Technical Data

Technical Notes

DIN 69 051, Part 1 defines a ball screw as follows:

An assembly comprising a ball screw shaft and a ball nut and which is capable of converting rotary motion into linear motion and vice versa. The rolling elements of the assembly are balls.

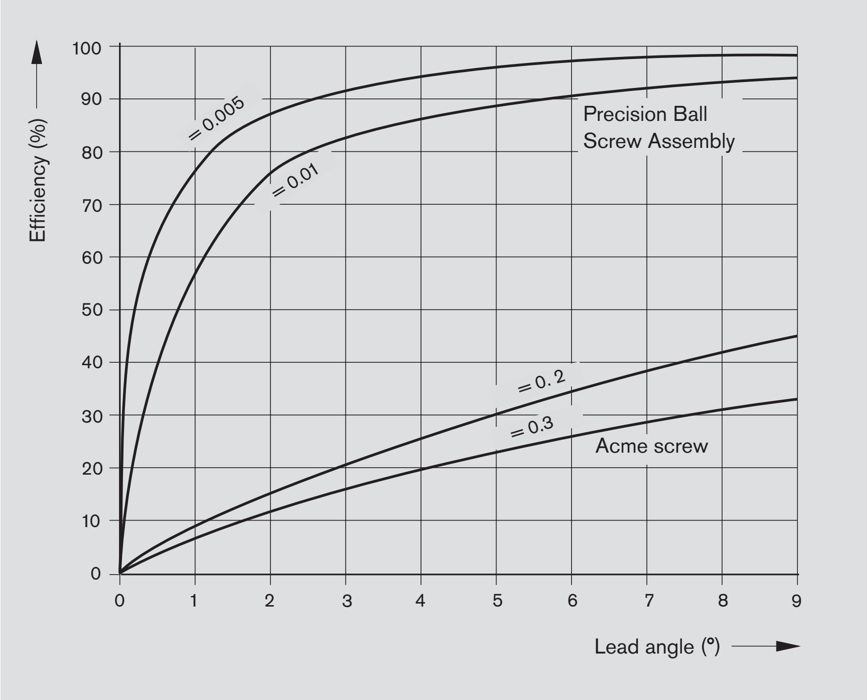
Advantages over the Acme screw drive

- The mechanical efficiency of an Acme screw drive is a maximum 50%, whereas a ball screw can reach a mechanical efficiency of up to 98%.
- Higher life expectancy due to negligible wear during operation
- Less drive power required
- No stick-slip effect
- More precise positioning
- Higher travel speed
- Less heat-up

Due to their high mechanical efficiency, ball screws are in principle not self-locking.

⚠ **Safety information**

For vertically installed assemblies, customers should check whether separate protection against falling loads, e.g. a safety nut, is required.
We recommend that a safety nut be installed for particularly critical applications in vertical set-ups.
Please ask.



Selection criteria for ball screws

The following factors should be considered when selecting the ball screw for a given application:

- degree of accuracy required (lead deviation)
- in-service load conditions
- service life
- critical speed
- buckling load
- rigidity/permissible clearance or desired preload
- characteristic speed (max. permissible linear speed)

The following points should be taken into consideration when selecting a ball screw assembly that is to be both cost-efficient and optimally designed:

- The lead is a decisive factor for the load-carrying capacity (depending on the maximum possible ball diameter) and the drive moment.
- The calculation of the service life should be based on average loads and average speeds, not on maximum values.
- In order for us to provide you with a customized solution, installation drawings or sketches of the ball nut environment should be enclosed with your inquiry.

⚠ **Note**

Radial and eccentric forces relative to the screw must be avoided as they have a negative effect on the life and proper function of the ball screw.

Where special conditions of use are involved, please ask.

Load-carrying capacities and service life
We calculate load-carrying capacities and service life in accordance with DIN 69 051, Part 4 and ISO 3408-4 (P5).

Basic static load rating C_0
The static load rating is an axial, concentrically acting force that induces a per-manent deformation of 0.0001 x the ball diameter between the ball and the ball raceway.

Basic dynamic load rating C
The dynamic load rating is an axial, concentrically acting force of constant magnitude and direction under which 90% of a sufficiently large amount of identical ball screws can achieve a nominal service life of one million revolutions.

Service life
The nominal life is expressed by the number of revolutions (or number of operating hours at constant speed) that will be attained or exceeded by 90% of a representative sample of identical ball screws before the first signs of material fatigue become evident. The nominal life is designated as L or L_h, depending on whether it is specified in revolutions or hours.

Short stroke
During a short stroke, the ball does not make a real turn. It is therefore impossible for an adequate lubricating film to form. This may result in premature wear. In the chart, the minimum required stroke (travel) for a 10% lower load rating is shown as a function of the number of turns and lead of the nut. Hence the most favorable range lies above each curve. It may help to have occasional longer strokes, which are performed with simultaneous relubrication as “lubricating strokes”. If in doubt, please ask.

Critical speed and buckling load
The critical speed and buckling load can be checked using the corresponding charts.
For precise calculations see formula 12 15, in “Design Calculations”

Characteristic speed $d_0 \cdot n$
Rexroth ball screws can be operated at very high speeds due to their internal ball recirculation system. Characteristic speeds of up to 150,000 are possible depending on the nut type.

$d_0 \cdot n \leq$ 150,000
$d_0 \cdot n \leq$ 80,000 (for eLINE and ECOplus series)
d_0 = nominal diameter (mm)
n = speed (min^{-1})

The theoretically possible maximum linear speed v_{max} (m/min) is specified on the page featuring the relevant nut. Actually attainable speeds are heavily dependent among other factors on preload and duty cycle. They are gen-erally restricted by the critical speed. (See “Design Calculations”)

Material, hardness
Our standard ball screw assemblies are made of high-quality, heat-treatable steel, carbon chrome alloy steels or case-hardened steels. The screw and nut raceways have a minimum Rockwell hardness of HRC 60. Ball screw assemblies made of corrosion-resistant steel (DIN EN ISO 683-17) are also available upon request. Unless otherwise specified, the screw ends are not hardened.

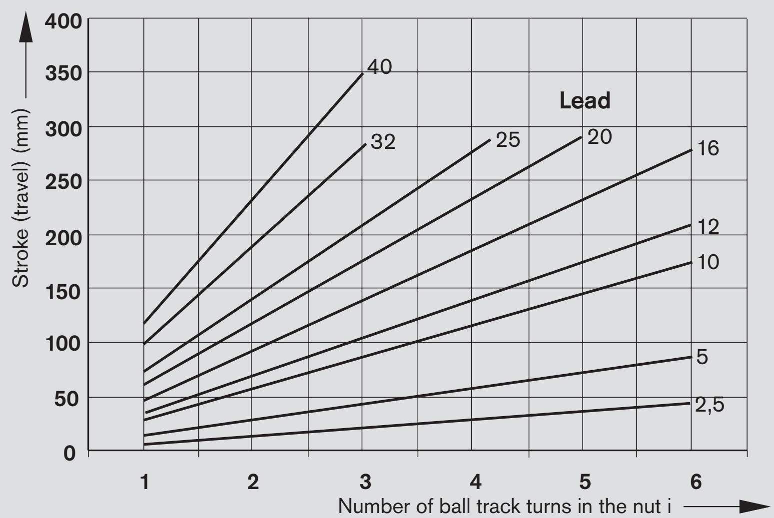
Sealing
Ball screws are precision assemblies that require protection against contamination. Flat protective covers and bellows type dust boots or the drive unit AGK are particularly suitable for this purpose. As there are many applications in which these methods do not provide sufficient protection, we have developed a gapless lip-type seal which ensures an optimal sealing effect and maintains high efficiency due to the low friction level. Our ball screws are therefore supplied with seals in their standard versions. At the customer’s request, these seals can be omitted or special seals used in their place. A reinforced version of the standard seal has been developed for those applications where heavy contamination of the screw ap-pears inevitable. The sealing effect has been improved further by increasing the preload. What must be borne in mind is the significantly higher friction torque in comparison with the standard friction torque (see Technical Data) and the associated increased heat build-up. The reinforced seal can be easily recognized externally by its dark green color.

Permissible operating temperatures
Ball screws are suitable for continuous operation at temperatures up to 80°C with temporary peaks of 100°C (measurements taken on the outer shell of the nut).

Permissible operating temperatures:
$-10°C \leq T_{operating} \leq 80°C$

Permissible bearing temperature:
$-15°C \leq T_{bearing} \leq 80°C$

Short stroke limit (load rating reduced by less than 10%)

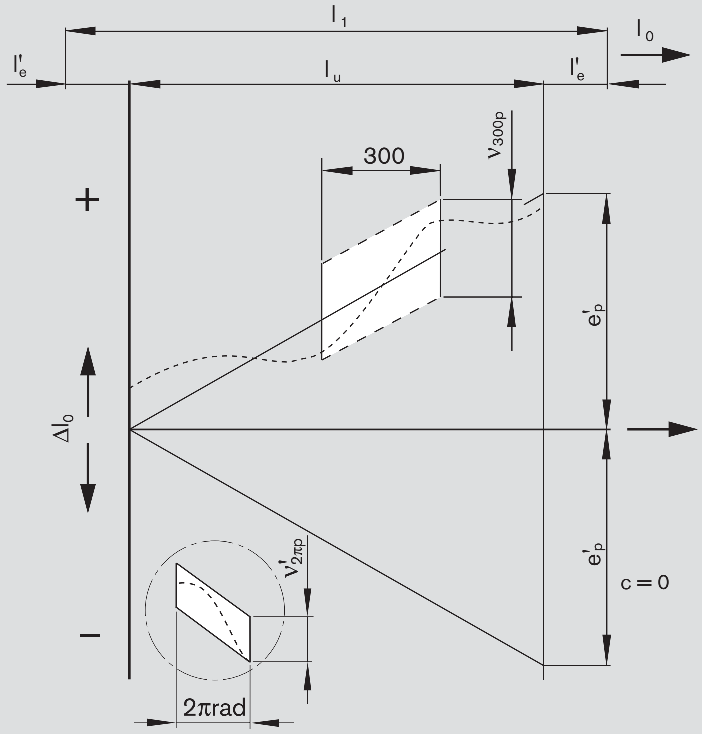


Technical Data

Acceptance Conditions and Tolerance Grades

Note: For eLINE Ball Screws, please refer to the data given in the "eLINE Ball Screw Assemblies" section.

T **Ball screw with precision-rolled screw SN-R**



Permissible travel deviation

in accordance with DIN 69 051, Part 3 and ISO 3408-3
Many values are significantly more accurate than those defined in DIN 69 051, Part 3 and ISO 3408-3.

Symbol definitions (excerpt):

- l_0 = nominal travel
- l_1 = thread length
- Δl_0 = travel deviation
- l_u = useful travel
- l'_e = excess travel (the closer tolerances for travel and hardness do not apply here)
- c = travel compensation (target travel deviation) (standard: c = 0)
- e'_p = tolerance mean actual travel deviation
- ν_{300p} = permissible travel deviation within 300 mm travel
- $\nu'_{2\pi p}$ = permissible travel deviation within one revolution

Improved values compared with DIN 69 051, Part 3 and ISO 3408-3 (tolerance reduced by half)

Useful travel l_u		tolerance mean actual travel deviation e'_p (µm) Tolerance grade		
>	≤	5	7	9
0	**100**	18	44	110
100	**200**	20	48	130
200	**315**	23	52	150
315		$e'_p = \frac{l_u}{300} \cdot \nu_{300p}$		

For precision screws SN-R the following values apply in all cases:

ν_{300p} (µm) Tolerance grade		
5	**7**	**9**
23	52	130

$\nu'_{2\pi p}$ (µm) Tolerance grade		
5	**7**	**9**
8	10	10

Non-usable length l'_e
(Excess travel)
Modified with respect to DIN 69051.

d_0 (mm)	l'_e (mm)
8	15
12, 16	20
20, 25, 32, 40	40
50, 63, 80	50

Minimum number of measurements within 300 mm (measuring interval) and excess travel to be taken into consideration

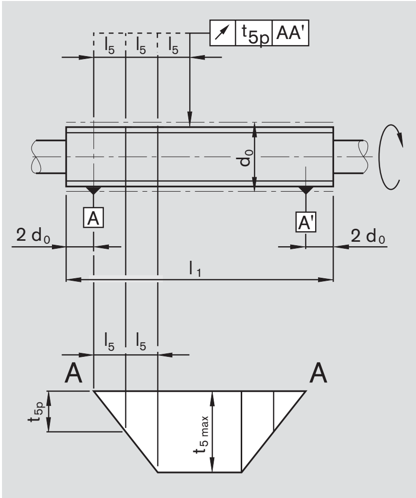
Lead P	Minimum number of measurements for tolerance grade		
(mm)	**5**	**7**	**9**
2.5	10	5	5
5	6	3	3
10	3	1	1
16	3	1	1
20	3	1	1
25	3	1	1
32	2	1	1
40	1	1	1

Technical Data

Acceptance Conditions and Tolerance Grades

Run-outs and location deviations based on DIN 69 051, Part 3 and ISO 3408-3

Radial run-out t_5 of the outer diameter of the ball screw shaft over the length l_5 used to determine the straightness in relation to AA'.

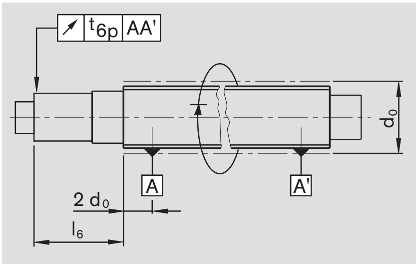


d_0		l_5	t_{5p} in µm for l_5 for tolerance grade	
above	up to		5	7; 9
= 6	12	80	32	40
12	25	160		
25	50	315		
50	100	630		
100	200	1250		

l_1/d_0		t_{5max} in µm for $l_1 \geq 4l_5$ for tolerance grade	
above	up to	5	7; 9
	40	64	80
40	60	96	120
60	80	160	200
80	100	256	320

Radial run-out t_6 of the bearing diameter in relation to AA' for $l_6 \leq l$.
Table value t_{6p} applies when $l_6 \leq$ reference length l.

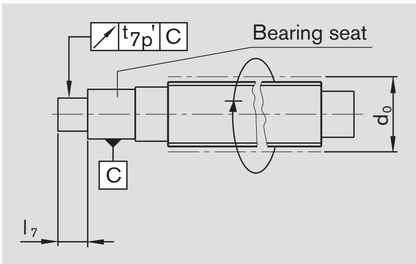
Where $l_6 > l$ then $t_{6a} \leq t_{6p} \cdot \frac{l_{6a}}{l}$



Nominal diameter d_0		Reference length l	t_{6p} in µm for $l_6 \leq l$ for tolerance grade
above	up to		5; 7; 9
= 6	20	80	20
20	50	125	25
50	125	200	25
125	200	315	25

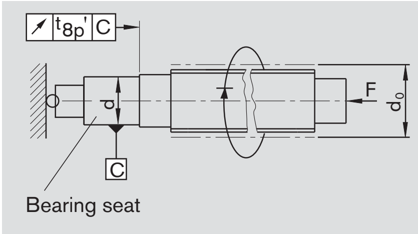
Coaxial deviation t_7' of the journal diameter of the ball screw shaft in relation to the bearing diameter for $l_7 \leq l$.
Table value t_{7p} applies when $l_7 \leq$ reference length l.

Where $l_7 > l$ then $t_{7a} \leq t_{7p} \cdot \frac{l_{7a}}{l}$



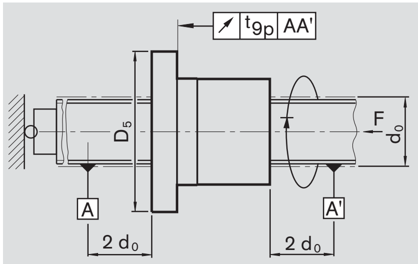
Nominal diameter d_0		Reference length l	t_{7p}' in µm for $l_7 \leq l$ for tolerance grade
above	up to		5; 7; 9
= 6	20	80	6
20	50	125	6
50	125	200	7
125	200	315	12

Axial run-out $\mathbf{t_8}$' of the shaft (bearing) face of the ball screw shaft in relation to the bearing diameter.



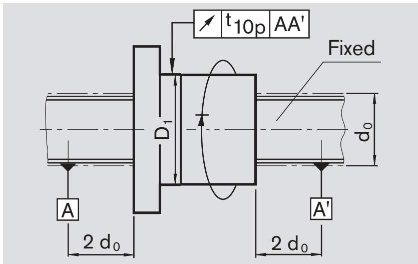
Nominal diameter d_0		t_{8p}' in µm for tolerance grade
above	up to	5; 7; 9
= 6	63	5
63	125	6
125	200	8

Axial run-out t_9 of the ball nut location face in relation to **A** and **A'** (for preloaded ball nuts only).



Flange diameter D_5		t_{9p} in µm for tolerance grade
above	up to	5; 7; 9
16	32	16
32	63	20
63	125	25
125	250	32
250	500	40

Radial run-out $\mathbf{t_{10}}$ of the outer diameter $\mathbf{D_1}$ of the ball nut in relation to A and **A'** (for preloaded and rotating ball nuts only). Fix screw against rotation before carrying out the measurement.



Outer diameter D_1		t_{10p} in µm for tolerance grade
above	up to	5; 7; 9
16	32	16
32	63	20
63	125	25
125	250	32
250	500	40

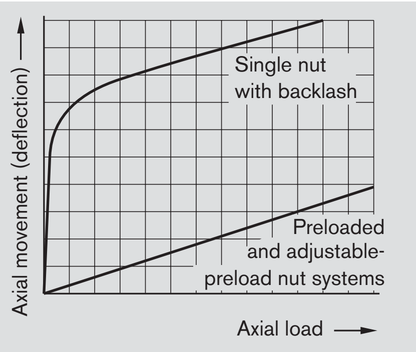
Please ask for details of permissible axial and radial run-out for driven nuts.

Technical Data

Preload and Rigidity

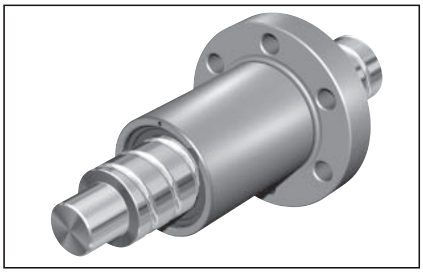
Nut system preload

In addition to single nuts with reduced backlash, Rexroth supplies preloaded or adjustable-preload nut systems.

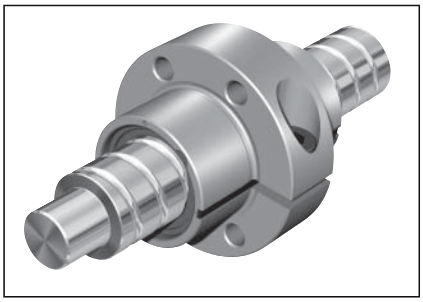


The rigidity of these types of Rexroth nut systems is approximately the same at the same preload. This is because the adjustable-preload single nut and the preloaded single nut have a much more compact design. The screw is typically far less rigid than the nut unit (for details see “Overall axial rigidity...”).

Preloaded single nut
Single nuts can be preloaded to 2%,3% or 5% of the basic dynamic load rating by means of optimized ball size selection.

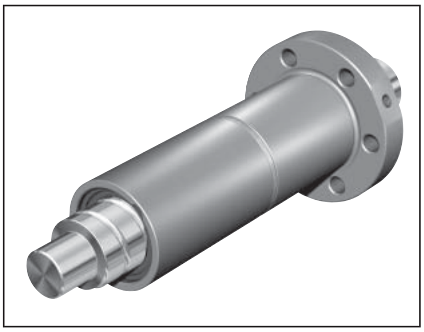


Adjustable-preload single nut
The adjustable-preload single nut allows cost-efficient design techniques to be implemented in a large number of applications. The radial clearance and preload are adjusted radially via a slot approx. 0.1 mm wide, see section “Mounting”. Depending on the application, we will preload the nut system to 2%, 3% or 5% of the basic dynamic load rating. The maximum preload equals approx. 5% of the basic dynamic load rating.

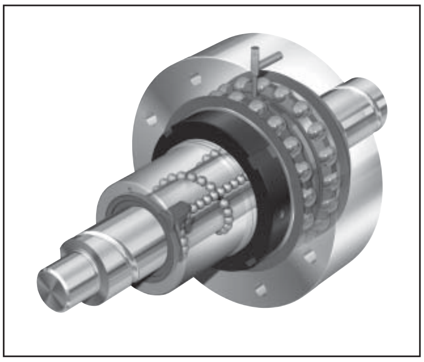


2-start single nut with flange
The 2-start single nut with flange is optimally preloaded to 2% or 3% of the dynamic load rating by means of ball size selection.

Double nut
Tensioning two single nuts against each other eliminates the inherent backlash of the ball screw, increases rigidity and thus improves positioning accuracy.
As excessive preload can cause a reduction in service life, we recommend that it not be more than $^1/_3$ of the average operating load. Depending on the application, we will preload the nut system to 7% or 10% of the basic dynamic load rating.



Driven nut
Like the single nut, the driven nut from the “Drive Units” catalog R310EN 3304 can be preloaded to 2%, 3% or 5% of the basic dynamic load rating by means of ball size selection.



Overall rigidity

The rigidity of a ball screw is also influenced by all adjoining parts such as bearings, housing bores, nut housings etc.

Overall axial rigidity R_{bs} of the ball screw

The overall axial rigidity $\mathbf{R_{bs}}$ is comprised of the component rigidity of the bearing $\mathbf{R_{fb}}$, the screw $\mathbf{R_S}$ and the nut unit $\mathbf{R_{nu}}$.

$$\frac{1}{R_{bs}} = \frac{1}{R_{fb}} + \frac{1}{R_S} + \frac{1}{R_{nu}} \quad (16)$$

Note:

Please note that in most cases the rigidity $\mathbf{R_S}$ of the screw will be significantly lower than the rigidity $\mathbf{R_{nu}}$ of the nut unit. In an assembly with a diameter of 40 x 10, for example, the rigidity $\mathbf{R_{nu}}$ of the nut unit is 2 to 3 times higher than the rigidity $\mathbf{R_S}$ of a screw with a length of 500 mm.

Rigidity of the bearing R_{fb}

The rigidity of the bearings corresponds to the values found in the bearing manufacturer's catalog.

See the corresponding tables in this catalog for rigidity values of the bearings offered by Rexroth.

Rigidity in the area of the nut unit R_{nu}

The rigidity in the area of the nut unit is calculated according per DIN 69 051 (P5).

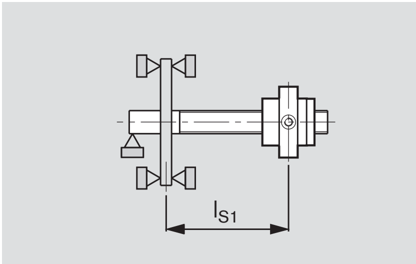
See the corresponding tables for rigidity values.

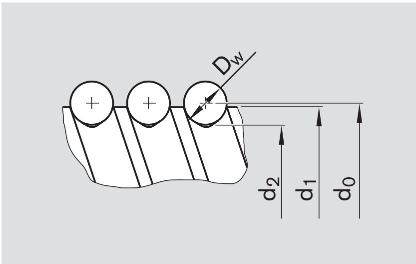
Rigidity of the screw R_S

The rigidity of the screw $\mathbf{R_S}$ depends on the type of bearing used.

See the corresponding tables for rigidity values.

1 Ball screw shaft is fixed at one end.

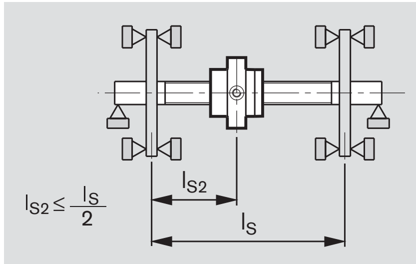




$$R_{S1} = 165 \cdot \frac{(d_0 - 0.71 \cdot D_W)^2}{l_{S1}} \quad (N/\mu m) \quad (17)$$

$\mathbf{R_{S1}}$	=	rigidity of the screw	(N/µm)
$\mathbf{d_0}$	=	nominal diameter	(mm)
$\mathbf{D_W}$	=	ball diameter	(mm)
$\mathbf{l_{S1}}$	=	distance between bearing and nut	(mm)

2 Ball screw shaft is fixed at both ends.



$$R_{S2} = 165 \cdot \frac{(d_0 - 0.71 \cdot D_W)^2}{l_{S2}} \cdot \frac{l_S}{l_S - l_{S2}} \quad (N/\mu m) \quad (18)$$

The lowest screw rigidity $\mathbf{R_{S2min}}$ occurs at the center of the screw ($l_{S2} = l_S/2$) and thus equals:

$$R_{S2min} = 660 \cdot \frac{(d_0 - 0.71 \cdot D_W)^2}{l_S} \quad (N/\mu m) \quad (19)$$

$\mathbf{R_{S2}}$	=	rigidity of the screw	(N/µm)
$\mathbf{d_0}$	=	nominal diameter	(mm)
$\mathbf{D_W}$	=	ball diameter	(mm)
$\mathbf{l_S}$	=	distance between bearing and bearing	(mm)
$\mathbf{l_{S2}}$	=	distance between bearing and nut	(mm)

Technical Data

Preload and Overall Rigidity of Single Nuts

Dynamic drag torque, preload and rigidity for screws of tolerance grade 5-7 with single nuts from diameter 16 mm (smaller diameters without backlash only) FSZ-E-S, FEP-E-S (2% only), FEM-E-S, FEM-E-C, ZEM-E-S; SEM-E-S and SEM-E-C (consider centering diameter D_1 to be set) (ZEV-E-S and FBZ-E-S with backlash only!)

- T_0 = overall dynamic drag torque
- T_0 = $T_{pr0} + T_{RD}$
- C = basic dynamic load rating
- C_0 = basic static load rating
- T_{RD} = dynamic drag torque of 2 seals
- R_S = rigidity of the screw
- R_{nu} = rigidity of the nut
- T_{pr0} = dynamic drag torque without a seal
- d_0 = nominal diameter
- P = lead
- D_w = ball diameter
- i = number of ball track turns

The values given for dynamic drag torque are proven practical indicators for the nut preloading.

Note:
Measurement of the dynamic load torque, see "Mounting."

Size	Load ratings		Backlash of single nut		Overall rigidity of the screw
D_0 x P x D_W - i	dyn. C (N)	stat. C_0 (N)	Standard	Reduced	R_S $\left(\frac{N \cdot m}{\mu m}\right)$
6 x 1R x 0.8 - 4	900	1290	0.01	0.005	5
6 x 2R x 0.8 - 4	890	1280	0.01	0.005	5
8 x 1R x 0.8 - 4	1020	1740	0.01	0.005	9
8 x 2R x 1.2 - 4	1870	2760	0.01	0.005	9
8 x 2.5R x 1.588 - 3	2200	2800	0.02	0.010	8
12 x 2R x 1.2 - 4	2240	4160	0.01	0.005	21
12 x 5R x 2 - 3	3800	5800	0.02	0.010	18
12 x 10R x 2 - 2	2500	3600	0.02	0.010	18
16 x 5R/L x 3 - 4	12300	16100	0.04	0.020	32
16 x 10R x 3 - 3	9600	12300	0.04	0.020	32
16 x 16R x 3 - 2	6300	7600	0.04	0.020	32
16 x 16R x 3 - 3	9300	12000	0.04	0.020	32
20 x 5R/L x 3 - 4	14300	21500	0.04	0.020	53
20 x 5R x 3 - 5	17500	27300	0.04	0.020	53
20 x 10R x 3 - 4	14100	21300	0.04	0.020	53
20 x 20R/L x 3.5 - 2	9100	12100	0.04	0.020	52
20 x 20R x 3.5 - 3	13300	18800	0.04	0.020	52
20 x 40R x 3.5 - 1 x 4	14000	26200	0.04	0.020	52
25 x 5R/L x 3 - 4	15900	27200	0.04	0.020	86
25 x 10R x 3 - 4	15700	27000	0.04	0.020	86
25 x 25R/L 3.5 - 2	10100	15100	0.04	0.020	84
25 x 25R x 3.5 - 3	14700	23300	0.04	0.020	84
25 x 25R x 3.5 -1.2 x 4	19700	39400	0.04	0.020	84
32 x 5R/L x 3.5 - 4	21600	40000	0.04	0.020	144
32 x 10R x 3.969 - 5	31700	58300	0.04	0.020	141
32 x 20R x 3.969 - 2	13500	21800	0.04	0.020	141
32 x 20R x 3.969 - 3	19700	33700	0.04	0.020	141
32 x 32R x 3.969 - 2	13400	22000	0.04	0.020	141
32 x 32R x 3.969 - 3	19500	34000	0.04	0.020	141
32 x 32R x 3.969 -1.2 x 4	26300	57600	0.04	0.020	141
32 x 64R x 3.969 -1 x 4	21100	49000	0.04	0.020	141
40 x 5R/L x 3.5 - 5	29100	64100	0.04	0.020	232
40 x 10R/L x 6 - 4	50000	86400	0.07	0.035	211
40 x 10R x 6 - 6	72100	132200	0.07	0.035	211
40 x 12R x 6 - 4	49900	86200	0.07	0.035	211
40 x 16R x 6 - 4	49700	85900	0.07	0.035	211
40 x 20R x 6 - 3	37900	62800	0.07	0.035	211
40 x 20R x 6 - 4 x 2	76400	171100	0.07	0.035	211
40 x 40R x 6 - 2	25500	40300	0.07	0.035	211
40 x 40R x 6 - 3	37000	62300	0.07	0.035	211
40 x 40R x 6 - 3 x 2	57200	124500	0.07	0.035	211
50 x 5R x 3.5 - 5	32000	81300	0.04	0.020	373
50 x 10R x 6 - 4	55400	109000	0.07	0.035	345
50 x 10R x 6 - 6	79700	166500	0.07	0.035	345
50 x 12R x 6 - 6	79600	166400	0.07	0.035	345
50 x 16R x 6 - 6	79400	166000	0.07	0.035	345
50 x 20R x 6.5 - 3	47900	87900	0.07	0.035	340
50 x 20R x 6.5 - 5	75700	149700	0.07	0.035	340
50 x 20R x 6.5 - 4 x 2	93200	228000	0.07	0.035	340
50 x 25R x 6.5 - 3 x 2	74100	175100	0.07	0.035	340
50 x 40R x 6.5 - 2	32100	55800	0.07	0.035	340
50 x 40R x 6.5 - 3 x 2	71400	171500	0.07	0.035	340
50 x 40R x 6.5 - 3	46500	85900	0.07	0.035	340
63 x 10R x 6 - 4	61800	140500	0.07	0.035	569
63 x 10R x 6 - 6	88800	214300	0.07	0.035	569
63 x 20R x 6.5 - 3	53200	112100	0.07	0.035	563
63 x 20R x 6.5 - 5	83900	190300	0.07	0.035	563
63 x 20R x 6.5 - 4 x 2	104600	292000	0.07	0.035	563
63 x 40R x 6.5 - 2	36900	74300	0.07	0.035	563
63 x 40R x 6.5 - 3	53400	114100	0.07	0.035	563
63 x 40R x 6.5 - 3 x 2	80000	217000	0.07	0.035	563
80 x 10R x 6.5 - 6	108400	291700	0.07	0.035	938
80 x 20R x 12.7 - 6	262700	534200	0.11	0.055	832

Size	Screws with single nuts									
	2% preload		3% preload			5% preload				
	R_{nu} (N/µm)	T_{pr0} (Nm)	R_{nu} (N/µm)	T_{pr0} (Nm)		R_{nu} (N/µm)	T_{pr0} (Nm)			
		Tolerance grade 5; 7		Tolerance grade 5; 7			Tolerance grade 5		Tolerance grade 7	
D_0 x P x D_W - i	max.	max.		min.	max.		min.	max.	min.	max.
6 x 1R x 0.8 - 4	–	–	–	–	–	–	–	–	–	–
6 x 2R x 0.8 - 4	–	–	–	–	–	–	–	–	–	–
8 x 1R x 0.8 - 4	–	–	–	–	–	–	–	–	–	–
8 x 2R x 1.2 - 4	–	–	–	–	–	–	–	–	–	–
8 x 2.5R x 1.588 - 3	70	0.004	–	–	–	–	–	–	–	–
12 x 2R x 1.2 - 4	110	0.005	–	–	–	–	–	–	–	–
12 x 5R x 2 - 3	100	0.009	–	–	–	–	–	–	–	–
12 x 10R x 2 - 2	60	0.006	–	–	–	–	–	–	–	–
16 x 5R x 3 - 4	210	0.040	240	0.020	0.10	280	0.05	0.15	0.04	0.16
16 x 10R x 3 - 3	160	0.030	190	0.010	0.08	220	0.04	0.12	0.03	0.12
16 x 16R x 3 - 2	100	0.020	120	0.005	0.06	140	0.03	0.08	0.02	0.08
16 x 16R x 3 - 3	160	0.030	180	0.010	0.08	210	0.04	0.11	0.03	0.12
20 x 5R/L x 3 - 4	260	0.060	300	0.030	0.14	350	0.07	0.21	0.06	0.23
20 x 5R x 3 - 5	330	0.070	375	0.040	0.17	440	0.09	0.26	0.07	0.28
20 x 10R x 3 - 4	260	0.060	300	0.030	0.14	350	0.07	0.21	0.06	0.23
20 x 20R/L x 3.5 - 2	130	0.040	150	0.020	0.09	180	0.05	0.14	0.04	0.15
20 x 20R x 3.5 - 3	200	0.050	220	0.030	0.13	270	0.07	0.20	0.05	0.21
20 x 40R x 3.5 - 1 x 4	215	0.060	–	–	–	–	–	–	–	–
25 x 5R/L x 3 - 4	310	0.080	350	0.040	0.20	410	0.10	0.30	0.08	0.32
25 x 10R x 3 - 4	320	0.080	360	0.040	0.19	430	0.10	0.29	0.08	0.31
25 x 25R/L x 3.5 - 2	160	0.050	180	0.030	0.12	210	0.06	0.19	0.05	0.20
25 x 25R x 3.5 - 3	240	0.070	270	0.040	0.18	320	0.09	0.28	0.07	0.29
25 x 25R x 3.5 -1.2 x 4	350	0.100	–	–	–	–	–	–	–	–
32 x 5R/L x 3.5 - 4	380	0.140	420	0.100	0.31	500	0.24	0.45	0.21	0.48
32 x 10R x 3.969 - 5	500	0.200	570	0.150	0.46	670	0.36	0.66	0.30	0.71
32 x 20R x 3.969 - 2	200	0.090	230	0.050	0.21	270	0.15	0.28	0.13	0.30
32 x 20R x 3.969 - 3	300	0.130	340	0.070	0.31	410	0.22	0.41	0.19	0.44
32 x 32R x 3.969 - 2	200	0.090	220	0.050	0.21	260	0.15	0.28	0.13	0.30
32 x 32R x 3.969 - 3	300	0.120	340	0.070	0.31	400	0.22	0.41	0.19	0.44
32 x 32R x 3.969 -1.2 x 4	440	0.170	–	–	–	–	–	–	–	–
32 x 64R x 3.969 -1 x 4	330	0.140	–	–	–	–	–	–	–	–
40 x 5R/L x 3.5 - 5	550	0.230	620	0.170	0.52	720	0.41	0.76	0.35	0.81
40 x 10R/L x 6 - 4	500	0.400	570	0.360	0.84	670	0.75	1.25	0.70	1.30
40 x 10R x 6 - 6	760	0.580	860	0.520	1.21	1010	1.08	1.80	1.01	1.87
40 x 12R x 6 - 4	510	0.400	580	0.300	0.90	680	0.75	1.25	0.70	1.30
40 x 16R x 6 - 4	510	0.400	580	0.300	0.89	680	0.75	1.24	0.70	1.29
40 x 20R x 6 - 3	380	0.300	430	0.230	0.68	510	0.57	0.95	0.53	0.99
40 x 20R x 6 - 4 x 2	881	0.610	1005	0.550	1.28	–	–	–	–	–
40 x 40R x 6 - 2	240	0.200	280	0.150	0.46	330	0.36	0.66	0.31	0.71
40 x 40R x 6 - 3	370	0.300	420	0.220	0.67	490	0.56	0.93	0.52	0.96
40 x 40R x 6 - 3 x 2	632	0.460	723	0.410	0.96	–	–	–	–	–
50 x 5R x 3.5 - 5	640	0.320	720	0.240	0.72	830	0.60	1.00	0.56	1.04
50 x 10R x 6 - 4	590	0.550	670	0.500	1.16	780	1.04	1.73	0.97	1.80
50 x 10R x 6 - 6	890	0.800	1000	0.720	1.67	1180	1.49	2.49	1.39	2.59
50 x 12R x 6 - 6	900	0.800	1020	0.720	1.67	1190	1.49	2.49	1.39	2.59
50 x 16R x 6 - 6	910	0.790	1030	0.710	1.67	1210	1.49	2.48	1.39	2.58
50 x 20R x 6.5 - 3	470	0.480	540	0.430	1.01	630	0.90	1.50	0.84	1.56
50 x 20R x 6.5 - 5	780	0.760	880	0.680	1.59	1050	1.42	2.37	1.32	2.46
50 x 20R x 6.5 - 4 x 2	1046	0.930	1192	0.840	1.96	–	–	–	–	–
50 x 25R x 6.5 - 3 x 2	813	0.740	928	0.67	1.56	–	–	–	–	–
50 x 40R x 6.5 - 2	300	0.320	340	0.240	0.72	410	0.60	1.00	0.56	1.04
50 x 40R x 6.5 - 3	450	0.470	520	0.420	0.98	610	0.87	1.45	0.81	1.51
50 x 40R x 6.5 - 3 x 2	788	0.710	900	0.640	1.50	–	–	–	–	–
63 x 10R x 6 - 4	700	0.780	790	0.700	1.64	920	1.46	2.43	1.36	2.53
63 x 10R x 6 - 6	1050	1.120	1190	1.010	2.35	1380	2.24	3.36	2.10	3.50
63 x 20R x 6.5 - 3	560	0.670	640	0.600	1.41	750	1.26	2.09	1.17	2.18
63 x 20R x 6.5 - 5	930	1.060	1060	0.950	2.22	1250	2.11	3.17	1.98	3.30
63 x 20R x 6.5 - 4 x 2	1271	1.320	1448	1.190	2.77	–	–	–	–	–
63 x 40R x 6.5 - 2	380	0.460	440	0.420	0.98	510	0.87	1.45	0.81	1.51
63 x 40R x 6.5 - 3	570	0.670	660	0.610	1.41	770	1.26	2.10	1.18	2.19
63 x 40R x 6.5 - 3 x 2	959	1.000	1095	0.901	2.12	–	–	–	–	–
80 x 10R x 6.5 - 6	1240	1.730	1390	1.820	3.38	1610	3.47	5.20	3.25	5.42
80 x 20R x 12.7 - 6	1400	4.200	1590	4.410	8.20	1870	8.41	12.61	7.88	13.14

Preload and Rigidity of Double Nuts

Dynamic drag torque, preload and rigidity for screws of tolerance grade 5-7 with double nuts FDM-E-S, FDM-E-C

T_0 = overall dynamic drag torque
T_0 = $T_{pr0} + T_{RD}$
C = basic dynamic load rating
C_0 = basic static load rating
T_{RD} = dynamic drag torque of 2 seals
R_S = rigidity of the screw
R_{nu} = rigidity of the nut
T_{pr0} = dynamic drag torque without a seal
d_0 = nominal diameter
P = lead
D_w = ball diameter
i = number of ball track turns

The values given for dynamic drag torque are proven practical indicators for the nut preloading.

Note:
Measurement of the dynamic load torque, see “Mounting.”

Size	Load ratings		Rigidity of the screw
	dyn. C	stat. C_0	R_S
D_0 x P x D_W - i	(N)	(N)	$\left(\frac{N \cdot m}{\mu m}\right)$
16 x 5R x 3 - 4	12300	16100	32
20 x 5R x 3 - 4	14300	21500	53
25 x 5R x 3 - 4	15900	27200	86
25 x 10R x 3 - 4	15700	27000	86
32 x 5R x 3.5 - 4	21600	40000	144
32 x 10R x 3.969 - 5	31700	58300	141
40 x 5R x 3.5 - 5	29100	64100	232
40 x 10R x 6 - 4	50000	86400	211
40 x 10R x 6 - 6	72100	132200	211
40 x 20R x 6 - 3	37900	62800	211
50 x 5R x 3.5 - 5	32000	81300	373
50 x 10R x 6 - 4	55400	109000	345
50 x 10R x 6 - 6	79700	166500	345
50 x 20R x 6.5 - 5	75700	149700	340
63 x 10R x 6 - 4	61800	140500	569
63 x 10R x 6 - 6	88800	214300	569
63 x 20R x 6.5 - 5	83900	190300	563
80 x 10R x 6.5 - 6	108400	291700	938
80 x 20R x 12.7 - 6	262700	534200	832

Size	Screws with double nuts FDM-E-S, FDM-E-C									
		7% preload					10% preload			
	R_{nu} (N/µm)	T_{pr0} (Nm)				R_{nu} (N/µm)	T_{pr0} (Nm)			
		Tolerance grade 5		Tolerance grade 7			Tolerance grade 5		Tolerance grade 7	
D_0 x P x D_W - i		min.	max.	min.	max.		min.	max.	min.	max.
16 x 5R x 3 - 4	310	0.03	0.08	0.02	0.09	350	0.04	0.12	0.03	0.13
20 x 5R x 3 - 4	390	0.04	0.12	0.03	0.13	430	0.06	0.17	0.05	0.18
25 x 5R x 3 - 4	460	0.06	0.17	0.04	0.18	510	0.08	0.24	0.06	0.25
25 x 10R x 3 - 4	470	0.05	0.16	0.04	0.18	530	0.08	0.24	0.06	0.25
32 x 5R x 3.5 - 4	550	0.10	0.29	0.08	0.31	610	0.19	0.36	0.17	0.39
32 x 10R x 3.969 - 5	750	0.20	0.37	0.17	0.40	830	0.28	0.53	0.24	0.57
40 x 5R x 3.5 - 5	790	0.23	0.42	0.20	0.46	870	0.33	0.61	0.28	0.65
40 x 10R x 6 - 4	740	0.39	0.73	0.34	0.78	830	0.60	1.00	0.56	1.04
40 x 10R x 6 - 6	1120	0.61	1.01	0.57	1.05	1250	0.87	1.44	0.81	1.50
40 x 20R x 6 - 3	570	0.30	0.55	0.25	0.59	630	0.45	0.76	0.42	0.79
50 x 5R x 3.5 - 5	920	0.31	0.58	0.27	0.63	1010	0.48	0.80	0.45	0.83
50 x 10R x 6 - 4	870	0.58	0.97	0.54	1.01	960	0.83	1.39	0.78	1.44
50 x 10R x 6 - 6	1300	0.84	1.39	0.78	1.45	1450	1.20	1.99	1.12	2.07
50 x 20R x 6.5 - 5	1170	0.79	1.32	0.74	1.38	1310	1.14	1.89	1.06	1.97
63 x 10R x 6 - 4	1020	0.82	1.36	0.76	1.42	1120	1.17	1.95	1.09	2.02
63 x 10R x 6 - 6	1520	1.17	1.96	1.10	2.04	1690	1.68	2.80	1.57	2.91
63 x 20R x 6.5 - 5	1390	1.11	1.85	1.04	1.92	1560	1.59	2.64	1.48	2.75
80 x 10R x 6.5 - 6	1770	1.82	3.04	1.70	3.16	1950	2.78	4.16	2.60	4.34
80 x 20R x 12.7 - 6	2070	4.71	7.06	4.41	7.36	2320	6.73	10.09	6.30	10.51

Technical Data

Friction Torques of Seals

Seal torque for single and double nuts

(ZEV-E-S is supplied without a seal)

T_0 = overall dynamic drag torque
T_0 = $T_{pr0} + T_{RD}$
T_{RD} = dynamic drag torque of 2 seals
T_{pr0} = dynamic drag torque without a seal
d_0 = nominal diameter
P = lead
D_w = ball diameter

Note:
Measurement of the dynamic load torque, see "Mounting."

Size	Dynamic drag torque			
	Standard seal	Reinforced seal	Low-friction seal	Standard seal for 2-start single nuts with flange
d_0 x P x D_W	T_{RD} approx. (Nm)	T_{RD} approx. (Nm)		T_{RD} approx. (Nm)
6 x 1R x 0.8	0.010	–	–	
6 x 2R x 0.8	0.010	–	–	
8 x 1R x 0.8	0.010	–	–	
8 x 2R x 1.2	0.020	–	–	
8 x 2.5R x 1.588	0.015	–	✓	
12 x 2R x 1.2	0.030	–	✓	
12 x 5R x 2	0.030	–	✓	
12 x 10R x 2	0.030	–	✓	
16 x 5R x 3	0.080	–	✓	
16 x 10R x 3	0.080	–	✓	
16 x 16R x 3	0.080	–	x	
20 x 5R x 3	0.100	–	x	
20 x 5L x 3	0.100	–	x	
20 x 10R x 3	0.120	–	–	
20 x 20R x 3.5	0.120	–	✓	
20 x 20L x 3.5	0.120	–	–	
20 x 40R x 3.5	0.040	–	✓	
25 x 5R x 3	0.120	0.34	✓	
25 x 5L x 3	0.120	–	✓	
25 x 10R x 3	0.150	0.29	✓	
25 x 25R x 3.5	0.200	0.25	✓	
25 x 25L x 3.5	0.200	–	✓	
32 x 5R x 3.5	0.250	0.51	x	
32 x 5L x 3.5	0.250	–	x	
32 x 10R x 3.969	0.250	0.46	x	
32 x 20R x 3.969	0.250	0.49	x	
32 x 32R x 3.969	0.250	0.45	x	
40 x 5R x 3.5	0.400	0.85	x	
40 x 5L x 3.5	0.400	–	–	
40 x 10R x 6	0.400	0.91	x	
40 x 10L x 6	0.400	–	x	
40 x 12R x 6	0.400	–	–	
40 x 16R x 6	0.400	–	–	
40 x 20R x 6	0.400	0.54	x	0.40
40 x 40R x 6	0.400	0.54	x	0.40
50 x 5R x 3.5	0.500	–	–	
50 x 10R x 6	0.600	0.95	–	
50 x 12R x 6	0.600	–	–	
50 x 16R x 6	0.600	–	–	
50 x 20R x 6.5	0.600	0.95	–	0.60
50 x 25R x 6.5	0.600	–	–	0.70
50 x 40R x 6.5	0.700	–	–	0.70
63 x 10R x 6	1.200	–	–	
63 x 20R x 6.5	1.200	1.00	–	1.20
63 x 40R x 6.5	1.200	1.40	–	1.20
80 x 10R x 6.5	1.400	–	–	
80 x 20R x 12.7	2.200	–	–	

Gap seal (0 Nm)
✓ Seal available
x Seal in preparation

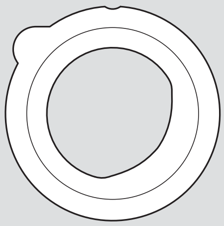
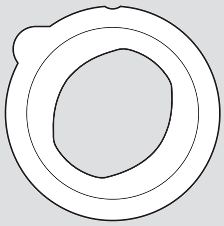
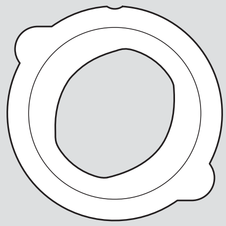
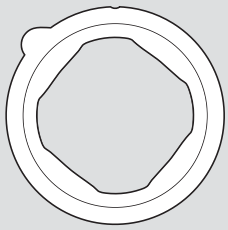
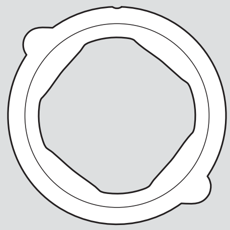
Please bear in mind the following when changing or retrofitting the seals:

All precision-rolled screws SN-R with small leads are designed as single-start screws (Fig. 1). There is therefore only one ball track on the screw.

However precision-rolled screws SN-R with higher leads are designed as 2-start or 4-start screws (Figs. 2 and 3).

“Reinforced seals” for precision-rolled screws SN-R are available as an option. These are identified by their opal-green color and their part number.

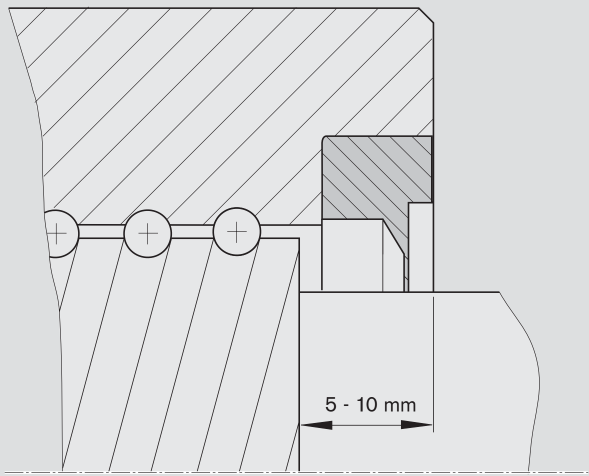
Low-friction seals for precision-rolled screws SN-R are available upon request. This version is currently in preparation. The seals are identified by their red-brown color and their part number.

	Standard nuts	2-start nuts
Fig. 1 Single-start seal		
Fig. 2 Seal for 2-start precision-rolled screw SN-R with average lead		
Fig. 3 Seal for 4-start precision-rolled screw SN-R with high lead		

Inserting the seal

Position the nut on the screw as illustrated in the diagram. Insert the seal so that its projection is in the recess and press it in until it snaps into the groove. While turning the nut on the screw, watch the sealing lip carefully and straighten it if necessary by applying pressure to the end surface. Ensure that the lip is not damaged.

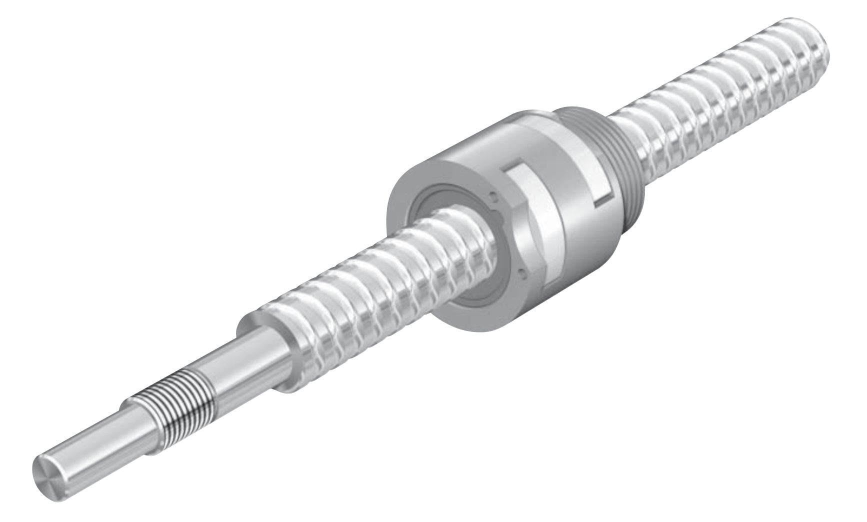
Detailed mounting instructions are delivered along with the parts.



eLINE Ball Screw Assemblies

eLINE Ball Screw with Screw-In Nut ZEV-E-S, Fixed Length

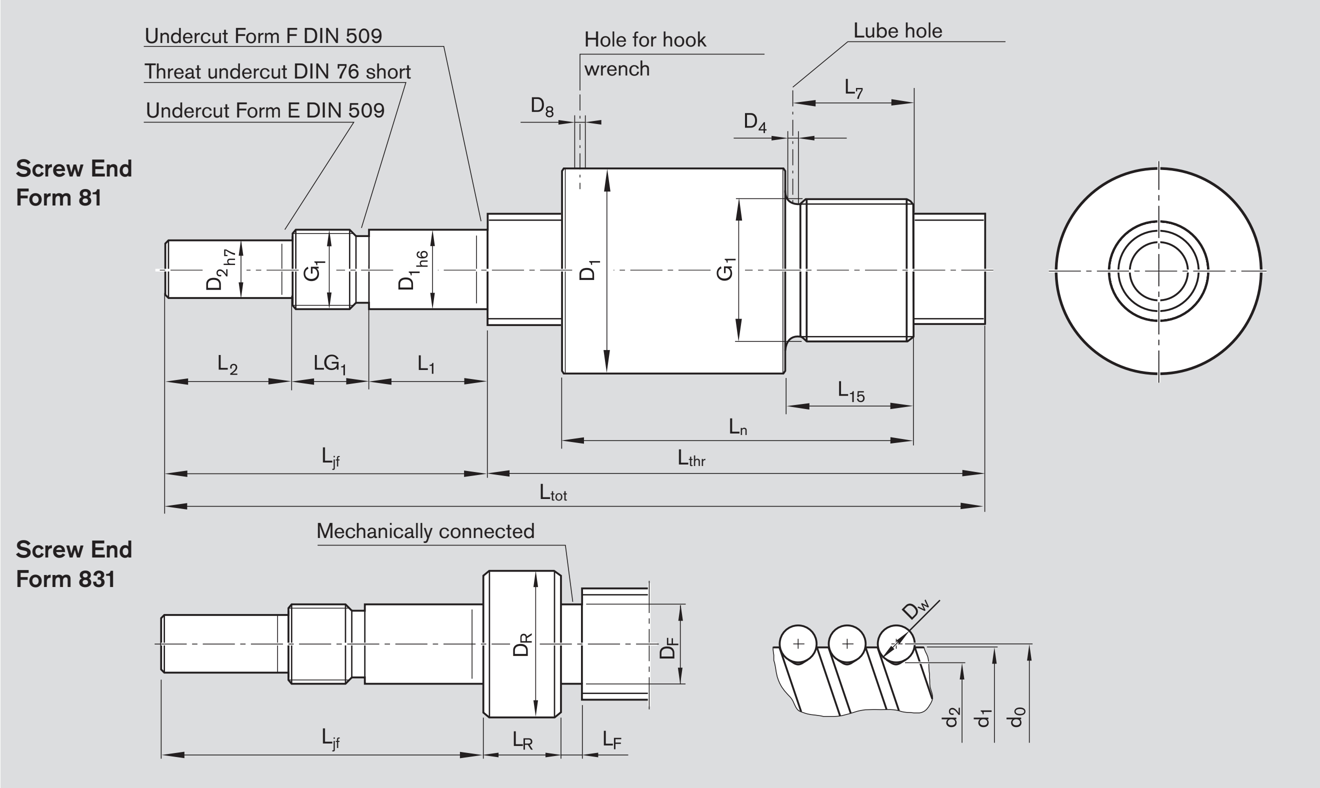
- Rexroth mounting dimensions
- Single fixed bearing
- With seals
- With backlash 0.1 mm
- Screw tolerance class T9 or T10



Ordering code:

d_0 = nominal diameter
P = lead
(R = right-hand, L = left-hand)
D_W = ball diameter
i = number of ball track turns

Size d_0 x P x D_w - i	Tolerance class	Length (mm) L_{tot}	L_{thr}	Part Numbers
12 x 5R x 2-3	T9	400	317	R2540 002 01
	T10	400	317	R2540 000 01
12 x 10R x 2-2	T9	400	317	R2540 002 02
	T10	400	317	R2540 000 02
16 x 5R x 3-3	T9	550	467	R2540 002 03
	T10	550	467	R2540 000 03
16 x 10R x 3-3	T9	550	467	R2540 002 04
	T10	550	467	R2540 000 04
20 x 5R x 3-4	T9	550	490	R2540 002 05
	T10	550	490	R2540 000 05



L_{tot} = overall length
L_{thr} = thread length

Ball nut

Size		Dimensions (mm)						
d_0	P	D_1	D_4 h10	D_8	G_1	L_n ±0,3	L_7	L_{15}
12	5	25.5	2.7	3.2	M20 x 1	36	8.5	10
12	10	25.5	2.7	3.2	M20 x 1	40	8.5	10
16	5	32.5	2.7	4.2	M26 x 1.5	40	10.5	12
16	10	32.5	2.7	4.2	M26 x 1.5	54	10.5	12
20	5	38.0	2.7	8.0	M35 x 1.5	50	12.5	14

Screw

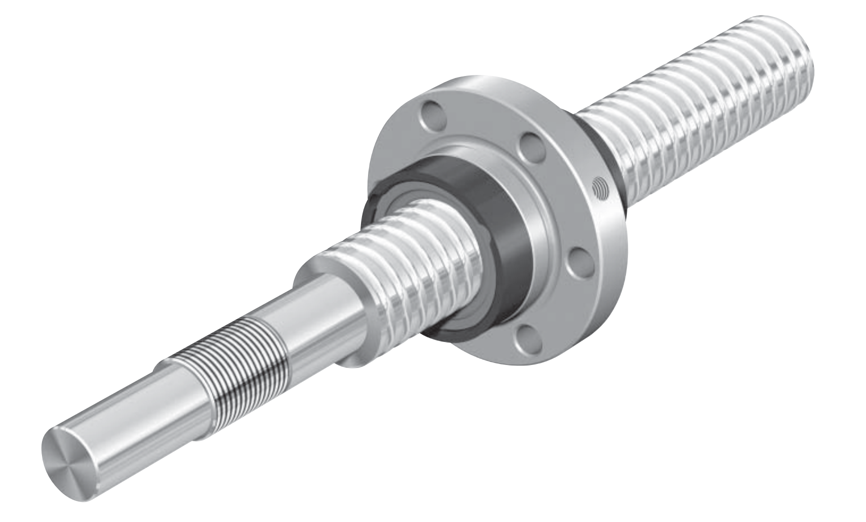
Size		Form	Dimensions (mm)												
d_0	P		d_1	d_2	L_{ZF}	D_R	L_R	D_F	L_F	D_1	L_1	D_2	L_2	G_1	LG_1
12	5	831	11.4	9.9	60	15	15	8.0	1	12	17	10	25	M12x1	18
12	10		11.4	9.9	60	15	15	8.0	1	12	17	10	25	M12x1	18
16	5		15.0	12.9	60	18	17	12.0	1	12	17	10	25	M12x1	18
16	10		15.0	12.9	60	18	17	12.0	1	12	17	10	25	M12x1	18
20	5	81	19.0	16.9	60	–	–	–	–	12	17	10	25	M12x1	18

Size		Load ratings		Linear speed v_{max}
d_0	P	dyn. C (N)	stat. C_0 (N)	(m/min)
12	5	2300	3500	30
12	10	1500	2200	60
16	5	5600	7100	25
16	10	5800	7400	50
20	5	8600	12900	20

eLINE Ball Screw Assemblies

eLINE Ball Screw with Flanged Single Nut FBZ-E-S, Fixed Length

- Rexroth mounting dimensions
- Single fixed bearing
- With seals
- With backlash 0.1 mm
- Screw tolerance class T9 or T10

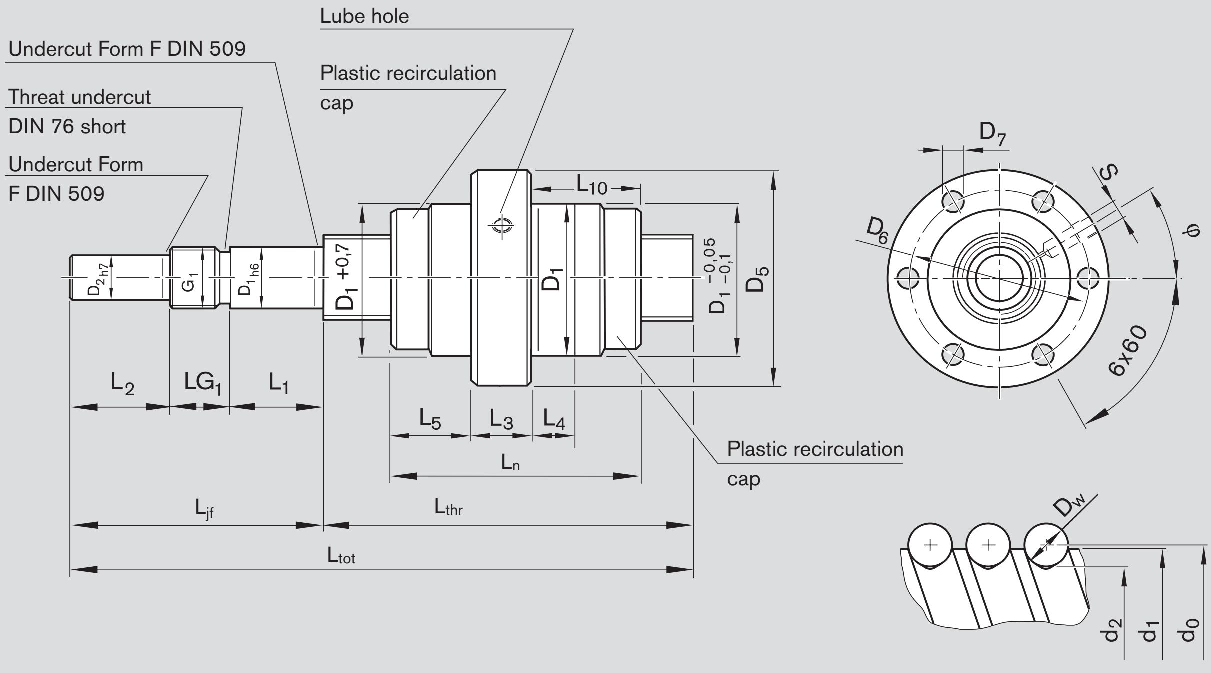


Ordering code:

d_0 = nominal diameter
P = lead
(R = right-hand, L = left-hand)
D_W = ball diameter
i = number of ball track turns

Size d_0 x P x D_w - i	Tolerance class	Length (mm) L_{tot}	 L_{thr}	Part Numbers
20 x 5R x 3-4	T9	550	490	R2540 002 06
	T10	550	490	R2540 000 06
25 x 5R x 3-4	T9	700	640	R2540 002 07
	T10	700	640	R2540 000 07
25 x 10R x 3-4	T9	700	640	R2540 002 08
	T10	700	640	R2540 000 08
32 x 5R x 3.5-4	T9	1200	1120	R2540 002 09
	T10	1200	1120	R2540 000 09
32 x 10R x 3.969-5	T9	1200	1120	R2540 002 10
	T10	1200	1120	R2540 000 10

Screw End
Form 81



Ball nut

Size		Dimensions (mm)										
d_0	P	D_1	D_5	D_6	D_7	L_n ±0,5	L_3	L_4	L_5	L_{10}	S	φ (°)
20	5	33	58	45	6.6	40	10	6	15.0	15	M6	30
25	5	38	63	50	6.6	43	10	6	16.5	16.5	M6	30
25	10	38	63	50	6.6	62	10	16	16.0	36.0	M6	30
32	5	48	73	60	6.6	46	12	6	17.0	17.0	M6	30
32	10	48	73	60	6.6	77	12	16	20.0	45.0	M6	30

Screw

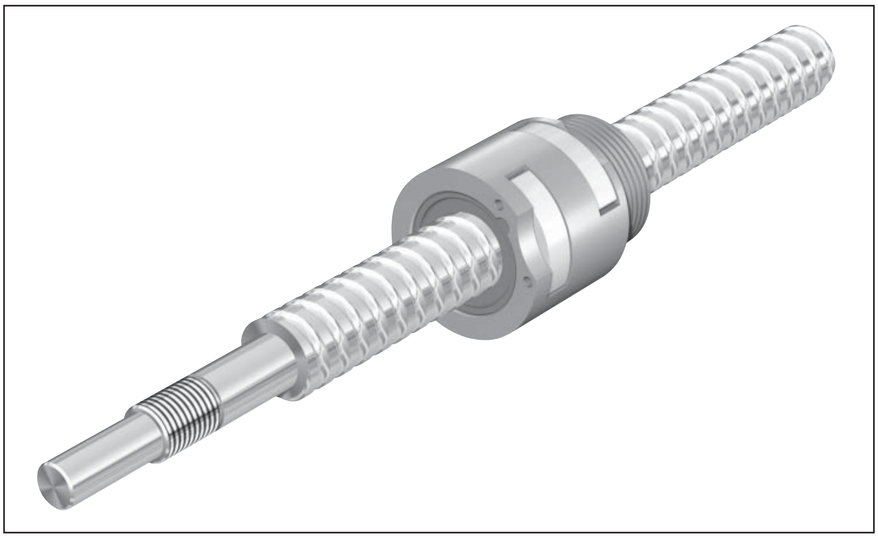
Size		Form	Dimensions (mm)								
d_0	P		d_1	d_2	L_{ZF}	D_1	L_1	D_2	L_2	G_1	LG_1
20	5	81	19.0	16.9	60	12	17	10	25	M12x1	18
25	5		24.0	21.9	60	15	19	12	25	M15x1	16
25	10		24.0	21.9	60	15	19	12	25	M15x1	16
32	5		31.0	28.4	80	20	25	18	40	M20x1	15
32	10		31.0	27.9	80	20	25	18	40	M20x1	15

Size		Load ratings		Linear speed v_{max}
d_0	P	dyn. C (N)	stat. C_0 (N)	(m/min)
20	5	8600	12900	20
25	5	9500	16300	16
25	10	9400	16200	32
32	5	13000	24000	13
32	10	19000	35000	25

eLINE Ball Screw Assemblies

eLINE Ball Screw with Screw-In Nut ZEV-E-S, Custom Length

- Rexroth mounting dimensions
- Single fixed bearing
- With seals
- With backlash 0.1 mm
- Screw tolerance class T9 or T10



$L_{thr} = L_{tot} - L_{jf} - L_{jl}$

L_{jf} = journal length, fixed bearing end
L_{jl} = journal length, floating bearing end
L_{tot} = overall length of screw
L_{thr} = thread length

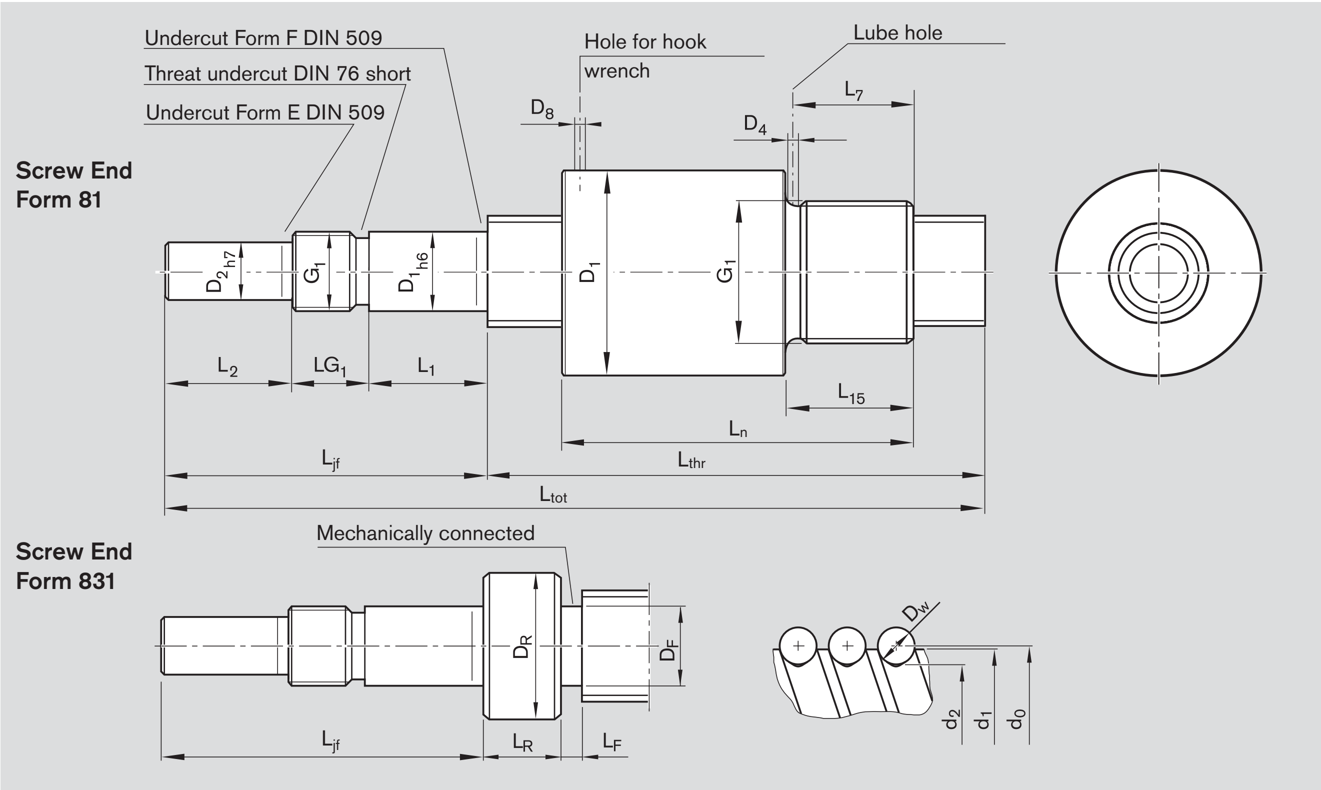
Note:
Consider excess travel ($2 \cdot d_0$)

Ordering code:

d_0 = nominal diameter
P = lead
(R = right-hand, L = left-hand)
D_W = ball diameter
i = number of ball track turns

Size d_0 x P x D_w - i	Tolerance class	Length (mm) $L_{tot\ max}$	$L_{thr\ max}$	Part Numbers
12 x 5R x 2-3	T9	1250	1182	R2540 002 11
	T10	1250	1182	R2540 002 21
12 x 10R x 2-2	T9	1250	1182	R2540 002 12
	T10	1250	1182	R2540 002 22
16 x 5R x 3-3	T9	1700	1624	R2540 002 13
	T10	1700	1624	R2540 002 23
16 x 10R x 3-3	T9	1700	1621	R2540 002 14
	T10	1700	1621	R2540 002 24
20 x 5R x 3-4	T9	2500	2427	R2540 002 15
	T10	2500	2427	R2540 002 25

When ordering, please ensure that part numbers and and desired total length L_{tot} are given.
(R2540 xx2 xx, xxxx mm).
L_{tot}



L_{tot} = overall length
L_{thr} = thread length

Ball nut

Size		Dimensions (mm)						
d_0	P	D_1	D_4 h10	D_8	G_1	L_n	L_7 ±0,3	L_{15}
12	5	25.5	2.7	3.2	M20 x 1	36	8.5	10
12	10	25.5	2.7	3.2	M20 x 1	40	8.5	10
16	5	32.5	2.7	4.2	M26 x 1.5	40	10.5	12
16	10	32.5	2.7	4.2	M26 x 1.5	54	10.5	12
20	5	38.0	2.7	8	M35 x 1.5	50	12.5	14

Screw

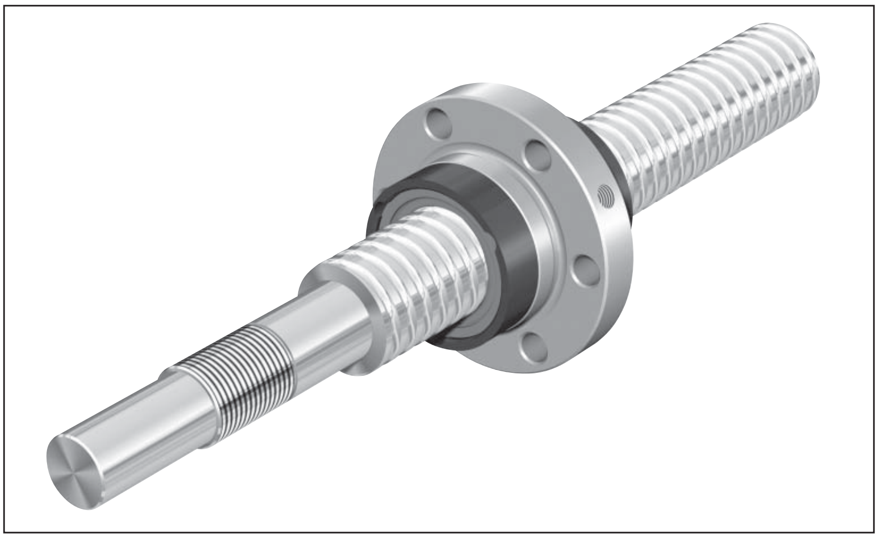
Size		Form	Dimensions (mm)												
d_0	P		d_1	d_2	L_{ZF}	D_R	L_R	D_F	L_F	D_1	L_1	D_2	L_2	G_1	LG_1
12	5	831	11.4	9.9	60	15	15	8.0	1	12	17	10	25	M12x1	18
12	10		11.4	9.9	60	15	15	8.0	1	12	17	10	25	M12x1	18
16	5		15.0	12.9	60	18	17	12.0	1	12	17	10	25	M12x1	18
16	10		15.0	12.9	60	18	17	12.0	1	12	17	10	25	M12x1	18
20	5	81	19.0	16.9	60	–	–	–	–	12	17	10	25	M12x1	18

Size		Load ratings		Linear speed v_{max}
d_0	P	dyn. C (N)	stat. C_0 (N)	(m/min)
12	5	2300	3500	30
12	10	1500	2200	60
16	5	5600	7100	25
16	10	5800	7400	50
20	5	8600	12900	20

eLINE Ball Screw Assemblies

eLINE Ball Screw with Flanged Single Nut FBZ-E-S, Custom Length

- Rexroth mounting dimensions
- Single fixed bearing
- With seals
- With backlash 0.1 mm
- Screw tolerance class T9 or T10



$L_{thr} = L_{tot} - L_{jf} - L_{jl}$

L_{jf} = journal length, fixed bearing end
L_{jl} = journal length, floating bearing end
L_{tot} = overall length of screw
L_{thr} = thread length

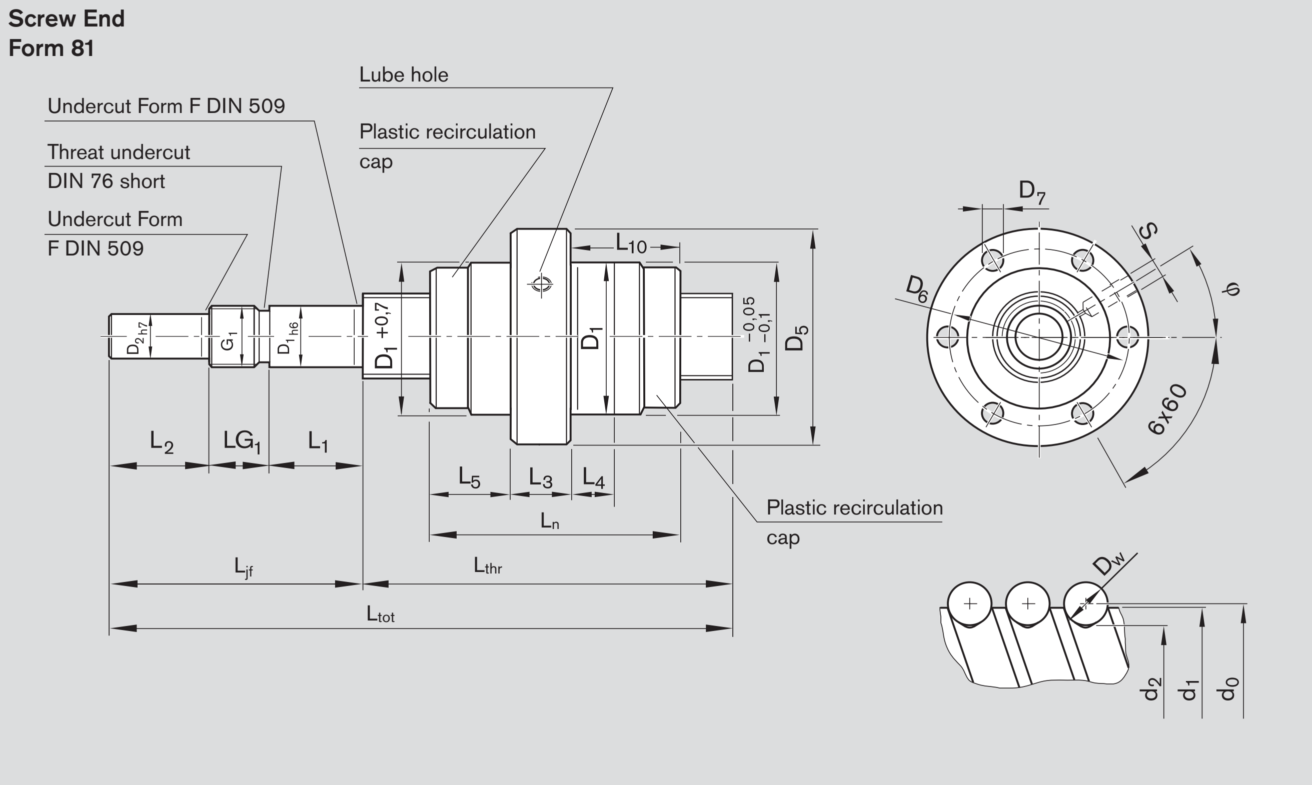
Note:
Consider excess travel ($2 \cdot d_0$)

Ordering code:

d_0 = nominal diameter
P = lead
(R = right-hand, L = left-hand)
D_W = ball diameter
i = number of ball track turns

Size d_0 x P x D_w - i	Tolerance class	Length (mm) $L_{tot\ max}$	$L_{thr\ max}$	Part Numbers
12 x 5R x 3-4	T9	2500	2427	R2540 002 16
	T10	2500	2427	R2540 002 26
25 x 5R x 3-4	T9	5000	4925	R2540 002 17
	T10	5000	4925	R2540 002 27
25 x 10R x 3-4	T9	5000	4925	R2540 002 18
	T10	5000	4925	R2540 002 28
32 x 5R x 3.5-4	T9	5000	4902	R2540 002 19
	T10	5000	4902	R2540 002 29
32 x 10R x 3.969-5	T9	5000	4902	R2540 002 20
	T10	5000	4902	R2540 002 30

When ordering, please ensure that part numbers and and desired total length L_{tot} are given.
(R2540 xx2 xx, xxxx mm).
└ L_{tot}



Ball nut

Size		Dimensions (mm)										
d_0	P	D_1	D_5	D_6	D_7	L_n ±0,5	L_3	L_4	L_5	L_{10}	S	φ (°)
20	5	33	58	45	6.6	40	10	6	15	15.0	M6	30
25	5	38	63	50	6.6	43	10	6	16.5	16.5	M6	30
25	10	38	63	50	6.6	62	10	16	16	36.0	M6	30
32	5	48	73	60	6.6	46	12	6	17	17.0	M6	30
32	10	48	73	60	6.6	77	12	16	20	45.0	M6	30

Screw

Size		Form	Dimensions (mm)								
d_0	P		d_1	d_2	L_{ZF}	D_1	L_1	D_2	L_2	G_1	LG_1
20	5	81	19.0	16.9	60	12	17	10	25	M12x1	18
25	5		24.0	21.9	60	15	19	12	25	M15x1	16
25	10		24.0	21.9	60	15	19	12	25	M15x1	16
32	5		31.0	28.4	80	20	25	18	40	M20x1	15
32	10		31.0	27.9	80	20	25	18	40	M20x1	15

Size		Load ratings		Linear speed v_{max}
d_0	P	dyn. C (N)	stat. C_0 (N)	(m/min)
20	5	8600	12900	20
25	5	9500	16300	16
25	10	9400	16200	32
32	5	13000	24000	13
32	10	19000	35000	25

eLINE Ball Screw Assemblies

Technical Data

Speed

v_{max} = 1 m/s

Dependant of size and lead

Acceleration

a_{max} = 20 m/s²

Dependant of size and lead

Temperature Stability

t = −10 bis 80 °C

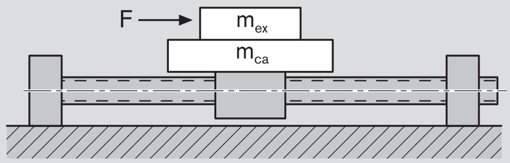
Temperature of surrounding environment

Seal

eLINE Ball Screw Assemblies come with seals, if required.

Information for calculation of horizontally installed assemblies

(in combination with suitable linear guides)



The load on bearing and life expectancy of eLINE Ball Screws is generally calculated as illustrated above. The following formula allows a simpler and more rapid estimation of the life expectancy.

Equivalent dynamic load on bearing for eLINE Ball Screws

Calculation of load on bearing

$$F_m = k_f \cdot (|(m_{ca} + m_{ex}) \cdot a| + |F_L|)$$

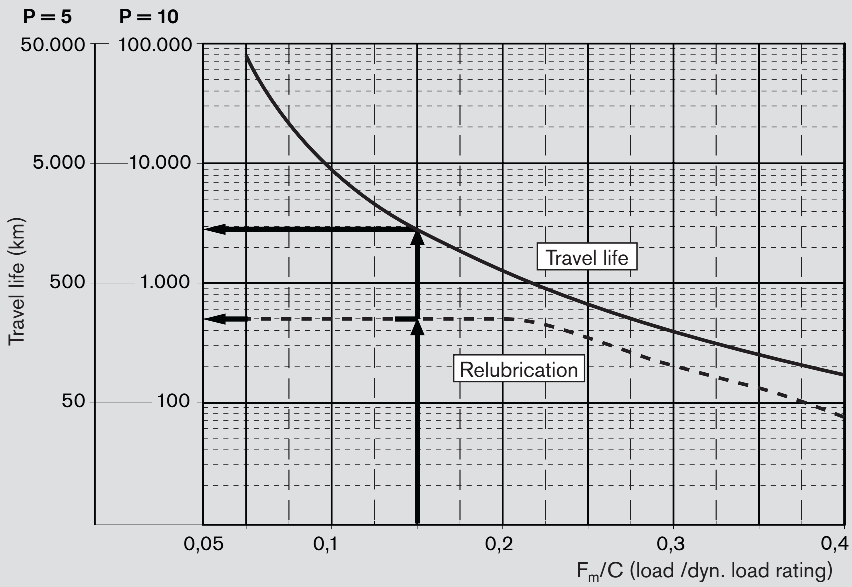
a	=	acceleration	(m/s²)
F_L	=	thrust	(N)
F_m	=	equivalent dynamic axial load	(N)
k_f	=	operating factor	–
m_{ca}	=	moved system mass	(kg)
m_{ex}	=	moved external load	(kg)

Recommended operating factors k_f

Operating factor	Application
0.8	Manually operated ball screw
1.0	Applications in clean environments
2.0	Auxiliary axes in machine tools
4.0	Use in heavily contaminated environments

Travel life of eLINE Ball Screws

The travel life is determined by calculating the ratio F_m/C.
This value can be used to read off the travel life and relubrication intervals from the chart.



Example:

If an eLINE Ball Screw with a 10 mm lead is loaded to 15% of the dynamic load rating, the travel life will be approx. 1500 km.
Relubrication is required every 500 km.

Relubrication every 50 x 10^6 rev.

P = 10	every 500 km
P = 5	every 250 km

eLINE Ball Screw Assemblies

Technical Data

Acceptance Conditions and Tolerance Grades

Permissible travel deviation

in accordance with DIN 69 051, Part 3 and ISO 3408-3

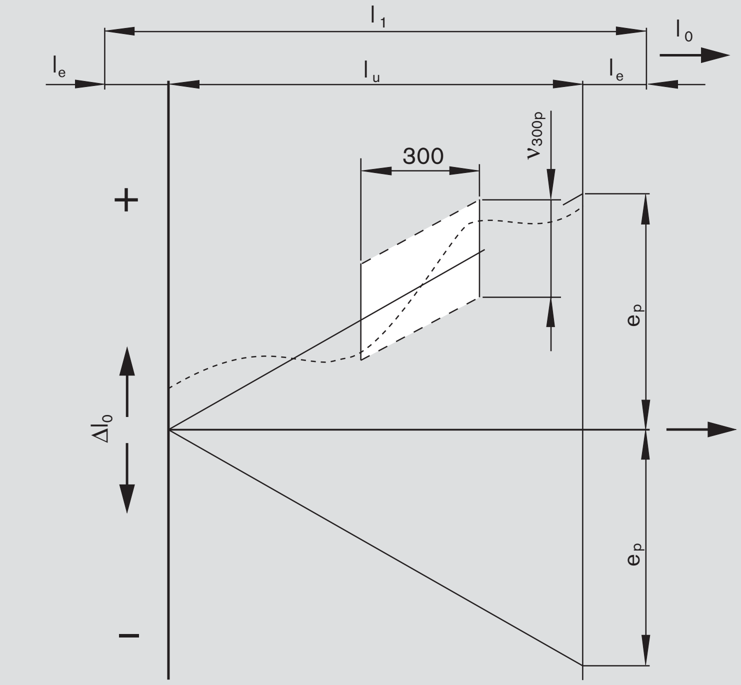
Symbol definitions (excerpt):

- l_0 = nominal travel
- l_1 = thread length
- Δl_0 = travel deviation
- l_u = useful travel
- l_e = excess travel
- e_p = tolerance for mean actual travel deviation
- ν_{300p} = permissible travel deviation within 300 mm travel
- $\nu'_{2\pi p}$ = permissible travel deviation within one revolution

Subindices:

p = Permissible

Ball screw with precision-rolled screw SN-R



Maximum permissible travel deviation e_p as per DIN 69051 or ISO 3408-3

Useful Travel (mm)	Tolerance e_p (µm) T9	T10
0	0	0
100	43.5	70.0
250	108.5	175.0
500	216.5	350.0
750	325.0	525.0
1000	433.5	700.0
1250	541.5	875.0
1500	650.0	1050.0
1750	758.5	1225.0
2000	866.5	1400.0
2250	975.0	1575.0
2500	1083.5	1750.0

$$e_p = \frac{l_u}{300} \cdot \nu_{300p}$$

ν_{300p} for T9 = 130 µm

ν_{300p} for T10 = 210 µm

Non-usable length l'_e

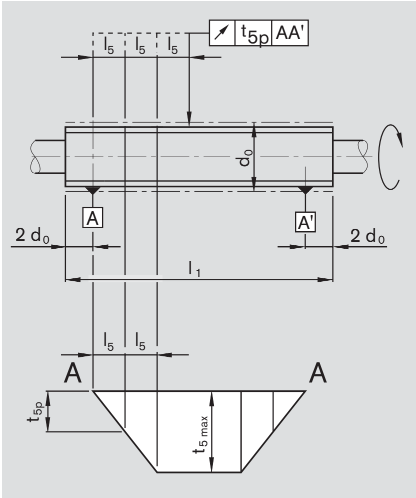
(Excess travel)

Modified with respect to DIN 69051.

d_0 (mm)	l'_e (mm)
12, 16	20
20, 25, 32	40

Run-outs and location deviations based on DIN 69 051, Part 3 and ISO 3408-3

Radial run-out t_5 of the outer diameter of the ball screw shaft over the length l_5 used to determine the straightness in relation to AA'.

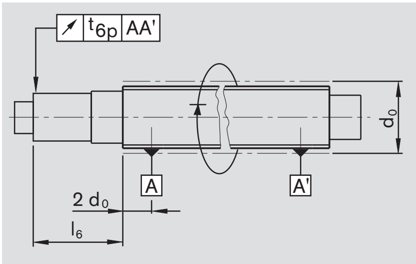


Nominal diameter d_0 (mm)		l_5	t_{5p} in µm for l_5 for tolerance grade	
above	up to	(mm)	9	10
6	12	80	40	80
12	25	160		
25	50	315		

l_1/d_0		t_{5max} in µm for $l_1 \geq 4l_5$ for tolerance grade	
above	up to	9	10
	40	80	160
40	60	120	240
60	80	200	400
80	100	320	640

Radial run-out t_6 of the bearing diameter in relation to AA' for $l_6 \leq l$.

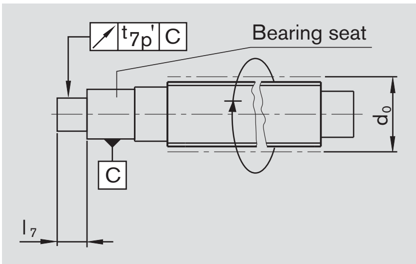
Where $l_6 > l$ then $t_{6a} \leq t_{6p} \cdot \frac{l_{6a}}{l}$



Nominal diameter d_0 (mm)		Reference length l	t_{6p} in µm for $l_6 \leq l$ for tolerance grade	
above	up to	(mm)	9	10
6	20	80	20	40
20	50	125	25	50

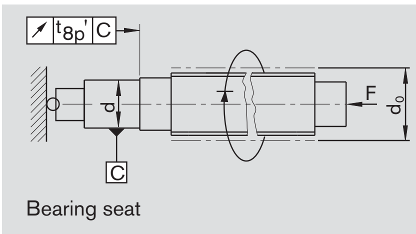
Coaxial deviation t_7' of the journal diameter of the ball screw shaft in relation to the bearing diameter for $l_7 \leq l$.

Where $l_7 > l$ then $t_{7a} \leq t_{7p} \cdot \frac{l_{7a}}{l}$



Nominal diameter d_0 (mm)		Reference length l	t_{7p}' in µm for $l_7 \leq l$ for tolerance grade	
above	up to	(mm)	9	10
6	20	80	6	12
20	50	125		

Axial run-out t_8' of the shaft (bearing) face of the ball screw shaft in relation to the bearing diameter.



Nominal diameter d_0 (mm)		t_{8p}' in µm for tolerance grade	
above	up to	9	10
6	**63**	5	12

Mounting

Condition as delivered

Rexroth Ball Screws are normally delivered with an initial supply of grease type Rexroth Dynalub. Relubrication with grease or oil is thus possible, and cartridges and cans of this grease are available. If another lubricant is used, you will need to check that it is compatible with the initial supply.

For special cases, the ball screws can also be supplied with only a preservative coating. This can be indicated by choosing the appropriate option number in the ordering code.

⚠ **Important**
The selected lubricant must be in the nut before the machine is started.

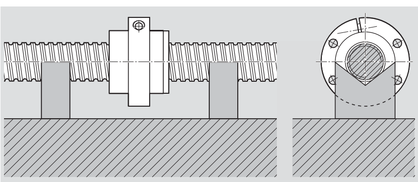
Cleaning

Various cleaning agents can be used to degrease and wash the assembly:
– aqueous cleaning agents
– organic cleaning agents

⚠ **Important**
Immediately after cleaning, thoroughly dry all parts, then apply a preservative coating or anti-corrosion oil. In all cases, take care to observe the appropriate legal regulations (environmental protection, health and safety at work, etc.) as well as the specifications for the cleaning agent (e.g. handling).

Storage

Ball screw assemblies are high-quality systems that must be treated with due care. In order to prevent damage and contamination, the elements should not be removed from the protective wrapping until immediately before installation. Once they have been removed from the packaging, they must be set down on V-shaped cradles.



Nut mounting

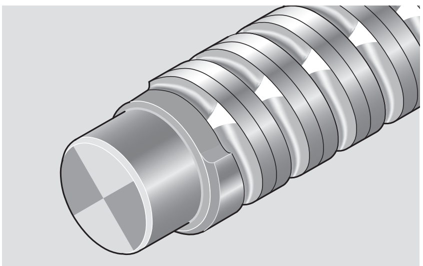
Preloaded single nut
Double nut

These models are always supplied with premounted nut units.

The nut unit and screw must not be disassembled. Should this become necessary for any reason, please ask.

Note: For Ball Screws with Front Lube Units, do not remove the nut and front lube unit from the screw.

Single nut with standard backlash
Single nut with reduced backlash
Adjustable-preload single nut
The nut unit may only be mounted on a screw with machined ends using a mounting arbor. In this case, the screw spigot serves to center the mounting arbor. On a screw end form “00”, a centering hole “Z” can be used to fit an auxiliary spigot as a mounting aid. The outer diameter of the arbor should be approx. 0.1 mm smaller than the root diameter of the screw. In most cases, the transport arbor on which the nuts are delivered may be used to mount the nut. The end of the screw thread must be carefully chamfered in order to prevent damage to the seal and the internal components of the nut unit.

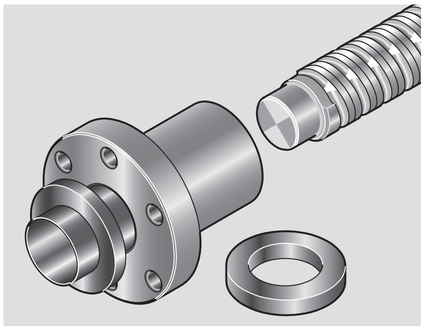


The various mounting steps are described below.

Proceed in reverse order when removing the nut from the screw. Take particular care not to damage the nut, screw or internal components, as this could result in the premature failure of the ball screw assembly.

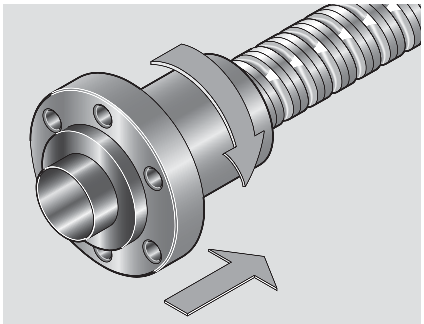
Mounting steps

The nut is to be mounted as follows:
Remove the rubber ring from one end of the mounting arbor.

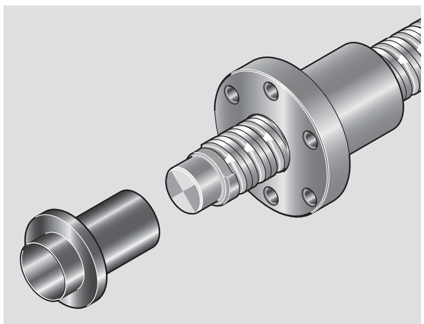


Push the mounting arbor with nut until it bears against the end of the thread. The arbor must make contact with no axial clearance.

Carefully turn the nut unit onto the thread, applying only slight thrust.

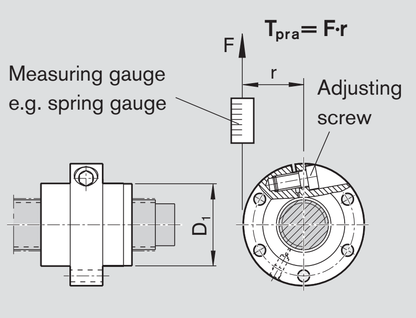


Remove the arbor only when the nut unit is fully located on the screw thread.



Preload of adjustable-preload single nuts

Measurement of the dynamic drag torque for SEM-E-C and SEM-E-S. Using the adjusting screw, reduce the clearance of the nut mounted on the screw until the corresponding dynamic drag torque T_{pr0} specified in the table ➟ page 123, has been attained (ball screw lightly oiled).
Check this torque along the entire length of the thread; if the torque deviates from the value specified in the table at any point along the thread, adjust accordingly.
Once the torque has been properly adjusted, the centering diameter D_1 must correspond to the values specified in the table ➟ pages 44 and 48. Cover the head of the screw with a protective cap.



T_{pra} = currently measured dynamic drag torque

Mounting instructions are supplied as standard along with every unit. Please ask for extra copies if needed.

Installation in the machine

It is not normally necessary to remove the preservative coating before installation.

- If the ball screw is contaminated it must first be cleaned (see “Cleaning”) and re-oiled
- Push the nut unit into the mounting bore, taking care to avoid any impact force or misalignment.
- Tighten the mounting screws using a torque wrench if necessary. Maximum tightening torque for the steel/steel material pairing ($R_m \geq 370$ N/mm²), see table.

Steel/steel material pairing			
Screw diameter (mm)	Tightening torque (Nm) Strength class per DIN ISO 898:		
	8.8	10.9	12.9
M3	1.3	1.8	2.1
M4	2.7	3.8	4.6
M5	5.5	8.0	9.5
M6	9.5	13.0	16.0
M8	23.0	32.0	39.0
M10	46.0	64.0	77.0
M12	80.0	110.0	135.0
M14	125.0	180.0	215.0
M16	195.0	275.0	330.0
M18	280.0	400.0	470.0
M20	390.0	560.0	650.0

- For the steel/aluminum and aluminum/aluminum material pairings ($R_m \geq 280$ N/mm²) the maximum tightening torques specified in the follow table apply.
  When driving screws into aluminum, the length of thread engagement should be at least 1.5 times the screw diameter.

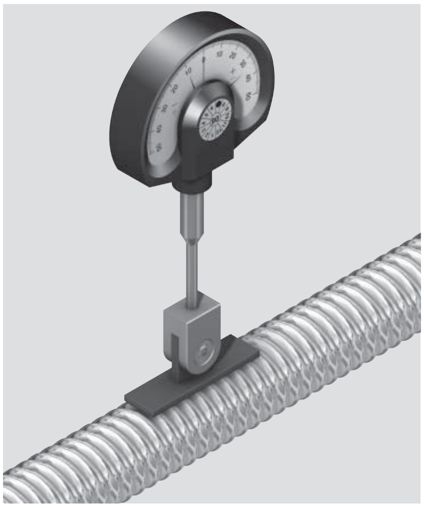
Steel/aluminum and aluminum/aluminum material pairings			
Screw diameter (mm)	Tightening torque (Nm) Strength class per DIN ISO 898:		
	8.8	10.9	12.9
M3	1.2	1.2	1.2
M4	2.4	2.4	2.4
M5	4.8	4.8	4.8
M6	8.5	8.5	8.5
M8	20.0	20.0	20.0
M10	41.0	41.0	41.0
M12	70.0	70.0	70.0
M14	110.0	110.0	110.0
M16	175.0	175.0	175.0
M18	250.0	250.0	250.0
M20	345.0	345.0	345.0

Tightening torques for fastening screws according to VDI 2230 for $\mu_G = \mu_K = 0.125$

Alignment of the precision ball screw assembly in the machine

A gauge with a self-aligning contact pad is available from Rexroth for easy alignment of the ball screw assembly.

Two pads of different lengths are available, which can be used depending on the screw lead:
- Part number R3305 131 19
  Length 33 mm for leads < 20
- Part number R3305 131 21
  Length 50 mm for leads > 20



Lubrication

When lubricating, please refer to the product and material safety data sheets for Dynalub which can be found online at www.boschrexroth.de/brl

Standard lubrication practices for ball bearings also apply to ball screws. Lubricant loss is, however, greater than that from conventional ball bearings, for instance, due to the axial motion between the screw and the nut.

Lifelong lubrication

If the Ball Screw is supplied completely pre-assembled with Front Lube Unit, it will require no relubrication for up to 300 million revolutions or five years in service. Afterwards, the Ball Screw can be relubricated as specified in the tables below.

Oil lubrication

The influence of the temperature on the performance of the ball screw is very sig-nificant, as the thermal expansion of the ball screw interferes with the positioning accuracy of the assembly.
One of the advantages of oil lubrication over grease lubrication is therefore the minimized heat build-up of the ball screw, particularly at high speeds.
As a rule, commercially available mineral base oils used for ball bearings are suitable. The necessary viscosity depends on the speed, temperature and load conditions of the respective application (see DIN 51517, 51519 and GfT Work-sheet 3).
Oils ranging from ISO VG 68 to approx. ISO VG 460 are used in practice. The high viscosity grades (e.g. ISO VG 460) should be preferred in general and partic-ularly for slow running screws. A maximum relubrication interval of up to 10 operating hours can be attained with small quantities from the adjacent table.
Please ask for details for driven nuts.

Relubrication quantity and intervals for oil

d_0	Lubricating quantity		Lubricating interval[1]													
	Initial lubrication	Relubrication	Time	Revolutions	Travel (km) with lead P =											
	V_e (ml)	V_n (ml/10 h)	(h)	(mill.)	1	2	2.5	5	10	12	16	20	25	32	40
6	0.300	0.030	10	1.3	1.3	2.6									
8	0.300	0.030	10	1.3	1.3	2.6	3.3								
12	0.300	0.030	10	1.3		2.6		6.5	13.0						
16	0.300	0.030	10	1.3				6.5	13.0		20.8				
20	0.600	0.060	10	1.0				5.0				20.0			40.0
25	0.600	0.060	10	1.0				5.0	10.0				25.0		
32	0.600	0.060	10	1.0				5.0	10.0			20.0		32.0	
40	2.000[2]	0.400[2]	10	1.0				5.0	10.0	12.0	16.0	20.0			40.0
50	4.000[2]	0.800[2]	10	1.0				5.0	10.0	12.0	16.0	20.0	25.0		40.0
63	4.000[2]	0.800[2]	10	1.0					10.0			20.0			40.0
80	8.000	1.600	10	1.0					10.0			20.0			40.0

d_0 = nominal diameter

1) The value first reached defines the lubricating interval.
2) For 2-start single nut FED-E-B: use double the quantity of lubricant

Limit conditions:

Load	=	$\leq$ 0.2 C
n_{min}	=	100 min^{-1}
$Temp_{max. nut}$	=	80 °C
$Temp_{continuous nut}$	=	60 °C

Orientation: – any
Operating mode: – driven screw
– no short stroking or hypercritical operation
Sealing: – standard

Grease lubrication

The advantage of grease lubrication is that the ball screw can run long distances on one supply of grease.
As a result, a lubricating system is not required in many cases. The amount of grease used should fill the nuts to approximately half of their capacity.
All commercially available high-quality ball bearing lubricating greases may be used.
Read the lubricant manufacturer's specifications carefully! Never use greases with solid lubricant components (e.g. graphite or MoS_2).

For relubrication, grease cartridges containing Dynalub 510 and 520 are available from Rexroth.
Greases in accordance with DIN 51825-K2K and, for higher loads, KP2K of NLGI grade 2 in accordance with DIN 51818 are recommended for the longest pos-sible lubrication intervals. Tests have shown that greases of NLGI grade 00 achieve only about 50% of the running performance of Class 2 at higher loads.
The relubrication interval depends on many factors such as the degree of contamination, operating temperature, load, etc. The following values can thus serve only as a guideline.

Relubrication intervals for NLGI-2 greases

d_0	Lubricating quantity	Lubricating interval										
	Relubrication	Revolutions	Travel (km) with lead P =									
	V_e (ml)	(mill.)	1	2	2.5	5	10	16	20	25	32	40
$\leq$ **40**	see table for	50	50	100	125	250	500	800	1000	1250	1600	2000
> **40**	NLGI-2 greases	10				50	100	160	200			400

d_0 = nominal diameter

Relubrication quantities for Standard series

For NLGI grade 2 and NLGI grade 00 greases:
The nut has to be lubricated with lubricant via the lube port before the ball screw is started.

Twice the relubrication quantity of grease is to be used when lubricating for the first time.

Size	Relubrication quantity of grease (g)		
	Single nut FEM-E-C / FEM-E-S / SEM-E-C SEM-E-S / ZEM-E-A / ZEM-E-S FED-E-B	Double nut FDM-E-C / FDM-E-S	
d_0 x P x D_W - i	Precision screw SN-R	Precision screw SN-R	
8 x 2.5R x 1.588 - 3	0.10	–	NLGI grade 00 Dynalub 520 or alternatively Castrol Longtime PD00
12 x 2R x 1.2 - 4	0.15	–	
12 x 5R x 2 - 3	0.30	–	
12 x 10R x 2 - 2	0.30	–	
16 x 5R x 3 - 4	0.60	1.7	NLGI grade 2 Dynalub 510 or alternatively Castrol Longtime PD2
16 x 10R x 3 - 3	0.80	–	
16 x 16R x 3 - 2	0.90	–	
16 x 16R x 3 - 3	1.10	–	
20 x 5R/L x 3 - 4	0.90	2.7	
20 x 5R x 3 - 5	1.00	–	
20 x 10R x 3 - 4	1.40	–	
20 x 20R/L x 3.5 - 2	1.70	–	
20 x 20R x 3.5 - 3	2.20	–	
25 x 5R/L x 3 - 4	1.40	3.2	
25 x 10R x 3 - 4	1.70	3.8	
25 x 25R/L x 3.5 - 2	2.40	–	
25 x 25R x 3.5 - 3	3.10	–	
32 x 5L x 3.5 - 4	2.30	–	
32 x 5R x 3.5 - 4	2.00	4.5	
32 x 10R x 3.969 - 5	2.80	6.0	
32 x 20R x 3.969 - 2	2.50	–	
32 x 20R x 3.969 - 3	3.20	–	
32 x 32R x 3.969 - 2	3.70	–	
32 x 32R x 3.969 - 3	4.90	–	
40 x 5L x 3.5 - 5	3.10	–	
40 x 5R x 3.5 - 5	2.70	6.9	
40 x 10L x 6 - 4	6.00	–	
40 x 10R x 6 - 4	6.00	15.1	
40 x 10R x 6 - 6	7.30	17.7	
40 x 12R x 6 - 4	6.10	–	
40 x 16R x 6 - 4	8.30	19.3	
40 x 20R x 6 - 3	7.80	18.5	
40 x 20R x 6 - 4 x 2	8.60	–	
40 x 40R x 6 - 2	9.40	–	
40 x 40R x 6 - 3	12.90	–	
40 x 40R x 6 - 3 x 2	13.80	–	
50 x 5R x 3.5 - 5	3.90	7.1	
50 x 10R x 6 - 4	8.00	19.7	
50 x 10R x 6 - 6	9.70	23.0	
50 x 12R x 6 - 6	10.40	–	
50 x 16R x 6 - 6	14.60	–	
50 x 20R x 6.5 - 3	11.40	–	
50 x 20R x 6.5 - 5	15.60	31.3	
50 x 20R x 6.5 - 4 x 2	9.10	–	
50 x 25R x 6.5 - 3 x 2	9.60	–	
50 x 40R x 6.5 - 2	13.90	–	
50 x 40R x 6.5 - 3	18.60	–	
50 x 40R x 6.5 - 3 x 2	17.60	–	
63 x 10R x 6 - 4	9.00	23.0	
63 x 10R x 6 - 6	11.00	27.0	
63 x 20R x 6.5 - 3	13.90	–	
63 x 20R x 6.5 - 5	19.20	39.4	
63 x 20R x 6.5 - 4 x 2	13.20	–	
63 x 40R x 6.5 - 2	17.00	–	
63 x 40R x 6.5 - 3	22.90	–	
63 x 40R x 6.5 - 3 x 2	24.80	–	
80 x 10R x 6.5 - 6	16.30	39.0	
80 x 20R x 12.7 - 6	59.00	119.5	

Lubrication

Relubrication quantities for Miniature, ECOplus and eLINE series.

For NLGI grade 2 and NLGI grade 00 greases:

The nut has to be lubricated with lubricant via the lube port before the ball screw is started.

Twice the relubrication quantity of grease is to be used when lubricating for the first time.

Size d_0 x P x D_w - i	Relubrication quantity of grease (g) Single nut, precision-rolled screw SN-R FEM-E-B -Miniature	FBZ-E-S	FSZ-E-S	FEP-E-S	ZEV-E-S	
6 x 1R x 0.8- 4	0.06	–	–	–	–	NLGI grade 00
6 x 2R x 0.8- 4	0.12	–	–	–	–	Dynalub 520
8 x 1R x 0.8 - 4	0.12	–	–	–	–	or alternatively
8 x 2R x 1.2 - 4	0.24	–	–	–	–	Castrol Long-
8 x 2.5R x 1.588 - 3	0.10	–	–	–	–	time PD00
12 x 2R x 1.2 - 4	0.15	–	–	–	–	
12 x 5R x 2 - 3	0.30	–	–	–	0.30	
12 x 10R x 2 - 2	0.30	–	–	–	0.30	
16 x 5L x 3 - 3	–	–	–	–	0.85	NLGI grade 2
16 x 5R x 3 - 3	–	–	–	–	0.85	Dynalub 510
16 x 10R x 3 - 3	–	–	–	–	1.00	or alternatively
20 x 5R x 3 - 4	–	0.7	0.7	–	1.20	Castrol Long-
20 x 5R x 3 - 5	–	–	–	–	–	time PD2
20 x 40R x 3.5 - 1 x 4	–	–	–	1.6	–	
25 x 5R x 3 - 4	–	1.1	1.1	–	–	
25 x 10R x 3 - 4	–	1.3	1.3	–	–	
25 x 25R x 3.5 - 1.2 x 4	–	–	–	1.5	–	
32 x 5R x 3.5 - 4	–	1.6	1.6	–	–	
32 x 10R x 3.969 - 5	–	2.3	2.3	–	–	
32 x 20R x 3.969 - 2	–	–	2.0	–	–	
32 x 32R x 3.969 - 1.2 x 4	–	–	–	2.6	–	
32 x 64R x 3.969 - 1 x 4	–	–	–	3.1	–	
40 x 5R x 3.5 - 5	–	–	2.2	–	–	
40 x 10R x 6 - 4	–	–	5.2	–	–	
40 x 20R x 6 - 3	–	–	6.7	–	–	

High-performance lubricant for Linear Motion Systems

(not released for the USA)

Product description Dynalub 510

Materialnummer	Packing unit
R3416 037 00	1 x 400 g

Dynalub 510 is an NLGI grade 2 lithium-based high-performance grease specially developed for linear motion systems. It is notable for offering excellent water resistance and protection against corrosion, and is suited for use at temperatures of between –20 °C and 80 °C.

Applications

Under conventional environmental con-ditions this ground-fiber, homogeneous grease is ideally suitable for the lubrication of linear elements:

- for loads of up to 0.5 C_{dyn}
- also for short-stroke applications ≥ 1 (mm)

Technical data

For further details, see "Safety Data Sheet Dynalub 510" R310EN 2052 (2004.04)

Chemical composition	Mineral oil, special lithium soap, agents	
Designation	KP2K-20	DIN 51 825
Appearance	Light-brown/beige, ground-fiber	
Service temperature range	–20 °C to +80 °C	
NLGI grade	2	
Worked penetration	265-295 1/10 mm	DIN ISO 2137
Water resistance	0-60, 1-90	DIN 51 807 P1
Melting point in °C	> 165	DIN ISO 2176
Flash point in °C	> 200 – base oil	DIN ISO 2592
Basic oil viscosity	100 mm^2/s 40 °C	DIN 51 562
	10 mm^2/s 100 °C	
Flow pressure at –20°C	< 1400 hPa	DIN 51 805
EMCOR test	0/0	DIN 51 802
Density at +25°C	approx. 0.92 g/cm^3	DIN 51 757
Copper corrosion	2 (24 h/120 °C)	DIN 51 811
Four ball tester welding load	> 2000 N	DIN 51 350 P4
Four ball tester impression diameter	0.93 (400 N, 1 h)	DIN 51 350 P5
Shelf life in original container	2 years	

Product description Dynalub 520

Materialnummer	Packing unit
R3416 043 00	1 x 400 g

Dynalub 520 is an NLGI grade 00 lithium-based high-performance grease specially developed for linear motion systems. It is notable for offering excellent water resistance and protection against corrosion, and is suited for use at temperatures of between –20 °C and +80 °C.

Applications

Under conventional environmental con-ditions this ground-fiber, homogeneous grease is ideally suited for the lubrication of miniature linear elements and for use in centralized lubrication systems.

Technical data

For further details, see "Safety Data Sheet Dynalub 520" R310EN 2053 (2004.04)

Chemical composition	Mineral oil, special lithium soap, agents	
Designation	KP00K-20	DIN 51 825
Appearance	Light-brown/beige, ground-fiber	
Service temperature range	–20 °C to +80 °C	
NLGI grade	00	
Worked penetration	400-430 1/10 mm	DIN ISO 2137
Water resistance	1-90	DIN 51 807 P1
Melting point in °C	> 160	DIN ISO 2176
Flash point in °C	> 200 – base oil	DIN ISO 2592
Basic oil viscosity	100 mm^2/s 40 °C	DIN 51 562
	10 mm^2/s 100 °C	
Flow pressure at –20°C	< 700 hPa	DIN 51 805
EMCOR test	0	DIN 51 802
Density at +25°C	approx. 0.92 g/cm^3	DIN 51 757
Copper corrosion	0-1 (24 h/100 °C)	DIN 51 811
Four ball tester welding load	1800 N	DIN 51 350 P4
Four ball tester impression diameter	0.80 (400 N, 1 h)	DIN 51 350 P5
Shelf life in original container	2 years	

Design Calculations

Upon request, we can perform all calculations to your specifications.

See “Design Calculation Service Form”, page 156.

Average speed and average load

Where the speed and load fluctuate, the service life must be calculated using the averages $\mathbf{F_m}$ and $\mathbf{n_m}$.

– where the speed fluctuates, the average speed $\mathbf{n_m}$ is calculated as follows:

$$n_m = \frac{|n_1| \cdot q_{t1} + |n_2| \cdot q_{t2} + \ldots + |n_n| \cdot q_{tn}}{100\%} \quad (1)$$

$n_1, n_2, \ldots n_n$	=	speeds in phases 1 … n	(min^{-1})
n_m	=	average speed	(min^{-1})
$q_{t1}, q_{t2}, \ldots q_{tn}$	=	discrete time step in phases 1 … n	(%)

The following applies for the effective equivalent bearing load:

Preload	Preload class factor X_{pr}
2% C	0.02
3% C	0.03
5% C	0.05
7% C	0.07
10% C	0.10

$$F > 2{,}8\, X_{pr} \cdot C \qquad F_{eff\,n} = |F_n|$$

$$F \leq 2{,}8\, X_{pr} \cdot C \qquad F_{eff\,n} = \left(\frac{|F_n|}{2{,}8 \cdot X_{pr} \cdot C} + 1\right)^{\frac{3}{2}} \cdot X_{pr} \cdot C$$

C	=	dynamic load rating	(N)
$F_{eff\,n}$	=	effective equivalent axial load during phase n	(N)
F_n	=	axial load during phase n	(N)
X_{pr}	=	preload factor	(–)

– where the load fluctuates and the speed is constant, the average load $\mathbf{F_m}$ is calculated as follows:

$$F_m = \sqrt[3]{|F_{eff\,1}|^3 \cdot \frac{q_{t1}}{100\%} + |F_{eff\,2}|^3 \cdot \frac{q_{t2}}{100\%} + \ldots + |F_{eff\,n}|^3 \cdot \frac{q_{tn}}{100\%}} \quad (2)$$

$F_{eff\,1}, F_{eff\,2}, \ldots F_{eff\,n}$	=	effective equivalent axial load during phases 1 … n	(N)
F_m	=	equivalent dynamic axial load	(N)
$q_{t1}, q_{t2}, \ldots q_{tn}$	=	discrete time step for $F_{eff\,1}, \ldots F_{eff\,n}$	(%)

– Where both the load and the speed fluctuate, the average load $\mathbf{F_m}$ is calculated as follows:

$$F_m = \sqrt[3]{\left|F_{eff\,1}\right|^3 \cdot \frac{|n_1|}{n_m} \cdot \frac{q_{t1}}{100\%} + \left|F_{eff\,2}\right|^3 \cdot \frac{|n_2|}{n_m} \cdot \frac{q_{t2}}{100\%} + \ldots + \left|F_{eff\,n}\right|^3 \cdot \frac{|n_n|}{n_m} \cdot \frac{q_{tn}}{100\%}} \quad (3)$$

$F_{eff\,1}, F_{eff\,2}, \ldots F_{eff\,n}$	=	effective equivalent axial load during phases 1 … n	(N)
F_m	=	equivalent dynamic axial load	(N)
$n_1, n_2, \ldots n_n$	=	speeds during phases 1 … n	(min^{-1})
n_m	=	average speed	(min^{-1})
$q_{t1}, q_{t2}, \ldots q_{tn}$	=	discrete time step for $F_{eff\,1}, \ldots F_{eff\,n}$	(%)

Nominal life

Service life in revolutions L

$$L = \left[\frac{C}{F_m}\right]^3 \cdot 10^6 \quad (4) \Rightarrow C = F_m \cdot \sqrt[3]{\frac{L}{10^6}} \quad (5) \Rightarrow F_m = \frac{C}{\sqrt[3]{\frac{L}{10^6}}} \quad (6)$$

C	=	dynamic load rating	(N)
F_m	=	equivalent dynamic axial load	(N)
L	=	service life in revolutions	(–)

Service life in hours L_h

$$L_h = \frac{L}{n_m \cdot 60} \quad (7)$$

L_h	=	service life	(h)
L	=	service life in revolutions	(–)
n_m	=	average speed	(min^{-1})

$$L_{h\,machine} = L_h \cdot \frac{DC_{machine}}{DC_{ball\,screw}} \quad (8)$$

$DC_{machine}$	=	duty cycle of the machine	(%)
$DC_{ball\,screw}$	=	duty cycle of the ball screw	(%)
$L_{h\,machine}$	=	nominal service life of the machine	(h)
L_h	=	nominal service life of the ball screw drive	(h)

Drive torque and drive power

Drive torque M_{ta}
for conversion of rotary motion into linear motion:

$$M_{ta} = \frac{F_L \cdot P}{2000 \cdot \pi \cdot \eta} \quad (9)$$

$$M_{ta} \leq M_p$$

F_L	=	thrust force	(N)
M_p	=	maximum permissible drive torque	(Nm)
M_{ta}	=	drive torque	(Nm)
P	=	lead	(mm)
η	=	mech. efficiency (approx. 0.9)	(–)

Transmitted torque M_{te}
for conversion of linear motion into rotary motion:

$$M_{te} = \frac{F_L \cdot P \cdot \eta'}{2000 \cdot \pi} \quad (10)$$

$$M_{te} \leq M_p$$

F_L	=	thrust force	(N)
M_p	=	maximum permissible drive torque	(Nm)
M_{te}	=	transmitted torque	(Nm)
P	=	lead	(mm)
η´	=	mech. efficiency (η´ approx. 0.8)	(–)

The dynamic drag torque must be taken into account for preloaded nuts.

Drive power P_a

$$P_a = \frac{M_{ta} \cdot n}{9550} \quad (11)$$

M_{ta}	=	drive torque	(Nm)
n	=	speed	(min^{-1})
P_a	=	drive power	(kW)

Design Calculations

Calculation example
Service life

Operating conditions

The service life of the machine should be 40,000 operating hours with the ball screw operating 60% of the time.

Proposed ball screw: 63 x 10

F_1 = 50 000 N	at	n_1 = 10 min^{-1}	for	q_1 = 6%	of the duty cycle
F_2 = 25 000 N	at	n_2 = 30 min^{-1}	for	q_2 = 22%	of the duty cycle
F_3 = 8 000 N	at	n_3 = 100 min^{-1}	for	q_3 = 47%	of the duty cycle
F_4 = 2 000 N	at	n_4 = 1 000 min^{-1}	for	q_4 = 25%	of the duty cycle
				100%	

Calculation procedure

Average speed $\mathbf{n_m}$

$$n_m = \frac{6}{100} \cdot |10| + \frac{22}{100} \cdot |30| + \frac{47}{100} \cdot |100| + \frac{25}{100} \cdot |1000| \quad (1)$$

$$n_m = 304\ min^{-1}$$

Average load $\mathbf{F_m}$ for variable load and variable speed

$$F_m = \sqrt[3]{|50000|^3 \cdot \frac{|10|}{304} \cdot \frac{6}{100} + |25000|^3 \cdot \frac{|30|}{304} \cdot \frac{22}{100} + |8000|^3 \cdot \frac{|100|}{304} \cdot \frac{47}{100} + |2000|^3 \cdot \frac{|1000|}{304} \cdot \frac{25}{100}} \quad (3)$$

$$F_m = 8757\ N$$

Required service life **L** (revolutions)
The service life **L** can be calculated by transposing the formulas (7) and (8):

$$L = L_h \cdot n_m \cdot 60$$

$$L_h = L_{h\ machine} \cdot \frac{DC_{ball\ screw}}{DC_{machine}}$$

$$L_h = 40000 \cdot \frac{60}{100} = 24000\ h$$

$$L = 24000 \cdot 304 \cdot 60$$

$$L = 437\ 760\ 000\ revolutions$$

Basic dynamic load rating **C**

$$C = 8757 \cdot \sqrt[3]{\frac{437\ 760\ 000}{10^6}} \quad (5) \qquad C \approx 66492\ N$$

Result and selection

The ball screw can now be selected from the Dimension Tables:

e.g. ball screw,
size 63 x 10R x 6 - 6, with preloaded single nut with flange FEM-E-S,
dynamic load rating C = 88 800 N,
part number R1512 640 13.

Note:
Take into account the dynamic load rating of the screw bearing used!

Cross check

Service life of the selected ball screw in revolutions

$$L = \left(\frac{88\ 800}{8757}\right)^3 \cdot 10^6 \quad (4) \qquad L \approx 1042 \cdot 10^6\ revolutions$$

Service life in hours $\mathbf{L_h}$

$$L_h = \frac{1042 \cdot 10^6}{304 \cdot 60} \quad (7)$$

$$L_h \approx 57\ 167\ hours$$

The life of the selected ball screw assembly is thus greater than the required service life of 24,000 hours (including operating hours). A smaller ball screw could therefore be selected.

Design Calculations

Critical speed n_{cr}

The critical speed n_{cr} depends on the diameter of the screw, the type of end fixity and the free length l_{cr}. No allowance must be made for guidance by a nut without preload.
The operating speed should not reach more than 80% of the critical speed.

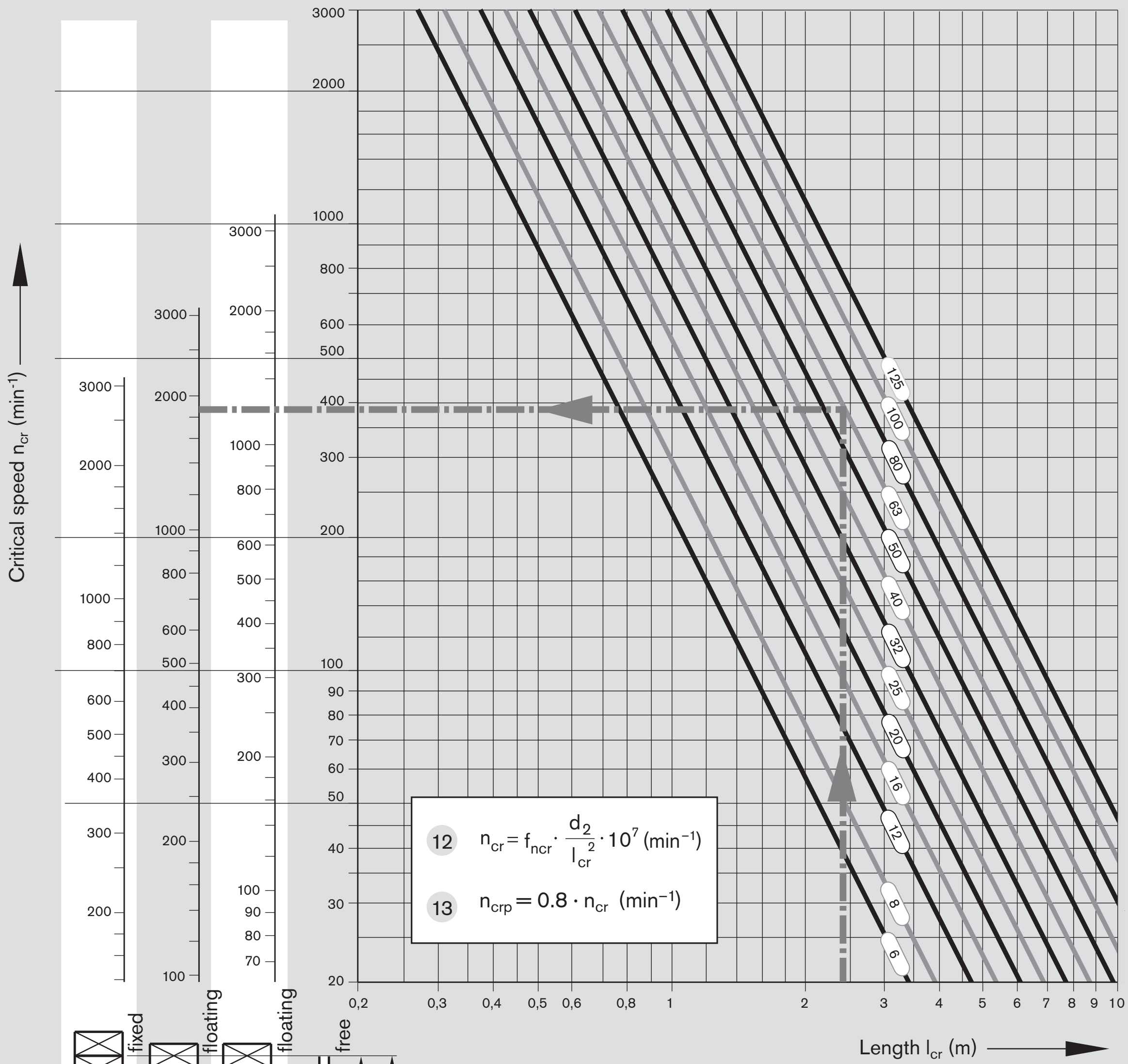
The characteristic speed and the max. permissible linear speed must be taken into account, see "Technical Notes".

Example

Screw diameter = 63 mm
Length l_{cr} = 2.4 m
End fixity II (fixed – supported)

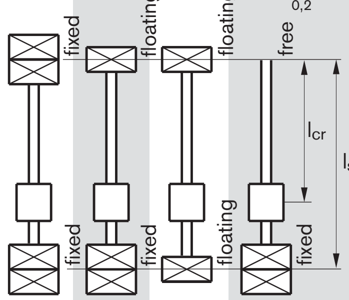
According to the graph, the critical speed is 1850 min^{-1}.
The permissible operating speed is thus 1850 min^{-1} x 0.8 = 1480 min^{-1}.

The maximum operating speed in our calculation example of n_4 = 1000 min^{-1} is therefore below the permissible operating speed.



$$n_{cr} = f_{ncr} \cdot \frac{d_2}{l_{cr}^2} \cdot 10^7 \ (min^{-1}) \quad (12)$$

$$n_{crp} = 0.8 \cdot n_{cr} \ (min^{-1}) \quad (13)$$



End fixity	I	II	III	IV
f_{ncr} value	27.4	18.9	12.1	4.3

n_{cr} = critical speed (min^{-1})
n_{crp} = permissible operating speed (min^{-1})
f_{ncr} = corrector value determined by bearing
d_2 = root diameter (see Dimension Tables) (mm)
l_{cr} = critical length for preloaded nut systems (mm)
l_s = distance between bearing and bearing (mm)
$l_{cr} = l_s$ for non-preloaded nut systems
For screw ends form 31 the end fixity can be assumed to be "fixed".

Permissible axial load on screw F_c (buckling load)

The permissible axial load on the screw F_c depends on the diameter of the screw, the type of end fixity and the effective free (unsupported) length l_c.

A safety factor of s ≥ 2 should be taken into consideration when determining the permissible axial load.

Example

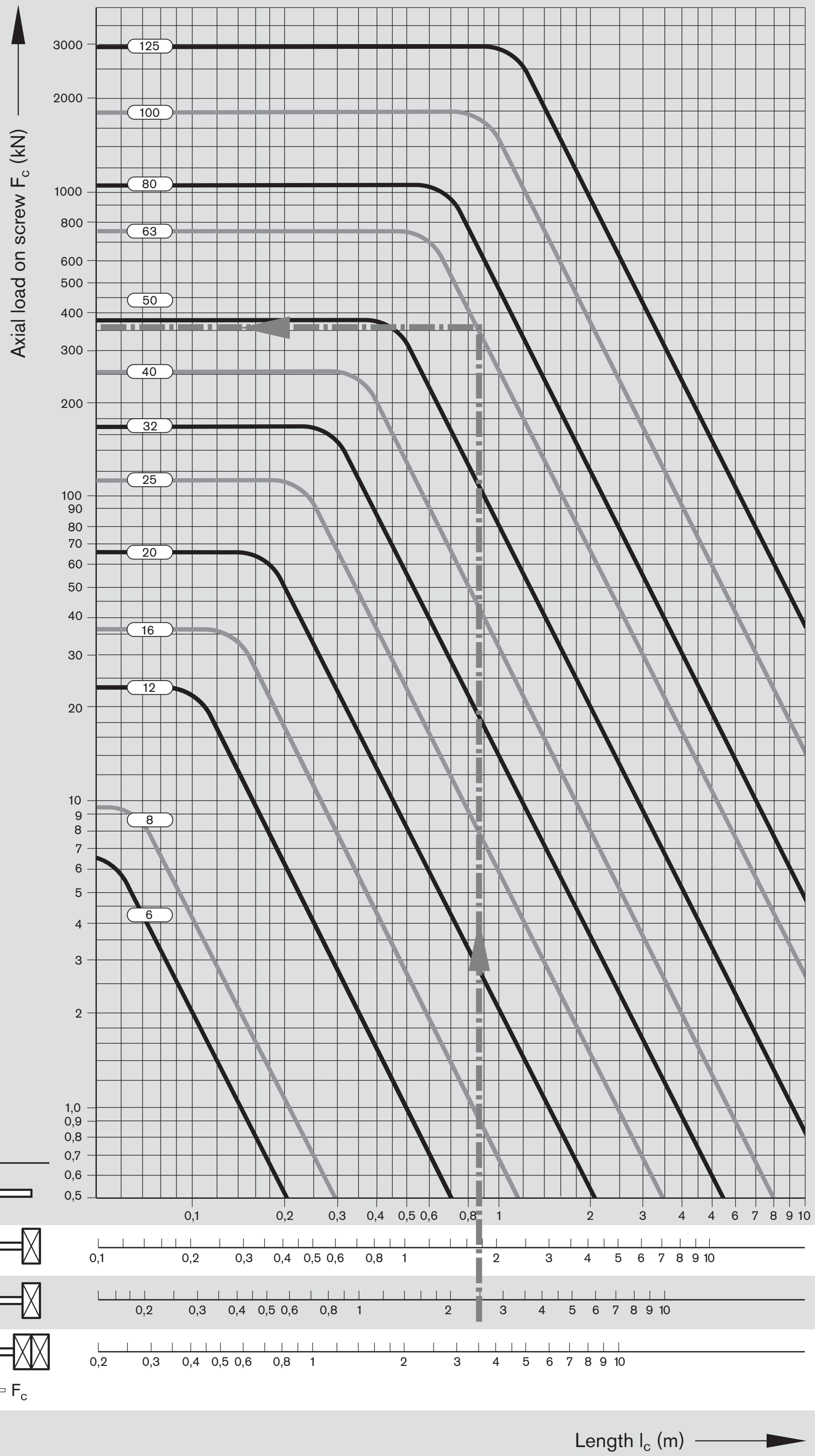
Screw diameter	=	63 mm
Lead	=	10 mm
Length l_c	=	2.4 m
End fixity II		(fixed – supported)

According to the graph, the theoretically permissible axial load is 360 kN.
A permissible axial load on the screw of 360 kN : 2 = 180 kN is achieved when applying the safety factor 2. This therefore lies above the maximum operating load of F_1 = 50 kN used in our calculation example.

(14) $$F_c = f_{Fc} \cdot \frac{d_2^4}{l_c^2} \cdot 10^4 \text{ (N)}$$

(15) $$F_{cp} = \frac{F_c}{2} \text{ (N)}$$

F_c = theoretically permissible axial load on screw
F_{cp} = permissible axial load during operation
f_{Fc} = corrector value determined by bearing
d_2 = root diameter (mm), see Dimension Tables
l_c = unsupported threaded length (mm)



f_{Fc} value	End fixity
2.6	IV
10.2	III
20.4	II
40.6	I

l_c F_c

Design Notes, Mounting Instructions

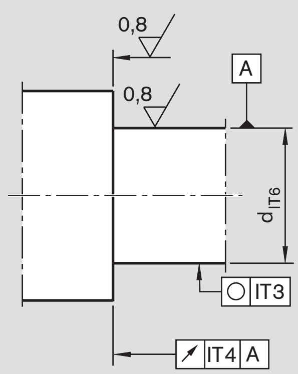
Bearing design

For customer-machined screw ends, please consider the design notes given for screw ends and housings.

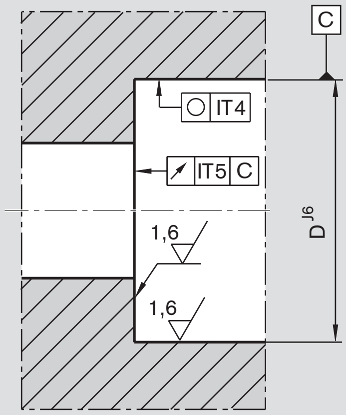
For Rexroth screw end designs, see “End Machining Details.”

Rexroth delivers complete drive systems, including the end bearings. Calculations are performed with the formulas used in the antifriction bearing industry.

Screw end



Housing

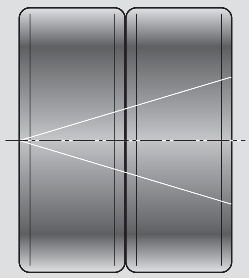


Mounting

Angular-contact thrust ball bearings and deep-groove ball bearings

When mounting the angular-contact thrust ball bearings LGF and LGN, ensure that the mounting forces are exerted only on the bearing rings. Never apply mounting forces via the anti-friction bearing elements or the seal rings! The two sections of the inner raceway may not be separated during assembly or disassembly for any reason! Tighten the mounting screws for screw-down or flange-mounted bearings in crosswise sequence. The mounting screws may be subjected only to tension amounting to a maximum of 70% of their yielding point. The screw-down (LGF) bearings have a groove on the cylindrical surface of the outer raceway for disassembly. The individual bearings of the bearing pair series LGF-C... and LGN-C... are marked on the cylindrical surfaces of the outer raceways (see Figure). The markings reveal the bearing sequence. The sealing rings should face outward after proper mounting.

Outer raceway markings for paired bearings



Slotted nut NMA, NMZ

The bearings are preloaded by tightening the nuts.

In order to prevent settling phenomena, we recommend first tightening the slotted nut by twice the value of the tightening torque M_A and then easing the load. Only then should the slotted nut be retightened to the specified tightening torque M_A. The two set screws are then alternately tightened using a hexagon socket wrench.

The components are disassembled in the reverse order, i.e. the set screws are to be removed before the slotted nut. The slotted nuts can be used several times when properly assembled and disassembled by competent personnel. The inner raceways of the bearings are dimensioned in such a way as to achieve a defined bearing preload sufficient for most applications when the slotted nut is tightened (M_A in accordance with Dimension Table).

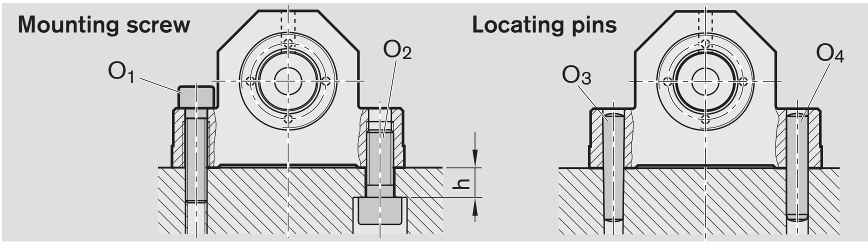
Lubrication, Mounting the Housing

Mounting the housing SEB

Tighten the pillow block mounting screws in crosswise sequence. See table for max. tightening torque. The housing nut fixes the entire bearing unit in the housing. Use a threadlocking adhesive to secure the housing nut in place.

⚠ **Note:**
Take care to align the screw and nut assembly, the bearings and the guideway precisely with one another. The Rexroth gauge is a useful aid here.

Size d_0 x P	h (mm)	O_1 DIN 912	O_2 DIN 912	O_3 – Tapered pin (hardened) O_4 – Straight pin (DIN 6325)
8 x 2,5	8	M5 x 20	M6 x 16	4 x 20
12 x 5	8	M5 x 20	M6 x 16	4 x 20
16 x 5	11	M8 x 35	M10 x 25	8 x 40
16 x 10	11	M8 x 35	M10 x 25	8 x 40
16 x 16	11	M8 x 35	M10 x 25	8 x 40
20 x 5	11	M8 x 35	M10 x 25	8 x 40
20 x 20	11	M8 x 35	M10 x 25	8 x 40
25 x 5	14	M10 x 40	M12 x 30	10 x 50
25 x 10	14	M10 x 40	M12 x 30	10 x 50
25 x 25	14	M10 x 40	M12 x 30	10 x 50
32 x 5	14	M10 x 40	M12 x 30	10 x 50
32 x 10	14	M10 x 40	M12 x 30	10 x 50
32 x 20	14	M10 x 40	M12 x 30	10 x 50
32 x 32	14	M10 x 40	M12 x 30	10 x 50
40 x 5	16	M12 x 50	M14 x 35	10 x 50
40 x 10	16	M12 x 50	M14 x 35	10 x 50
40 x 20	16	M12 x 50	M14 x 35	10 x 50
40 x 40	16	M12 x 50	M14 x 35	10 x 50



Tightening torques for fastening screws according to VDI 2230 for $\mu_G = \mu_K = 0.125$

Steel/steel material pairing

	Strength class for O_1; O_2	M5	M6	M8	M10	M12	M14
(Nm)	**8.8**	5.5	9.5	23	46	80	125
	12.9	9.5	16.0	39	77	135	215

Steel/aluminum and aluminum/aluminum material pairings

	Strength class for O_1; O_2	M5	M6	M8	M10	M12	M14
(Nm)	**8.8**	4.8	8.5	20	41	70	110
	12.9	4.8	8.5	20	41	70	110

Lubrication of the end bearings

Bearings for ball screw assemblies are lubricated with grease for a lifetime of reliable service. It should be noted, however, that grease lubrication does not facilitate the dissipation of heat in the bearings. The bearing temperature should therefore not exceed 50°C, particularly in machine tool applications. Angular-contact thrust ball bearings of the series LGF, LGN are lubricated for life with grease KE2P-35 per DIN 51825. For regreasing, the quantities stated in the table below can be applied via the lube ports provided on the bearings. The maximum interval can be assumed to be 350 million revolutions, in which case the larger of the two quantities should be used. As a rule, the initial grease quantity will therefore last for the entire service life of a ball screw assembly.

Relubrication quantities for angular-contact thrust ball bearings

Designation		Quantity (g)	Designation		Quantity (g)	Designation		Quantity (g)
LGN-B-0624		0.3 / 0.2						
LGN-B-1034		0.3 / 0.2						
LGN-B-1242	LGF-B-1255	0.4 / 0.3						
LGN-B-1747	LGF-B-1762	0.5 / 0.4						
LGN-B-2052	LGF-B-2068	0.8 / 0.5						
LGN-B-2557	LGF-B-2575	1.0 / 0.6	LGN-C-2557	LGF-C-2575	2.0 / 1.2			
LGN-B-3062	LGF-B-3080	1.0 / 0.6	LGN-C-3062	LGF-C-3080	2.0 / 1.2			
LGN-B-3572	LGF-B-3590	1.6 / 0.9						
LGN-A-4075		2.0 / 1.2				LGN-A-4090	LGF-B-40115	6.0 / 3.5
LGN-A-5090		2.5 / 1.5				LGN-A-50110	LGF-A-50140	9.0 / 5.5

End Bearings

Design Calculations

Resulting and equivalent bearing loads

For angular-contact thrust ball bearings LGN and LFG
Angular-contact thrust ball bearings are preloaded. The chart shows the resulting axial bearing load F_{ax} as a function of preload and axial operating load F_{Lax}. For a purely axial load $F_{comb} = F_{ax}$.

$\alpha = 60°$	X	Y
$\frac{F_{ax}}{F_{rad}} \leq 2.17$	1.90	0.55
$\frac{F_{ax}}{F_{rad}} \leq 2.17$	0.92	1.00

α = pressure angle
F_{ax} = resulting bearing load
F_{Lax} = operating load
X, Y = dimensionless factor

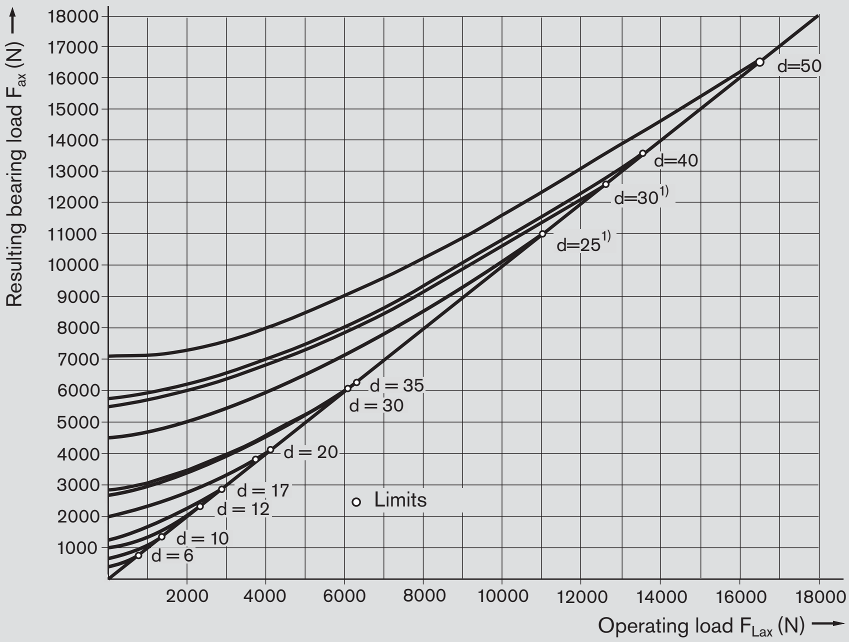
If the radial operating forces are not insignificant, the equivalent bearing loads are calculated according to formula 20.

Bearings for ball screw assemblies are also able to accommodate tilting moments. As a rule, the moments that usually occur due to the weight and drive motion of the screw do not need to be incorporated in the calculation of the equivalent bearing load.

$$F_{comb} = X \cdot F_{rad} + Y \cdot F_{ax} \quad (20)$$

F_{ax} = resulting axial bearing load (N)
F_{comb} = combined equivalent bearing load (N)
F_{rad} = radial bearing load (N)

Internal preload limit and resulting bearing load



1) Four row version

Permissible static axial load for bearing series LGF

The permissible static axial load of LGF-series bearings in screw-down direction is:

$$F_{0ax\,p} \leq \frac{C_0}{2}$$

$F_{0ax\,p}$ = permissible static axial bearing load (N)

The static axial load rating C_0 is stated in the Dimension Tables.

Resulting and equivalent bearing loads

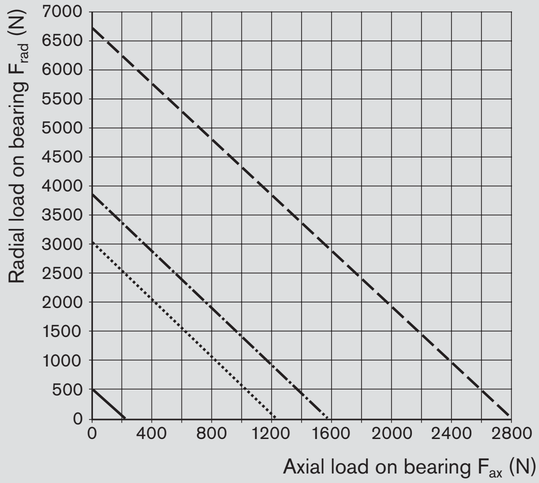
For angular-contact thrust ball bearings LGL
Before determining the combined equivalent load F_{comb}, the bearing size must be checked against the chart for static load limits.
A bearing will only be suitable for a particular application when the intersection point between the axial and radial bearing loads lies below the load limit curve.

$$F_{comb} = X \cdot F_{rad}^{A} + Y \cdot F_{ax}^{B} + Z \quad (21)$$

Bearing size	X	Y	Z	A	B
LGL-D-0624	0.003	0.1300	140	1.90	1.40
LGL-A-1244	0.076	0.0460	580	1.28	1.30
LGL-A-1547	0.022	0.0110	540	1.45	1.50
LGL-A-2060	0.017	0.0082	960	1.45	1.50

F_{ax} = axial bearing load (N)
F_{comb} = combined equivalent bearing load (N)
F_{rad} = radial bearing load (N)
X, Y, Z = calculation factors (–)
A, B = exponents (–)

Static load limit



Average speed and average bearing load
When the bearing load varies in steps over a specific period of time, calculate the dynamic equivalent bearing load using formula 22.
When the speed varies, use formula 23.
In these formulas $\mathbf{q_t}$ denotes the discrete time steps for the individual phases in %.

$$F_m = \sqrt[3]{F_{comb1}^{3} \cdot \frac{|n_1|}{n_m} \cdot \frac{q_{t1}}{100} + F_{comb2}^{3} \cdot \frac{|n_2|}{n_m} \cdot \frac{q_{t2}}{100} + \ldots + F_{combn}^{3} \cdot \frac{|n_n|}{n_m} \cdot \frac{q_{tn}}{100}} \quad (22)$$

$$n_m = \frac{q_{t1}}{100} \cdot |n_1| + \frac{q_{t2}}{100} \cdot |n_2| + \ldots + \frac{q_{tn}}{100} \cdot |n_n| \quad (23)$$

$F_{comb1} \ldots F_{combn}$ = combined equivalent axial load in phases 1 … n (N)
F_m = dynamic equivalent bearing load (N)
$n_1 \ldots n_n$ = speeds in phases 1 … n (min^{-1})
n_m = average speed (min^{-1})
$q_{t1} \ldots q_{tn}$ = discrete time steps in phases 1 … n (%)

Service life and load safety factor

Nominal life
The nominal life is calculated as follows:

Note:
Take into account the dynamic load rating of the nut!

$$L = \left(\frac{C}{F_{comb}}\right)^{3} \cdot 10^{6} \quad (24)$$

$$L_h = \frac{16666}{n_m} \left(\frac{C}{F_{comb}}\right)^{3} \quad (25)$$

C = dynamic bearing load rating (N)
F_{comb} = combined equivalent bearing load (N)
L = nominal service life in revolutions (–)
L_h = nominal service life in operating hours (h)
n_m = average speed (min^{-1})

Static load safety factor
The static load safety factor for machine tools should not be lower than 4.

$$S_0 = \frac{C_0}{F_{0max}} \quad (26)$$

F_{0max} = maximum static load (N)
C_0 = static load rating (N)
S_0 = static load safety factor (–)