Rolled Ball Screw

Technical Information of Rolled Ball Screws

"Zero" Axial Clearance

Low price Quick Delivery
Ball Screw shafts are mass-produced by thread rolling process result in considerable cost reduction.
Always stocked for short delivery.

High Transmission Efficiency

As ball roll between a screw shaft and nut, smooth rotation and high transmission efficiency are possible. Therefore, driving torque is lower one third as compared with that of conventional sliding screws, and moreover, it is easy to change the linear action to the rotary motion.

Outstanding durability

Rigidly selected materials, proper heat-treatment and advanced processing are combined to provide outstanding durability.

Material and heat-treatment

	MATERIAL	HEAT-TREATMENT	HARDNESS
SCREW SHAFT	S55C	INDUCTION HARDENING	HRC56~62
NUT	SCM420	HADENING AFTER CARBURIZATION	HRC58~62
STEEL BALL	SCN420	HARDENING	HRC60 OR MORE

Size of Rolled Ball Screws

O.D.OF SCREW SHAFT	LEAD		
	4	5	10
16		500 1000 1500 2000	
20		500 1000 1500 2000	
25		1000 1500 2000 2500	1000 1500 2000 2500
32		1000 1500 2000 3000	1000 1500 2000 3000
40		1000 2000 3000 4000 5000	1000 2000 3000 4000 5000
		1000 2000 3000 4000 5000	1000 2000 3000 4000 5000

Axial Play

O.D.OF SCREW SHAFT	C7	C10
1605 1610 2005 2505	0.04mm	0.10mm
2510 3205 3210	0.07mm	0.17mm
4005 4010	0.10mm	0.10mm

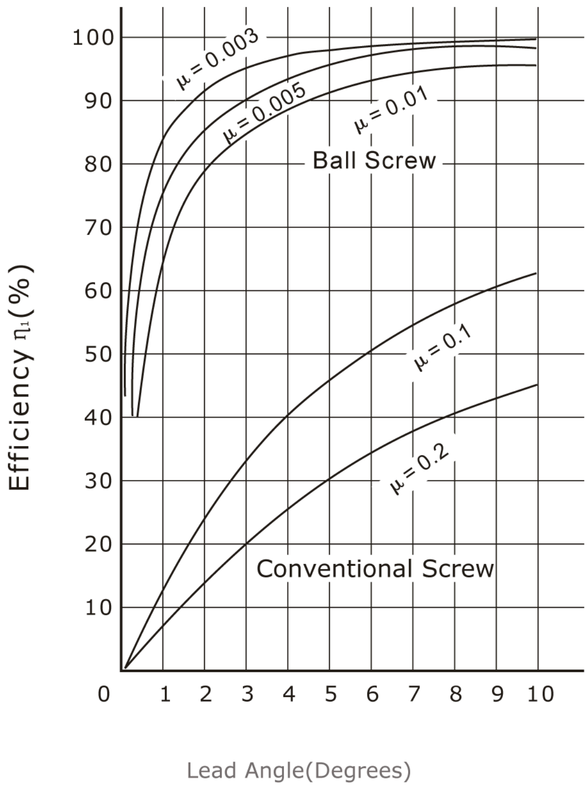
Features Ball Screws

(1)High Reliability

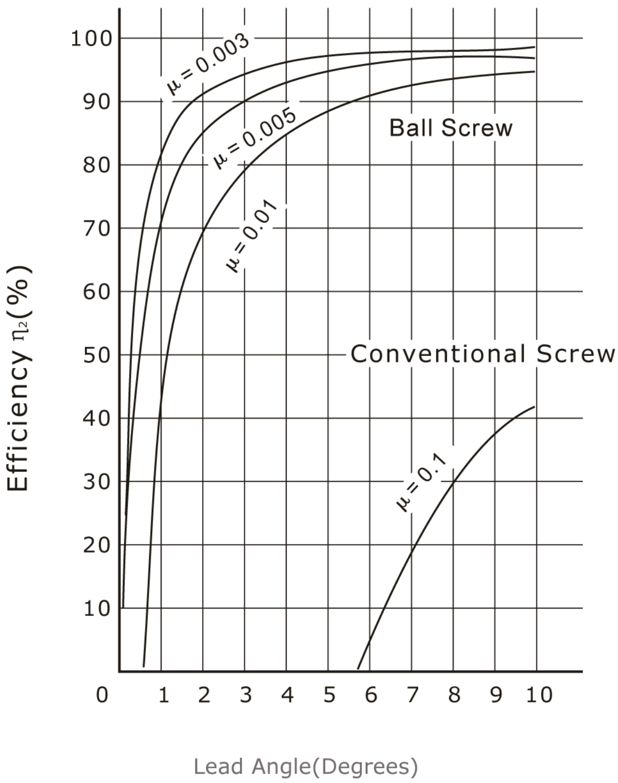
has very stringent quality control standards covering every production process. With proper lubrication and use, trouble-free operation for an extended period of time is possible.

(2)Smooth Operation

The high efficiency of ball screws is vastly superior to conventional screws as shown in Fig. 1.1. The torque required is less than 30%. Linear motion can be easily changed from rotary motion.



Normal usage(to convert rotary motion to linear motion)



Special usage(to convert linear motion to rotary motion)

μ : friction coefficient

$$T = \frac{P \cdot l}{2\pi\eta_1}$$

T = Torque kgf • cm
P = Force kgf
l = Lead cm
η_1 = Efficiency

$$T = \frac{P \cdot l}{2\pi\eta_2}$$

T = Torque kgf • cm
P = Force kgf
l = Lead cm
η_2 = Efficiency

Fig. 1.1 Mechanical Efficiency of Ball Screws

(3)High Rigidity and Preload
When axial play is minimized in conventional screw-nut assemblies, the actuating torque becomes excessive and the operation is not smooth. The axial play in precision ball screws may be reduced to zero by preloading and a light smooth operation is still possible. Therefore, both low torque and high rigidity can be obtained simultaneously.
Ball screws have gothic arch groove profiles (Fig. 1.2) which allow these conditions to be achieved.

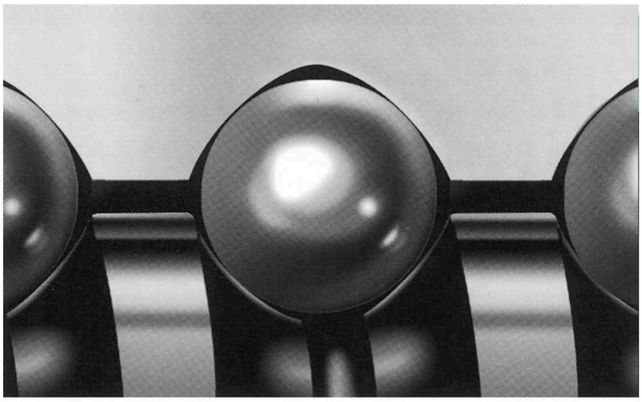


Fig. 1.2 Groove Shape of Precision Ball Screw

(4)Circulation Method
Fig. 1.3 is ball return tube method. (T type \ E type)
Fig. 1.4 is ball deflector method. (I type \ K type)

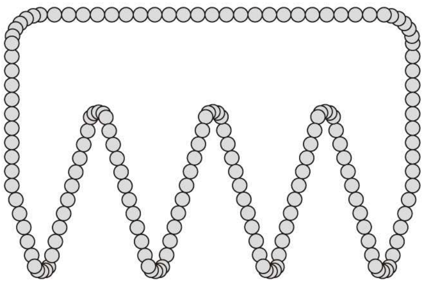


Fig. 1.3 Ball Retum Tube method.

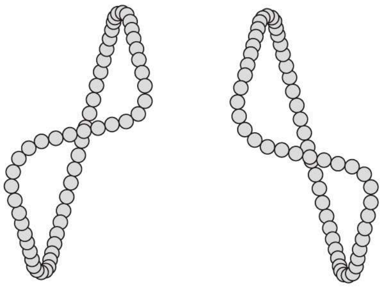


Fig. 1.4 Ball Deflector method.

(5)High Durability
Rigidly selected materials, intensive heat treating and processing techniques, backed by years of experience, have resulted in the most durable ball screws manufactured.
(As show Table 1.1 and Fig. 1.5)

Table 1.1 Material and Heat Treatment

ITEM	MATERIAL	HEAT TREATMENT	HARDNESS
SCREW	SCM450 S55C	INDUCTION HEATING HARDENING	HRC58~62
NUT	SCM420	CARBONIZING HARDENING	HRC58~62
STEEL BALL	SUJ2		HRC60° UP

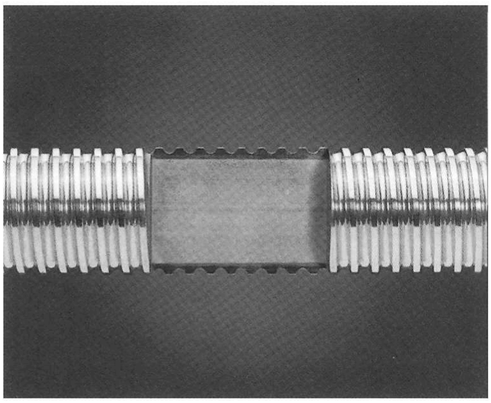


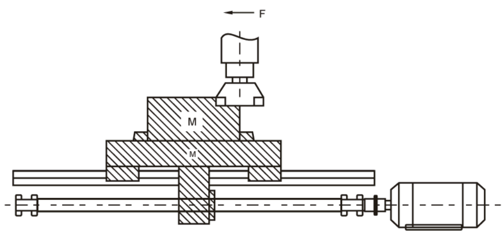
Fig. 1.5 Heat Treatment

Key Points for Ball Screw Selection and Calculation

Key points for ball screws selection

When ball screws are subjected to selection, it is a most fundamental rule that you must first clearly find out what the operation conditions are before going ahead with the final design. Moreover, the elements of your selection include load weight, stroke, torque, position determination accuracy, tracking motion, hardness, lead stroke, nut inside diameter, etc., All elements are mutually related, any change to one of the elements will lead to the changes of other elements, special attention should always be paid to the balance among the elements.

Calculation for ball screws selection



Design conditions

1.Working table weight 300 Kg
2.Working object weight 400 kg
3.Maximal 700 mm
4.Fast feed speed 10 m/min
5.Minimal disassembly ability 10 μ=m/stroke
6.Driving motor DC motor (MAX 1000 min^{-1})
7.Guiding surface friction coefficient (μ=0.05~0.1)
8.Running rate 60%
9.Accuracy review items
10.Inertia generated during acceleration/deceleration can be neglected because the time periods involved are comparatively small.

1.Setting of operation conditions

(a) Machine service life time reckonig of H (hr)

H= ☐ × ☐ × ☐ × ☐

hours/day days/year life years Running

(b) Mechanical conditions

Calculation Date / Difference Operations	Speed/rotations	Cutting resistance	Sliding resistance	Time used
Fast feed	m / min / min^{-1}	kgf	kgf	%
Light cutting	/			
Medium cutting	/			
Heavy cutting	/			

(c) Position determination accuracy

Feed accuracy error factor includes load accuracy and system rigidity. Thermal displacement due to heat generation and positional error of the guide system is also important factors.

1.Setting of operation conditions

(a) Machine service life time reckon of H (hr)

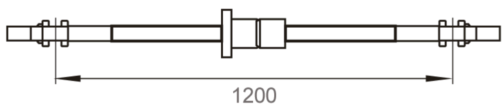
H=12 hrs × 250 days × 10 years × 0.6 Running =18000hr

(b) Mechanical conditions

Calculation Date / Difference Operations	Speed/rotations	Cutting resistance	Sliding resistance	Time used
Fast feed	10m / min / 1000min^{-1}	0 kgf	70 kgf	10 %
Light cutting	6 / 600	100	70	50
Medium cutting	2 / 200	200	70	30
Heavy cutting	1 / 100	300	70	10

Sliding resistance = (300+400) × 0.1=70 kgf

Key points for ball screws selection	Calculation for ball screws selection
2. Ball screws lead stroke l (mm) $l = \dfrac{\text{Fast feed stroke (m/min) x 1000}}{\text{Max. Rotating speed (min}^{-1}\text{) of motor}}$ (mm)	2. Ball screws lead stroke l (mm) $l = \dfrac{10000}{1000} = 10$ (mm) Minimal disassembly = $\dfrac{\text{10mm}}{\text{1000 stroke}}$ = 0.01 mm/stroke
3. Computation of average load Pe (kg f) $Pe = \left(\dfrac{P_1^3 n_1 t_1 + P_2^3 n_2 t_2 + \cdots + P_n^3 n_n t_n}{n_1 t_1 + n_2 t_2 + \cdots + n_n t_n} \right)^{1/3}$ $Pe = \dfrac{2Pmax + Pmin}{3}$ pe ≒ 0.65Pmax pe ≒ 0.75Pmin	3. Computation of average load Pe (kg f) Pe = $\left(\dfrac{70^3 \times 1000 \times 10 + 170^3 \times 600 \times 50 + 270^3 \times 200 \times 30 + 370^3 \times 100 \times 10}{1000 \times 10 + 600 \times 50 + 200 \times 30 + 100 \times 10} \right)^{1/3}$ $= \left(\dfrac{31.7 \times 10^{13}}{4.7 \times 10^{4}} \right)^{1/3}$ ≒ 189 kg f
4. Average number of rotations n_m $n_m = \dfrac{n_1 t_1 + n_2 t_2 + \cdots + n_n t_n}{100}$	4. Average number of rotations n_m $n_m = \dfrac{1000 \times 10 + 600 \times 50 + 200 \times 30 + 100 \times 10}{100}$ $= \dfrac{4.7 \times 10^{4}}{100}$ $= 470 \text{ min}^{-1}$
5. Calculation of required dynamic rated load Ca Ca = Pe • fs	5. Calculation of required dynamic rated load Ca Ca = 189 x 5=945 (kg f)
6. Calculation of required static rated load Coa Coa = Pmax • fs	6. Calculation of required static rated load Coa Coa = 369 x5 =1845 (kg f)
7. Selection of nut type Ca > 945 Coa > 1845 Select the nut types with basic dynamic rated load and basic static rated load as specified above.	7. Selection of nut type Choose SF I 4010 on the catelogue Ca= 3178 kg f Coa= 9480 kg f

Key points for ball screws selection	Calculation for ball screws selection
8. Calculation of life confirmation Lt (h) $L_t = \left(\frac{Ca}{Pe \cdot fw} \right)^3 \cdot \frac{1}{60n_m} \cdot 10^6$	8. Calculation of life confirmation Lt (h) $L_t = \left(\frac{3178}{189 \cdot 2} \right)^3 \cdot \frac{1}{60 \cdot 470} \cdot 10^6$ =20479(h)
9. Determination of screw length Screw length = Maximal stroke + Nut length + 2 x reserved length at shaft end	9. Determination of screw length Screw length = 700+93+2 x 81 = 874 mm
10. Mounting distance of screw length	10. Mounting distance of screw length(F-F support) 
11. Permissible axial load	11. Permissible axial load Omitted because of F-F support
12. Permissible revolution speed n and dm $n = \alpha \times \frac{60\lambda^2}{2\pi L^2} \sqrt{\frac{EIg}{\gamma A}} = f \frac{dr}{L^2} \times 10^7 \text{ (rpm)}$ dm = Shaft dia. x Maximal speed	12. Permissible revolution speed n and dm $n = \frac{21.9 \times 35.2 \times 10^7}{1200^2}$ $= 5353 \text{min}^{-1} > n_{max}$ dm = 40 x 1000 = 40000 < 50000
13. Countermeasure against thermal displacement and rigidity	13. Counter measure against thermal displacement and rigidity (a) It is estimated there would be a temperature rise of 2~5℃ with the ball screws of the general machinery, take temperature rise of 2℃ to computer the extension of ball screw. $\Delta_l = \alpha \cdot t \cdot L$ $= 11.7 \times 10^{-6} \times 2 \times 700 \text{ mm} \fallingdotseq 0.016 \text{ mm}$ $F_P = \frac{EA\Delta_l}{L}$ $= \frac{2.06 \times 10^4 \times \frac{\pi \times 35.2^2}{4} \times 0.016}{700} \fallingdotseq 458 \text{ kgf}$

Key points for ball screws selection	Calculation for ball screws selection
(Reference) Force exerted on ball screw when inertia is considered ◎ When used horizontally 1. During acceleration $P_{ACC} = Mg \times \mu + \frac{M \times V}{60 \times \Delta t}$ 2. During deceleration $P_{DEC} = Mg \times \mu - \frac{M \times V}{60 \times \Delta t}$ ◎ When used vertically 1. During acceleration while descending, during deceleration while ascending $P_U = Mg - \frac{M \times V}{60 \times \Delta t}$ 2. During acceleration while descending, during deceleration while ascending $P_D = Mg + \frac{M \times V}{60 \times \Delta t}$ M : Mass of moving object (kg) g : Acceleration of gravity (9.8m/s) V : Velocity (m/min) t : Acceleration / deceleration time (s) μ: Friction coefficient	Deviation can be corrected by estimating the temperature rise per extension of 0.016mm, and taking into consideration of the pre-tension of 458 kgf . (b) Rigidity (1) Directional rigidity $\delta_{SF} = \frac{PL}{4AE} = \frac{27 \times 1200}{4 \times \frac{\pi \times 35.2^2}{4} \times 2.06 \times 10^4}$ $= 0.00036$ mm $K_S = \frac{370}{0.00036} = 10.3 \times 10^5$ kgf / mm (2) Rigidity of steel ball and nut groove $n = \frac{41.8 \times \pi \times 2.5}{6.35} = 52$ $Q = \frac{370}{52 \sin 45^\circ} = 10$ $\delta_{NS} = \frac{0.00057}{\sin 45^\circ} \left(\frac{10^2}{6.35}\right)^{1/3} \times \frac{1}{0.7}$ $= 2.9 \times 10^{-3}$ mm $K_N = \frac{370}{2.9 \times 10^{-3}} = 1.28 \times 10^5$ kgf / mm (2) Rigidity of bracing bearings Where, nut rigidity 50 kgf / mm $\delta_B = \frac{370}{50 \times 2} = 3.7$ μm $K_B = \frac{370}{0.0037} = 1 \times 10^5$ kgf / mm ◎ $\delta_{TOTAL} = 0.36 + 2.9 + 3.7 = 6.96$ μm
14. Confirmation of the ball screw life	14. Confirmation of the ball screw life L=20479(h) > 18000 (h)

Key Points for Ball Screw Selection and Calculation

Lubrication

Adequate lubrication must be provided when ball screw is used, insufficient lubrication will result in contact of metal, which in turn leads to increase of friction and friction loss, thus cause failure or shortening of service life.
Lubricants applied to ball screws can be divided into 2 types, namely lubricating oil and consistent grease. In general speaking, in respect of maintenance, consistent grease will lead to increase of dynamic friction torque linearly along with increase of rotating speed, hence oil lubrication is deemed the better better way when speed exceeds 3-5 m/min; however don't forget the fact that there have been examples that using grease has been capable of achieving speed of 10 m/min, with respect to the equipment.

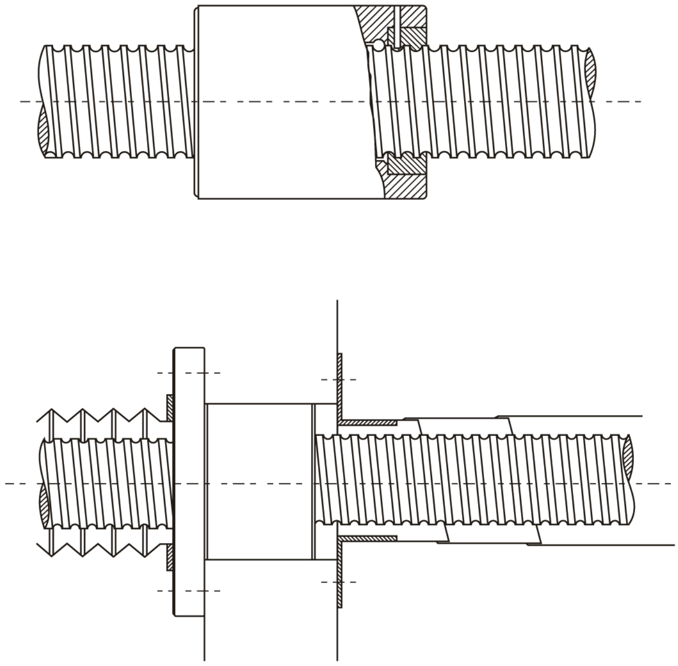


Fig. 5.1 Dust proof Method by Telescopic Cover and Bellows

Table 2.1 Inspection of lubrication and interval of refill

Method	Interval	Check Item	Replenish or Change Interval
Auto. Intermittent oil supply	Weekly	Oil level, contamination	Add at each check, as required depending on tank level
Grease	nitially 2-3 months	Contamination \on entry of chip	Replenish yearly or according to the inspection results
Oil bath	Daily	Oil level	To be determined according to consumption

Contaminant Prevention

Any foreign matter or water, if allowed to enter the ball screw, may increase friction and cause damage.
For example, the entry of chips or cutting oil may be expected with machine tools depending on the work environment. Where entry of foreign matter is anticipated, use a bellows or telescopic cover as shown in Fig. 5.1, to cover the screw shaft completely.

Offset load

When offset load phenomenon occurs, screw life and noise tend to be directly affected, which would usually be accompanied with hand feel of rough running. In the event unload running and running right after assembling demonstrate different degree of cases, this should be ascribed to the poor assembly accuracy which will produce offset load phenomenon as shown in Fig. 5.2

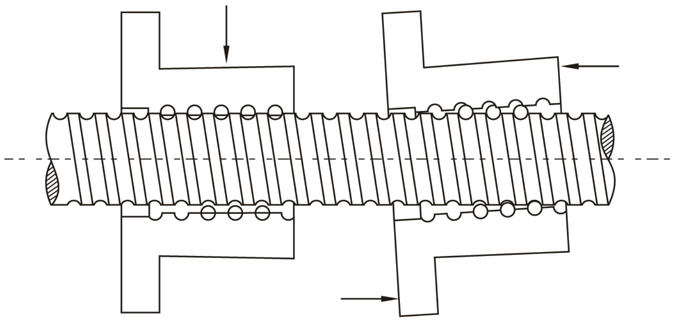
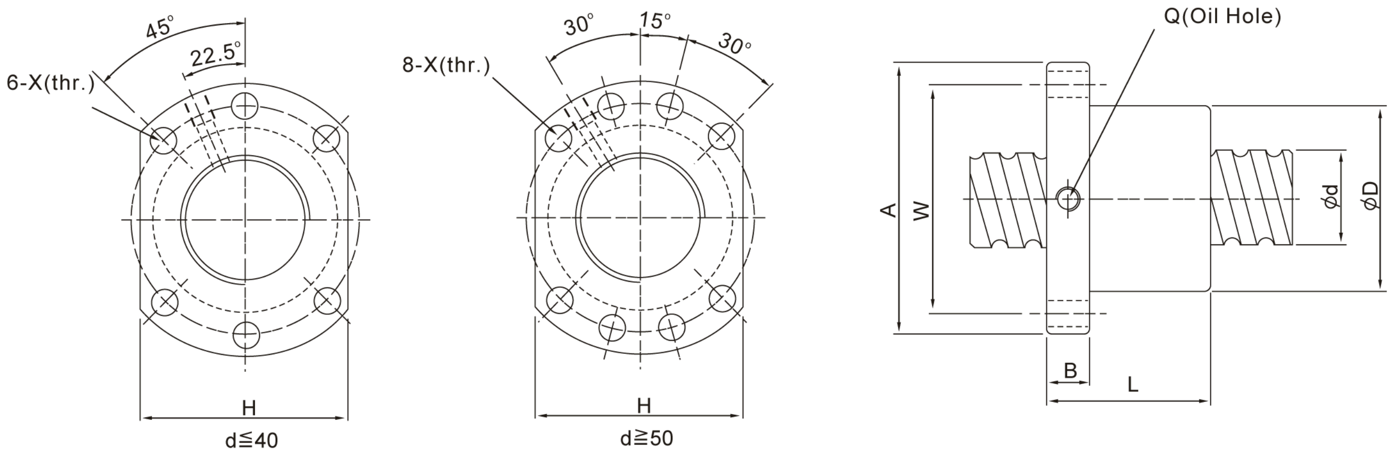


Fig. 5.2 Offset load

SFU-Standard Series

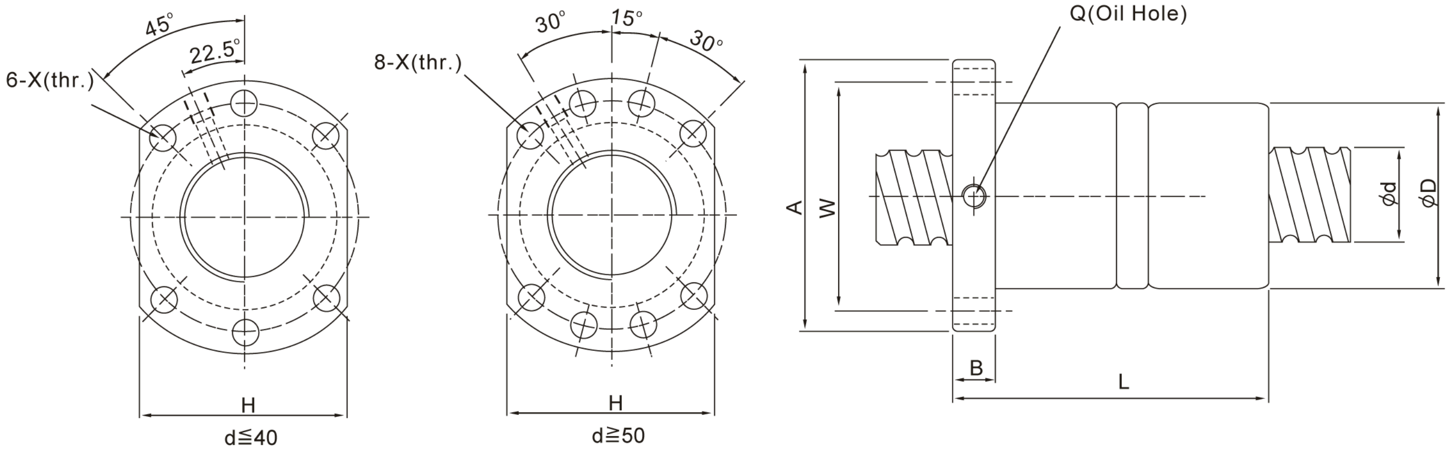


Unit:mm

I：Lead　Da：Ball Dia.　n：Number of Circuits　K：Stiffness (kg/μm)
Ca：Basic Dynamic Rating Load (kgf)　Coa：Basic Static Rating Load (kgf)

Part No.	Dimensions													
	d	I	Da	D	A	B	L	W	X	H	Q	n	Ca	Coa	K
SFU1604	16	4	2.381	28	48	10	40	38	5.5	40	M6	4	629	1270	35
SFU1605		5	3.175	28	48	10	50	38	5.5	40	M6	4	780	1790	20
SFU1610		10	3.175	28	48	10	57	38	5.5	40	M6	3	721	1249	15
SFU2004	20	4	2.381	34	57	11	46	45	5.5	40	M6	4	670	1480	41
SFU2005		5	3.175	36	58	10	51	47	6.6	44	M6	4	1130	2380	25
SFU2505	25	5	3.175	40	62	10	51	51	6.6	48	M6	4	1280	3110	35
SFU2510		10	4.762	40	62	12	85	51	6.6	48	M6	4	1944	3877	33
SFU3205	32	5	3.175	50	80	12	52	65	9	62	M6	4	1450	4150	40
SFU3210		10	6.350	50	80	12	90	65	9	62	M6	4	3390	7170	79
SFU4005	40	5	3.175	63	93	14	55	78	9	70	M8	4	1610	5330	49
SFU4010		10	6.350	63	93	14	93	78	9	70	M8	4	3910	9520	50
SFU5010	50	10	6.350	75	110	16	93	93	11	85	M8	4	4450	12500	65
SFU5020		20	7.144	75	110	16	138	93	11	85	M8	4	4644	14327	59.5

DFU-Standard Series



Unit:mm

I：Lead　Da：Ball Dia.　n：Number of Circuits　K：Stiffness (kg/μm)
Ca：Basic Dynamic Rating Load (kgf)　Coa：Basic Static Rating Load (kgf)

Part No.	Dimensions													
	d	I	Da	D	A	B	L	W	X	H	Q	n	Ca	Coa	K
DFU1604-4	16	4	2.381	28	48	10	80	38	5.5	40	M6	4	629	1270	35
DFU1605-4		5	3.175	28	48	10	100	38	5.5	40	M6	4	780	1790	20
DFU1610-3		10	3.175	28	48	10	118	38	5.5	40	M6	3	721	1249	15
DFU2004-4	20	4	2.381	36	58	10	80	47	6.6	44	M6	4	699	1617	41
DFU2005-4		5	3.175	36	58	10	101	47	6.6	44	M6	4	1130	2380	25
DFU2505-4	25	5	3.175	40	62	10	101	51	6.6	48	M6	4	1280	3110	35
DFU2510-4		10	4.762	40	62	12	145	51	6.6	48	M6	4	1944	3877	33
DFU3205-4	32	5	3.175	50	80	12	102	65	9	62	M6	4	1450	4150	40
DFU3210-4		10	6.35	50	80	12	162	65	9	62	M6	4	3390	7170	79
DFU4005-4	40	5	3.175	63	93	14	105	78	9	70	M8	4	1610	5330	49
DFU4010-4		10	6.35	63	93	14	165	78	9	70	M8	4	3910	9520	50
DFU5010-4	50	10	6.35	75	110	16	171	93	11	85	M8	4	4450	12500	65
DFU5020-4		20	7.144	75	110	16	280	93	11	85	M8	4	4644	14327	59.5

POWER BELT

MAGYARORSZÁG:
www.powerbelt.hu
linearistechnika@powerbelt.hu
+36 1/455-2079

УКРАЇНА:
www.powerbelt.com.ua
liniyna.technika@powerbelt.com.ua
+380 3131 31306

ROMÂNIA:
www.powerbelt.ro
tehnicaliniara@powerbelt.ro
+40 75 6138142

SLOVENSKO:
www.powerbelt.sk
linearnatechnika@powerbelt.sk
+421 2 446 38 144