radial and angular misalignments
- Backlash-free shaft attachment - backlash-free torque transmission
- Low moment of inertia
- High degree of torsional stiffness - simultaneous low restoring forces
- Insensible to temperature up to 250° C
- Safe, reliable torque transmission even at high speeds without balancing of the coupling
- Simple and fast assembly
- Maintenance free

ROBA®-DX

Structural shapes



Torsionally rigid, backlash-free, flexible steel bellows coupling

Sizes 0–5

Type 931.311

931.333

931.343 (only size 3)

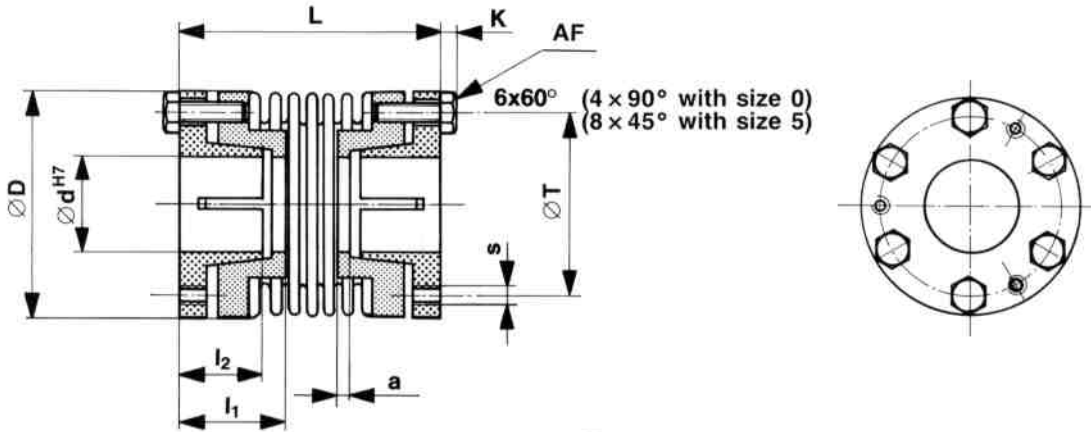


Fig. 1 Type 931.311

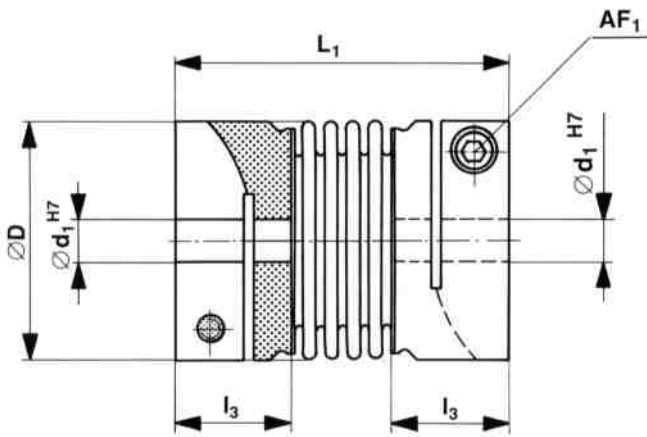


Fig. 2 Type 931.333

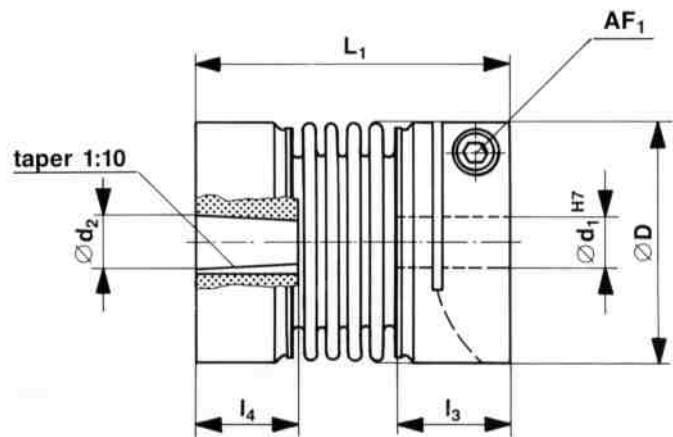


Fig. 3 Type 931.343 (only size 3)

Order example:

To be included when ordering, please state:	size	type	bore Ø	bore Ø
Order number:		931.3 _ _	d	d
			d ₁	d ₁
			d ₂	d ₁

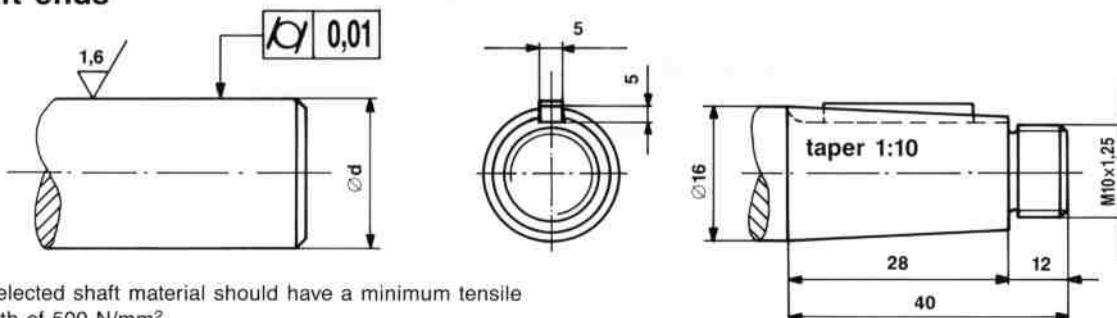
0 ÷ 5

- taper bushing 1
- clamping hub 3
- hub for tapered shaft 1:10 Ø16 (only size 3) 4

possible diameters d / d₁ / d₂
see table of dimensions

Example: order number 2/931.311/Ød 20/Ød 25

Shaft ends



The selected shaft material should have a minimum tensile strength of 500 N/mm².

Fig. 4

Torsionally rigid flexible steel bellows coupling

**Sizes 0 – 5 Type 931.311
931.333
931.343 (only size 3)**

Technical data

size	coupling nominal torque T_{KN} [Nm]	max. speed n_{max} [rpm]	torsional stiffness C_T [Nm/rad]	axial stiffness C_a [N/mm]	screw tightening torque taper bushing AF [Nm]	screw tightening torque clamping hub AF ₁ [Nm]
0	30	13000	11000	125	2,9	5
1	60	11000	17000	110	2,9	10
2	100	9500	31000	135	5,5	18
3	200	9000	53000	200	9,5	18
4	350	7500	90000	175	17	43
5	600	6300	140000	135	15	87

size	Type 931.311		Type 931.333		Type 931.343	
	mass moment of inertia I [kgm ²]	weight G [kg]	mass moment of inertia I [kgm ²]	weight G [kg]	mass moment of inertia I [kgm ²]	weight G [kg]
0	0,000048	0,26	0,000082	0,35	—	—
1	0,000129	0,44	0,00020	0,57	—	—
2	0,000362	0,78	0,00049	0,92	—	—
3	0,000752	1,12	0,00094	1,19	0,00107	1,51
4	0,001460	1,62	0,00217	2,07	—	—
5	0,003750	2,90	0,00505	3,38	—	—

Table of dimensions

size	a	D	d_{min}		d_{max}	$d_1 min$		$d_1 max$	d_2	K
			from ²⁾	from ³⁾		from ²⁾	from ³⁾			
0	2	41	9	13	16	9	13	20	—	2,8
1	3	50	12	15	20	12	16	25	—	2,8
2	4	60	15	19	25	15	19	32	—	3,5
3	6	71	24	28	35	25	37	42	16	4,0
4	7,5	82	30	35	42	30	35	45	—	5,5
5	9,5	98	35	41	50	35	38	55	—	5,5

size	L ¹⁾	L ₁	I ₁ ¹⁾	l ₂	l ₃	l ₄	s	T	AF	AF ₁
0	46	61	21,5	17,3	22	—	2 × M4	30,5	7	3
1	54	69	25	20	24	—	2 × M4	38	7	4
2	63	83	29	23	28	—	2 × M5	47	8	5
3	72	87	33	25	28	30	2 × M6	58	10	5
4	81	105	37	27	36	—	2 × M8	66	13	6
5	98	125	45	33	40	—	4 × M8	80	13	8

- 1) dimensions in untensioned condition
- 2) transmittable min. rated torque 70% T_{KN}
- 3) transmittable rated torque 100% T_{KN}

subject to technical alterations.

Mounting instructions for ROBA[®]-DX couplings

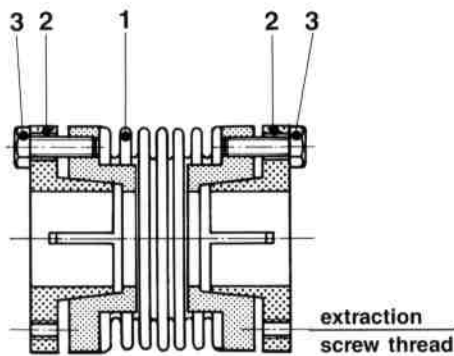


Fig. 5 Type 931.311

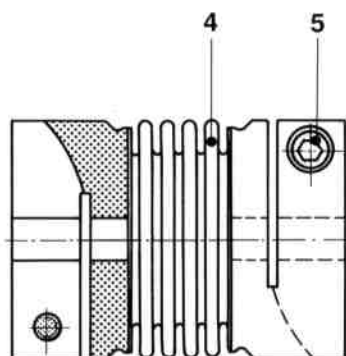


Fig. 6 Type 931.333

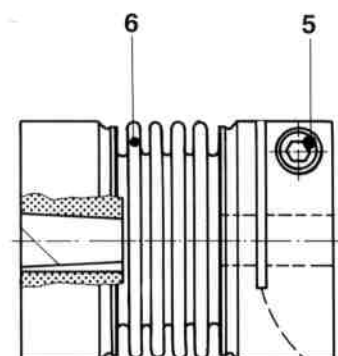


Fig. 7 Type 931.343 (only size 3)

Parts list

- 1 Steel bellows with hubs
- 2 Taper bushing
- 3 Hexagon head cap screw
- 4 Steel bellows with clamping hubs
- 5 Cap screw
- 6 Steel bellows with clamping hub and hub for tapered shaft

Delivery condition

The ROBA[®]-DX steel bellows couplings are supplied ready for installation. The surfaces of taper bushings*, clamping hubs* and hubs are phosphated, the steel bellows are made of stainless steel.

(* bores of the taper bushings and clamping hubs are blank, but phosphated.)

Temperature resistance

The ROBA[®]-DX is an all-steel coupling and, therefore, insensible to temperatures up to +250° C.

General mounting instructions

The bores of the taper bushings and clamping hubs are provided with a H7-tolerance as standard. We recommend a h6-tolerance* for the shaft. The bores or the shafts respectively must **not be lubricated or oiled**. The coating of preservation in the bores must be washed off (petroleum grease, testing benzene, cold cleaning medium or similar).

(* please contact the works for other shaft tolerances.)

Assembly

The output and input shafts must project into the complete length of the taper bushing (2) or clamping hubs (4) respectively (Fig. 8).

The hexagon head cap screws (3) in the taper bushings (2) are tightened diametrically opposite in several steps to the "screw tightening torque" mentioned on table 1. First the taper bushing or clamping hub respectively must be tightened completely before the other one is started.

During tightening of the hexagon head cap screw (3) the taper bushing (2) is pushed into the hub of the steel bellows (1). During tightening of the cap screws (5) (see table 1 for tightening torque) the clamping hub (4) is pressed together. Torque is transmitted due to friction.

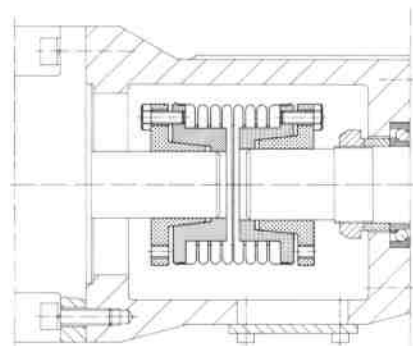


Fig. 8

Mounting examples for ROBA[®]-DX couplings

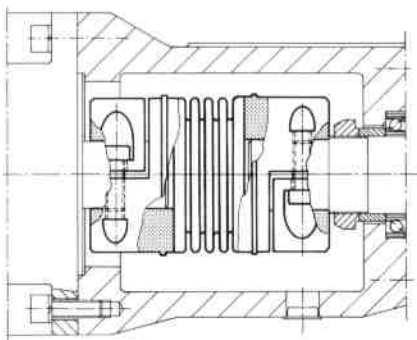


Fig. 9

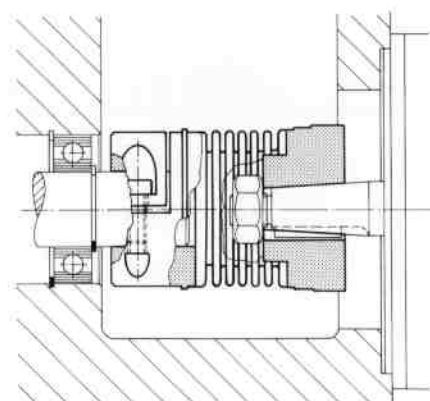


Fig. 10

Dismantling

For dismantling there are two extraction tapped holes in the taper bushings (2) (four for size 5) (figure 5). When all hexagon head cap screws (3) are unscrewed, the taper bushings (2) with the hexagon head cap screws (3) can be pushed out off the hubs of the steel bellows (1).

Before input or output sides are extended to remove the coupling, it must be guaranteed that the shaft-hub-connections are unscrewed to avoid damage to the steel bellows.

For dismantling the clamping hub (4) only the cap screws (5) must be unscrewed. Afterwards the coupling can be removed from the shaft easily.

Permissible shaft misalignments

The ROBA®-DX compensates radial, axial and angular shaft misalignments, Fig. 12. The max. permissible shaft misalignments from table 1 must not achieve simultaneously the max. value. If there are several kinds of misalignments simultaneously, they influence each other, i. e. the permissible value of the misalignment depends on each other according to Fig. 11. The amount of actual misalignments, in percentage of the max. amount, must not exceed 100%.

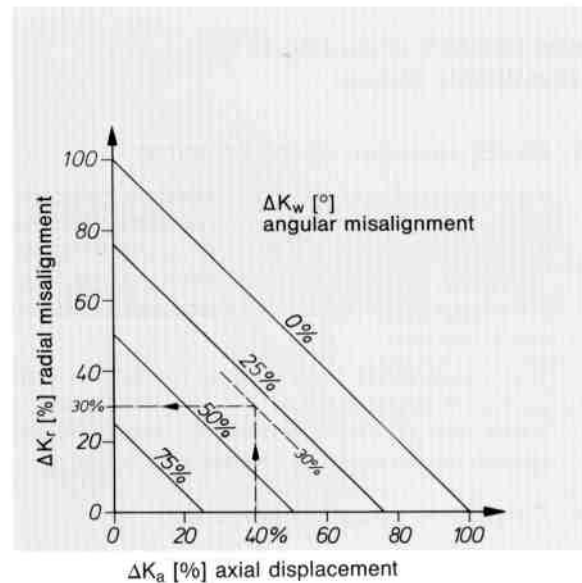
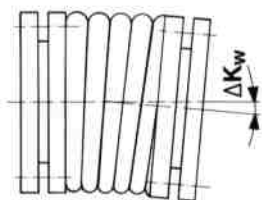
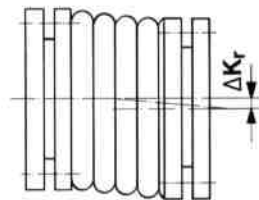


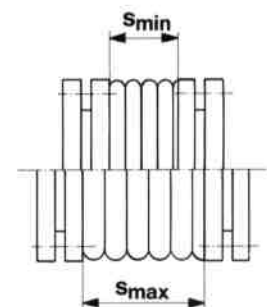
Fig. 11



angular misalignment



radial misalignment



axial displacement

Fig. 12

ROBA®-DX	size	0	1	2	3	4	5
axial displacement ΔK_a	[mm]	$\pm 0,4$	$\pm 0,5$	$\pm 0,6$	$\pm 0,8$	$\pm 1,0$	$\pm 1,2$
radial misalignment ΔK_r	[mm]	0,1	0,1	0,15	0,2	0,25	0,3
angular misalignment ΔK_w	[°]	1,5	2	2	2	2	2
screw tightening torque (3) (Fig. 5)	[Nm]	2,9	2,9	5,5	9,5	17	15
screw tightening torque (5) (Fig. 6)	[Nm]	5	10	18	18	43	87

Table 1

How to select ROBA[®]-DX couplings:

1. Determination according to the transmittable torque:

1.1 Direct selection of the coupling:

If the customer knows all torques effective for the coupling during operation (also short torque peaks) and there are no shaft misalignments and temperatures over 50° C, then a coupling has to be selected whose nominal torque according to the catalogue is over the max. torques existing during operation.

The nominal torque of the coupling corresponds to the permanent changing torque, i. e. the coupling can be loaded up to $\pm T_{KN}$ with a lot of torque changes, whatever desired, without expecting an endurance failure.

1.2 Calculated coupling selection:

If the customer only knows the marginal data of his drive, the following procedure is recommended:

The nominal max. torque determined of the motor power data or of the data of the working machine is calculated to the actual existing application conditions by means of factors.

The following calculation is made:

$$T_{KN} \geq M_{max.} \times f_a \times f_w \times f_t \text{ [Nm]}$$

T_{KN} [Nm] = nominal torque of the coupling according to catalogue

$M_{max.}$ [Nm] = max. drive torque

The value for $M_{max.}$ can be calculated according to the common equations or it can be taken out of the corresponding catalogues.

f_a [-] presents the application factor.
The numerical value is taken from the diagram 1, on which the load characteristic value f_B (page 9), and the group of the drive are considered.

f_w [-] represents the so-called misalignment factor (diagram 2). This results from the amount of all shaft misalignments ΔK_w (see page 7, fig. 11) of a ROBA[®]-DX coupling and must be considered when selecting the coupling.

f_t [-] must be considered with temperatures over 50° C. This can be taken from diagram 3.

Ask Mayr!

Mayr offers a variety of other solutions. If you don't find optimum solution in our programme, please do not hesitate to contact our engineer for making your custom designed modification.

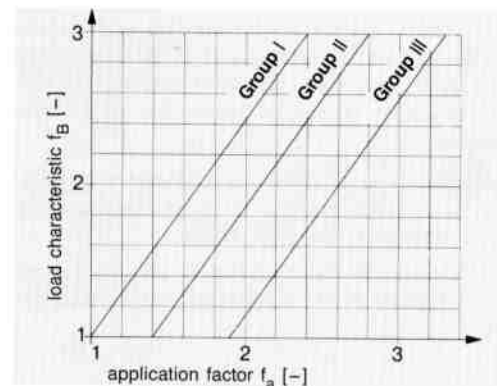


Diagram 1

Design of the drive unit (diagram 1):

Group I: electric motors, steam turbines, gas turbines, hydraulic motors.

Group II: reciprocating machines with more than two cylinders, water turbines.

Group III: reciprocating engines with one or two cylinders.

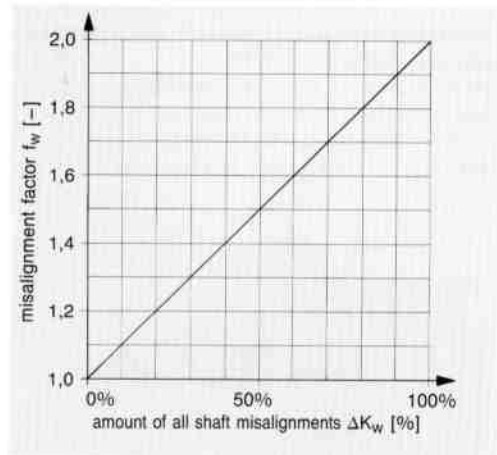


Diagram 2

Misalignment factor f_w (diagram 2):

The misalignment factor results from the amount of all shaft misalignments ΔK_w (see page 7, fig. 11) of a ROBA[®]-DX.

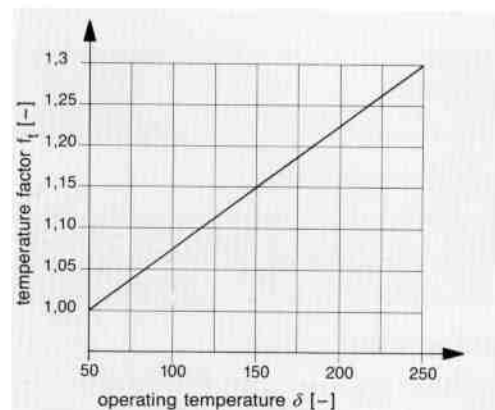


Diagram 3

Temperature factor f_t (diagram 3):

The ROBA[®]-DX couplings are unaffected by temperature. The temperature factor f_t , however, must be considered with temperatures over 50° C when selecting the size.

How to select ROBA®-DX couplings

2. Selection according to the torsional spring rigidity of the coupling

2.1 Static design

In case of very high requirements regarding the accuracy of the torsional angular transmission of the coupling, its flexible deformation depending on the max. transmittable torque presents a design criterion which, compared to the selection according to the torque, may cause a selection of a bigger size.

The flexible twisting of the coupling can be determined according to the following equation:

$$\alpha = \frac{180}{\pi} \times \frac{1}{C_t} \times M_{max.} \quad [^\circ]$$

C_t [Nm/rad] = torsional spring rigidity of the coupling

M_{LK} [Nm] = max load torque effective on the coupling

2.2 Dynamic design

Normally drive units consisting of motor, coupling and drive elements with coupled rotational or linearly moved masses can be considered as a 2 mass system.

A typical machine tool example is shown on fig. 13.

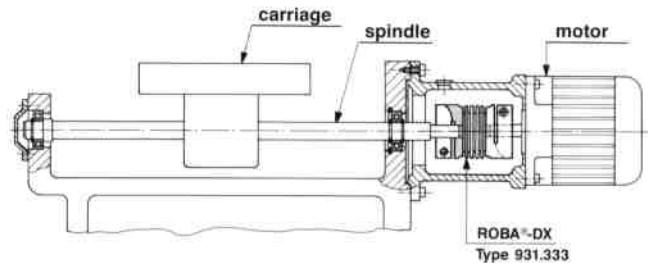


Fig. 13

The natural frequency of such a system can be calculated according to following equation:

$$f_{res} = \frac{1}{2\pi} \times \sqrt{C_t \times \frac{I_{mot} + I_{mach}}{I_{mot} \times I_{mach}}} \quad [Hz]$$

C_t [Nm/rad] = torsional spring rigidity of the coupling

I_{mot} [kgm²] = mass moment of inertia of the drive motor

I_{mach} [kgm²] = mass moment of inertia of the driven component

Ensure that the mass moment of inertia of the coupling is added by half each to the input or output components respectively.

Rotating or linearly moved masses existing at the output side can be reduced to the output shaft by means of corresponding equations.

The natural frequency of the system being able to vibrate should be at least at 1,3- to 1,5-times of the value of the excitation frequency which is supported by the high torsional spring rigidity values of the ROBA®-DX couplings.

The excitation frequencies are for example with inputs of machine tools between 150 and 400 Hz.

Further it should be tried to achieve the value "1" for such kinds of drives as ratio of the mass moment of inertias in input and output.

Load characteristics numbers f_B

f_B	machine	f_B	machine
2	construction machines	2	paper machines
1,5	chemical industry	2	pulp grinders
1,5	agitators (viscuous liquids)	2	calendars
1,5	agitators (flooding liquids)	2	suction rolls
1,5	centrifuges		pumps
2	pipeline pumps	1,8	centrifugal pumps
	conveying plants	2	reciprocating pumps
2	freight elevators	2	positive-displacement pumps
2	passenger elevators		compressors
1,5	conveyors	2,5	reciprocating compressors
2	blowers, fans	1,5	turbo compressors
1,5	generators		rolling mills
	plastic processing	3	shears
2,5	extruders	3	cold-rolling mills
2	blenders	2,5	wire drawing machines
	wood working machines	3	continuous casting plants
2	crane systems		washing machines
	metal working machines		nonmetallic minerals
2	machine tools	3,5	mills, crushers
3	stamping machines, presses	2	rotary furnaces
	food processing		
3	mills		
2	kneading machines		
1,5	packaging machines		

Table 2

Calculation example for ROBA[®]-DX coupling selection

Given data: Machine tools with following data:

Drive unit:	AC servo motor	power	P_N	=	2 [kW]
		nominal speed	n_N	=	1500 [rpm]
		nominal torque	M_N	=	12,7 [Nm]
		max. torque	$M_{N\ max}$	=	84 [Nm]
		motor mass moment of inertia	I_{mot}	=	0,010 [kgm ²]

Output unit: Ball screw spindle coupled directly through ROBA[®]-DX coupling

Mass moment of inertia reduced on spindle resulting from carriage and spindle $I_{mach} = 0,008$ [kgm²]

Misalignments: 30%

Max. ambient temperature: 50° C

Required: 1. Determination of the required coupling size

$$T_{KN} \geq M_{max.} \times f_b \times f_w \times f_t$$

Application factor f_a :

design of the drive unit: electro motor, group I
load characteristic: $f_b = 2$ (table 2, machine tools)
application factor: $f_a = 1,70$ (diagram 1)
misalignment factor: $f_w = 1,3$ (diagram 2)

Temperature factor f_t $f_t = 1$ (diagram 3)

$$T_{KN} \geq 84 \text{ Nm} \times 1,7 \times 1,3 \times 1 = \underline{\underline{185,6 \text{ Nm}}}$$

Selected coupling: ROBA[®]-DX size 3, Type 931.311

$T_{KN} = 200 \text{ Nm}$
with torsional spring rigidity $C_t = 53 \times 10^3 \text{ Nm/rad}$
with mass moment of inertia $I_K = 0,000752 \text{ kgm}^2$

2. Flexible twisting of the coupling with max. drive torque

$$\alpha = \frac{180}{\pi} \times \frac{1}{C_t} \times M_{max.}$$

$$\alpha = \frac{180}{\pi} \times \frac{1}{53000 \text{ Nm/rad}} \times 84 \text{ Nm} = 0,09^\circ$$

3. Design regarding the vibration of the coupling

Consideration of the drive as 2-mass system

Natural frequency of the system:

$$f_{res} = \frac{1}{2\pi} \times \sqrt{C_t \times \frac{I_{mot} + I_{mach}}{I_{mot} \times I_{mach}}}$$

Half the coupling mass moment of inertia has to be added to both motor and spindle inertias.

$$f_{res} = \frac{1}{2\pi} \times \sqrt{53000 \text{ Nm/rad} \times \frac{(0,010 + 0,00038) \text{ kgm}^2 + (0,008 + 0,00038) \text{ kgm}^2}{(0,010 + 0,00038) \text{ kgm}^2 \times (0,008 + 0,00038) \text{ kgm}^2}}$$

$$f_{res} = \mathbf{538 \text{ Hz}}$$

For the expected excitation frequency of 150–400 Hz sufficient distance is available.