MOTION & CONTROL
NSK

For High-Speed Machine Tool Spindles

Neo-Brid™ Angular Contact Ball Bearings

Ceramic (Si_3N_4) balls and stainless steel are combined to maximize limiting speed and rigidity


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NSK Neo-Brid™ Angular Contact Ball Bearings improve high-speed spindle drive performance with their precision, rigidity and low heat generation

Advanced machine tools operate at high spindle speeds. Bearings and lubrication system must match such levels of performance for the full benefits of speed to be realized. NSK's Neo-Brid Angular Contact Ball Bearings are designed for minimal increase in temperature during high-speed spindle revolution.

Ceramic angular ball bearings are widely employed in metalcutting machine spindle drive systems. Their inner and outer rings are made of bearing steel while their rolling elements are made of ceramic (Si_3N_4).

Because the rolling elements have a small coefficient of linear expansion—about 20% that of bearing steel—the internal clearances of bearings are larger than in the case of steel ball bearings as temperature increases while the main spindle is revolving. This reduces preload during rotation and enables high-speed rotation with a minimal temperature rise under fixed position preload.

The inner rings of Neo-Brid Angular Contact Ball Bearings are made of stainless steel. Their smaller coefficient of linear expansion results in a larger internal clearance during rotation and more effective reduction of preload. (Patent pending: Patent Journal No. 7-30788, 1995).

1. Types of Bearings for High Speed Spindles

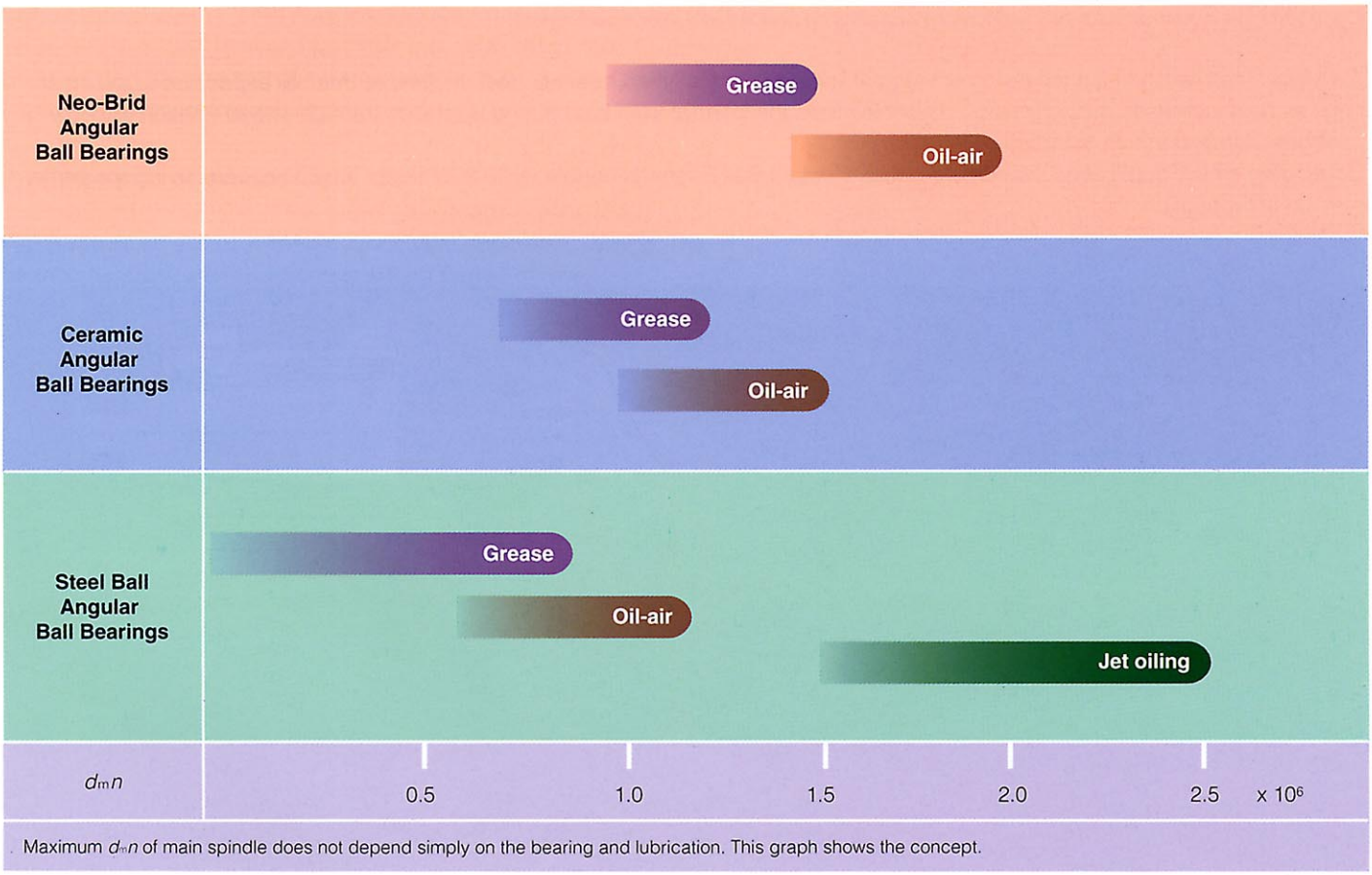


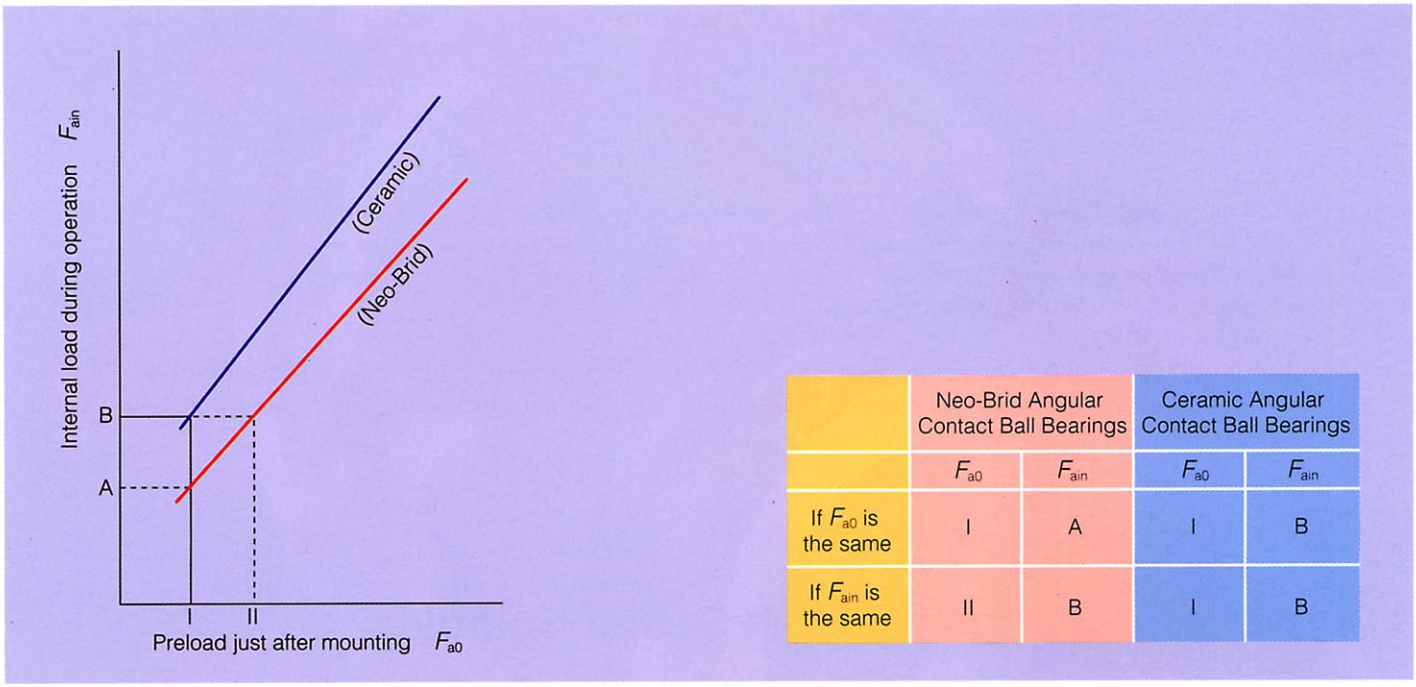
Fig. 1. Bearing type and lubrication method determine d_mn range for fixed position preloaded applications

Neo-Brid Angular Contact Ball Bearings enable alternative methods of lubrication. In the case of conventional steel ball bearings, jet oiling is required. But in the case of Neo-Brid Angular Contact Ball Bearings, jet oiling can be replaced by oil-air lubrication, or in the case of Ceramic Angular Contact Ball Bearings, oil-air lubrication can be replaced by grease lubrication. These replacement options simplify design of the main spindle lubricating system, and significantly reduce the total design cost.

2. Features of Neo-Brid Angular Contact Ball Bearings

(1) Low heat generation and ultra-high-speed rotation

During high-speed rotation under fixed-position preload, the increase in the internal axial load is reduced more than in the case of ceramic angular ball bearings.



	Neo-Brid Angular Contact Ball Bearings		Ceramic Angular Contact Ball Bearings	
	F_{a0}	F_{ain}	F_{a0}	F_{ain}
If F_{a0} is the same	I	A	I	B
If F_{ain} is the same	II	B	I	B

Fig. 2. Change in internal load during operation depends on preload just after mounting

Stainless steel, which has a smaller coefficient of linear expansion than bearing steel, minimizes thermal expansion of the inner rings as heat increases during rotation. This minimizes the internal axial load during operation for high-speed rotation with low heat generation. (Figs. 2, 3 and 4)

Depending on the application, Neo-Brid Angular Contact Ball Bearings enable up to 20% faster spindle speeds using the same method of lubrication.

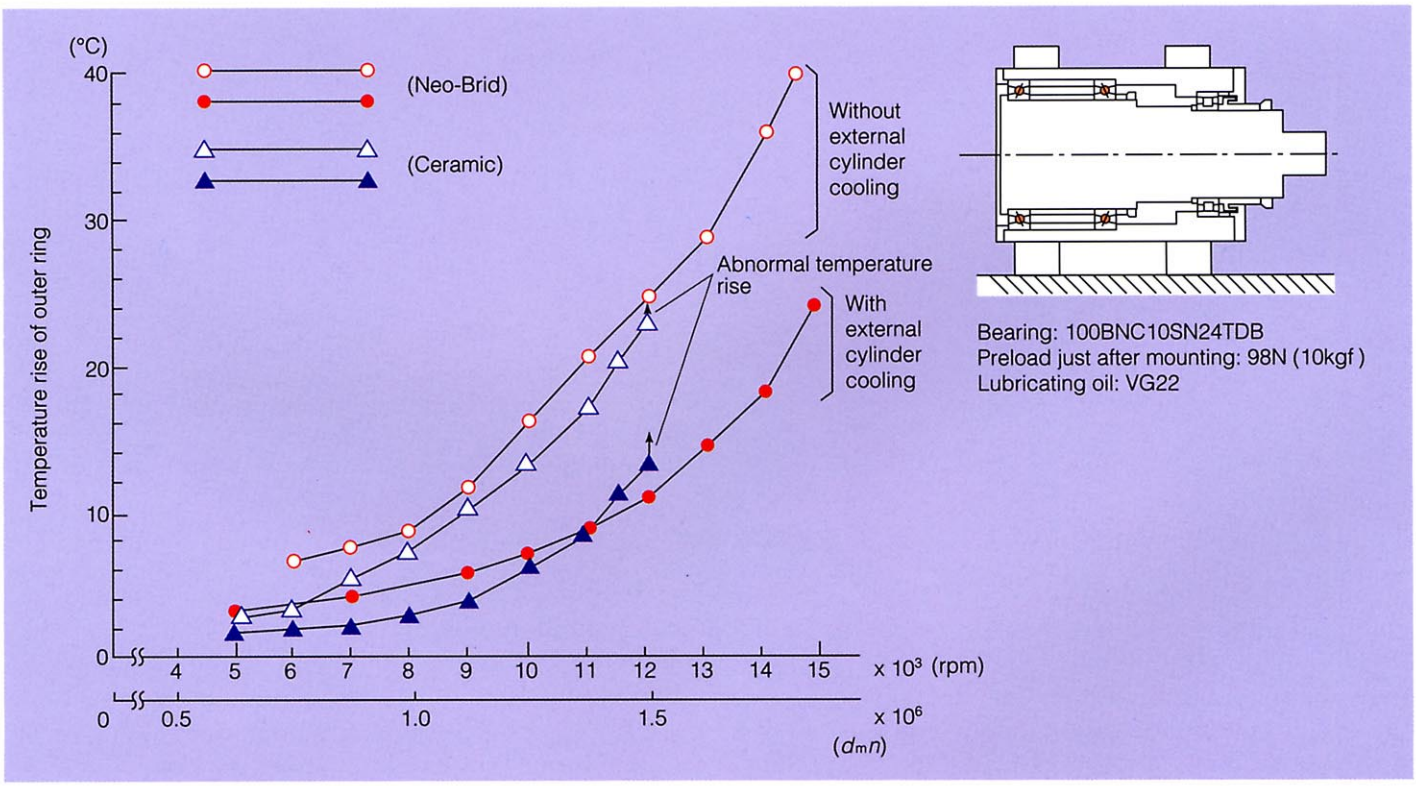


Fig. 3. Temperature rise as a function of speed for oil-air lubrication

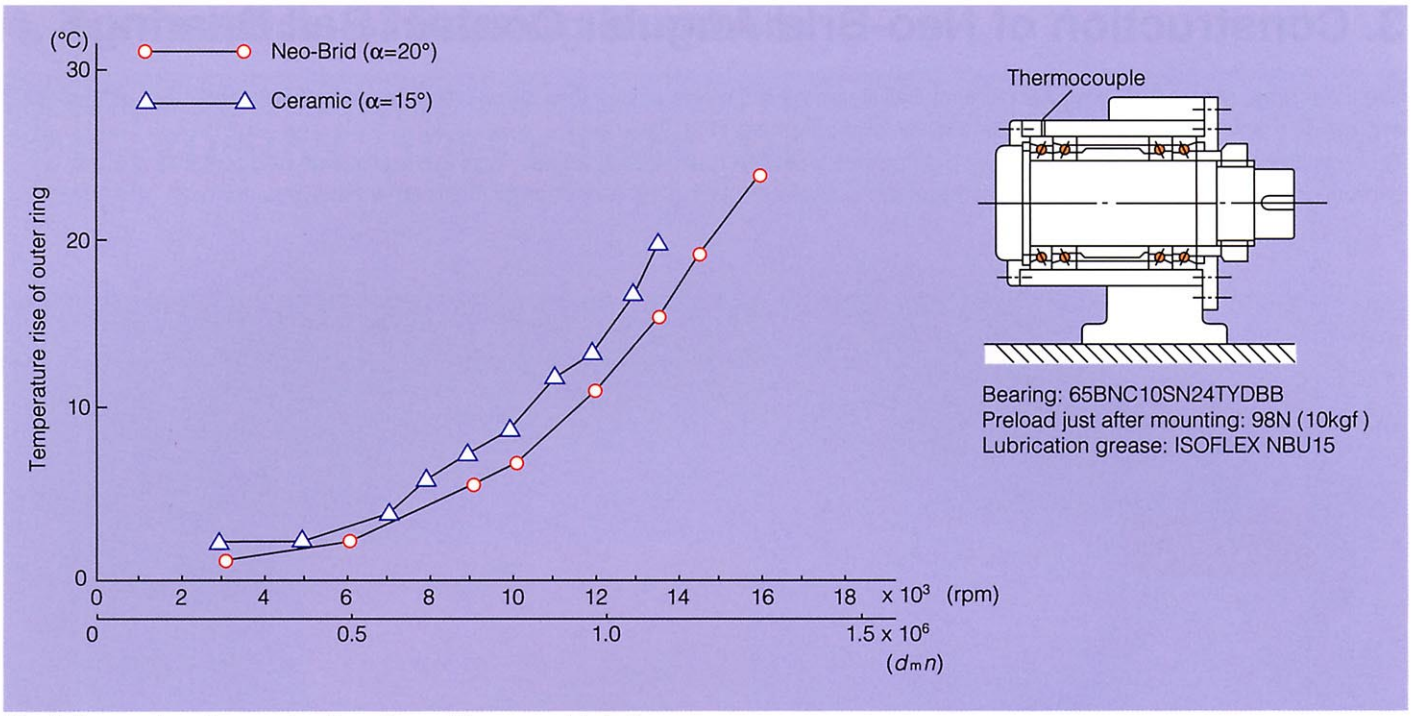


Fig. 4. Temperature rise as a function of speed for grease lubrication

(2) High rigidity

Compared with Ceramic Angular Contact Ball Bearings, Neo-Brid Angular Contact Ball Bearings have a smaller internal axial load which increases with rotational speed. If the maximum spindle speed is the same, then the value for the bearing preload just after mounting of the main spindle can be increased beyond that of ceramic angular ball bearings, resulting in improved rigidity of the main spindle.

(3) Extension of grease life

The low-heat generation of the bearings extends grease life. (Fig. 5) Fig. 6 shows an example of NSK lubrication endurance testing. The bearing temperature is stable over a long period of time.

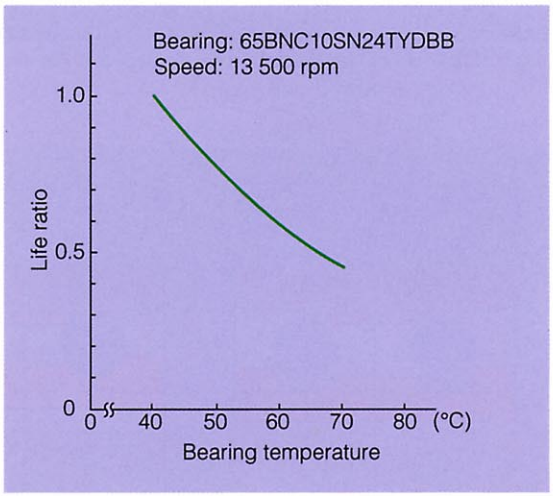


Fig. 5. Relationship between bearing temperature and grease life

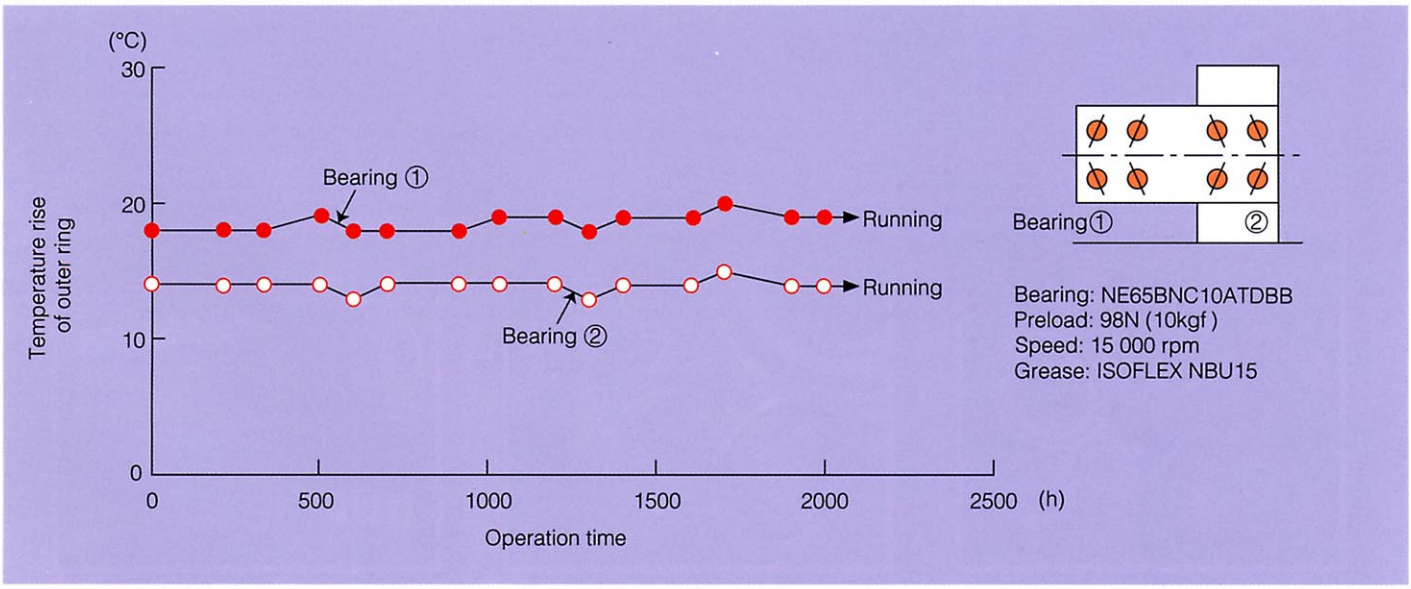
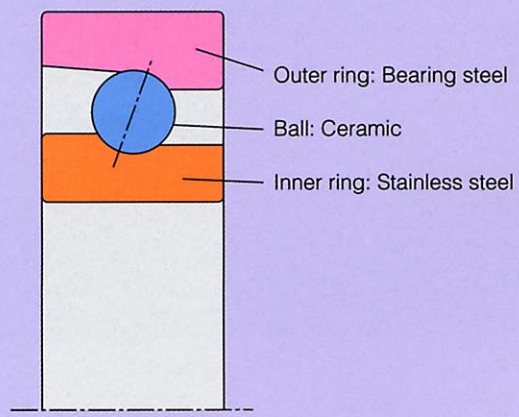


Fig. 6. Endurance test (grease lubrication)

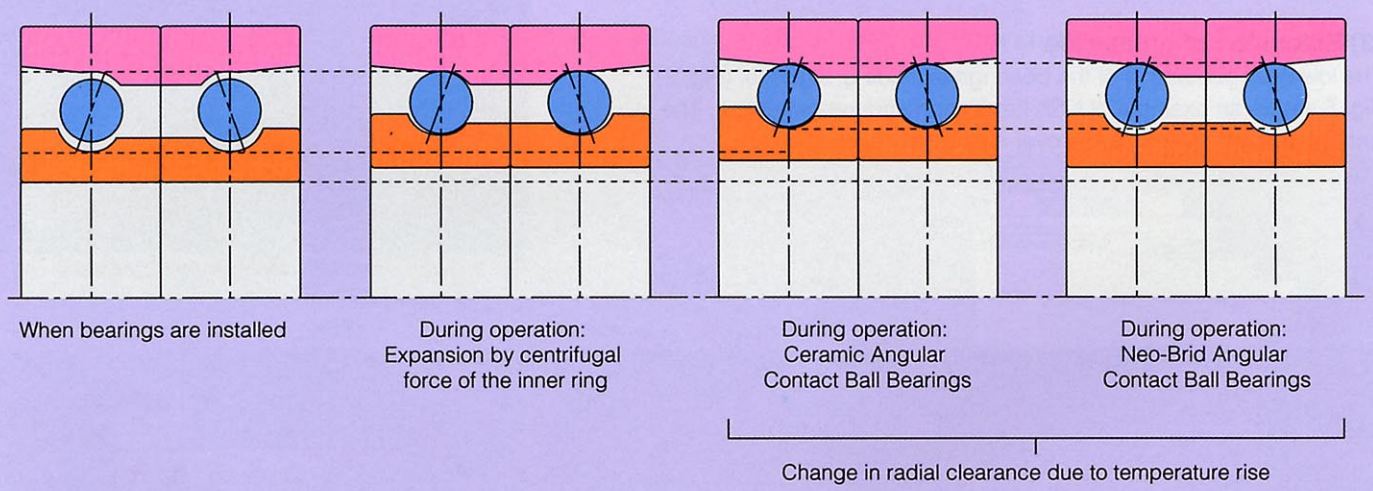
3. Construction of Neo-Brid Angular Contact Ball Bearings

The inner rings of Neo-Brid Angular Contact Ball Bearings are made of stainless steel, which has a smaller coefficient of linear expansion than bearing steel. The balls are made of ceramics. (Fig. 7)
This construction reduces the temperature difference between the inner and outer rings during rotation and reduces the expansion of the inner rings due to centrifugal force, thereby limiting the reduction in the internal clearance. (Fig. 8)



	Neo-Brid Angular Contact Ball Bearings	Ceramic Angular Contact Ball Bearings
Inner ring material	Stainless steel	Bearing steel
Coefficient of linear expansion	10×10^{-6} / °C	12.5×10^{-6} / °C

Fig. 7. Structure of Neo-Brid Angular Contact Ball Bearings



* This figure shows the relationship between the expansion of the inner and outer rings of a bearing and the internal clearance of a bearing, but clearance is enlarged. Preload (clearance is negative) is applied on the bearings when they are installed.

Fig. 8. Temperature rise during operation and changes in internal clearance of a bearing due to expansion by centrifugal force of the inner ring

4. Formulation of Bearing Numbers

NE 70 BNC 10 TY DB L P4

Material symbols

Material for the rolling element is silicon nitraide (Si_3N_4)
Material for the inner ring is stainless steel

Nominal bearing bore diameter

Bearing type symbol

Dimesion series symbols

10: Same bore and outside daimeter and width dimension as the 70 series
19: Same bore and outside daimeter and width dimension as the 79 series

Cage symbols

T: Phenolic cage
($D_{pw} \times n \leq 1.4 \times 10^6$)
TY: Polimaide cage
($D_{pw} \times n \leq 1.2 \times 10^6$)

If $D_{pw} \times n > 1.4 \times 10^6$
please consult NSK

$$D_{pw} \fallingdotseq \frac{\text{(Outside diameter + Bore diameter)}}{2}$$

Combination symbols

DB: Back-to-Back duplex bearing
DT: Tandem duplex bearing
DBB: Four-row bearing

Pre-load symbols

L: Standard preload
CP: Preload clearance (CP10: -10μm)
CA: Axial clearance (CA10: +10μm)

Precision symbols

P4: JIS Class 4
P2: JIS Class 2

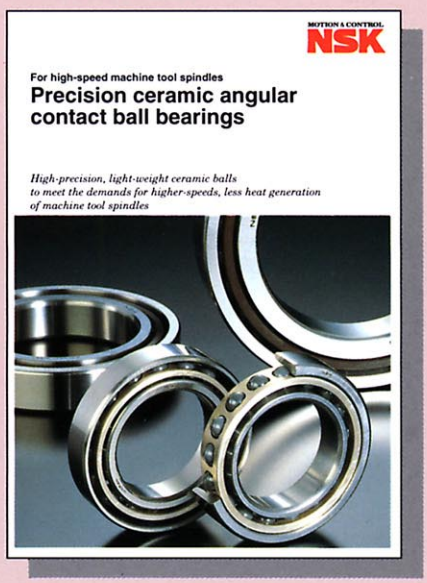
5. Information on Related Topics

●Pamphlet on "Fine-Lub" oil-air lubricators

CAT No. A1387

●Catalog of "Precision Ceramic Angular Contact Ball Bearings" for high-speed machine tool spindles

CAT No. A1392



●Catalog of "Precision Rolling Bearings" for machine tool spindles

CAT No. E124