Screw Technology Co., Ltd.

Round Nut with Flange,
Internal Deflector (M-ISNF)

Round Nut without Flange,
Internal Deflector (M-ISNC)

Round Nut with Thread Mount,
Internal Deflector (M-ISNA)

Http://www.screw-tech.com

catalogue

Brief introduction of our Miniature Ball Screw

Miniature ball screw assemblies are conventionally understood to be systems with a nominal diameter of 16mm or less. Their miniaturized nut geometries are achieved through the use of optimized recirculation systems with very small balls. These ball screws are usually not preloaded or only slightly preloaded to ensure the smoothest possible travel. Miniature Ball Screw is normally used in high precision equipments and apparatus.

Application of Miniature Ball Screw

◊ CNC machines: CNC machine, CNC milling machine, milling machine, EDM machines, grinding machine, wire cut EDM machine, CNC boring machine.
◊ Industrial equipment: printing equipment, automation machinery, textile machine, drawing machine, injection molding machine, paper processing equipment.
◊ Electronic machines: measuring robot, XY working table, medical equipment, SMT Equipment, semiconductor equipment, other automation equipments.
◊ Transport machinery: material handling equipment, elevated actuator.
◊ Others: antenna leg actuator, valve operator etc.

Features of Miniature Ball Screws

●High mechanical efficiency

Miniature ball Screws are fitted with steel Balls, providing rolling contact between the Nut and Screw Shaft, allowing for mechanical efficiency of over 90% and reducing the required Torque to less than one-third that of conventional Lead Screws. The design of the Screwtech's Ball Screws also allows linear motion to be converted into rotary motion easily (Fig. A-81).

●Axial play

With conventional Triangular and Trapezoidal Screw threads, reducing the Axial play increases the rotational Torque due to the sliding friction. Screwtech Ball Screws, on the other hand, are very easily rotated, even with no Axial play. The use of Double Nuts also provides increased Rigidity.

●High precision

Screwtech Ball Screws are machined, assembled, and inspected using the technology of ultra-precision Lead Screw and Screw Gauge machining, under the temperature controlled room. High precision and accurate positioning ensure high reliability in use.

●Long service life

The Ball Screw movement results in virtually no wear, as the rolling-contact design, combined with the use of carefully selected heat-treated materials, results in an extremely low friction. This is the reason that high precision can be kept over long period.

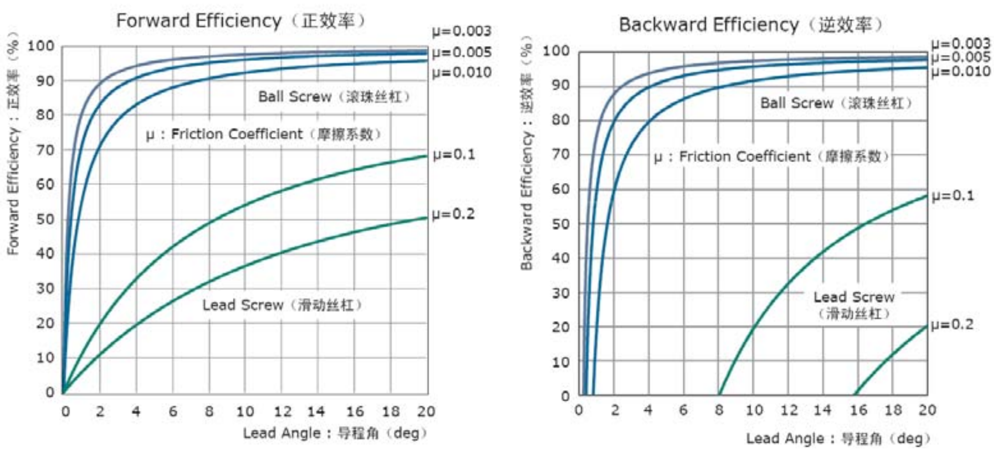
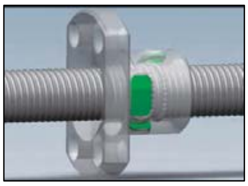


Fig. A-81 Mechanical Efficiency

Construction of Miniature Ball Screws

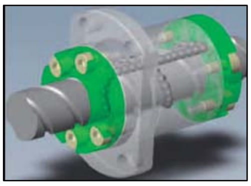


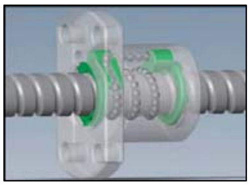
● Internal-deflector system

The Internal-deflector system employs a lightweight Miniature Ball Screw, which enables the Nut diameter and length to be reduced to the smallest possible size. The Balls bear the load while rolling along the screw groove between the Shaft and the Nut. The Balls are continuously circulated, transferred to the adjacent groove in the screw via the Internal-deflector channel and then back to the loaded groove area.

●End-cap system

The End-cap system is a recirculating system in which the Balls advance by rolling through the screw groove between the Nut and the Screw Shaft. The Balls are then returned via the holes in the Nut and the channels in the recirculating sections of the End-caps on either end of the Nut.



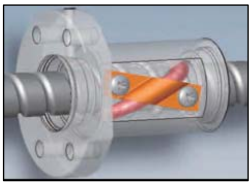


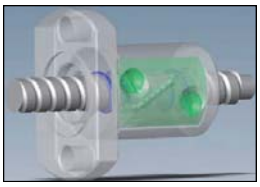
●End-deflector system

The Balls are circulated from End-deflector incorporated inside the Nut or outside the Nut through the hole in the Nut and the channels in the recirculating sections. Ball Nut diameter can be smaller than Return-plate system. This is suitable for the middle lead Ball Screws.

●Return-tube system

In the Return-tube system, Balls rolling between the Nut and Shaft are picked up from the screw groove by the end of the Return-tube built into the Nut. Then, they flow back through the Return-tube to the screw groove.



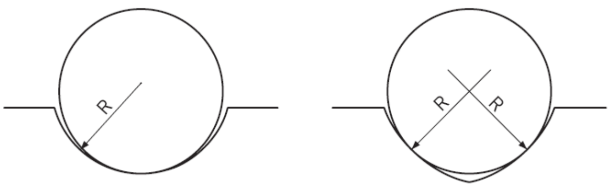


● Return-plate system

The Return-plate system uses coil-type deflectors incorporated inside the Nut to pick up the steel Balls and circulate them via the Return-plate channel. This system has the advantage of allowing the use of a Nut that is smaller in diameter than those employed in Return-tube systems. In addition, the upward-angle installation of the Return-plate ensures even smoother rotation.

●The profile of thread

Ball screws may have either a circular arc profile, formed of a single arc, or a gothic arc profile, formed from two arcs. Screwtech Ball Screws feature a gothic arc profile.



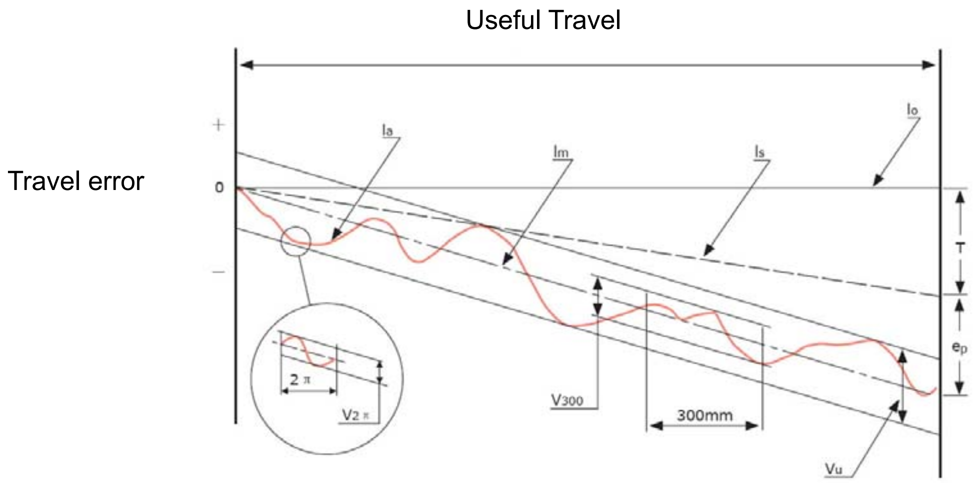
The range of Miniature Ball Screw

The range of our miniature Ball Screws is from φ4mm to φ16mm as shaft nominal diameter. Maximum limit of overall lengths are shown below. Maximum limit of overall lengths will vary depending on the shaft end configuration, materials. Please inquire Screwtech for details.

Shaft nominal diameter	Accuracy Grade				
	C0	C1	C3	C5	C7
4	90	120	160	170	240
6	140	180	240	250	350
8	200	250	330	350	450
10	260	320	420	450	650
12	320	390	510	550	700
14	380	460	600	660	700
16	450	540	700	770	1000
Note: if required length exceeds the number in table above, please ask Screwtech representative.					

Lead accuracy of Ball Screws

Ball Screw lead accuracy conforming to JIS B1192 is specified by the tolerance of actual mean travel error over the Nut effective travel amount, or Screw Shaft effective length, travel variation and travel variation within arbitrary 300mm, travel variation within arbitrary 1 revolution（2π rad） over the Screw Shaft effective length. Tolerance of each accuracy grades are shown in the Table A-83, 84, 85.



Nominal travel (lo): A mount of travel for a particular number of revolutions along nominal Lead.

Specified Lead (Phs): Lead diftering slighty from the nominal Lead, often selectd to compensate for an expected elongation caused by an increase in temperature or Load.

Target specified travel (T): Target value for cumulative specified Lead which has been increased or decreased in advance.

Specified travel (ls): Amount of travel for a particular number of revolutions along specified Lead.

Actual travel (la): actual displacement of Ball Nut relative to the Ball Screw shaft, or vice versa, for a given number of revolutions.

Actual mean travel (lm): Straight line representing the trend of actual travel. To be found by method of the least square or similar methods from the travel curve over the Ball Screw useful travel or the effective screw thread length.

Actual mean travel deviation (ep): Difference between the actual mean trave(lm) and the nominal trave(l0) or the specified trave(ls), within the useful travel.。

Travel variation (Vu):The maximum width of the actual travel curve enclosed between two parallel lines along the actual mean travel line.

Travel variation (V300): The widest range of the actual travel for any 300mm within the useful travel or the effective screw thread length.

Travel variation (V2π):The widest range of the actual travel for one revolution （2π rad） within the useful travel or the effective screw thread length.

Table A-83 : Tolerance on actual mean travel deviation(±ep) and permissible variation of precision Miniature Ball Screw

Unit: μm

Accuracy Grade		C1		C3		C5		Ct7	Ct10
V2π		4		6		8		/	/
V300		5		8		18		52	100
Useful thread length(mm)		e_p	V_u	e_p	V_u	e_p	V_u	e_p	V_u
over	up to								
-	100	6	5	12	8	23	18	/	/
100	200	7	5	13	10	25	20	/	/
200	315	8	5	15	10	27	20	/	/
315	400	9	6	16	12	30	23	/	/
400	500	10	7	18	13	35	25	/	/
500	630	11	8	21	15	40	27	/	/
630	800	13	9	24	16	46	30	/	/
800	1000	15	10	29	18	54	35	/	/

Ball Screw Run-out and Mounting Tolerances

In the purpose of correspondence to ISO, Japan Industrial Standard (JIS B1191, 1192) of Ball Screw was revised in 1997 (JIS B1192-1997 unified). Regarding accuracy grade, C series (current JIS C0, 1, 3, 5) and Cp, Ct series(standard corresponding to ISO) was established. There are some differences between C series and Cp, Ct series in notation and tolerances for accuracy of Ball Screw mounting section, but Screwtech uses notation of Fig. A-86 below and standard tolerance value, which conforms to C series standard, and regarding 7 grade, 10 grade, KSS refers to Cp, Ct serie standard.

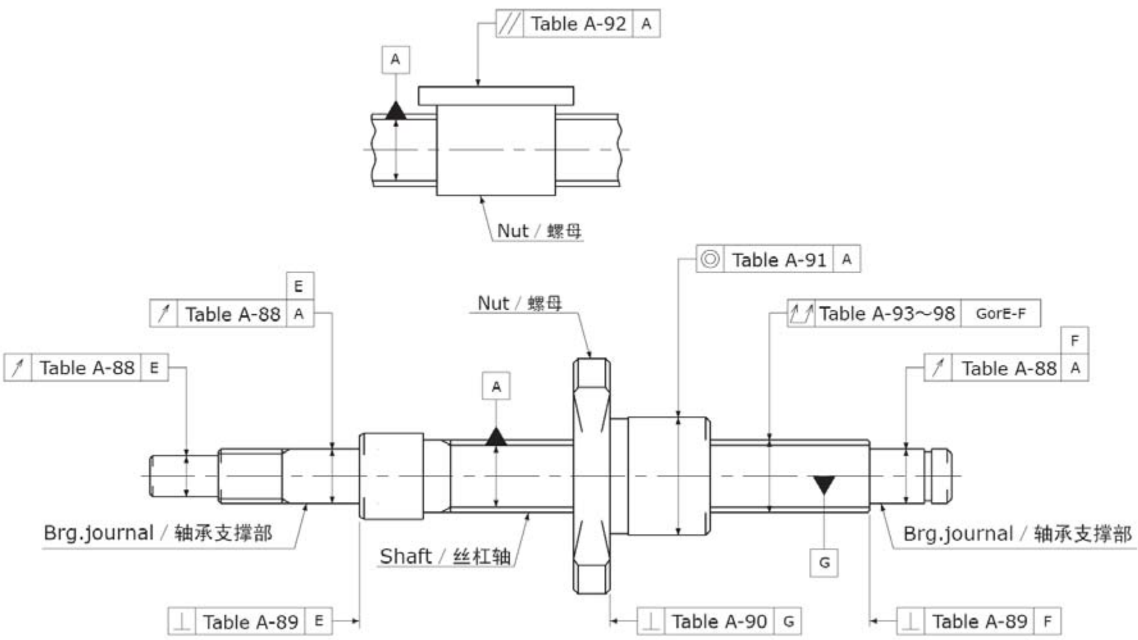


Table A-88: Radial Run-out of Bearing seat related to the centerline of screw groove and Radial Run-out of journal diameter related to the Bearing seat

Unit: μm

Shaft nominal diameter (mm)		Permissible deviation of Radial Run-out				
over	up to	C1	C3	C5	C7	C10
-	8	5	8	10	14	40
8	12	5	8	11	14	40
12	16	6	9	12	14	40

Table A-89: Axial Run-out (Perpendicularity) of Shaft (Bearing) face related to the centerline of the Bearing seat

Unit: μm

Shaft nominal diameter (mm)		Permissible deviations of Axial Run-out（Perpendicularity）				
over	up to	C1	C3	C5	C7	C10
-	8	3	4	5	7	10
8	12	3	4	5	7	10
12	16	3	4	5	7	10

Table A-90: Axial Run-out (Perpendicularity) of Ball Nut location face related to the centerline of Screw Shaft

Unit: μm

Nut outside diameter (mm)		Permissible deviations of Axial Run-out(Perpendicularity)				
over	up to	C1	C3	C5	C7	C10
-	20	6	8	10	14	20
20	32	6	8	10	14	20
32	50	7	8	11	18	30

Table A-91: Radial Run-out of Ball Nut location diameter related to the centerline of Screw Shaft

Unit: μm

Nut outside diameter (mm)		Permissible deviations of Radial Run-out				
over	up to	C1	C3	C5	C7	C10
-	20	6	9	12	20	40
20	32	7	10	12	20	40
32	50	8	12	15	30	60

Table A-92: Parallelism of rectangular Ball Nut related to the centerline of Screw Shaft

Unit: μm

Mounting length (mm)		Permissible deviations of Parallelism				
over	up to	C1	C3	C5	C7	C10
-	50	6	8	10	17	30
50	100	8	10	13	17	30

Table A-94: Total Run-out in radial direction of Screw Shaft related to the centerline of Screw Shaft (C1)

Unit: mm

C1 accuracy grade		**Shaft nominal diameter**		
	over	**-**	**8**	**12**
	up to	**8**	**12**	**16**
Shaft total length		**Permissible deviations of total Run-out in radial direction**		
over	**up to**			
—	125	0.020	0.020	0.015
125	200	0.030	0.025	0.020
200	315	0.040	0.030	0.025
315	400	0.045	0.040	0.030
400	500	-	0.050	0.040
500	630	-	0.060	0.045
630	800	-	-	0.060
800	1000	-	-	0.075

Table A-95: Total Run-out in radial direction of Screw Shaft related to the centerline of Screw Shaft (C3)

Unit: mm

C3 accuracy grade		**Shaft nominal diameter**		
	over	**-**	**8**	**12**
	up to	**8**	**12**	**16**
Shaft total length		**Permissible deviations of total Run-out in radial direction**		
over	**up to**			
—	125	0.025	0.025	0.020
125	200	0.035	0.035	0.025
200	315	0.050	0.040	0.030
315	400	0.060	0.050	0.040
400	500	-	0.065	0.050
500	630	-	0.070	0.055
630	800	-	-	0.070
800	1000	-	-	0.095

Table A-96: Total Run-out in radial direction of Screw Shaft related to the centerline of Screw Shaft (C5)

Unit: mm

C5 accuracy grade		**Shaft nominal diameter**		
	over	**-**	**8**	**12**
	up to	**8**	**12**	**16**
Shaft total length		**Permissible deviations of total Run-out in radial direction**		
over	**up to**			
—	125	0.035	0.035	0.035
125	200	0.050	0.040	0.040
200	315	0.065	0.055	0.045
315	400	0.075	0.065	0.055
400	500	-	0.080	0.060
500	630	-	0.090	0.075
630	800	-	-	0.090
800	1000	-	-	0.120

Table A-97: Total Run-out in radial direction of Screw Shaft related to the centerline of Screw Shaft (C7)

Unit: mm

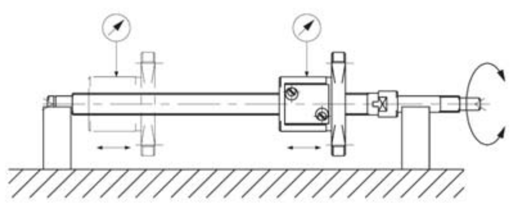
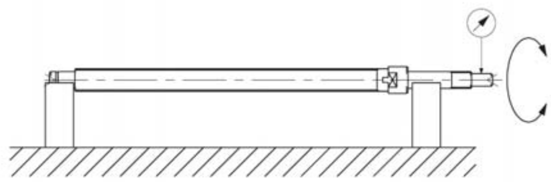
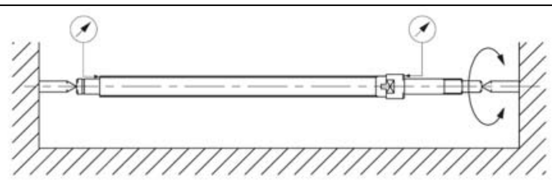
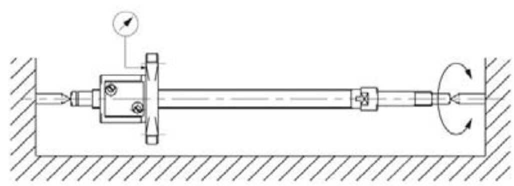
C7 accuracy grade		**Shaft nominal diameter**		
	over	**-**	**8**	**12**
	up to	**8**	**12**	**16**
Shaft total length		**Permissible deviations of total Run-out in radial direction**		
over	**up to**			
—	125	0.060	0.055	0.055
125	200	0.075	0.065	0.060
200	315	0.100	0.080	0.070
315	400	-	0.100	0.080
400	500	-	0.120	0.095
500	630	-	0.150	0.110
630	800	-	-	0.140
800	1000	-	-	0.170

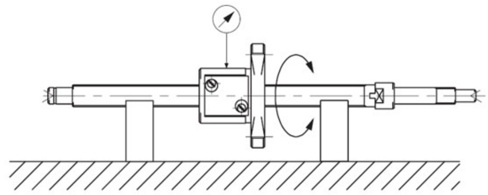
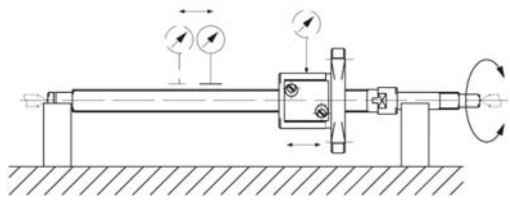
Table A-98: Total Run-out in radial direction of Screw Shaft related to the centerline of Screw Shaft (C10)

Unit: mm

C10 accuracy grade		Shaft nominal diameter		
	over	-	8	12
	up to	8	12	16
Shaft total length		Permissible deviations of total Run-out in radial direction		
over	up to			
—	125	0.100	0.095	0.090
125	200	0.140	0.120	0.110
200	315	0.210	0.160	0.130
315	400	-	0.210	0.160
400	500	-	0.270	0.200
500	630	-	0.350	0.250
630	800	-	0.460	0.320
800	1000	-	-	0.420

Measuring method of Ball Screw Run-out and mounting tolerances

1. Radial Run-out of Bearing seat related to the centerline of screw groove (Table A-88) Place the Ball Screw in identical V-blocks at both Bearing seat. Place the dial gauge perpendicular to the Nut cylindrical surface. Rotate Screw Shaft slowly and record the dial gauge readings. Measurement should be done at near both ends of threaded part.	
2. Radial Run-out of journal diameter related to the Bearing seat (Table A-88) Place the Ball Screw in identical V-blocks at both Bearing seats. Place the dial gauge perpendicular to the journal cylindrical surface. Rotate the Screw Shaft slowly and record the dial gauge readings.	
3. Axial Run-out (Perpendicularity) of shaft (Bearing) face related to the centerline of the Bearing seat (Table A-89) Support a Screw Shaft at both centers. Place the dial gauge perpendicular to the end face of the journal. Rotate the Screw Shaft slowly and record the dial gauge readings.	 Note: This method is equivalent to the one, which is supported at both Bearing seats, because Bearing seats are ground related to both centers.
4. Axial Run-out (Perpendicularity) of Ball Nut location face related to the centerline of Screw Shaft (Table A-90) Support the Ball Screw at both centers. Place the dial gauge perpendicular to the flange face. Rotate the Screw Shaft with Ball Nut slowly and record the dial gauge readings. Secure the Ball Nut against rotation on the Screw Shaft.	

5. Radial Run-out of Ball Nut location diameter related to the centerline of Screw Shaft (Table A-91) Place the Ball Screw on V-blocks at adjacent sides of the Ball Nut. Place the dial gauge perpendicular to the cylindrical surface of Ball Nut. Secure the Screw Shaft against rotation of Ball Nut. Rotate Ball Nut slowly and record the dial gauge readings.	
6. Total Run-out in radial direction of Screw Shaft related to the centerline of Screw Shaft (Table A-93 to 98) Place the Ball Screw in identical V-blocks at both Bearing seats, or support the Ball Screw at both centers. Place the dial gauge with measuring shoe at the several points over the full thread length. Rotate the Screw Shaft slowly and record the dial gauge readings. Maximum value of measurement should be the Total Run-out.	

Axial play and Preload

For standard Single Nut Ball Screws under normal conditions, a slight Axial play exists between the Screw Shaft and Nut. Consequently, when Axial loads act on Single Nut Ball Screws, total amount of Axial play and Elastic displacement due to Axial load becomes backlash. In order to prevent this backlash in Ball Screws, the Axial play can be reduced to a negative value. That is what we call “Preload", which is the method of causing Elastic deformation to the Balls between the Screw Shaft and Nut in advance.

●Axial play
Symbol and permissible value for Axial play are shown in Table A-102.
Combination of accuracy grade and symbol are shown in Table A-103.

Table A-102 : Symbol and permissible value for Axial play

Symbol	**Z0**	**Z02**	**Z05**	**Z20**	**Z50**
Axial play	0 (preloaded)	0.002 max.	0.005 max.	0.02 max.	0.05 max.

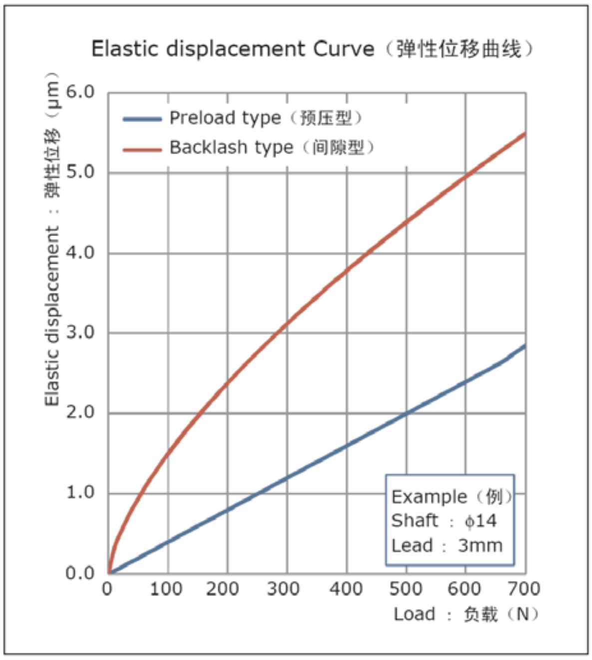
Table A-103: Combination of accuracy grade and Axial play

Accuracy Gradea	Symbol				
	Z0	**Z2**	**Z5**	**Z20**	**Z50**
C0	C0-Z0	/	/	/	/
C1	C1-Z0	C1-Z02	/	/	/
C3	C3-Z0	C3-Z02	C3-Z05	C3-Z20	C3-Z50
C5	/	/	C5-Z05	C5-Z20	C5-Z50
C7	/	/	/	C7-Z20	C7-Z50
C10	/	/	/	C10-Z20	C10-Z50

Note: When combinations other than the above are requested, please inquire Screwtech.

●Preload effect

Preload is not only used for removing Axial play, it also has the effect of reducing the amount of Axial displacement due to Axial load, and improving the Rigidity in Ball Screws. Fig. A-104 shows the difference of the amount of Elastic displacement (theoretical value) regarding Ball Screw with Axial play and Ball Screw with Preload under the axial load.



●Proper amount of Preload

Although the amount of Preload should be determined by the required Rigidity and the permissible amount of backlash, when setting Preload, there are some concerning issues as follows.

1). Increased Dynamic Drag Torque

2). Heat generation

lowering of positioning accuracy due to the temperature rise.

3). Shortened life

Therefore, it is advisable to establish the amount of Preload at the lowest possible limits.

●Preload methods

Generally, a method of Double Nut Preload by inserting a spacer between two Nuts is adopted. SCREWTECH Ball Screw adopts “Oversized Ball Preload” by inserting Balls slightly bigger than space between Screw Shaft and Nut. As a result, it can eliminate Axial play even with a Single Nut and it is possible to maintain compact. Moreover, operating performance will never be deteriorated by using spacer Balls (Balls with slightly smaller diameter than those of the oversize Balls) alternatively with oversize Balls.

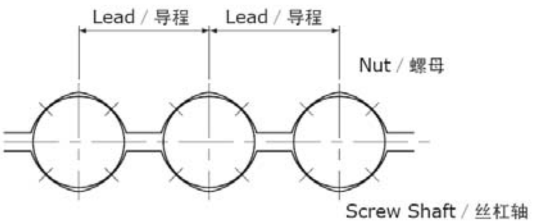


Fig. A-105: Preload by oversized Balls

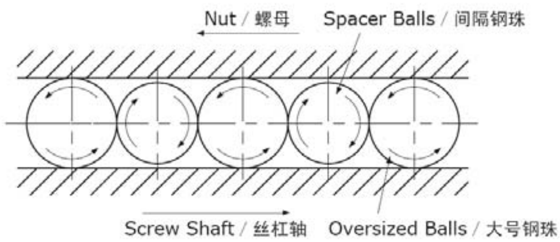


Fig. A-106: Spacer Balls

●Preload control

It is difficult to control Preload amount by measuring. Therefore, Preload of Ball Screw is controlled by measuring Preload Dynamic Drag Torque, which is converted from Preload amount. Amount of Preload Dynamic Drag Torque is decided with customers by specification drawing. Preload Dynamic Drag Torque is measured under specific condition to verify the amount of Axial play is 0. Dynamic Drag Torque installed actual machine will vary depending on lubricating condition, load condition and so on. Starting torque (Torque for starting Ball Screw) is slightly bigger than Dynamic Drag Torque.

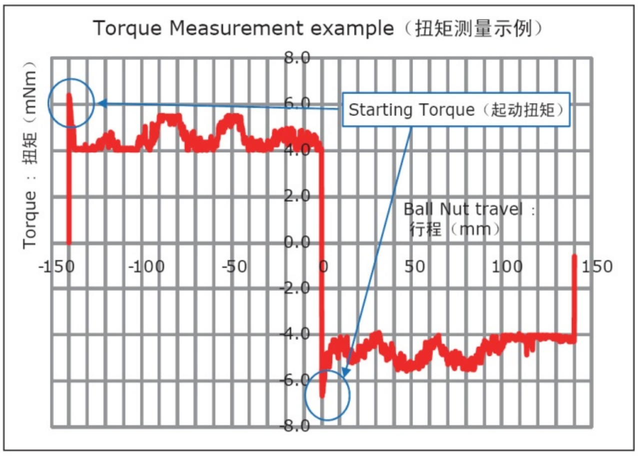
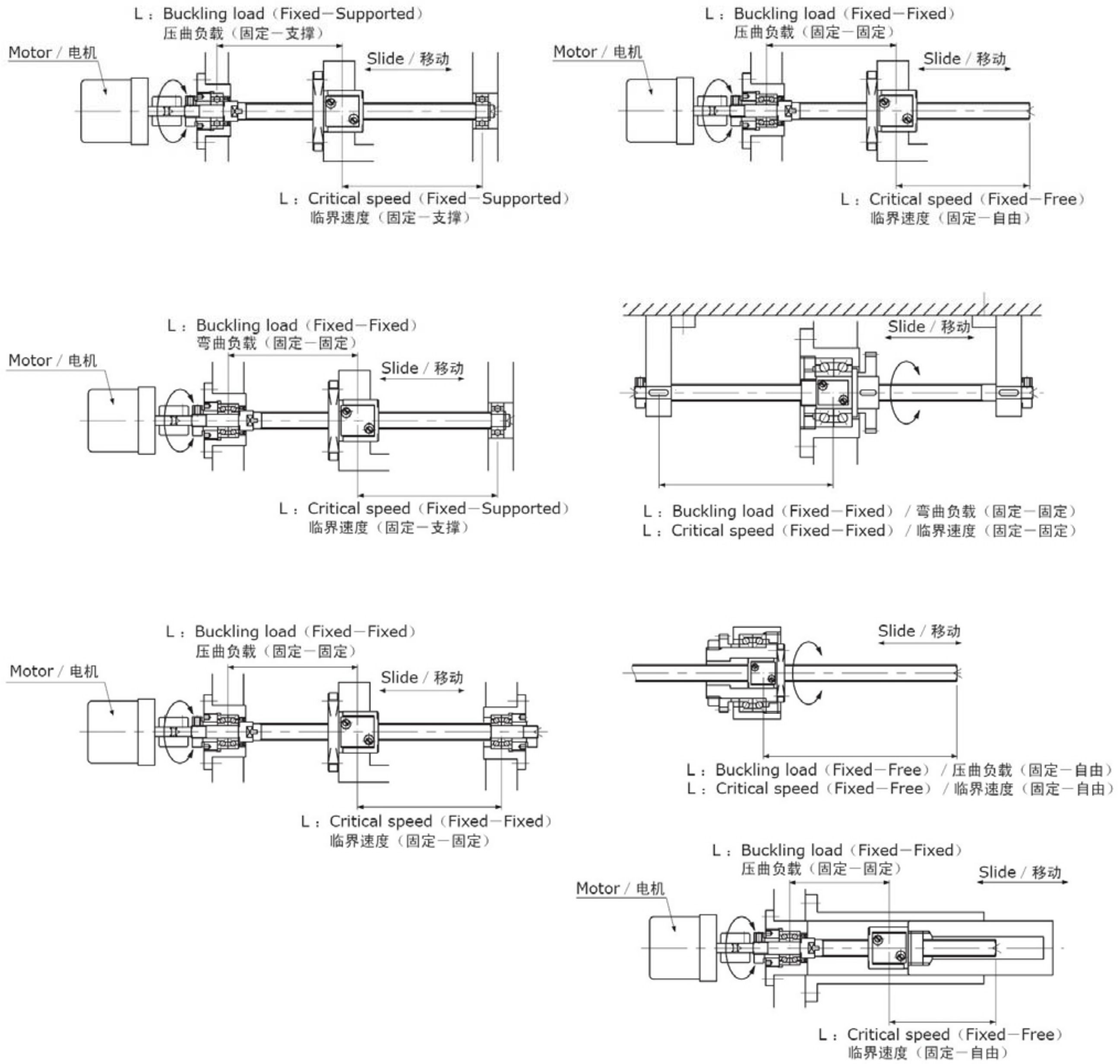


Fig. A-107: Dynamic Drag Torpue measurement

Ball Screw mounting methods

Typical Ball Screw's mounting methods are shown in Fig. A-101. Mounting configuration affects permissible Axial load in relation to buckling, as well as permissible speed in relation to critical speed. Please refer to below when studying strength and speed.



Rust prevention and Lubrication

●Rust prevention

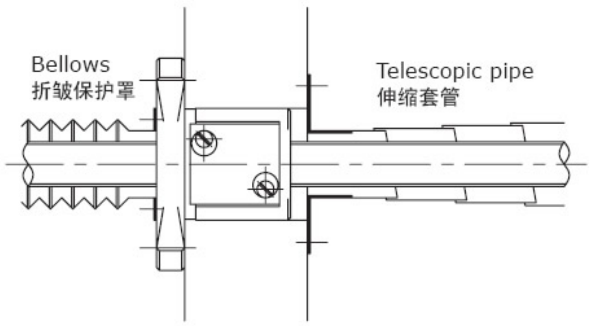
SCREWTECH Ball Screws are applied anti-rust oil when shipping in case of no specific instruction. This oil should be

removed before use. Wash Ball Screws with cleaned Kerosine and apply lubricant (Grease or Oil) on Ball Screw. As customer's request, specified Grease or Oil can be applied, but it should be noted that they are not suitable for long term storage purpose and rust might occur.

Note: Anti-rust oil is focused on anti-rust performance and it does not have lubricating function. Therefore, when using Ball Screws with anti-rust oil coating, the problems such as shortened Life, increase of Torque and abnormal heat generation *occurs.*

●Lubrication

In Ball Screw use, lubricant should be required. If lubricant is not applied with, the problem such as increase of Torque and shortened Life occurs. Applying lubricant can minimize temperature increases, decline of mechanical efficiency due to friction, and deterioration of accuracy caused by wear. Ball Screw lubrication is divided into Greasing and Oiling. A regular lithium-soap-based Grease and ISO VG32-68 Oil (turbine Oil #1 to #3) are recommended. It is highly important to choose lubricant depending on customer's usage. Especially in case of Miniature Ball Screws, malfunction such as increase of Torque are caused by the stir resistance.



Dust prevention

In Ball Screws, if dust or other contaminations intrude into the Ball Nut, wear is accelerated, the screw groove will be damaged, circulation will be obstructed due to Ball fracture, damage of recirculation parts and so on. Eventually, the Ball Screws will cease to function. Where the possibility of dust or other contaminant exists, the screw thread section cannot be left exposed, and dust prevention measure such as a bellows or Telescopic pipe must be taken.

Screwtech Miniature Ball Screws are concentrated on compact design for a feature of Miniature Ball Screw. Therefore, all models in the catalogue are the dimension without seals. Please inquire Screwtech if seals are required. Please note that Nut dimension may change due to seal installation. Some models cannot install the seals.

Special Surface treatment

Surface treatment can be possible for the purpose of rust prevention. Black Chrome treatment (BCr) is SCREWTECH standard surface treatment for the purpose of rust prevention. Please inquire SCREWTECH if other surface treatments are needed.

● Feature of SCREWTECH Ball Screws with Black Chrome (BCr) coating

· Due to thin film thickness (2 to 3μm), mating part can be applicable with BCr.
· Due to strict production management, film thickness can be treated equally and smoothness is kept.
· High anti-rust ability is possible.
· The surface treatment is officially authorized by MIL standard (MIL-DTL-14538D)
· To improve sliding characteristics, BCr+fluorine resin coating is also available.

Permissible Axial load

It is recommended that Ball Screw Shafts be used almost exclusively under tension load conditions. However, in some applications, compression loads may exist, and under such conditions it must be determined that Shaft buckling will not occur. Also, when the mounting span distance is short, there is a restriction on the permissible tension or compression load and the Basic Static Load Rating Coa unrelated to mounting. Buckling load, permissible tension and permissible compression load can be calculated below.

● **Permissible compression load calculation for buckling**: $P = \alpha \times \frac{n\pi^2 E?}{L^2}$ $N\{kgf\}$ (Formula for Oiler)

α: Safety Factor 0.5

E: Young's modulus 2.08 ×10^5 N/mm^2(MPa) {21,200kgf/mm^2}

I: Screw Shaft minimum moment of inertia of area $I = \frac{\pi}{64} d^4$ mm^4

d: srew Shaft Root diameter mm

L: Mounting span distance mm

N: Factor for Ball Screw mounting method

Supported-Supported	n=1
Fixed-Supported	n=2
Fixed-Fixed	n=4
Fixed-Free	n=1/4

● **Permissible tension, compression load calculation for Screw Shaft yield stress:**

$P = \sigma \times A$ $N\{kgf\}$

σ: Permissible stress 98N/mm^2(MPa) {10kgf/mm^2}

A: Screw Shaft minimum section area $A = \frac{\pi}{4} d^2$ mm^2

d: Screw Shaft Root diameter mm

Permissible speed

For Screw Shaft rotation, the mounting method determines the established rotation limits. When this value is approached, resonance phenomenon can occur, and operation becomes impossible. There is also rotation limit which causes damages to recirculating parts. This limit is unrelated to mounting methods.

● Permissible speed calculation for critical speed: $N = \beta \times \frac{60\lambda^2}{\sigma} \times \sqrt{\frac{E \cdot I \cdot g}{\gamma \cdot A \cdot L^4}}$ $min^{-1}\{rpm\}$

β: Safety Factor 0.8

E: Young's modulus 2.08 ×10^5 N/mm^2(MPa) {21,200kgf/mm^2}

I: Screw Shaft minimum moment of inertia of area $I = \frac{\pi}{64} d^4$ mm^4

d: Screw Shaft Root diameter mm

g: Gravity acceleration 9.8×10^3 mm/sec^2

γ: Material specific gravity 7.7×10^{-5} N/mm^3 {7.85×10^{-6}kgf/mm^3}

A: Screw Shaft minimum section area $A=\frac{\pi}{4}d^2$ mm^2

L: Mounting span distance mm

λ : Factor for Ball Screw mounting method

Supported-Supported	λ =3.14
Fixed-Supported	λ =3.927
Fixed-Fixed	λ =4.73
Fixed-Free	λ =1.88

● Rotation limits for damage on recirculating parts

Generally, regarding critical speed for damage on recirculating parts, limitation is established by dn value, which is multiplied Shaft nominal diameter of revolution, but dn value cannot be applied to Miniature Ball Screws. For Screwtech Ball Screws, please consider rotation limits by damage on recirculating parts as 3,500 to 4,000rpm. This value varies depending on operating conditions and environment. Please inquire Screwtech for details.

Rigidity in feed screw system

In precision machinery, to improve positioning accuracy of the feed screws or to increase Rigidity for load, the Rigidity of the entire feed screw system must be examined. Feed screw system Rigidity is as follows.

$$\frac{1}{K}=\frac{1}{K_1}+\frac{1}{K_2}+\frac{1}{K_3}+\frac{1}{K_4} \quad \mu m/N \ \{\mu m/kgf\}$$

K:	Total Rigidity of feed screw system	N/μm{kgf/μm}
K1:	Screw Shaft Rigidity	N/μm{kgf/μm}
K2:	Nut Rigidity	N/μm{kgf/μm}
K3:	Support Bearing Rigidity	N/μm{kgf/μm}
K4:	Nut, Bearing fitting part Rigidity	N/μm{kgf/μm}

●Total Rigidity of feed screw system K

$$K=\frac{Fa}{\delta} \quad \mu m/N \ \{\mu m/kgf\}$$

Fa: Axial load applied to feed screw system N{kgf}

δ: Elastic displacement of feed screw system μm

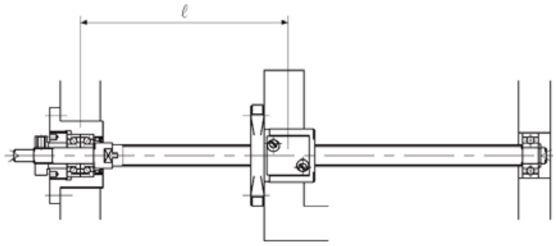


Fig. A-108: Fixed-Free in axial direction

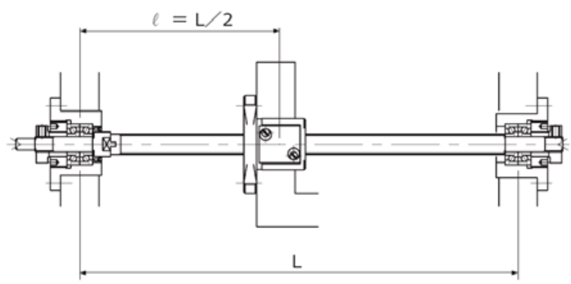
● Screw Shaft Rigidity K1

(1) In case of general mounting(Fixed-Free in axial direction)(Fig. A-108)

$$K_1=\frac{A\cdot E}{\ell}x10^{-3} \quad N/\mu m\{kgf/\mu m\}$$

(2) In case of Fixed-Fixed mounting in axial direction(Fig. A-109)

$$K_1=\frac{A\cdot E}{\ell\ (L-\ell)}x10^{-3} \quad N/\mu m\{kgf/\mu m\}$$



The max. axial displacement occurs when r ＝ L/2. The formula is as follows.

$$K_1=\frac{4\cdot A\cdot E}{L}x10^{-3}\quad N/\mu m\{kgf/\mu m\}$$

A : Screw Shaft minimum section area

$$A=\frac{\pi}{4}d^2\quad mm^2$$

d： Screw Shaft Root diameter mm

E： Young's modulus 2.08 ×105 N/mm (2 MPa) {21,200kgf/mm2}

l： Axial distance between fixed point & Nut center mm

L： Mounting span distance mm

Accordingly, the amount of Screw Shaft Elastic displacement δ due to Axial load Fa is as follows.

$$\delta=\frac{Fa}{K_1}\quad \mu m$$

● **Nut Rigidity K2**

(1) Rigidity of Single Nut with backlash

The theoretical static Rigidity K2 of the Nut under an Axial load equivalent to 30% of the Basic Dynamic Load Rating Ca is described in dimension table. For Axial loads which are not 30% of the Basic Dynamic Load Rating Ca, please use the following formula. Please inquire SCREWTECH regarding theoretical Static Rigidity of model types which are not in dimension table.

$$K'_2=K_2x(\frac{Fa}{0.3Ca})^{1/3}\quad N/\mu m\{kgf/\mu m\}$$

K2: Nut Rigidity in dimension table N/μm{kgf/μm}

Fa: Axial load N{kgf}

Ca: Basic Dynamic Load Rating N{kgf}

(2) Rigidity of preloaded Ball Nut

The theoretical static Rigidity K2 under a Preload equivalent to 5% (10% for Double Nut) of the Basic Dynamic Load Rating Ca is described in dimension table. For Preload amounts other than the above, please use the following formula. In case of Preload type Ball Screws, Rigidity varies depending on the dispersion of Preload Dynamic Drag Torque. Therefore, please inquire SCREWTECH for details. SCREWTECH will calculate theoretical Static Rigidity of required Nut models, which are not in the dimension table.

Single Nut with oversized Ball Preload

$$K'_2=K_2x(\frac{Fa}{0.05Ca})^{1/3}\quad N/\mu m\{kgf/\mu m\}$$

Double Nut with oversized Ball Preload

$$K'_2=K_2x(\frac{Fa}{0.1Ca})^{1/3}\quad N/\mu m\{kgf/\mu m\}$$

K2: Nut Rigidity in dimension table N/μm{kgf/μm}

Ga: Preload amount N{kgf}

Ca: Basic Dynamic Load Rating N{kgf}

●Support Bearing Rigidity K3

Support Bearing Rigidity varies depending on the type of Bearing and amount of Preload. Please inquire Bearing manufacturers.

●Nut, Bearing fitting part Rigidity K4

Rigidity of Nut mounting part and Bearing mounting part vary depending on machine structure and design. Screwtech cannot mention the details but a design of high Rigidity must be considered.

●Screw Shaft torsion Rigidity

For positioning error due to torsion, this error is a relatively small compared to axial displacement. However, if investigation is required, the following formula may be used for calculation.

$$\theta=\frac{32TL}{\pi GD^4}\times\frac{180}{\pi}\times 10 \text{ deg}$$

θ: Torsion angle due to torsion moment		deg
T: Torsion moment		N·cm{kgf·cm}
L: Distance between Nut & Shaft end support		mm
G: Modulus of Rigidity	8.3×104 N/mm2 (MPa)	{8,500 kgf/mm2}
d: Screw Shaft Root diameter		mm

Amount of axial displacement δa due to torsion angle is as follows.

$$\delta a=\ell \times \frac{\theta}{360}\times 10^3 \quad \mu m$$

ℓ : Lead mm

Basic Load Rating and Basic Rating Life

●Basic Dynamic Load Rating Ca and Basic Rating Life

The Basic Rating Life of Ball Screws means the total number of revolutions which 90% of the Ball Screws can endure. Failure is indicated by flaking caused by rolling fatigue on the surface of grooves or Balls. These figures are valid when a group of the same type Ball Screws are operated individually under the same conditions. The Basic Dynamic Load Rating Ca is the Axial load for which the Basic Rating Life is 1,000,000 revolutions. These values are listed under Ca in the dimension tables. Ball Screw's Basic Rating Life L10 can be estimated using Basic Dynamic Load Rating Ca in the following formula.

$$L_{10}=\left(\frac{Ca}{f\cdot Fa}\right)^3\times 10^6 \text{ rev}$$

Also, in place of the total number of revolutions, the Basic Rating Life can be expressed in hours: L10h or traveled distance：L10d, and these can be calculated through the following formulas.

$$L_{10h}=\left(\frac{1}{60\cdot N}\right)\times L_{10} \text{ hours}$$

$$L_{10d}=\left(\frac{\ell}{10^6}\right)\times L_{10} \text{ km}$$

s

Ca: Basic Dynamic Load Rating N {kgf}

Fa: Axial load N {kgf}

N: Revolution min^{-1} {rpm}

ℓ: Lead mm

F: Lead factor

f＝1.0~1.2 for almost no vibration, no shock condition

f＝1.2~1.5 for slight vibration, shock condition

f＝1.5~3.0 for severe vibration, shock condition

Generally, Axial load on the most machine is not constant and it can be divided into several operating pattern. In this case, Basic Rating Life can be calculated to figure up average Axial load Fam, average Revolution Nm in the following formula.

Axial load N{kgf}	Revolution Min^{-1}{rpm}	Working time %
Fa1	N1	t1
Fa2	N2	t2
Fa3	N3	t3

$$Fam = \left(\frac{Fa_1^3 \cdot N_1 \cdot t_1 + Fa_2^3 \cdot N_2 \cdot t_2 + Fa_3^3 \cdot N_3 \cdot t_3}{N_1 \cdot t_1 + N_2 \cdot t_2 + N_3 \cdot t_3}\right)^{1/3} \quad N\ \{kgf\}$$

$$N_m = \frac{N_1 \cdot t_1 + N_2 \cdot t_2 + N_3 \cdot t_3}{t_1 + t_2 + t_3} \quad min^{-1}\ \{rpm\}$$

Also, for Axial loads which vary linearly, the average Axial load Fam can be calculated approximately using the following formula.

$$Fam = \frac{Fa\ min + 2 \cdot Fa\ max}{3} \quad N\ \{kgf\}$$

Fa min: Minimum Axial load N {kgf}
Fa max: Maximum Axial load N {kgf}

Note: As the Basic Rating Life varies due to lubricating conditions, and contaminations, Moment load or Radial load, etc., this should be considered a rough estimate only.

●Basic Static Load Rating Coa

The Basic Static Load Rating Coa is the Axial Static load at which the amount of permanent deformation (Ball + Raceway) occurring at the maximum stress contact point between the Ball and Raceway surfaces is 1/10,000 times the Ball diameter. These values are listed under Coa in the dimension tables. The Basic Static Load Rating Coa values apply to investigation of stationary state or extremely low Revolution load conditions (less than 10 rpm). However, in most cases the amount of permanent deformation causes absolutely no problems under the general conditions. The maximum permissible load Fa max for the screw groove can be found by using the following formula.

$$Fa\ max = \frac{Coa}{fs} \quad N\ \{kgf\}$$

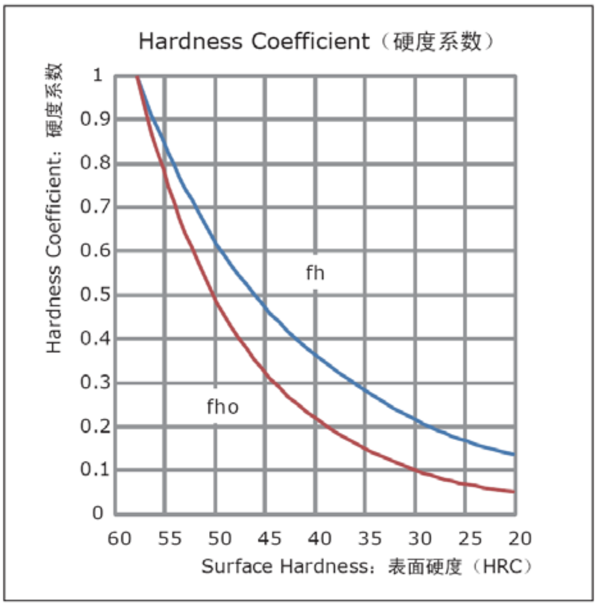
fs : Static safety factor
fs＝1~2 for normal operation
fs＝2~3 for vibration, shock

●Hardness coefficient

For Surface hardness of less than HRC58, the Basic Dynamic Load Rating Ca and the Basic Static Load Rating Coa must be adjusted. Adjustment is made by the following formula.

Ca' ＝ fh • Ca (N)
Coa' ＝ fho • Coa (N)

fh, fho: Hardness coefficient (See graph right)



Driving Torque

The feed screw system Driving Torque T is expressed according to the following formula.

T＝T1＋T2＋T3＋T4 N·m{kgf·cm}

T1:	Acceleration Torque	N·m{kgf·cm}
T2:	Load Torque	N·m{kgf·cm}
T3:	Preload Dynamic Drag Torque	N·m{kgf·cm}
T4:	Additional Torque	N·m{kgf·cm}

When Motor selection, the feed screw system Driving Torque is needed.

T1~T3 can be calculated by the following formula

● Acceleration Torque T1

T1＝α·I N·m

$$\alpha=\frac{2\pi N}{60T} \quad \text{rad/sec}^2$$

$$I = I_w \cdot A^2 + I_s \cdot A^2 + I_A \cdot A^2 + I_B \quad \text{kg} \cdot \text{m}^2$$

$$I_w = m_w x\left(\frac{\ell}{2\pi}\right)^2 x10^{-6} \quad \text{kg} \cdot \text{m}^2$$

$$I_s = m_s x\left(\frac{d^2}{8}\right)^2 x10^{-6} \quad \text{kg} \cdot \text{m}^2$$

$$m_s = \pi\left(\frac{d}{2}\right)^2 xLx\gamma x10^{-9} \quad \text{kg}$$

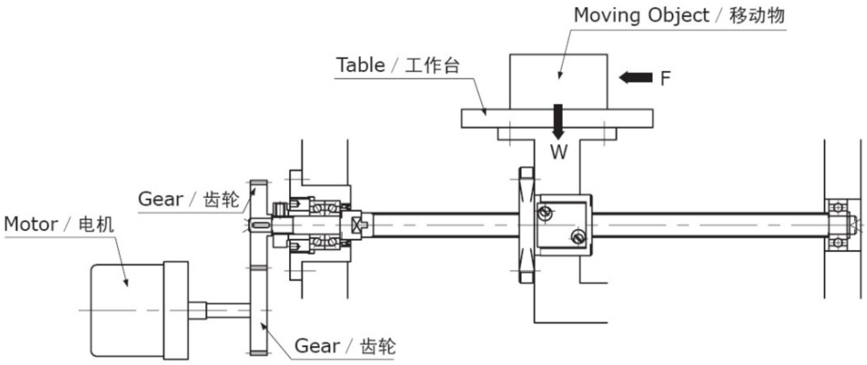
α: Angular acceleration	rad/sec2
I: Inertia moment	kg·m2
Iw: Inertia moment of moving object by Motor axial conversion	kg·m2
Is: Inertia moment of Screw Shaft	kg·m2
I_A: Inertia moment of gears on screw side	kg·m2
I_B: Inertia moment of gears on motor side	kg·m2
m_W: Mass of moving object	kg·m2
m_S: Mass of Screw Shaft	kg
ℓ: Lead	kg
d: Screw Shaft diameter	mm
L: Ball Screw length	mm
γ: Specific gravity	mm
A: Reduction ratio	7,850 kg/m^3
N: Motor speed	Min^{-1}
t: Acceleration time	sec

● Load Torque T2

$$T_2 = \frac{P \cdot \ell \cdot A}{2\pi\eta} x10^{-3} = \frac{(F+\mu W)}{2\pi\eta} \cdot \ell \cdot Ax10^{-3} \quad \text{N·m}$$

$$T_2 = \frac{P \cdot \ell \cdot A}{2\pi\eta} x10^{-1} = \frac{(F+\mu W)}{2\pi\eta} \cdot \ell \cdot Ax10^{-1} \quad \text{kgf·cm}$$

P: Axial load	N{kgf}
F: Load	N{kgf}
W: Weight of moving object	N{kgf}
ℓ: Lead	mm
μ: Sliding surface friction coefficient	
η: Efficiency 0.9	
A: Reduction ratio	



● **Preload Dynamic Drag Torque T3**

$$T_3 = 0.05x(\tan\beta)^{-0.5}x\frac{Fa \cdot \ell}{2\pi}x10^{-3} \quad N{\cdot}m$$

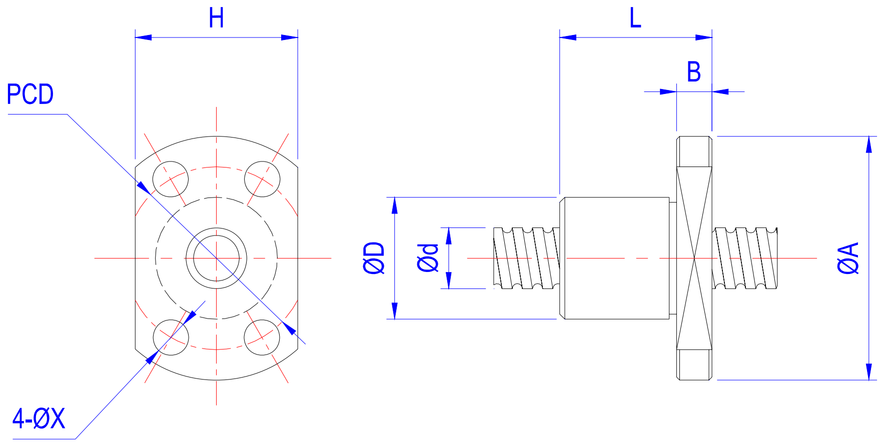
$$T_3 = 0.05x(\tan\beta)^{-0.5}x\frac{Fa \cdot \ell}{2\pi}x10^{-1} \quad kgf{\cdot}cm$$

β: Lead angle	deg
Fa: Preload	N{kgf}
ℓ: Lead	mm

● **Additional Torque T4**

Described as Torque which occurs in addition to those listed above. For example, support Bearing friction Torque, oil seal resistance Torque, etc.

Round Nut with Flange, Internal Deflector (M-ISNF)

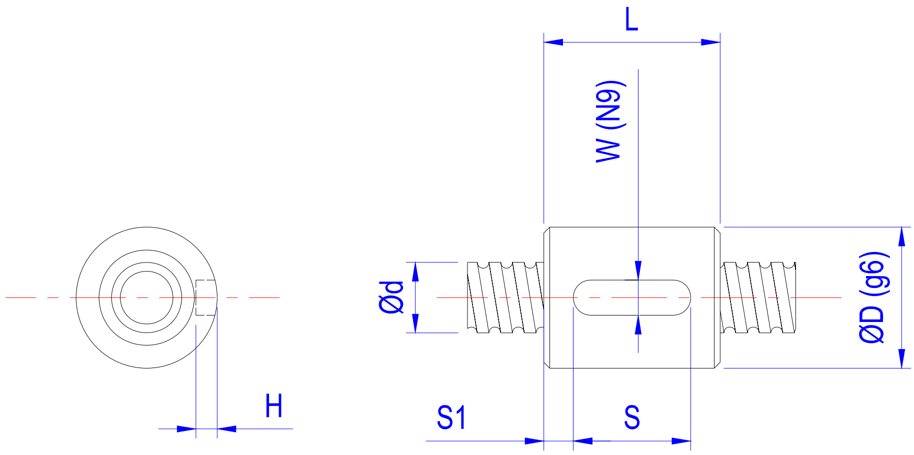


Code	d	P	Dw	n	Ca	Coa	K	Nut Dimension									
								D	A	B	L	PCD	H	X	Y	Z	Q
M-ISNF0401	4	1	0.8	2	40	51	2.8	10	20	3	12	15	14	2.9	/	/	/
M-ISNF0601	6	1	0.8	3	73	121	6.8	12	24	3.5	15	18	16	3.4	/	/	/
M-ISNF0602	6	2	1.2	3	73	121	6.8	12	24	3.5	15	18	16	3.4	/	/	/
M-ISNF0801	8	1	0.8	3	135	225	7.4	14	27	4	16	21	18	3.4	/	/	/
M-ISNF0802	8	2	1.2	3	135	225	7.4	14	27	4	16	21	18	3.4	/	/	/
M-ISNF0802.5	8	2.5	1.2	3	177	278	7.4	16	29	4	26	23	20	3.4	/	/	/
M-ISNF1002	10	2	1.588	3	185	305	9.0	18	35	5	28	27	22	4.5	/	/	/
M-ISNF1003	10	3	2.0	3	185	305	9.0	18	35	5	28	27	22	4.5	/	/	/
M-ISNF1004	10	4	2.381	3	395	590	9.0	26	46	10	34	36	28	4.5	/	/	/
M-ISNF1201	12	1	0.8	3	173	317	11	20	37	5	28	29	24	4.5	/	/	/
M-ISNF1202	12	2	1.588	3	173	317	11	20	37	5	28	29	24	4.5	/	/	/
M-ISNF1202.5	12	2.5	1.2	3	173	317	11	20	37	5	28	29	24	4.5	/	/	/
M-ISNF1203	12	3	3	3	173	317	11	20	37	5	28	29	24	4.5	/	/	/
M-ISNF1204	12	4	2.381	3	454	722	11	24	40	6	28	39	29	3.5	6	3.5	/
M-ISNF1205	12	5	2.5	3	619	883	17	22	37	8	38	29	24	4.5	/	/	/
M-ISNF1402	14	2	1.2	3	287	633	12	21	40	6	23	31	26	5.5	/	/	/
M-ISNF1602	16	2	1.588	3	253	670	12	25	43	10	40	35	29	5.5	/	/	/
M-ISNF1602.5	16	2.5	1.2	3	253	670	12	25	43	10	40	35	29	5.5	/	/	/
M-ISNF1603	16	3	2.0	3	253	670	12	25	43	10	40	35	29	5.5	/	/	/
M-ISNF1604	16	4	2.381	3	640	1340	16	28	48	10	42	39	34	4.5	8	4.5	M6

Not: the size and shape of the nut can be made as per customers' requirement.

P: lead . Dw: ball diameter n: number of ball recirculation. K: stiffness (Kgf/μm).
Ca: basic dynamic rating load (Kgf). Coa: basic static rating load (Kgf).

Round Nut without Flange, Internal Deflector (M-ISNC)

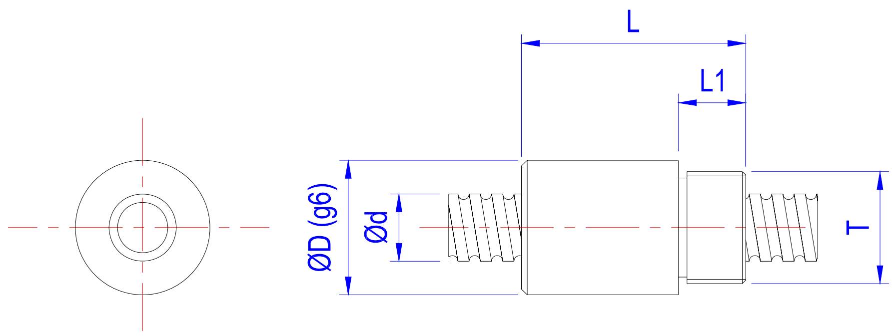


Code	d	P	Dw	n	Ca	Coa	K	Nut Dimension	
								D	L
M-ISNC0401	4	1	0.8	2	40	51	2.8	10	12
M-ISNC0601	6	1	0.8	3	73	121	6.8	12	15
M-ISNC0602	6	2	1.2	3	73	121	6.8	12	15
M-ISNC0801	8	1	0.8	3	135	225	7.4	14	16
M-ISNC0802	8	2	1.2	3	135	225	7.4	14	16
M-ISNC0802.5	8	2.5	1.2	3	177	278	7.4	16	26
M-ISNC1002	10	2	1.588	3	185	305	9.0	18	28
M-ISNC1003	10	3	2.0	3	185	305	9.0	18	28
M-ISNC1004	10	4	2.381	3	395	590	9.0	26	34
M-ISNC1201	12	1	0.8	3	173	317	11	20	28
M-ISNC1202	12	2	1.588	3	173	317	11	20	28
M-ISNC1202.5	12	2.5	1.2	3	173	317	11	20	28
M-ISNC1203	12	3	3	3	173	317	11	20	28
M-ISNC1204	12	4	2.381	3	454	722	11	24	28
M-ISNC1205	12	5	2.5	3	619	883	17	22	38
M-ISNC1402	14	2	1.2	3	287	633	12	21	23
M-ISNC1602	16	2	1.588	3	253	670	12	25	40
M-ISNC1602.5	16	2.5	1.2	3	253	670	12	25	40
M-ISNC1603	16	3	2.0	3	253	670	12	25	40
M-ISNC1604	16	4	2.381	3	640	1340	16	28	42

Not: the size and shape of the nut can be made as per customers' requirement.

P: lead . Dw: ball diameter n: number of ball recirculation. K: stiffness (Kgf/μm).
Ca: basic dynamic rating load (Kgf). Coa: basic static rating load (Kgf).

Round Nut with Thread Mount, Internal Deflector (M-ISNA)

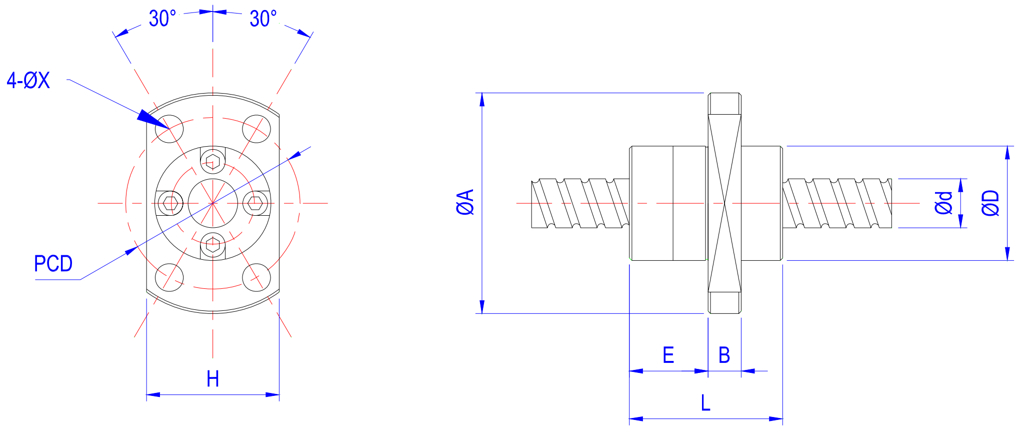


Code	d	P	Dw	n	Ca	Coa	K	Nut Dimension			
								D	L	L1	T
M-ISNA0401	4	1	0.8	2	40	51	2.8	10	15	5	M8x0.75
M-ISNA0601	6	1	0.8	2	73	121	6.8	12	15	5	M10x1
M-ISNA0602	6	2	1.2	3	73	121	6.8	12	20	6	M10x1
M-ISNA0801	8	1	0.8	3	135	225	7.4	16	22	8	M14x1
M-ISNA0802	8	2	1.2	3	135	225	7.4	16	27	8	M14x1
M-ISNA0802.5	8	2.5	1.2	3	177	278	7.4	16	29	8	M14x1
M-ISNA1002	10	2	1.588	3	185	305	9.0	18	28	7	M16x1
M-ISNA1003	10	3	2.0	3	185	305	9.0	18	28	7	M16x1
M-ISNA1004	10	4	2.381	3	395	590	9.0	26	34	10	M16x1
M-ISNA1201	12	1	0.8	3	173	317	11	20	39	10	M18x1
M-ISNA1202	12	2	1.588	3	173	317	11	20	28	10	M18x1
M-ISNA1202.5	12	2.5	1.2	3	173	317	11	20	28	10	M18x1
M-ISNA1203	12	3	2.0	3	173	317	11	20	33	10	M18x1
M-ISNA1204	12	4	2.381	3	454	722	11	24	28	10	M20x1
M-ISNA1205	12	5	2.5	3	619	883	17	24	38	10	M20x1
M-ISNA1402	14	2	1.2	3	287	633	12	24	38	10	M20x1
M-ISNA1602	16	2	1.588	3	253	670	12	25	44	10	M22x1
M-ISNA1602.5	16	2.5	1.2	3	253	670	12	25	44	10	M22x1
M-ISNA1603	16	3	2.0	3	253	670	12	25	44	10	M22x1
M-ISNA1604	16	4	2.381	3	640	1340	16	28	42	10	M24x1.5

Not: the size and shape of the nut can be made as per customers' requirement.

P: lead . Dw: ball diameter n: number of ball recirculation. K: stiffness (Kgf/μm).
Ca: basic dynamic rating load (Kgf). Coa: basic static rating load (Kgf).

End-cap Nut of High Speed (M-ESNF)

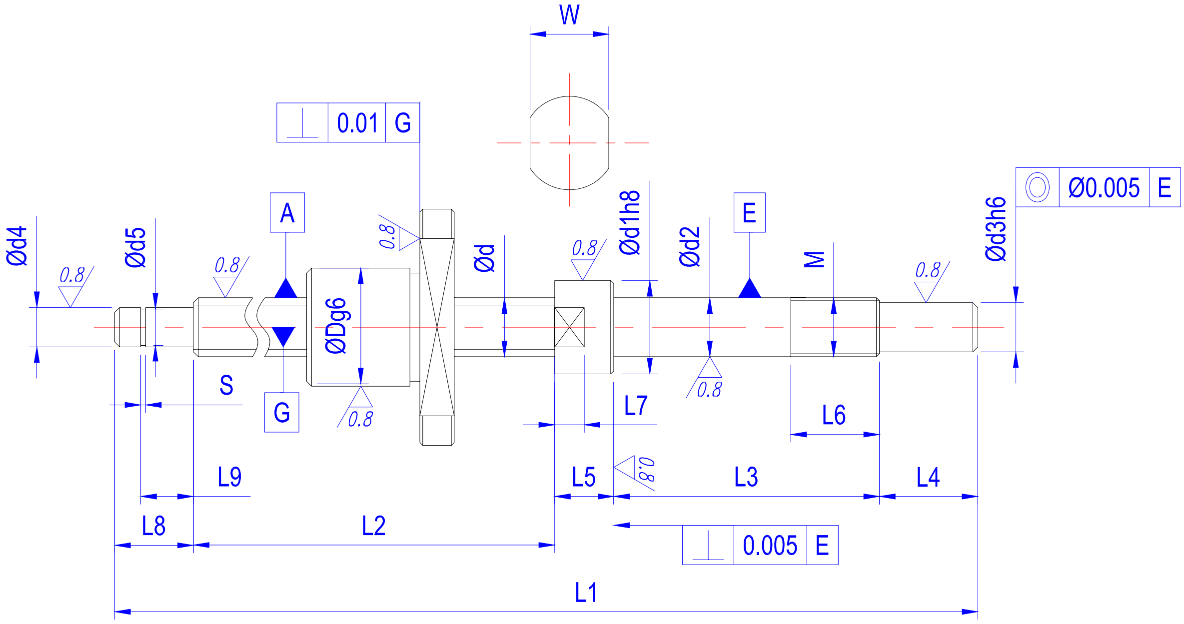


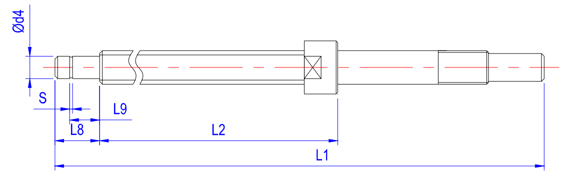
Code	d	P	Dw	n	Ca	Coa	Nut Dimension							
							D	A	E	B	L	X	PCD	H
M-ESNF0606	6	6	1.0	1.6x2	87	145	14	27	8	4	17	3.4	21	16
M-ESNF0610	6	10	1.2	1.2x2	95	160	14	27	11.5	4	23	3.4	21	16
M-ESNF0808	8	8	1.5875	1.6x2	220	380	18	31	10	4	20	3.4	25	20
M-ESNF0812	8	12	1.5875	1.6x2	220	400	18	31	17	4	27	3.4	25	20
M-ESNF1010	10	10	2.0	1.6x2s	330	590	23	40	13	5	24	3.4	32	25
M-ESNF1015	10	15	2.0	1.6x2s	330	640	23	40	22	5	33	4.5	32	25
M-ESNF1210	12	10	2.381	1.7x2	510	980	24	41	14.5	6	30	4.5	33	26

Not: the size and shape of the nut can be made as per customers' requirement.

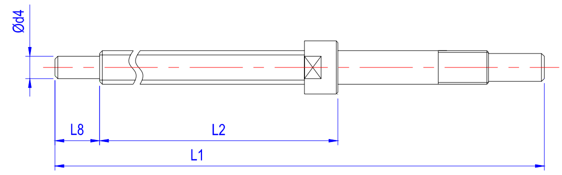
P: lead . Dw: ball diameter n: number of ball recirculation. K: stiffness (Kgf/μm).
Ca: basic dynamic rating load (Kgf). Coa: basic static rating load (Kgf).

Suggested End Machining of Screw Shaft

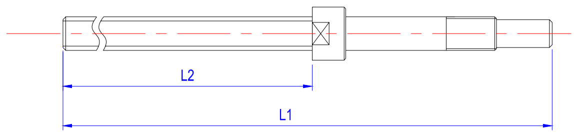




A Type



B Type



C Type

Unit: mm

d	Fixed End										Support end				
											A type				
											B type				
	d1	L5	L7	W	d2	L3	M	L6	d3	L4	d4	L8	d5	S	L9
4	6 0/-0.018	6	2.5	5	4 -0.001/-0.006	18	M4x0.5	6.5	3 0/-0.006	5	3 -0.002/-0.010	7	2.7	0.5	4.35
6	8 0/-0.022	7	3	7	5 -0.001/-0.006	19	M5x0.5	6.5	4 0/-0.008	6	4 -0.002/-0.012	8	3.7	0.5	5.35
8	9.5 0/-0.022	7	3	8	6 -0.001/-0.006	22.5	M6x0.75	7	4.5 0/-0.008	7.5	6 -0.002/-0.012	9	5.7	0.8	6.8
10	11.5 0/-0.027	8	4	10	8 -0.001/-0.006	27	M8x1.0	9	6 0/-0.008	10	6 -0.002/-0.012	9	5.7	0.8	6.8
12	14 0/-0.027	10	5	12	10 -0.002/-0.008	30	M10x1.0	10	8 0/-0.009	15	8 -0.004/-0.012	10	7.6	0.9	7.9
14	15 0/-0.027	10	5	12	12 -0.003/-0.011	30	M12x1.0	10	10 0/-0.009	15	10 -0.004/-0.012	12	9.6	1.15	9.15
16	16 0/-0.027	10	5	12	12 -0.003/-0.011	30	M12x1.0	10	10 0/-0.009	15	10 -0.004/-0.012	12	9.6	1.15	9.15

Note: other customized end machining is available upon request.

Ballscrew Request Form

Company:	Address:	
Tel:		
Fax:	Country:	
Machine Type:	Delivery Point:	
Application:	Desired Delivery Date:	Quantity:

1	**Required Specifications**
	A1. Thread Direction: ☐ L ☐ R / A2. Number Of Thread (1~4):
	B1. Screw Nominal O.D: / B2. Lead: / B3. Effective Turns:
	C1. Thread Length: / C2. Overall Length: / C3. Accuracy Grade:
	D. Nut Type: ☐ Miniature Series ☐ End Deflector Series ☐ External Ball Circulation Series ☐ End Cap Series ☐ Internal Ball Circulation Series ☐ High Lead Series ☐ Heavy Load Series
2	**Load Condition**
	A1. Stroke: *mm* / *A2.Max. Rotation Speed: r.p.m* / *A3.Motor Specifications: kw*
	B1. Mounting Method :☐ Vertical ☐ Horizonta ☐Oblígue / B2. Declining Angle: / B3. Mounting Span: *mm.*
	C1. Accelereation Time : *S.* / *C2. Accelereation Speed : m/s2.* / *C3. Rapid Feed Speed : m/min.*
	D. Life : ×106 revs | *km* | *hr*
	E. Working Axial Load : Rapid Feed: *kgf* | *Feed Speed: mm/min* | *Time:* Ratio(%) Light Cutting: *kgf* | *Feed Speed: mm/min* | *Time:* Ratio(%) Heavy Cutting: *kgf* | *Feed Speed: mm/min* | *Time:* Ratio(%)
	F. Max. Axial Static Load : *kgf*
	G. Table Weight: *kg* / *G.: Work Piece Weight: kg*
	H. Linear Guide Way: ☐ Ball Type ☐ Roller Type ☐ Box Way
	I. Mount Method: ☐ Fixed-Fixed ☐ Fixed-Supported ☐ Fixed-Free ☐ Supported-Supported
3	**Lead Accuracy, Axial Clearance, Preload and Stiffness**
	A. Specified Travel (T): *mm*
	B1. Positioning Accuracy: *mm(No Load)* / *B2. Repeatability Accuracy: mm(No Load)*
	C1. Preload: *kgf* / *C2. Preload Torque: kgf/cm*
	D. Axial play: *mm (No Load)*
	E. Nut Stiffness: *kgf/μm*
4	**Other Conditions**
	A. Lubrication Oil: | Grease: | Other:
	B. Ambient Temperature: ☐ ℃ ☐ ℉
	C. Special Conditions:

Screw Technology Co., Ltd.

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