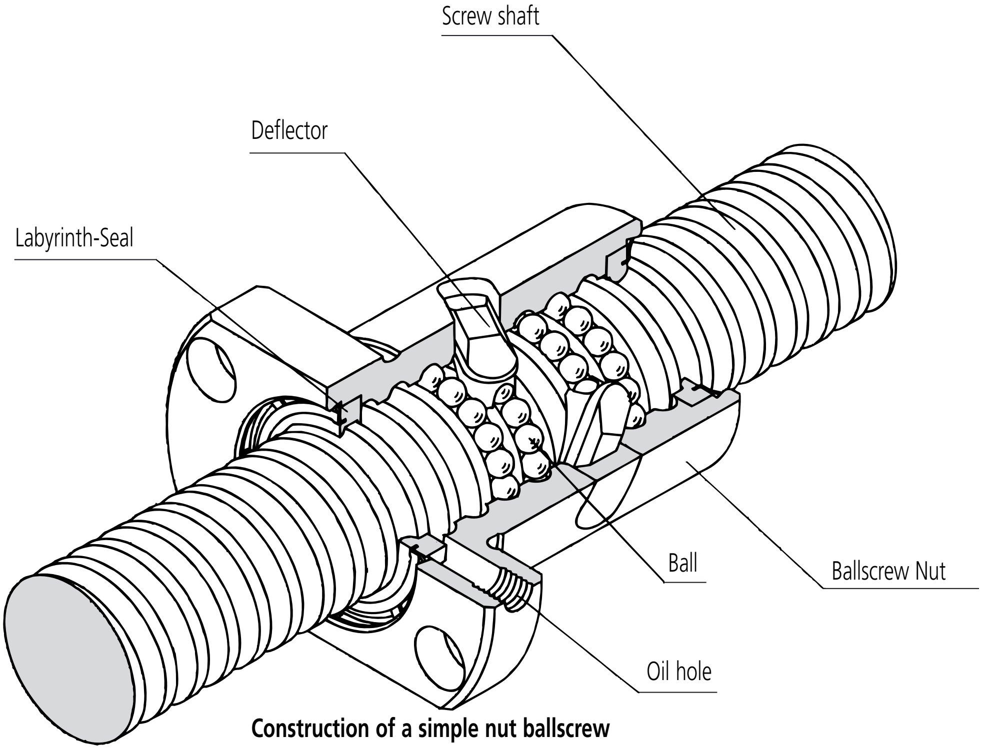
TECHNICAL

LINEAR MOTION

Precision Ballscrews



Construction of a simple nut ballscrew

Availability

Precision ballscrews can be delivered with the following specifications at short notice:

- according to DIN 69051, part 5 (ISO 3408-5)
- with large lead

Precision Rolled Ballscrews

Ground precision ballscrews are best suited for applications, where high axial rigidity is required. Precision rolled ballscrews are a cost-effective alternative to ground ground ballscrews. These products match the accuracy grades of the standard DIN 69051, part 3, as well as ISO 3408-3.

Standard / Accuracy grade / Manufacturing method		JIS (Jap. industrial standard) C3	C5	DIN/ISO Cp3	Cp5	Ct5
		Ground		Precision rolled		
Preload	Double nut	0.05 Ca	0.05 Ca	0.05 Ca	0.05 Ca	—
	EP Pitch shifted	0.05 Ca	0.05 Ca	0.02 Ca	0.02 Ca	—
	EB Ball selection	0.02 Ca	0.02 Ca	0.02 Ca	0.02 Ca	—

Support Units and Srew Shafts with Finished Ends Available

Precision ballscrews can be delivered with support units and the appropriate shaft ends.

Precision Ballscrews according to DIN 69051 (1989)

EPB/EBB (Form B)

Single Nut
Preloaded/With Axial Play
Available screw shaft diameter x lead:
16 x 05 - 63 x 20

BLK

Single Nut
Without Axial Play
Available screw shaft diameter x lead:
16 x 16 - 40 x 40

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Precision Ballscrews

Screw Shaft Selection

Available Diameter/Lead Combinations

The tables below indicate the standard combinations of the screw shafts and leads. If a diameter and lead combination other than those specified in the tables is required, please contact our technical department.

EB/EP Series (ground)

Precision Class	C3 and C5 Lead 5	10	20
Screw Shaft Diameter 16	●	-	-
20	●	-	-
25	●	●	-
32	●	●	-
40	●	●	●*
50	●	●	●*
63	-	●	●

● Standard. *EB only.

EB/EP Series (precision rolled)

Precision Class	Cp3 and Cp5 Lead 5	10	20
Screw Shaft Diameter 16	●	-	-
20	●	-	-
25	●	●	-
32	●	●	-
40	-	●	●*
50	-	-	-
63	-	-	-

● Standard. *EB only.

BLK Series (precision rolled)

Precision Class	C3 and C5 Lead 16	20	25	32	40
Screw Shaft Diameter 16	●	-	-	-	-
20	-	●	-	-	-
25	-	-	●	-	-
32	-	-	-	●	-
40	-	-	-	-	●

● Standard.

Limitations of Screw Shafts Lengths

The table below presents the maximum screw shaft lengths by accuracy grade for rolled and precision ballscrews. If the requested shaft length exceeds the range specified in the table below, please contact our technical department.

Limitation of screw shaft length by accuracy grade

Screw Shaft Diameter	Ground C3	C5	Precision Rolled Cp3	Cp5	Ct5
16	550	550	1100	1250	1400
20	850	850	1600	1700	1800
25	1260	1260	2000	2200	2400
32	1670	1670	2800	3000	3200
40	2070	2070	3700	4000	4300
50	2600	2600	-	-	-
63	2600	2600	-	-	-

Permissible Rotational Speed

Dangerous screw shaft speed
At high rotational speeds, the ballscrew causes resonance due to the characteristic frequency of the screw shaft, which may make operation impossible. The shaft speed should therefore be set at a level below the resonant point (critical speed).
Figure 1 indicates the relationship between screw-shaft diameter and critical speed.
Permissible rotational speed based on the critical speed can be calculated using equation (8), wherein 0.8 is used as a safety factor.

$$N_1 = \frac{60 \cdot \lambda_1^2}{2\pi \cdot l_b^2} \times \sqrt{\frac{E \cdot 10^3 \cdot I}{\lambda \cdot A}} \times 0.8 = \lambda_2 \cdot \frac{d_1}{l\, b^2} \cdot 10^7$$

where

N1	:	permissible rotational speed determined based on the critical speed	(min^{-1})
l_b	:	distance between mounting positions	(mm)
E	:	Young's modulus	(2.06×10^5 N/mm²)
I	:	minimum geometrical moment of inertia of the screw-shaft cross section	(mm⁴)
		$I = \frac{\pi}{64} \cdot d_1^4$ d_1: Screw-shaft thread min diameter	(mm)
γ	:	density (specific gravity)	(7.85×10^{-6} kg/mm³)
A	:	screw-shaft cross-sectional area	(mm²)
		$A = \frac{\pi}{4} \cdot d_1^2$	

λ_1 and λ_2 = coefficient depending on the mounting method

Fixed/free:	$\lambda_1 = 1.875$	$\lambda_2 = 3.4$
Supported/supported:	$\lambda_1 = 3.142$	$\lambda_2 = 9.7$
Fixed/supported:	$\lambda_1 = 3.927$	$\lambda_2 = 15.1$
Fixed/fixed:	$\lambda_1 = 4.730$	$\lambda_2 = 21.9$

DN Value

The permissible rotational speed of the ballscrew should be determined based on the critical speed and DN value.

The permissible rotational speed determined based on the DN value can be calculated using equations (1) through (3).

Precision-Ground Ballscrew

$$N_2 = \frac{100\,000}{D} \quad \ldots\ldots (1)$$

(For BNF, BNFN and BIF 70.000)

where

N_2	:	permissible rotational speed determined based on the DN value	(min^{-1})
D	:	ball center-to-center diameter (presented in the dimension table)	(mm)

Rolled Ballscrew (excluding the large-lead type)

$$N_2 = \frac{50\,000}{D} \quad \ldots\ldots (2)$$

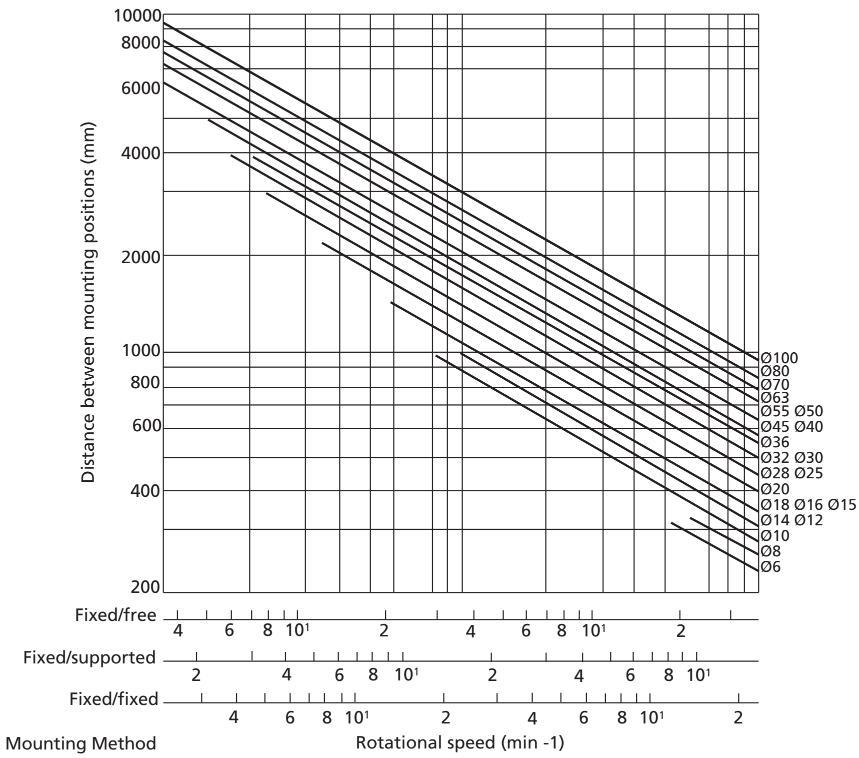
Large-Lead Rolled Ballscrew (BLK)

$$N_2 = \frac{70\,000}{D} \quad \ldots\ldots (3)$$

N_1 or N_2, whichever is lower, is taken as the permissible rotational speed.

For operating rotational speeds greater than N_2, high-speed ballscrew models are available. If you require these models, please contact our technical department.

Permissible Rotational Speed Diagram



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Permissible Axial Load

Screw-shaft buckling load

The ballscrew to be used should not buckle under the maximum compressive load applied in its axial direction.
Figure 2 shows the relationship between the screw-shaft diameter and the buckling load.
The buckling load can be calculated using equation (4), wherein 0.5 is used as a safety factor.

$$P_1 = \frac{n_1 \cdot \pi^2 \cdot E \cdot I}{l_a^2}\ 0.5 = n_2 \cdot \frac{d_1^4}{l_a^2}\ 10^4 \cdots\cdots\cdots (4)$$

where

P_1:	buckling load	(N)
l_a:	distance between mounting positions	(mm)
E :	Young's modulus	(2.06×10^5 N/mm^2)
I :	minimum geometrical moment of inertia of the screw-shaft cross section	(mm^4)

$$I = \frac{\pi}{64} \cdot d_1^4$$

d_1: Screw-shaft thread min diameter (mm)

n_1 and n_2 : coefficient depending on the mounting method

Fixed/free:	$n_1 = 0.25$	$n_2 = 1.3$
Fixed/supported:	$n_1 = 2.0$	$n_2 = 10.0$
Fixed/fixed:	$n_1 = 4.0$	$n_2 = 20.0$

Permissible tensile-compressive load of the screw shaft

Where an axial load is exerted on the ballscrew, the screw shaft to be used should be determined in consideration of buckling load and the permissible tensile-compressive load that can exert yielding stress on the shaft.

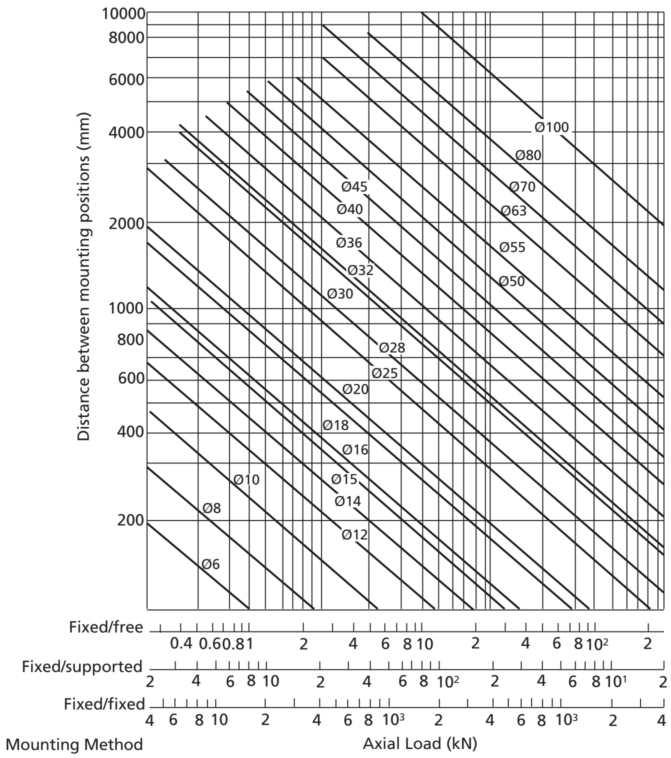
The permissible tensile-compressive load can be calculated using equation (5).

Precision-Ground Ballscrew

$$P_2 = \delta \cdot \frac{\pi}{4} \cdot d_1^2 = 116 \cdot d_1^2 \cdots\cdots\cdots (5)$$

P_2:	permissible tensile-compressive load	(N)
δ:	permissible tensile-compressive stress	(147 N/mm^2)
d1:	screw-shaft thread minor diameter	(mm)

Permissible Axial Load Diagram



TECHNICAL

Static Safety Factor

If the ballscrew, whether at rest or in motion, receives an excessive load or significant impact, localized permanent deformation develops between the raceway and balls.

Over a certain level, the permanent deformation hinders the smooth movement of the ballscrew. Normally, the basic static load rating (C_{0a}) is taken as the permissible axial load.

Basic static load rating (C_{0a})
The basic static load rating is the static load with a non-varying direction and magnitude that makes the sum of the permanent deformation of the rolling elements and raceway 0.0001 times the rolling-element diameter. With the ballscrew, the basic static load rating is defined in relation to the axial load.

Various values for the ballscrew are presented in the corresponding dimension tables in this catalog.

Static safety factor
The basic static load rating (C0a) is normally equal to the permissible axial load of the ballscrew. Depending on the operating conditions, use of a static safety factor such as that specified below should be considered. Please be aware that the ballscrew may receive an unpredictable external force due to vibration and impact while it is at rest or in motion, or due to inertia resulting from starting and stopping.

$$Fa\ max = \frac{C_{0a}}{f_s}$$

Fa max	: Permissible axial load	(kN)
C_{0a}	: Basic static load rating	(kN)
f_s	: Static safety factor	(see table below)

Static Safety Factor (fs)

Host machine	Load conditions	f_s lower limit
General Industrial Machine	When not subjected to vibration or impact	1.0 ~ 1.3
	When subjected to vibration and impact	2.0 ~ 3.0
Machine Tool	When not subjected to vibration or impact	1.0 ~ 1.5
	When subjected to vibration and impact	2.5 ~ 7.0

Considering Service Life

Service life of ballscrew units
The ballscrew in motion under an external load receives repeated stress on its raceways and balls. When the stress reaches a certain point, the raceways fatigue and eventually break, and their surfaces peel. Such peeling is called flaking.

The service life of a ballscrew unit is the total number of revolutions that the unit achieves before the first flaking occurs as a result of the rolling fatigue of the raceways or balls.

The service life of ballscrew units varies greatly from unit to unit, even if they are manufactured to the same specifications and remain in service under the same operating conditions. Therefore, guidelines for determining the service life of a ballscrew unit are given based on the nominal life, which is defined below.

The nominal life is the total number of revolutions that 90% of identical ballscrew units in a group, when operated independently of one another under the same conditions, can achieve without developing flaking.

Basic dynamic load rating C_a
The basic dynamic load rating (C_a) of the ballscrew is used to calculate its service life when it is operated under a load.
The basic dynamic load rating (C_a) is the load with a nonvarying direction and magnitude that makes the nominal life L of identical ballscrew units in a group, when operated independently of one another, 106 (revolutions). (Basic dynamic load rating C_a is presented in the corresponding dimension tables.)

The dynamic load C_a is based on the calculation method according to ISO 3408-5 respectively DIN 69051 (1989). This calculation method is defined by the European and Japanese ballscrew manufacturers as a universally valid standard.

Service-life calculation
The nominal life of the ballscrew can be calculated by an equation (6) using the values for the basic dynamic load rating (Ca) and applied axial load.

(1) Nominal life (total number of revolutions)

$$L = \left(\frac{C_a}{fw \cdot Fa}\right)^3 \cdot 10^6 \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where

L :	nominal life (total number of revolutions)	(rev)
		(min^{-1})
Ca :	basic dynamic load rating	(N)
Fa :	applied axial load	(N)
fw :	load factor	(see table on the next page)

Load Factor (f_W)

Vibration and impact	Velocity (V)	f_W
Very Light	Very low: V % 0.25 m/s	1.0 ~ 1.2
Light	Low: 0.25 < V % 1.0 m/s	1.2 ~ 1.5
Medium	Intermediate: 1.0 < V % 2.0 m/s	1.5 ~ 2.0
Heavy	High: V > 2.0 m/s	2.0 ~ 3.5

(2) Service life in hours

If the number of revolutions per minute is known, the service life in hours can be calculated by an equation (7) using the value for the nominal life (L).

$$Lh = \frac{L}{60 \cdot n} = \frac{L \cdot l}{2 \cdot 60 \cdot S \cdot ls} \quad \ldots\ldots\ldots\ldots\ldots(7)$$

where

Lh	:	service life in hours	(h)
n	:	number of revolutions per minute	(min^{-1})
S	:	number of reciprocal operations per minute	(min^{-1})
l	:	ballscrew lead	(mm)
ls	:	stroke length	(mm)

(3) Service life in running distance

This can be calculated by an equation (8) using the values for the nominal life (L) and the ballscrew lead.

$$Ls = \frac{L \cdot l}{10^6} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

where

Ls	:	service life in running distance	(km)
l	:	ballscrew lead	(mm)

(4) Applied load and service life in consideration of the preload

For a ballscrew used with a preload applied to the nut, the service life should be calculated in consideration of the preload, which is the internal load on the nut. If you have questions about the preload, please contact us, and be sure to specify the relevant model number.

(5) Mean axial load

When the axial loads applied to the ballscrew fluctuate, the service life should be calculated based on the mean axial load of the varying axial loads.

The mean axial load (F_m) is the load that makes the service life of the ballscrew equivalent to that under varying loads exerted during operation.

Where loads vary incrementally, the mean axial load can be obtained using the following equation:

$$Fm = \sqrt[3]{\frac{1}{L}\left(F_{a1}^3 l_1 + F_{a2}^3 l_2 + \cdots + F_{an}^3 l_n\right)} \quad \ldots\ldots(9)$$

Fm	:	mean axial load	(N)
F_{an}	:	varying load	(N)
ln	:	running distance achieved under load (F_n)	(mm)
L	:	total running distance	(mm)

To determine the service life in the number of revolutions or hours instead of distance, obtain the distance using the equation shown below, and calculate the mean axial load.

$$l = l1 + l2 + \cdots l n$$
$$l1 = N_1 \cdot t_1$$
$$l2 = N_2 \cdot t_2$$
$$l n = N_n \cdot t_n$$

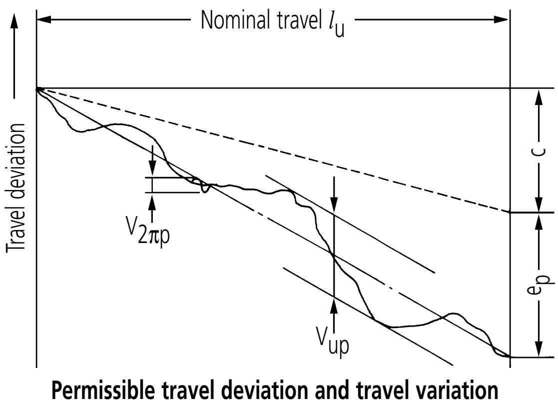
where

N	:	number of revolutions
t	:	time

Ballscrew Accuracy Grades

Travel Variation and Travel Deviation

The accuracy grades of the precision rolled ballscrews are related to standards ISO 3408 and DIN 69051. The accuracy grades of the ground ballscrews are controlled in accordance of the Japanese standard JIS B 1191 and JIS B 1192.



Permissible travel deviation and travel variation in relation to the nominal travel

Definitions according to ISO 3408:

e_p:	Tolerance on specified travel. The difference between the maximum and minimum values of the permissible actual mean travel.
V_{up}:	Permissible travel variation in relation to the nominal travel l_u.
$V_{2\pi p}$:	Permissible travel variation in relation to one rotation 2π rad.
V_{300p}:	Permissible travel deviation over 300 mm travel.
c:	Travel compensation. The difference between the specified travel and nominal travel within the useful travel (Standard: c = 0).

Table 1

Tolerance on specified travel ± e_p and permissible travel variation V_{up} in relation to the nominal travel l_u for positioning ballscrews.

Unit : µm

Standard Accuracy grade Nominal travel l_u mm		JIS				DIN/ISO			
		C3		C5		Cp3 1)		Cp5 2)	
Over	to (incl.)	ep	Vup	ep	Vup	ep	Vup	ep	Vup
—	315	12	8	23	18	12	12	23	23
315	400	13	10	25	20	13	12	25	25
400	500	15	10	27	20	15	13	27	26
500	630	16	12	30	23	16	14	32	29
630	800	18	13	35	25	18	16	36	31
800	1000	21	15	40	27	21	17	40	34
1000	1250	24	16	46	30	24	19	47	39
1250	1600	29	18	54	35	29	22	55	44
1600	2000	35	21	65	40	35	25	65	51
2000	2500	41	24	77	46	41	29	78	59
2500	3150	50	29	93	54	50	34	96	69
3150	4000	62	35	115	65	62	41	115	82
4000	5000	76	41	140	77	76	49	140	99
5000	6300	—	—	170	93	—	—	170	119
6300	8000	—	—	213	115	—	—	—	—
8000	10000	—	—	265	140	—	—	—	—

Table 2

Permissible travel variation in relation to one rotation 2_{rad} and permissible travel variation over 300 mm travel for positioning ballscrews.

Unit : µm

Standard Accuracy grade	JIS		DIN/ISO	
	C3	C5	Cp3 1)	Cp5 2)
V300p	8	18	12	23
V2πp	6	8	6	8

Table 3

Tolerance on specified travel e_p and permissible travel variation over 300 mm travel V_{300p} for transport ballscrews.

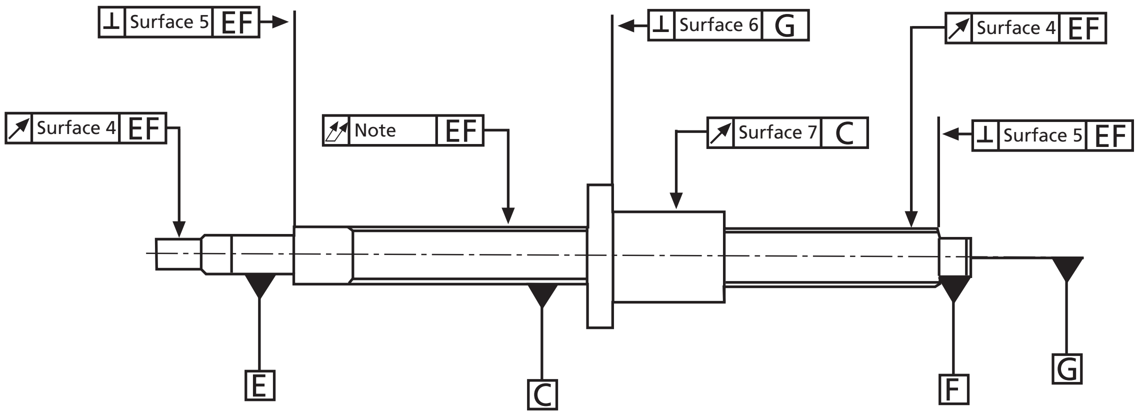
Standard Accuracy grade	DIN/ISO Ct5 3)
e_p	$e_p = 2 \frac{l_u}{300} V_{300p}$
V_{up}	not defined
V_{300p}	23
$V_{2\pi p}$	not defined

[1] Cp3 = Positioning ballscrews of the accuracy grade 3 according to DIN 63051 part 3 / ISO 3408 part 3
[2] Cp5 = Positioning ballscrews of the accuracy grade 5 according to DIN 63051 part 3 / ISO 3408 part 3
[3] Ct5 = Transport ballscrews of the accuracy grade 5 according to DIN 63051 part 3 / ISO 3408 part 3

Mounting Surface Accuracy C3 and C5

The mounting surface for the accuracy grades C3 and C5 of the ground precision ballscrews is specified in the Japanese standard JIS.

Only valid for the types BIF, BNFN, BNF, EB and EP



Notes: The overall radial runout of the screw shafts axis is defined in JIS B 1191 and 1192. For the radial run-out see table 8.

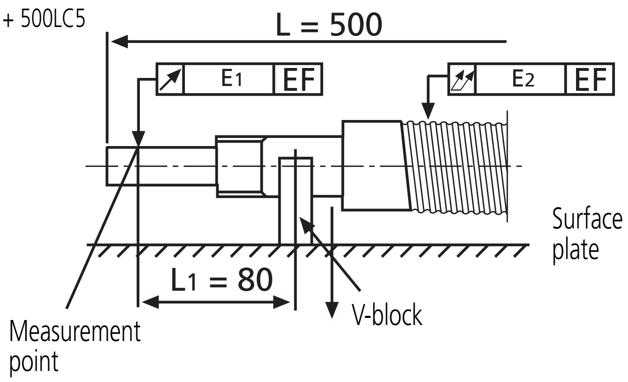
Table 3

Radial runout of the journal diameter in respect to EF

Unit : µm

Shaft Dia. D_0 (mm) Accuracy grade Over	Up to (incl.)	Journal Dia. (max) C3	C5
12	20	9	12
20	32	10	13
32	50	12	15

Example: Type BIF2005-RRG0 + 500LC5



$E_1 = e + \Delta e$

e: Standard value in table 4 (0.012)
Δe: Corrected value

$\Delta e = \frac{L_1}{L} \cdot E_2$

E_2: Overall radial runout in respect to EF according JIS.

$= \frac{80}{500} \cdot 0.060 = 0.010$

$E_1 = 0.012 + 0.010 = 0.022$

Notes: The overall runout of the thread root as seen in table 4 depends on the overall runout of the screw shaft. Therefore, like in the example, the proportion between the screw shaft length L and the measurement point must be set.

Table 5

Perpendicularity of the screw shaft supported portion in respect to EF

Unit : µm

Shaft Dia. d_0 (mm) Accuracy grade Over	Up (to incl.)	Perpendicularity C3	C5
12	20	4	5
20	32	4	5
32	50	4	5

Unit : µm

Table 6

Perpendicularity of the flange mounting surface in respect to G

Unit : µm

Nut Outer Dia. (mm) Accuracy grade Over	Up (to incl.)	Perpendicularity C3	C5
20	32	8	10
32	50	8	11
50	80	10	13
80	125	12	15

Table 7

Perpendicularity of the flange mounting surface in respect to G

Unit : µm

Nut Outer Dia. (mm) Accuracy grade Over	Up (to incl.)	Perpendicularity C3	C5
20	32	10	12
32	50	12	15
50	80	15	19
80	125	20	27

Table 8

Radial runout of the outer screw shaft diameter in respect to EF

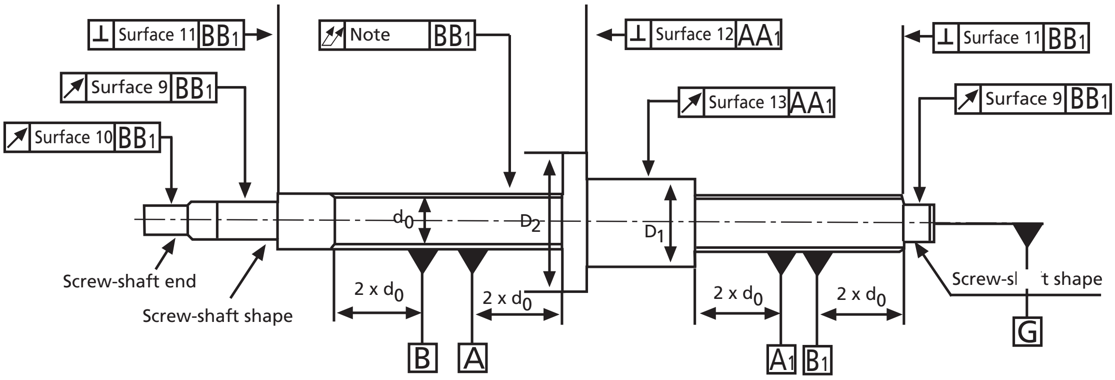
Unit : µm

	Standard Screw Shaft outer Dia. d_0 (mm) Over	Over Up to (Incl.) Up to (Incl.)	C3 12 20	C3 20 32	C3 32 50	C3 50 60	C5 12 50	C5 20 32	C5 32 50	C5 50 80
Screw Shaft Overall Length (mm)	-	125	20	-	-	-	35	-	-	-
	125	200	25	20	-	-	40	35	-	-
	200	315	30	30	-	-	45	40	-	-
	315	400	40	35	25	-	55	45	35	-
	400	500	50	40	30	-	60	50	45	35
	500	630	55	45	35	30	75	60	50	40
	630	800	70	55	40	35	90	70	55	45
	800	1000	95	65	50	40	120	85	65	50
	1000	1250	120	85	60	45	150	100	75	60
	1250	1600	160	110	75	55	190	130	95	70
	1600	2000	-	140	95	70	-	170	120	85
	2000	2500	-	-	125	85	-	-	150	110

Mounting Surface Accuracy Cp and Ct

The mounting surface for the accuracy grades Cp and Ct of the rolled precision ballscrews according to the standards DIN and ISO.

Only valid for the types EPA, EPB, EPC, EBA, EBB, EBC and BLK



LINEAR MOTION

Precision Ballscrews

Table 9

Radial runout of the journal in respect to BB.

Unit : µm

Nominal Dia. d_0 (mm) Over	Up to (incl.)	l (mm)	Radial Runout Cp3	Cp5 / Ct5
6	20	80	12	20
20	50	125	16	25

Table 10

Coaxial deviation of the journal diameter in respect to the bearing diameter (D).
Ballscrew is placed at the points BB.

Unit : µm

Nominal Dia. d_0 (mm) Over	Up to (incl.)	l (mm)	Coaxial Deviation Cp3	Cp5 / Ct5
6	20	80	6	8
20	50	125	8	10

Table 11

Axial runout of the bearing journal in respect to BB.

Unit : µm

Nominal Dia. d_0 (mm) Over	Up to (incl.)	Axial Runout Cp3	Cp5 / Ct5
6	63	4	5

Table 12

Perpendicularity of the flange mounting surface in respect to AA

Unit : µm

Flange Dia. D_2 (mm) Over	Up (to incl.)	Perpendicularity Cp3	Cp5 / Ct5
16	32	12	16
32	63	16	20
63	125	20	25
125	200	25	32

Table 13

Radial runout of the outer diameter of the nut in respect to AA.

Unit : µm

Outer Dia. D_1 (mm) Over	Up (to incl.)	Runout Cp3	Cp5 / Ct5
16	32	12	16
32	63	16	20
63	125	20	25
125	200	25	32

Table 14

Radial runout of the outer screw shaft diameter over the length 5 to determine the straightness in respect to BB.

Unit : µm

Screw Shaft Outer Dia. d_0 (mm) Over	Up to (incl.)	Reference Length l_5 (mm)	Runout Cp3	Cp5 / Ct5
12	25	160	25	32
25	50	315	25	32

Table 15

Maximum radial runout of the outer nut diameter valid for $l_1 \geq 4\ l_5$.

Unit : µm

l_1 / d_0 Over	Up to (incl.)	Runout (max) Cp3	Cp5 / Ct5
-	40	50	64
40	60	75	96
60	80	125	160
80	100	200	256

l_1 = Effective screw shaft length (mm)
d_0 = Screw shaft outer diameter (mm)
l_5 = Reference length (mm)
For more detailed information and test instructions see DIN 69051, part 3.

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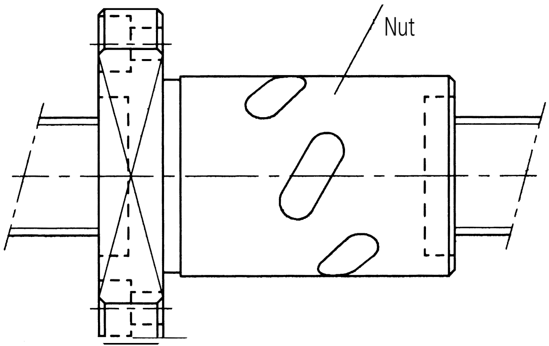
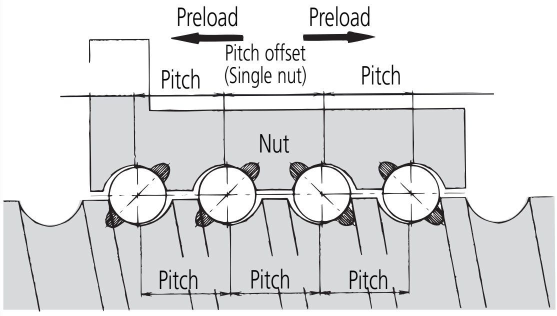
Precision Ballscrews

The preload eliminates the axial clearance of the ballscrew and improves the rigidity. Furthermore, the preload ensures positioning accuracy.

Preloading methods

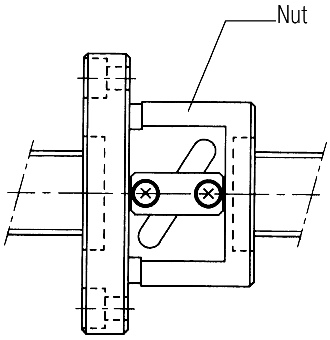
(A) Pitch shift method: The pitch is shifted at the central part of the nut to create the requested preload.

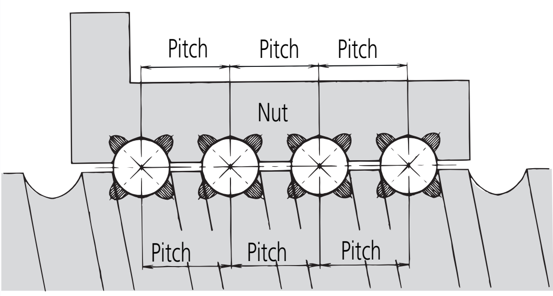




Screw Shaft

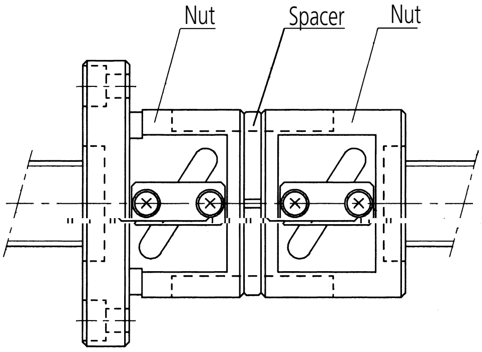
(B) Ball selection: To create the requested preload the nut is filled with balls in a certain diameter.

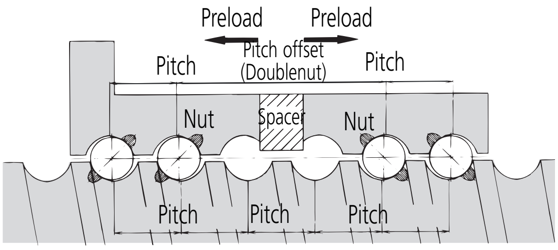




Screw Shaft

(C) Double nut method: Between two nuts a spacer creates the required preload.





Screw Shaft

Rigidity of the preloaded ballscrew

Nuts A and B of a double nut ballscrew receive preload F_{a0} as a result of the spacer. The preload causes elastic displacement δ_{a0} to be applied to both nuts. If an axial load F_a is exerted from outside under these conditions, the displacements of both nuts become as follows:

$\delta_a = \delta_{a0} + \delta_{a1}$ $\qquad$ $\delta_b = \delta_{a0} - \delta_{a1}$

That is, the loads exerted on nuts A and B are as follows:

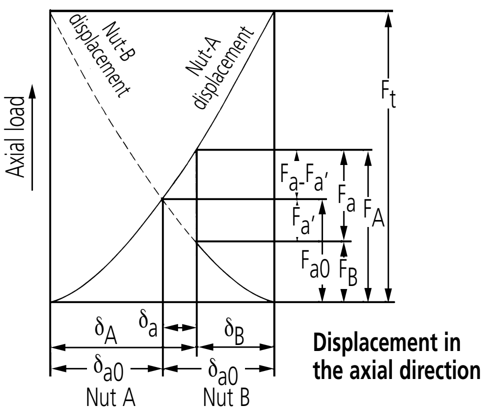
$F_A = F_{a0} + F_a - F_{a'} = F_a + F_p$ $\qquad$ $F_B = F_{a0} - F_{a'} = F_p$

Axial load and elastic displacement are connected as follows:

$\delta_{a0} = K \cdot F_{a0}^{2/3}$ $\qquad$ $2\,\delta_{a0} = K \cdot F_1^{2/3}$

$\left(\frac{F_1}{F_{a0}}\right)^{2/3} = \frac{2\,\delta_{a0}}{\delta_{a0}} = 2$ $\qquad$ $F_t = 2.8\,F_{a0} \approx 3\,F_{a0}$

The most optimum preload level is one-third of the maximum axial load. Standard values for the maximum preload are mentioned previously. A too high preload shortens the life time and increases the heat development.



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Axial Rigidity of the Feed-Screw System

Let the axial rigidity of a feed-screw system be K. Then, the elastic displacement in the axial direction can be obtained using equation.

$$\delta = \frac{F_a}{K}$$

δ	:	Feed-screw system elastic displacement in the axial direction	(µm)
F_a	:	applied axial load	(N)

The rigidity (K) of this feed-screw system can be obtained using equation (30).

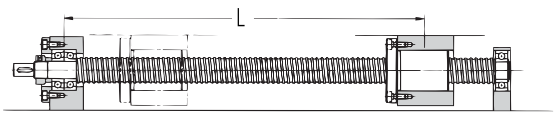
$$\frac{1}{K} = \frac{1}{K_S} + \frac{1}{K_N} + \frac{1}{K_B} + \frac{1}{K_H}$$

K	:	axial rigidity of the feed-screw system	(N/µm)
K_S	:	axial rigidity of the screw shaft	(N/µm)
K_N	:	axial rigidity of the Nut	(N/µm)
K_B	:	axial rigidity of the support bearing	(N/µm)
K_H	:	rigidity of the Nut Bracket and support bearing bracket	(N/µm)

Axial rigidity of the screw shaft

The axial rigidity of a screw shaft varies depending on the shaft mounting method.

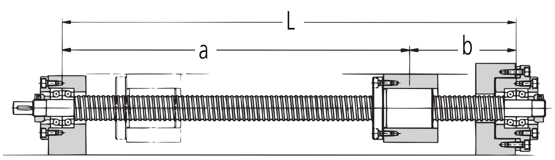
(1) For "fixed/supported" (free)



$$K_S = \frac{A \cdot E}{1000 \cdot L}$$

A	:	screw-shaft cross-sectional area	(mm^2)
		$A = \frac{\pi}{4} d_1^2$	
		(d_1: screw-shaft-thread minor diameter)	(mm)
E	:	Young's modulus	($2.06 \cdot 10^5$ N/mm^2)
L	:	distance between mounting positions	(mm)

(2) For "fixed/fixed"



$$K_S = \frac{A \cdot E \cdot L}{1000 \cdot a \cdot b}$$

At the point at which $a = b = \frac{L}{2}$

K_S becomes the minimum and the elastic displacement in the axial direction the maximum.

$$K_S = \frac{4A \cdot E}{1000L}$$

Axial rigidity of a nut

The axial rigidity of a Nut varies significantly depending on the preload levels.

Dimension tables include theoretical axial rigidity values when an axial load with a magnitude of 30% of the basic dynamic load rating (C_a) is exerted on the Nut. These values, however, do not take into account the rigidity of the Nut mounting brackets. Therefore, as a general rule, take 80% of the values given in the table.

When the applied axial load with a magnitude other than 30% of the basic dynamic load rating (C_a) is exerted on the Nut, rigidity values can be calculated using equation.

$$K_N = K \left(\frac{F_a}{0.3\,C_a}\right)^{1/3} \cdot 0.8$$

where

K_N	:	axial rigidity of the Nut	(N/µm)
K	:	rigidity value given in the dimension table	(N/µm)
F_a	:	applied axial load	(N)
C_a	:	basic dynamic load rating	(N)

Axial rigidity of the support bearing

The axial rigidity of the support bearings for the ballscrew varies by bearing type.
A typical calculation for determining the axial rigidity of an angular contact ball bearing can be made using equation.

$$K_B \approx \frac{3F_{a0}}{\delta_{a0}}$$

where

K_B	:	axial rigidity of the support bearing	(N/µm)
F_{a0}	:	preload on the support bearing	(N)
δ_{a0}	:	displacement in the axial direction	(µm)

$$\delta_{a0} = \frac{0.45}{\sin\alpha} \left(\frac{Q^2}{D_a}\right)^{1/3}$$

$$Q = \frac{F_{a0}}{Z \sin\alpha}$$

where

Q	:	axial load	(N)
D_a	:	ball diameter of the support bearing	(mm)
α	:	initial contact angle of the support bearing	(°)
Z	:	number of balls	

If you are not certain of these values, please contact the manufacturer of the bearing to be used.

Axial rigidity of the nut bracket and support bearing bracket

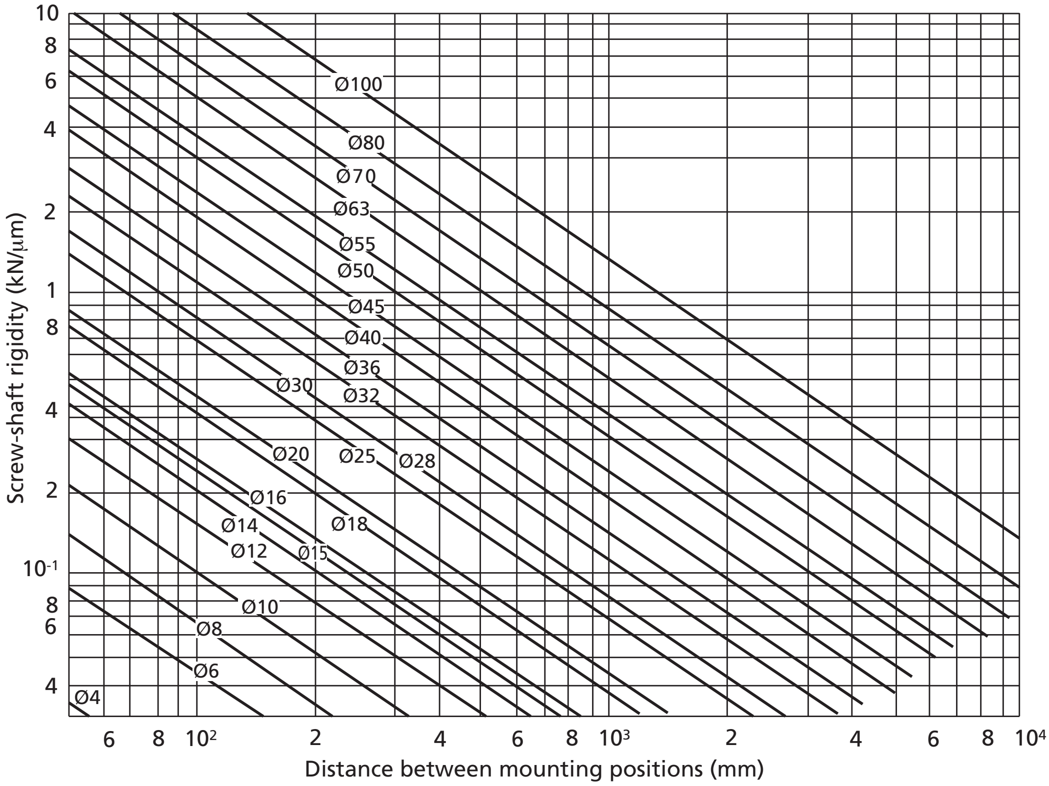
Take this into consideration in the design of your system. Set the rigidity as high as possible.

TECHNICAL

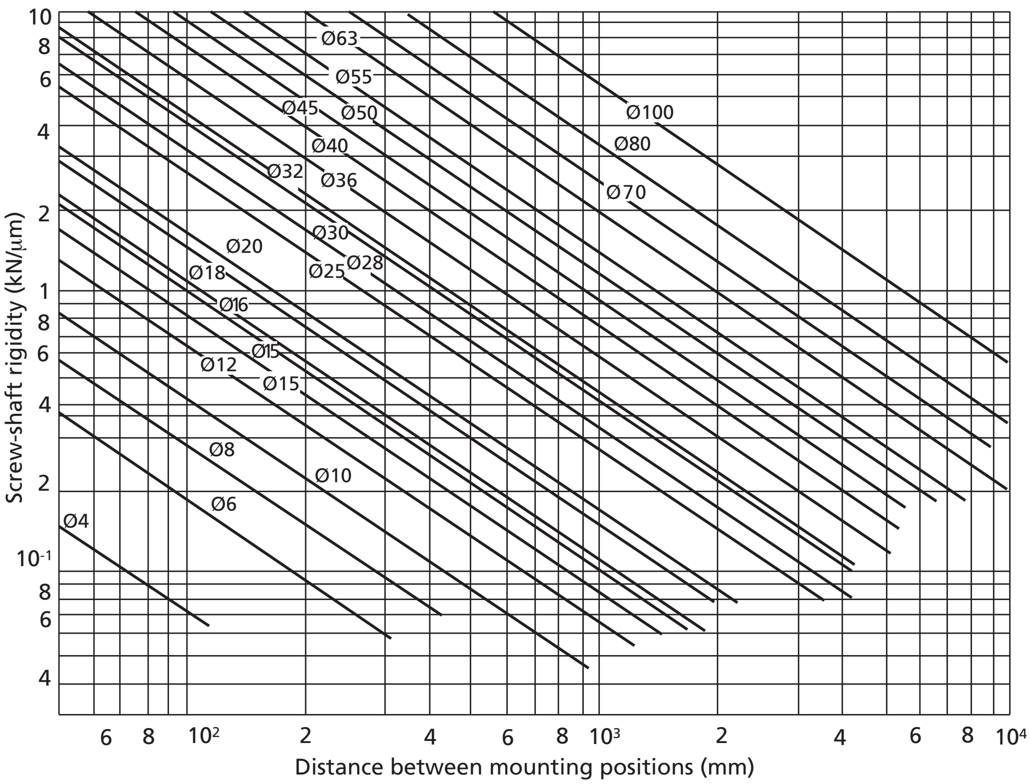
LINEAR MOTION

Precision Ballscrews

Axial Rigidity of a Screw Shaft (Fixed/Free and Fixed Supported)



Axial Rigidity of Screw a Shaft (Fixed/Fixed)



Precision Ballscrews

Lubrication

To ensure the optimum performance of the ballscrew, the correct lubricant and lubrication method for the relevant operating conditions should be selected.

Amount of lubricant

Insufficient lubricant causes poor lubrication, whereas an excessive amount of lubricant generates heat and increases resistance. It is therefore important to determine the optimum amount of lubricant for the relevant operating conditions.

Grease

The appropriate amount of grease is normally approximately 1/3 of the volume of the space within the nut.

Oil

The table below gives guidelines for the amount of oil. Please note, however, that the amount of oil depends on the stroke, type of oil used, and operating conditions (e.g., need to prevent heat generation).

Guidelines for the amount of oil (interval: 3min)

Shaft Diameter (mm)	Amount of Oil (cm^3)
16 - 18	0.07
20 - 25	0.10
28 - 32	0.15
36 - 40	0.25

Handling

As friction is reduced to a very low level in the ballscrew, when it is held upright, the nut can easily fall off the screw shaft.

Please be aware of this when holding the ballscrew upright. If the nut is not in place, the balls will also fall off, which may damage the ball circulation mechanism including the return pipe. Should the nut be detached from the screw shaft, contact our technical department.

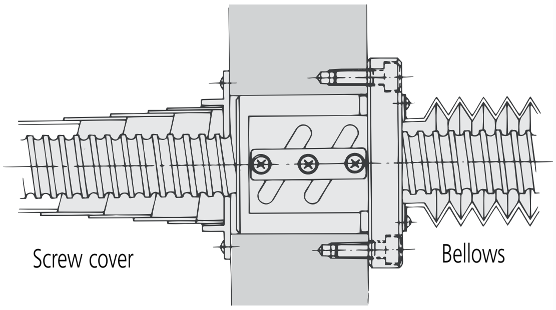
Some ballscrews have exposed ball circulation mechanisms (return pipe, end cap), so be very careful to avoid dents and similar impacts.

Contamination Protection

Dust and foreign matter that enter the ballscrew may cause accelerated wear and breakage, as with rolling bearings. Therefore, where contamination by dust and foreign matter (e.g., cutting chips) is likely, screw shafts must always be completely covered with contamination protection devices such as bellows or screw covers. If the ballscrew is used in an atmosphere free from foreign matter but with suspended dust, the labyrinth seal (for Precision Ballscrews) and brush seal (for Rolled Ballscrews) can be used in place of contamination protection devices. When placing an order, be sure to specify the model number.

The labyrinth seal is designed to maintain a clearance between the seal and screw-shaft raceway, so that torque does not develop and no heat is generated. However, its effect in contamination protection is limited.

In ballscrews other than the large-lead and super-lead types, there is no difference in nut dimensions between those with and without a seal.



Contamination Protection Cover

Installation

When attaching the ballscrew to a machine, do not detach the nut from the screw shaft. If it is necessary to detach the nut, apply a sleeve with a bore approximately 1 mm smaller than the screw-shaft thread minor diameter so as to prevent balls from falling off. Although the thread of the ballscrew is hardened and finished by grinding, forcible driving of a part onto the screw shaft or into the nut may cause an indentation in the raceway. When assembling parts on the screw shaft and nut, take care not to apply excessive force to the shaft and nut.

Misalignment between the screw-shaft supported portion and the nut exerts an unnatural force on the ballscrew, resulting in problems such as heavy rotation. Similar symptoms appear when the nut and the shaft supported portion are tilted. These problems accelerate wear on the ballscrew, which may significantly decrease its service life. Therefore, in terms of the mounting accuracy, pay close attention to misalignment and tilt. Upon completion of mounting, the ballscrew must be checked by moving it over the entire stroke to ensure that there is no problem with its operation.

In designing your ballscrew system, make sure that no radial load or moment is exerted on the ballscrew. Remember that a radial load or moment may significantly decrease the service life and cause malfunctions.