

## 3

AKD®

Integrated service provider for  
automation core components

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Official website



WeChat Official Account



Module Life Verification



3D Model Selection Website



# Company Profile

Shenzhen Jinwangda Electromechanical Co., Ltd. (brand AKD) was established in 2009. We are a national high-tech enterprise dedicated to the research and development, production, and sales of high-end automation core components, as well as a specialized and innovative technology enterprise in Guangdong Province.

Main products: Precision linear guides, precision ball screws, precision planetary roller screws, precision reducers, KKR steel-based modules, GTHA embedded aluminum-based modules, KTH/KTB/KCH/KCB series aluminum-based modules, KDG/KDA/KY series electric cylinders, linear motors, DD motors, hollow rotary tables, screws and support seats, etc.

Application fields: Semiconductor, 3C electronics, new energy, LCD/LED panels, medical, machine tools, humanoid robots, and other high-end automation industries.

Management System: ISO9001 Quality Management System.

Intellectual Property: The company has 8 invention patents, 33 utility model patents, 29 appearance patents, and 11 software copyrights.

Product certification: CE, ROHS.

AKD always adheres to the values of pragmatism and innovation, and the development concept of trust and persistence; Dedicated to building a well-known brand in the field of high-end automation core components, gradually achieving the internationalization of AKD brand. Through decades of continuous efforts and focus, AKD's revenue has always maintained a steady growth trend, with a wide range of market applications, creating a double good reputation for both brand and product, and winning unanimous recognition from peers and customers.



**Mission:**  
Make industrial design more precise and easy to operate.

**Vision:**  
Become a cost-effective and long-term reliable partner for customers!  
Become a leading brand in automation core components.

**Core values:**  
Pragmatic and innovative.

- National High-Tech Enterprise
- Shenzhen High-Tech Enterprise

- Guangdong SRDI Enterprise
- Partner Unit of Robotics Technology and the State Key Laboratory

**Accuracy**  
Precision, pursuit of precision

**Kind**  
Treat customers, employees, and shareholders with sincerity and friendliness

**Design**  
Design, originality, and innovation

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## Ball screw series

With high positioning accuracy and high-speed movement, it can bear loads in different directions at the same time, and is advantaged by easy assembly and simple lubrication structure

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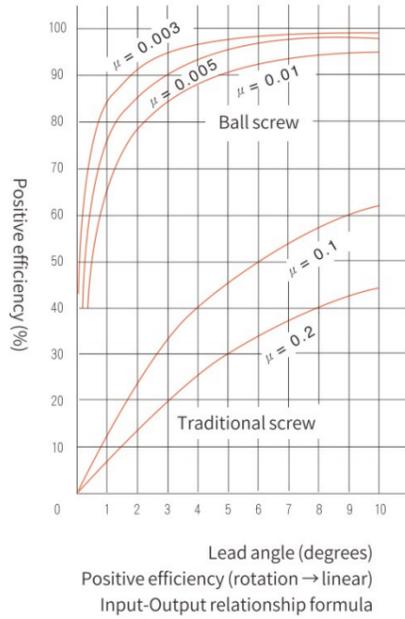
1-1 Characteristics of ball screws

(1) High reliability

Ball screws are based on many years of accumulated product technology. From materials, heat treatment, manufacturing, inspection to shipment, they are managed with strict quality assurance system, thus having high reliability.

(2) Smooth motion

As shown in figure 1.1.1, ball screws have higher efficiency than traditional screws, requiring only 30% or less torque, and can easily convert linear motion into rotary motion. Even with preload, ball screws can maintain the smooth motion characteristics.



μ: friction coefficient (grinding screw μ=0.005 rotary screw μ=0.01)

$$P = \frac{2\pi\eta_1 \times T}{\ell}$$

T = input torque kgf · cm  
P = output thrust kgf  
ℓ = lead cm  
η<sub>1</sub> = positive efficiency

$$T = \frac{\ell \times \eta_2 \times P}{2\pi}$$

T = input torque kgf · cm  
P = output thrust kgf  
ℓ = lead cm  
η<sub>2</sub> = positive efficiency

Figure 1.1.1 Mechanical Efficiency of Ball Screws

(3) No backlash and high rigidity

As shown in Figure 1.1.2, ball screws adopt a Gothic arch groove shape, and the axial clearance can be easily adjusted to a minimum. In addition, the preload adjustment is made between one or two nuts to eliminate axial clearance, so that it has appropriate rigidity to meet the operating conditions.

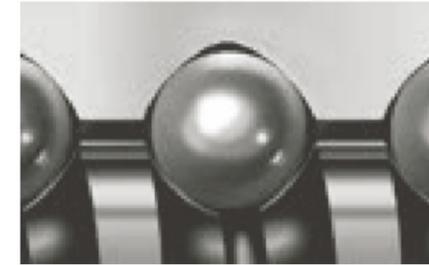


Figure 1.1.2 Gothic arch groove

(4) Circulation method

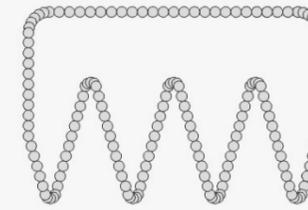


Figure 1.1.3 Outer circulation

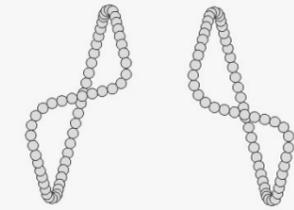


Figure 1.1.4 Inner circulation

(5) Excellent durability

Based on many years of accumulated ball screw production technology, the strict materials, high heat treatment and processing technology are adopted to provide durable products. It is shown in Table 1.1.1 and Figure 1.1.5.

Table 1.1.1 Material and Heat Treatment

Product Name	Material	Hardness
Screw rod	Screw - high carbon steel Cr-Mo alloy steel	HRC 58° ~64°
Nut	Nut - chrome molybdenum alloy steel	HRC 58° ~62°
Steel ball	Steel ball-chrome molybdenum alloy steel	HRC 62° UP

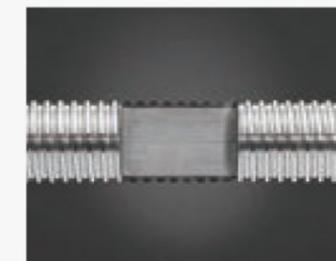
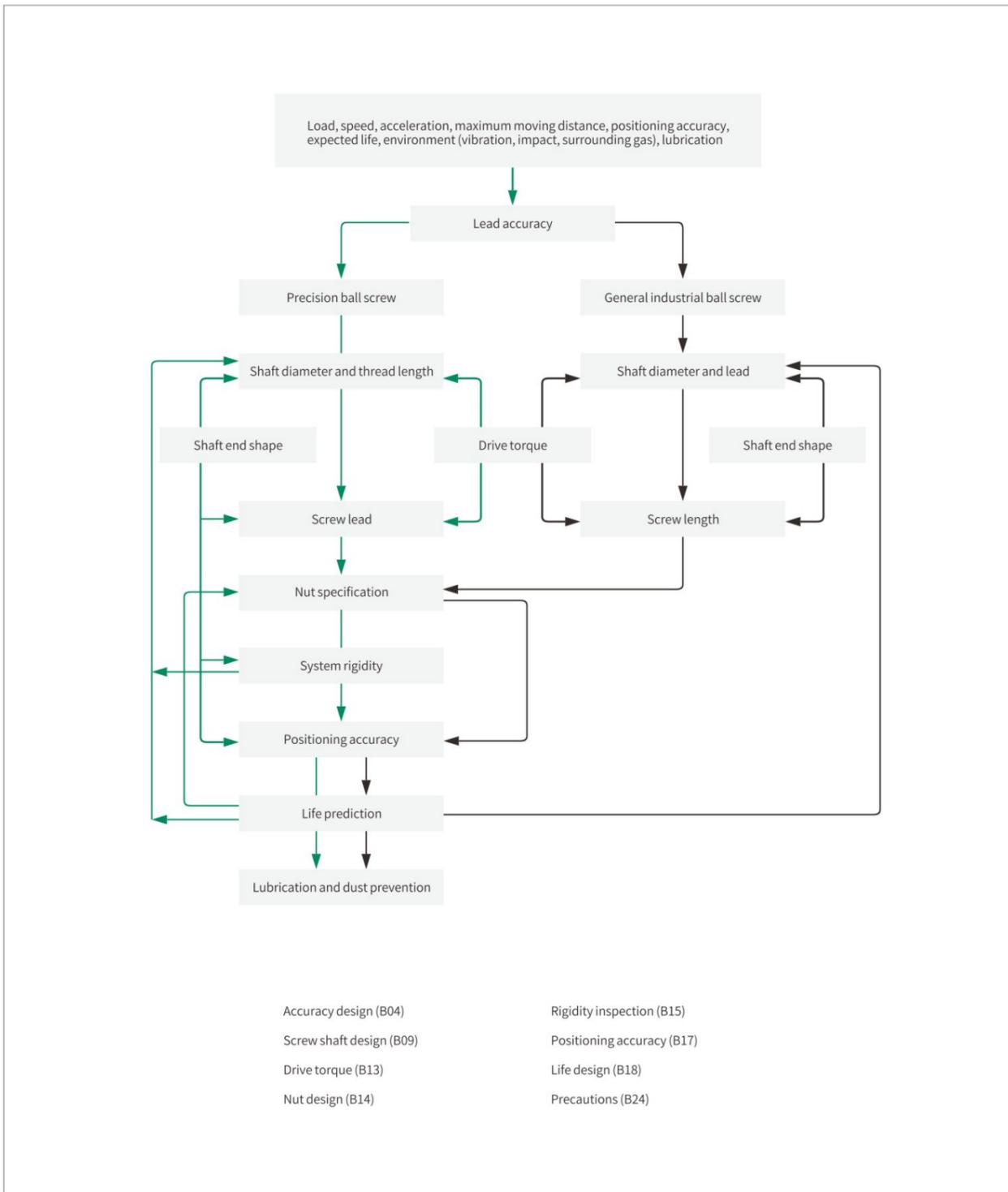


Figure 1.1.5 Heat Treatment Diagram

1-2 Selection Steps of Ball Screw



1-3 Accuracy Design

The lead accuracy of precision ball screws (C0 level ~ C5 level) is based on JIS standards and is specified by four characteristic items (E, e,  $e_{300}$ ,  $e_{2\pi}$ ). The definitions and tolerances of each characteristic are shown in Figure 1.3.1 and Tables 1.3.1 to 1.3.3. The accumulative lead errors for general ball screws C7, C10 are specified by taking the maximum width error tolerance within any 300 mm of effective thread length, as well as the  $e_{300}$  from Table 1.3.3, which are 0.05 mm and 0.21 mm respectively.

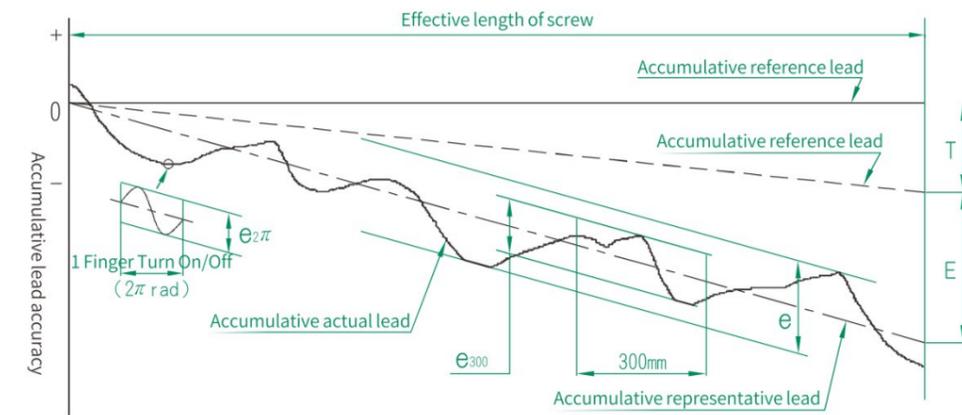


Figure 1.3.1 Instructions of lead accuracy

Terminology	Marks	Description	Admissible value
Target value of accumulative lead	T	Within the effective thread range, it refers to the difference between the accumulative reference lead and the accumulative nominal lead, that is, considering factors such as thermal expansion and elastic deformation in operation. The accumulative nominal lead is corrected in advance, and the screw is manufactured accordingly. Its value is determined by experiment or experience.	
Accumulative actual lead		Actually measured accumulative lead.	
Accumulative representative lead		The straight line representing the accumulative actual lead trend is obtained from the accumulative actual lead curve by the least squares method or the similar.	
Error of accumulative representative lead	E	The value of accumulative representative lead minus accumulative reference lead.	Table 1.3.2
Change	e $e_{300}$ $e_{2\pi}$	The maximum width of accumulative actual lead sandwiched between two straight lines drawn parallel to the accumulative representative lead is specified by the following three items. Maximum width within the effective thread length range.  The maximum width of any 300 mm taken within the effective thread length range. Within the range of one revolution of screw shaft, the maximum width of the difference between actually measured value and the reference value of axial movement of nut corresponding to any rotation angle.	Table 1.3.2 Table 1.3.3 Table 1.3.3

1-3 Accuracy Design

Table 1.3.2 Tolerance of Accumulative Representative Lead Error ( $\pm E$ ) and Change ( $e$ ) (JIS B 1192) Unit:  $\mu\text{m}$

Accuracy Grade			C0		C1		C2		C3		C5		C7	C10
	More than	Below	$\pm E$	$e$	$e$	$e$								
Effective thread length (mm)		100	3	3	3.5	5	5	7	8	8	18	18	$\pm 50/300\text{mm}$	$\pm 210/300\text{mm}$
	100	200	3.5	3	4.5	5	7	7	10	8	20	18		
	200	315	4	3.5	6	5	8	7	12	8	23	18		
	315	400	5	3.5	7	5	9	7	13	10	25	20		
	400	500	6	4	8	5	10	7	15	10	27	20		
	500	630	6	4	9	6	11	8	16	12	30	23		
	630	800	7	5	10	7	13	9	18	13	35	25		
	800	1000	8	6	11	8	15	10	21	15	40	27		
	1000	1250	9	6	13	9	18	11	24	16	46	30		
	1250	1600	11	7	15	10	21	13	29	18	54	35		
	1600	2000			18	11	25	15	35	21	65	40		
	2000	2500			22	13	30	18	41	24	77	46		
	2500	3150			26	15	36	21	50	29	93	54		
	3150	4000			30	18	44	25	60	35	115	65		
	4000	5000					52	30	72	41	140	77		
	5000	6300					65	36	90	50	170	93		
6300	8000							110	60	210	115			
8000	10000									260	140			
10000	12500									320	170			

Table 1.3.3 Comparison Table of International Standard Screw Accuracy Unit:  $\mu\text{m}$

Class		Grinding level					Rolling level		
		C0	C1	C2	C3	C5	C5	C7	C10
e <sub>300</sub>	ISO, DIN	-	6	-	12	23	23	52	210
	JIS	3.5	5	-	8	18	18	50	210
	AKD	3.5	5	7	8	18	23	50	210

1-3-2 Axial Clearance

The axial clearance preload levels of precision ball screws are shown in Table 1.3.4.

Table 1.3.4 Axial Clearance Preload Level

Accuracy Grade	P0	P1	P2	P3	P4
Clearance	Yes	No	No	No	No
Preload	No	No	Light	Medium	Heavy

1-3 Accuracy Design

The excessive preload will cause a large increase in friction torque and temperature rise effect, which will shorten the expected life. However, too low preload will make the ball screw insufficient rigidity and increase the possibility of losing steps. AKD recommends that the maximum preload shall not exceed 8% of the dynamic load for CNC machine tools. For automated X-Y platform mechanisms, the maximum preload shall not exceed 5% of the dynamic load.

Table 1.3.5 Preload (P2) Reference Value

Specification	Single-nut spring force (kgf)	Double-nut spring force (kgf)
1605	0.1~0.3	0.3~0.6
2005	0.1~0.3	0.3~0.6
2505	0.2~0.5	0.3~0.6
3205	0.2~0.5	0.5~0.8
4005	0.2~0.5	0.5~0.8
2510	0.2~0.5	0.5~0.8
3210	0.3~0.6	0.5~0.8
4010	0.3~0.6	0.5~0.8
5010	0.3~0.6	0.8~1.2
6310	0.6~1.0	0.8~1.2
8010	0.6~1.0	0.8~1.2

Table 1.3.6 Maximum Axial Clearance of Rolling-level and Grinding-level Ball Screws (P0) Unit: mm

Screw outer diameter size	Maximum axial clearance of rolling-level ball screw	Maximum axial clearance of grinding-level ball screw
Ø04~Ø14 Micro ball screw	0.05	0.015
Ø15~Ø40 Medium-sized ball screw	0.08	0.025
Ø50~Ø100 Large-sized ball screw	0.12	0.05

1-3-3 Mounting Part Accuracy of Ball Screw

For the accuracy for mounting part of ball screw, the necessary items are shown below:

- (1) Measure the circumferential runout in radius direction of screw support relative to the axis A of thread groove.
- (2) Measure the coaxiality of the part mounting position relative to the axis F of screw support.
- (3) Measure the perpendicularity of end face of the support relative to the axis E of screw shaft support.
- (4) Measure the perpendicularity of nut reference surface or flange mounting surface relative to the screw axis G.
- (5) Measure the coaxiality of outer edge circle (cylindrical) of nut relative to the screw axis A.
- (6) Measure the parallelism of nut outer edge (flat head mounting surface) relative to the screw axis C.
- (7) Total runout in radius direction of screw axis.

The accuracy items described tools here are based on JISB1191, 1192.

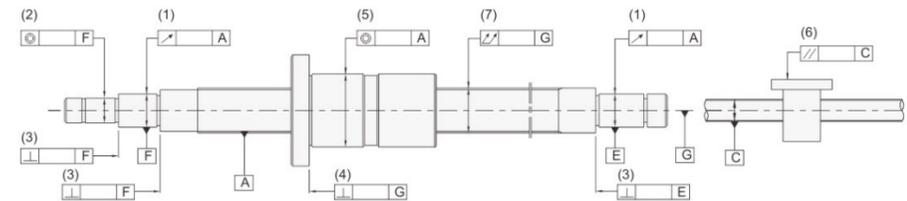


Figure 1.3.2 Accuracy of Ball Screw Installation Position

1-3 Accuracy Design

1-3-4 Preload Torque

The preload torque generated when rotating a ball screw with preload is shown in Figure 1.3.3. The allowable range of preload torque change rate is roughly based on JIS specifications, as shown in Table 1.3.7.

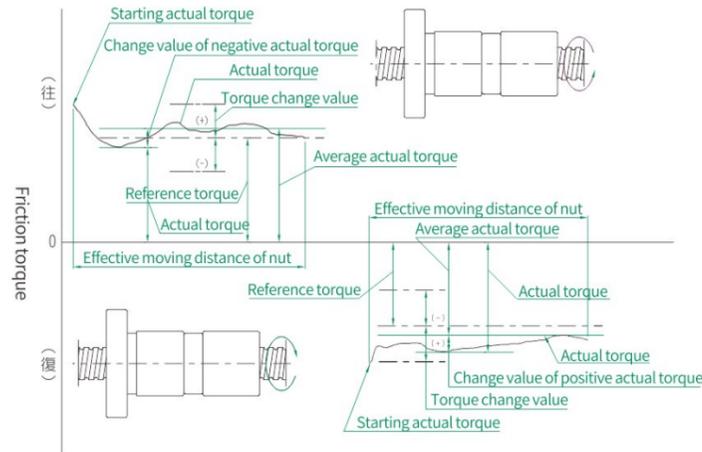


Figure 1.3.3 Description of preload torque

Meaning of Terminology

(1) Preload

To eliminate the screw clearance and increase the screw rigidity, one set of large-sized steel balls (about 2μ) are filled into the nut, or two nuts that are displaced relative to each other in the direction of screw shaft are used to generate the internal action of screw.

(2) Preload dynamic torque

After applying the specified preload to ball screw, it refers to the dynamic torque required to continuously rotate screw shaft or nut without external load.

(3) Reference torque

It is (1) in Figure 1.3.3, namely the preload torque set as the target.

(4) Torque change value

It refers to the change value of preload torque set as the target. It depends on the positive or negative value relative to reference torque.

(5) Torque change rate

It refers to change rate relative to the reference torque.

(6) Actual torque

Actually measured preload dynamic torque of ball screw.

(7) Average actual torque

It is the arithmetic average between the maximum and minimum torque actually measured when making nuts reciprocating within the effective length of thread part.

(8) Actual torque change value

It is the maximum change value measured when making nuts reciprocating within the effective length of thread part, and the minimum depends on the positive or negative value relative to actual torque.

(9) Actual torque change rate

It refers to the change rate relative to the average actual torque.

1-3 Accuracy Design

Table 1.3.7 Allowable range of torque change rate

Reference torque kgf · cm		Effective screw length										
		4000 Below				4000~10000 Below			-			
		Slenderness ratio: 1:40 below		Slenderness ratio: 40~1:60 below		-			-			
		Class		Class		Class			Class			
Exceeding	Below	C0	C1	C2, C3	C5	C0	C1	C2, C3	C5	C1	C2, C3	C5
2	4	±35%	±40%	±45%	±55%	±45%	±45%	±55%	±65%	-	-	-
4	6	±25%	±30%	±35%	±45%	±38%	±38%	±45%	±50%	-	-	-
6	10	±20%	±25%	±30%	±35%	±30%	±30%	±35%	±40%	-	±40%	±45%
10	25	±15%	±20%	±25%	±30%	±25%	±25%	±30%	±35%	-	±35%	±40%
25	63	±10%	±15%	±20%	±25%	±20%	±20%	±25%	±30%	-	±30%	±35%
63	100	-	-	±15%	±20%	-	-	±20%	±25%	-	±25%	±30%

Notes: 1. The slenderness ratio is the value obtained by dividing the thread length (mm) of screw shaft by outer diameter of screw shaft.  
2. The reference torque is 2kgf × cm below, and managed separately according to AKD specifications.

Calculation of reference torque  $T_P$

The calculation formula for reference torque  $T_P$  (kgf × cm) of the preloaded ball screw is as follows.

$$T_P = 0.05 (\tan\beta)^{-0.5} \cdot \frac{F_{a0} \cdot \ell}{2\pi}$$

Wherein,  $F_{a0}$  = preload (kgf)  
 $\beta$  = lead angle  
 $\ell$  = lead (cm)

Measurement condition

The preload torque ( $T_P$ ) is determined under the test conditions as shown in Figure 1.3.4. It involves rotating the screw shaft and measuring the force (F) required to prevent nut from rotating with it. The measured value of (F) is then multiplied by the length of force arm (L), and the product obtained is  $T_P$ .

$$T_P = F \cdot L$$

Measurement condition

- (1) The measurement is carried out without a scraper.
- (2) The measured rotation speed is 100rpm.
- (3) The viscosity of used lubrication oil complies with provisions of JSK2001 (Viscosity Classification of Lubricating Oils for Industrial Use) based on ISOVG68.

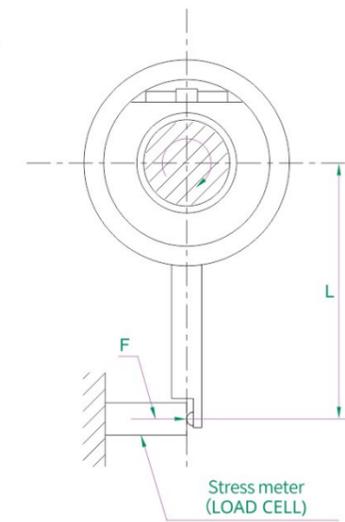


Figure 1.3.4 Measurement method of preload dynamic torque

1-4 Screw Shaft Design

1-4-1 Installation Method

The installation method is an important item when selecting the appropriate ball screw specification. Figures 1.4.1 to 1.4.8 are installation examples. When the operating conditions need to be judged under stricter conditions or special installation methods are used, resulting in unclear judgment conditions, please contact with AKD.

(Installation method of screw shaft and nut)

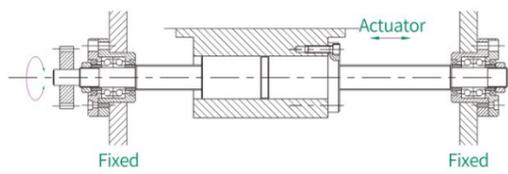


Figure 1.4.1

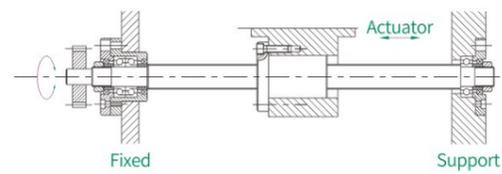


Figure 1.4.5

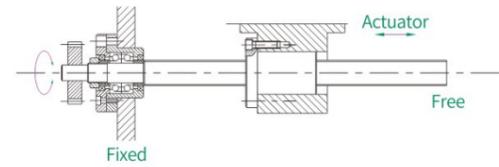


Figure 1.4.2

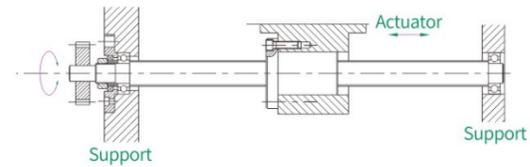


Figure 1.4.6

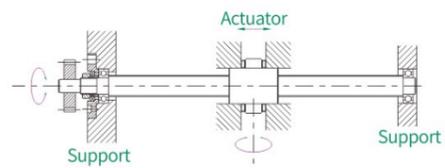


Figure 1.4.3

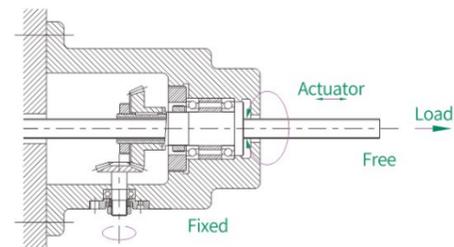


Figure 1.4.7

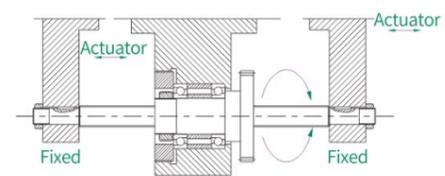


Figure 1.4.4

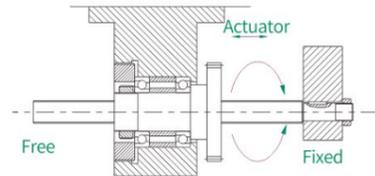


Figure 1.4.8

(Installation methods of screw shafts for various machine tools)

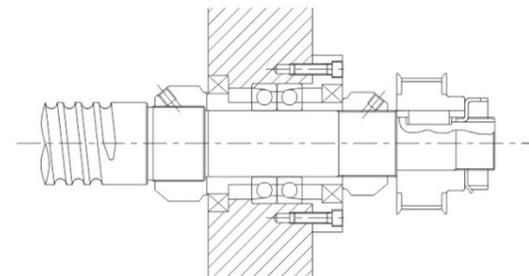


Figure 1.4.9

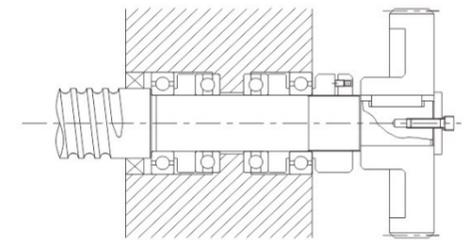


Figure 1.4.11

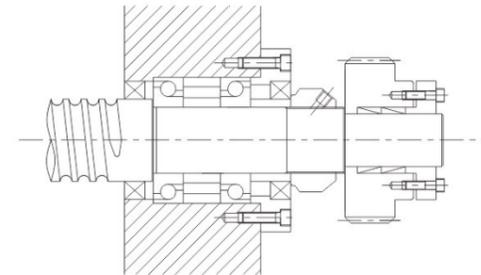


Figure 1.4.10

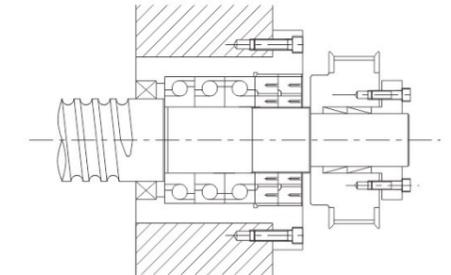


Figure 1.4.12

(Bearing installation method when pre-tensioning is applied)

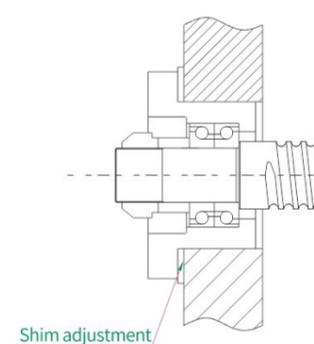


Figure 1.4.13

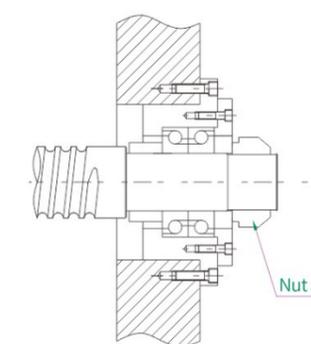


Figure 1.4.14

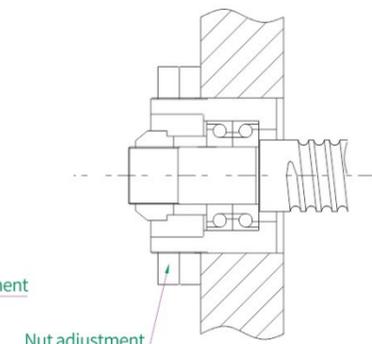


Figure 1.4.15

1-4 Screw Shaft Design

1-4-2 Allowable Axial Load

(1) Buckling load

Due to the action of compressive load, it is necessary to check the buckling safety of screw shaft. Figure 1.4.16 shows a chart that organizes the allowable compressive load of buckling according to the outer diameter of screw. (When the outer diameter of screw shaft is 125mm above, please calculate according to the following formula.) The scale of allowable axial load is selected according to the support method of ball screw.

$$P = \alpha \cdot \frac{I \cdot N \cdot \pi^2 \cdot E}{L^2} = m \frac{dr^4}{L^2} \cdot 10^3$$

Wherein

$\alpha$ : safety coefficient ( $\alpha = 0.5$ )

E : longitudinal elastic coefficient ( $E = 2.1 \cdot 10^4 \text{ kgf/mm}^2$ )

I : minimum second torque of screw shaft section

$$I = \frac{\pi}{64} dr^4 (\text{mm}^4)$$

dr : teeth root diameter of screw shaft (mm)

L : installation distance (mm)

m · N : the coefficient is determined according to the installation method of ball screw

Support - support m = 5.1 (N = 1)

Support - support m = 10.2 (N = 2)

Fixed - fixed m = 20.3 (N = 4)

Fixed - free m = 1.3 (N = 1/4)

(2) Allowable tensile and compressive load

When the installation distance is short, please check the following two items not related to the installation.

- Allowable tensile and compressive load (formula below) as corresponding to the reduced stress of screw shaft.
- Allowable load of full ball groove part

$$P = \sigma A = 11.8 dr^2 (\text{kgf})$$

Wherein,

P: allowable tensile and compressive load (kgf)

$\sigma$ : allowable tensile and compressive stress (kgf/mm<sup>2</sup>)

A: cross-sectional area of teeth root diameter of screw shaft (mm<sup>2</sup>)

dr: teeth root diameter of screw shaft (mm)

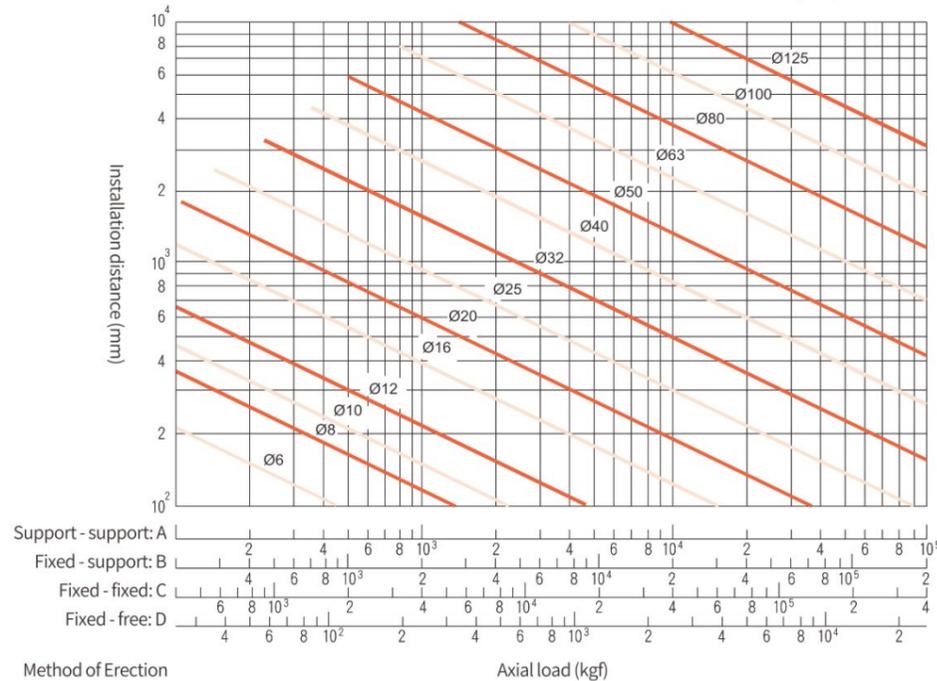


Figure 1.4.16 Allowable Compressive Load of Buckling

1-4 Screw Shaft Design

1-4-3 Allowable Rotation Speed

(1) Critical speed

It must be checked that the rotation speed of ball screw does not resonate with the natural vibration frequency of the screw (the speed at which resonance occurs is called the critical speed), and the allowable rotation speed is less than 80% of critical speed.

Figure 1.4.17 shows the allowable rotation speed relative to the critical speed as a line graph according to outer diameter of screw. (When the outer diameter of screw shaft is 125mm above, please calculate according to the following formula.) The scale of allowable rotation speed is selected according to the support method of ball screw. When the rotation speed used is higher than critical speed, leading to problems, please add an intermediate support to increase the natural vibration frequency of screw, which is also an effective method.

(2) Dm · n value

The allowable rotation speed is also limited by the Dm × N value (Dm: the center diameter of steel ball, unit: mm, N: rotation speed, unit: rpm) representing the peripheral speed.

For precision (grinding level C7 above)  
Dm × N ≤ 70,000

For general industrial (rolling)  
Dm × N ≤ 50,000

If it is necessary to manufacture ball screws exceeding the above limit, the special measures are required. Please contact with AKD before selection.

※ When the ratio of screw length to shaft diameter is  $\epsilon > 70$ , the special arrangements are required for manufacturing, please contact with AKD.

$$n = \alpha \cdot \frac{60\lambda^2}{2\pi L^2} \sqrt{\frac{Eg}{\gamma A}} = f \frac{dr}{L^2} \cdot 10^7 (\text{rpm})$$

Wherein

$\alpha$  : safety coefficient ( $\alpha = 0.8$ )

E : longitudinal elastic coefficient ( $E = 2.1 \cdot 10^4 \text{ kgf/mm}^2$ )

I : minimum second torque of screw shaft section

$$I = \frac{\pi}{64} dr^4 (\text{mm}^4)$$

dr : teeth root diameter of screw shaft (mm)

g : gravitational acceleration ( $g = 9.8 \cdot 10^3 \text{ mm/s}^2$ )

$\gamma$  : density of material ( $\gamma = 7.8 \cdot 10^6 \text{ kgf/mm}^3$ )

A : cross-sectional area of screw shaft ( $A = \pi dr^2 / 4 \text{ mm}^2$ )

L : installation distance (mm)

f,  $\lambda$  : coefficients determined according to the installation method of ball screw

Support - support f = 9.7 ( $\lambda = \pi$ )

Fixed - support f = 15.1 ( $\lambda = 3.927$ )

Fixed - fixed f = 21.9 ( $\lambda = 4.730$ )

Fixed - free f = 3.4 ( $\lambda = 1.875$ )

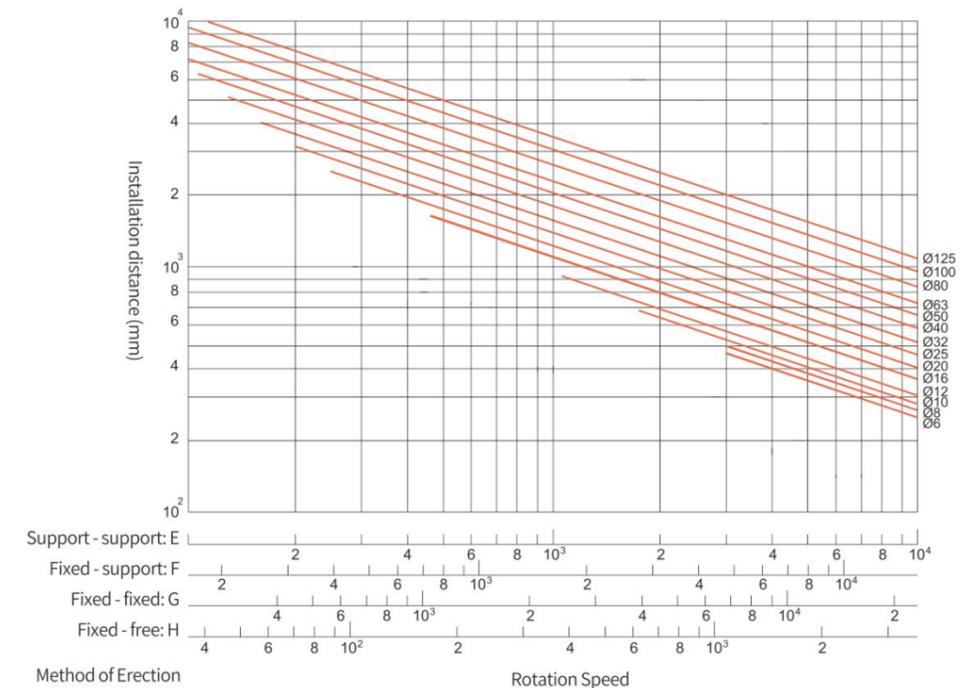


Figure 1.4.17 Allowable Rotation Speed of Shaft Relative to the Critical Rotation Speed

Ball screw

Ball screw

1-5 Drive torque

1-5-1 Drive Torque TS of Drive Shaft

$T_S = T_P + T_D + T_F$  (at constant speed)  
 $T_S = T_G + T_P + T_D + T_F$  (during acceleration)  
 $T_G$ : acceleration torque (1)  $T_P$ : load torque (2)  
 $T_D$ : preload torque (3)  $T_F$ : friction torque (4)

(1) Acceleration torque  $T_G$

$T_G = J\alpha$  (kgf · cm)  
 $\alpha = \frac{2\pi n}{60\Delta t}$  (rad/s<sup>2</sup>)  
 $J$ : Inertia torque converted from motor shaft (kgf · cm<sup>2</sup>)  
 $\alpha$ : angular acceleration (rad/s<sup>2</sup>)  
 $n$ : rotation speed (min<sup>-1</sup>)  
 $\Delta t$ : start-up time (sec)

(4) Friction torque  $T_F$

$T_F = T_B + T_O + T_J$  (kgf · cm)  
 $T_B$ : friction torque of support shaft  
 $T_O$ : friction torque of free shaft  
 $T_J$ : friction torque of motor shaft

(2) Load Torque  $T_P$

$T_P = \frac{P \cdot l}{2\pi\eta_1}$  (kgf · cm)  
 $P = F + \mu M g$   
 $P$ : axial load (kgf)  
 $l$ : lead (cm)  
 $\eta_1$ : positive efficiency  
 Efficiency when converting rotary motion into linear motion  
 $F$ : cutting force (kgf)  
 $\mu$ : friction coefficient  
 $M$ : mass of moving object (kg)  
 $g$ : gravitational acceleration (9.8 m/s<sup>2</sup>)

$T_P = \frac{P \cdot l \cdot \eta_2}{2\pi}$  (kgf · cm)

$\eta_2$ : reverse efficiency  
 Efficiency when converting linear motion into rotary motion

(3) Preload torque  $T_D$

$T_D = \frac{K \cdot P_{PL} \cdot l}{\sqrt{\tan \alpha} \cdot 2\pi}$  (kgf · cm)  
 $K$ : internal coefficient  
 (It is usually used as 0.05)  
 $P_{PL}$ : preload amount (kgf)  
 $l$ : lead (cm)  
 $\alpha$ : lead angle

[Reference] Load Inertia Torque (Table 1.5.1)  
 $J = J_{BS} + J_{CU} + J_W + J_M$

$J_{BS}$ : inertia torque of ball screw shaft  
 $J_{CU}$ : coupler inertia torque  
 $J_W$ : inertia torque of linear motion part  
 $J_M$ : inertia torque of the motor shaft roller part

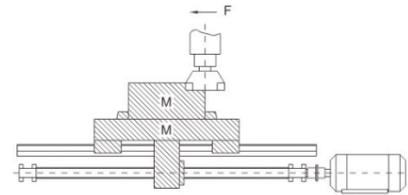


Figure 1.5.1 Load inertia torque

Table 1.5.1 Conversion Formula of Load Inertia Torque

Inertia torque converted from motor shaft	Formula	J
Cylindrical load		$\frac{\pi \rho L D^4}{32}$
Linear motion object		$\frac{M}{4} \left( \frac{V \cdot l}{\pi \cdot N_M} \right)^2 = \frac{M}{4} \left( \frac{P}{\pi} \right)^2$
Unit		kg · m <sup>2</sup>
Inertia torque during deceleration		$J_M = \left( \frac{N_l}{N_M} \right)^2 J /$

$\rho$ : density (kg/m<sup>3</sup>)  $\rho = 7.8 \cdot 10^3$   
 $L$ : cylinder length (m)  
 $D$ : cylinder diameter (m)  
 $M$ : mass of linear motion part (kg)  
 $V$ : speed of linear moving object (m/min)  
 $N_M$ : rotation speed of motor shaft (min<sup>-1</sup>)  
 $P$ : moving distance of object in linear motion per revolution of the motor (m)  
 $N_l$ : rotation speed in linear motion (min<sup>-1</sup>)  
 $J /$ : inertia torque in the load direction  
 $J_M$ : inertia torque in the motor direction

1-6 Nut Design

1-6-1 Nut Selection

(1) Series  
 When selecting a series, the required accuracy, required delivery date, size (screw shaft outer diameter, lead/screw shaft outer diameter ratio), preload amount, etc. shall be considered.

(2) Circulation method  
 Select the circulation method: please consider the space economy of nut installation part. The characteristics of circulation method are shown in Table 1.6.1.

(3) Number of circuits  
 The required performance, life, etc. shall be considered when selecting the number of circuits.

(4) Flange shape (flange)  
 Please select it according to the space of nut installation part.

(5) Oil filling hole  
 The precision ball screw is equipped with oil filling hole, which is used when the machine is assembled and for regular replenishment.

Table 1.6.1 Reference Types of Nut Circulation

Circulation method	Specification		Characteristics
	Single nut	Double nuts	
Inner circulation	SFNI SFK SFNU BSH	DFU DFI	<ul style="list-style-type: none"> <li>The outer diameter of the nut is small (not taking up space).</li> <li>It is suitable for small lead/screw shaft outer diameter ratio.</li> </ul>
End cover circulation	SFY SFH SFA SFYA		<ul style="list-style-type: none"> <li>It is suitable for high-speed feed applications.</li> </ul>

1-6-2 Nut Type

U-, I-, and M-type nuts

In this type, the steel balls move along the groove of circulator, cross the crest of screw thread and return to the origin. Generally, a roll of steel balls circulates once.  
 (As shown in Figure 1.6.1 below) This type of screw must have at least one end with full teeth, which is suitable for screws with smaller outer diameters.

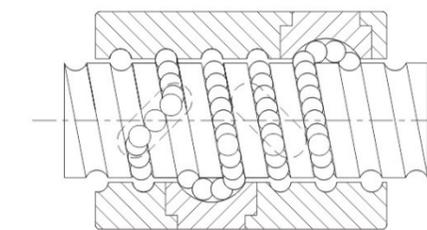


Figure 1.6.1 U, I, M-type nut diagram

K-type nuts

The circulation principle is the same as that of type I, but the circulation positions are all located on the keyway at the same angle in different circulations.  
 (As shown in Figure 1.6.2 below)

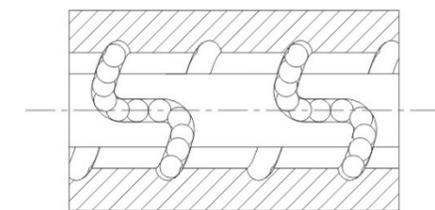


Figure 1.6.1 K-type nut diagram

Ball screw

Ball screw

1-6 Nut Design

Y, H, A nuts

Thin and flexible material on both ends of the dust blade reinforces the scraping effect. Reinforcement of the circulation return structure increases the high rigidity and high speed function. (Fig. 1.6.4 below)

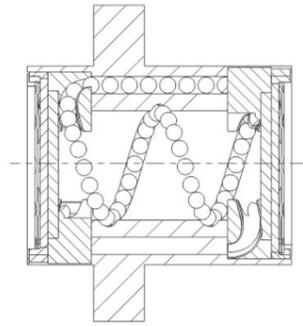


Figure 1.6.4 Y, YA, H, A, J-type nut diagram

1-7 Rigidity Review

Insufficient rigidity of the peripheral structure of the screw is one of the main causes of out-of-step. Thus, in order to obtain good positioning accuracy in precision machinery such as NC working machinery, it is necessary to consider the balance of the axial rigidity and the torsional rigidity of each part of the drive screw during design.

Static rigidity K

The elastic deformation and rigidity of the drive screw system in the shaft direction can be found from the following equation.

$$K = \frac{P}{e} \text{ (kgf/mm)}$$

- P : Shaft load carried by the drive screw system (kgf)
- e : Axial elastic displacement of drive screw system (mm)
$$\frac{1}{K} = \frac{1}{K_S} + \frac{1}{K_N} + \frac{1}{K_B} + \frac{1}{K_H} \text{ (mm/kgf)}$$
- K<sub>S</sub> : Directional rigidity of screw shaft (1)
- K<sub>N</sub> : KN: Shaft direction rigidity of nuts (2)
- K<sub>B</sub> : Directional rigidity of support shaft (3)
- K<sub>H</sub> : Shaft direction rigidity of nut and bearing mounting part (4)

(1) Directional rigidity of screw shaft K<sub>S</sub> and displacement δ<sub>S</sub>

$$K_S = \frac{P}{\delta_S} \text{ (kgf/mm)}$$

P : Shaft direction load (kgf)

Occasion of fix-fix installation

$$\delta_{SF} = \frac{PL}{4AE} \text{ (mm)}$$

$$\delta_{SS} = 4\delta_{SF}$$

δ<sub>SF</sub> : Directional displacement of occasion of fix-fix installation

δ<sub>SS</sub> : Directional displacement of occasion other than fix-fix installation

A : Cross-sectional area of teeth root diameter of screw shaft (mm<sup>2</sup>)

E : Longitudinal elasticity coefficient (2.1 · 10<sup>4</sup>kgf/mm<sup>2</sup>)

L : Distance between installations (mm)

L<sub>0</sub> : Distance between loading points (mm)

Occasion other than fix-fix installation

$$\delta_{SS} = \frac{PL_0}{AE} \text{ (mm)}$$

(2) Axial rigidity K<sub>N</sub> and displacement δ<sub>N</sub> of nuts

$$K_N = \frac{P}{\delta_N} \text{ (kgf/mm)}$$

(a) For single nut

$$\delta_{NS} = \frac{K}{\sin\beta} \left[ \frac{Q^2}{d} \right]^{\frac{1}{3}} \cdot \frac{1}{\zeta} \text{ (mm)}$$

$$Q = \frac{P}{n \cdot \sin\beta} \text{ (kgf)}$$

$$n = \frac{D_0 \pi m}{d}$$

Q : Load of a steel ball (kgf)

n : No. of steel balls

k : A constant determined by material, shape and size k ≈ 5.7 · 10<sup>-4</sup>

β : Contact angle (45°)

P : Shaft direction load (kgf)

d : Diameter of steel ball (mm)

ζ : Accuracy, internal construction factor

m : Effective number of turns

D<sub>0</sub> : Ball center diameter (mm)

$$D_0 = \frac{l}{\tan\alpha \cdot \pi} \text{ (mm)}$$

l : Lead (mm)

α : Lead angle

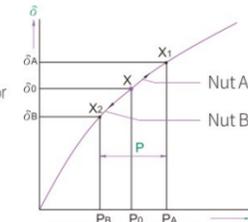


Figure 1.7.1

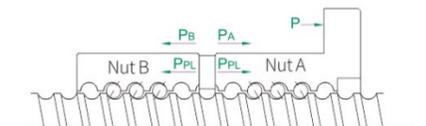


Figure 1.7.2 Double nut preload

(b) For double nuts

In order to eliminate the preload P of nut B when the preload weight P<sub>PL</sub> is about three times the axial load weight P, the preload weight P should be set within 1/3 of the maximum axial load weight.

The maximum preload weight is 0.25Ca as the standard. The displacement amount is 1/2 of the displacement of a single nut when the axial load weight is three times the preload.

$$K_N = \frac{P}{\delta_{NW}} = \frac{3P_{PL}}{\delta_{NS/2}} = \frac{6P_{PL}}{\delta_{NS}} \text{ (kgf/mm)}$$

δ<sub>NS</sub> : Displacement of a single nut (mm)  
 δ<sub>NW</sub> : Displacement of a double nut (mm)  
 (Explanation of the rigidity of a double nut)

As shown in Figures 1.7.1 and 1.7.2, when a preload of P<sub>PL</sub> is applied to the two nuts A and B, both nuts A and B are elastically deformed to reach the point X. If an external force P is added here, nut A moves from point X to point X<sub>1</sub>, and nut B will move from point X to point X<sub>2</sub>. Then, the following can be obtained based on the formula for the displacement of a single nut δ<sub>NS</sub>.

$$\delta_0 = aP_{PL}^{\frac{2}{3}} \quad \text{a deformation coefficient}$$

The displacements of the nut diagrams A and B are: δ<sub>A</sub> = aP<sub>PL</sub><sup>2/3</sup>

The displacements of the nuts A and B coming from the external force P are equal.

So δ<sub>A</sub> - δ<sub>0</sub> = δ<sub>B</sub> - δ<sub>0</sub> or the external force added to the nuts A and B is only P, so if P<sub>A</sub> increases

$$P_A - P_B = P$$

$$\delta_B = 0$$

To prevent the external force applied to the nut B from being absorbed by the nut A and becoming smaller. Thus, with δ<sub>B</sub> = 0

$$aP_A^{\frac{2}{3}} - aP_{PL}^{\frac{2}{3}} = aP_{PL}^{\frac{2}{3}}$$

$$P_A^{\frac{2}{3}} = 2P_{PL}^{\frac{2}{3}}$$

$$P_A = \sqrt[3]{8} P_{PL} \approx 3P_{PL}$$

Thus, from Fig. 1.7.3, it can also be judged that, when the preload amount is three times of the load weight in the axial direction, the single nut is 1/2 of the displacement amount, and the rigidity is two times

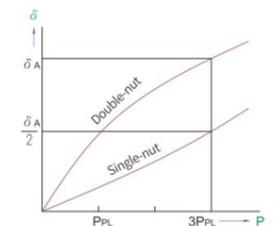


Figure 1.7.3

(3) Axial-direction rigidity of support shaft K<sub>B</sub> and displacement δ<sub>B</sub>

$$K_B = \frac{P}{\delta_B} \text{ (kgf/mm)}$$

As a support shaft for ball screws and widely used in the combination of precision machine, the rigidity of angled ball bearings is derived from the following formula:

$$\delta_B = \frac{2}{\sin\beta} \left[ \frac{Q^2}{d} \right]^{\frac{1}{3}} \text{ (mm)} \quad Q = \frac{P}{n \cdot \sin\beta} \text{ (kgf)}$$

Q : Load of a steel ball (kgf)

n : No. of steel balls

β : Contact angle (45°)

P : Shaft direction load (kgf)

d : Diameter of steel ball (mm)

(4) The axial rigidity K<sub>H</sub> and the displacement δ<sub>H</sub> of the nut and bearing mounting part were developed at the beginning of the machine development. Please pay special attention to the high rigidity of the mounting part.

$$K_H = \frac{P}{\delta_H} \text{ (kgf/mm)}$$

Ball screw

Ball screw

1-8 positioning accuracy

Among the factors of feed accuracy error, the lead accuracy and the rigidity of the feed system are the key points of review. The thermal deformation caused by temperature rise and the assembly accuracy of the guide surface also need to be considered.

1-8-1 Selection of lead accuracy

Table 1.8.1 shows the recommended range of use of ball screw accuracy classes according to different applications.

Table 1.8.1 Example of accuracy class for ball screws according to applications

Purpose		Purpose							
		C0	C1	C2	C3	C5	C7	C10	
NC working machinery	Lathe	X	○	○	○	○	○	○	○
		Y				○	○	○	
	Milling/boring machines	XY		○	○	○	○	○	
		Z			○	○	○	○	
	Machining center	XY		○	○	○	○	○	
		Z			○	○	○	○	
	Fixture boring machine	Y	○	○					
		Z	○	○					
	Drilling Machines	XY				○	○	○	
		Z					○	○	
	Grinding machine	X	○	○	○	○	○	○	
		Z		○	○	○	○	○	
	Discharge machining machine	XY		○	○	○	○	○	
		(Z)			○	○	○	○	
	Wire cutting machine/Discharge machining machine	Y		○	○	○			
UV			○	○	○	○	○		
High-speed punching machine	XY				○	○	○		
Laser machining machine	XY				○	○			
	Z				○	○			
Woodworking machine				○	○	○	○		
General-purpose machine, special-purpose machine				○	○	○	○	○	
Semiconductor related device	Exposure device	○	○						
	Chemical treatment device				○	○	○	○	
	Wire bonding machine		○	○	○				
	Probe tester	○	○	○	○				
	Inserting machine for electronic parts			○	○	○	○		
Industrial robot	Orthogonal co-ordinate	Assembly	○	○	○	○	○		
		Others				○	○	○	
	Vertical and multi-joint	Assembly			○	○	○		
		Others				○	○	○	
Cylindrical coordinate			○	○	○	○			
Steel equipment machinery					○	○	○		
Injection moulding machine					○	○	○		
3D measuring machine	○	○	○						
Transaction machine					○	○	○		
Image processing device	○	○							
Nuclear power generation.	Control rod				○	○	○		
	Vibration absorption device						○	○	
Aircraft				○	○				

1-8-2 Countermeasures for thermal shift

The elongation and displacement of the screw shaft due to heat can cause deterioration in positioning accuracy. The thermal change can be calculated from the following equation.

$$\Delta l = \alpha \cdot \Delta t \cdot L$$

$\Delta l$  : Elongation in screw shaft direction

$\alpha$  : Coefficient of thermal expansion

$\Delta t$  : Screw temperature variation (deg)

$L$  : Effective length of thread

That is, for every 1°C of temperature rise, an elongation of 12µm occurs on a 1m long screw shaft. Thus, even if the lead of the ball screw is processed with high precision, it will not be able to meet the high-precision positioning requirements due to the displacement caused by temperature rise. When the service conditions of ball screw require high speed, the relative heat generation is also increased, and the influence of temperature rise will also become greater.

The temperature rise countermeasures for ball screws are as follows:

- (1) Control heat value
  - The heat value of the ball and the preloading amount of the supporting bearing should be correct and appropriate.
  - Proper selection and supply of lubricants.
  - Increase the lead of the ball screw and reduce the return speed.
- (2) Apply forced cooling
  - The screw shaft is hollowed out and filled with coolant.
  - The outer edge of the screw shaft is cooled with lubricating oil or air.
- (3) Avoid the influence of temperature rise. First, use the WARMING UP to a state of stable temperature at high speed before the use.
  - Pre-tension force is applied to the screw shaft during mounting.
  - The target value of the cumulative lead is predetermined to be negative.
  - Locate using closed loop mode.

1-9 Life design

1-9-1 Ball screw life

Even if the ball screw is used in a reasonable state, it will therefore be unusable after a period of time. The life of the ball screw is the time until it cannot be used, which is generally divided into the fatigue life when peeling occurs and the precision deterioration life caused by wear.

1-9-2 Basic static load rating  $C_{0a}$

The basic static rated load refers to the axial load when the sum of the permanent deformation of the ball groove contact part in the screw shaft and nut bearing the maximum stress reaches 0.01% of the ball diameter.

1-9-3 Basic dynamic load rating  $C_a$

The dynamic rated load refers to a batch of the same ball screws rotate 106 times under the same conditions, and 90% of the screws will not flake due to rolling fatigue. At this point, the axial load that they bear refers to the dynamic rated load

Load-life relationship  $L_a = \left(\frac{1}{P}\right)^3$  L: Lifetime P: Load

1-9-4 Fatigue life

Average load  $P_e$

(1) When the load in the axle direction changes from time to time, please calculate the average load of the equivalent fatigue under the conditions of each variable load.

(As shown in Table 1.9.1)

$$P_e = \left( \frac{P_1^3 n_1 t_1 + P_2^3 n_2 t_2 + \dots + P_n^3 n_n t_n}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n} \right)^{\frac{1}{3}} \text{ (kgf)}$$

Axial load (kgf)	Rotation count (min <sup>-1</sup> )	Time (%)
$P_1$	$n_1$	$t_1$
$P_2$	$n_2$	$t_2$
⋮	⋮	⋮
$P_n$	$n_n$	$t_n$

However  $t_1 + t_2 + t_3 + \dots + t_n = 100$

Table 1.9.1 Life Time for Various Applications

Purpose	Life time (h)
Working I machinery	20000
General industrial machinery	10000
Automatic control machine	15000
Measuring device	15000

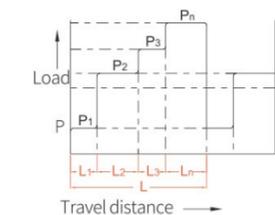


Figure 1.9.1

Ball screw

Ball screw

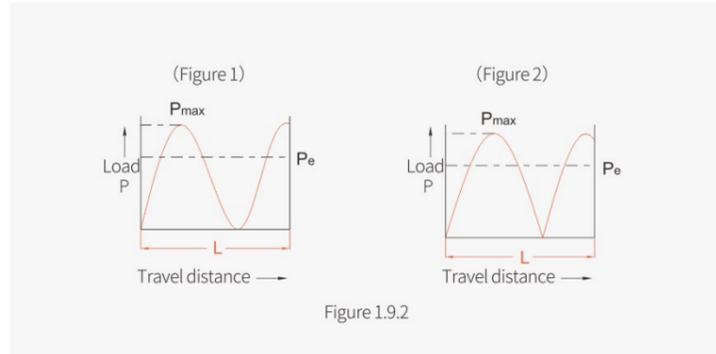
1-9 Life design

$$P_e = \frac{2P_{max} + P_{min}}{3} \text{ (kgf)}$$

$P_{max}$  : Max. axial load (kgf)  
 $P_{min}$  : Min. axial load (kgf)

(2) When the load changes according to the sinusoidal curve (as shown in Fig. 1.9.2 on the right)

$P_e \cong 0.65 P_{max}$  ..... (Figure 1)  
 $P_e \cong 0.75 P_{max}$  ..... (Figure 2)



1-9-5 Life calculation

Although the fatigue life is generally expressed by the total cycle speed, it is also expressed by the total cycle speed time and the total travel distance. The following formula can be obtained: Here:

$$L = \left[ \frac{C_a}{P_a \cdot f_w} \right]^3 \cdot 10^6 \quad L_t = \frac{L}{60n} \quad L_s = \frac{L \cdot \ell}{10^6}$$

Here:

$L$  : Rated fatigue life (rev)       $f_w$  : Load factor (operating condition factor)       $n$  : RPM  
 $L_s$  : Travel distance life (km)       $L_t$  : Life time (h)       $\ell$  : Lead (mm)  
 $P_a$  : Axial load (kgf)       $C_a$  : Basic dynamic load rating (kgf)

Table 1.9.2 Load Factor ( $f_w$ )

Vibration/shock during repeated motions	Velocity (V)	$f_w$
Minor	At micro speed: $V \leq 0.25$ m/s	1~1.2
Small	At low speed: $0.25 < V \leq 1$ m/s	1.2~1.5
At medium speed	At medium speed: $1 < V \leq 2$ m/s	1.5~2
Major	At high speed: $V > 2$ m/s	2~3.5

Table 1.9.3 Safety Factor ( $f_s$ )

Use machinery	Load conditions	$f_s$
Working machinery	At normal operation	1.0 ~ 1.3
	At shock and vibration	2.0 ~ 3.0
General industrial machinery	At normal operation	1.0 ~ 1.5
	At shock and vibration	2.5 ~ 7.0

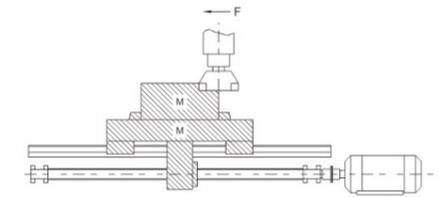
Required dynamic load rating  $C_a$   
 $C_a = P_e \cdot f_s$

Required Static load rating  $C_{0a}$   
 $C_{0a} = P_{max} \cdot f_s$

Key points of selecting ball screw rod

When selecting ball screw, first try to investigate the operating conditions before deciding on the design, which is the basic principle. Moreover, the selected elements include load weight, stroke, torque, positioning accuracy, repeated positioning accuracy, rigidity, lead and nut aperture, and all elements are related. Changes in one of the elements will cause changes in the other elements, and attention must be paid to the balance among the elements.

Selective calculation of ball screw



Design Conditions

1. Worktable weight 300 Kg
2. Workpiece weight 400 Kg
3. Max. travel 700 mm
4. Feed speed 10 m/min
5. Min. decomposition energy 10μm/stroke
6. Drive motor DC motor (MAX 1000 min)
7. Friction coefficient of guide surface ( $\mu=0.05\sim0.1$ )
8. Rotation rate 60 %
9. Precision review items
10. The inertia force during acceleration and deceleration may not be considered because it occupies a small proportion of time.

1. Setting of running conditions

(a) Presumption of mechanical life time H (hr)

$$H = \frac{\text{Rotation time/A day}}{\text{Rotation a day/Year}} \cdot \frac{\text{How many years of lifespan}}{\text{Rotational efficiency}}$$

(b) Mechanical conditions

Computing data	Speed/RPM	Cutting resistance	Sliding resistance	Service Time
Quick feed	m/min/min <sup>-1</sup>	kgf	kgf	%
Slight cutting	/			
Medium cutting	/			
Heavy cutting	/			

(c) Positioning accuracy

Among the factors of feed accuracy error, the lead accuracy and the rigidity of the feed system are the key points of review. The thermal deformation caused by temperature rise and the assembly accuracy of the guide surface also need to be considered.

1. Setting of running conditions

(a) Presumption of mechanical life H (hr)

$$H = 12\text{hr} \times 250 \text{ days} \times 10 \text{ years} \times 0.6 \text{ rotation rate} = 18000 \text{ hr}$$

(b) Mechanical conditions

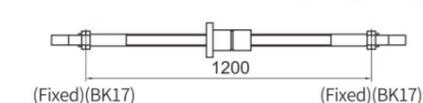
Computing data	Speed/RPM	Cutting resistance	Sliding resistance	Service Time
Quick feed	10m/min/ 1000min <sup>-1</sup>	0 kgf	70 kgf	10 %
Slight cutting	6/600	100	70	50
Medium cutting	2/200	200	70	30
Heavy cutting	1/100	300	70	10

$$\text{Sliding resistance} = (300 + 400) \cdot 0.1 = 70 \text{ kgf}$$

Ball screw

Ball screw

Key points of selection	Calculation of selection
<p>2. Ball screw lead <math>l</math> (mm)</p> $l = \frac{\text{Feed speed (m/min)} \cdot 1000}{\text{Maximum motor return speed (min}^{-1})} \text{ (mm)}$	<p>2. Ball screw lead <math>l</math> (mm)</p> $l = \frac{10000}{1000} = 10(\text{mm})$ <p>Minimum resolution = <math>\frac{10\text{mm}}{1000 \text{ Stroke}}</math> = 0.01 mm/Stroke</p>
<p>3. Calculation of average load <math>P_e</math> = (kgf)</p> $P_e = \left[ \frac{P_1^3 n_1 t_1 + P_2^3 n_2 t_2 + \dots + P_n^3 n_n t_n}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n} \right]^{\frac{1}{3}}$ $P_e = \frac{2P_{\max} + P_{\min}}{3}$ <p><math>P_e \approx 0.65 P_{\max}</math> <math>P_e \approx 0.75 P_{\max}</math></p>	<p>3. Calculation of average load <math>P_e</math> = (kgf)</p> $P_e = \left[ \frac{70^3 \cdot 1000 \cdot 10 + 170^3 \cdot 600 \cdot 50 + 270^3 \cdot 200 \cdot 30 + 370^3 \cdot 100 \cdot 10}{1000 \cdot 10 + 600 \cdot 50 + 200 \cdot 30 + 100 \cdot 10} \right]^{\frac{1}{3}}$ $= \left[ \frac{31.7 \cdot 10^{10}}{4.7 \cdot 10^4} \right]^{\frac{1}{3}}$ <p><math>\approx 189 \text{ kgf}</math></p>
<p>4. Average rpm (<math>n_m</math>)</p> $n_m = \frac{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}{100}$	<p>4. Average rpm (<math>n_m</math>)</p> $n_m = \frac{1000 \cdot 10 + 600 \cdot 50 + 200 \cdot 30 + 100 \cdot 10}{100}$ $= \frac{4.7 \cdot 10^4}{100} = 470 \text{ min}^{-1}$
<p>5. Calculation of dynamic rated load <math>C_a</math> (kgf) required</p> $C_a = P_e \cdot f_s$	<p>5. Calculation of dynamic rated load <math>C_a</math> (kgf) required</p> $C_a = 189 \cdot 5 = 945 \text{ (kgf)}$
<p>Calculation of static rated load <math>C_{oa}</math> (kgf) required</p> $C_{oa} = P_{\max} \cdot f_s$	<p>Calculation of static rated load <math>C_{oa}</math> (kgf) required</p> $C_{oa} = 369 \cdot 5 = 1845 \text{ (kgf)}$
<p>7. Selection of nut type</p> <p><math>C_a &gt; 945</math> <math>C_{oa} &gt; 1845</math></p> <p>Select the type of nut whose basic dynamic load rating and basic static load rating exceed the value calculated by the above formula.</p>	<p>7. Selection of nut type</p> <p>Select according to the model table SFN12510</p> <p><math>C_a = 2954</math> (kgf) <math>C_{oa} = 7295</math> (kgf)</p>

Key points of selection	Calculation of selection
<p>8. Calculation of life time <math>L_t</math>(h)</p> $L_t = \frac{L}{60n} = \left( \frac{C_a}{P_e \cdot f_w} \right)^3 \cdot 10^6 \cdot \frac{1}{60n}$	<p>8. Calculation of life time <math>L_t</math>(h)</p> $L_t = \left( \frac{2954}{189 \cdot 2} \right)^3 \cdot 10^6 \cdot \frac{1}{60 \cdot 470} = 42544(\text{h})$
<p>9. Decision of distance between supporting bearings</p>	<p>9. Decision of distance between supporting bearings</p>  <p>(Fixed)(BK17) 1200 (Fixed)(BK17)</p>
<p>10. Decision of screw length</p> <p>Shortest screw length = max. stroke + nut length + reserved amount at two axle ends</p>	<p>10. Decision of screw length</p> <p>Screw length = 700 + 85 + 76 + 76 = 937 mm 937 mm &lt; 1200 mm</p>
<p>11. The review of the allowable axial load</p>	<p>11. The review of the allowable axial load is omitted because it is fixed-fixed and supported.</p>
<p>12. Review of allowable rpm <math>N</math> and <math>DN</math></p> $N = \alpha \cdot \frac{60\lambda^2}{2\pi L^2} \sqrt{\frac{Eg}{\gamma A}} = f \frac{dr}{L^2} \cdot 10^7 (\text{rpm})$ <p><math>DN = \text{Bearing O.D} \times \text{Max. rpm}</math></p>	<p>12. Review of allowable rpm <math>N</math> and <math>DN</math></p> $N = \frac{21.9 \cdot 21.86 \cdot 10^7}{1200^2} = 3324 \text{ min}^{-1} < n_{\max}$ <p><math>DN = 25 \cdot 1000 = 25000 &lt; 50000</math></p>
<p>13. Thermal displacement countermeasures</p> $\Delta l = \alpha \cdot \Delta t \cdot L$ <p><math>\Delta l</math>: Elongation in screw shaft direction <math>\alpha</math>: Coefficient of thermal expansion <math>\Delta t</math>: Screw temperature variation (deg) <math>L</math>: Effective length of thread</p>	<p>13. Thermal countermeasures</p> <p>Thermal countermeasure: Generally, it is estimated mechanically that the temperature rise of the ball screw is about 2-5°C, and the extension of the ball screw is calculated by increasing by 2°C.</p> $\Delta l = \alpha \cdot \Delta t \cdot L = 11.7 \cdot 10 \cdot 2 \cdot 700\text{mm}$ $\approx 0.016\text{mm}$ $F_p = \frac{EA\Delta l}{L}$ $= \frac{2.06 \cdot 10^4 \cdot \pi \cdot 21.86^2 \cdot 0.016}{4 \cdot 700}$ $\approx 177(\text{kgf})$

Key points of selection	Calculation of selection
<p>14. Review of rigidity (1) Directional rigidity of screw shaft <math>K_s</math> and displacement <math>\delta_s</math> <math>K_s = \frac{P}{\delta_s}</math> (kgf/mm) P: Shaft direction load (kgf) <math>\delta_{SF} = \frac{PL}{4AE}</math> (mm)</p> <p>(2) Axial load <math>\delta_s</math> <math>\delta_{NS} = \frac{K}{\sin\beta} \left[ \frac{Q^2}{d} \right]^{\frac{1}{3}} \cdot \frac{1}{\xi}</math> (mm) <math>Q = \frac{P}{n \cdot \sin\beta}</math> (kgf) <math>n = \frac{D_0 \pi m}{d}</math></p> <p>(3) Axial direction rigidity <math>K_b</math> and displacement <math>\delta_b</math> of the supporting shaft <math>K_b = \frac{P}{\delta_b}</math> (kgf/mm)</p>	<p>14. Review of rigidity When the temperature rise of 0.016 mm is estimated and the pre-tension force of 177kgf is added, the deviation can be corrected. (1) Directional rigidity <math>\delta_{SF} = \frac{PL}{4AE} = \frac{27 \cdot 1200}{4 \cdot \frac{\pi \cdot 21.86^2}{4} \cdot 2.06 \cdot 10^4}</math> <math>= 0.00105</math> (mm) <math>K_s = \frac{370}{0.00105} = 3.5 \cdot 10^5</math> kgf/mm</p> <p>(2) Rigidity of ball and nut groove <math>n = \frac{26.62 \cdot \pi \cdot 4}{4.762} = 70</math> <math>Q = \frac{370}{70 \sin 45^\circ} = 10</math> <math>\delta_{NS} = \frac{0.00057}{\sin 45^\circ} \left( \frac{10^2}{4.762} \right)^{\frac{1}{3}} \cdot \frac{1}{0.7}</math> <math>= 3.2 \cdot 10^{-3}</math> mm <math>K_N = \frac{370}{3.2 \cdot 10^{-3}} = 1.27 \cdot 10^5</math> kgf/mm</p> <p>(3) Rigidity of supporting bearing Calculated with nut rigidity of 50kgf/<math>\mu</math>m <math>\delta_b = \frac{370}{51 \cdot 2} = 3.6 \mu</math>m <math>K_b = \frac{370}{0.0036} = 1 \cdot 10^5</math> kgf/mm ● <math>\delta_{TOTAL} = 1.05 + 3.2 + 3.6 = 7.85 \mu</math>m</p>
<p>15. Confirmation of ball screw life</p>	<p>15. Confirmation of ball screw life <math>L = 42544</math> (h) &gt; 18000 (h)</p>

1-10 Precautions for using the ball screw

The ball screw is a precision component. Please take special care not to make sharp objects or tools hit the tooth surface, and to avoid knocking or collision scratches when assembling the ball screw, and the nut should not be separated from the screw or overtravel. Please do not force to install the ball screw if accidental disengaging occurs, as this may cause the ball screw to jam, please contact our specialist. (As shown in Fig. 1.10.1)

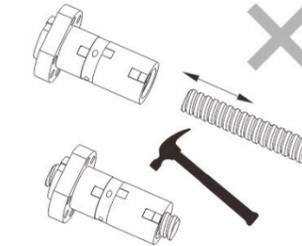


Figure 1.10.1 Incorrect Use Method

If you need to remove the nut and reinstall it, a tube with an outer diameter smaller than the bottom diameter of the screw shall be used. Turn the nut into the transfer tube to make sure the ball does not fall. (Refer to B25)

1-10-1 Lubrication

When using ball screws, there must be enough lubrication. For insufficient lubrication, the metal may be contacted, resulting in increased friction and wear, thus causing faults or shortening the service life. The lubricants used in ball screw can be divided into lubricating oil and grease. Generally, for maintenance, the grease can increase the dynamic friction torque line with the increase of the rotation speed. When exceeding 3-5m/min, it is better to lubricate with oil. But, do not forget that there have been examples of grease reaching 10 m/min; For the equipment, there are also greases that are suitable for lower cost greases. Generally, in order to give full play to the ball screw function, about 5m/min lubricating oil is the most appropriate choice.

Table 1.10. 1 shows the general index of the interval between inspection and refilling of lubricants. Before the refilling, the used lubrication paste attached to the screw shaft should be wiped off.

Table 1.10. 1 Inspection and Filling of Lubricants

Lubricating method	Time interval	Check Items	Filling or replacement interval
Automatic oil supply at an interval	Every week	Oil dirty	Fill at each inspection, but appropriate filling is required according to oil groove capacity
Grease	2-3 months at the initial work period	Mixing of dirty powder	Usually, filling is carried out every year, but it needs to be refilled appropriately according to the inspection results
Oil bath	Before commencement of work each day	Oil level management	Specify according to consumption state

1-10-2 Dust-proof/protection

The same as rolling bearing, when there is foreign matter mixed in or moisture, wear of ball screw will increase, and sometimes it leads to damage. For example, due to the operating environment, the operating machinery may be mixed with chips or cutting oil. Thus, when there is a possibility of foreign objects mixing from the outside, the screw shaft should be completely covered with folded cloth (snake belly type) or sleeve telescopic tube as shown in Fig. 1.10.2.

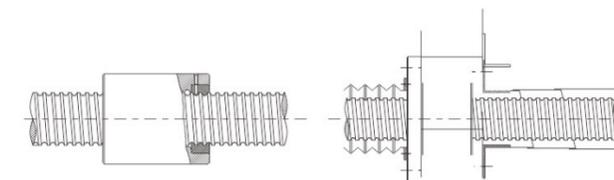


Figure 1.10.2 Dustproof mechanism

1-10-3 Eccentric load

In case of any eccentric load, it will directly affect the life and noise of the screw, and it is mostly accompanied by the feel of poor operation. If the smoothness of the screw is different in no-load and after assembly, in addition to noting the accuracy of the screw, it is mostly due to the unbalanced load caused by poor combination accuracy, as shown in Fig. 1.10.3.

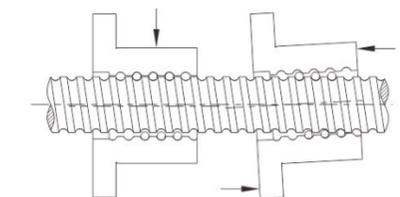


Figure 1.10.3 Eccentric load

Ball screw

Ball screw

1-10 Precautions for using the ball screw

1-10-4 Single-outlet nut assembly instructions

If the product ordered is a single-output nut of re-manufactured level, please observe the following steps for assembly:

Table 1.10. 2 Operating Steps for Nut Assembly

	
(1) Cut the fixing line on the nut.	(2) Place the converter tube on the front end of the correct size screw.
	
(3) Turn the nut into the screw along the thread of the screw rod.	(4) Turn the whole stroke of the nut into the screw rod. Attention! Ensure that all the travel of the nut is transferred to the screw before moving the converter tube away.

1-10-5 Machining specification

(1) If you choose a ball screw with internal circulation or end-cap circulation, the thread at one end of the screw must be teething and the maximum shoulder size must be less than the bottom diameter. If the shoulder size is greater than the bottom diameter, but the thread must be left on the shoulder to facilitate the insertion of the nut. As shown in Fig. 1.10.4.

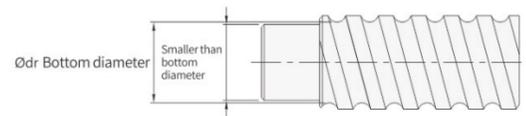


Figure 1.10.4 Gear outlet - Necessary condition of inner circulation shaft end

(2) When the screw is heat treated, the threaded tooth part processed near the shoulder has a length of 10-20mm and must be kept soft to facilitate the shoulder processing. The area is marked on the AKD surface as shown in Fig. 1.10.5. If you have special requirements, please inquire with AKD sales staff at the time of ordering.

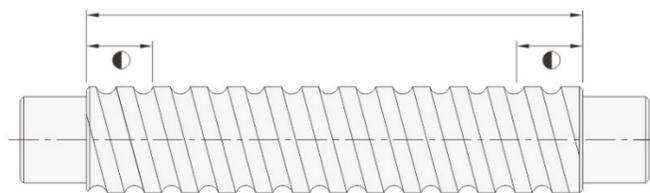


Figure 1.10.5 Range of Effective Heat Treatment for Screw

Nominal designation for ball screw

2-1-1 Screw sub-code	<b>SFNU R 25 05 T4 - D G C5 - 600 - P1 - B2 + N4 N4 - D123</b>	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	None: Standard nut and not machined shaft end D123: Customer code (attached to special nut or machined shaft end)
2-1-2 Screw code	<b>SFNU R 25 05 T4 - D - B2 + N4 - D123</b>	①	②	③	④	⑤	⑥	⑪	⑫	N/A: Standard nut D123: Customer code (attached to special nut)					
2-1-3 Screw code	<b>SS R 25 05 F C7 - 600 + N4 - D123</b>	①	②	③	④	⑦	⑧	⑨	⑬	N/A: Non-machined shaft end D123: Customer code (attached to the machined shaft end)					

① <b>Nominal model</b> SFA SFNU SFNI SFY SFUL XSV SFK BSH CTH SFT (Dedicated to the Lithium Battery Industry) SFQ (Purpose-made) SC (Screw only - Standard) SS (Screw only - Special type)	② <b>Thread direction</b> R: Right L: Left LR: Left-right rotation  ③ <b>Screw shaft O.D</b> Unit: mm	⑤ <b>No. of steel balls (No. of turns No. of columns)</b> T2 T3 T4 A1 A2 B1 C1 D1 E1	⑦ <b>Process code</b> G: Grinding F: Re-manufacture  ⑧ <b>Grade of lead accuracy</b> C3, C5, C7, C10
④ <b>Screw lead</b> Unit: mm	⑥ <b>Flange type</b> N: No cutting edge S: Single cutting edge D: Double cutting edge	⑨ <b>Screw shaft length</b> Unit: mm	
⑩ <b>Axial clearance preload grade</b> P0, P1, P2	⑪ <b>Nut</b> (omitted if it is 1) Example: two nuts on one axis: B2	⑬ <b>Surface treatment of screw shaft</b> B1: Blacken N1: Chrome plated N5: Black chrome plated	
⑫ <b>Nut surface treatment</b> B1: Blacken N1: Chrome plated N4: Black chrome plated			

※ When neither the nut nor the screw is subject to surface treatment, the labelling is omitted.  
 ※ For the screw with grinding grade of C5 or above, AKD shipment inspection is attached with inspection table

Ball screw

Ball screw

2-1 Nominal designation for ball screws

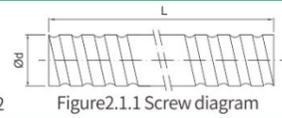


Table 2.1.1 Comparison of Precision Screw Standard Size Ø~32

Outside Diameter (d)	Model		Lead accuracy level	Thread direction		Thread number	Standard screw coding
	Screw lead (l)	Beam size (Da)		R: Right	L: Left		
4	1	0.8	C7, C5, C3	R	1	SCR00401	
	1	0.8	C7, C5, C3	R	1	SCR00601	
6	6	1.2	C7, C5, C3	R	1	SCR00606	
	1	0.8	C7, C5, C3	R/L	1	SCR00801	
8	2	1.2	C7, C5, C3	R/L	1	SCR00802	
	2.5	1.2	C7, C5, C3	R	1	SCR0082.5	
	8	1.2	C7, C5, C3	R	1	SCR00808	
10	2	1.2	C7, C5, C3	R/L	1	SCR01002	
	4	2	C7, C5, C3	R	1	SCR01004	
12	2	1.2	C7, C5, C3	R/L	1	SCR01202	
	4	2.5	C7, C5, C3	R	1	SCR01204	
	5	2.5	C7, C5, C3	R	1	SCR01205	
	5	2.5	C7, C5, C3	R	1	SSR01205	
	10	2.5	C7, C5, C3	R	1	SCR01210-B	
14	2	1.2	C7, C5, C3	R/L	1	SCR01402	
	4	2.5	C7, C5, C3	R	1	SCR01404	
15	10	3.175	C7, C5, C3	R	1	SCR01510	
	20	3.175	C7, C5, C3	R	1	SCR01520	
16	2	1.2	C7, C5, C3	R/L	1	SCR01602	
	4	2.381	C7, C5, C3	R	1	SCR01604(N)	
	5	3.175	C7, C5, C3	R/L	1	SCR01605	
	10	3.175	C7, C5, C3	R/L	1	SCR01610	
	16	2.778	C7, C5, C3	R	2	SCR01616	
20	32	2.778	C7, C5, C3	R	2	SCR01632	
	2	1.2	C7, C5, C3	R	1	SCR02002	
	4	2.381	C7, C5, C3	R	1	SCR02004(N)	
	5	3.175	C7, C5, C3	R/L	1	SCR02005	
	10	3.969	C7, C5, C3	R	1	SCR02010	
	20	3.175	C7, C5, C3	R	1	SCR02020	
	20	3.175	C7, C5, C3	R	2	SCR02020	
25	40	3.175	C7, C5, C3	R	2	SCR02040	
	2	1.2	C7, C5, C3	R	1	SCR02502	
	4	2.381	C7, C5, C3	R	1	SCR02504(N)	
	5	3.175	C7, C5, C3	R/L	1	SCR02505	
	6	3.969	C7, C5, C3	R	1	SCR02506	
	8	4.762	C7, C5, C3	R	1	SCR02508	
	10	4.762	C7, C5, C3	R/L	1	SCR02510-A	
	10	6.35	C7, C5, C3	R	1	SCR02510-B	
32	25	3.969	C7, C5, C3	R	2	SCR02525	
	50	3.969	C7, C5, C3	R	2	SCR02550	
	4	2.381	C7, C5, C3	R	1	SCR03204(N)	
	5	3.175	C7, C5, C3	R/L	1	SCR03205	
	6	3.969	C7, C5, C3	R	1	SCR03206	
32	8	4.762	C7, C5, C3	R	1	SCR03208	
	10	6.35	C7, C5, C3	R/L	1	SCR03210	
	20	6.35	C7, C5, C3	R	1	SCR03220	
	32	4.762	C7, C5, C3	R	2	SCR03232	
	64	4.762	C7, C5, C3	R	2	SCR03264	

Table 2.1.2 Comparison of Precision Screw Standard Size Ø40~80

Unit: mm

Outside Diameter (d)	Model		Lead accuracy level	Thread direction		Thread number	Standard screw coding
	Screw lead (l)	Beam size (Da)		R: Right	L: Left		
40	5	3.175	C7, C5, C3	R / L	1	SCR04005	
	6	3.969	C7, C5, C3	R	1	SCR04006	
	8	4.762	C7, C5, C3	R	1	SCR04008	
	10	6.35	C7, C5, C3	R / L	1	SCR04010	
	20	6.35	C7, C5, C3	R	1	SCR04020	
	40	6.35	C7, C5, C3	R	2	SCR04040	
50	80	6.35	C7, C5, C3	R	2	SCR04080	
	5	3.175	C7, C5, C3	R	1	SCR05005	
	10	6.35	C7, C5, C3	R / L	1	SCR05010	
	20	9.525	C7, C5, C3	R	1	SCR05020	
		7.144	C7, C5, C3	R	1	SCR05020	
	50	7.938	C7, C5, C3	R	2	SCR05050	
100	7.938	C7, C5, C3	R	2	SCR050100		
63	10	6.35	C7, C5, C3	R	1	SCR06310	
	20	9.525	C7, C5, C3	R	1	SCR06320	
80	10	6.35	C7, C5, C3	R	1	SCR08010	
	20	9.525	C7, C5, C3	R	1	SCR08020	

Table 2.1.3A Comparison of Precision Screw Standard Size Ø16~50

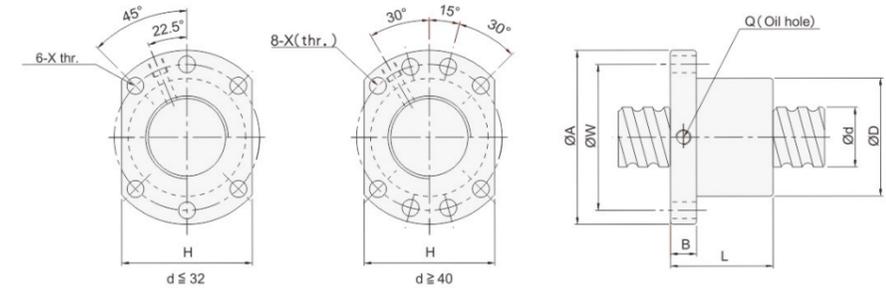
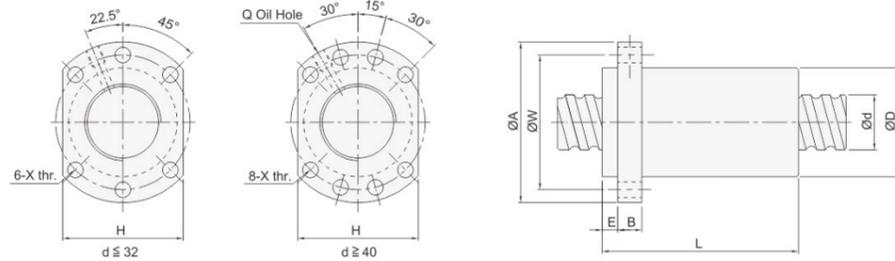
Unit: mm

Outside Diameter (d)	Model		Lead accuracy level	Thread direction		Thread number	Standard screw coding
	Screw lead (l)	Beam size (Da)		R: Right	L: Left		
12	10	2.5	C7, C5, C3	R	1	SSR01210	
16	5	2.778	C7, C5, C3	R	1	SSR01605	
	10	2.778	C7, C5, C3	R	1	SSR01610	
	16	2.778	C7, C5, C3	R	1	SSR01616	
	20	2.778	C7, C5, C3	R	1	SSR01620	
	30	2.778	C7, C5, C3	R	1	SSR01630	
20	10	3.175	C7, C5, C3	R	1	SSR02010	
25	10	3.175	C7, C5, C3	R	1	SSR02510	
	25	3.175	C7, C5, C3	R	1	SSR02525	
32	10	3.969	C7, C5, C3	R	1	SSR03210	
	20	3.969	C7, C5, C3	R	1	SSR03220	
	32	6.35	C7, C5, C3	R	1	SSR03232	
40	10	6.35	C7, C5, C3	R	1	SSR04010	
	20	6.35	C7, C5, C3	R	1	SSR04020	
	40	6.35	C7, C5, C3	R	1	SSR04040	
50	10	6.35	C7, C5, C3	R	1	SSR05010	
	20	6.35	C7, C5, C3	R	1	SSR05020	
	50	6.35	C7, C5, C3	R	1	SSR05050	

The above are standard specifications. If you have any other requirements, please contact AKD business personnel for consultation

SFA Size and specification of precision series

SFNU Size and specification of precision series



Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size									Load rating of ball nut		Stiff kgf/ μm	
				D	A	E	B	L	W	H	X	Q	Number of Steel Balls n	Ca (kgf)		Coa (kgf)
SFA1205B1*	12	5	2.5	24	40	5	10	30	32	30	4.5	-	2.8×1	661	1316	19
SFA1210B1*		10	2.5	24	40	5	10	42	32	30	4.5	-	2.8×1	642	1287	19
SFA1605C1*	15	5	2.778	28	48	5	10	31	38	40	5.5	M6	3.8×1	1112	2507	30
SFA1610B1*		10	2.778	28	48	5	10	42	38	40	5.5	M6	2.8×1	839	1821	23
SFA1616A1*		16	2.778	28	48	5	10	43	38	40	5.5	M6	1.8×1	552	1137	14
SFA1620A1*		20	2.778	28	48	5	10	50	38	40	5.5	M6	1.8×1	554	1170	14
SFA2005C1*	20	5	3.175	36	58	7	10	33	47	44	6.6	M6	3.8×1	1484	3681	37
SFA2010C1*		10	3.175	36	58	7	10	52	47	44	6.6	M6	3.8×1	1516	3833	40
SFA2020A1*		20	3.175	36	58	7	10	52	47	44	6.6	M6	1.8×1	764	1758	19
SFA2020B1*		20	3.175	36	58	7	10	72	47	44	6.6	M6	2.8×1	1118	2734	29
SFA2505C1*	25	5	3.175	40	62	7	10	33	51	48	6.6	M6	3.8×1	1650	4658	43
SFA2510C1*		10	3.175	40	62	7	12	52	51	48	6.6	M6	3.8×1	1638	4633	45
SFA2525A1*		25	3.175	40	62	7	12	60	51	48	6.6	M6	1.8×1	843	2199	22
SFA3205C1	32	5	3.175	50	80	9	12	35	65	62	9	M6	3.8×1	1839	6026	51
SFA3210C1	31	10	3.969	50	80	9	12	53	65	62	9	M6	3.8×1	2460	7255	55
SFA3220B1		20	3.969	50	80	9	12	72	65	62	9	M6	2.8×1	1907	5482	43
SFA3232A1		32	3.969	50	80	9	12	78	65	62	9	M6	1.8×1	1257	3426	27
SFA4010C1	38	10	6.35	63	93	9	14	57	78	70	9	M8	3.8×1	5035	13943	67
SFA4020B1		20	6.35	63	93	9	14	78	78	70	9	M8	2.8×1	3959	10715	54
SFA4040A1		40	6.35	63	93	9	14	96	78	70	9	M8	1.8×1	2585	6648	34
SFA5005C1	50	5	3.175	75	110	10.5	15	42	93	85	11	M8	3.8×1	2207	9542	68

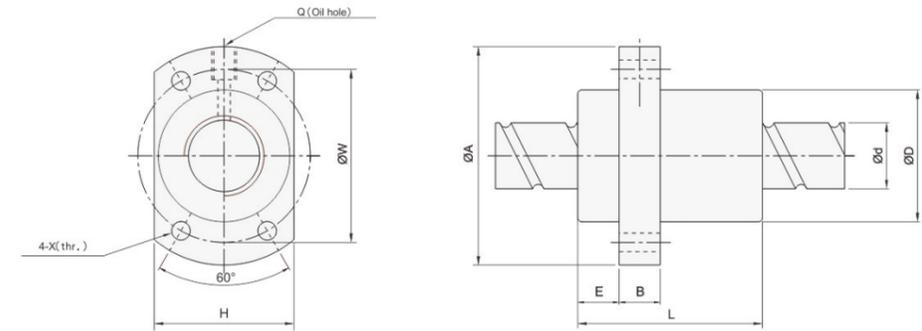
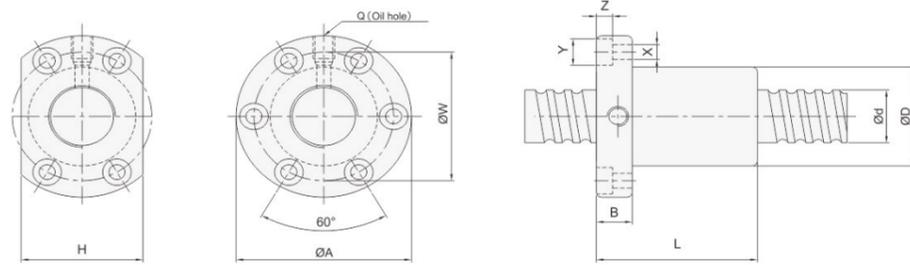
Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size									Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/ μm
				D	A	B	L	W	H	X	Q	Number of Steel Balls n			
SFNU1204T4	12	4	2.5	24	40	10	40	32	30	4.5	-	1x4	902	1884	26
SFNU1605T4*	16	5	3.175	28	48	10	45	38	40	5.5	M6	1x4	1380	3052	32
SFNU1610T3*		10	3.175	28	48	10	57	38	40	5.5	M6	1x3	1103	2401	26
SFNU2005T4*	20	5	3.175	36	58	10	51	47	44	6.6	M6	1x4	1551	3875	39
SFNU2505T4*	25	5	3.175	40	62	10	51	51	48	6.6	M6	1x4	1724	4904	45
SFNU2510T4*		10	4.762	40	62	12	80	51	48	6.6	M6	1x4	2954	7295	50
SFNU3205T4*	32	5	3.175	50	80	12	52	65	62	9	M6	1x4	1922	6343	54
SFNU3210T4*		10	6.35	50	80	12	85	65	62	9	M6	1x4	4805	12208	61
SFNU4005T4*	40	5	3.175	63	93	14	55	78	70	9	M8	1x4	2110	7988	63
SFNU4010T4*		10	6.35	63	93	14	88	78	70	9	M8	1x4	5399	15500	73
SFNU5010T4*	50	10	6.35	75	110	16	88	93	85	11	M8	1x4	6004	19614	85
SFNU6310T4	63	10	6.35	90	125	18	93	108	95	11	M8	1x4	6719	25358	99
SFNU6320T4	63	20	9.525	95	135	20	149	115	100	13.5	M8	1x4	11444	36653	112
SFNU8010T4	80	10	6.35	105	145	20	93	125	110	13.5	M8	1x4	7346	31953	109
SFNU8020T4	80	20	9.525	125	165	25	154	145	130	13.5	M8	1x4	12911	47747	138
SFNU10020T4	100	20	9.525	150	202	30	180	170	155	17.5	M8	1x4	14303	60698	162

\* If marked with \*, left thread can be made. \* SFU01204T4 Nut standard product is not attached with scraper

SFNI Size and specification of precision series

SFY Size and specification of precision series



Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size										Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/ µm	
				D	A	B	L	W	H	X	Y	Z	Q				Number of Steel Balls n
SFNI1605T4 *	16	5	3.175	30	49	10	45	39	34	4.5	8	4.5	M6	1x4	1380	3052	33
SFNI1610T3 *		10	3.175	34	58	10	57	45	34	5.5	9.5	5.5	M6	1x3	1103	2401	27
SFNI2005T4 *	20	5	3.175	34	57	11	51	45	40	5.5	9.5	5.5	M6	1x4	1551	3875	39
SFNI2505T4 *	25	5	3.175	40	63	11	51	51	46	5.5	9.5	5.5	M8	1x4	1724	4904	45
SFNI2510T4 *		10	4.762	46	72	12	80	58	52	6.5	11	6.5	M6	1x4	2954	7295	51
SFNI3205T4 *	32	5	3.175	46	72	12	52	58	52	6.5	11	6.5	M8	1x4	1922	6343	52
SFNI3210T4 *		10	6.35	54	88	15	85	70	62	9	14	8.5	M8	1x4	4805	12208	62
SFNI4005T4 *	40	5	3.175	56	90	15	55	72	64	9	14	8.5	M8	1x4	2110	7988	59
SFNI4010T4 *		10	6.35	62	104	18	88	82	70	11	17.5	11	M8	1x4	5399	15500	72
SFNI5010T4 *	50	10	6.35	72	114	18	88	92	82	11	17.5	11	M8	1x4	6004	19614	83
SFNI6310T4	63	10	6.35	85	131	22	93	107	95	14	20	13	M8	1x4	6719	25358	95
SFNI8010T4	80	10	6.35	105	150	22	93	127	115	14	20	13	M8	1x4	7346	31953	109

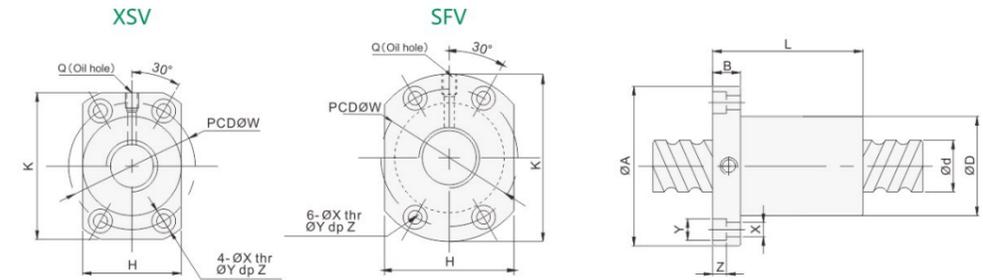
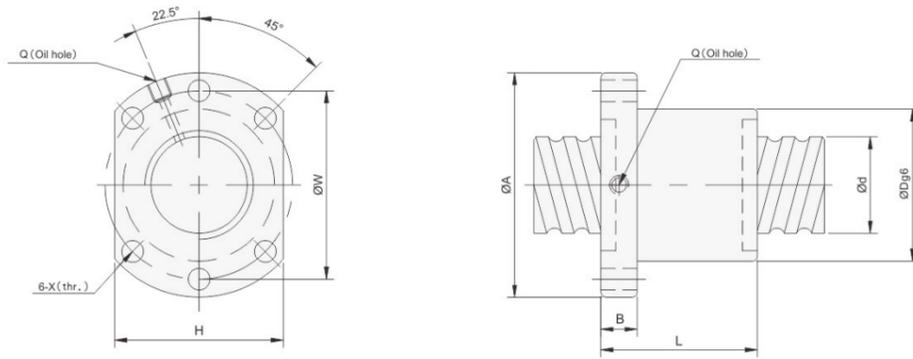
Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size										Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/ µm
				D	A	E	B	L	W	H	X	Q	Number of Steel Balls n			
SFY1616A2	16	16	2.778	32	53	10.1	10	45	42	34	4.5	M6	1.8x2	1073	2551	31
SFY2020A2	20	20	3.175	39	62	13	10	52	50	41	5.5	M6	1.8x2	1387	3515	37
SFY2525A2	25	25	3.969	47	74	15	12	64	60	49	6.6	M6	1.8x2	2074	5494	45
SFY3232A2	32	32	4.762	58	92	17	12	78	74	60	9	M6	1.8x2	3021	8690	58
SFY4040A2	40	40	6.35	73	114	19.5	15	99	93	75	11	M6	1.8x2	4831	14062	70
SFY5050A2	50	50	7.938	90	135	21.5	20	117	112	92	14	M6	1.8x2	7220	21974	86

2 times the lead Nominal model	Shaft diameter d	Screw lead l	Beam size Da	Nut size										Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/ µm
				D	A	E	B	L	W	H	X	Q	Number of Steel Balls n			
SFY1632T2	16	32	2.778	32	53	10.1	10	42.5	42	34	4.5	M6	0.8x2	493	1116	11
SFY2040T2	20	40	3.175	39	62	13	10	48	50	41	5.5	M6	0.8x2	653	1597	15
SFY2550T2	25	50	3.969	47	74	15	12	58	60	49	6.6	M6	0.8x2	976	2495	19

SFUL Specification and size of left-handed nut

XSV Size and specification of series



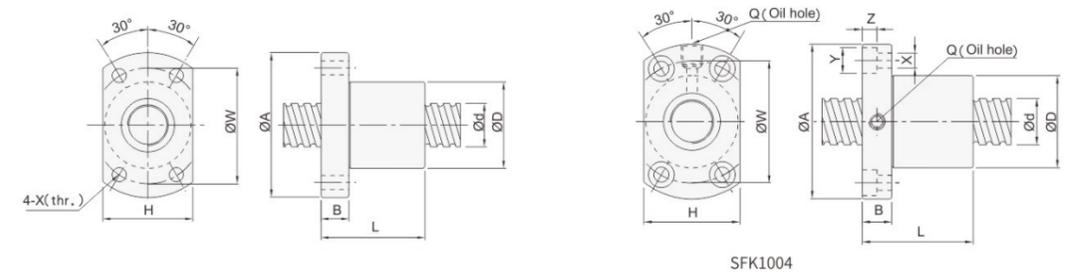
Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size								Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/μm	
				D	A	B	L	W	H	X	Q				
SFUL1204T4	12	4	2.381	24	40	10	40	32	30	4.5	-	1x4	860	1794	24
SFUL1605T4	16	5	3.175	28	48	10	45	38	40	5.5	M6	1x4	1380	3052	32
SFUL1610T3	16	10	3.175	28	48	10	57	38	40	5.5	M6	1x3	1103	2401	26
SFUL2005T4	20	5	3.175	36	58	10	51	47	44	6.6	M6	1x4	1551	3875	39
SFUL2505T4	25	5	3.175	40	62	10	51	51	48	6.6	M6	1x4	1724	4904	45
SFUL2510T4	25	10	4.762	40	62	12	80	51	48	6.6	M6	1x4	2954	7295	50
SFUL3205T4	32	5	3.175	50	80	12	52	65	62	9	M6	1x4	1922	6343	54
SFUL3210T4	32	10	6.35	50	80	12	85	65	62	9	M6	1x4	4805	12208	61
SFUL4005T4	40	5	3.175	63	93	14	55	78	70	9	M8	1x4	2110	7988	63
SFUL4010T4	40	10	6.35	63	93	14	88	78	70	9	M8	1x4	5399	15500	73
SFUL5010T4	50	10	6.35	75	110	16	88	93	85	11	M8	1x4	6004	19614	85

Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size												Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)
				D	A	B	L	W	H	K	X	Y	Z	Q	Number of Steel Balls n		
XSV1205D1	12	5	2.5	30	50	10	37	40	32	45	4.5	8	4.5	M6	5x1	661	1316
XSV1210B1	12	10	2.5	30	50	10	40	40	32	45	4.5	8	4.5	M6	2.8x1	411	638
XSV1605D1	15	5	2.778	34	58	10	40	45	34	50	5.5	9.5	5.5	M6	4.8x1	1404	3166
XSV1610B1	15	10	2.788	34	58	10	51.3	45	34	50	5.5	9.5	5.5	M6	2.8x1	839	1821
XSV1620A1	15	20	2.788	34	58	10	54	45	34	50	5.5	9.5	5.5	M6	1.8x1	554	1170
XSV2010C1	20	10	3.175	46	75	13	57	59	46	66	6.6	11.5	5.5	M6	3.8x1	1516	3833
XSV2020A2	20	20	3.175	46	75	13	51.5	59	46	66	6.6	11.5	5.5	M6	1.8x2	764	1758
SFV2005D1	20	5	3.175	44	67	11	57	55	52	-	5.5	-	5.5	M6	4.8x1	1814	4650

SFK Size and specification of precision series

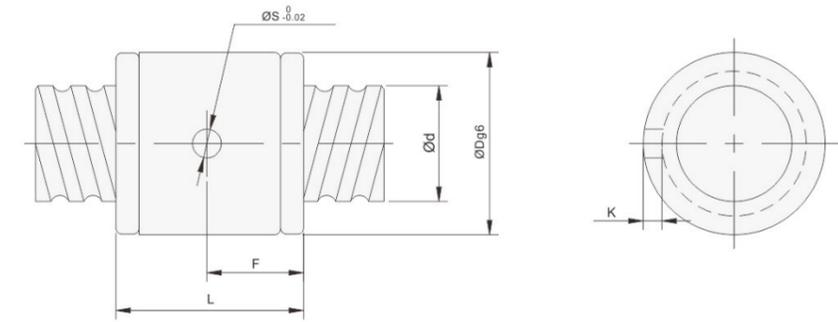
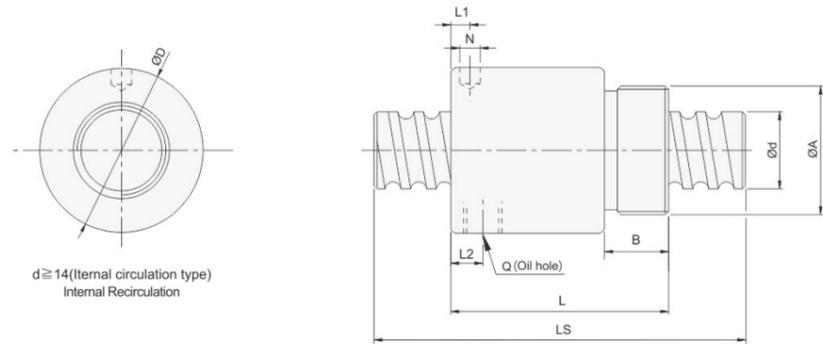


Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size												Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/μm
				D	A	B	L	W	H	X	Y	Z	Q	Number of Steel Balls n				
SFK0601T3	6	1	0.8	12	24	3.5	15	18	16	3.4	-	-	-	1x3	111	224	9	
SFK0801T3*	8	1	0.8	14	27	4	16	21	18	3.4	-	-	-	1x3	161	403	14	
SFK0802T3*		2	1.2	14	27	4	16	21	18	3.4	-	-	-	1x3	222	458	13	
SFK0802.5T3	10	2.5	1.2	16	29	4	26	23	20	3.4	-	-	-	1x3	221	457	13	
SFK1002T3*		2	1.2	18	35	5	28	27	22	4.5	-	-	-	1x3	243	569	15	
SFK1004T3	12	4	2	26	46	10	34	36	28	4.5	8	4.5	M6	1x3	468	905	17	
SFK1202T3*		2	1.2	20	37	5	28	29	24	4.5	-	-	-	1x3	334	906	22	

\* If marked with \*, left thread can be made.  
 \* SFK0401T3 nut standard product is not attached with scraper, for the rest of the specification, the scraper is operational. Please inquiry the business personnel before placing an order

BSH Size and specification of precision series CTH Specific size for embedded sliding table



Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size									Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)	Stiff kgf/ $\mu$ m
				D	A	B	L	L1	N	L2	Q	Number of Steel Balls n			
BSH0802T3	8	2.5	1.2	17.5	M15x1P	7.5	23.5	10	3	—	—	3x1	189	381	11
BSH1002T3	10	2	1.2	19.5	M17x1P	7.5	22	3	3.2	—	—	3x1	277	664	17
BSH1004T3		4	2	25	M20x1P	10	34	3	3	—	—	3x1	400	754	14
BSH1204T3	12	4	2.5	25.5	M20x1P	10	34	13	3	—	—	3x1	804	1649	23
BSH1205T3		5	2.5	25.5	M20x1P	10	39	16.25	3	—	—	3x1	801	1644	24
BSH1605T3	16	5	3.175	32.5	M26x1.5P	12	42	19.25	3	—	—	3x1	1077	2289	25
BSH2005T3	20	5	3.175	38	M35x1.5P	15	45	20.3	3	—	—	3x1	1211	2906	30

\* O.D  $\Phi$ 8~ $\Phi$ 16 nut standard product is not attached with scraper

Unit: mm

Model	Shaft diameter d	Screw lead l	Beam size Da	Nut size						Dynamic load rating Ca (kgf)	Static load rating Coa (kgf)
				D	L	F	S	K	Number of Steel Balls n		
CTH1205B1	12	5	2.5	24	30	15	6	3	2.8x1	661	1316
CTH1210B1	12	10	2.5	24	42	21	6	3	2.8x1	642	1287
CTH1220A2	12	20	2.5	24	46	23	6	3	1.8x2	670	1010
CTH1605C1	15	5	2.78	28	31	15.5	8	3	3.8x1	1112	2507
CTH1610B1	15	10	2.78	28	42	21	8	3	2.8x1	839	1821
CTH1620A1	15	20	2.78	28	50	25	8	3	1.8x1	861	1820
CTH2005C1	20	5	3.18	36	33	16.5	8	3	3.8x1	1484	3681
CTH2010C1	20	10	3.18	36	52	26	8	3	3.8x1	1516	3833
CTH2020A1	20	20	3.18	36	52	26	8	3	1.8x1	764	1758

# Introduction to roller screws

## Roller screws

A wide assortment of industries rely on AKD roller screws for their actuation requirements. Leading the trend to move from traditional forms of linear actuation, AKD roller screws represent the state of the art driving force for powerful electro-mechanical actuation.

AKD is a pioneer in the technology of roller screws and offers high quality, high performance and the widest assortment of roller screws available on the market.

The AKD in-house highly integrated manufacturing process uses the latest machining technology including soft and hard machining, heat treatment (induction and through hardening), grinding and assembly operations. AKD manufacturing facilities also house laboratories dedicated to life tests, tribology, noise measurement and metallurgy. Beyond the standard assortment made from high grade bearing steel, AKD offers special variants with stainless steel and high temperature steel combined with coatings, etc. to respond to the most demanding applications.

AKD offers three main variants of planetary roller screws that do not require roller recirculation:

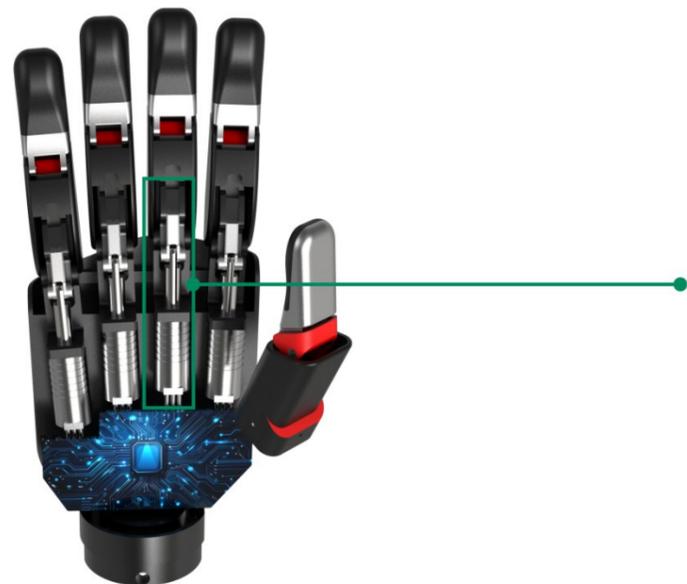
- SPRS Standard Planetary Roller Screw
- RPRS Reverse Planetary Roller Screw
- CPRS Circulating Planetary Roller Screw
- DPRS Differential Planetary Roller Screw

AKD offers a wide assortment of recirculating roller screws. Since the rollers are circumferentially grooved, after each complete revolution around the nut, the grooved rollers must be recirculated back to their starting point on one side of the nut, with the help of cams and axial groove inside the nut.

Small leads are possible with a relatively larger thread pitch on the shaft and nut. This feature offers the ideal combination of small lead, high load carrying capacity, a high degree of stiffness and precision.

Nevertheless, the recirculating roller screws present lower speed and acceleration capabilities than planetary roller screws.

## Ball Screw for Humanoid Robot Dexterous Hands



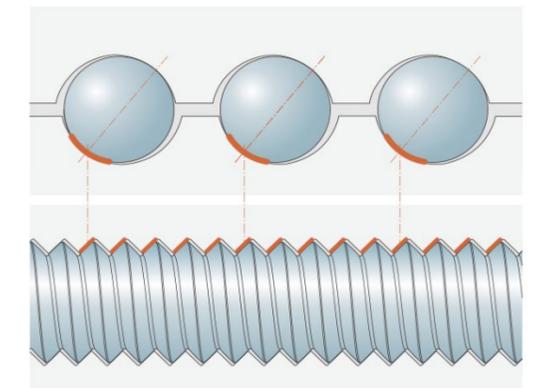
With planetary roller screws, the application load is transmitted from the nut to the shaft through the barrel-shaped surfaces of the rollers. The number of contacts and the total surface area of the contacts between the shaft, the rollers and the nut are substantially increased compared to the ball screw design, resulting in larger dynamic and static load carrying capacities (fig. 1).

The absence of recirculating element embodies the fundamental conceptual advantage of the planetary roller screws. This feature eliminates the main failure mode of ball screws, that is linked to the recirculation of the balls. Indeed, recirculating heavily loaded balls induces alternate stresses on the balls and shock loads arising from the change of trajectory.

In addition, satellite rollers never come into contact with each other. This is a significant advantage of this product over most ball screw designs. Balls come into contact with each other in most ball screw designs, generating friction and adding a potential failure mode to the ball screw concept.

With recirculating roller screws, the application load transfers from the shaft to the nut through a set of grooved rollers. This design permits very small leads while offering high load carrying capacity and axial stiffness.

Fig. 1  
Comparison of ball screws and roller screws contact area



Roller screw concept	Advantages over a ball screw	User benefits
Large number of contact points	High load carrying capacity and up to 10 times longer service life	Lower total cost of ownership (TCO)
Satellite rollers	Roller screw rotational speeds up to 50% higher than a ball screw with similar carrying capacity Roller screw acceleration up to 3 times higher Absence of recirculation eliminating a significant failure mode	Increased speed of operations Higher productivity Higher degree of reliability
Planetary roller screws with small lead (down to 2,00 mm)	High load carrying capacity compared to ball screws with small lead which are designed with small diameter balls which have low load carrying capacity	High load carrying capacity combined with positioning accuracy and reduced torque requirements
Evenly spaced planetary or recirculating rollers	Good operation in applications with changes of direction, stable friction torque	Low noise High degree of reliability
Recirculating roller screws with small lead down to 1 mm	High load carrying capacity, high axial stiffness that cannot be obtained with a ball screw of similar lead and diameter Very small input torque	High resolution, high stiffness, long service life, robustness

Recirculating roller screws SPRS: Standard dynamic load carrying capacity  $C_r$  [kN]

Nominal diameter $d_1$ mm	Nominal diameter	Lead [mm]				
		1 kN	2	3	4	5
8	SPRS	8,5				
10	SPRS	8,95	8,95			
12	SPRS	10,3	10,3			
16	SPRS	11,5	11,5			
20	SPRS	18,5	18,5			
25	SPRS	32,9	32,9			
32	SPRS	64,3	64,3			
40	SPRS	79,1	49,9			
50	SPRS	190	98,1	153	98,1	
63	SPRS		186		186	
80	SPRS				325	
100	SPRS					469
125	SPRS					756

## Preferred range

SPRS (C or F): Recirculating roller screw with axial play  
 SPRS (C or F): Recirculating roller screw without backlash

Recirculating roller screws PV, with internal preload: Standard dynamic load carrying capacity  $C_r$  [kN]

Nominal diameter $d_1$ mm	Nominal diameter	Lead [mm]				
		1 kN	2	3	4	5
8	SPRS	4,88				
10	SPRS	5,14	5,14			
12	SPRS	5,96	5,96			
16	SPRS	6,71	6,71			
20	SPRS	10,6	10,6			
25	SPRS	18,9	18,9			
32	SPRS	36,9	36,9			
40	SPRS	45,4	28,7			
50	SPRS	109	56,3	88	56,3	
63	SPRS		107		107	
80	SPRS				187	
100	SPRS					269
125	SPRS					434

## Technical concepts

## Introduction to AKD roller screws

Roller screws convert rotary motion into linear motion and vice-versa. Loads are transferred from the screw shaft to the nut through a roller set, therefore, roller screws relate to general bearing technology. Various types of bearing steel are used to attain the hardness and material fatigue properties required for carrying heavy application loads over extended periods of service. Certain bearing concepts such as load ratings, load cycles, nominal calculated life and service life, stiffness, speed ratings, lubrication requirements, etc. are explained below to guide customers through the roller screw selection process. The selection parameters are included in this chapter. To make the best selection of a roller screw, the designer should consider the following parameters such as the load cycle, the linear or rotational speed, the required life, the rates of acceleration and deceleration, the cycle rate, the environment, the lead accuracy, the stiffness, and any other special requirements.

For additional information about the roller screws selection process, please contact your local AKD representative.

Basic dynamic load carrying capacity  $C_a$ 

The dynamic load carrying capacity is used to compute the nominal fatigue life of roller screws. It corresponds to the axial load, constant in magnitude and direction, concentric with the roller screw axis, under which the calculated nominal fatigue life as defined by ISO 3408-5 reaches one million revolutions.

Nominal fatigue life  $L_{10}$ 

Nominal fatigue life  $L_{10}$  is, according to the ISO definition, the life attained or exceeded by 90% of a sufficiently large group of identical roller screws, working under identical conditions (alignment, axially and centrally applied load, speed, acceleration, lubrication, temperature and cleanliness).

The nominal life of a roller screw is the statistical number of millions of revolutions which the roller screw is capable of reaching before the first signs of flaking signifying material fatigue occurs on one of the rolling surfaces.

When reliability greater than 90% is required, the calculated nominal life must be corrected. See values for the correction factor in table 1. For example, if a reliability of 98% is required,  $L_r = 0,33 L_{10}$ , where  $L_{10}$  is calculated using.

Table 1

Correction factor for reliability		
Reliability [%]	Correction factor	$L_n$
90	1,00	$L_{10}$
95	0,62	$L_5$
96	0,53	$L_4$
97	0,44	$L_3$
98	0,33	$L_2$
99	0,21	$L_1$

## Service life

The actual life achieved by a specific roller screw is known as service life. In addition to material fatigue, service life can be reduced by inadequate lubrication, wear, corrosion, contamination and, more generally, loss of the functional characteristics required by the application.

Experience with similar applications will help in selecting the right screw to obtain the desired service life. Structural requirements such as the strength of screw ends and nut attachments should also be considered.

To attain  $L_{10}$  life performance, the maximum cycle operating load  $F_{max}$  should not exceed 80% of  $C_s$  (for SPRS and CPRS product assortments) to limit the Hertzian pressure at the rollers/raceways contact points. If  $F_{max}$  exceeds 50% of the  $C_a$  value, please contact your AKD representative for validation.

For small strokes (shorter than the nut length) or short oscillations, additional considerations such as the actual total number of loading cycles on any specific area of the shaft, and the false brinelling effect should be taken into account1).

## Equivalent dynamic load $F_m$

The loads acting on the screw can be calculated according to the laws of mechanics if the external forces are known or can be calculated. For product sizing and selection, it is necessary to calculate the equivalent dynamic load: this is the hypothetical load, constant in magnitude and direction, acting axially and centrally on the screw, which, if applied, would have the same influence on the screw life as the actual loading conditions which the screw will be subjected to.

Radial and moment loads must be accommodated by linear guides. It is extremely important to resolve these possible problems early in the design stage. Radial forces are detrimental to the life and expected performance of the screw (fig. 2).

Please refer to the chapter entitled Recommendations for assembly.

If misalignment, uneven loading, shock loads, etc. cannot be avoided, they must be taken into account during the sizing of the screw. Their influence on the screw's nominal life can generally be estimated1).

## Basic static load carrying capacity $C_{0a}$

Roller screws should be selected based on the basic static load carrying capacity  $C_{0a}$ , rather than the basic dynamic load carrying capacity, when they are subjected to continuous continuous or intermittent shock loads while operating in stationary conditions for short periods of time.

The permissible load is determined by the permanent deformation caused by the load acting at the contact points. The static load carrying capacity is, according to ISO standards, the purely axially and centrally applied static load which creates, by calculation, a total (rolling element + threaded surface) permanent deformation equal to  $1/10000$  of the curvature diameter of the rolling element.

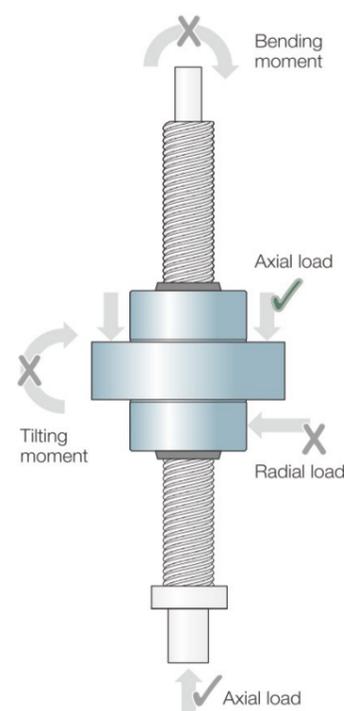
In order to prevent surface damage, to keep smooth running and low noise level, AKD recommends that the application loads do not exceed 80% of the static load carrying capacity  $C_{0a}$ , which equals to a static safety factor  $s_0$  of 1,25.

Usually the  $C_{0a}$  value corresponds to a Hertzian contact pressure ranging between 4 500 and 4 800 Mpa.

The basic dynamic and static load carrying capacities are related to the material properties, and vary with the material hardness at the contact points. Please refer to the paragraph explaining "materials, heat treatment and coatings".

The basic static load carrying capacity must be, at a minimum, equal to the product of the maximum applied axial static load and a static safety factor  $s_0$ . Past experience with similar applications and requirements of maximum static load occurrence, running smoothness and noise level will guide the selection of  $s_0$ .

Fig. 2  
Permissible and prohibited loading on roller screw



For applications requiring high precision, roller screws should operate significantly below the static load carrying capacity, which means operation with a higher value for the static safety factor  $s_0$ .

For heavily loaded applications where precision, noise level and running smoothness are not critical to the performance expectations, roller screws can operate at load levels close to the basic static load carrying capacity. With these conditions, special care must be paid to proper lubrication.

## Critical rotating speed for screw shafts $n_{cr}$

A roller screw with the nut in a given position has a natural frequency of vibration in bending mode. When the screw shaft is rotating, it is important that the rotational speed not excite its natural frequency. If it does, it would result in elastic radial deflection of the shaft. In extreme conditions, without damping, the screw shaft could be bent. The natural frequency of the roller screw changes continuously as the nut moves along the shaft and in relation to the shaft supports. The positive effect of this axial nut displacement is that there is generally no time for the amplitude of the vibration at a given natural frequency to build up.

For calculation of the critical rotating speed, the shaft is the equivalent of a cylinder with an external diameter equal to the root diameter of the thread. The formula uses a parameter whose value is dictated by the mounting of the screw shaft ends, whether the screw shaft end is free, radially supported or fixed.

As a general rule, the nut is not considered to be a support for the screw shaft. Because of the potential inaccuracies in the mounting of the screw assembly, a safety factor of 0,8 is applied to the calculated critical speed.

Calculations where the nut is considered to be a support for the shaft or calculations which reduce the safety factor, require practical tests and possibly optimization of the design.

## Permissible speed limit ( $n d_0$ ) and acceleration

The permissible speed limit is the speed that a screw cannot reliably exceed at any time. It corresponds to the limiting speed of the rotation of rollers or of the recirculation of the rollers (SPRS type) inside the nut. It is expressed as the product of maximum rotational speed  $n$  (r/min) and the nominal diameter  $d_0$  (mm) of the screw shaft. The speed limits quoted in this catalogue are the maximum speeds that may be applied for short periods of time with optimized conditions of alignment, light external load or preload, and with appropriate lubrication.

Permissible speed limits for each technology:

- Planetary roller screw (SPRS) and inverted roller screw (RPRS):  $n d_0 \leq 160\,000$
- Recirculating roller screw (CPRS):  
 $n d_0 \leq 30\,000$  for  $d_0 \leq 25$  mm  
 $n d_0 \leq 20\,000$  for  $d_0 > 25$  mm

Running a screw continuously at the permissible speed limit may reduce the service life of the nut mechanism.

### Important:

High speeds combined with high loads yield a relatively short nominal life<sup>1</sup>).

In the case of high accelerations, decelerations or fast movement reversal, AKD recommends either working under a nominal external load or applying a light preload to the nut to avoid roller sliding on the shaft.

The preload for screws subjected to high accelerations must be calculated to be sure that the rolling elements do not slide<sup>1</sup>).

However, excessive preload will generate an unacceptable increase in frictional heat.

Roller screws preloaded for optimum rigidity should not be operated continuously at high speeds.

Recirculating roller screws should not be operated at permanent high linear speeds or at their maximum speed rating.

High speeds will be detrimental to the recirculation cam's life. In addition, noise levels will increase.

Roller screws

## Efficiency $\eta$

Screw performance depends primarily on the geometry of the contact surfaces, their finish and the helix angle of the thread.

It also depends on the working conditions (load, speed, lubrication, preload, alignment, etc.).

Direct efficiency  $\eta$  is used to define the input torque required to transform the rotation of one component into the translation of another (diagram 2).

Conversely, indirect efficiency  $\eta'$  is used to define the axial load required to transform the translation of one component into the rotation of another one. It is also used to define the braking torque required to prevent that rotation (diagram 3).

The reference coefficient of friction  $\mu_{ref}$  would be achievable with perfect operating conditions of lubrication, alignment, etc. and it would result in generating a theoretical direct efficiency  $\eta$ , or a theoretical indirect efficiency  $\eta'$ . Because such laboratory conditions are not encountered with real applications, we define a practical coefficient of friction  $\mu_{prac}$  used to estimate the practical efficiencies  $\eta_p$  and  $\eta'_p$ .

Practical efficiencies range between the starting efficiencies of a newly installed screw and that of a properly run-in screw. These practical values of efficiency are calculated with a practical value for the coefficient of friction  $\mu_{prac}$ .

To account for real installation, running conditions and the experience of real life application, this practical coefficient of friction  $\mu_{prac}$  corresponds to the reference coefficient of friction  $\mu_{ref}$  increased by 30% (diagram 1).

This calculation method reduces the practical efficiency of the screw versus its theoretical efficiency by about 5%.

Generally, the practical efficiency increases with speed, and over time with running in effect.

**Note:**

The helix angle alpha can be calculated using formula

Diagram 1

Reference and practical coefficient of friction

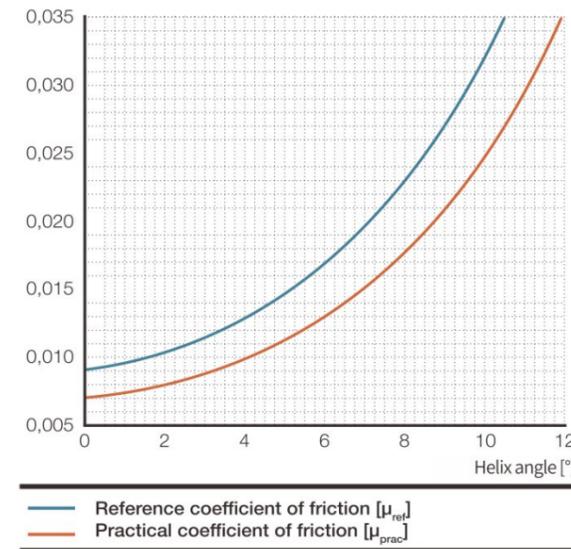


Diagram 2  
Theoretical and practical direct efficiency

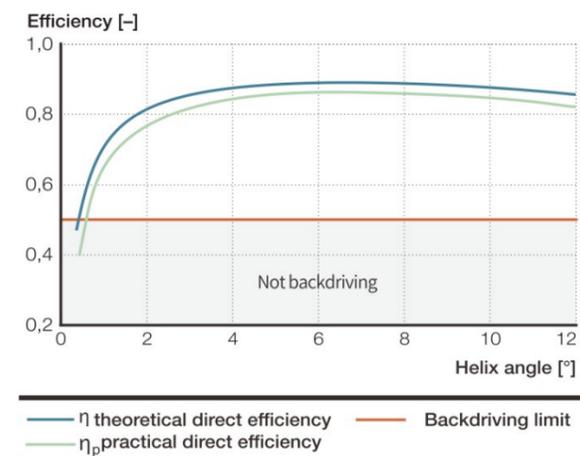
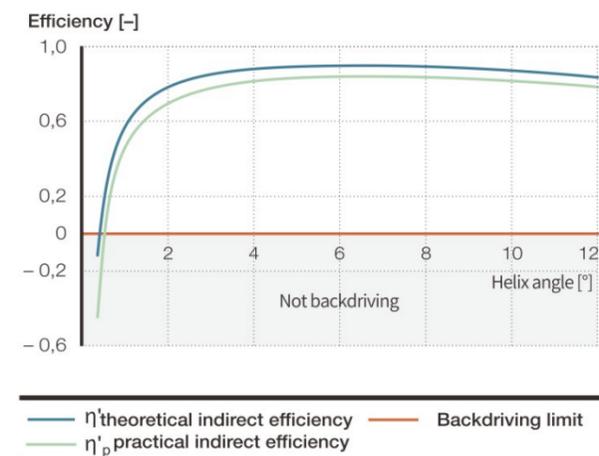


Diagram 3  
Theoretical and practical indirect efficiency



Roller screws

## Back-driving and braking torque $T_b$

Except for one specific recirculating roller screw dimension (50x1) and for some specific sizes of inverted roller screws, roller screws are reversible or can be back-driven under most circumstances.

A braking mechanism (gear reducer or brake) must be part of the design if back-driving is to be avoided.

If back-driving is required, special care must be taken to align the whole system. Misalignment significantly increases the coefficient of friction by tilting and, consequently, increases the axial force required to back-drive the mechanism.

**Attention:**

Vertical installations and applications presenting a risk of falling loads require special care by designers and users. It is the customer's responsibility to determine the need for back-up locking devices and safety systems.

## Static axial stiffness $R_t$

The static axial stiffness of a complete roller screw assembly is the ratio of the external axial load applied to the system and the axial displacement of the face of the nut in relation to the fixed (anchored) end of the screw shaft. The inverse of the system's overall stiffness is equal to the sum of all inverted values of stiffness for each component (screw shaft, roller nut, support bearings, etc.).

Therefore, the overall stiffness of the system is always lower than the lowest value for stiffness of any individual component.

### Nut stiffness $R_n$

When a preload is applied to a nut, the internal play is eliminated. Additionally, the squeeze load responsible for generating the preload creates initial Hertzian elastic deformation at the contact points. This leads to an increase in stiffness proportionate to the preload value.

The theoretical elastic deformation at the contact points does not take into account machining inaccuracies, actual sharing of the load between the different contact surfaces, or elasticity of the nut and screw shaft.

For this reason, two stiffness values are given in the catalogue:

- $R_{ng}$ : This is the minimum nominal stiffness reached by any nut and roller assembly. This value, based on laboratory measurements, is a practical value and does not require any correction factor. It takes into account production tolerances, actual load sharing, preload torque tolerance, deflection of the nut body, etc. It can be used to calculate the total stiffness during the roller screw selection process.
- $R_n$ : This value corresponds to the reference nominal stiffness of a nut and roller assembly with all geometrical dimensions centered within the tolerances. It corresponds to the optimum stiffness level.

$R_{nr}$  is always greater than  $R_{ng}$ . Both values are determined by applying an external axial load, centered on the screw shaft and equal to twice the preload force.

### Shaft stiffness $R_s$

The elastic deformation of the screw shaft is proportional to its length and inversely proportional to the square of its root diameter.

According to the relatively low stiffness of the shaft, an increase of the nut preload (and its stiffness) will, in most cases, not increase significantly the overall stiffness of the system.

Consequently, the preload stated in the catalogue for each screw dimension is the maximum and should not be exceeded.

## Break away torque $T_x$

This is the amount of torque required to overcome the following forces to start rotation:

- (a) The total inertia of all moving parts accelerated by the source of power (including rotational and linear movements)
- (b) The internal friction of the screw/nut assembly, bearings and associated guidance systems.

In general, the torque required to overcome inertia (a) is greater than the friction torque (b). The coefficient of friction  $\mu_s$  for a high-efficiency screw, when it starts moving, is estimated to reach up to twice the amount of the practical dynamic coefficient of friction  $\mu_{prac}$ , under normal operating conditions.

## Driving torque $T_t$

This is the total torque required from the electric motor to overcome inertia, external forces, preload, friction, etc. Please see calculation formulae.

## Materials, heat treatment and coatings

### Choice of steel material

Standard screw shafts are mainly manufactured from pre-treated 50CrMo4 (otherwise 42CrMo4) which is surface hardened by induction. Through hardened 100Cr6 bearing steel is used for nuts and rollers.

100Cr6 can also be selected for the screw shaft for operation at higher temperature up to 180 °C, or if the application presents a concern for wear.

Material properties are detailed in table 3.

Stainless steel can be used for all types of roller screws. Properties offered by these special steel variants are summarized in table 2.

Table 2

Selection of stainless steels			
Steel (ISO standard)	Description	Shaft hardness [HRC]	Relative corrosion resistance
X105CrMo17	Martensitic stainless steel	58–60	**
X30Cr13	Martensitic stainless steel	50–55	***
X12CrNiMoV12–3	Carburizing stainless steel	58–60	***
X40CrMoVN16–2	Nitrogen stainless steel	58–60	****
X5CrNiCuNb16–4	Precipitation hardening stainless steel	38–45	*****
X5CrNiCuNb16–4	Martensitic stainless steel	40–45	*****

Table 3

Selection of standard steels							
Component	Steel	Supplying state	Heat treatment	Maximum allowed operating temperature	Surface hardness at standard tempering temperature [HRC]	Customer benefits	
Standard shaft	50CrMo4 or 42CrMo4	Pre-treated	Tensile strength 880 to 1030 MPa Yield strength > 650 Mpa	Induction hardening	110 °C	58 to 60	Good wear resistance Resilience
Standard shaft on request	50CrMo4	Pre-treated	Tensile strength 880 to 1030 MPa Yield strength > 650 Mpa	Induction hardening Higher tempering temperature	150 °C	58 to 60	Good wear resistance and medium temperature operation Resilience
Special shaft	100Cr6	Pre-treated	Tensile strength 840 to 970 MPa Yield strength > 500 Mpa	Induction hardening	180 °C	59 to 63	Higher wear resistance, adapted to higher operating temperature but more brittle
Nut & rollers	100Cr6	Annealed		Through hardening	180 °C	58 to 62	Good wear resistance and high temperature operation

### Effect of surface hardness on roller screw basic load rating

According to the ISO reference calculations, the load ratings provided in the catalogue are given for surface hardness above 654 HV (58 HRC). For materials or treatments resulting in a lower hardness, correction factors should be applied to the dynamic and static load carrying capacities:

$$C_{a \text{ corrected}} = C_a \left( \frac{HV_{\text{actual}}}{654} \right)^2$$

$$C_{0a \text{ corrected}} = C_{0a} \left( \frac{HV_{\text{actual}}}{654} \right)^2$$

#### Note:

654 HV is equivalent to 58 HRC

### Surface coatings

AKD offers various types of surface coatings for improved roller screw performances:

- Manganese phosphate coating of carbon steels to improve corrosion resistance
- Low friction coating is available on request<sup>1)</sup>

## Operating temperature

Operating at high temperatures will lower the steel hardness, alter the thread accuracy, may increase the oxidation of the materials and change the lubricant properties.

With operating temperature lower than -20 °C, the core resilience of the material can become critical. The lower the temperature, the more brittle the material becomes, especially with a long or thin screw shaft. Bending stresses or shock loads increase the risk of fractures.

Applications with high cycling rates and high loads can generate excessive amounts of heat. To eliminate excess heat, AKD can provide a nut mechanism, with cooling chambers. When connected to a customer supplied water circulation system, temperatures can be stabilized, enabling higher cycling rates and increased productivity.

## Screw shaft buckling or column strength $F_c$

The column loading of a screw shaft must be checked when it is subjected to dynamic or static compression loading.

The maximum permissible compressive load is calculated using the Euler formulae, with a safety factor of 3 to 5, depending on the application. The type of shaft end mounting is critical for selecting the proper coefficient to be used in the Euler formulae.

When the screw shaft has a single diameter along its total length, the root diameter of the threaded shaft is used for the calculation. When the screw shaft comprises different sections with varying diameters, calculation becomes more complex<sup>1)</sup>.

## Shaft design

It is possible to deliver screws with one end larger than the shaft outside diameter  $d_1$ . This design feature is frequently used in conjunction with support bearings with large bore diameter.

To grind the thread efficiently, an undercut with root diameter  $d_2$  and length  $l_1$  is needed (fig. 3 and table 4).

### Designing the screw shaft ends

Customers designing their screw shaft ends are responsible for checking their strength against static and dynamic operating conditions.

The simple approach considers the shaft end diameters. Stress concentration factors must be used.

Zone A must be checked for strength against torsion and zone B must be checked for strength against torsion and tension (fig. 4).

### Important:

Application loads reaching the basic load rating  $C_n$  generate very high mechanical stresses on the shaft ends. AKD strongly recommends that shaft ends be calculated with extreme care for such applications.

Table 4

Type of roller screw	Design conditions	Value for $l_2$
SPRS	$d_3 \leq 1,85 d_1$ Lead $P_h \leq 8$ mm	$l_2 \geq 12$ mm
	$d_3 \leq 1,85 d_1$ Lead $P_h > 8$ mm	$l_2 \geq 1,4 P_h$
CPRS	$d_3 \leq 1,85 d_1$ Lead $P_h = 1$ mm	$l_2 \geq 12$ mm
	$d_3 \leq 1,85 d_1$ Sizes $d_0 P_h = 40 \times 2$ or $50 \times 2$ or $63 \times 2$ mm	$l_2 \geq 12$ mm
	$d_3 \leq 1,85 d_1$ All other types of recirculating roller screws	$l_2 \geq 14$ mm
<b>All types of roller screws</b>	$d_3 > 1,85 d_1$	

Fig. 3

Shaft design with shoulder

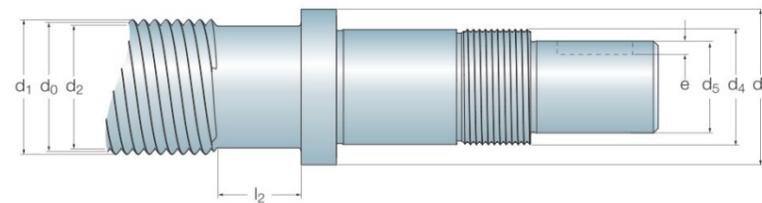
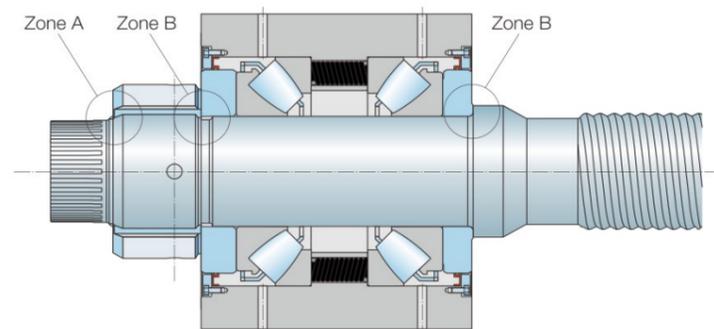


Fig. 4

Shaft end with support bearing



### Zone A: Torsion only

The nominal shear stress  $\tau$  caused by the input torque  $T$  is given by:

$$\tau = \frac{16\,000\,T}{\pi d_3^3}$$

This value is increased by a stress concentration factor  $f_4$  to give the real shear stress  $\tau_p$

$$\tau_p = f_4 \tau$$

According to von Mises, the total stress  $\sigma_t$

$$\sigma_t = 1,73 \tau_p$$

For safety,  $\sigma_t$  should be less than 67% of the yield strength.

If the end diameter  $d_5$  includes a key-way of depth  $e$ , calculate using  $(d_5 - e)$  instead of  $d_5$ .

The angle of twist of the screw shaft is given by

$$\Theta = \frac{7,48\,Tl}{d_0^4}$$

where

$l$  = length between motor and nut

The linear positioning error,  $\delta$ , caused by this twist is

$$\delta = \frac{P_h \Theta}{360}$$

### Note:

Stress concentration factors  $f_4$  and  $f_5$  are available in all general mechanical

### Units:

$d$ : mm

$\tau$ : N/mm<sup>2</sup> [MPa]

$\sigma$ : N/mm<sup>2</sup> [MPa]

$\Theta$ : degree [°]

$\delta$ : mm

$F$ : N

### Zone B: Axial + torsional stresses

The nominal axial stress caused by the axial load  $F$  is given by

$$\sigma = \frac{4\,F}{\pi d_4^2}$$

This value is increased by a stress concentration factor  $f_5$  to give the real principal stress  $\sigma_p$

$$\sigma_p = f_5 \sigma$$

As for zone A calculation

$$\tau_p = f_4 \tau$$

According to von Mises, the total stress  $\sigma_t$

$$\sigma_t = (\sigma_p^2 + 3 \tau_p^2)^{1/2}$$

For safety,  $\sigma_t$  should be less than 67% of the yield strength.

# Lead precision and manufacturing tolerances

## Lead precision

Generally speaking, the precision indicated defines the lead precision class that complies with ISO 3408-3, e.g. G1, G3 and G5 (tables 14 and 15).

Standard lead precision is G5. On re-quest, AKD can deliver roller screws with G3 or G1 lead precision.

A roller screw lead precision class is primarily defined by the maximum permitted travel variation  $V_{300p}$  over a threaded length of 300 mm (table 14).

Lead precision characteristics are de-fined by the permitted lead error  $e_p$ , and the permitted travel variation  $V_{up}$ , measured at 20 °C over the useful stroke  $l_u$  (tables 15, 16 and fig. 15).

Some customer applications require a travel compensation  $c$  to account for the effect of operating temperature on the lead precision: a temperature var-iation by 1 °C results in dimensional change of 11,5  $\mu$ m/m of screw shaft length. Consequently, if needed, a travel compensation  $c$  can be achieved.

- Standard case with  $c=0$  (fig. 16)
- Case with customer specific value of  $c$  (fig. 17)

Lead precision graphs can be supplied on request.

Table 14  
Maximum permitted travel variation over 300 mm

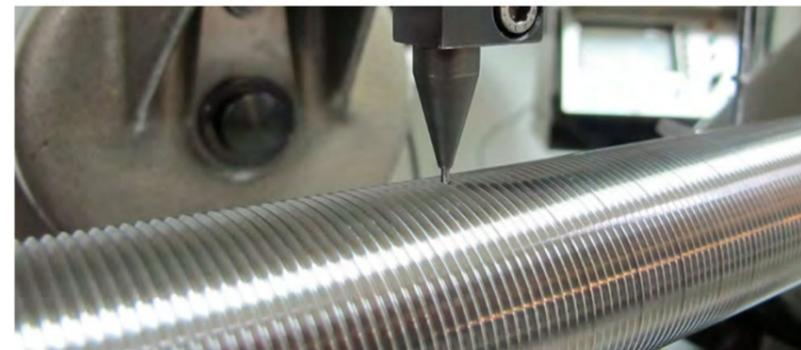
G1	G3	G5
$V_{300p}$ $\mu$ m	$V_{300p}$	$V_{300p}$
6	12	23

Table 15  
Travel deviation and maximum permitted travel variation over the useful travel  $l_u$

$l_u$ over mm	incl.	G1		G3		G5	
		$e_p$ $\mu$ m	$V_{up}$	$e_p$	$V_{up}$	$e_p$	$V_{up}$
0	315	6	6	12	12	23	23
315	400	7	6	13	12	25	25
400	500	8	7	15	13	27	26
500	630	9	7	16	14	32	29
630	800	10	8	18	16	36	31
800	1 000	11	9	21	17	40	34
1 000	1 250	13	10	24	19	47	39
1 250	1 600	15	11	29	22	55	44
1 600	2 000	18	13	35	25	65	51
2 000	2 500	22	15	41	29	78	59
2 500	3 150	26	17	50	34	96	69
3 150	4 000	32	21	62	41	115	82
4 000	5 000			76	49	140	99
5 000	6 300					170	119

Table 16  
Useful travel

Type of roller screw	Useful travel $l_u = \text{threaded length} - 2 l_e$ where
Planetary roller screw	$l_e = 1 \times \text{lead}$
Recirculating roller screw	$l_e = 5 \times \text{lead}$



## Symbols used in figures

- $l_u$  useful travel
- $l_e$  excess travel (no lead precision required)
- $l_m$  actual mean travel (line which best fits the actual travel curve by method of least squares)
- $l_0$  nominal travel
- $l_s$  specified travel
- $c$  travel compensation (difference between  $l_s$  and  $l_0$  to be defined by the customer)
- $e_p$  permitted mean travel deviation (lead error) over the specified travel
- $e_a$  actual (measured) mean travel deviation over the specified travel
- $V$  travel variation (or permissible band width)
- $V_{300p}$  maximum permitted travel variation over 300 mm
- $V_{up}$  maximum permitted travel variation over the useful travel  $l_u$
- $V_{300a}$  measured travel variation over 300 mm
- $V_{ua}$  measured travel variation over  $l_u$
- $V_{2\pi p}$  maximum permitted travel variation within  $2\pi$  rad
- $V_{2\pi a}$  actual travel variation measured within  $2\pi$  rad

Table 15  
Definition of lead error measurement

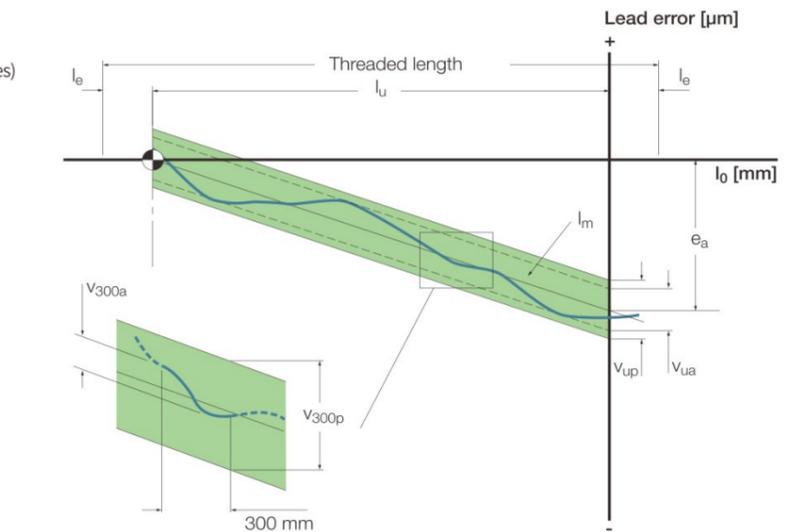


Table 16  
Case without travel compensation

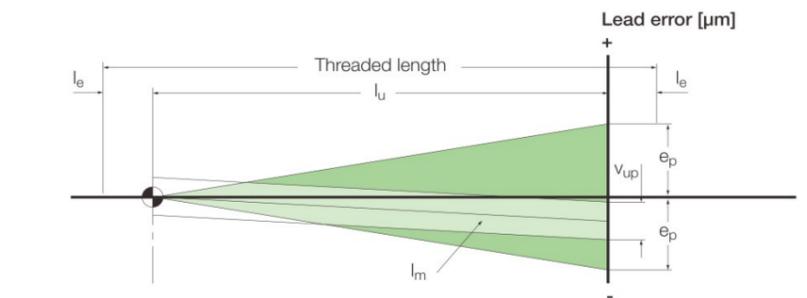
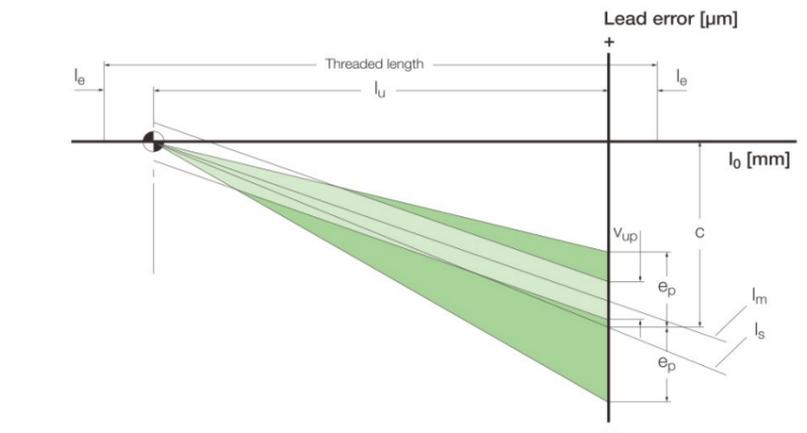


Table 17  
Case with negative travel compensation



Roller screws

Roller screws

**Permissible travel variation  $V_{2\pi p}$  within  $2\pi$  rad (one revolution)**

The maximum permissible travel variation  $V_{2\pi p}$  over one revolution can be an important parameter for some very high precision applications.

This lead precision parameter  $V_{2\pi p}$  is explained in figure 18. Values in accordance with ISO standards 3408-3 are provided in table 17.

On request, AKD can measure and provide the actual travel variation  $V_{2pa}$  over one revolution, for nominal screw diameters up to 40 mm and screw lengths up to 1 000 mm.

**Matching of travel deviation for screws working in parallel**

When 2 or more screws are used together in parallel on one piece of equipment, it's often important to match their lead deviations.

A value M is defined as the maximum difference between the mean travel of any screw in a set. In cases where three or more screws are installed, M represents the maximum difference between the two most extreme mean travels of the set of screws (table 18).

Figure 19, figure 20 and figure 21 represent 3 typical application examples.

Table 17

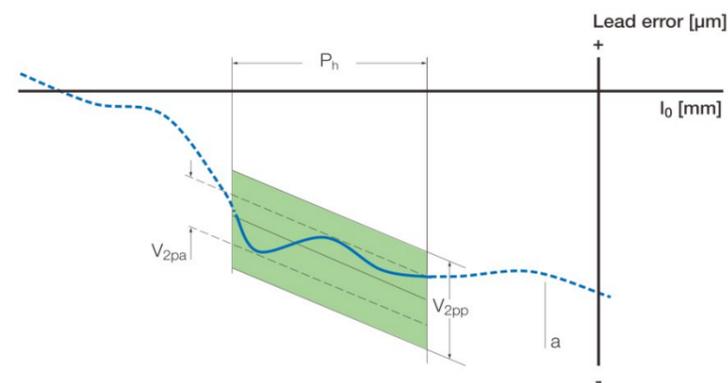
Maximum permitted travel variation within $2\pi$ rad	
Lead precision grade	$V_{2\pi p}$ μm
-	
G1	4
G3	6
G5	8

Table 18

Maximum mean travel deviation	
Numbers of screws in a set	M μm
2	$V_{up}$
> 2	$1,5 V_{up}$

Fig. 18

Travel deviation within  $2\pi$  rad



a is actual travel deviation

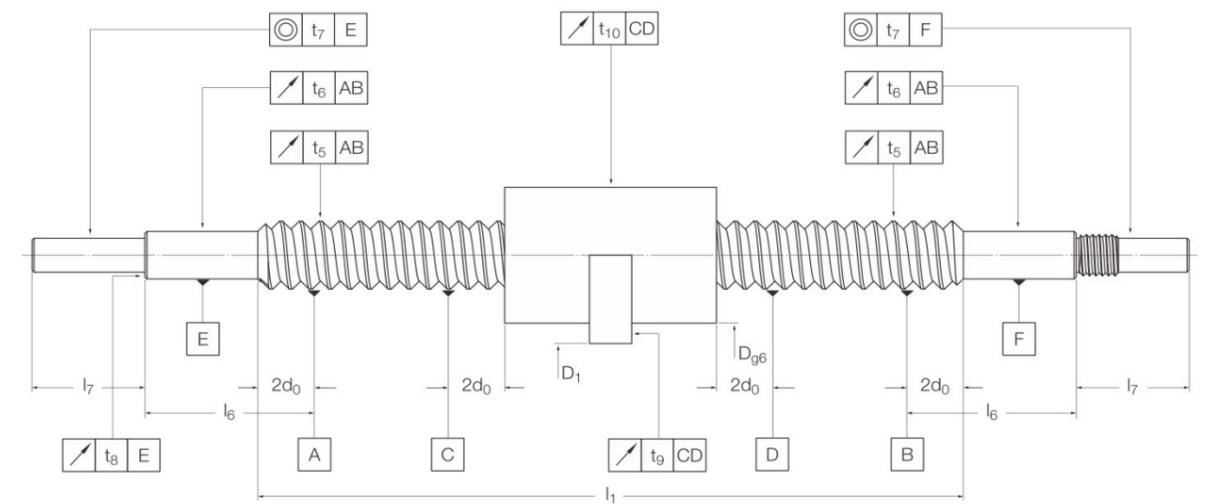
**Manufacturing tolerances**

Parameters other than lead precision correspond in standard to class 5 of ISO 3408-3. If the application requires special tolerances, ISO class 3 or ISO class 1, please specify these requirements in the inquiry.

- Tables 19 to 23 for manufacturing tolerances class 5
- Tables 24 to 28 for manufacturing tolerances class 3
- Tables 29 to 33 for manufacturing tolerances class 1

Fig. 22

Manufacturing tolerances



**Shaft:**

- t5: straightness
- t6: radial run-out of journal diameter
- t7: concentricity of ends/journal diameter
- t8: axial run-out of bearing support face

**Nut:**

- t9: axial run-out of the nut flange face
- t10: radial run-out of the nut diameter/screw

Roller screws

Roller screws

Manufacturing tolerances class 5

Manufacturing tolerances class 3

Table 19

Table 20

Nominal diameter d <sub>0</sub> over mm	incl.	Threaded length l <sub>1</sub> l <sub>1 ref</sub> mm	Tolerance
			if l <sub>1</sub> ≤ l <sub>1 ref</sub> t <sub>5</sub> µm
6	12	320	32
12	25	640	32
25	50	1 260	32
50	100	2 520	32
100	200	5 000	32
200		1)	1)

Ratio	Tolerance
if l <sub>1</sub> > l <sub>1 ref</sub> l <sub>1</sub> /d <sub>0</sub> Proportion	t <sub>5</sub> µm
≤ 40	64
≤ 60	96
≤ 80	160
≤ 100	256

Table 24

Table 25

Nominal diameter d <sub>0</sub> over mm	incl.	Threaded length l <sub>1</sub> l <sub>1 ref</sub> mm	Tolerance
			if l <sub>1</sub> ≤ l <sub>1 ref</sub> t <sub>5</sub> µm
6	12	320	25
12	25	640	25
25	50	1 260	25
50	100	2 520	25
100	200	5 000	25
200		1)	1)

Ratio	Tolerance
if l <sub>1</sub> > l <sub>1 ref</sub> l <sub>1</sub> /d <sub>0</sub> Proportion	t <sub>5</sub> µm
≤ 40	50
≤ 60	75
≤ 80	125
≤ 100	200

Table 21

Table 26

Nominal diameter d <sub>0</sub> over mm	incl.	Tolerance				
		t <sub>6</sub> µm	t <sub>6 mini</sub>	t <sub>7</sub>	t <sub>7 mini</sub>	t <sub>8</sub>
6	20	0,25 x l <sub>6</sub>	20	0,10 x l <sub>7</sub>	8	5
20	50	0,20 x l <sub>6</sub>	25	0,08 x l <sub>7</sub>	10	5
50	63	0,16 x l <sub>6</sub>	32	0,06 x l <sub>7</sub>	12	5
63	125	0,16 x l <sub>6</sub>	32	0,06 x l <sub>7</sub>	12	6
125	200	0,13 x l <sub>6</sub>	40	0,05 x l <sub>7</sub>	16	8
200		1)	1)	1)	1)	1)

Nominal diameter d <sub>0</sub> over mm	incl.	Tolerance				
		t <sub>6</sub> µm	t <sub>6 mini</sub>	t <sub>7</sub>	t <sub>7 mini</sub>	t <sub>8</sub>
6	20	0,15 x l <sub>6</sub>	12	0,08 x l <sub>7</sub>	6	4
20	50	0,13 x l <sub>6</sub>	16	0,06 x l <sub>7</sub>	8	4
50	63	0,10 x l <sub>6</sub>	20	0,05 x l <sub>7</sub>	10	4
63	125	0,10 x l <sub>6</sub>	20	0,05 x l <sub>7</sub>	10	5
125	200	0,08 x l <sub>6</sub>	25	0,04 x l <sub>7</sub>	12	6
200		1)	1)	1)	1)	1)

Table 22

Table 23

Nut flange outer diameter		Tolerance
D <sub>1</sub> over mm	incl.	t <sub>9</sub> µm
16	32	16
32	63	20
63	125	25
125	250	32
250	500	40

Nut body outer diameter		Tolerance
D over mm	incl.	t <sub>10</sub> µm
16	32	16
32	63	20
63	125	25
125	250	32
250	500	40

Table 27

Table 28

Nut flange outer diameter		Tolerance
D <sub>1</sub> over mm	incl.	t <sub>9</sub> µm
16	32	12
32	63	16
63	125	20
125	250	25
250	500	32

Nut body outer diameter		Tolerance
D over mm	incl.	t <sub>10</sub> µm
16	32	12
32	63	16
63	125	20
125	250	25
250	500	32

Measured by rotating the shaft and nut together

Measured by rotating the nut around the fixed shaft

Measured by rotating the shaft and nut together

Measured by rotating the nut around the fixed shaft

Manufacturing tolerances class 1

Table 29

Nominal diameter $d_0$		Threaded length $l_1$ $l_1 \text{ ref}$	Tolerance if $l_1 \leq l_1 \text{ ref}$ $t_5$ $\mu\text{m}$
over mm	incl.		
6	12	320	20
12	25	640	20
25	50	1 260	20
50	100	2 520	20
100	200	5 000	20
200		1)	1)

Table 30

Tolerance	
if $l_1 > l_1 \text{ ref}$ $l_1/d_0$ Proportion	$t_5$ $\mu\text{m}$
$\leq 40$	40
$\leq 60$	65
$\leq 80$	100
$\leq 100$	160

Table 31

Nominal diameter $d_0$		Tolerance				
over mm	incl.	$t_6$ $\mu\text{m}$	$t_{6 \text{ mini}}$	$t_7$	$t_{7 \text{ mini}}$	$t_8$
6	20	$0,12 \times l_6$	10	$0,06 \times l_7$	5	3
20	50	$0,10 \times l_6$	12	$0,05 \times l_7$	6	3
50	63	$0,08 \times l_6$	16	$0,04 \times l_7$	8	3
63	125	$0,08 \times l_6$	16	$0,04 \times l_7$	8	4
125	200	1)	1)	1)	1)	1)
200	240	1)	1)	1)	1)	1)

Table 32

Nut flange outer diameter $D_1$		Tolerance $t_9$ $\mu\text{m}$
over mm	incl.	
16	32	10
32	63	12
63	125	16
125	250	20
250	500	1)

Measured by rotating the shaft and nut together

Table 33

Nut body outer diameter $D$		Tolerance $t_{10}$ $\mu\text{m}$
over mm	incl.	
16	32	10
32	63	12
63	125	16
125	250	20
250	500	1)

Measured by rotating the nut around the fixed shaft

Calculation formulae

Basic life rating

$$L_{10} = \left( \frac{C_a}{F_m} \right)^3$$

Required load rating

$$C_{\text{req}} = F_m (L_{10 \text{ req}})^{1/3}$$

where

- $L_{10}$  = basic rating life [million revolutions]
- $C_a$  = basic dynamic load rating [N]
- $C_{\text{req}}$  = required dynamic load rating [N]
- $F_m$  = cubic mean load [N]
- $L_{10 \text{ req}}$  = required life [million revolutions]

Equivalent mean load

- Duty cycle with step loading

$$F_m = \left( \frac{\sum F_i^3 l_i}{\sum l_i} \right)^{1/3}$$

where

- $l_i$  = length of stroke segment  $i$
- $F_i$  = load during stroke  $i$
- $F_i$  can be either a fixed value, or a calculation for continuous load varying cycles

- Duty cycle with continuous load variation

$$F_m = \frac{F_{\text{min}} + 2 F_{\text{max}}}{3}$$

where

- $F_{\text{min}}$  = minimum load
- $F_{\text{max}}$  = maximum load

Critical speed of screw shaft (no safety factor)

$$n_{\text{cr}} = 49 \times 10^6 \frac{f_1 d_2}{l_{\text{cr}}^2}$$

where

- $n_{\text{cr}}$  = critical speed [r/min]
- $d_2$  = screw shaft root diameter [mm]
- $l_{\text{cr}}$  = free length, or distance between the two supports [mm]
- $f_1$  = mounting factor
- 0,9 ●● fixed, free (→ fig. 25)
- 2,5 ●● radial support, radial support (→ fig. 26)
- 3,8 ●● fixed, radial support (→ fig. 27)
- 5,6 ●● fixed, fixed (→ fig. 28)

Notes:

- For each particular application, the most unfavorable conditions must be considered
- It is generally recommended to apply a safety factor of 0,8 to the calculated value of the critical speed  $n_{\text{cr}}$  of the screw shaft.

Speed limit of the mechanism (maximal speed applied through very short periods)

- $n \ d_0 \leq 160\ 000$  for all types of planetary roller screws
- $n \ d_1 \leq 30\ 000$  for SV, BV, PV with  $d_1 \leq 25$  mm
- $n \ d_1 \leq 20\ 000$  for SV, BV, PV with  $d_1 > 25$  mm

where

- $n$  = rotational speed [r/min]
- $d_0$  = screw shaft nominal diameter for all types of planetary roller screws [mm]
- $d_1$  = screw shaft nominal diameter for recirculating roller screws [mm]

- Maximum permissible acceleration:  $12\ 000 \text{ rad/s}^2$  for all types of planetary roller screws
- $4\ 000 \text{ rad/s}^2$  for all types of recirculating roller screws

Fig. 25  
Mounting factor  $f_1 = 0,9$

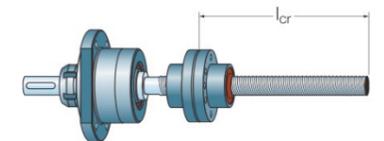


Fig. 26  
Mounting factor  $f_1 = 2,5$

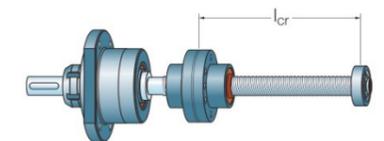


Fig. 27  
Mounting factor  $f_1 = 3,8$

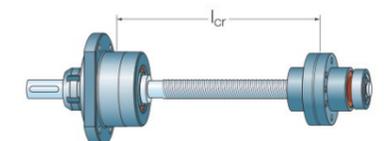
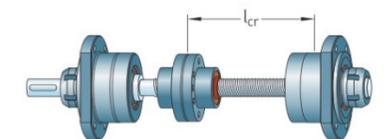


Fig. 28  
Mounting factor  $f_1 = 5,6$



### Buckling strength with safety factor 3

$$F_c = \frac{34 \times 10^3 f_3 d_2^4}{l_{Fc}^2}$$

where

$F_c$  = buckling strength [N]

$d_2$  = screw shaft root diameter [mm]

$l_{Fc}$  = distance between the fixed support bearing and the extended position of the nut [mm]

$f_3$  = mounting factor

0,25  fixed, free

( $\rightarrow$  fig. 29)

2  fixed, radial support

( $\rightarrow$  fig. 30)

4  fixed, fixed

( $\rightarrow$  fig. 31)

### Helix angle

$$\alpha = \text{Atan} \left( \frac{P_h}{\pi d} \right)$$

where

$d$  = nominal diameter of screw shaft [mm]

•  $d_0$  for SR planetary roller screws

•  $d_1$  for SV recirculating roller screws

•  $D_0$  for ISR inverted roller screws

$P_h$  = lead [mm]

### Theoretical efficiencies

Direct ( $\rightarrow$  diagram 2, page 24)

$$\eta = \frac{1}{1 + \frac{\pi d}{P_h} \mu_{ref}}$$

where

$\mu_{ref}$  is extracted from the coefficient of friction diagram ( $\rightarrow$  diagram 1 page 24)

$\alpha$  = helix angle [°]

$d$  = nominal diameter of screw shaft [mm]

•  $d_0$  for SR planetary roller screws

•  $d_1$  for SV recirculating roller screws

•  $D_0$  for ISR inverted roller screws

$P_h$  = lead [mm]

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Indirect ( $\rightarrow$  diagram 3, page 24)

$$\eta' = 2 - \frac{1}{\eta}$$

### Practical efficiencies

Direct ( $\rightarrow$  diagram 2, page 24)

$$\eta_p = \frac{1}{1 + \frac{\pi d}{P_h} \mu_{prac}}$$

where

$\mu_{prac}$  is extracted from the coefficient of friction diagram ( $\rightarrow$  diagram 1, page 24)

$\alpha$  = helix angle [°]

$d$  = nominal diameter of screw shaft [mm]

•  $d_0$  for SR planetary roller screws

•  $d_1$  for SV recirculating roller screws

•  $D_0$  for ISR inverted roller screws

$P_h$  = lead [mm]

Indirect ( $\rightarrow$  diagram 3, page 24)

$$\eta' = 2 - \frac{1}{\eta_p}$$

### Input torque in a steady state

$$T = \frac{F P_h}{2000 \pi \eta_p}$$

where

$T$  = input torque [Nm]

$F$  = external load [N]

$P_h$  = lead [mm]

$\eta_p$  = practical direct efficiency

### Power requirement in a steady state

$$P = \frac{F n P_h}{60000 \eta_p}$$

where

$P$  = power required [W]

$n$  = revolutions per minute [r/min]

### Preload torque

$$T_{pr} = \frac{F_{pr} P_h}{1000 \pi} \left( \frac{1}{\eta_p} - 1 \right)$$

where

$T_{pr}$  = preload torque [N]

$F_{pr}$  = preload force [N]

### Braking torque (the restraining torque considered in a back-driving system)

$$T_b = \frac{F P_h \eta'}{2000 \pi}$$

where

$T_b$  = braking torque [Nm]

$F$  = external load [N]

To consider the worst case conditions, we use the theoretical indirect efficiency.

Fig. 29  
Mounting factor  $f_3 = 0,25$

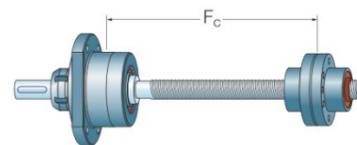


Fig. 30  
Mounting factor  $f_3 = 2$

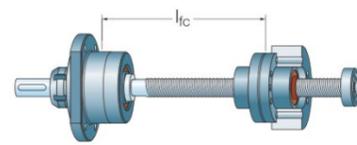
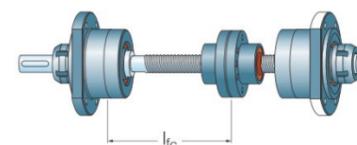


Fig. 31  
Mounting factor  $f_3 = 4$



### Nominal motor torque during acceleration

For a horizontal screw

$$T_t = T_f + T_{pr} + \frac{P_h(F + m_L \mu_f g)}{2000 \pi \eta_p} + \dot{\omega} \Sigma I$$

For a vertical screw

$$T_t = T_f + T_{pr} + \frac{P_h(F + m_L g)}{2000 \pi \eta_p} + \dot{\omega} \Sigma I$$

where

$T_t$  = driving torque [Nm]

$T_f$  = friction torque in support bearings, motors, seals, etc... [Nm]

$T_{pr}$  = preload torque [Nm]

$\mu_f$  = coefficient of friction of guidance systems

$\omega$  = angular acceleration [rad/s<sup>2</sup>]

$m_L$  = mass in movement [kg]

$g$  = acceleration of gravity [9,8 m/s<sup>2</sup>]

$\Sigma I = I_M + I_L + I_S \cdot 10^{-9}$

where

$$I_L = m_L \left( \frac{P_h}{2\pi} \right)^2 \cdot 10^{-6}$$

where

$I_M$  = inertia of motor [kgm<sup>2</sup>]

$I_S$  = inertia of screw shaft per meter [kgmm<sup>2</sup>/m]

$l$  = length of screw shaft [mm]

For a hollow shaft, the actual inertia is calculated as follows:

$$I_{S \text{ actual}} = I_S \cdot 10^{-9} \left( \frac{d_0^4 - d_b^4}{d_0^4} \right)$$

where

$d_b$  = bore diameter of the shaft [mm]

### Nominal braking torque during deceleration

For a horizontal screw

$$T'_b = \frac{P_h \eta' [F + m_L \mu_f g]}{2000 \pi} + \dot{\omega} \Sigma I - T_f - T_{pr}$$

For a vertical screw

$$T'_b = \frac{P_h \eta' [F + m_L g]}{2000 \pi} + \dot{\omega} \Sigma I - T_f - T_{pr}$$

where

$T'_b$  = braking torque during deceleration [Nm]

### Static axial stiffness of a complete roller screw assembly

$$\frac{1}{R_t} = \frac{1}{R_s} + \frac{1}{R_n} + \frac{1}{R_p}$$

where

$R_t$  = stiffness of a complete assembly [N/ $\mu$ m]

$R_s$  = shaft stiffness [N/ $\mu$ m]

$R_n$  = nut stiffness [N/ $\mu$ m]

$R_p$  = support bearings stiffness [N/ $\mu$ m]

### Shaft stiffness

Fixed-free or fixed-radial support

( $\rightarrow$  fig. 32)

$$R_s = 165 \frac{d_2^2}{l_{s1}}$$

Fixed-fixed assembly

( $\rightarrow$  fig. 33)

$$R_s = \frac{165 d_2^2 l_s}{l_{s1} (l_s - l_{s1})}$$

### Note:

The lowest stiffness is reached when the nut is in central position

$$l_{s1} = \frac{l_s}{2} \rightarrow R_s = \frac{165 d_2^2}{l_s} \times 4$$

where

$l_{s1}$  = distance between center of fixed support bearing and center of nut [mm]

$l_s$  = distance between centers of fixed support bearings

For additional information, please contact your local Ewellix representative.

Fig. 32

Configuration with fixed support and radial support for stiffness calculation

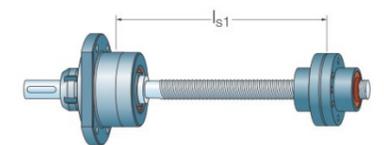
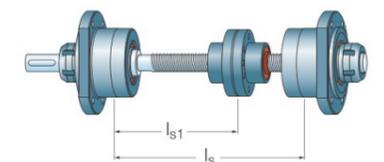


Fig. 33

Configuration with two fixed supports for stiffness calculation



## Calculation example

- Customer wishes to select a planetary roller screw for his application
- To achieve the required linear speed of the application, customer has preselected a lead of 20 mm. Screw rotational speed is 600 r/min during the operation cycle
- Nut type should be flanged for assembly purposes
- Roller screw shaft is horizontally mounted, with one fixed end on the start position, and the other end on radial support
- Load cycle is shown in **diagram 12**
- Operation is 1 cycle/minute, 7 hours/day, 260 days /year for 5 years minimum

### Calculation of equivalent mean load $F_m$

$$F_1 = 50\,000 \text{ N} \quad \text{on } L_1 = 1\,500 \text{ mm}$$

$$F_{2m} = \frac{2F_1 + F_2}{3} = 45\,833 \text{ N} \quad \text{on } L_2 = 1\,000 \text{ mm}$$

$$F_{3m} = 37\,500 \text{ N} \quad \text{on } L_3 = 1\,250 \text{ mm}$$

$$F_{4m} = 20\,500 \text{ N} \quad \text{on } L_4 = 1\,250 \text{ mm}$$

$$F_m = \sqrt[3]{\frac{50\,000^3 \times 1\,500 + 45\,833^3 \times 1\,000 + 37\,500^3 \times 1\,250 + 20\,500^3 \times 1\,250}{1\,500 + 1\,000 + 1\,250 + 1\,250}}$$

$$F_m = 41\,590 \text{ N}$$

### Calculation of required dynamic carrying capacity $C_{a \text{ req}}$

With consideration to the operational cycle:

With the preselection of lead  $P_h = 20 \text{ mm}$

Minimum  $L_{10} = 60 \times 7 \times 260 \times 5 = 546\,000$  cycles

$$L_{10} = 546\,000 \frac{1\,500 + 1\,000 + 1\,250 + 1\,250}{20}$$

$$= 136,5 \times 106 \text{ revolutions}$$

$$C_{a \text{ req}} = F_m (L_{10})^{1/3} = 41\,590 (136,5)^{1/3} = 214\,141 \text{ N}$$

Looking at the product tables, we find that:

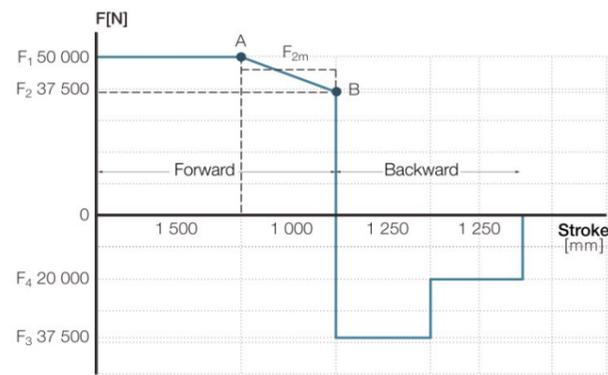
SRF 48 x 20R with  $C_a = 265\,690 \text{ N}$  satisfies the requirement of minimum dynamic carrying capacity

### Selection of support bearing

The table on **page 109** indicates that support bearing size FLRBU7 is recommended for screw type SRF 48 x 20R.

In the following calculations, we will assume that the radial support at the other end of the screw shaft has a total width of 50 mm.

Diagram 12  
Application load cycle



## Efficiencies

### Theoretical direct efficiency

$$\alpha = \text{Atan} \left( \frac{P_h}{\mu d_0} \right) = 7,55^\circ$$

Taken from the coefficient of friction reference diagram (→ **diagram 1, page 24**)

where

$$\mu_{\text{ref}} = 0,016$$

$$\mu_{\text{prac}} = 0,021$$

$$\eta = \frac{1}{1 + \frac{\pi d_0}{P_h} \mu_{\text{ref}}} = 0,892$$

### Theoretical indirect efficiency

$$\eta' = 2 - \frac{1}{\eta} = 0,879$$

### Practical direct efficiency

We consider the practical coefficient of friction  $\mu_{\text{prac}} = 0,021$

$$\eta_p = \frac{1}{1 + \frac{\pi d_0 \mu_{\text{prac}}}{P_h}} = 0,863$$

### Input torque in a steady state

Phase 1 has the highest application load  $F_{\text{max}} = 50\,000 \text{ N}$

$$T = \frac{F P_h}{2\,000 \pi \eta_p} = \frac{50\,000 \times 20}{2\,000 \pi \times 0,863} = 184,4 \text{ Nm}$$

### Power requirement in a steady state

Phase 1 has the highest application load  $F_{\text{max}} = 50\,000 \text{ N}$

Rotational speed is 600 r/min

$$P = \frac{50\,000 \times 600 \times 20}{60\,000 \times 0,863} = 11\,587 \text{ W}$$

### Braking torque

Phase 1 has the highest application load  $F_{\text{max}} = 50\,000 \text{ N}$

$$T_b = \frac{50\,000 \times 20 \times 0,879}{2\,000 \pi} = 139,9 \text{ Nm}$$

### Critical speed of screw shaft

For the critical speed evaluation, we have to consider the most critical configurations for the screw, where we encounter the longest shaft free length. In the present case study, the two most critical configurations are:

**A)** Nut at start position (zero stroke) that gives a free length of 2 608,5 mm between the center of the nut and the center of the radial support at the end of the shaft (→ **page 49 and fig. 34**).

In this configuration, the mounting conditions are supported/supported with a corresponding factor  $f_1 = 2,5$ . The root diameter  $d_2 = 45,5 \text{ mm}$ , the calculated critical speed is:

$$n_{\text{cr}} = 49 \times 10^6 \frac{2,5 \times 45,5}{2\,608,5^2} = 819 \text{ r/min}$$

By applied a safety factor of 0,8:

$$n_{\text{cr}} \times 0,8 = 819 \times 0,8 = 655 \text{ r/min} > 600 \text{ r/min} \rightarrow \text{Ok}$$

**B)** Nut at full stroke of 2 500 mm that gives a free length of 2 719,5 mm between the center of the nut and the center of the fixed support bearing (→ **page 49, fig. 35**).

In this configuration, the mounting conditions are fixed/supported with corresponding factor  $f_1 = 3,8$

The calculation is:

$$n_{\text{cr}} = 49 \times 10^6 \frac{3,8 \times 45,5}{2\,719,5^2} = 1\,146 \text{ r/min}$$

$$n_{\text{cr}} \times 0,8 = 1146 \times 0,8 = 917 \text{ r/min} > 600 \text{ r/min} \rightarrow \text{Ok}$$

### Speed limit

$$n \ d_0 = 600 \times 48 = 28\,000 < 160\,000 \rightarrow \text{Ok}$$

### Buckling strength with safety factor = 3

We must consider two critical situations for calculating the buckling strength.

Point **(A)** (→ **diagram 12, page 47**) with maximum application load at end of phase 1 (travel = 1 500 mm) (→ **fig. 36, page 49**).

In this configuration, the mounting conditions are fixed/supported with corresponding factor  $f_3 = 2$

$$F_{\text{cr}} = \frac{34 \times 10^3 \times 2 \times 45,5^4}{1\,719,5^2} = 98\,571 \text{ N} > F_1 = 50\,000 \text{ N} \rightarrow \text{Ok}$$

Point **(B)** (→ **diagram 12, page 47**) with lower application load and longer total travel of 2 500 mm at end of phase 2 (→ **fig. 37, page 49**)

$$F_{\text{cr}} = \frac{34 \times 10^3 \times 2 \times 45,5^4}{2\,719,5^2} = 39\,407 \text{ N} > F_2 = 37\,500 \text{ N} \rightarrow \text{Ok}$$

### Same case with customer selecting a preloaded roller screw

Should the customer prefer a preloaded roller screw for the application in order to have a stiffer assembly, then the initial selection would be:

PRK 60 x 20R with  $C_a = 217\,610 \text{ N}$

Now check this screw against all dimensioning parameters.

## Efficiencies

### Theoretical direct efficiency

$$\alpha = \text{Atan} \left( \frac{P_h}{\pi d_0} \right) = 6,05^\circ$$

Taken from the coefficient of friction reference diagram

(→ diagram 1, page 24)

where

$$\mu_{\text{ref}} = 0,013$$

$$\mu_{\text{prac}} = 0,017$$

$$\eta = \frac{1}{1 + \frac{\pi d_0 \mu_{\text{ref}}}{P_h}} = 0,891$$

### Theoretical indirect efficiency

### Practical direct efficiency

$$\eta' = 2 - \frac{1}{\eta} = 0,877$$

We consider the practical coefficient of friction

$$m_{\text{prac}} = 0,017$$

$$\eta = \frac{1}{1 + \frac{\pi d_0 \mu_{\text{prac}}}{P_h}} = 0,862$$

## Input torque in a steady state

Phase 1 has the highest application load  $F_{\text{max}} = 50\,000\text{ N}$

$$T = \frac{50\,000 \times 20}{2\,000 \pi \times 0,862} = 184,6\text{ Nm}$$

## Power requirement in a steady state

Phase 1 has the highest application load  $F_{\text{max}} = 50\,000\text{ N}$

Rotational speed is 600 r/min

$$P = \frac{50\,000 \times 600 \times 20}{60\,000 \times 0,862} = 11\,600\text{ W}$$

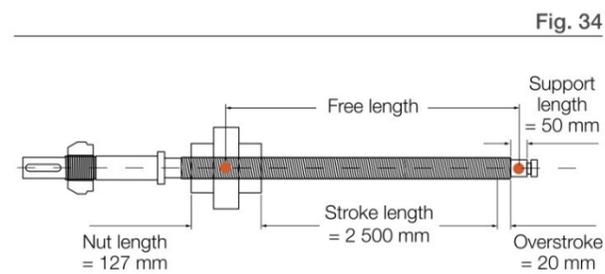


Fig. 34

$$\text{Free length} = 127/2 + 2\,500 + 20 + 50/2 = 2\,608,50$$

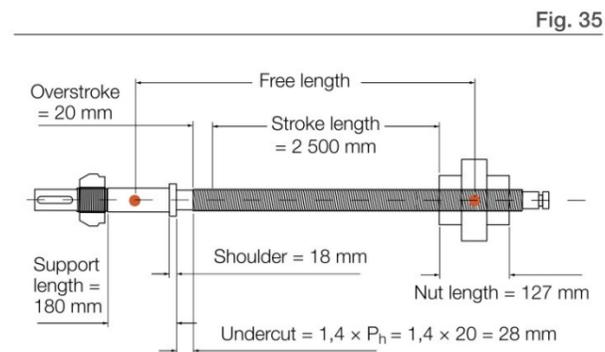


Fig. 35

$$\text{Free length} = 127/2 + 2\,500 + 20 + 28 + 18 + 180/2 = 2\,719,50$$

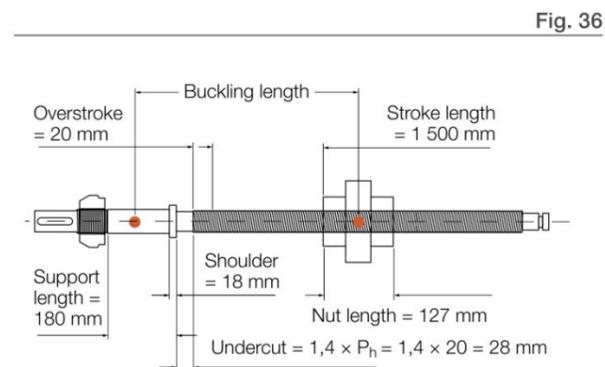


Fig. 36

$$\text{Buckling length} = 127/2 + 1\,500 + 20 + 28 + 18 + 180/2 = 1\,719,50$$

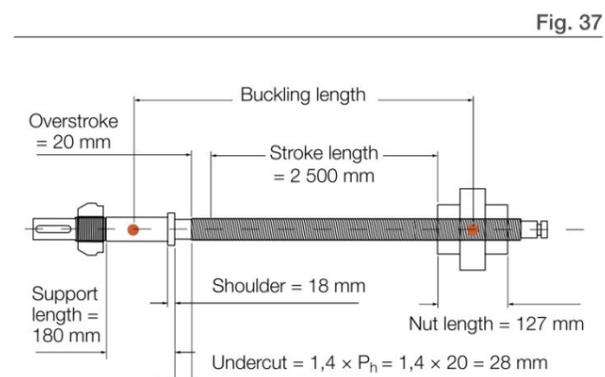


Fig. 37

$$\text{Buckling length} = 127/2 + 2\,500 + 20 + 28 + 18 + 180/2 = 2\,719,50$$

## Braking torque

Phase 1 has the highest application load  $F_{\text{max}} = 50\,000\text{ N}$

$$T_b = \frac{F P_h \eta'}{2\,000 \pi} = \frac{50\,000 \times 20 \times 0,877}{2\,000 \pi} = 139,6\text{ Nm}$$

## Critical speed of screw shaft

Screw type PRK 60 x 20R has a larger nominal diameter and a larger root diameter than screw type SRF 48 x 20R that was already calculated. Therefore, the critical speed will not be a problem for screw size PRK 60 x 20R.

## Axial stiffness

In product table on page 75, we find that nominal preload  $F_{\text{pr}} = 2\,326\text{ N}$

First, we confirm that the internal preload is appropriate for the application:

- Minimum application load in phase 4:  
 $F_4 = 20\,000\text{ N}$
- $F_4$  is greater than  $2,83 \times 2\,326\text{ N} = 6\,583\text{ N}$

This is to make sure that the nut half that does not carry the load is completely unloaded and does not face marginal loading with risk of sliding. Nominal preload  $F_{\text{pr}} = 2\,326\text{ N}$  is OK for the application.

Under this nominal preload conditions ( $F_{\text{pr}} = 2\,326\text{ N}$ ), the minimum nominal stiffness of the nut is  $R_{\text{ng}} = 700\text{ N}/\mu\text{m}$  (product table on page 75).

Total axial stiffness of the roller screw is:

$$\frac{1}{R_t} = \frac{1}{R_s} + \frac{1}{R_{\text{ng}}}$$

At point (B) (→ diagram 12, page 47), full stroke:

With  $d_2 = 57,5\text{ mm}$  for roller screw size PRK 60 x 20R

$$R_s = 165 \frac{57,5^2}{2\,719,5} = 201\text{ N}/\mu\text{m}$$

$$\frac{1}{R_t} = \frac{1}{201} + \frac{1}{700} \rightarrow R_t = 156\text{ N}/\mu\text{m} \text{ at full stroke}$$

If we include the axial stiffness of the fixed support bearing FLRBU7, we calculate the total system stiffness:

$R_{\text{support bearing}} = 1\,250\text{ N}/\mu\text{m}$

$$\frac{1}{R_{\text{total system}}} = \frac{1}{R_t} + \frac{1}{R_{\text{ng}}} + \frac{1}{R_{\text{bearing}}} = \frac{1}{201} + \frac{1}{700} + \frac{1}{1\,250}$$

→  $R_{\text{total system}} = 139\text{ N}/\mu\text{m}$  at full stroke

Planetary Roller Screw

SPRS Standard Planetary Roller Screw



SPRS Standard Planetary Roller Screw



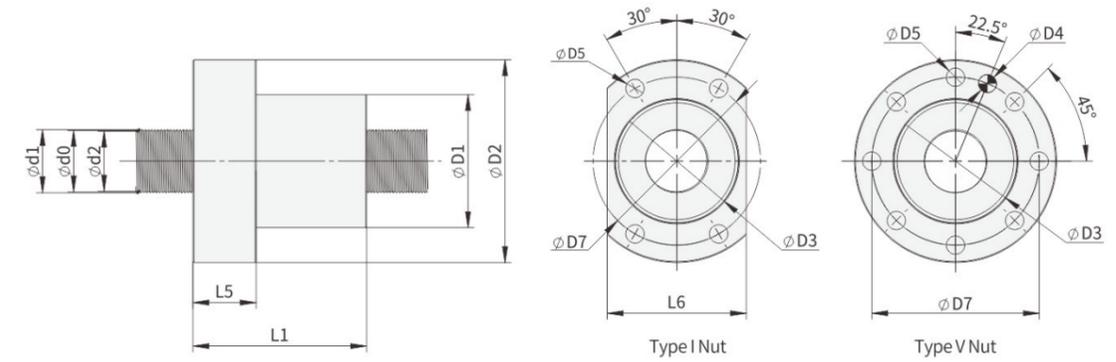
RPRS Reverse Planetary Roller Screw



CPRS Circulating Planetary Roller Screw



DPRS Differential Planetary Roller Screw



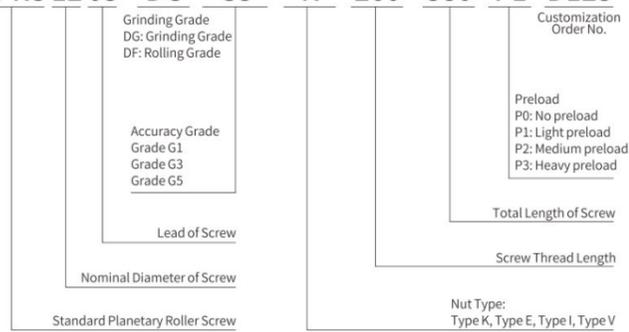
Model	D x P	N	Screw Shaft		Single Nut				Nut												Forward Efficiency	Reverse Efficiency			
			Helix Angle (°)	(mm)			(KN)		(N2/3 μm)	(mm)															
				ød1	ød0	ød2	Ca	Coa	FK	øD1	øD2	øD3	øD4	øD5	øD7	L1	L2	L3	L4	L5			L6		
SPRS 8	2	5	4.55	8.17	10.5	7.76	9.1	18.1	36.3	25	26	5	21	M5	4.8	36	31	41	25.3	10	3	13	26	0.79	0.78
	3		6.81	8.23		7.63	9.0	15.6	26.7															0.80	0.79
	4		9.04	8.29		7.48	9.7	16.0	23.4															0.79	0.78
SPRS 10	2	5	3.47	10.64	10.5	10.31	12.1	22.1	46.4	25	26	5	21	M5	4.8	36	31	41	25.3	10	3	13	26	0.78	0.76
	3		5.20	10.69		10.21	13.0	21.4	36.9															0.80	0.78
	4		6.91	10.75		10.10	14.2	22.3	32.6															0.80	0.79
SPRS 12	2	5	3.04	12.14	12	11.81	13.3	23.9	47.6	28	46	5	24	M5	4.8	36	31	41	27.3	10	3	13	28	0.77	0.74
	3		4.55	12.20		11.71	14.3	23.2	37.9															0.79	0.78
	4		6.06	12.25		11.60	15.7	24.2	33.3															0.80	0.79
	5		7.55	12.30		11.49	16.5	24.3	29.8															0.80	0.79
SPRS 15	2	5	2.43	15.14	15	14.82	22.4	49.3	66.7	34	56	5	30	M6	5.8	45	40	50	35.7	14	4	18	36	0.75	0.72
	3		3.64	15.20		14.72	23.2	44.9	50.9															0.78	0.76
	4		4.85	15.26		14.61	24.4	44.1	43.3															0.79	0.78
	5		6.06	15.32		14.51	26.3	45.8	39.4															0.80	0.79
	6		7.26	15.37		14.39	27.2	45.4	35.8															0.80	0.79
SPRS 18	2	5	2.03	18.14	18	17.82	28.8	67.5	76.5	40	62	5	30	M6	5.8	51	48	58	41.7	18	4	18	42	0.73	0.69
	3		3.01	18.21		17.72	31.9	67.7	61.8															0.77	0.74
	4		4.05	18.27		17.62	34.1	67.9	53.2															0.79	0.77
	5		5.05	18.33		17.52	33.3	60.6	44.0															0.80	0.78
	6		6.06	18.38		17.41	35.2	62.0	40.6															0.80	0.79
	8		8.05	18.48		17.18	36.6	59.8	34.5															0.80	0.78
SPRS 20	2	5	1.63	20.14	20	16.82	31.2	74.5	83.5	45	72	5	30	M6	5.8	51	48	58	41.7	18	4	18	42	0.71	0.67
	3		2.43	20.20		16.72	33.2	74.7	71.8															0.73	0.69

\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.

Ordering Method

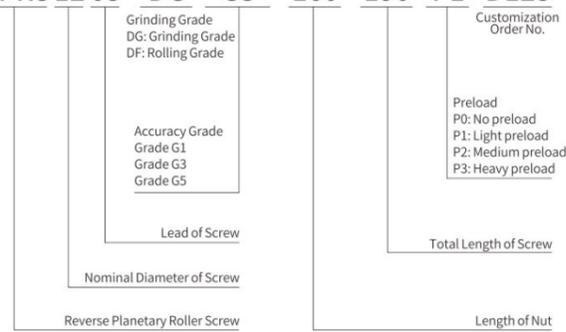
Standard Planetary Roller Screw

SPRS 12 03 - DG G3 - K - 260 - 380 - P1 - D123



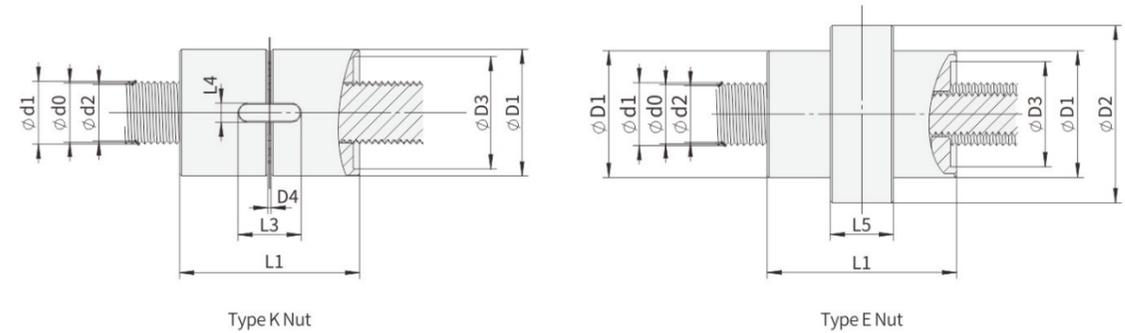
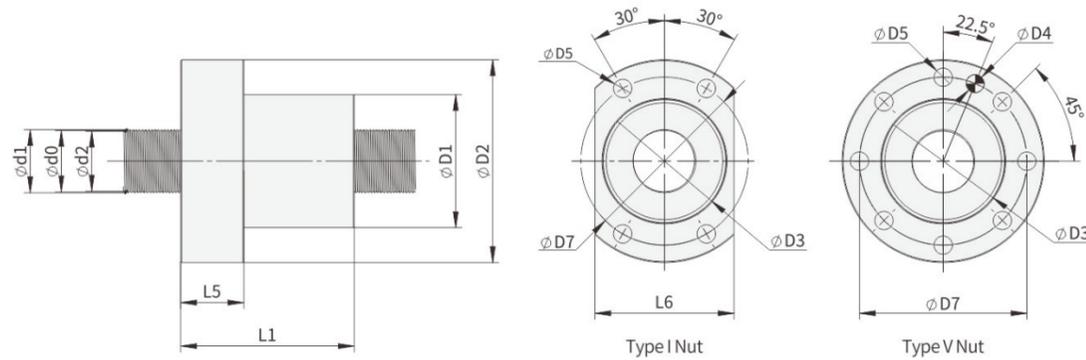
Reverse Planetary Roller Screw

RPRS 12 03 - DG G3 - 160 - 190 - P1 - D123



SPRS Standard Planetary Roller Screw

SPRS Standard Planetary Roller Screw



Model	D x P	N	Screw Shaft						Single Nut			Nut																Forward Efficiency	Reverse Efficiency
			Helix Angle (°)	(mm)			(KN)			(N2/3 μm)	(mm)																		
				∅d1	∅d0	∅d2	Ca	Coa	FK		∅D1	∅D2	∅D3	∅D4	∅D5	∅D7	L1	L2	L3	L4	L5	L6							
SPRS 20	20	5	5	2	1.87	19.64	19.32	35.6	91.9	87.8	42	64	39	5	M6	5.8	53	55	65	43.7	20	4	20	44	0.72	0.68			
				3	2.80	19.71	19.22	38.9	90.5	70.1															0.76	0.73			
				4	3.74	19.77	19.12	41.6	90.7	60.4															0.78	0.76			
				5	4.67	19.83	19.02	43.7	90.2	53.5															0.79	0.78			
				6	5.59	19.88	18.91	43.0	82.9	46.0															0.80	0.79			
				8	7.44	19.99	18.69	44.9	80.4	39.2															0.80	0.79			
				10	9.27	20.07	18.45	46.6	79.3	34.7															0.79	0.77			
SPRS 21	21	5	5	2	1.74	21.14	20.82	44.0	96.2	89.2	45	67	41	5	M6	5.8	56	55	65	47	20	5	18	47	0.72	0.66			
				3	2.60	21.21	20.72	48.1	94.8	70.9															0.75	0.72			
				4	3.47	21.27	20.62	51.6	95.0	61.3															0.78	0.76			
				5	4.33	21.33	20.52	54.1	94.3	54.2															0.79	0.77			
				6	5.20	21.39	20.42	56.8	95.4	49.6															0.80	0.78			
				8	6.91	21.49	20.20	55.7	84.2	39.7															0.80	0.79			
				10	8.62	21.59	19.97	57.8	87.6	35.1															0.80	0.78			
SPRS 23	23	5	5	2	1.62	22.64	22.32	46.2	100.3	90.4	48	71	44	5	M6	7.0	59	55	65	49.7	20	4	20	50	0.71	0.65			
				3	2.43	22.71	22.22	50.5	98.7	71.8															0.75	0.72			
				4	3.24	22.77	22.12	51.1	98.9	62.1															0.77	0.75			
				5	4.05	22.83	22.02	56.8	98.3	54.9															0.79	0.77			
				6	4.85	22.89	21.92	59.6	99.5	50.2															0.79	0.78			
				8	6.46	23.00	21.70	58.5	87.7	40.2															0.80	0.79			
				10	8.05	23.10	21.48	60.8	86.5	35.6															0.80	0.78			
SPRS 25	25	6	6	3	2.28	24.17	23.77	40.4	80.9	76.0	48	71	44	5	M6	7.0	59	48	58	49.7	18	4	20	50	0.74	0.71			
				6	4.55	24.33	23.52	44.6	73.6	49.9															0.79	0.78			
				12	9.04	24.57	22.95	52.2	74.8	35.3															0.79	0.78			
		5	5	2	1.52	24.14	22.82	59.2	144.5	107.1	53	84	48	5	M6	7.0	70	64	78	55.5	25	6	20	55	0.80	0.63			
				4	3.04	24.27	23.63	70.1	145.1	74.1															0.77	0.74			
				5	3.79	24.34	23.53	74.0	129.2	66.0															0.78	0.76			
				6	4.55	24.40	23.42	76.6	143.6	59.6															0.79	0.78			
				8	6.06	24.51	23.21	82.6	146.2	51.9															0.80	0.79			
				10	7.55	24.61	22.99	81.5	133.3	43.6															0.80	0.79			
				15	11.25	24.81	22.38	86.9	130.0	35.0															0.78	0.76			

\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.

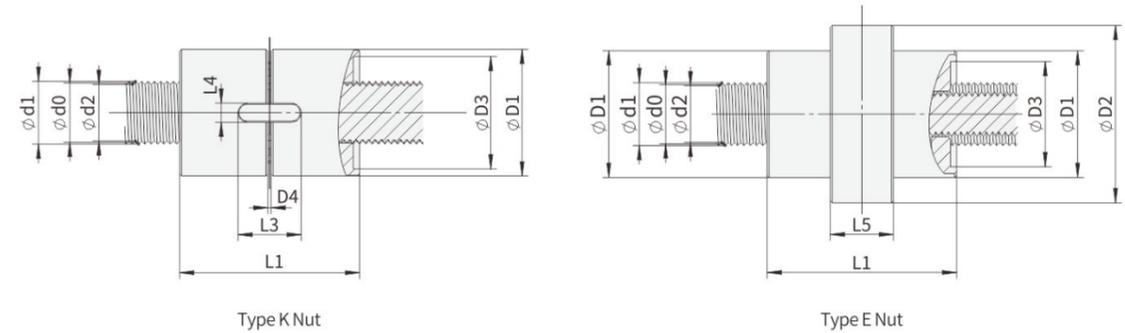
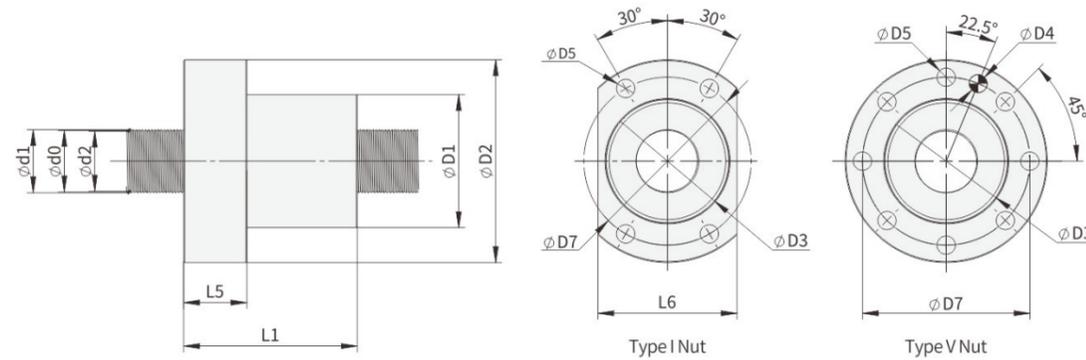
Model	D x P	N	Screw Shaft						Single Nut			Nut																Forward Efficiency	Reverse Efficiency											
			Helix Angle (°)	(mm)			(KN)			(N2/3 μm)	(mm)																													
				∅d1	∅d0	∅d2	Ca	Coa	FK		∅D1	∅D2	∅D3	∅D4	∅D5	∅D7	L1	L2	L3	L4	L5	L6																		
SPRS 27	27	5	5	2	1.35	27.14	26.82	65.4	158.0	110.9	53	83	50	5	M6	7.0	68	65	79	55.2	20	5	22	55	0.68	0.61														
				4	2.70	27.28	26.63	77.4	158.6	76.6															0.76	0.73														
				5	3.37	27.34	26.53	82.1	159.5	68.6															0.77	0.75														
				6	4.05	27.40	26.43	85.4	159.2	62.1															0.79	0.77														
				8	5.39	27.52	26.22	89.8	155.5	52.8															0.80	0.78														
				10	6.72	27.62	26.00	94.5	156.0	47.4															0.80	0.79														
				15	10.03	27.84	25.41	95.3	138.3	35.7															0.79	0.77														
SPRS 30	30	5	5	2	1.22	30.14	29.82	78.0	199.0	123.1	62	92	58	5	M6	9.0	77	71	85	64.7	20	6	27	64	0.66	0.58														
				4	2.43	30.28	29.63	91.7	197.2	84.0															0.75	0.72														
				5	3.04	30.34	29.53	97.6	200.0	75.5															0.77	0.74														
				6	3.64	30.41	29.43	101.1	197.9	68.3															0.78	0.76														
				8	4.85	30.52	29.23	106.7	193.8	58.1															0.79	0.78														
				10	6.06	30.63	29.01	114.9	201.6	52.9															0.80	0.79														
				15	9.04	30.87	28.44	115.8	179.3	39.9															0.79	0.78														
SPRS 36	36	6	6	6	3.04	36.34	35.53	92.5	189.2	76.7	68	102	62	5	M6	9.0	85	68	80	70.2	25	5	27	70	0.77	0.74														
				12	6.06	36.63	35.01	103.7	177.5	51.2															0.80	0.79														
				18	9.04	36.86	34.43	108.4	166.4	40.4															0.79	0.78														
				24	11.98	37.04	33.80	129.1	181.1	34.3															0.77	0.74														
				2	1.01	36.14	35.82	98.5	263.4	138.7															74	110	68	5	M6	9.0	92	82	96	76.7	28	6	25	76	0.63	0.54
				4	2.03	36.28	35.63	116.6	264.2	95.4																													0.73	0.69
				5	2.53	36.35	35.54	123.0	264.7	84.5																													0.75	0.72
6	3.04	36.41	35.44	127.8	262.2	76.7	0.77	0.74																																
8	4.05	36.53	35.24	136.0	260.1	65.6	0.79	0.77																																
10	5.05	36.65	35.03	145.2	266.6	59.1	0.80	0.78																																
15	7.55	36.91	34.48	156.8	261.5	47.7	0.80	0.79																																
20	10.03	37.12	33.88	188.6	286.9	40.3	0.79	0.77																																

\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.



SPRS Standard Planetary Roller Screw

SPRS Standard Planetary Roller Screw



Model	D x P	N	Screw Shaft						Single Nut			Nut																Forward Efficiency	Reverse Efficiency
			Helix Angle (°)	(mm)			(KN)		(N2/3 μm)	(mm)																			
				∅d1	∅d0	∅d2	Ca	Coa	FK	∅D1	∅D2	∅D3	∅D4	∅D5	∅D7	L1	L2	L3	L4	L5	L6								
SPRS 64	64	6	1.71	64.35	64	63.54	232.5	722.0	137.3	115	180	106	7	M8x1	17.5	150	118	129	118	45	8	40	117	0.77	0.71				
			3.42	64.68		63.06	275.8	712.6	94.5															0.78	0.75				
			5.12	64.97		62.54	302.8	703.3	76.0															0.80	0.76				
			6.81	65.23		61.99	390.2	839.3	68.2															0.80	0.75				
			8.49	65.46		61.41	372.1	769.1	57.7															0.80	0.78				
			10.15	65.66		60.80	361.5	731.3	51.4															0.79	0.77				
SPRS 70	70	6	1.59	69.36	69	68.55	292.2	1008.0	160.5	130	172	115	9	M8x1	13.5	152	140	170	133.7	50	10	45	132	0.70	0.67				
			3.17	69.68		68.06	347.5	997.4	110.5															0.77	0.75				
			4.75	69.98		67.55	382.6	986.8	89.0															0.79	0.75				
			6.32	70.25		67.01	477.8	1138.9	78.4															0.80	0.79				
			7.88	70.48		66.43	471.9	1107.5	68.4															0.80	0.79				
			9.43	70.70		65.84	453.9	1034.5	60.3															0.79	0.78				
SPRS 75	75	5	2.43	75.70	75	74.08	453.0	1307.4	116.7	150	210	140	10.5	M8x1	17.5	180	175	191	153	63	10	45	152	0.75	0.72				
			3.64	76.01		73.58	500.0	1296.4	94.3															0.78	0.76				
			4.85	76.31		73.07	581.9	1499.5	82.7															0.79	0.79				
			6.06	76.58		72.53	584.6	1486.5	73.7															0.80	0.79				
SPRS 80	80	6	2.73	80.69	80	79.07	350.6	936.8	105.3	138	180	130	10.5	M8x1	13.5	160	130	158	141.7	50	10	35	140	0.76	0.73				
			4.10	81.00		78.57	389.7	941.2	85.4															0.79	0.77				
			5.45	81.28		78.04	477.4	1103.2	75.7															0.80	0.79				
			6.81	81.53		77.48	487.5	1126.5	68.2															0.80	0.79				
SPRS 87	87	5	2.10	87.70	87	86.08	552.0	1671.6	129.8	175	235	162	10.5	M8x1	17.5	200	190	215	178	63	10	45	177	0.73	0.70				
			3.14	88.03		85.60	597.6	1676.5	105.1															0.77	0.75				
			4.19	88.33		85.09	698.9	1961.6	92.5															0.79	0.77				
			5.23	88.62		84.57	698.7	1926.3	81.9															0.80	0.78				
			6.26	88.89	84.03	714.4	1972.7	75.6																0.80	0.79				

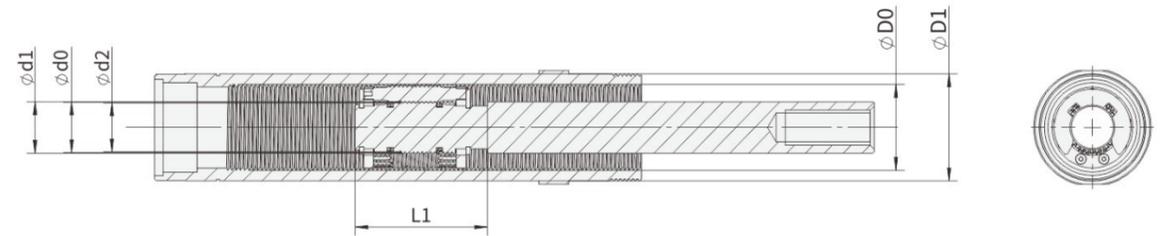
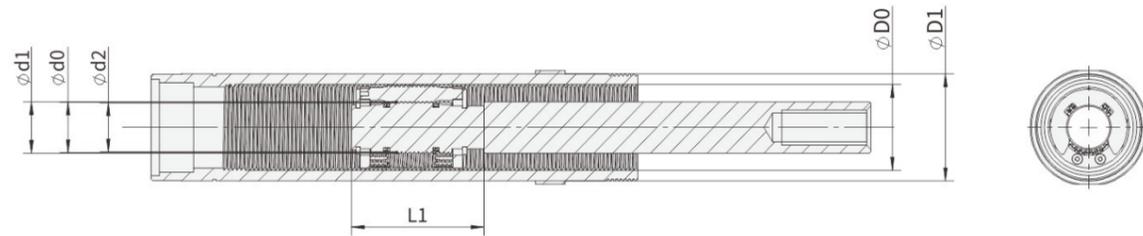
\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.

Model	D x P	N	Screw Shaft						Single Nut			Nut																Forward Efficiency	Reverse Efficiency													
			Helix Angle (°)	(mm)			(KN)		(N2/3 μm)	(mm)																																
				∅d1	∅d0	∅d2	Ca	Coa	FK	∅D1	∅D2	∅D3	∅D4	∅D5	∅D7	L1	L2	L3	L4	L5	L6																					
SPRS 92	92	6	2.38	92.70	92	91.08	484.8	1482.0	129.1	160	220	146	10.5	M8x1	17.5	190	155	179	163	63	10	45	162	0.74	0.72																	
			3.56	93.01		90.58	530.8	1450.1	103.4															0.78	0.76																	
			4.75	93.30		90.06	632.7	1697.6	91.5															0.79	0.78																	
			5.93	93.58		89.53	650.3	1746.4	82.9															0.80	0.79																	
			7.10	93.83		88.97	645.9	1709.0	74.8															0.80	0.79																	
SPRS 100	100	6	2.19	100.70	100	99.08	719.1	2384.7	153.2	185	260	172	10.5	M8x1	17.5	225	200	220	188	63	10	50	187	0.73	0.71																	
			3.28	101.02		98.59	767.8	2343.0	123.0															0.78	0.77																	
			4.37	101.32		98.08	781.0	2349.2	106.0															0.79	0.77																	
			5.45	101.60		97.55	780.1	2307.5	94.0															0.80	0.78																	
			SPRS 120	120		5	2.76	101.04	99															97.61	950.9	3238.7	135.4	200	275	186	15	M8x1	17.5	240	250	271	203	63	10	50	202	0.76
3.68	101.35	97.11			967.6		3245.0	116.4		0.78	0.76																															
4.60	101.65	96.60			980.3		3251.1	103.8		0.79	0.78																															
5.51	101.93	96.07			990.1		3257.2	95.0		0.80	0.78																															
SPRS 120	120	6	2.73	121.03	120	118.60	967.5	3300.6	142.3	220	260	200	15	M10x1	17.5	240	230	260	223	100	10	50	222	0.76	0.73																	
			3.64	121.35		118.11	984.6	3308.0	122.6															0.78	0.76																	
			4.55	121.64		117.59	992.2	3286.8	108.8															0.79	0.78																	
			5.45	121.92		117.06	1007.6	3322.8	99.9															0.80	0.78																	
			SPRS 120	120		5	2.28	121.05	120															118.62	1075.5	3823.6	143.1	240	300	240	15	M10x1	17.5	270	280	300	243	100	10	55	242	0.74
3.04	121.37	118.13			1104.8		3888.3	124.4		0.77	0.74																															
3.79	121.68	117.63			1104.7		3809.0	109.5		0.78	0.76																															
4.55	121.98	117.12			1121.6		3846.9	100.0		0.79	0.78																															
			5.30	121.26	116.59	1110.7	3741.3	91.4																0.80	0.78																	

\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.

RPRS Reverse Planetary Roller Screw

RPRS Reverse Planetary Roller Screw



Model	D x P		N	(°)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(KN)	(KN)	(N2/3µm)	Axial clearance	Forward Efficiency	Reverse Efficiency
				Helix Angle	ød1	ød0	ød2	øD0	øD1	L	Ca	Coa	FK			
RPRS	9	3.0	3	6.06	9.3	9	8.75	15	20	26	8.5	15.4	26.3	0.02	0.78	0.66
		3.5		7.06	9.3		8.5				9.2	15.8	22.5	0.03	0.79	0.67
RPRS	10.5	1.2	3	2.08	10.6	10.5	10.34	17.5	24	33	9.1	15.8	40.8	0.01	0.80	0.68
		2.0		3.47	10.70		10.16				11.4	17.7	32.6	0.02	0.73	0.62
RPRS	12	2.0	3	3.04	12.20	12	11.66	20	25	35	15.3	25.7	36.5	0.02	0.72	0.61
		3.0		4.55	12.30		11.55				16.5	27.1	29.9	0.02	0.77	0.66
		4.5		6.81	12.52		11.3				17.7	27	25.3	0.03	0.77	0.66
RPRS	13.5	2.0	3	2.70	13.71	13.5	13.17	22.5	28	38	17.9	28.9	37.2	0.02	0.71	0.60
		3.0		4.05	13.8		13.03				19.8	27.2	31.9	0.02	0.76	0.63
		4.5		6.06	13.92		12.87				22.3	27.1	27.1	0.03	0.77	0.65
RPRS	15	2.0	3	2.43	15.21	15	14.67	25	32	48	27.7	55.2	50.9	0.02	0.70	0.60
		3.0		3.64	15.29		14.48				29.1	51.5	39.4	0.02	0.75	0.64
		4.5		5.46	15.45		14.32				30.8	50.3	31.6	0.03	0.76	0.65
RPRS	18	2.0	3	2.03	18.22	18	17.68	30	38	50	34.5	73.4	58.5	0.02	0.68	0.57
		3.0		3.04	18.30		17.49				37.2	71.1	46.9	0.02	0.73	0.63
		4.0		4.05	18.38		17.33				37.9	64.8	38.5	0.03	0.75	0.64
RPRS	21	2.0	3	1.74	21.22	21	20.7	35	45	56	54.5	106.0	67.5	0.02	0.67	0.57
		3.0		2.60	21.31		20.52				59.6	104.8	54.2	0.02	0.71	0.61
		4.0		3.47	21.39		20.33				63.3	103.7	46.5	0.03	0.74	0.66
RPRS	24	2.0	3	1.52	24.22	24	23.7	40	50	65	67.90	148.12	74.7	0.02	0.65	0.54
		3.0		2.28	24.32		23.52				74.89	148.58	60.7	0.02	0.69	0.58
		4.0		3.04	24.40		23.33				80.32	149.04	52.2	0.03	0.73	0.62
		5.0		3.79	24.48		23.14				84.73	149.50	46.8	0.03	0.76	0.65
RPRS	27	2.0	3	1.35	27.23	27	26.69	45	55	70	74.70	163.02	77.2	0.02	0.71	0.68
		3.0		2.03	27.33		26.52				83.08	165.32	63.1	0.03	0.73	0.69
		4.0		2.70	27.41		26.33				87.22	160.36	53.3	0.03	0.76	0.73
		5.0		3.37	27.49		26.14				92.00	160.82	47.6	0.03	0.77	0.73
RPRS	28	2.0	4	1.30	28.17	28	27.77	42	52	70	56.49	128.80	85.1	0.02	0.67	0.60
		3.0		1.95	28.25		27.65				62.38	129.26	69.1	0.02	0.72	0.69
		4.0		2.60	28.33		27.52				65.96	126.78	58.7	0.03	0.75	0.72
		5.0		3.25	28.39		27.38				66.70	119.42	50.1	0.03	0.77	0.75
		6.0		3.90	28.46		27.24				70.20	121.07	46.4	0.03	0.78	0.77

\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.

Model	D x P		N	(°)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(KN)	(KN)	(N2/3µm)	Axial clearance	Forward Efficiency	Reverse Efficiency
				Helix Angle	ød1	ød0	ød2	øD0	øD1	L	Ca	Coa	FK				
RPRS	30	2	3	1.22	30.23	30	29.69	50	60	75	89.42	206.17	85.9	0.02	0.66	0.58	
		3		1.82	30.33		29.52				98.72	206.72	69.4	0.03	0.72	0.67	
		4		2.43	30.42		29.34				104.51	203.14	58.3	0.03	0.75	0.72	
		5		3.04	30.50		29.15				109.66	201.66	52.4	0.03	0.77	0.74	
		6		3.64	30.58		28.96				116.75	208.38	48.6	0.04	0.78	0.76	
RPRS	36	2	4	1.01	36.18	36	35.77	54	64	80	79.95	198.17	102.7	0.02	0.63	0.52	
		3		1.52	36.26		35.65				87.77	196.88	82.1	0.02	0.70	0.63	
		4		2.03	36.34		35.53				93.66	195.59	70.5	0.03	0.82	0.69	
		5		2.53	36.41		35.40				97.70	192.46	62.2	0.03	0.73	0.72	
		6		3.04	36.48		35.26				102.12	193.02	56.7	0.03	0.77	0.74	
RPRS	39	2	3	1.40	39.34	39	38.53	65	75	90	146.74	342.24	85.7	0.03	0.68	0.62	
		3		1.87	39.44		38.36				156.68	340.31	73.8	0.03	0.72	0.68	
		4		2.34	39.53		38.18				164.59	338.38	65.5	0.03	0.74	0.72	
		5		2.80	39.62		38.00				171.21	336.44	59.3	0.04	0.76	0.73	
		6		3.27	39.69		37.80				178.57	339.85	55.1	0.04	0.77	0.75	
RPRS	44	2	4	1.24	44.26	44	43.65	66	76	80	124.29	311.33	100.5	0.02	0.66	0.58	
		3		1.66	44.34		43.53				133.95	314.18	86.6	0.03	0.71	0.65	
		4		2.07	44.42		43.41				140.85	312.62	77.1	0.03	0.73	0.70	
		5		2.49	44.49		43.28				145.27	306.54	69.2	0.03	0.75	0.72	
		6		2.90	44.56		43.15				153.46	316.11	64.9	0.03	0.76	0.74	
RPRS	48	2	3	1.14	48.34	48	47.53	80	90	114	201.20	511.70	102.6	0.03	0.65	0.56	
		3		1.52	48.45		47.37				215.83	512.62	87.7	0.03	0.70	0.63	
		4		1.90	48.55		47.20				227.06	510.23	78.2	0.03	0.72	0.68	
		5		2.28	48.64		47.02				238.28	514.37	71.3	0.04	0.74	0.71	
		6		2.66	48.73		46.84				241.41	495.60	64.4	0.04	0.75	0.73	
RPRS	48	7	3	3.04	48.81	48	46.65	80	90	114	255.48	516.21	61.3	0.04	0.77	0.74	
		8		3.42	48.88		46.45				262.84	517.13	57.8	0.05	0.78	0.75	
		9		3.79	48.95		46.25				263.12	498.36	53.9	0.05	0.78	0.76	

\*Maximum Backlash for Single Nut: 0.02-0.05 mm  
 \*Axial clearance can be provided as per requirement  
 \*Parameter notes: P - Lead; D - Reference diameter; N - Number of screw threads; d1 - Screw outer diameter; d0 - Nominal diameter; d2 - Screw root diameter; Ca - Dynamic load rating; Coa - Static load rating; Fk - Stiffness factor.

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## Ball spline

Large load capacity, zero clearance in rotation direction, high sensitivity, high rigidity, simple assembly

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Ball spline

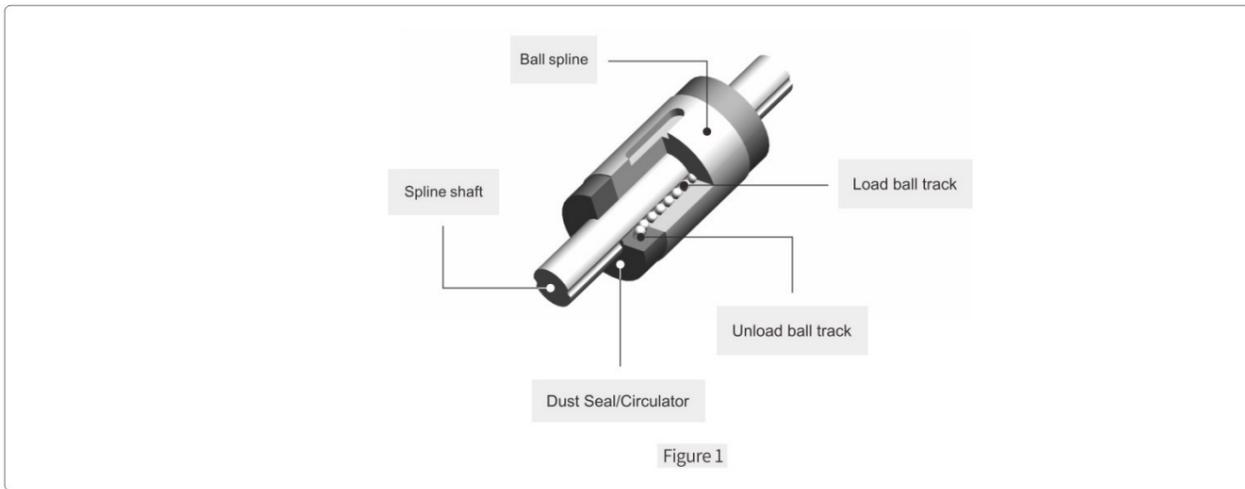
Structure and advantages of ball spline

1. Introduction of ball spline

The ball spline uses the ball installed in the outer profile of the spline shaft to carry out smooth rolling and torque transmission in the precision grinding rolling groove at the same time. AKD adopts a unique contact point design with a larger contact angle (40). In addition to high sensitivity, it can greatly improve the load capacity. It is suitable for environments where vibration and impact loads are too large, positioning accuracy is required, and high-speed motion performance is required, and it can also play an effective role in such environment. Even if it is used instead of a linear ball bushing, the rated load of the ball spline is ten times that of a linear bushing under the condition of the same shaft diameter, so the design can become very compact. Even under the action of cantilever load, torque, it can be used safely and has high durability.

2. Ball spline structure

Ball splines can be divided into five types: Round flange KLF, cylinder AKD KLT, enhanced dust-proof KZF, square flange KOF and cylinder KOT. Due to the size of the shaft diameter, the contact path of the steel balls can be divided into 2 rows (180°) (KLF/KLT/KZF6 ~ 20) (KOT/KOF8 ~ 25) and 4 rows (70°) (KLF/KLT/KZF25 ~ 50) Hollow shafts are also available for optional use.



3. Advantages of ball splines

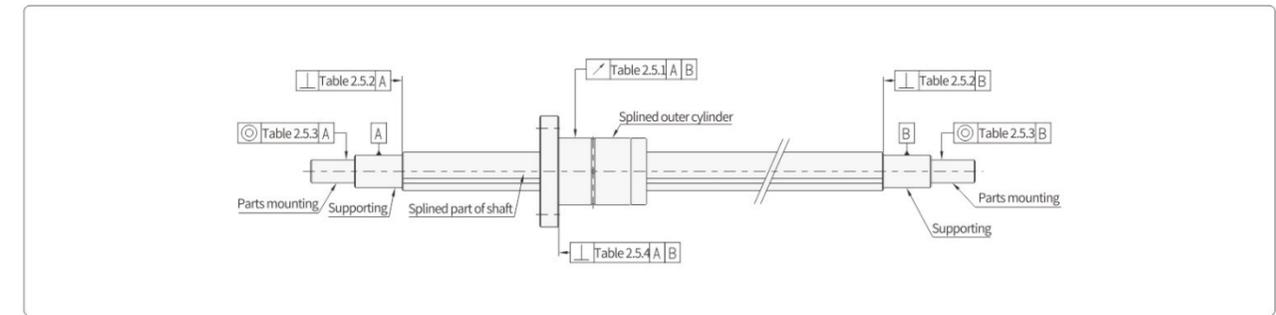
<b>Heavy load capacity</b>	The rolling groove of the ball is precisely ground and formed, and the contact is made at a 40° angle of Gothic. Due to the large contact angle, it has a large load capacity in both radial and torque directions.
<b>Zero clearance in rotating direction</b>	The spline shaft is combined with the outer cylinder of the spline by using 2-4 rows of ball rows with contact angle of 40°, and the clearance in the rotating direction can be zero by adjusting the preload mode.
<b>High sensitivity</b>	Due to the special design of the steel ball contact point, in addition to high rigidity, it is more sensitive and can reduce energy waste.
<b>High Rigidity</b>	Due to the large contact angle, it has high rigidity, and appropriate preload can be applied according to the situation, so it can obtain high torque rigidity and torque rigidity.
<b>Simple assembly</b>	Due to the special design, even if the spline outer cylinder is separated from the spline shaft, the steel balls will not fall off. Thus, assembly maintenance and inspection work can be easily carried out.

Ball spline

Precision design

1. Precision level

The accuracy of the ball spline is expressed by the swing of the spline shaft support by the outer diameter of the spline. It is divided into ordinary grade (N), advanced grade (H), and precision grade (P). The test items are shown in the figure below.



2. Accuracy specification

The test items of ball splines are shown in Tables 2.5.2 ~ 2.5.5.

Table 2.5.1 Max. swing of spline outer diameter to spline shaft support

Unit: μm

Nominal shaft diameter(mm)		6, 8			10			12, 13, 15, 16, 20			25, 30			40, 50		
		Ordinary	High	Precision	Ordinary	High	Precision	Ordinary	High	Precision	Ordinary	High	Precision	Ordinary	High	Precision
Spline shaft length(mm)	More than															
	Below															
-	200	72	46	26	59	36	20	56	34	18	53	32	18	53	32	16
	200	133	89	57	83	54	32	71	45	25	58	39	21	58	36	19
	315	185	126	82	103	68	41	83	53	31	70	44	25	63	39	21
	400	236	163	108	123	82	51	95	62	38	78	50	29	68	43	24
	500	-	-	-	151	102	65	112	75	46	88	57	34	74	47	27
	630	-	-	-	190	130	85	137	92	58	103	68	42	84	54	32
	800	-	-	-	-	-	-	170	115	75	124	83	52	97	63	38
	1000	-	-	-	-	-	-	-	-	-	151	102	65	114	76	47

Table 2.5.2 Straight angle of spline shaft end to spline shaft support (max. accuracy)

Unit: μm

Accuracy					Common level (N)	Advanced (H)	Precision-level (P)
6	8	10			22	9	6
12	13	15	16	20	27	11	8
	25	40			33	13	9
	40	50			39	16	11

## Ball spline

## Ball spline

Table 2.5.3 Concentricity of parts mounting to spline shaft support (max. accuracy)

Unit:  $\mu\text{m}$ 

Accuracy		Common level (N)	Advanced (H)	Precision-level (P)
Nominal shaft diameter(mm)				
6	8	33	14	8
10		41	17	10
12	13	46	19	12
15	16	53	22	13
20	25	62	25	15

Table 2.5.4 Plane perpendicularity of spline outer cylinder flange mounting facing spline shaft support (max. accuracy)

Unit:  $\mu\text{m}$ 

Accuracy		Common level (N)	Advanced (H)	Precision-level (P)
Nominal shaft diameter(mm)				
6	8	17	11	8
10	12	33	13	9
13	15	30	16	11
16	20	46	19	13

Table 2.5.5 Accuracy class of effective length of spline shaft

Unit:  $\mu\text{m}$ 

Accuracy Precision	Common level(N)	Advanced(H)	Precision-level(P)
Allowable value	33	13	6

Note: Apply to any effective part of 100mm spline shaft

## Lubrication

The filling time of grease varies according to the service conditions. Usually, when used, the grease is filled or replaced based on the running distance of 100km (6 months to 1 year). Apply grease in the outer cylinder of the spline, or grease in the rolling groove of the spindle.

## Material and surface treatment

According to the conditions such as service environment, it is sometimes necessary to carry out anti-rust treatment or change the material used. Please contact AKD for antirust treatment and change of materials used.

## Use Precautions

## Disposal

- Please do not decompose each part, otherwise it may lead to the entry of foreign objects or the loss of function.
- Please be noted that the spline outer cylinder and spline shaft may fall due to their own weight after tilting.
- Please do not let the ball spline fall or knock, otherwise it may cause scratches and damage. In addition, when it is counterbalanced, even if the appearance is not damaged, it may also lead to functional loss.
- Please note to prevent the entry of foreign objects such as garbage and chips. Otherwise, it may cause damage to the ball circulation components and loss of function.
- Please avoid using it under conditions exceeding 80°C. If used under the condition exceeding 80°C, please contact AKD.
- Due to the different types of coolants, sometimes it may bring obstacles to the product functions. Consult AKD for use in an environment where coolant may enter the inside of the splined outer cylinder.
- When the foreign objects such as rubbish and sawing powder are attached, please wash first and then refill the lubricant.
- Please consult in advance when using in special environments such as places where vibration is often required, such as clean room, vacuum, low temperature or high temperature
- If the positioning pin hole is required to be machined on the ball flower with flange, please contact AKD.

## Lubrication

- Please wipe the anti-rust oil carefully and fill lubricant before the use.
- Please avoid mixing lubricants with different properties.
- When used in special environments such as places with frequent vibrations, clean rooms, vacuum, low or high temperatures, it may not be possible to use the usual lubricants. Please contact AKD for details.
- When using special lubricants, please contact AKD in advance.
- When use the oil for lubrication, sometimes it is very likely that the lubrication oil cannot be reached due to the mounting direction. Please contact AKD for details.
- The lubrication interval varies with the service conditions. Please contact AKD for details.

## Storage

When storing the ball spline, place it in the envelope specified by AKD and place it horizontally to avoid high temperature, low temperature and high humidity.

## Set-up

## Inner diameter tolerance of supporting part

The fitting of the splined outer cylinder and the support seat is usually over-fitting. When the precision of ball splines is not required, the clearance fit can be used.

Table 2.9.1

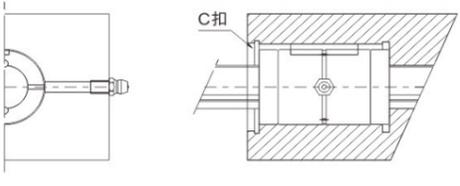
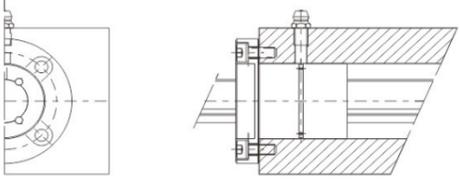
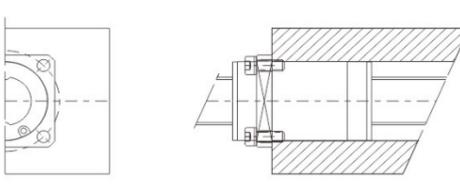
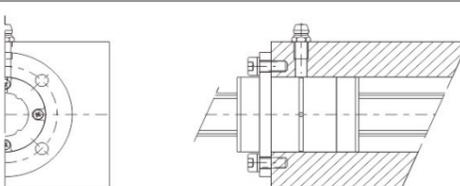
Applicable parts	Inner diameter tolerance of support mount
Normal operating conditions	H7
The area with clearance controlled	J6

Ball spline

Mounting of ball splines

Examples of splined outer cylinder mounting are shown in Table 2.9.2. Although the fixed strength in the direction of the spline shaft is not required to be very high, the phenomenon of knocking it in without fixing it should be avoided.

Table 2.9.2

(C-buckle fixed)	
KLF Integral flange	
KLF Integral flange	
KLF Integral flange	

Fitting of splined outer cylinder

When placing the splined outer cylinder in the axial direction, insert it slowly with a fixture (Fig. 2.9.1). Do not knock on the side plate or gasket.

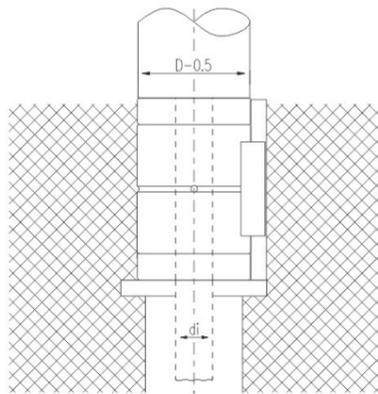


Table 2.9.1

Table 2.9.3 Dimension of cutter for splined outer cylinder

Model	Nominal diameter	6	8	10	13	16	20	25	30	40	50
BO	di	5.0	7.0	8.5	11.5	14.5	18.5	23	28	37.5	46.5
Model	Nominal diameter	-	8	10	12	15	20	25	-	-	-
BO	di	-	7.0	8.5	10.5	11	16	20.5	-	-	-

Unit: mm

Ball spline

Spline shaft

Spline shaft can be divided into precision solid spline shaft, special spline shaft and hollow spline shaft (K and N). The shape of the spline shaft can be manufactured according to your requirements. Thus, when estimating or placing an order, please provide a drawing of the desired spline shaft.

Section shape of spline shaft

Table 1 shows the cross-section shape of the spline shaft. If the spline shaft needs to be cylindrical, do not exceed the minor diameter size ( $\Phi$ d) as much as possible.

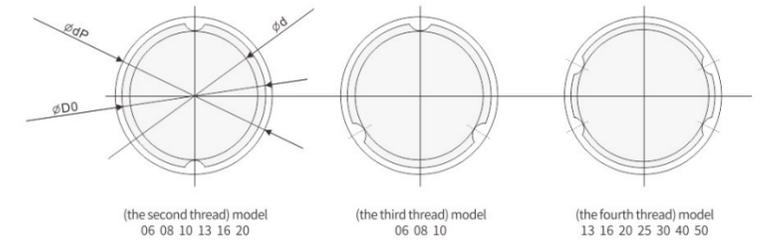


Table 1 Section Shape of Spline Shaft

Unit: mm

Nominal shaft diameter	6	8	10	13	16	20	25	30	40	50
$\phi$ d in minor diameter	5.5	7.5	8.95	11.78	14.68	18.58	23.38	28.48	37.25	46.98
$\phi$ D0 h7 in major diameter	6	8	10	13	16	20	25	30	40	50
Ball center diameter $\phi$ dp	7	9	11.34	14.58	17.48	21.79	27.02	32.08	43.63	54.18
Mass (Kg/m)	0.22	0.39	0.6	1.03	1.56	2.44	3.8	5.49	9.69	15.19

\* The size of  $\phi$ d in the minor diameter is the value at which no groove is left after machining.

Hole shape for standard hollow spline shaft

Table 2 shows the hole shape of standard hollow spline shafts (K and N) of KLT and KLF types.

This table may be used when operations such as piping, wiring, venting or weight reduction are required.

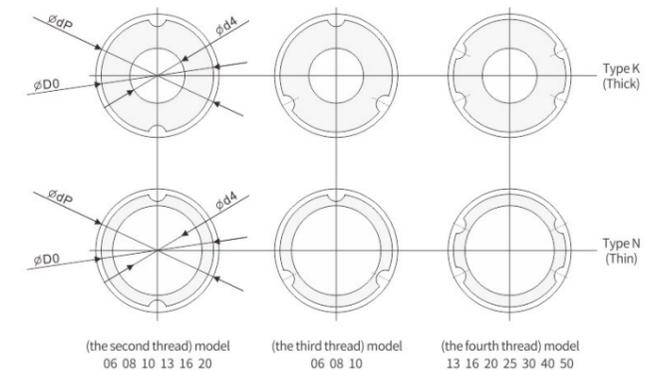


Table 2 Section Shape of Standard Hollow Spline Shaft

Unit: mm

Nominal shaft diameter	6	8	10	13	16	20	25	30	40	50	
$\phi$ D0 h7 in major diameter	6	8	10	13	16	20	25	30	40	50	
Ball center diameter $\phi$ dp	7	9	11.34	14.58	17.48	21.79	27.02	32.08	43.63	54.18	
Type K	Aperture ( $\phi$ d4)	2	3	4	7	8	10	12	16	20	26
	Mass (Kg/m)	0.177	0.33	0.506	0.872	1.25	1.82	2.92	3.93	6.75	11.4
Type N	Aperture ( $\phi$ d4)	/	/	/	/	11	14	18	21	29	36
	Mass (Kg/m)	/	/	/	/	0.83	1.34	1.96	2.88	5.1	7.9

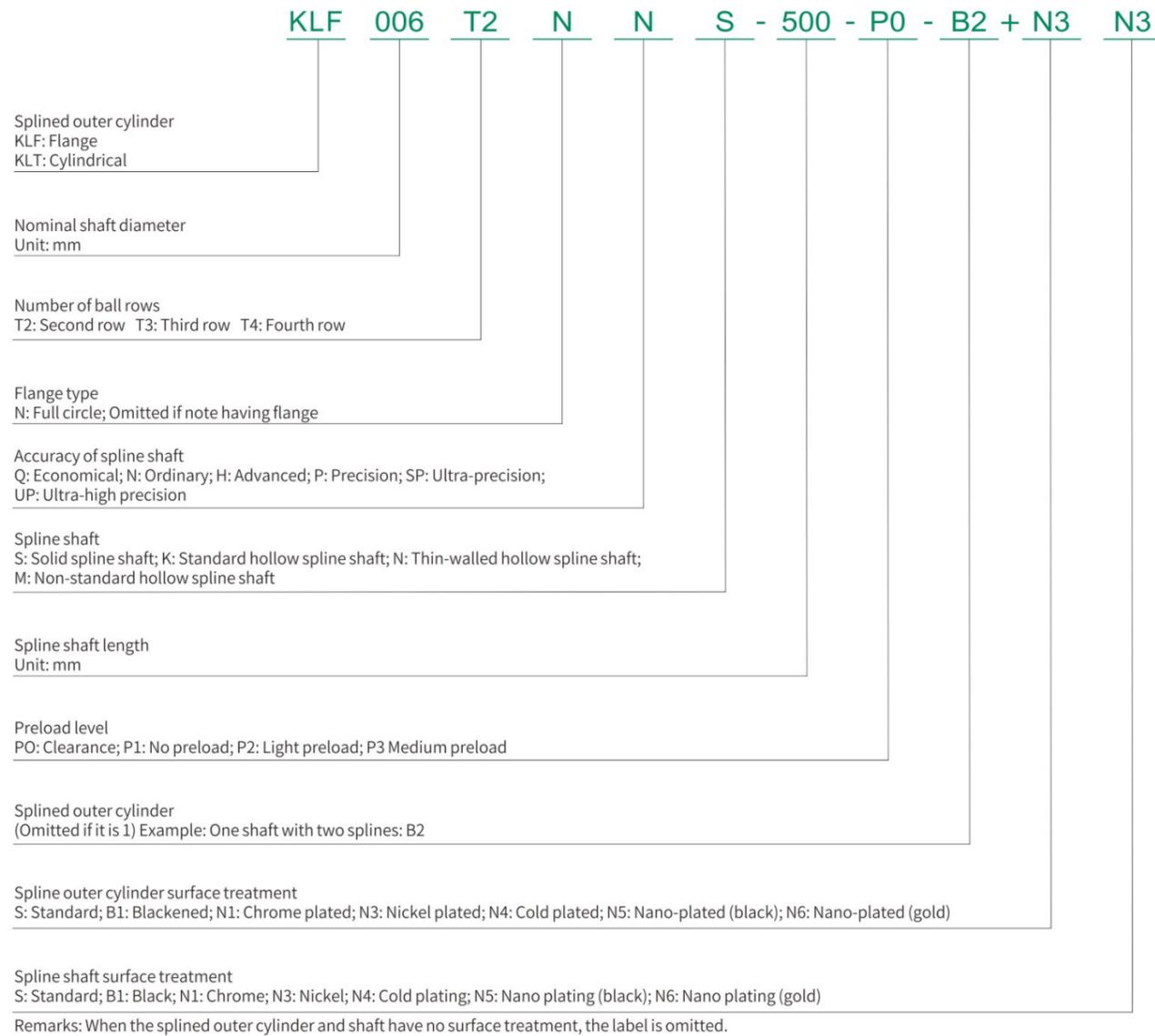
Note) Standard hollow spline shafts can be divided into K and N types. When ordering, please mark "K" or "N" after the model to show the difference.

Ball spline

1. Description of KLF & KLT series product specifications

KLF and KLT series are divided into two types: current matching and single output, both of which have the same specifications. The main difference is that the existing type is cut by the original AKD factory according to customer orders, and the splined outer cylinder is assembled and shipped, and the assembly accuracy can reach the precision level; The single-outlet spline shaft and spline outer cylinder can be shipped separately, which is more convenient to use, but the combination accuracy cannot reach the precision level. However, AKD still has strict quality control in the manufacturing process, so the accuracy of the single-output model is currently at the world-class level and the assembly is easy. Customers can stock up, process and assemble by themselves, which is quite convenient.

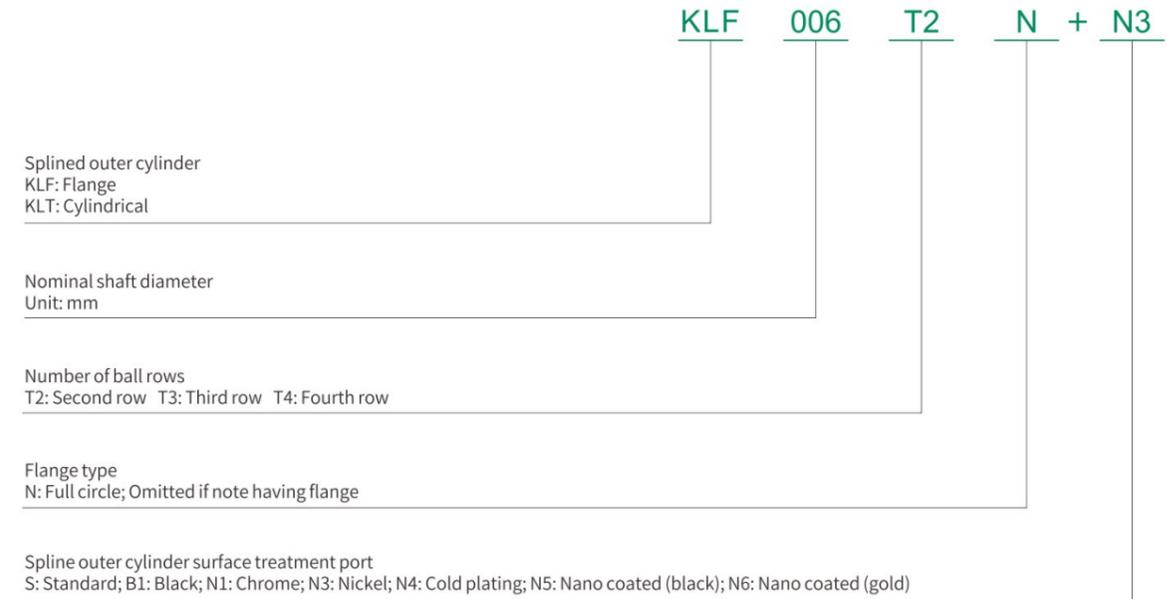
Model of ball spline group for available ball spline group



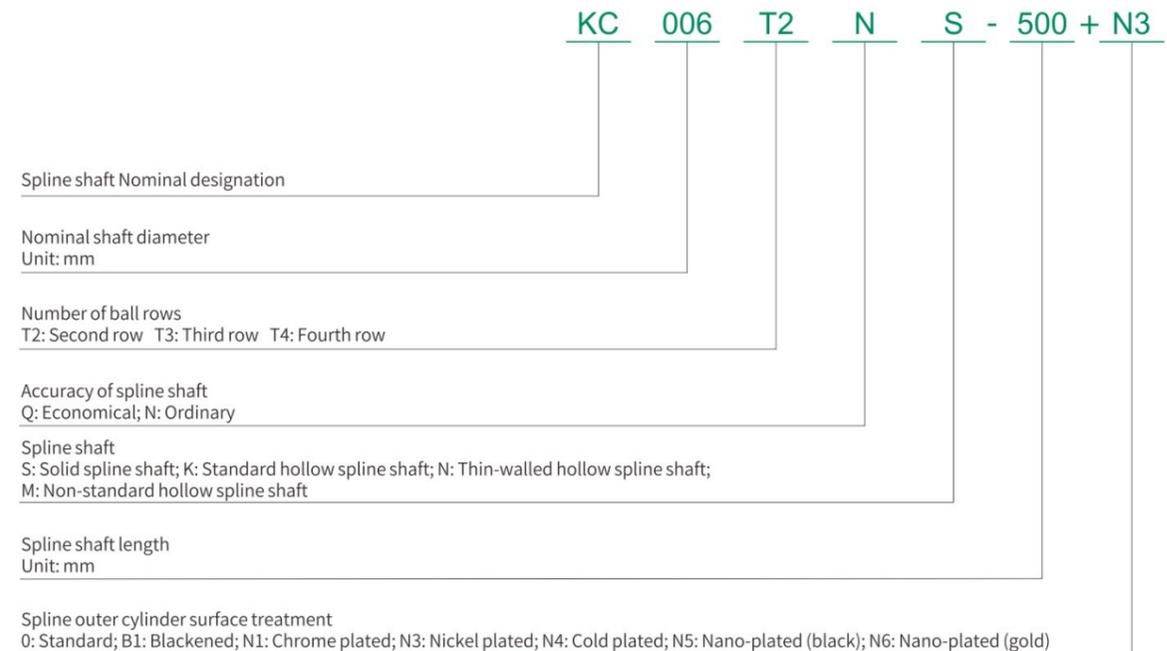
Ball spline

2. Nominal code of KLF & KLT series single-output

Type of single-outlet spline outer cylinder



Model of single-outlet spline shaft



Ball spline

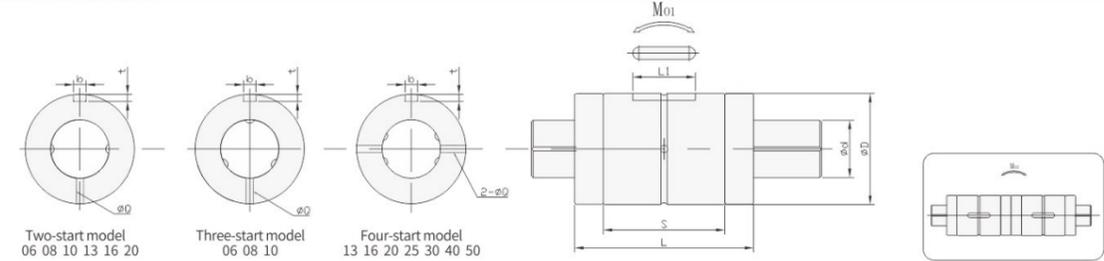
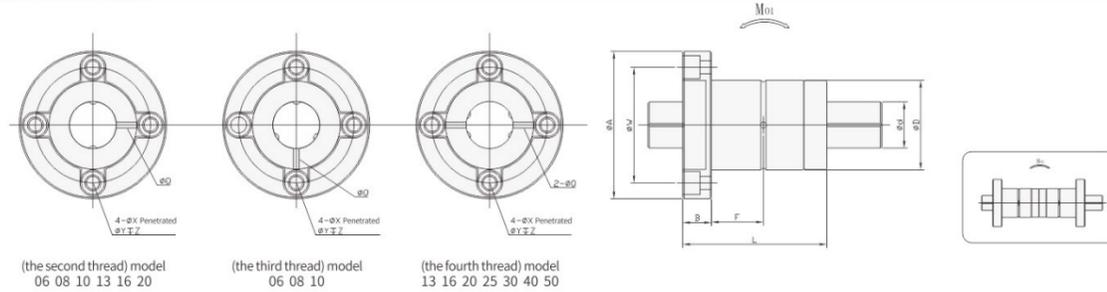
Ball spline

3. Specification and size of KLF series

3. Specification and size of KLF series

KLF round flange

KLT outer cylinder



Nominal model	Shaft diameter		Spline bearing sleeve								Mounting Holes		
	d	h7	Ball series	D	L	A	B	F	Oil hole Q	W	X	Y	Z
	h7										X	Y	Z
KLF006T2	6	h7	2	14	22	30	6	7.5	1	22	3.4	6.5	3.5
KLF006T3			3										
KLF008T2	8	h7	2	16	24	32	8	7.5	1.5	24	3.4	6.5	4.5
KLF008T3			3										
KLF010T2	10	h7	2	21	31	42	9	10.5	1.5	32	4.5	8	4
KLF010T3			3										
KLF013T2	13	h7	2	24	35	44	9	11	1.5	33	4.5	8	4.5
KLF013T4			4										
KLF016T2	16	h7	2	31	47	51	10	18	2	40	4.5	8	6
KLF016T4			4										
KLF020T2	20	h7	2	35	53	58	10	18	2	45	5.5	9.5	5.4
KLF020T4			4										
KLF025T4	25	h7	4	42	70	65	13	26.5	3	52	5.5	9.5	8
KLF030T4	30	h7	4	47	77	75	13	30	3	60	6.6	11	8
KLF040T4	40	h7	4	64	100	100	18	36	4	82	9	14	12
KLF050T4	50	h7	4	80	121	124	20	46.5	4	102	11	17.5	12

Nominal model	Shaft diameter		Spline bearing sleeve					Mounting Holes		
	d	h7	Steel balls	D	L	S	L1	Oil hole	b	t
	h7							Q	H8	+0.05 0
KLT006T2	6	h7	2	14	22	16.4	10.5	1	2.5	1.2
KLT006T3			3							
KLT008T2	8	h7	2	16	24	16	10.5	1.5	2.5	1.2
KLT008T3			3							
KLT010T2	10	h7	2	21	31	20	13	1.5	3	1.5
KLT010T3			3							
KLT013T2	13	h7	2	24	35	24	15	1.5	3	1.5
KLT013T4			4							
KLT016T2	16	h7	2	31	47	36	17.5	2	3.5	2
KLT016T4			4							
KLT020T2	20	h7	2	35	53	41	29	2	4	2.5
KLT020T4			4							
KLT025T4	25	h7	4	42	70	54	36	3	4	2.5
KLT030T4	30	h7	4	47	77	60	42	3	4	2.5
KLT040T4	40	h7	4	64	100	70	52	4	6	3.5
KLT050T4	50	h7	4	80	121	91	58	4	8	4

Nominal model	Base torque rating		Basic rated load		Static permissible moment		Quality	
	C <sub>T</sub>	C <sub>OT</sub>	C	C <sub>0</sub>	M <sub>01</sub>	M <sub>02</sub>	Outer cylinder	Axial
	N · m	N · m	kN	kN	N · m	N · m	g	kg/m
KLF006T2	4.51	7.44	1.34	2.2	3.82	34.1	36.5	0.22
KLF006T3	6.31	10.43	1.34	2.2	5.35	47.74	38	0.2
KLF008T2	5.88	9.7	1.34	2.2	3.82	37.43	47	0.39
KLF008T3	8.23	13.58	1.34	2.2	5.35	52.41	52	0.36
KLF010T2	15.87	22.04	2.79	3.89	9.31	83.59	100	0.6
KLF010T3	22.22	30.86	2.79	3.89	13.03	117.03	110	0.56
KLF013T2	28.32	38.61	3.88	5.29	14.7	122.1	117	1.03
KLF013T4	49.56	54.05	4.26	6.35	25.72	213.68	125	1
KLF016T2	46.75	72.81	5.34	8.32	36.35	255.68	226	1.56
KLF016T4	81.81	127.42	7.04	12.88	63.62	447.44	245	1.5
KLF020T2	77.42	118.48	7.1	10.86	54.19	372.4	303	2.44
KLF020T4	135.48	207.34	10.2	18.7	126.5	651.7	320	2.4
KLF025T4	215.5	421.5	9.82	15.61	101.43	672.18	550	3.8
KLF030T4	296.55	616.71	11.37	19.4	153.66	914.05	725	5.49
KLF040T4	1032.63	1725.29	29.12	39.52	358.58	2414.13	1715	9.69
KLF050T4	1762.92	2982.63	40.04	55.03	505.48	4201.45	3175	15.19

Nominal model	Base torque rating		Basic rated load		Static permissible moment		Quality	
	C <sub>T</sub>	C <sub>OT</sub>	C	C <sub>0</sub>	M <sub>01</sub>	M <sub>02</sub>	Outer cylinder	Axial
	N · m	N · m	kN	kN	N · m	N · m	g	kg/m
KLT006T2	4.51	7.44	1.34	2.2	3.82	34.1	14	0.22
KLT006T3	6.31	10.43	1.34	2.2	5.35	47.74	15.5	0.2
KLT008T2	5.88	9.7	1.34	2.2	3.82	37.43	16	0.39
KLT008T3	8.23	13.58	1.34	2.2	5.35	52.41	20	0.36
KLT010T2	15.87	22.04	2.79	3.89	9.31	83.59	37	0.6
KLT010T3	22.22	30.86	2.79	3.89	13.03	117.03	45	0.56
KLT013T2	28.32	38.61	3.88	5.29	14.7	122.1	52	1.03
KLT013T4	49.56	54.05	4.26	6.35	25.72	213.68	60	1
KLT016T2	46.75	72.81	5.34	8.32	36.35	255.68	130	1.56
KLT016T4	81.81	127.42	7.04	12.88	63.62	447.44	149	1.5
KLT020T2	77.42	118.48	7.1	10.86	54.19	372.4	188	2.44
KLT020T4	135.48	207.34	10.2	18.7	126.5	651.7	210	2.4
KLT025T4	215.5	421.5	9.82	15.61	101.43	672.18	375	3.8
KLT030T4	296.55	616.71	11.37	19.4	153.66	914.05	395	5.49
KLT040T4	1032.63	1725.29	29.12	39.52	358.58	2414.13	843	9.69
KLT050T4	1762.92	2982.63	40.04	55.03	505.48	4201.45	1758	15.19

1kN≈102kgf 1N·m≈0.102kgf·m

1kN≈102kgf 1N·m≈0.102kgf·m

CONTENTS



Rotary Series

Large load capacity, zero clearance in rotation direction, high sensitivity, high rigidity, simple assembly

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### 1-1 Features of AKD Precision Rotary Ball Screw/Spline

AKD rotary ball screw and spline is designed to move linearly and rotationally in one assembly, with symmetrical orientation design between the outer and inner ball screw or spline nut. Both rotary and spiral movement can be achieved simultaneously.

AKD rotary line is the most ideal key component in scara robots, industrial robots, pick & place, laser engraving, transporting and many other multi-directional application.

#### Zero clearance/High rigidity

AKD rotary series featured 40° angular (Back to back) contact angle within the bearing. It enables self-aligning with minor mounting error and bears higher axial load to achieve better accuracy. Custom preload can be applied to reduce clearance and increase high rigidity. (as shown in Fig 1.1.1)

#### High speed/Smooth running performance

The rotary series uses AKD high lead screw to maintain high speed and smoothness during operating.

#### Noise reduction

The precision ground screw thread and spline groove make sure the ball bearing travel fluently during operations which reduce the skidding, friction and noise level and thus improve the service performance and life.

#### Easy-Assembly/Compactness

AKD rotary line features a one-piece compact and easy mounting design.

#### Accuracy

Please refer to chart D05~09 for detail.

#### Spline alternative

AKD offers customized end for ball spline. Hollow spline is also available for special operation requirement such as pipe or wire-arrangement, evacuating and light weight.

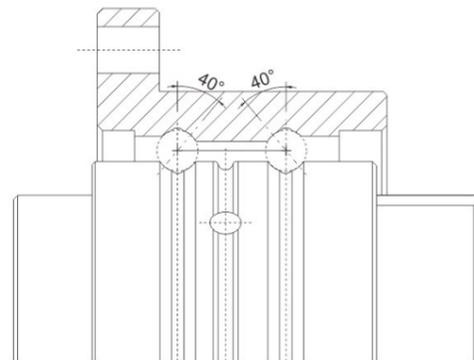


Fig 1.1.1 DB-type (Back to back)

Table 1.1.1 Mass series

Rotary Ball Screw - KFBY Type	Rotary Ball Spline - KLBF Type
Ball Screw/Spline - KBBY Type	Ball Screw/Spline - KBLY Type

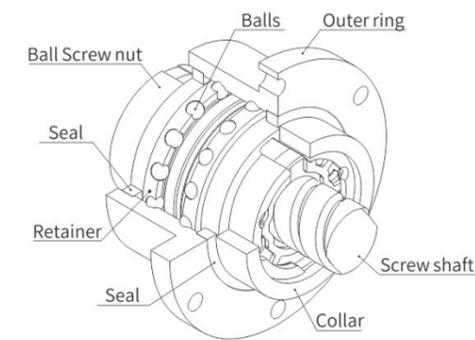


Fig 1.1.2 The Structure of KFBY - series

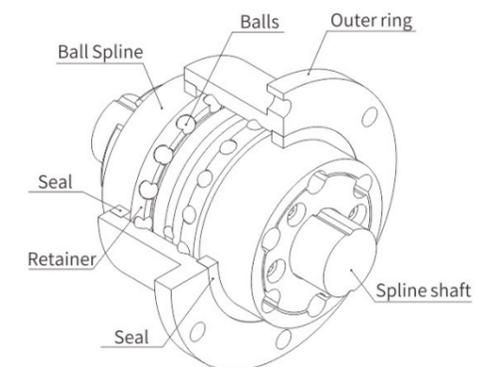
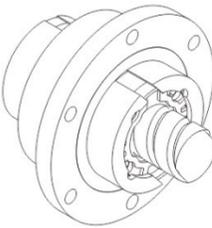
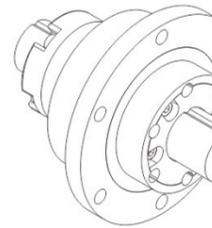
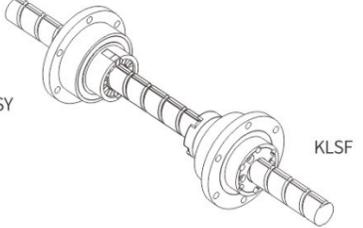
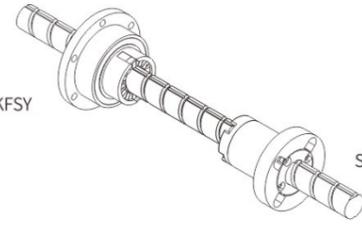


Fig 1.1.3 The Structure of KLBF - series

Precision Ball Screw Spline

Precision Ball Screw Spline

Table 1.1.2 Compact series

<p>Rotary Ball Screw - KFSY Type</p> 	<p>Rotary Ball Spline - KLSF Type</p> 
<p>Ball Screw/Spline - KSSY Type</p> 	<p>Ball Screw/Spline - KSLY Type</p> 

1-2 Accuracy

1-2-1 RBBY, RBLY Accuracy Standards

The Ball Screw/Spline is manufactured as the following specifications.

**【Ball Screw】**

Axial clearance : 0 or less  
 Lead accuracy : C5  
 (Refer to C06 for more details)

**【Ball Spline】**

Clearance in the rotational direction : 0 or less  
 (P1 : light preload)  
 (Refer to B20-21 for more details)  
 Accuracy grade : class H  
 (Refer to B22 for more details)

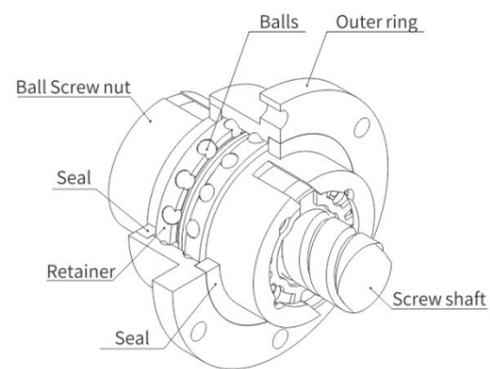
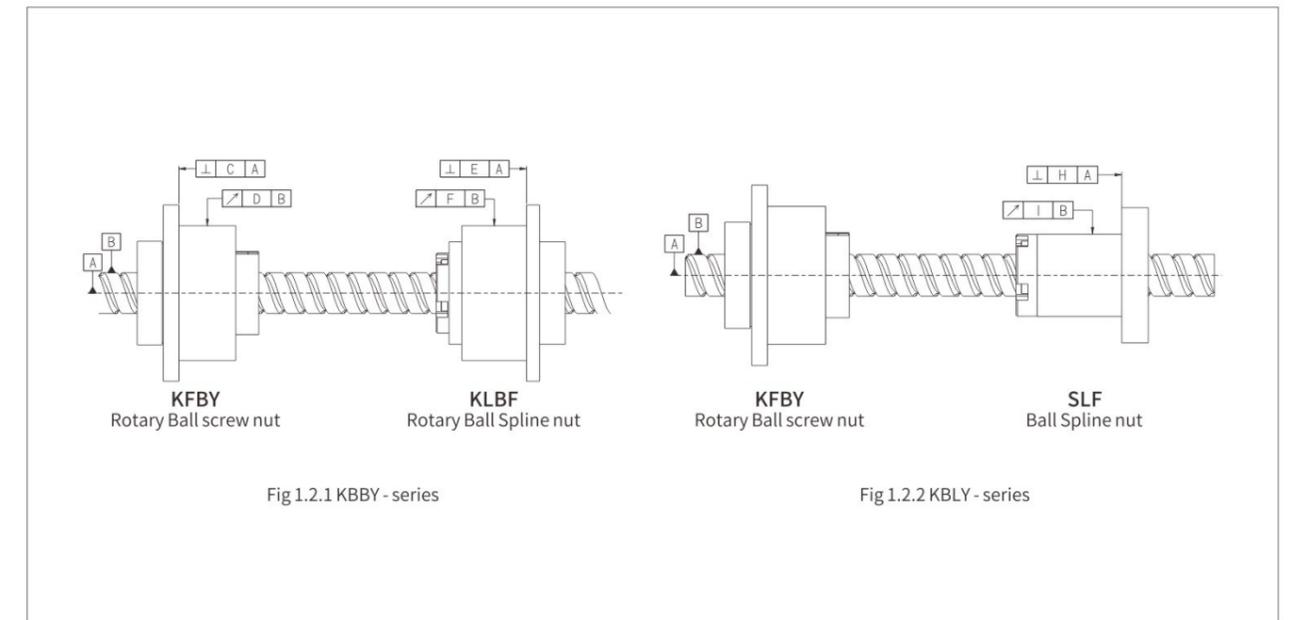


Fig 1.1.4 The Structure of KFSY - series

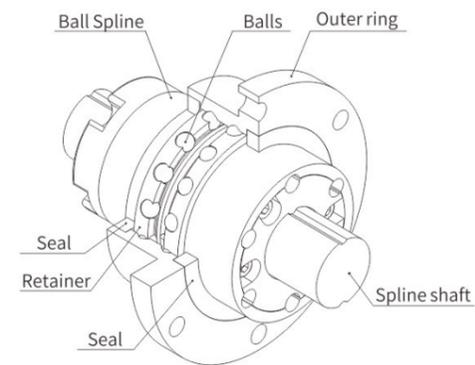


Fig 1.1.5 The Structure of KLSF - series

Model No.	C	D	E	F	H	I
KBBY01616 KBLY01616	0.018	0.021	0.016	0.020	0.013	0.016
KBBY02020 KBLY02020	0.018	0.021	0.016	0.020	0.013	0.016
KBBY02525 KBLY02525	0.021	0.021	0.018	0.024	0.016	0.016
KBBY03232 KBLY03232	0.021	0.021	0.018	0.024	0.016	0.016
KBBY04040 KBLY04040	0.025	0.025	0.021	0.033	0.019	0.019
KBBY05050 KBLY05050	0.025	0.025	0.021	0.033	0.019	0.019

Precision Ball Screw Spline

Precision Ball Screw Spline

1-2-2 KFBY Accuracy Standards

The accuracy of model KFBY is according to JIS standard (JIS B 1192-1997) except for the circular runout of Ball Screw axis(D) and the perpendicularity of the flange-mounting surface against the screw axis (C).

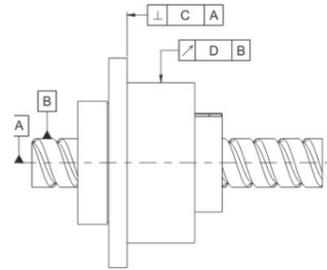


Fig 1.2.3 KFBY - series

Unit : mm

Lead angle accuracy Model No.	Rolled C7		Rolled C10		Ground C7		Ground C5		Ground C3	
	C	D	C	D	C	D	C	D	C	D
KFBY01616	0.035	0.065	0.035	0.065	0.023	0.035	0.016	0.020	0.013	0.017
KFBY02020	0.035	0.065	0.035	0.065	0.023	0.035	0.016	0.020	0.013	0.017
KFBY02525	0.035	0.065	0.035	0.065	0.023	0.035	0.018	0.024	0.015	0.020
KFBY03232	0.035	0.065	0.035	0.065	0.023	0.035	0.018	0.024	0.015	0.020
KFBY04040	0.046	0.086	0.046	0.086	0.026	0.046	0.021	0.033	0.018	0.026
KFBY05050	0.046	0.086	0.046	0.086	0.026	0.046	0.021	0.033	0.018	0.026

1-2-3 KSSY, KSLY Accuracy Standards

The Ball Screw/Spline is manufactured as the following specifications.

**[Ball Screw]**

Axial clearance : 0 or less  
Lead accuracy : C5  
(Refer to C06 for more details)

**[Ball Spline]**

Clearance in the rotational direction : 0 or less  
(P1 : light preload)  
(Refer to B20-21 for more details)  
Accuracy grade : class H  
(Refer to B22 for more details)

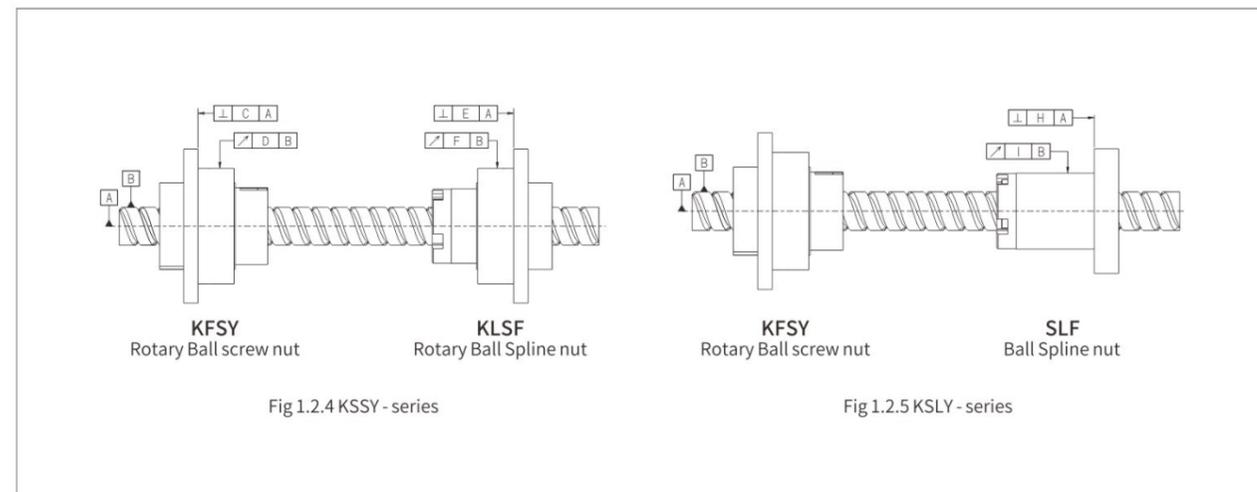


Fig 1.2.4 KSSY - series

Fig 1.2.5 KSLY - series

Model No.	C	D	E	F	H	I
KSSY01616 KSLY01616	0.018	0.021	0.016	0.020	0.013	0.016
KSSY02020 KSLY02020	0.018	0.021	0.016	0.020	0.013	0.016
KSSY02525 KSLY02525	0.021	0.021	0.018	0.024	0.016	0.016
KSSY03232 KSLY03232	0.021	0.021	0.018	0.024	0.016	0.016
KSSY04040 KSLY04040	0.025	0.025	0.021	0.033	0.019	0.019

1-2-4 KFSY Accuracy Standards

The accuracy of model KFSY is according to JIS standard (JIS B 1192-1997) except for the circular runout of Ball Screw axis (D) and the perpendicularity of the flange-mounting surface against the screw axis (C).

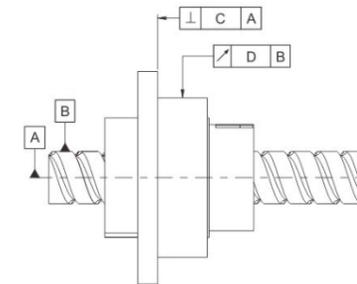


Fig 1.2.3 KFSY - series

Unit : mm

Lead angle accuracy Model No.	Rolled C7		Rolled C10		Ground C7		Ground C5		Ground C3	
	C	D	C	D	C	D	C	D	C	D
KFSY01616	0.035	0.065	0.035	0.065	0.023	0.035	0.016	0.020	0.013	0.017
KFSY02020	0.035	0.065	0.035	0.065	0.023	0.035	0.016	0.020	0.013	0.017
KFSY02525	0.035	0.065	0.035	0.065	0.023	0.035	0.018	0.024	0.015	0.020
KFSY03232	0.035	0.065	0.035	0.065	0.023	0.035	0.018	0.024	0.015	0.020
KFSY04040	0.046	0.086	0.046	0.086	0.026	0.046	0.021	0.033	0.018	0.026

Precision Ball Screw Spline

Precision Ball Screw Spline

1-2-5 KLBF, KLSF Accuracy Standards

Accuracy Grades

The accuracy of the Ball Spline is determined by the nodding action of the spline-nut and classified into three accuracy class : Normal (N), High (H) and Precision (P).

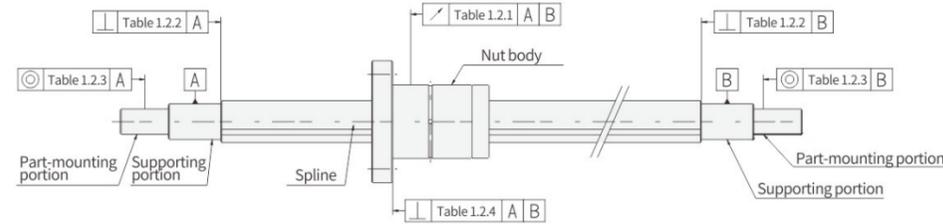


Fig 1.2.7

Accuracy Specification

Tables 1.2.1 ~ 5 indicate the the measurement items of Ball Spline.

Table1.2.1 The Maximum nodding action of Spline Nut on the support unit.

Unit :  $\mu\text{m}$

Length	Nominal Diameter	16, 20			25, 32			40, 50		
		N	H	P	N	H	P	N	H	P
Above	Below									
-	200	56	34	18	53	32	18	53	32	16
200	315	71	45	25	58	39	21	58	36	19
315	400	83	53	31	70	44	25	63	39	21
400	500	95	62	38	78	50	29	68	43	24
500	630	112	-	-	88	57	34	74	47	27
630	800	-	-	-	103	68	42	84	54	32

Table1.2.2 The Maximum perpendicularity of Spline-shaft end on the support unit.

Unit :  $\mu\text{m}$

Nominal Diameter	Accuracy	Normal (N)	High (H)	Precision (P)
		16	20	27
25	32	33	13	9
40	50	39	16	11

Table1.2.3 The concentricity between components assembly part and attach surface.

Unit :  $\mu\text{m}$

Nominal Diameter	Accuracy	Normal (N)	High (H)	Precision (P)
		16	20	46
25	32	53	22	13
40	50	62	25	15

Table1.2.4 The perpendicularity of flange on the attach surface

Unit :  $\mu\text{m}$

Nominal Diameter	Accuracy	Normal (N)	High (H)	Precision (P)		
		16	20	25	32	30
40	50	46	19	13		

Table1.2.5 The accuracy grade on the effective length accuracy

Unit :  $\mu\text{m}$

Accuracy	Normal (N)	High (H)	Precision (P)
Permissible Value	33	13	6

Note : Measurement only applies to any 100mm on the Spline shaft.

1-3 Example of Assembly -KFBY

1-3-1 Example of Mounting Rotary Ball Screw Model KFBY

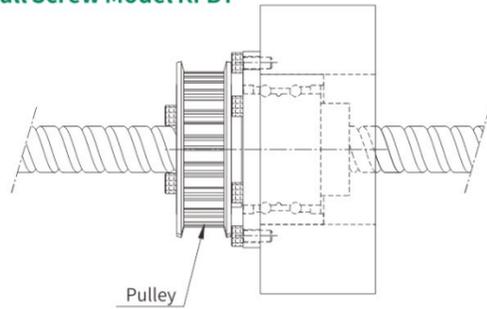


Fig 1.3.1

Example of Mounting Model KFBY

(1) Ball screw nut fixed, screw shaft floated. (Suitable for a long table)

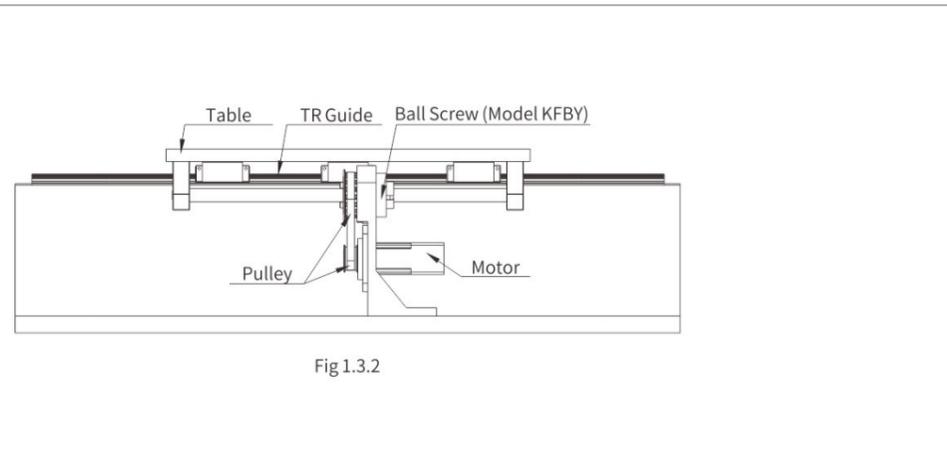


Fig 1.3.2

(2) Ball screw nut floated, screw shaft fixed. (Suitable for a short table and a long stroke)

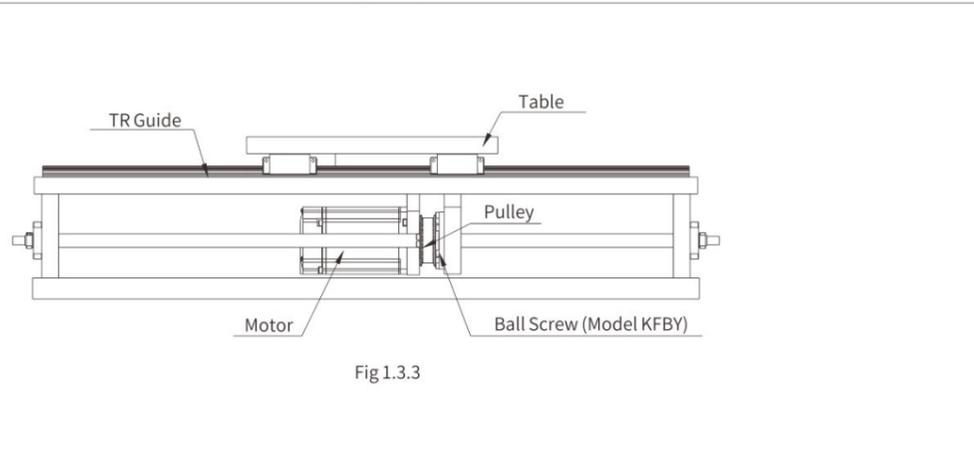


Fig 1.3.3

1-4 Example of Assembly - KBBY

1-4-1 Example of Mounting Precision Ball Screw/Spline Model KBBY

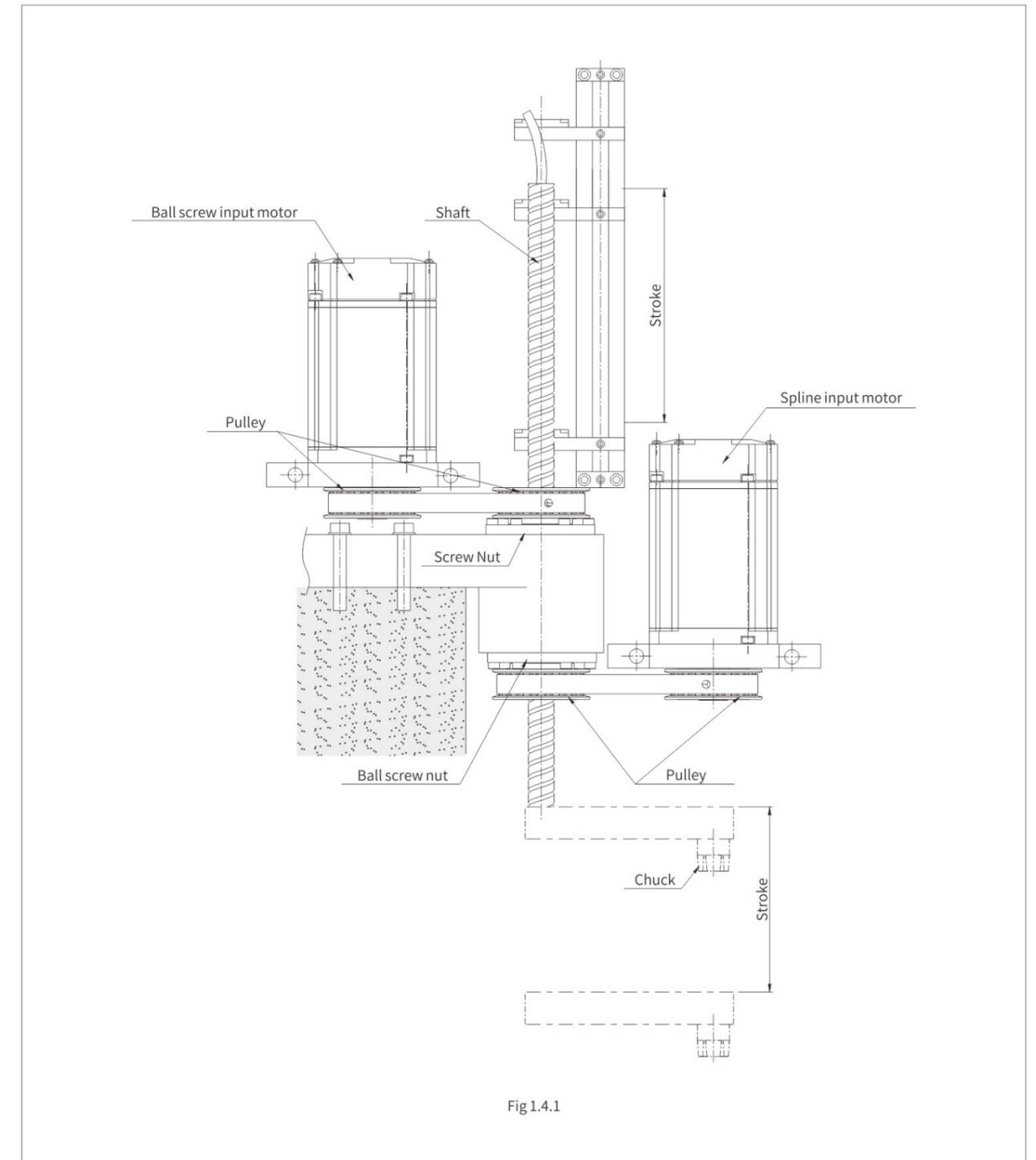


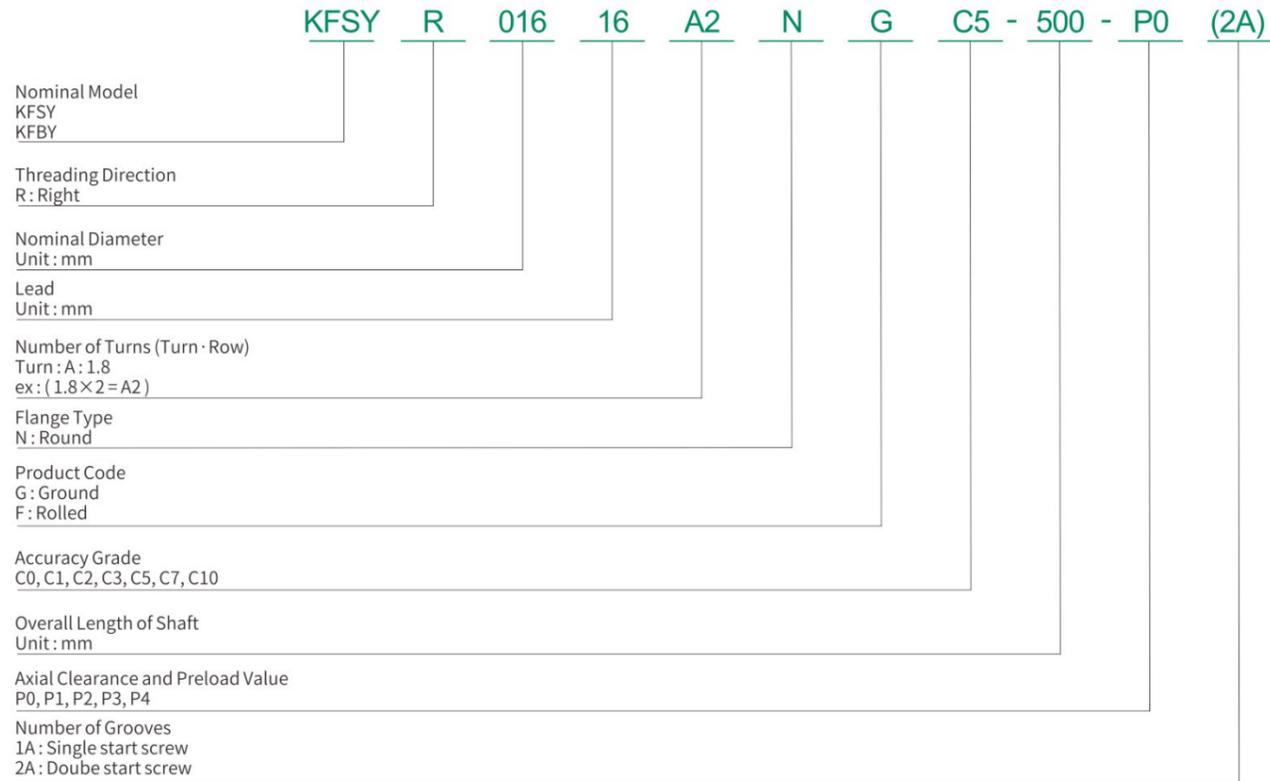
Fig 1.4.1

Precision Ball Screw Spline

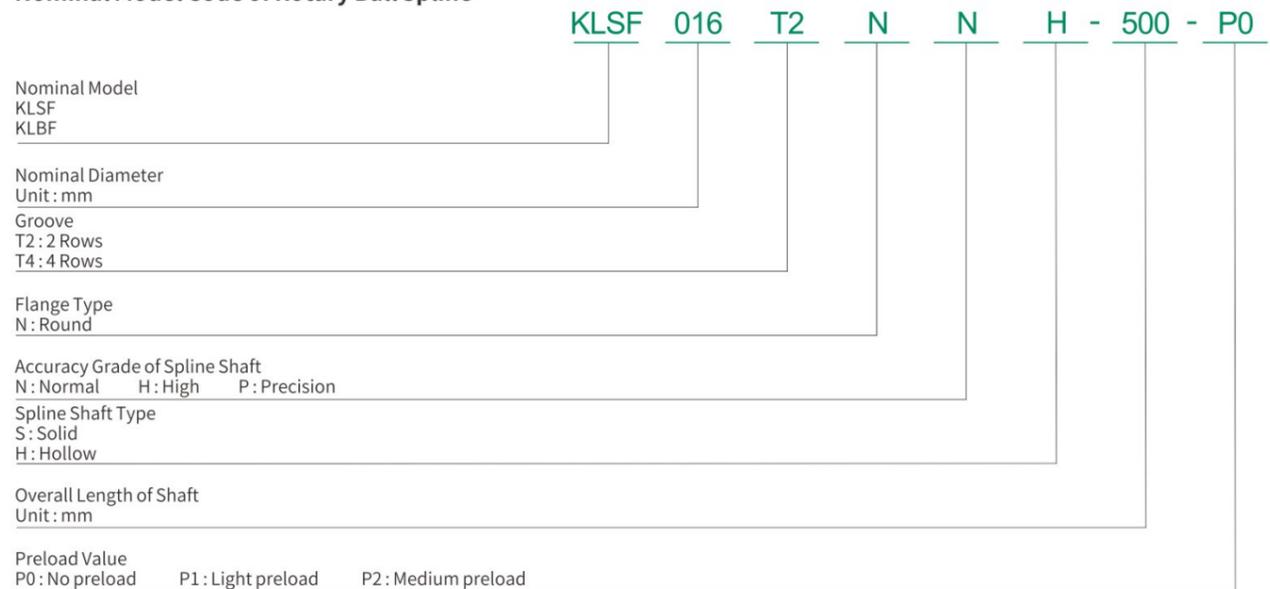
Precision Ball Screw Spline

1-5 Nominal Model Code of Rotary Series

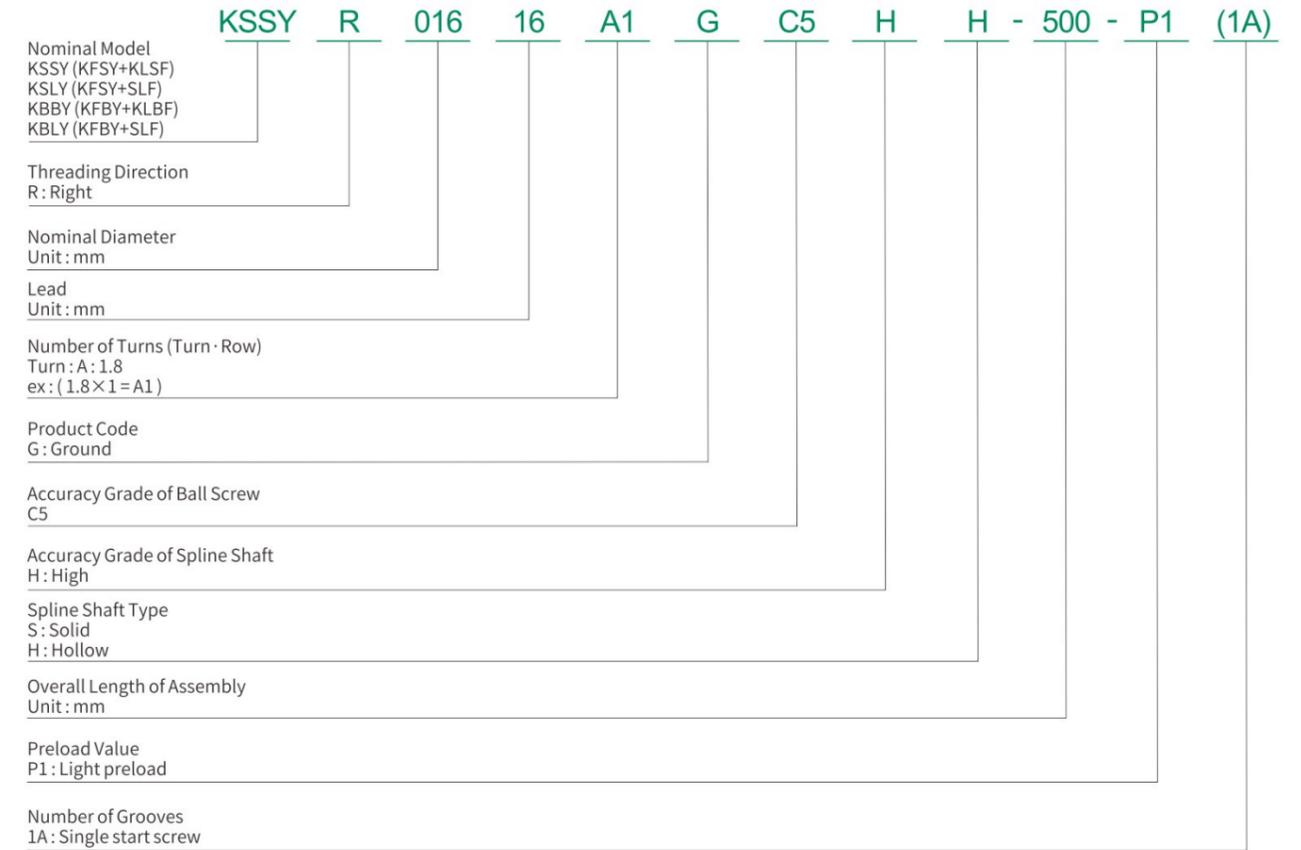
Nominal Model Code of Rotary Ball Screw



Nominal Model Code of Rotary Ball Spline

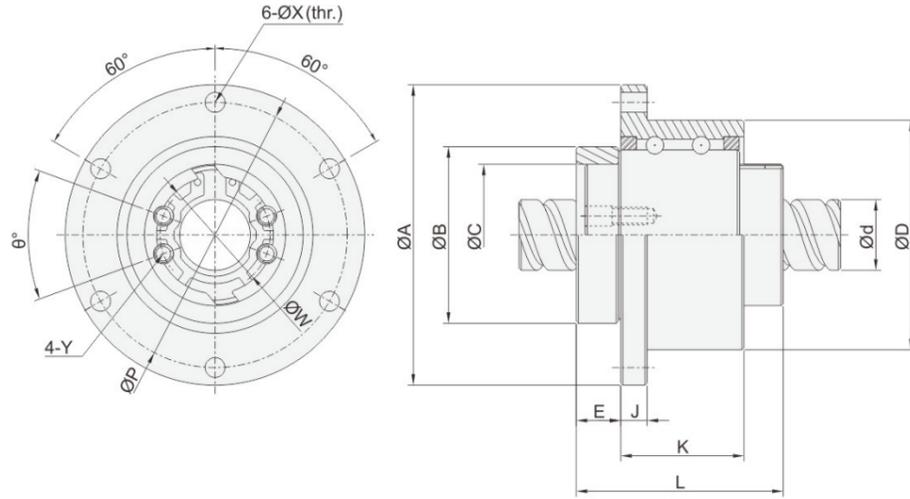


Nominal Model Code of Rotary Ball Screw and Ball Spline



1-5 Nominal Model Code of Rotary Series

KFBY Series Specifications

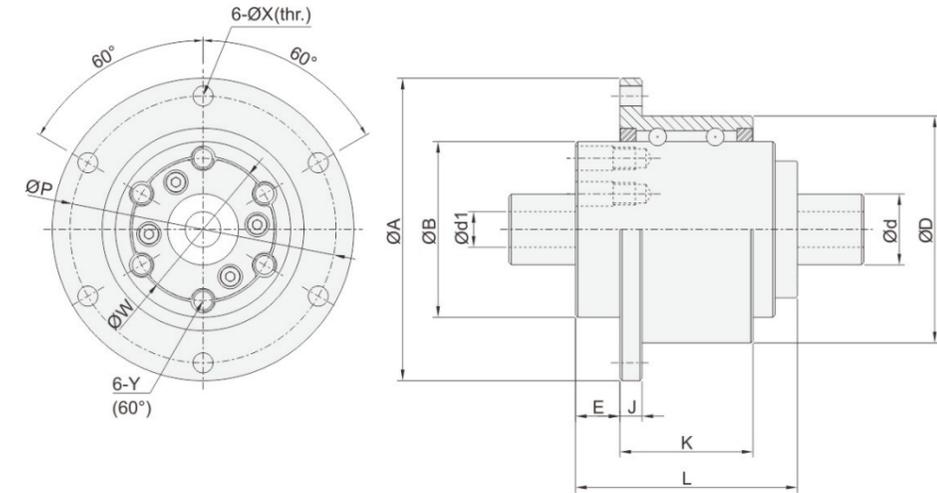


Unit : mm

Model No.	Shaft diameter d	Screw lead l	Beam size Da	Number of Turns	Support Bearing Load Rating		Ball Screw Nut Dimension													Screw Nut Load Rating	
					Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	θ	Ca (kgf)	Coa (kgf)
KFBY01616-1.8	16	16	2.778	1.8x1	750	1593	52 <sup>0</sup> <sub>-0.007</sub>	68	40 <sup>0</sup> <sub>-0.025</sub>	47	32 <sup>+0.025</sup> <sub>0</sub>	101	6	28	60	4.5	25	M4	40	591	1275
KFBY01616-3.6	16	16	2.778	1.8x2	750	1593	52 <sup>0</sup> <sub>-0.007</sub>	68	40 <sup>0</sup> <sub>-0.025</sub>	47	32 <sup>+0.025</sup> <sub>0</sub>	101	6	28	60	4.5	25	M4	40	1073	2551
KFBY02020-1.8	20	20	3.175	1.8x1	1066	2452	62 <sup>0</sup> <sub>-0.007</sub>	78	50 <sup>0</sup> <sub>-0.025</sub>	53.5	39 <sup>+0.025</sup> <sub>0</sub>	111	7	34.5	70	4.5	31	M5	40	764	1758
KFBY02020-3.6	20	20	3.175	1.8x2	1066	2452	62 <sup>0</sup> <sub>-0.007</sub>	78	50 <sup>0</sup> <sub>-0.025</sub>	53.5	39 <sup>+0.025</sup> <sub>0</sub>	111	7	34.5	70	4.5	31	M5	40	1387	3515
KFBY02525-1.8	25	25	3.969	1.8x1	1119	2765	72 <sup>0</sup> <sub>-0.007</sub>	92	58 <sup>0</sup> <sub>-0.03</sub>	65	47 <sup>+0.025</sup> <sub>0</sub>	158	8	35	81	5.5	38	M6	40	1142	2747
KFBY02525-3.6	25	25	3.969	1.8x2	1119	2765	72 <sup>0</sup> <sub>-0.007</sub>	92	58 <sup>0</sup> <sub>-0.03</sub>	65	47 <sup>+0.025</sup> <sub>0</sub>	158	8	35	81	5.5	38	M6	40	2074	5494
KFBY03232-1.8*	32	32	4.762	1.8x1	2087	5586	80 <sup>0</sup> <sub>-0.007</sub>	105	66 <sup>0</sup> <sub>-0.03</sub>	81	58 <sup>+0.03</sup> <sub>0</sub>	215	9	42.5	91	6.6	48	M6	40	1664	4345
KFBY04040-1.8*	40	40	6.35	1.8x1	3183	9306	110 <sup>0</sup> <sub>-0.008</sub>	140	90 <sup>0</sup> <sub>-0.035</sub>	102	73 <sup>+0.03</sup> <sub>0</sub>	165	11	64.5	123	9	61	M8	50	2662	7031
KFBY05050-1.8*	50	50	7.938	1.8x1	4328	12573	120 <sup>0</sup> <sub>-0.008</sub>	156	100 <sup>0</sup> <sub>-0.035</sub>	121	90 <sup>+0.035</sup> <sub>0</sub>	29	12	70	136	11	75	M10	50	3978	10987

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KLBF Series Specifications

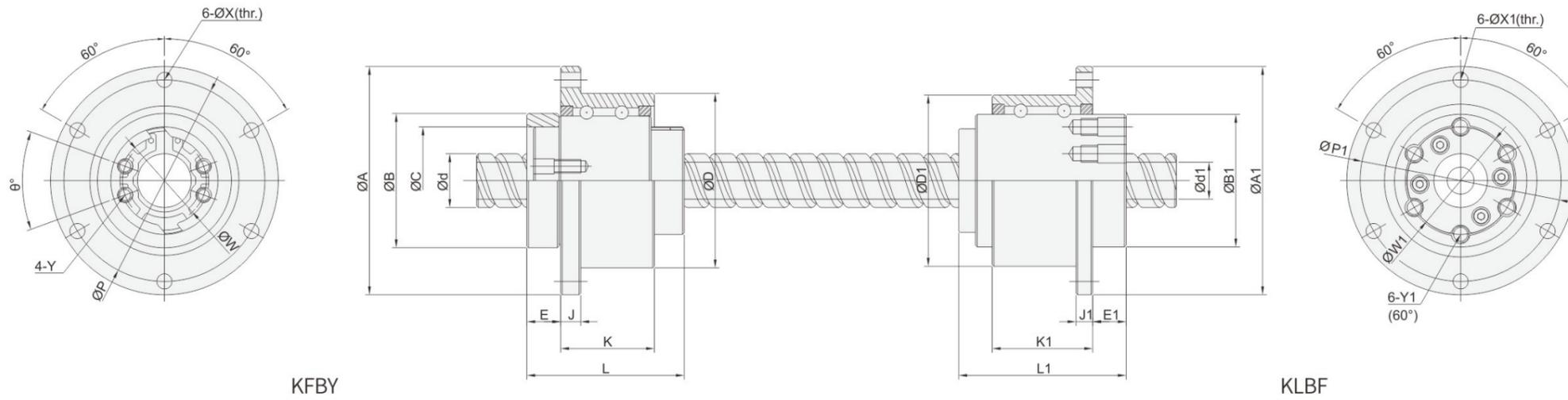


Unit : mm

Model No.	Shaft diameter d	Ball Ø d1	Row	Support Bearing Load Rating		Spline Nut Dimension													Ball Spline Load Rating	
				Ca (kgf)	Coa (kgf)	D	A	B	L	E	J	K	P	X	W	Y	Ca (kgf)	Coa (kgf)		
KLBF016	16	8	2	746	1597	52 <sup>0</sup> <sub>-0.007</sub>	68	39.5 <sup>0</sup> <sub>-0.025</sub>	50	10	5	30	60	4.5	32	M5	545	849		
KLBF020	20	10	2	1011	2138	56 <sup>0</sup> <sub>-0.007</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	63	12	6	42	64	4.5	36	M5	736	1124		
KLBF025	25	15	4	1558	4616	62 <sup>0</sup> <sub>-0.007</sub>	78	53 <sup>0</sup> <sub>-0.03</sub>	71	13	6	49	70	4.5	45	M6	1003	1593		
KLBF032	32	16	4	2087	5586	80 <sup>0</sup> <sub>-0.007</sub>	105	65.5 <sup>0</sup> <sub>-0.03</sub>	80	17	9	54	91	6.6	55	M6	1324	2251		
KLBF040	40	20	4	3141	8705	100 <sup>0</sup> <sub>-0.008</sub>	130	79.5 <sup>0</sup> <sub>-0.03</sub>	100	23	11	63	113	9	68	M6	2972	4033		
KLBF050	50	26	4	4317	12585	120 <sup>0</sup> <sub>-0.008</sub>	156	99.5 <sup>0</sup> <sub>-0.035</sub>	125	25	12	87	136	11	85	M10	4086	5615		

1-5 Nominal Model Code of Rotary Series

KBBY Series Specifications



Unit : mm

Model No.	Shaft diameter d	Screw lead l	Beam size Da	Number of Turns	Support Bearing Load Rating		Ball Screw Nut Dimension														Screw Nut Load Rating	
					Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	θ	Ca (kgf)	Coa (kgf)	
KBBY01616-1.8	16	16	2.778	1.8x1	750	1593	52 <sup>0</sup> <sub>-0.007</sub>	68	40 <sup>0</sup> <sub>-0.025</sub>	47	32 <sup>+0.025</sup> <sub>0</sub>	10.1	6	28	60	4.5	25	M4	40	591	1275	
KBBY02020-1.8	20	20	3.175	1.8x1	1066	2452	62 <sup>0</sup> <sub>-0.007</sub>	78	50 <sup>0</sup> <sub>-0.025</sub>	53.5	39 <sup>+0.025</sup> <sub>0</sub>	11	7	34.5	70	4.5	31	M5	40	764	1758	
KBBY02525-1.8	25	25	3.969	1.8x1	1119	2765	72 <sup>0</sup> <sub>-0.007</sub>	92	58 <sup>0</sup> <sub>-0.03</sub>	65	47 <sup>+0.025</sup> <sub>0</sub>	15.8	8	35	81	5.5	38	M6	40	1142	2747	
KBBY03232-1.8*	32	32	4.762	1.8x1	2087	5586	80 <sup>0</sup> <sub>-0.007</sub>	105	66 <sup>0</sup> <sub>-0.03</sub>	81	58 <sup>+0.03</sup> <sub>0</sub>	21.5	9	42.5	91	6.6	48	M6	40	1664	4345	
KBBY04040-1.8*	40	40	6.35	1.8x1	3183	9306	110 <sup>0</sup> <sub>-0.008</sub>	140	90 <sup>0</sup> <sub>-0.035</sub>	102	73 <sup>+0.03</sup> <sub>0</sub>	16.5	11	64.5	123	9	61	M8	50	2662	7031	
KBBY05050-1.8*	50	50	7.938	1.8x1	4328	12573	120 <sup>0</sup> <sub>-0.008</sub>	156	100 <sup>0</sup> <sub>-0.035</sub>	121	90 <sup>+0.035</sup> <sub>0</sub>	29	12	70	136	11	75	M10	50	3978	10987	

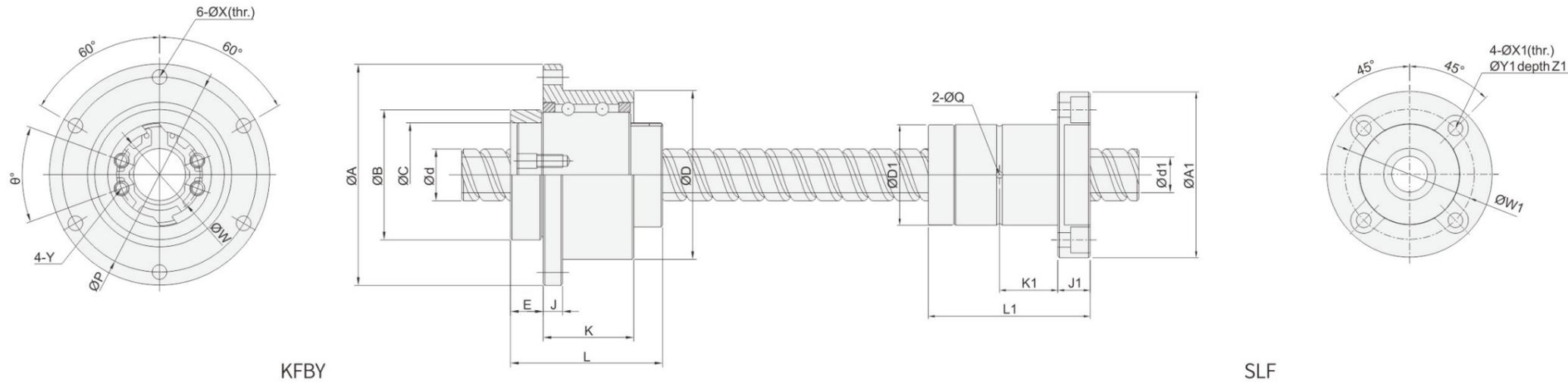
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Unit : mm

Model No.	Shaft diameter d	Ball Ø d1	Row	Support Bearing Load Rating		Spline Nut Dimension														Screw Nut Load Rating	
				Ca (kgf)	Coa (kgf)	D1	A1	B1	L1	E1	J1	K1	P1	X1	W1	Y1	Ca (kgf)	Coa (kgf)			
KBBY01616	16	11	2	746	1597	52 <sup>0</sup> <sub>-0.007</sub>	68	39.5 <sup>0</sup> <sub>-0.025</sub>	50	10	5	30	60	4.5	32	M5	545	849			
KBBY02020	20	14	2	1011	2138	56 <sup>0</sup> <sub>-0.007</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	63	12	6	42	64	4.5	36	M5	736	1124			
KBBY02525	25	18	4	1558	4616	62 <sup>0</sup> <sub>-0.007</sub>	78	53 <sup>0</sup> <sub>-0.03</sub>	71	13	6	49	70	4.5	45	M6	1003	1593			
KBBY03232	32	23	4	2087	5586	80 <sup>0</sup> <sub>-0.007</sub>	105	65.5 <sup>0</sup> <sub>-0.03</sub>	80	17	9	54	91	6.6	55	M6	1324	2251			
KBBY04040	40	29	4	3141	8705	100 <sup>0</sup> <sub>-0.008</sub>	130	79.5 <sup>0</sup> <sub>-0.03</sub>	100	23	11	63	113	9	68	M6	2972	4033			
KBBY05050	50	36	4	4317	12585	120 <sup>0</sup> <sub>-0.008</sub>	156	99.5 <sup>0</sup> <sub>-0.035</sub>	125	25	12	87	136	11	85	M10	4086	5615			

1-5 Nominal Model Code of Rotary Series

KBLY Series Specifications



Unit : mm

Model No.	Shaft diameter d	Screw lead l	Beam size Da	Number of Turns	Support Bearing Load Rating		Ball Screw Nut Dimension														Screw Nut Load Rating	
					Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	θ	Ca (kgf)	Coa (kgf)	
KBLY01616-1.8	16	16	2.778	1.8x1	750	1593	52 <sup>0</sup> <sub>-0.007</sub>	68	40 <sup>0</sup> <sub>-0.025</sub>	47	32 <sup>+0.025</sup> <sub>0</sub>	10.1	6	28	60	4.5	25	M4	40	591	1275	
KBLY02020-1.8	20	20	3.175	1.8x1	1066	2452	62 <sup>0</sup> <sub>-0.007</sub>	78	50 <sup>0</sup> <sub>-0.025</sub>	53.5	39 <sup>+0.025</sup> <sub>0</sub>	11	7	34.5	70	4.5	31	M5	40	764	1758	
KBLY02525-1.8	25	25	3.969	1.8x1	1119	2765	72 <sup>0</sup> <sub>-0.007</sub>	92	58 <sup>0</sup> <sub>-0.03</sub>	65	47 <sup>+0.025</sup> <sub>0</sub>	15.8	8	35	81	5.5	38	M6	40	1142	2747	
KBLY03232-1.8*	32	32	4.762	1.8x1	2087	5586	80 <sup>0</sup> <sub>-0.007</sub>	105	66 <sup>0</sup> <sub>-0.03</sub>	81	58 <sup>+0.03</sup> <sub>0</sub>	21.5	9	42.5	91	6.6	48	M6	40	1664	4345	
KBLY04040-1.8*	40	40	6.35	1.8x1	3183	9306	110 <sup>0</sup> <sub>-0.008</sub>	140	90 <sup>0</sup> <sub>-0.035</sub>	102	73 <sup>+0.03</sup> <sub>0</sub>	16.5	11	64.5	123	9	61	M8	50	2662	7031	
KBLY05050-1.8*	50	50	7.938	1.8x1	4328	12573	120 <sup>0</sup> <sub>-0.008</sub>	156	100 <sup>0</sup> <sub>-0.035</sub>	121	90 <sup>+0.035</sup> <sub>0</sub>	29	12	70	136	11	75	M10	50	3978	10987	

※Items labeled with \* are customized products. For these product orders, please contact AKD in advance.

Unit : mm

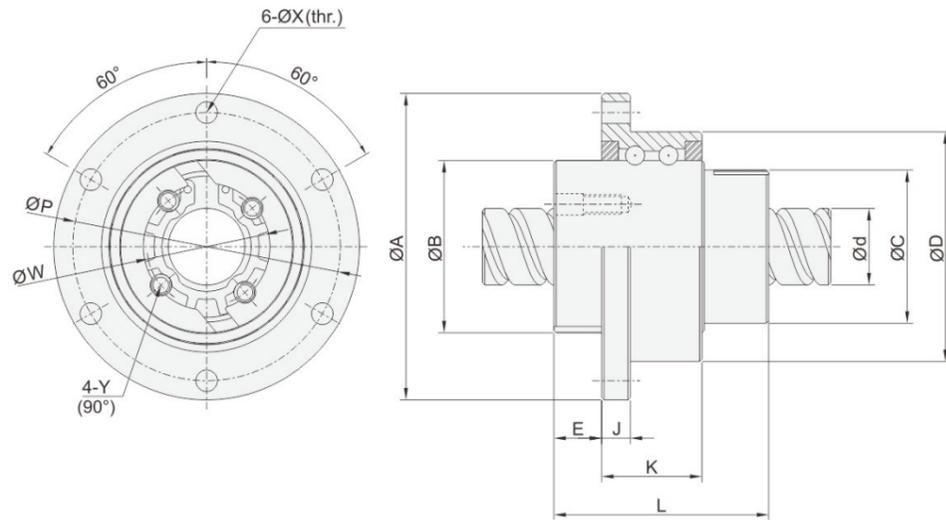
Model No.	Shaft diameter d	Ball Ø d1	Row	Spline Nut Dimension											Screw Nut Load Rating	
				D1	A1	L1	J1	K1	W1	X1	Y1	Z1	Q	Ca (kgf)	Coa (kgf)	
KBLY01616	16	11	2	31 <sup>0</sup> <sub>-0.016</sub>	51	50	10	18	40	4.5	8	6	2	545	849	
KBLY02020	20	14	2	35 <sup>0</sup> <sub>-0.016</sub>	58	56	10	18	45	5.5	9.5	5.4	2	724	1109	
KBLY02525	25	18	4	42 <sup>0</sup> <sub>-0.016</sub>	65	71	13	26.5	52	5.5	9.5	8	3	1003	1593	
KBLY03232	32	23	4	49 <sup>0</sup> <sub>-0.016</sub>	77	80	13	30	62	6.6	11	6.5	3	1324	2251	
KBLY04040	40	29	4	64 <sup>0</sup> <sub>-0.019</sub>	100	100	18	36	82	9	14	12	4	2972	4033	
KBLY05050	50	36	4	80 <sup>0</sup> <sub>-0.019</sub>	124	125	20	46.5	102	11	17.5	12	4	4086	5615	

Precision Ball Screw Spline

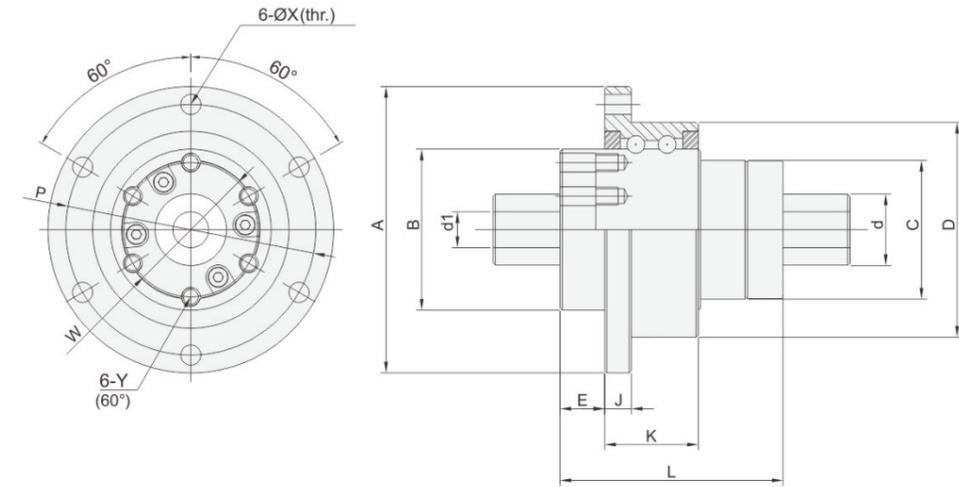
Precision Ball Screw Spline

1-5 Nominal Model Code of Rotary Series

KFSY Series Specifications



KLSF Series Specifications



Unit : mm

Model No.	Shaft diameter d	Screw lead l	Beam size Da	Number of Turns	Support Bearing Load Rating		Ball Screw Nut Dimension											Screw Nut Load Rating		
					Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	Ca (kgf)	Coa (kgf)
KFSY01616-1.8	16	16	2.778	1.8x1	730	1484	48 <sup>-0.009</sup> <sub>-0.025</sub>	64	36 <sup>0</sup> <sub>-0.025</sub>	45	32	10	6	21	56	4.5	25	M4	591	1275
KFSY01616-3.6	16	16	2.778	1.8x2	730	1484	48 <sup>-0.009</sup> <sub>-0.025</sub>	64	36 <sup>0</sup> <sub>-0.025</sub>	45	32	10	6	21	56	4.5	25	M4	1073	2551
KFSY02020-1.8	20	20	3.175	1.8x1	788	1811	56 <sup>0.001</sup> <sub>-0.029</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	52	39	11	6	21	64	4.5	31	M5	764	1758
KFSY02020-3.6	20	20	3.175	1.8x2	788	1811	56 <sup>0.001</sup> <sub>-0.029</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	52	39	11	6	21	64	4.5	31	M5	1387	3515
KFSY02525-1.8	25	25	3.969	1.8x1	1094	2607	66 <sup>0.001</sup> <sub>-0.029</sub>	86	52 <sup>0</sup> <sub>-0.03</sub>	64	47	13	7	25	75	5.5	38	M6	1142	2747
KFSY02525-3.6	25	25	3.969	1.8x2	1094	2607	66 <sup>0.001</sup> <sub>-0.029</sub>	86	52 <sup>0</sup> <sub>-0.03</sub>	64	47	13	7	25	75	5.5	38	M6	2074	5494
KFSY03232-1.8*	32	32	4.762	1.8x1	1191	3233	78 <sup>0.001</sup> <sub>-0.029</sub>	103	63 <sup>0</sup> <sub>-0.03</sub>	78	58	14	8	25	89	6.6	48	M6	1664	4345
KFSY04040-1.8*	40	40	6.35	1.8x1	2216	6685	100 <sup>0.012</sup> <sub>-0.034</sub>	130	79.5 <sup>0</sup> <sub>-0.035</sub>	99	73	16.5	10	33	113	9	61	M8	2662	7031

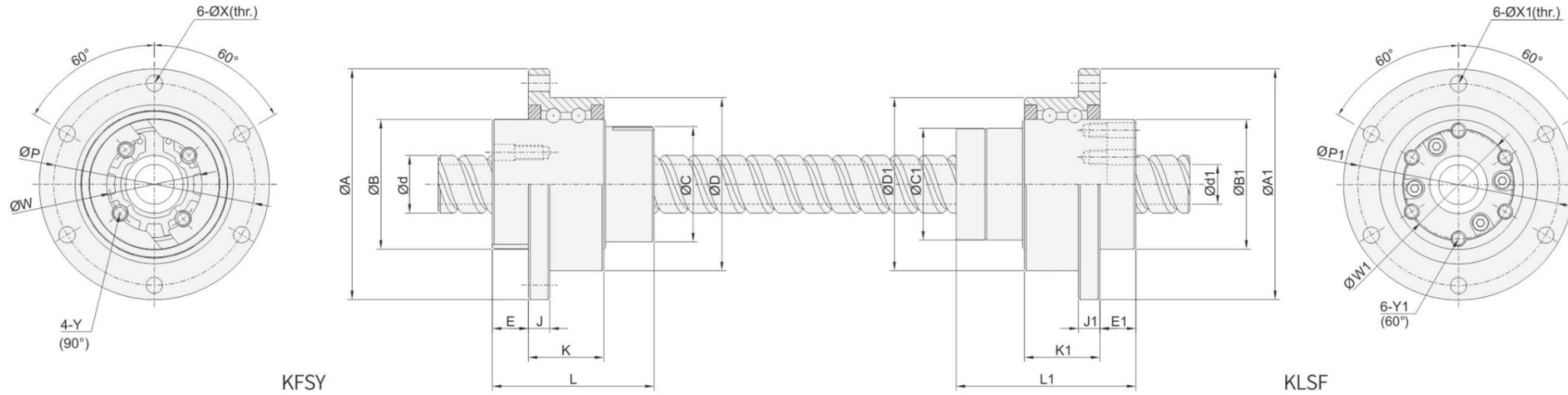
※ Items labeled with \* are customized products. For these product orders, please contact AKD in advance.

Unit : mm

Model No.	Shaft diameter d	Ball Ø d1	Row	Support Bearing Load Rating		Spline Nut Dimension											Screw Nut Load Rating		
				Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	Ca (kgf)	Coa (kgf)
KLSF016	16	8	2	730	1484	48 <sup>-0.009</sup> <sub>-0.025</sub>	64	36 <sup>0</sup> <sub>-0.025</sub>	50	31	10	6	21	56	4.5	30	M4	545	849
KLSF020	20	10	2	788	1811	56 <sup>-0.001</sup> <sub>-0.029</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	63	35	12	6	21	64	4.5	36	M5	736	1124
KLSF025	25	15	4	1094	2607	66 <sup>-0.001</sup> <sub>-0.029</sub>	86	52 <sup>0</sup> <sub>-0.03</sub>	71	42	13	7	25	75	5.5	44	M5	1003	1593
KLSF032	32	16	4	1191	3233	78 <sup>-0.001</sup> <sub>-0.029</sub>	63	62 <sup>0</sup> <sub>-0.03</sub>	80	52	17	8	25	89	6.6	54	M6	1324	2251
KLSF040	40	20	4	2216	6685	100 <sup>-0.012</sup> <sub>-0.034</sub>	130	79.5 <sup>0</sup> <sub>-0.035</sub>	100	64	20	10	33	113	9	68	M6	2972	4033

1-5 Nominal Model Code of Rotary Series

KSSY series specifications



Unit : mm

Model No.	Shaft diameter d	Screw lead l	Beam size Da	Number of Turns	Support Bearing Load Rating		Ball Screw Nut Dimension											Screw Nut Load Rating		
					Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	Ca (kgf)	Coa (kgf)
KSSY01616-1.8	16	16	2.778	1.8x1	730	1484	48 <sup>-0.009</sup> <sub>-0.025</sub>	64	36 <sup>0</sup> <sub>-0.025</sub>	45	32	10	6	21	56	4.5	25	M4	591	1275
KSSY02020-1.8	20	20	3.175	1.8x1	788	1811	56 <sup>-0.01</sup> <sub>-0.029</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	52	39	11	6	21	64	4.5	31	M5	764	1758
KSSY02525-1.8	25	25	3.969	1.8x1	1094	2607	66 <sup>-0.01</sup> <sub>-0.029</sub>	86	52 <sup>0</sup> <sub>-0.03</sub>	64	47	13	7	25	75	5.5	38	M6	1142	2747
KSSY03232-1.8*	32	32	4.762	1.8x1	1191	3233	78 <sup>-0.01</sup> <sub>-0.029</sub>	103	63 <sup>0</sup> <sub>-0.03</sub>	78	58	14	8	25	89	6.6	48	M6	1664	4345
KSSY04040-1.8*	40	40	6.35	1.8x1	2216	6685	110 <sup>-0.012</sup> <sub>-0.034</sub>	130	79.5 <sup>0</sup> <sub>-0.035</sub>	99	73	16.5	10	33	113	9	61	M8	2662	7031

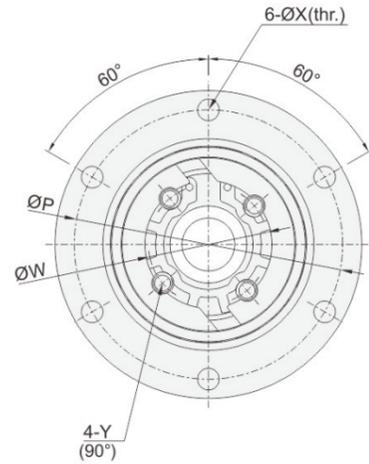
※Items labeled with \* are customized products. For these product orders, please contact AKD in advance.

Unit : mm

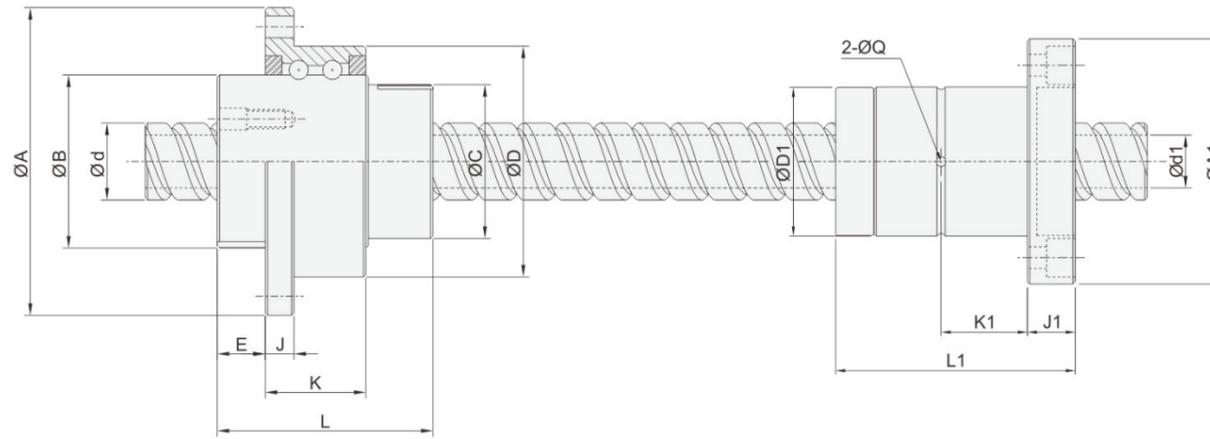
Model No.	Shaft diameter d	Ball Ø d1	Row	Support Bearing Load Rating		Spline Nut Dimension											Screw Nut Load Rating		
				Ca (kgf)	Coa (kgf)	D1	A1	B1	L1	C1	E1	J1	K1	P1	X1	W1	Y1	Ca (kgf)	Coa (kgf)
KSSY01616	16	11	2	730	1484	48 <sup>-0.009</sup> <sub>-0.025</sub>	64	36 <sup>0</sup> <sub>-0.025</sub>	50	31	10	6	21	56	4.5	30	M4	545	849
KSSY02020	20	14	2	788	1811	56 <sup>-0.01</sup> <sub>-0.029</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	63	35	12	6	21	64	4.5	36	M5	736	1124
KSSY02525	25	18	4	1094	2607	66 <sup>-0.01</sup> <sub>-0.029</sub>	86	52 <sup>0</sup> <sub>-0.03</sub>	71	42	13	7	25	75	5.5	44	M5	1003	1593
KSSY03232	32	23	4	1191	3233	78 <sup>-0.01</sup> <sub>-0.029</sub>	103	63 <sup>0</sup> <sub>-0.03</sub>	80	52	17	8	25	89	6.6	54	M6	1324	2251
KSSY04040	40	29	4	2216	6685	100 <sup>-0.012</sup> <sub>-0.034</sub>	130	79.5 <sup>0</sup> <sub>-0.035</sub>	100	64	20	10	33	113	9	68	M6	2972	4033

1-5 Nominal Model Code of Rotary Series

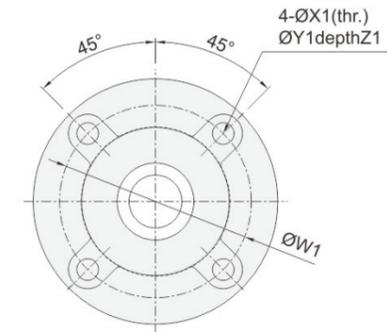
KSLY Series Specifications



KFSY



SLF



Unit : mm

Model No.	Shaft diameter d	Screw lead l	Beam size Da	Number of Turns	Support Bearing Load Rating		Ball Screw Nut Dimension											Screw Nut Load Rating		
					Ca (kgf)	Coa (kgf)	D	A	B	L	C	E	J	K	P	X	W	Y	Ca (kgf)	Coa (kgf)
KSLY01616-1.8	16	16	2.778	1.8x1	730	1484	48 <sup>-0.009</sup> <sub>-0.025</sub>	64	36 <sup>0</sup> <sub>-0.025</sub>	45	32	10	6	21	56	4.5	25	M4	591	1275
KSLY02020-1.8	20	20	3.175	1.8x1	788	1811	56 <sup>-0.01</sup> <sub>-0.029</sub>	72	43.5 <sup>0</sup> <sub>-0.025</sub>	52	39	11	6	21	64	4.5	31	M5	764	1758
KSLY02525-1.8	25	25	3.969	1.8x1	1094	2607	66 <sup>-0.01</sup> <sub>-0.029</sub>	86	52 <sup>0</sup> <sub>-0.03</sub>	64	47	13	7	25	75	5.5	38	M6	1142	2747
KSLY03232-1.8*	32	32	4.762	1.8x1	1191	3233	78 <sup>-0.01</sup> <sub>-0.029</sub>	103	63 <sup>0</sup> <sub>-0.03</sub>	78	58	14	8	25	89	6.6	48	M6	1664	4345
KSLY04040-1.8*	40	40	6.35	1.8x1	2216	6685	90 <sup>-0.012</sup> <sub>-0.034</sub>	130	79.5 <sup>0</sup> <sub>-0.035</sub>	99	73	16.5	10	33	113	9	61	M8	2662	7031

※ Items labeled with \* are customized products. For these product orders, please contact AKD in advance.

Unit : mm

Model No.	Shaft diameter d	Ball Ø d1	Row	Spline Nut Dimension											Screw Nut Load Rating	
				D1	A1	L1	J1	K1	W1	X1	Y1	Z1	Q	Ca (kgf)	Coa (kgf)	
KSLY01616	16	11	2	31 <sup>0</sup> <sub>-0.016</sub>	51	50	10	18	40	4.5	8	6	2	545	849	
KSLY02020	20	14	2	35 <sup>0</sup> <sub>-0.016</sub>	58	56	10	18	45	5.5	9.5	5.4	2	724	1109	
KSLY02525	25	18	4	42 <sup>0</sup> <sub>-0.016</sub>	65	71	13	26.5	52	5.5	9.5	8	3	1003	1593	
KSLY03232	32	23	4	49 <sup>0</sup> <sub>-0.016</sub>	77	80	13	30	62	6.6	11	6.5	3	1324	2251	
KSLY04040	40	29	4	64 <sup>0</sup> <sub>-0.019</sub>	100	100	18	36	82	9	14	12	4	2972	4033	

# CE - 01 - SFNUR2505T4

01	中国China
02	香港Hong Kong
03	台湾Taiwan
04	美国United States
05	新加坡Singapore
06	马来西亚Malaysia
07	越南Vietnam
08	印度India
09	印度尼西亚Indonesia
10	俄罗斯Russia
11	欧盟（德国、法国等）European Union (Germany, France, etc.)
12	韩国South Korea
13	墨西哥Mexico
14	泰国Thailand
15	巴西Brazil
16	埃及Egypt
17	日本Japan
18	中东Middle East