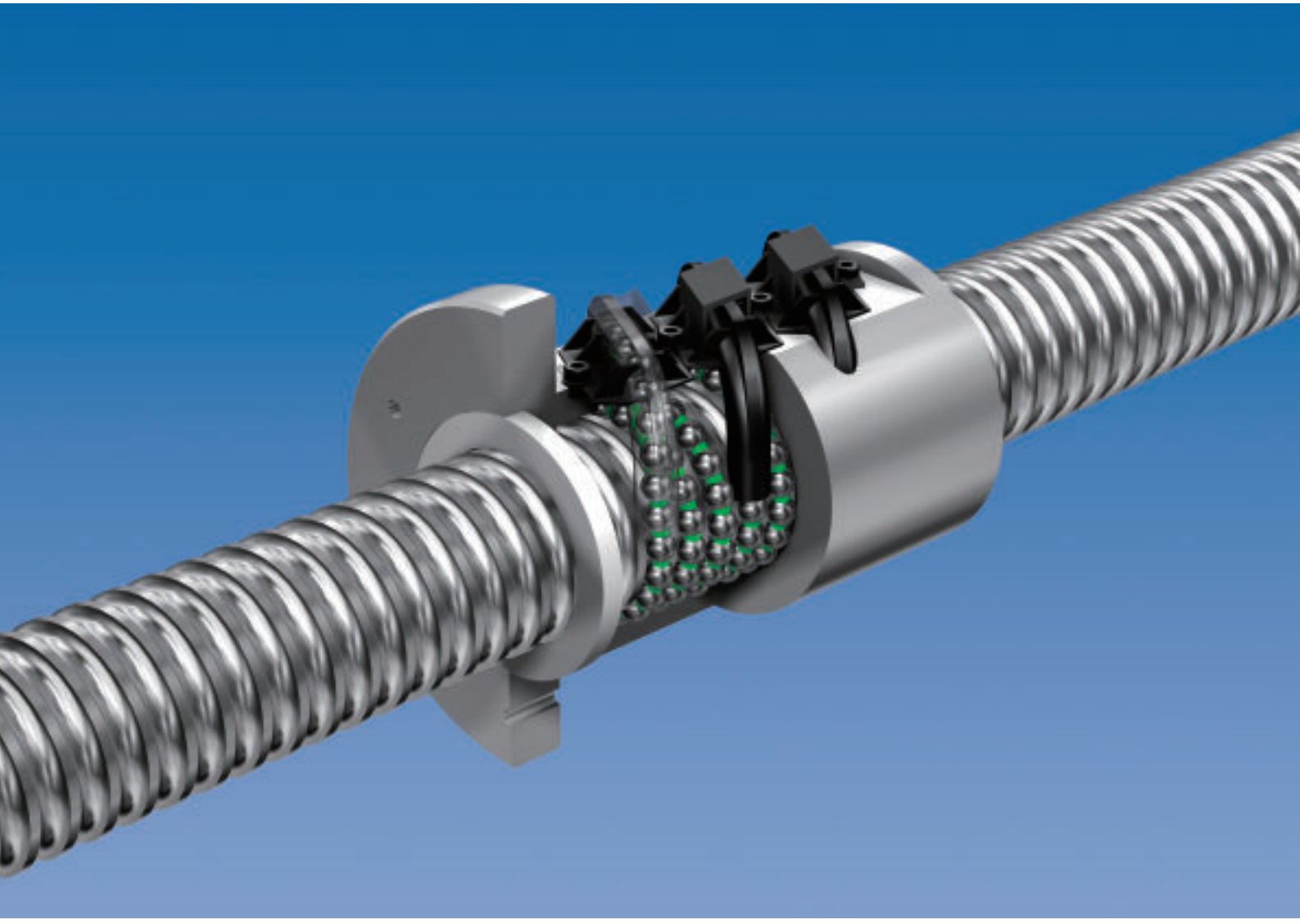
Caged-Ball High-Load Ball Screw

High load capacity
High speed
Low torque fluctuation
Low noise and long-term maintenance-free operation

HBN



For details, visit THK at **www.thk.com**
*Product information is updated regularly on the THK website.

THK CO., LTD.
TOKYO, JAPAN

CATALOG No.296-4E

Allows a machine used in high-load range to be motor driven

Caged-Ball High-Load Ball Screw

HBN

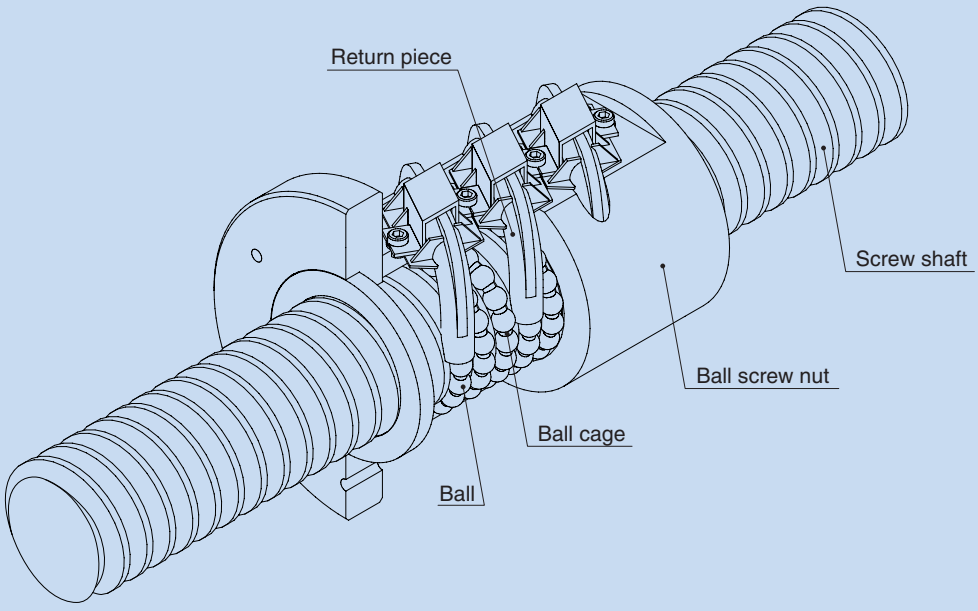


Fig. 1 Structural Drawing of Model HBN

Construction

Caged-Ball high-load ball screw model HBN is characterized by its internal structure design optimum for operation under high-load conditions and, thus, by a significantly enhanced load rating as compared with conventional ball screws.
Model HBN is provided with a ball cage that encases the balls to eliminate ball-to-ball collisions and friction and improve the retention of a lubricant. This allows a longer service life, lower noises, and lower torque fluctuation even under high-load conditions.
Model HBN supports a circulating mechanism with enhanced strength that allows the return piece to pick up balls in the near tangential direction. The circulating mechanism makes the use with DN value 130,000 possible.

Applications

- Injection molding machine
- Pressing machine
- Blow molding machine
- Extrusion molding machine
- Other machines

In particular,

you can use HBN efficiently instead of a hydraulic cylinder.

Model HBN is more excellent than the hydraulic cylinder in terms of:

1. energy saving (power consumption 1/5 to 1/3 times less than that of the hydraulic cylinder);
2. clean environment;
3. machine controllability;
4. maintainability; and
5. positioning accuracy.

Features

High load

The HBN has the internal structure suitable for a high load. It takes full advantage of the ball cage, being resistant to the load rating load more than twice higher that of the conventional product.

High speed

The return piece for the HBN is based on the circulating mechanism that picks up balls in the near tangential direction. The nearly ideal circulating mechanism allows balls to run unforcedly. It enables the use of the return piece and the ball cage designed to provide sufficient strength, under the DN value rated at 130,000.

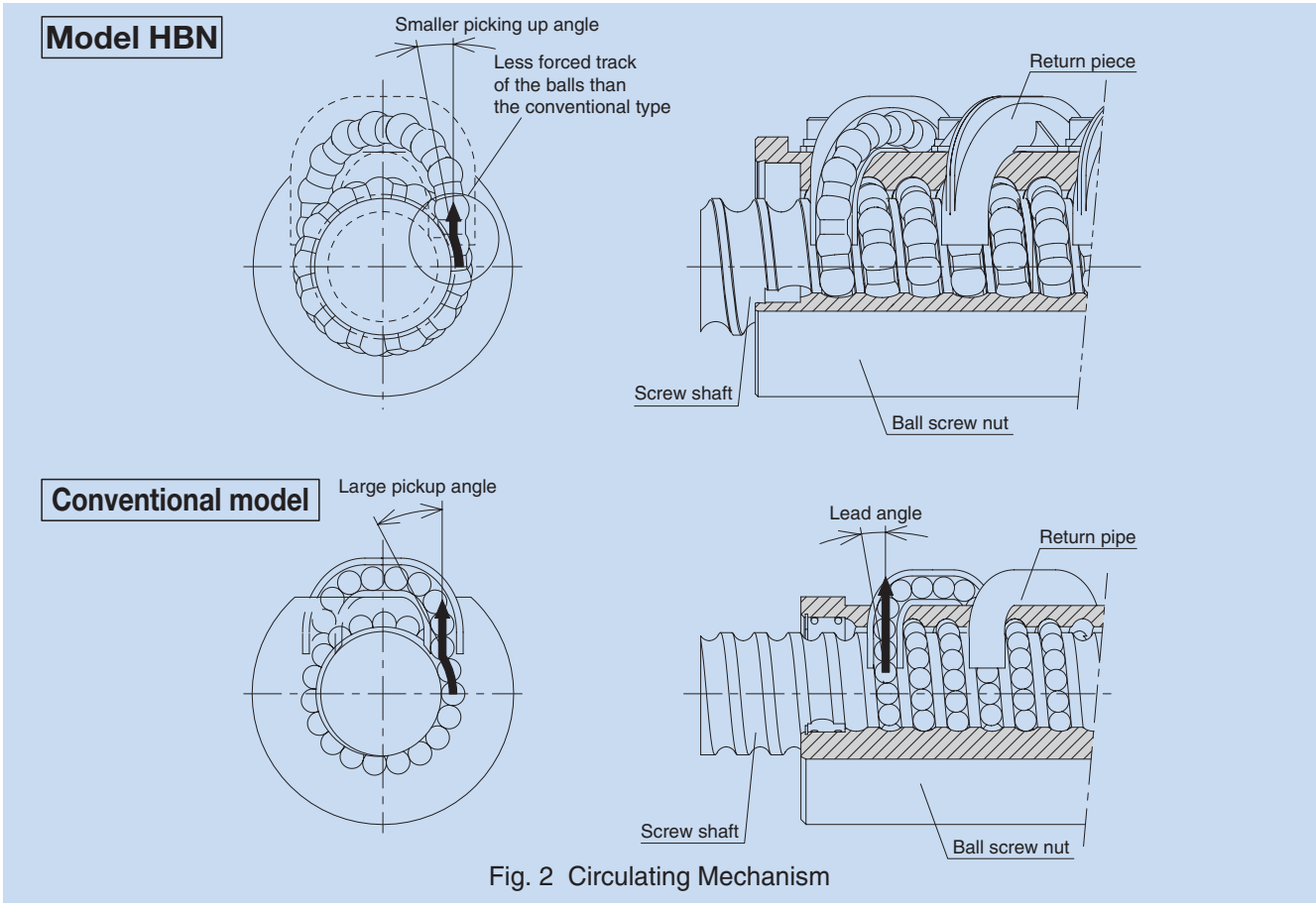


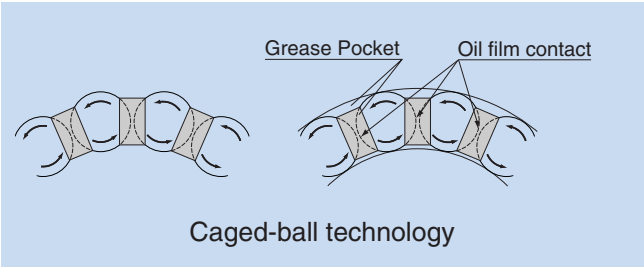
Fig. 2 Circulating Mechanism

Smooth motion

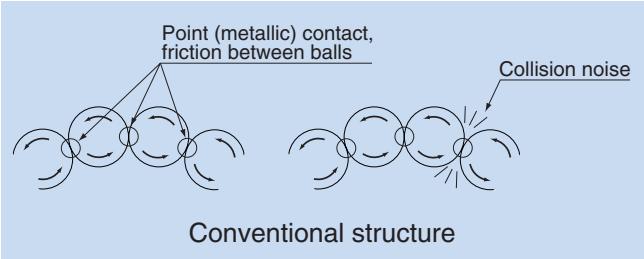
The use of a ball cage eliminates ball-to-ball friction, offering higher durability, lower dynamic torque fluctuation, and smoother motion.

Low noise

The use of a ball cage eliminates collision noise. The return piece has no lips and picks up balls and is also capable of suppressing collision noise. It contributes to implementing operation under lower noises.



Caged-ball technology



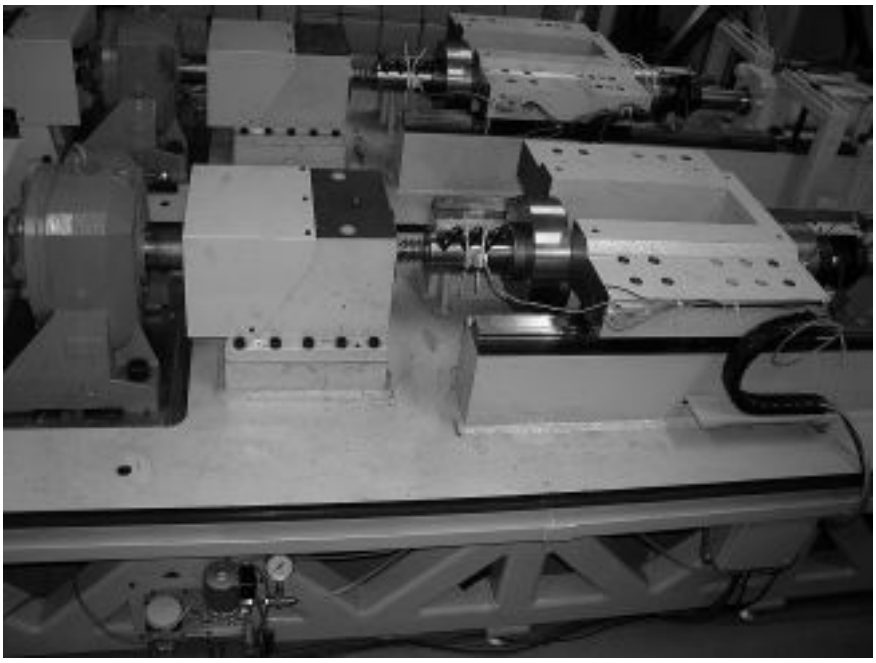
Conventional structure

Performance

■Data of a load durability test for HBN

Load durability testing

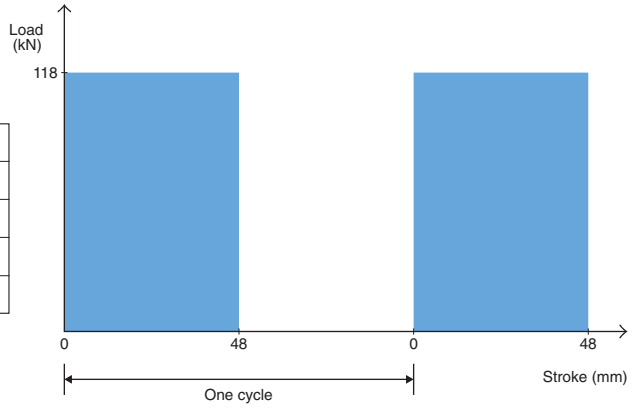
Test piece: HBN5016−7. 5RRG2+700LC7



Load durability tester

Data

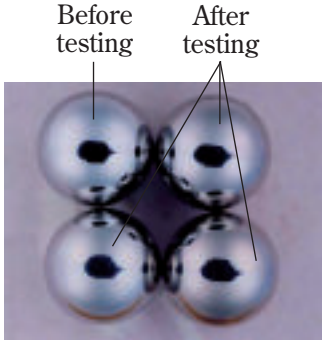
Applied load	118kN
Stroke	48mm
Travel speed	Up to 3.8m/min
Shaft rotation speed	Up to 240min^{-1}
Lubrication	Grease lubrication (LUBE LUBER MY-2)



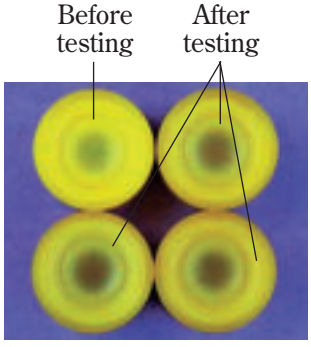
Loading pattern

Ball screw nut

Ball screw shaft



Balls



Ball Cage

Result

The HBN has incurred no errors over 3 million cycles of running. (Still running)

■Data of a high-speed durability test for HBN

High-speed durability testing
Test piece: HBN5016−7. 5RRG2+1200LC7

Data

Stroke	480mm
Travel speed	Up to 40m/min
Acceleration	Up to 9.8m/s^2
Shaft rotation speed	Up to 2500min^{-1}
Lubrication	Grease lubrication (LUBE LUBER MY-2)

Result

The HBN has incurred no errors over 2,000 km of running. (Still running)

■Data of smoothness evaluation

Torque measurement
Test piece: HBN5016−7. 5RRG2+1200LC7

Data

Stroke	200mm
Travel speed	0.96m/min
Shaft rotation speed	60min^{-1}
Lubrication	Grease lubrication (LUBE LUBER MY-2)

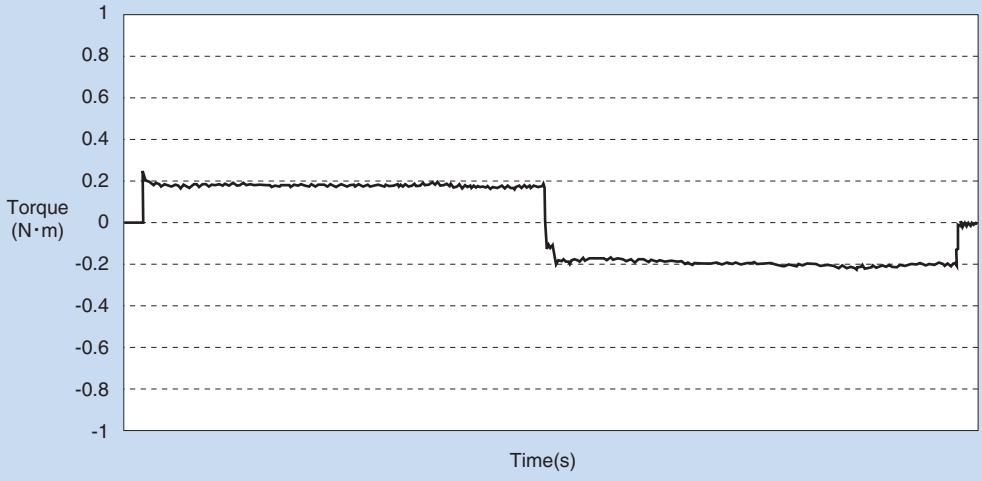


Fig. 3 Torque measurements

■Data of a noise test for HBN

Noise measurement
Test pieces: HBN3210−5RRG2+994LC7
: BNF3210−5RRG2+994LC7

Data

Stroke	600mm
Lubrication	Grease lubrication (LUBE LUBER MY-2)

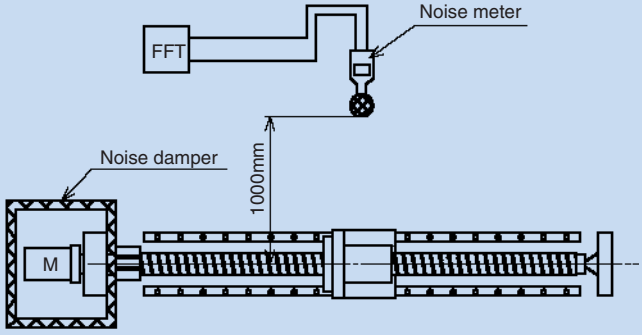


Fig. 4 Noise Meter

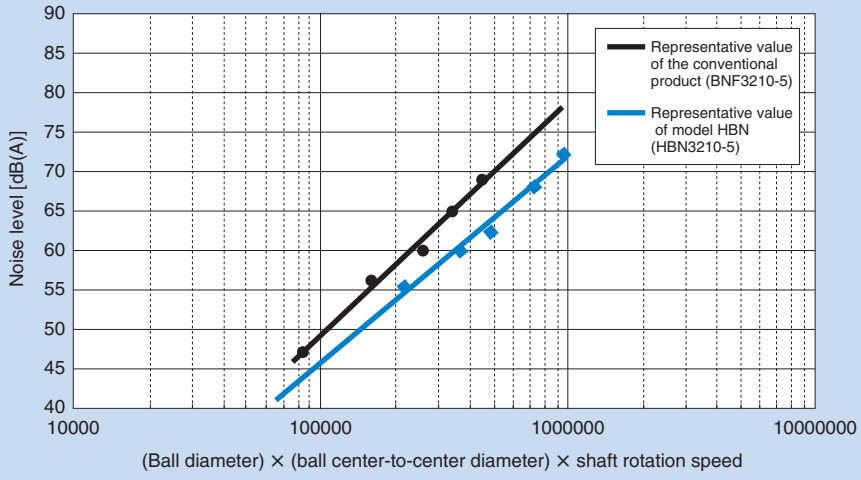


Fig. 5 Ball Screw Noise Level

Result

HBN produces 3 to 5 dBA less noise than the conventional product.

Static Safety Factor

The basic static load rating C_{0a}

The basic static load rating (C_{0a}) generally equals to the permissible axial load of a Ball Screw. Depending on the conditions, it is necessary to take into account the following static safety factor against the calculated load. When the Ball Screw is stationary or in motion, unexpected external force may be applied through an inertia caused by the impact or the start and stop.

■Static safety factor

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

Fa_{max} : Permissible Axial Load [kN]
C_{0a} : Basic static load rating [kN]
f_s : Static safety factor (see Table 1)

Table 1 Static Safety Factor (f_s)

Machine using the LM system	Load conditions	Lower limit of f_s
General industrial machinery	Without vibration or impact	1.0 to 3.5
	With vibration or impact	2.0 to 5.0
Machine tool	Without vibration or impact	1.0 to 4.0
	With vibration or impact	2.5 to 7.0

The basic static load rating (C_{0a}) is a static load with a constant direction and magnitude whereby the sum of the permanent deformation of the rolling element and that of the raceway on the contact area under the maximum stress is 0.0001 times the rolling element diameter. With the Ball Screw, it is defined as the axial load. (Specific values of each Ball Screw model are indicated in the specification tables for the corresponding model number.)

■Safety Factor as Regards the Permissible Load (Model HBN)

High-load Ball Screw model HBN is designed to achieve a longer service life under high-load conditions than conventional ball screws. It is necessary to take into account the permissible load Fp for the axial load. The permissible load Fp is the maximum axial load that the high-load Ball Screw can receive. Be sure to use the product within this value.
When a largest thrust load acting on the ball screw undergoes change due to shock or other factors, safety must be taken into consideration as regards to the permissible load Fp.

$$\frac{Fp}{Fa} > 1$$

Fp : Permissible load [kN]
Fa : Applied Axial Load [kN]

Rated Life and Service Life Time

Basic dynamic load rating Ca

The basic dynamic load rating (Ca) is used in calculating the service life when a Ball Screw operates under a load. The basic dynamic load rating is a load with interlocked direction and magnitude under which the nominal life (L) equals to 10^6rev. when a group of the same Ball Screw units independently operate. (Specific basic dynamic load ratings (Ca) are indicated in the specification tables of the corresponding model numbers.)

■Rated Life

The service life of the Ball Screw is calculated from the following equation using the basic dynamic load rating (Ca) and the applied axial load.

● Nominal Life (Total Number of Revolutions)

$$L = \left(\frac{Ca}{f_w \cdot Fa}\right)^3 \times 10^6$$

L	: Nominal life (total number of revolutions)	[rev]
Ca	: Basic dynamic load rating	[N]
Fa	: Applied axial load	[N]
f_w	: Load factor	(See Table 2)

Table 2 Load factor (f_w)

Vibrations/ impact	Speed (V)	f_w
Faint	Very low V≦0.25 m/s	1 to 1.2
Weak	Slow 0.25<V≦1 m/s	1.2 to 1.5
Medium	Medium 1<V≦2 m/s	1.5 to 2
Strong	High V>2 m/s	2 to 3.5

* For the rated service life, the load is calculated under condition that proper lubrication is applied and products are mounted within the suggested alignment values. The mounting components and surface are not prepared correctly, it can have adverse affect on the service life.

■Service life time

If the revolutions per minute is determined, the service life time can be calculated from the following equation using the nominal life (L).

$$L_h = \frac{L}{60 \times N} = \frac{L \times Ph}{2 \times 60 \times n \times \ell_s}$$

L_h	: Service life time	[h]
N	: Revolutions per minute	[min^{-1}]
n	: Number of reciprocations per minute	[min^{-1}]
Ph	: Ball Screw lead	[mm]
ℓ_s	: Stroke length	[mm]

Accuracy Standard and Axial Clearance

Accuracy standard

The THK high-load ball screw is manufactured according to JIS B 1192 (precision ball screw) in terms of accuracy. The lead accuracy is measured using a reliable laser instrument for assurance. For details about the standard value, see our general catalog.

Axial clearance

The THK high-load ball screw is accompanied by the standard G2 axial clearance. Ball screws with other clearance are also available if you need them. (See the Table below.) The ball screw with the GT or G1 clearance under C7 may have a partially negative clearance.

Table 2 Axial Clearance

Unit:mm

Clearance symbol	GT	G1	G2	G3
Axial clearance	0 to 0.005	0 to 0.01	0 to 0.02	0 to 0.05

High-Load Ball Screw Installation

Generally, the axial load applied to the ball screw is absorbed by a flange surface. We recommend using the following approach to installation. If the bolt is subject to a tensile load depending on the installation condition, you should fully consider the bolt strength.

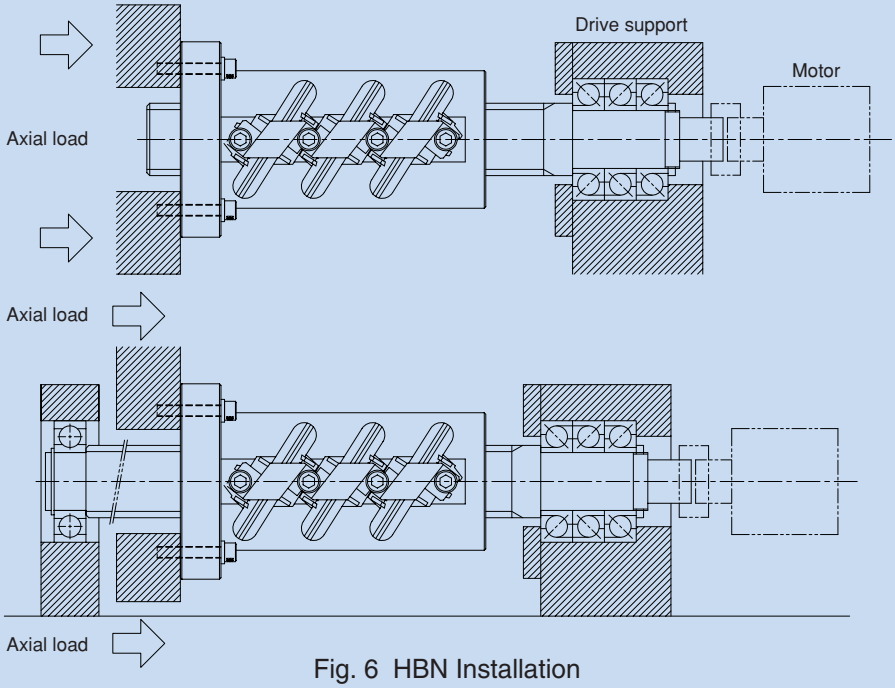
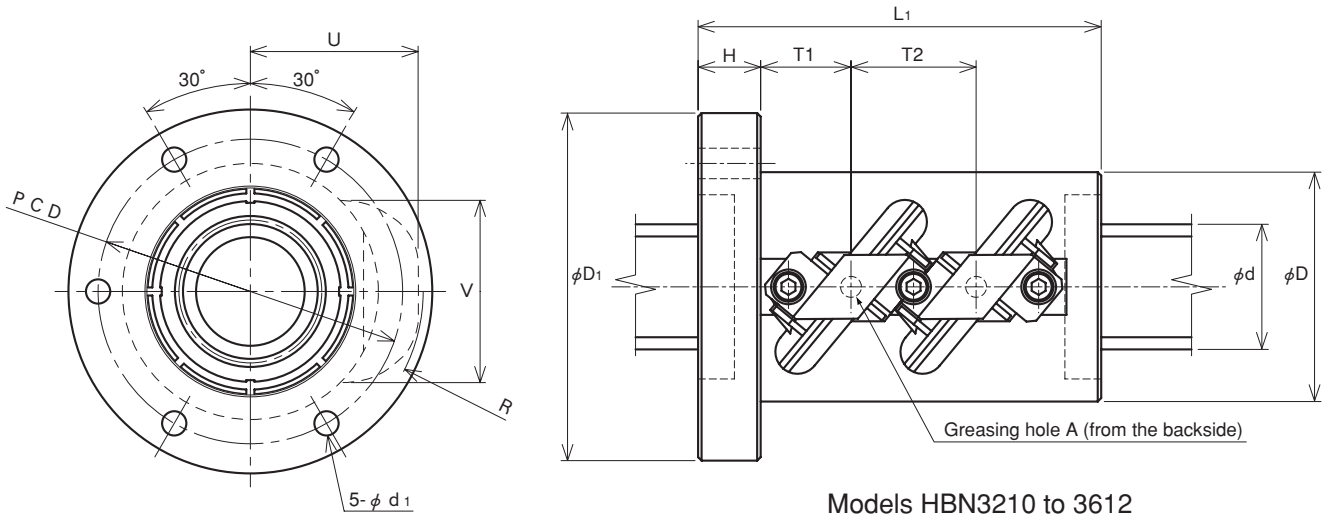


Fig. 6 HBN Installation

Model HBN



Models HBN3210 to 3612

Model No.	Screw shaft outer diameter d	Lead Ph	Ball center-to-center diameter dp	Thread minor diameter dc	No. of loaded circuits Rows × turns	Basic load rating Ca [kN]	Basic load rating Coa [kN]	Permissible load* Fp [kN]	Rigidity K [N/μm]
HBN 3210-5	32	10	34.0	26.0	2×2.5	102.9	191.3	31.9	1077
HBN 3610-5	36	10	38.0	30.0	2×2.5	108.2	220.4	33.5	1176
HBN 3612-5	36	12	38.4	29.0	2×2.5	141.1	267.7	43.7	1207
HBN 4010-7.5	40	10	42.0	34.0	3×2.5	162.6	366.0	50.4	1910
HBN 4012-7.5	40	12	42.4	33.0	3×2.5	212.4	441.6	65.8	1922
HBN 5010-7.5	50	10	52.0	44.0	3×2.5	179.1	462.7	55.5	2279
HBN 5012-7.5	50	12	52.4	43.0	3×2.5	235.7	572.2	73.1	2345
HBN 5016-7.5	50	16	53.0	39.6	3×2.5	379.6	820.9	117.7	2392
HBN 6316-7.5	63	16	66.0	52.6	3×2.5	427.1	1043.8	132.4	2898
HBN 6316-10.5	63	16	66.0	52.6	3×3.5	577.1	1461.3	178.9	4029
HBN 6320-7.5	63	20	66.5	49.6	3×2.5	578.8	1283.1	179.4	3030

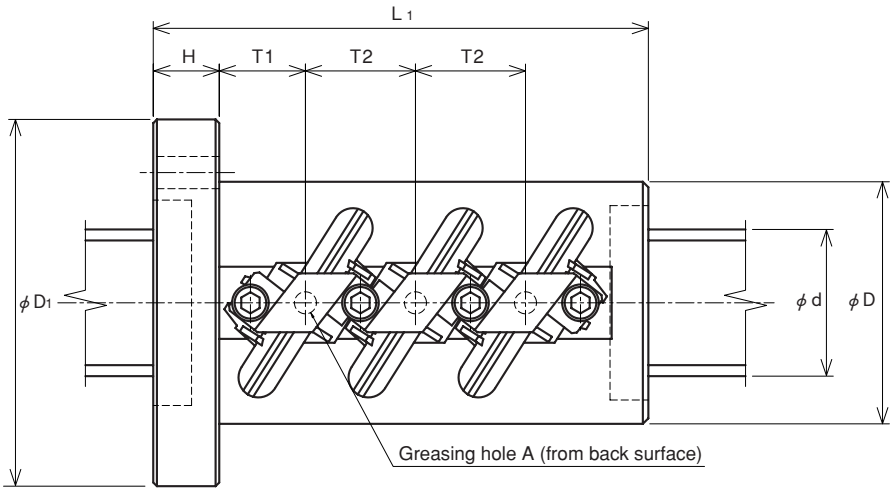
Note: Permissible load Fp* indicates the maximum load in the axial direction that the corresponding Ball Screw model can receive. All HBN models are designed to achieve long service life under higher loads than the conventional ball screw models.

■ Example of model number coding

HBN3210-5 RR G2 +1200L C7

1 2 3 4 5

1 Model number 2 Seal symbol (RR: labyrinth seals on both ends)
3 Symbol for clearance in the axial direction 4 Overall screw shaft length (mm) 5 Accuracy symbol



Models HBN4010 to 6320

Unit:mm

	Nut dimensions												Screw shaft inertial moment/mm	Nut mass	Shaft mass
	Outer diameter D	Flange diameter D_1	Overall length L_1	H	PCD	d_1	T1	T2	U_{MAX}	V_{MAX}	R_{MAX}	Greasing hole A	[kg·cm²/mm]	[kg]	[kg/m]
	58	85	98	15	71	6.6	22	30	43	46	43.5	M6	8.08×10^{-3}	1.8	5.26
	62	89	98	15	75	6.6	22	30	45	50	46	M6	1.29×10^{-2}	1.9	6.79
	66	100	116	18	82	9	26	36	49	52.5	50	M6	1.29×10^{-2}	2.8	6.55
	66	100	135	18	82	9	23.5	30	46.5	54	48	M6	1.97×10^{-2}	2.9	8.52
	70	104	152	18	86	9	26	36	51	56	52	M6	1.97×10^{-2}	3.7	5.24
	78	112	135	18	94	9	23.5	30	52	63.5	54.5	M6	4.82×10^{-2}	3.7	13.7
	80	114	152	18	96	9	26	36	56	66	58.5	M6	4.82×10^{-2}	4.4	13.34
	95	135	211	28	113	9	37.5	48	64.5	69.6	65.2	PT-1/8	4.82×10^{-2}	10.0	12.1
	105	139	211	28	122	9	37.5	48	70.5	82	72.5	PT-1/8	1.21×10^{-1}	10.6	20.2
	105	139	259	28	122	9	53.5	64	70.5	82	73	PT-1/8	1.21×10^{-1}	17.4	20.2
	117	157	252	32	137	11	44	60	79	86.5	80	PT-1/8	1.21×10^{-1}	17.2	19.13

Note Each rigidity value in the table represent the spring constant obtained from the load and the elastic displacement when a load in the axial direction that is 30% of the basic dynamic load rating (Ca) is applied.
Since this value does not include rigidity of parts related to the ball screw nut mounting section, the actual rigidity may be approx. 80% of this value. If the load in the axial direction (Fa) is not equal to 0.3 Ca, the rigidity value (K_N) can be obtained in the following equation.

$$K_N = K \left(\frac{Fa}{0.3Ca} \right)^{\frac{1}{3}}$$

K:Rigidity value in the table

THK Caged-Ball High-Load Ball Screw HBN

⚠ Precautions on use

- **Permissible rpm**
  - Under high rpm, the high-load ball screw may resonate with the characteristic frequency of the ball screw shaft, being unable to function. You must use the ball screw below the resonance point (hazardous speed). (For details, see our general catalog.) In addition, the ball screw is restricted by the DN value (product of rpm and center ball diameter) independently of the installation approach. Note the two points. (HBN's permissible DN value: 130,000)
- **Notes on handling**
  - The ball screw is a precision product. Should you drop or strike the ball screw, it may be damaged or its function may be changed. If the nut is taken off the screw shaft (ball screw section), the ball and the cage come off. You should use particular care for handling.
- **Installation**
  - If you force a part against the screw shaft or the nut, the revolving surface may be impressed. When installing a part, take care not to apply unnecessary force to the screw shaft and the nut.
  - If the screw shaft support does not correspond to the nut, the service life may be extremely shortened.You should, therefore, take particular care for installed part accuracy and installation accuracy.
- **Coolant**
  - If you use HBN in an environment where coolant or the like penetrates the nut, the product function may be damaged depending on its type. Contact THK.
- **Temperature range during operation**
  - You should not use HBN at a temperature of 80 or more degrees C because it is made of special resin.
- **Lubrication**
  - The high-load ball screw requires lubrication.
  - If you use the ball screw under a high load, we recommend LUBE LUBER MY-2 grease as the standard.
  - Except for a special case, the ball screw contains grease which can be used as is. After commissioning at your site, you should grease the ball screw to be used again.
  - If you use the ball screw in an environment always subject to vibration, in a clean room, in a vacuum chamber, or in other special environments at low or high temperature, the regular grease may be inapplicable. In such a case, please feel free to contact THK.

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