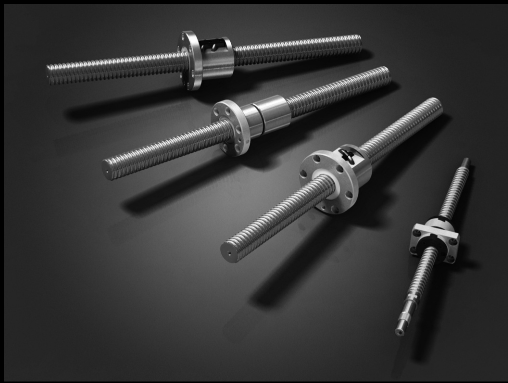


Ball Screw

THK General Catalog

Features of the Ball Screw

Driving Torque One Third of the Sliding Screw

With the Ball Screw, balls roll between the screw shaft and the nut to achieve high efficiency. Its required driving torque is only one third of the conventional sliding screw. (See Fig.1 and Fig.2.) As a result, it is capable of not only converting rotational motion to straight motion, but also converting straight motion to rotational motion.

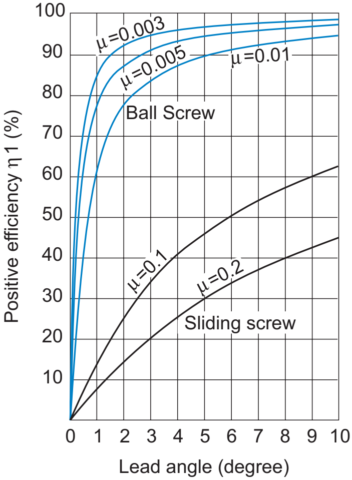


Fig.1 Positive Efficiency (Rotational to Linear)

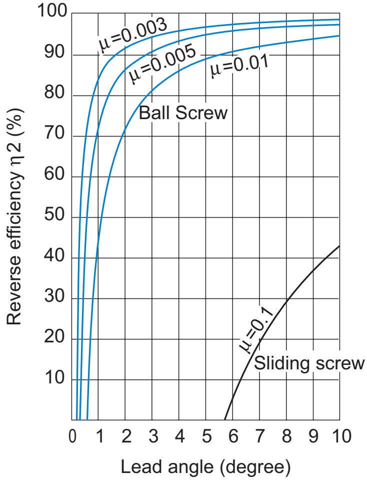


Fig.2 Reverse Efficiency (Linear to Rotational)

[Calculating the Lead Angle]

$$\tan\beta = \frac{Ph}{\pi \cdot d_P} \quad \cdots\cdots\cdots(1)$$

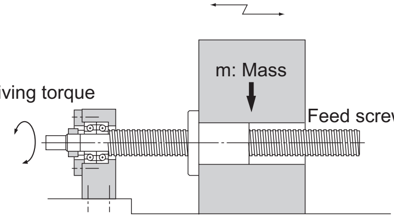
β	: Lead angle	(°)
d_P	: Ball center-to-center diameter	(mm)
Ph	: Feed screw lead	(mm)

[Relationship between Thrust and Torque]
The torque or the thrust generated when thrust or torque is applied is obtained from equations (2) to (4).

● Driving Torque Required to Gain Thrust

$$T = \frac{Fa \cdot Ph}{2\pi \cdot \eta 1} \quad \cdots\cdots\cdots(2)$$

T : Driving torque (N-mm)
Fa : Frictional resistance on the guide surface (N)
$Fa = \mu \times mg$
μ : Frictional coefficient of the guide surface
g : Gravitational acceleration ($9.8\ m/s^2$)
m : Mass of the transferred object (kg)
Ph : Feed screw lead (mm)
$\eta 1$: Positive efficiency of feed screw
(see Fig.1 on A-664)



● Thrust Generated When Torque is Applied

$$Fa = \frac{2\pi \cdot \eta 1 \cdot T}{Ph} \quad \cdots\cdots\cdots(3)$$

Fa : Thrust generated (N)
T : Driving torque (N-mm)
Ph : Feed screw lead (mm)
$\eta 1$: Positive efficiency of feed screw
(see Fig.1 on A-664)

● Torque Generated When Thrust is Applied

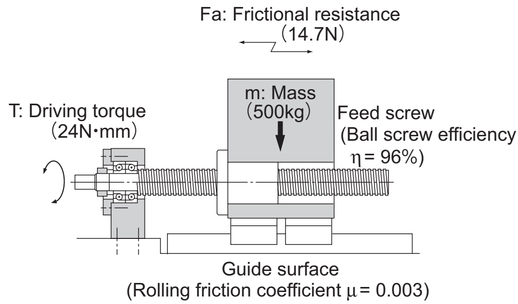
$$T = \frac{Ph \cdot \eta 2 \cdot Fa}{2\pi} \quad \cdots\cdots\cdots(4)$$

T : Torque generated (N-m)
Fa : Thrust generated (N)
Ph : Feed screw lead (mm)
$\eta 2$: Reverse efficiency of feed screw
(see Fig.2 on A-664)

[Examples of Calculating Driving Torque]

When moving an object with a mass of 500 kg using a screw with an effective diameter of 33 mm and a lead length of 10 mm (lead angle: 5°30'), the required torque is obtained as follows.

Rolling guide (μ = 0.003)
Ball Screw (from μ = 0.003, η = 0.96)



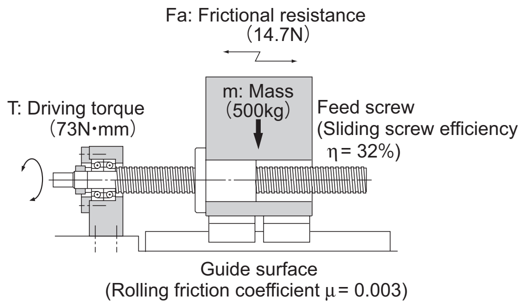
Frictional resistance on the guide surface

Fa=0.003×500×9.8=14.7N

Driving torque

$$T = \frac{14.7 \times 10}{2\pi \times 0.96} = 24\ N \cdot mm$$

Rolling guide (μ = 0.003)
Ball Screw (from μ = 0.2, η = 0.32)



Frictional resistance on the guide surface

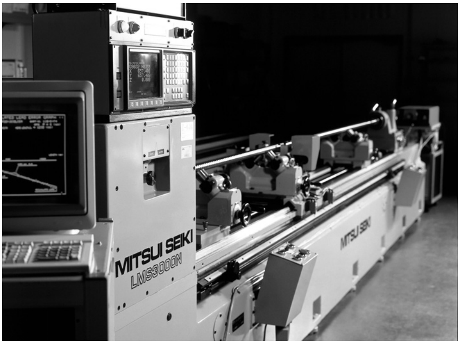
Fa=0.003×500×9.8=14.7N

Driving torque

$$T = \frac{14.7 \times 10}{2\pi \times 0.32} = 73\ N \cdot mm$$

Ensuring High Accuracy

The Ball Screw is ground with the highest-level facilities and equipment at a strictly temperaturecon-trolled factory, Its accuracy is assured under a thorough quality control system that covers assembly to inspection.



Automatic lead-measuring machine using laser

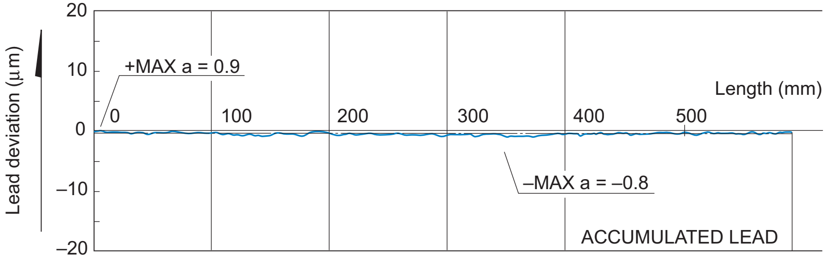


Fig.3 Lead Accuracy Measurement

[Conditions]
Model No.: BIF3205-10RRG0+903LC2

Table1 Lead Accuracy Measurement Unit: mm

Item	Standard value	Actual measurement
Directional target point	0	—
Representative travel distance error	±0.011	−0.0012
Fluctuation	0.008	0.0017

Capable of Micro Feeding

The Ball Screw requires a minimal starting torque due to its rolling motion, and does not cause a slip, which is inevitable with a sliding motion. Therefore, it is capable of an accurate micro feeding.
Fig.4 shows a travel distance of the Ball Screw in one-pulse, 0.1-µm feeding. (LM Guide is used for the guide surface.)

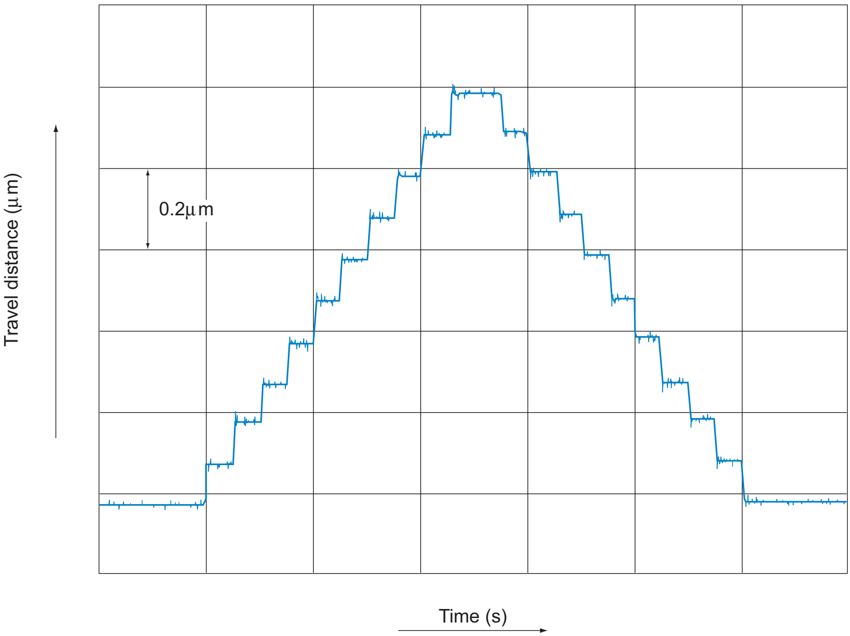


Fig.4 Data on Travel in 0.1-µm Feeding

High Rigidity without Backlash

Since the Ball Screw is capable of receiving a preload, the axial clearance can be reduced to below zero and the high rigidity is achieved because of the preload. In Fig.5, when an axial load is applied in the positive (+) direction, the table is displaced in the same (+) direction. When an axial load is provided in the reverse (-) direction, the table is displaced in the same (-) direction. Fig.6 shows the relationship between the axial load and the axial displacement. As indicated in Fig.6, as the direction of the axial load changes, the axial clearance occurs as a displacement. Additionally, when the Ball Screw is provided with a preload, it gains a higher rigidity and a smaller axial displacement than a zero clearance in the axial direction.

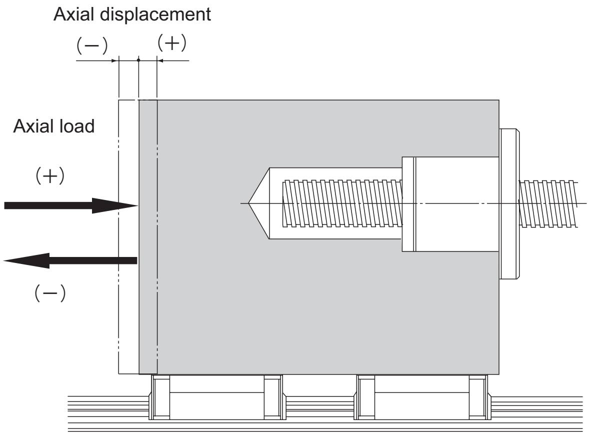


Fig.5

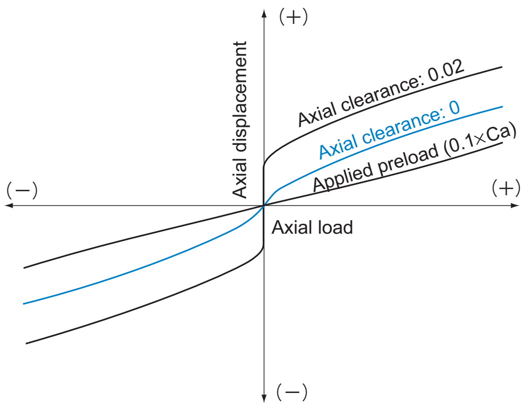


Fig.6 Axial Displacement in Relation to Axial Load

Capable of Fast Feed

Since the Ball Screw is highly efficient and generates little heat, it is capable of a fast feed.

[Example of High Speed]
Fig.7 shows a speed diagram for a large lead rolled Ball Screw operating at 2 m/s.

[Conditions]

Item	Description
Sample	Large Lead Rolled Ball Screw WTF3060 (Shaft diameter: 30mm; lead: 60mm)
Maximum speed	2m/s (Ball Screw rotational speed: 2,000 min^{-1})
Guide surface	LM Guide model SR25W

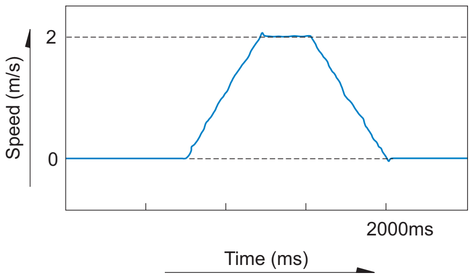


Fig.7 Velocity diagram

[Example of Heat Generation]

Fig.8 shows data on heat generation from the screw shaft when a Ball Screw is used in an operating pattern indicated in Fig.9

[Conditions]

Item	Description
Sample	Double-nut precision Ball Screw BNFN4010-5 (Shaft diameter: 40 mm; lead: 10 mm; applied preload: 2,700 N)
Maximum speed	0.217m/s (13m/min) (Ball Screw rotational speed: 1300 min^{-1})
Low speed	0.0042m/s (0.25m/min) (Ball Screw rotational speed: 25 min^{-1})
Guide surface	LM Guide model HSR35CA
Lubricant	Lithium-based grease (No. 2)

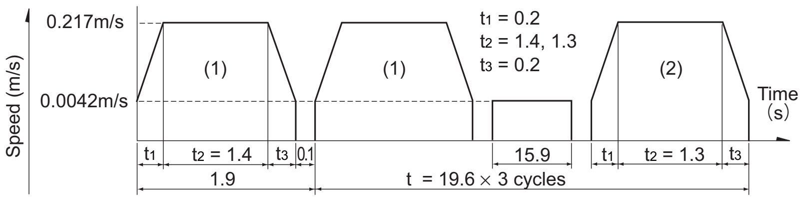


Fig.8 Operating Pattern

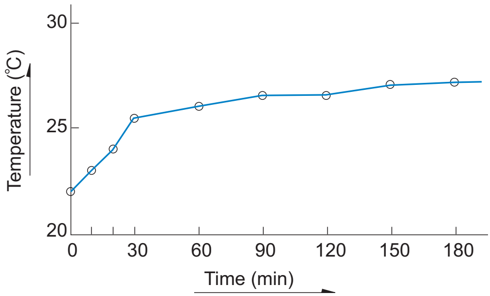
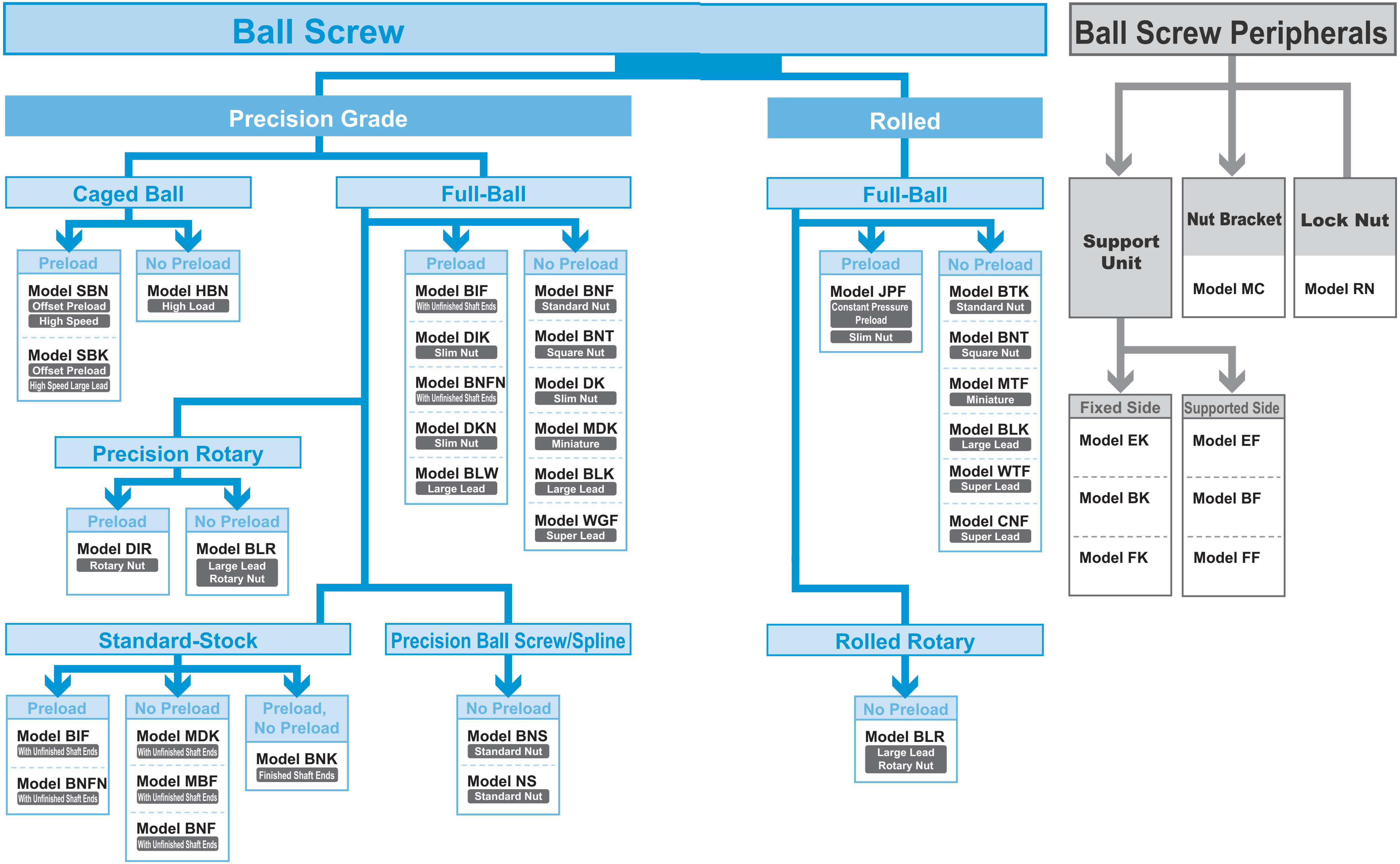


Fig.9 Ball Screw Heat Generation Data

Types of Ball Screws



Ball Screw