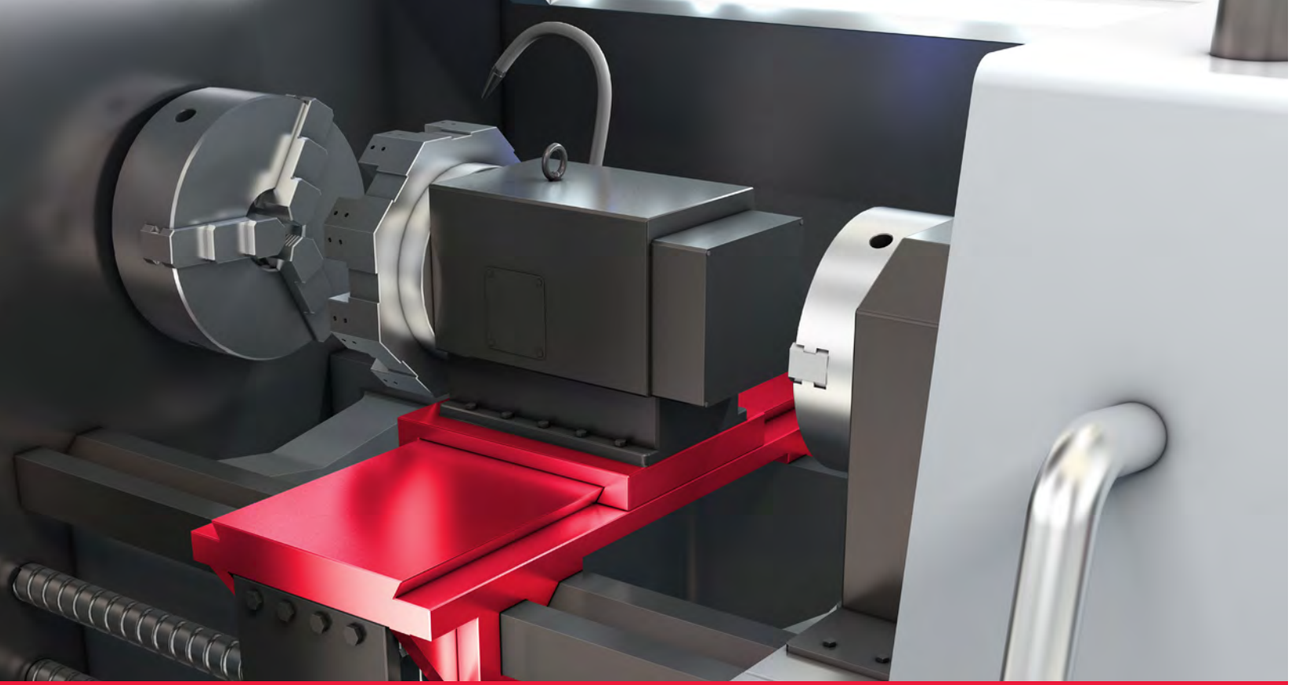
NSK

SUPER PRECISION BEARINGS

FOR MACHINE TOOL APPLICATIONS

STAY IN MOTION. STAY IN CONTROL.



ENABLING NEXT-GENERATION MACHINING

Machine tools are essential infrastructure to industry, providing critical components for countless manufacturing sectors. As such, optimization of precision and throughput are symbiotic: machining centers are required to minimize processing time and maximize output, all the while producing stringently high-quality finished parts.

To meet these challenges, NSK applies our prowess with advanced material technologies and optimized product design to deliver bearings for machine tools that achieve:

› Superior running accuracy with reduced NRRO

› Ultra-high speeds with low temperature rise

› Higher capacity for machining versatility

› Exceptional wear resistance for longer spindle life

With NSK Super Precision bearings, machine tool builders and operators can realize next-generation speed, capacity and reliability to accelerate throughput and efficiency. Precisely.

NSK

SUPER PRECISION BEARINGS

HEAT-RESISTANT SHX STEEL

NSK Super Precision Bearings are manufactured with high-purity Z Steel to achieve a long operating life under normal conditions in wide ranging applications. For machine tools running at maximum capacity at ultra-high speeds under high temperatures, NSK offers NSKROBUST series bearings manufactured with special high-endurance SHX Steel with special heat treatment technology. Decisive performance advantages include:

- 4 times longer fatigue life than SUJ2 Z Steel
- Considerably higher seizure resistance (**Figure 1**), exceeding that of heat-resistant M50 aerospace bearing steel
  - Higher wear resistance achieved with superior material hardness (**Figure 2**)
    - 20% higher limiting speeds compared to SUJ2 steel

Fig.1: Seizure Limit - 4 balls test (oil bath)

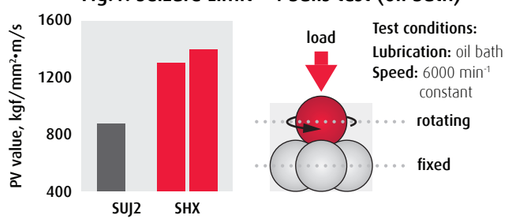


Fig.2: Wear resistance - 2 cylindrical rollers test

Test conditions:
Surface pressure: 880 MPa
Sliding ratio: 30%
Lubrication: spindle oil, 2 cc/min
Temperature: room temperature

CERAMIC BALLS

Ceramic hybrid bearings deliver advanced performance characteristics that can be transformational in machine tools. NSK offers silicon nitride (Si_3N_4) ceramic balls as a standard option for angular contact ball bearings to achieve ultra-high machining speeds, in addition to a considerable array of advantages:

- Higher rigidity and rotational accuracy, enabling high-accuracy machining
- Lower sliding friction in high-speed applications (**Figure 3**)
- Lower heat generation (**Figure 4**)
- Higher seizure resistance
- Longer grease life due to low heat generation

EQTF™ BALLS

Ultra-long life EQTF balls deliver superior wear and seizure resistance in NSKROBUST angular contact ball bearings, derived from advanced material composition and carbonitriding.

Fig.3: Comparison of friction loss

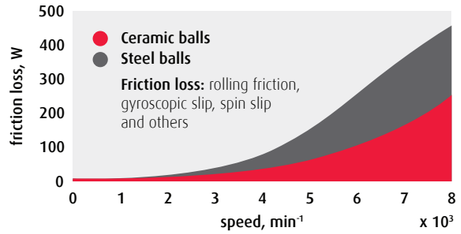
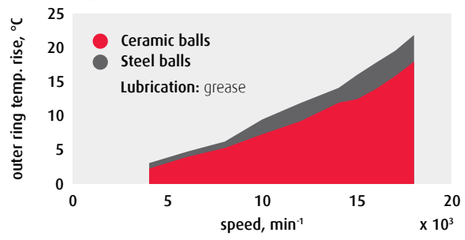


Fig.4: Comparison of temperature rise



ENGINEERED POLYMER CAGES

NSK engineered polymer cages are optimized to support the ultra-high speeds of next-gen machining requirements: they're lighter (1/6 of the weight of brass cages), self-lubricating and have a low friction coefficient. NSK Super Precision machine tool bearings equipped with engineered polymer cages generate less heat at high-speed rotation. They are also engineered to deliver high strength and excellent wear resistance.

Table 1: Characteristics and use of engineered polymer cages

CAGE MATERIAL		PERFORMANCE CHARACTERISTICS	ANGULAR CONTACT BALL BEARINGS	ANGULAR CONTACT THRUST BALL BEARINGS	CYLINDRICAL ROLLER BEARINGS	BALL SCREW SUPPORT BEARINGS
Engineered polymers	Nylon 46	low friction and low temperature rise at high speeds; especially effective with grease lubrication	TYN	TYN		T85
	PEEK	high strength with excellent wear resistance; low NRRO; ultra-high speeds	TS		TP	
	PPS	high strength with low deformation due to centrifugal force; low NRRO; ultra-high speeds	TSR		TB	

NSKHPS ANGULAR CONTACT BALL BEARINGS

NSKHPS high-accuracy angular contact ball bearings deliver superlative performance for general machine tool applications. Internal design, component and materials optimization ensure efficiency and extended bearing life in high-speed and high-load applications. For reduced wear, contamination resistance and markedly improved grease life, our NSKHPS series are also available with a non-contact seal option.

DESIGN FEATURES

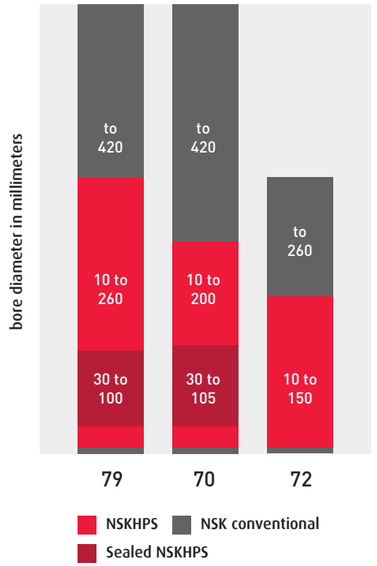
- Manufactured with improved steel purity, increasing bearing fatigue life by as much as 15%
- High-performance cage design options - polyamide and phenolic resin - to meet application requirements
- Available with ceramic balls for higher seizure resistance and lower heat generation
- Non-contact sealed design option
- Available with 15°, 25° and 30° contact angles
- Various preload and accuracy options
- Universal matching

SEALED DESIGN OPTION

NSKHPS sealed high-accuracy angular contact ball bearings deliver considerable operating benefits:

- Prevents contamination and lubricant breakdown, with grease life extended by as much as 50%
- Reduces wear to raceway and ball surfaces
- Zero speed loss from non-contact seal design
- Ease of handling - installation is 4 times faster, and risk of maintenance contamination is eliminated
- Simple adoption - dimensionally interchangeable with open bearings

Fig.5: Range of availability



Left: open-type bearing with phenolic resin cage (TR) and ceramic balls

Above: sealed-type bearing with polyamide resin cage (TYN) and steel balls

DESIGNATION SYSTEM

NSKHPS HIGH-ACCURACY ANGULAR CONTACT BALL BEARINGS

Dimension Series	Bore Reference No.	Contact Angle	Material - Balls	Cage	Closure	Arrangement	Preload	Accuracy	Grease Type	Grease Fill
70	14	C	SN24	TR	V1V	DU	EL	P4Y	MTE	X

DESIGNATION		ATTRIBUTE
Dimension series	79	19 series
	70	10 series
	72	02 series
Bore reference no.		multiply x 5 for bore diameter in mm
Contact angle	C	15° contact angle
	A5	25° contact angle
	A	30° contact angle
Material	blank	SUJ2 steel balls
	SN24	Si_3N_4 ceramic balls
Cage	TYN	ball guided, polyamide resin
	TR	outer ring guided, phenolic resin
Closure	blank	open bearing
	V1V	non-contact rubber seal
Arrangement *	SU	single row, universal matching
	DU	double row, universal matching
	DUD	three row, universal matching
	QU	four row, universal matching

DESIGNATION		ATTRIBUTE
Preload	EL	extra-light preload
	L	light preload
	M	medium preload
	H	heavy preload
	CPXX	special preload, in microns
	CAXX	special clearance, in microns
Accuracy	P2	ISO class 2
	P3	dimensional accuracy ISO class 4, running accuracy ISO class 2
	P4	ISO class 4
	P4Y	special dimensional accuracy with running accuracy ISO class 4
Grease type	MTS	for ultra-high speeds
	MTE	for high loads and high speeds
Grease fill	X	15% of internal space
	K	20% of internal space
	L	30% of internal space

* For additional information about bearing arrangements and possible combinations, refer to “Angular Contact Ball Bearing Combinations” on page 26.

NSKROBUST™ ANGULAR CONTACT BALL BEARINGS

FOR ULTRA HIGH-SPEED MACHINING

In order to meet accelerating production requirements, machining centers must minimize processing time. As a result, machine tool spindles have to operate at increasingly high speeds. For spindle bearings, rising to challenges in the form of seizure resistance and fatigue life are critical. NSKROBUST angular contact ball bearings are designed precisely to support ultra high-speed rotation, achieving precision-machined surfaces with exceptional reliability.

DESIGN FEATURES

- Special design series equipped with a larger complement of smaller balls to support higher limiting speeds than conventional high-accuracy series bearings (**Figure 6**)
- Dimensionally interchangeable with conventional bearings
- Available in four design series with alternative material configurations for inner / outer rings and balls (**see Table 2**)
- High-performance polyamide, phenolic and engineered PPS resin cage design options available to meet specific application requirements
- With contact angles of 15° (BSR), 18° (BNR) and 25° (BER)
- Non-contact sealed design option
- Various preload and accuracy options
- Universal matching, supporting multiple combined arrangements

Table 2: NSKROBUST series and construction

NSKROBUST SERIES	BEARING RINGS	BEARING BALLS	TYPICAL APPLICATIONS
S type	SUJ2 steel	SUJ2 steel	general industries, information technology
E type	SUJ2 steel	EQTF steel	
H type	SUJ2 steel	ceramic	automotive, general industries
X type	SHX steel	ceramic	die casting, aircraft components

Fig.6: Relative limiting speeds by series

Left: "SURSAVE™" bearing with PPS resin cage (TSR) and ceramic balls

Above: NSKROBUST bearing with phenolic resin cage (T) and ceramic balls

DESIGNATION SYSTEM

NSKROBUST ANGULAR CONTACT BALL BEARINGS

Nominal Bore Diameter	Dimension Series	Cage	Closure	Preload	Grease Type
70	10	T	V1V	EL	MTS
BNR	H		SU	P4Y	X
Type / Contact Angle	Material - Rings / Balls		Arrangement	Accuracy	Grease Fill

DESIGNATION		ATTRIBUTE
Nominal bore dia.		expressed in millimeters
Type / contact angle	BER	25° contact angle
	BNR	18° contact angle
	BSR	15° contact angle
Dimension series	19	19 series
	29	29 series (wide)
	10	10 series
	20	20 series (wide)
	02	02 series
Material - rings / balls	S	SUJ2 steel rings and balls
	E	SUJ2 steel rings / EQTF balls
	H	SUJ2 steel rings / Si_3N_4 ceramic balls
	X	SHX steel rings / Si_3N_4 ceramic balls
Cage	TYN	ball guided, polyamide resin
	T,TA,TX	outer ring guided, phenolic resin
	TSR	outer ring guided, PPS resin
Closure	blank	open bearing
	V1V	non-contact rubber seal
Arrangement *	SU	single row, universal matching
	DU	double row, universal matching
	DUD	three row, universal matching
	QU	four row, universal matching

DESIGNATION		ATTRIBUTE
Preload	EL	extra-light preload
	L	light preload
	M	medium preload
	H	heavy preload
	CPXX	special preload, in microns
	CAXX	special clearance, in microns
Accuracy	P2	ISO class 2
	P3	dimensional accuracy ISO class 4, running accuracy ISO class 2
	P3W	ISO class 3 with special inner / outer ring width tolerances
	P4	ISO class 4
	P4Y	special dimensional accuracy with running accuracy ISO class 4
Grease type	MTS	for ultra-high speeds
	MTE	for high loads and high speeds
Grease fill	X	15% of internal space
	K	20% of internal space
	L	30% of internal space

* For additional information about bearing arrangements and possible combinations, refer to "Angular Contact Ball Bearing Combinations" on page 26.

SPINSHOT™ II AND ROBUSTSHOT

ADVANCED SOLUTIONS FOR OIL-AIR LUBRICATION

A reliable, continuous supply of lubrication to the working surfaces of spindle bearings is a particular challenge. Conventional oil-air lubrication injection methods - injecting lubricant into the side of the bearing using a nozzle - can be ineffective due to the air vortex generated around the rotating bearing. NSK SPINSHOT II and ROBUSTSHOT bearings deliver two decidedly different but efficient approaches to guaranteeing a reliable, even supply of lubricant to bearings operating at ultra-high speeds.

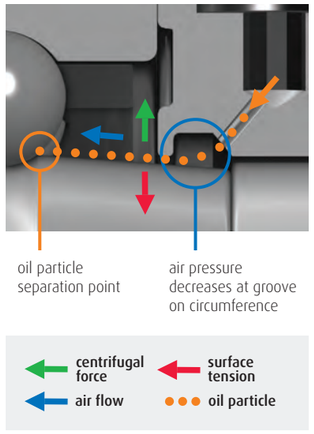
SPINSHOT II PERFORMANCE FEATURES

- Heat and seizure resistance - with SHX steel inner and outer rings
- High-speed performance - in position preload up to 2.5 million d_mn with jacket cooling (maximum 2.7 million d_mn without jacket cooling)
- Silent operation - 3 to 5 dB quieter than conventional oil-air lubrication
- Orientation - remains stable in either vertical or horizontal spindle orientation
- Reduced air consumption - as low as 1/3 of that in conventional oil-air lubrication
- Low heat generation - with ceramic balls

ROBUSTSHOT DESIGN FEATURES

- Available in NSKROBUST series BNR (18° contact angle) and BER (25° contact angle)
- With an outer ring lubrication groove and 2 through-holes
- Additional outer ring grooves (2) with O-rings to facilitate fit and sealing
- High-performance outer ring guided phenolic resin cage
- Equipped with ceramic balls as standard
- Various preload and accuracy options
- Universal matching and combination arrangements

Fig.7: Spinshot II structure



Left: ROBUSTSHOT direct lubrication angular contact ball bearing

Above: Spinshot II advanced oil-air lubrication design

DESIGNATION SYSTEM

SPINSHOT II AND ROBUSTSHOT ANGULAR CONTACT BALL BEARINGS

Nominal Bore Diameter		Dimension Series		Cage		Arrangement		Accuracy	
80	BNR	10	H	T	E34	DB	EL	P3	+Y3
Type / Contact Angle		Material - Rings, Balls		Lubrication Feature		Preload		Accessories - O-rings	

DESIGNATION		ATTRIBUTE
Nominal bore dia.		expressed in millimeters
Type / contact angle	BER	25° contact angle
	BNR	18° contact angle
Dimension series	19	19 series
	10	10 series
Material - rings / balls	H	SUJ2 steel rings / Si_3N_4 ceramic balls
	XE	SHX steel rings / Si_3N_4 ceramic balls
Cage	T	outer ring guided, phenolic resin
Lubrication feature	E34	outer ring lubrication groove, holes and 2 O-ring grooves, oil lubrication
	E55	outer ring lubrication groove, holes and 2 O-ring grooves, grease lubrication
Arrangement *	SU	single row, universal matching
	DU	double row, universal matching
	DUD	three row, universal matching
	QU	four row, universal matching

DESIGNATION		ATTRIBUTE
Preload	EL	extra-light preload
	L	light preload
	M	medium preload
	CAXX	special clearance, in microns
Accuracy	P2	ISO class 2
	P3	dimensional accuracy ISO class 4, running accuracy ISO class 2
	P4	ISO class 4
Accessories	+Y3	2 x O-rings mounted on the outer ring
	+KLXX	spacer, width in millimeters

indicates features and designations specific to Spinshot II

* For additional information about bearing arrangements and possible combinations, refer to “Angular Contact Ball Bearing Combinations” on page 26.

CYLINDRICAL ROLLER BEARINGS - SINGLE ROW

FEATURING NSKROBUST FOR ULTRA HIGH-SPEED MACHINING

For conventional high-capacity machining requirements, NSK has optimized internal design to deliver extended life with our NSKHPS series single row cylindrical roller bearings with machined brass cage. Where machine speed is a priority, NSKROBUST series bearings deliver superior ultra high-speed performance with high rigidity and stability with low heat generation. Advanced material options for rings and rollers offer greater heat and seizure resistance and extended bearing fatigue life.

NSKROBUST DESIGN FEATURES

- Optimized internal design for utmost bearing fatigue life
- Heat-resistant and highly rigid PEEK resin cage provides stability at ultra-high speeds
- Cage design improves effective lubricant distribution
- Low heat generation enables longer lubricant life
- Available with heat-resistant SHX steel rings and rollers for longer fatigue life (4 times) and higher limiting speeds
- Available with cylindrical and tapered bores
- Various clearance and accuracy options

Fig.9: Comparison of limiting speeds

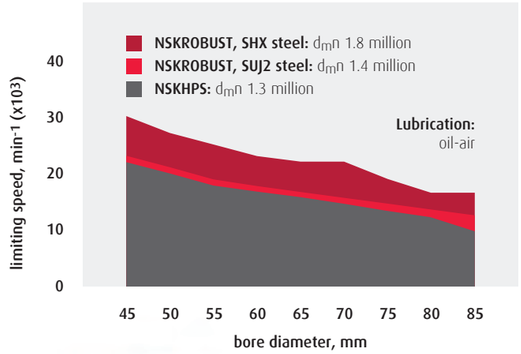
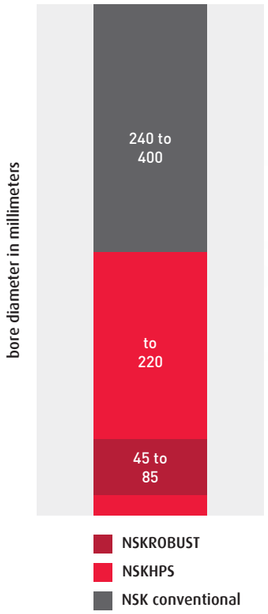


Fig.8: Range of Availability



Left: NSKROBUST series bearing with PEEK cage for ultra-high speeds

Above: NSKHPS series bearing with machined brass cage for long-life performance

DESIGNATION SYSTEM

SINGLE ROW CYLINDRICAL ROLLER BEARINGS - STANDARD AND NSKROBUST

Bearing Type		Bore Reference No.		Internal Design	Cage		Radial Internal Clearance	
N	10	12	RX	Z	TP	KR	CC0	P4
Dimension Series		Material - Rings, Rollers			Bore Type		Accuracy	

DESIGNATION		ATTRIBUTE
Bearing type	N	single row cylindrical roller bearing with inner ring ribs
Dimension series	10	10 series
Bore reference no.		multiply x 5 for bore diameter in mm
Material - rings / rollers	blank	SUJ2 steel rings / rollers, standard
	RS	SUJ2 steel rings / rollers, NSKROBUST
	RX	SHX steel rings / rollers, NSKROBUST
Internal design	blank	standard type
	Z	low heat generation type
Cage	blank	inner ring rib guided brass cage
	MR	roller guided brass cage
	TP	outer ring guided PEEK resin cage

DESIGNATION		ATTRIBUTE
Bore type	blank	cylindrical bore
	KR/K	1:12 tapered bore
Radial internal clearance	CC0	standard for tapered bore
	CC1	standard for cylindrical bore
	CCGXX	special clearance, in microns
Accuracy	P2	ISO class 2
	P4	ISO class 4
	P5	ISO class 5
	P4Y	special dimensional accuracy with ISO class 4 running accuracy

DOUBLE ROW CYLINDRICAL ROLLER BEARINGS

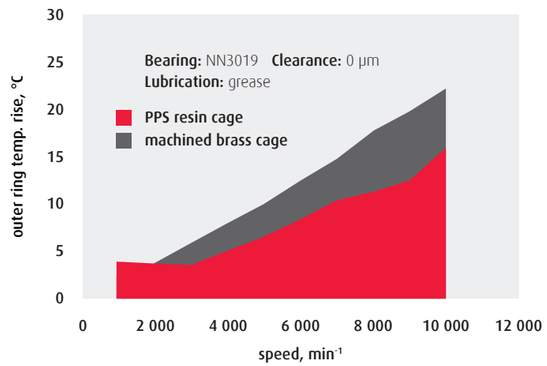
FEATURING NSKHPS AND APTSURF SERIES

NSK double row cylindrical roller bearings deliver superior performance in machining applications requiring high rigidity and high radial load capacity. Featuring NSKHPS optimized internal design, high performance levels and bearing life have been dramatically increased. Higher accuracy of all bearing components has dramatically reduced rotational vibration (APTSURF) - ensuring reliable, high precision and cost-effective machine tool performance.

NSKROBUST DESIGN FEATURES

- Available in series NN30, NN39, NN49 and NNU49
- NSKHPS high-performance range available for P5 accuracy and higher, up to 360 mm outside diameter
- Low vibration APTSURF specification available for P4 accuracy and higher, up to 360 mm outside diameter
- Standardly equipped with machined brass cage
- Advanced PPS resin cage available for NN30 series, supporting higher limiting speeds with high rigidity, low heat generation and reduced wear
- Low heat generation NN-Z series also available, specifically for free-end bearings
- Available with cylindrical and tapered bores
- Various clearance and accuracy options

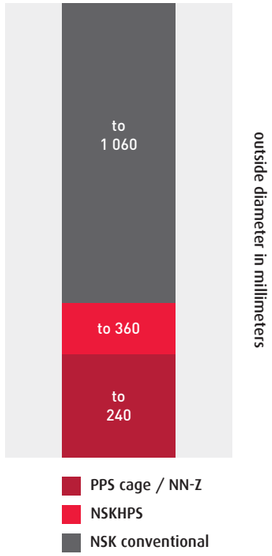
Fig.10: Comparison of temperature rise



Left: NN30 series double row cylindrical roller bearing with PPS resin cage

Above: NNU49 series bearing with machined brass cage

Fig.11: Range of Availability



DESIGNATION SYSTEM

NSK

DOUBLE ROW CYLINDRICAL ROLLER BEARINGS

Bearing Type		Bore Reference No.		Cage	Bore Type		Radial Internal Clearance	
NN	30	17		TB	KR	E44	CC0	P4
Dimension Series		Internal Design			Lubrication Features		Accuracy	

DESIGNATION		ATTRIBUTE
Bearing type	NN	double row with inner ring ribs
	NNU	double row with outer ring ribs
Dimension series	30	30 series
	39	39 series
	49	49 series
Bore reference no.		multiply x 5 for bore diameter in mm
Internal design	blank	standard type
	Z	low heat generation type
Cage	blank	rib guided brass cage
	TB	roller guided PPS resin cage
	MB	roller guided brass cage
Bore type	blank	cylindrical bore
	KR/K	1:12 tapered bore

DESIGNATION		ATTRIBUTE
Lubrication features	blank	no lubrication features
	E44	outer ring lubrication groove and holes
Radial internal clearance	CC0	standard for tapered bore
	CC1	standard for cylindrical bore
	CC9	smaller than normal clearance
	CCGXX	special clearance, in microns
Accuracy	P2	ISO class 2
	P4	ISO class 4
	P5	ISO class 5
	P4Y	special dimensional accuracy with ISO class 4 running accuracy

ANGULAR CONTACT THRUST BALL BEARINGS

NSKROBUST AND NSKTAC SERIES

Superior high-speed capability and high rigidity are required of ball bearings used for sustaining axial loads in machine tool spindles. For such requirements, NSK offers a trio of design options to suit prevailing performance characteristics and structure. All of these bearings are designed for use in combination with cylindrical roller bearings and are manufactured with special outer diameter tolerances to ensure that - when mounted - any radial load is supported entirely by the cylindrical roller bearings.

NSKROBUST DESIGN FEATURES

NSKROBUST bearings are designed to deliver high-speed performance with low heat generation, without compromising rigidity.

- BTR types have a 40° contact angle and deliver high rigidity with high speeds
- BAR types have a 30° contact angle and deliver higher speeds than BTR types
- Polyamide resin cages are particularly suited for stability and low friction at high speeds
- Available with ceramic balls for higher seizure resistance and lower heat generation, as well as ultra-long-life EQTF balls

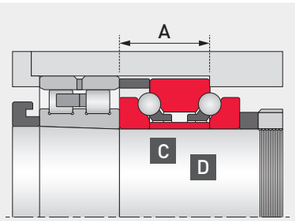
NSKTAC D AND F SERIES

High rigidity is the priority with NSKTAC series double direction angular thrust ball bearings. TAC F series bearings are duplex sets with a 50° contact angle; TAC D series are separable double row bearings with a 60° contact angle. Both are available with machined brass cage.

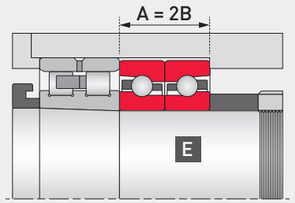
INTERCHANGEABILITY

NSKROBUST bearings have special width dimensions to enable simple replacement of TAC20 series bearings without shaft or housing modifications (see **Figure 12**). For the replacement of TAC29 series bearings, please contact NSK.

Fig.12: Interchanging NSKTAC > NSKROBUST



NSKTAC20D bearing with NN30 cylindrical



BAR / BTR bearings with NN30 cylindrical

Above: upgrading speed to NSKROBUST bearings - remove spacer C and replace spacer D with spacer E.

Left: NSKROBUST bearings with ceramic ball in "DB" arrangement

Above: NSKTAC D series double direction angular contact thrust ball bearing

DESIGNATION SYSTEM

NSKROBUST ANGULAR CONTACT THRUST BALL BEARINGS

Nominal Bore Diameter		Dimension Series		Cage		Preload	
100	BAR	10	S	TYN	DB	L	P4A
Type / Contact Angle		Material - Rings, Balls		Arrangement		Accuracy	

DESIGNATION		ATTRIBUTE
Nominal bore dia.		expressed in millimeters
Type / contact angle	BAR	30° contact angle
	BTR	40° contact angle
Dimension series	10	10 series bore and O.D., special width
Material - rings / balls	S	SUJ2 steel rings and balls
	E	SUJ2 steel rings / EQTF balls
	H	SUJ2 steel rings / Si_3N_4 ceramic balls

DESIGNATION		ATTRIBUTE
Cage	TYN	ball guided polyamide resin
	MY	ball guided machined brass
	blank	outer ring guided machined brass
Arrangement	DB	double row, back-to-back
Preload	EL	extra-light preload
	L	light preload, standard
Accuracy	P2A	ISO class 2 with special OD tolerances
	P4A	ISO class 4 with special OD tolerances

NSKTAC D AND F SERIES ANGULAR CONTACT THRUST BALL BEARINGS

Nominal Bore Diameter		Dimension Series		Accuracy	Spacer		Lubrication Features		Preload	
150	TAC	20D	MY	PN7	+LXX	C7	E44	DB	EL	P4A
Bearing Type		Cage			Preload		Arrangement		Accuracy	

DESIGNATION		ATTRIBUTE
Nominal bore dia.		expressed in millimeters
Bearing type	TAC	angular contact thrust ball bearing
Dimension series	20D,X,F	for combination with NN30 cylindrical
	29D,F	for combination with NN39 and NN49
Cage	M, MY	machined brass
Accuracy	PN7	special precision accuracy
	P4A	ISO class 4 with special OD tolerances
	P5A	ISO class 5 with special OD tolerances

DESIGNATION		ATTRIBUTE
Spacer	+LXX	inner ring spacer, width in millimeters
Preload	C6	extra-light preload
	C7	light preload, standard
	EL	extra-light preload
	L	light preload, standard
Lubrication features	blank	no lubrication feature
	E44	outer ring lubrication holes
Arrangement	DB	double row, back-to-back

specific to NSKTAC D series specific to NSKTAC F series

NSKHPS TAC C SERIES BALL SCREW SUPPORT BEARINGS

NSKHPS TAC C support bearings for ball screw drives are designed to deliver utmost fatigue life and performance capacity in modern machine tool feeding systems. A 60° contact angle and optimized internal design allow these bearings to support large axial forces while providing rigid and accurate ball screw support. NSKHPS TAC C bearings are available as open bearings or sealed for contamination resistance and considerably longer grease life.

DESIGN FEATURES

- Manufactured with high-purity steel, optimizing fatigue strength / bearing life and boosting dynamic load ratings
- 60° contact angle and maximized ball complement provide high axial rigidity
- Special design polyamide cage supports high speeds with low friction
- Available as open bearings or with light contact seals; non-contact seals are available for some sizes
- Heavy preload is standard
- Universal matching, supporting multiple combined arrangements

SEALED DESIGN OPTION

- Sealed NSKHPS TAC C bearings are standardly equipped with light-contact DDG seals for effective prevention of contamination and grease leakage
- Light-contact design supports high-speed operation with low torque and low heat generation
- Sealed bearings are pre-packed with WPH water-proof grease that resists high temperatures and is less likely to soften and leak

Left: NSKHPS TAC C ball screw support bearing - open type

Above: with light-contact DDG seal

DESIGNATION SYSTEM

NSKTAC C SERIES BALL SCREW SUPPORT BEARINGS

Nominal Bore Diameter		Nominal Outer Diameter		Closure		Preload	
30	TAC	62	C	DDG	SU	H	PN7C
Bearing Type		Internal Design		Arrangement		Accuracy	

DESIGNATION		ATTRIBUTE
Nominal bore dia.		expressed in millimeters
Bearing type	TAC	angular contact thrust ball bearing
Nominal outer dia.		expressed in millimeters
Internal design	C	60° contact angle
Closure	blank	open bearing
	DDG	light contact rubber seal

DESIGNATION		ATTRIBUTE
Arrangement *	SU	single row, universal matching
Preload	H	heavy preload standard
Accuracy	PN7C	NES class 7C (axial runout equivalent to P2)

* For additional information about bearing arrangements and possible combinations, refer to “Angular Contact Ball Bearing Combinations” on page 26.

NSKHPS BSBD SERIES BALL SCREW SUPPORT BEARINGS

NSK's BSBD series of support bearings for ball screw drives are designed to facilitate accurate positioning of a workpiece or machine component quickly and efficiently. A double row configuration with a 60° contact angle enables the bearings to support large axial forces in both directions with accuracy and rigidity. The bearings are supplied sealed, greased for life and ready for easy installation for both housing mounting (BSN type) and direct mounting (BSF type).

DESIGN FEATURES

- Double row angular contact thrust ball bearing design with a 60° contact angle, accommodating high axial loads in both directions
- Multi-lip contact seals ensure excellent grease retention and high resistance to dust penetration, with low friction and low heat generation at high speeds
- Greased for life, but equipped with lubrication grooves and holes to facilitate relubrication during operation
- Available as conventional BSN type for housing mounting, or extended outer ring BSF type featuring mounting holes and an extraction groove for easy direct installation and removal

MATCHED PAIRS

BSN and BSF ball screw support bearings are available as matched pairs (DT) for applications where higher load capacities and/or higher stiffness are required. The outer diameter surfaces of the bearings are marked for proper matching and alignment. Matching surfaces are adjusted in order to control preload of each individual bearing.

HEAVY SERIES

A heavy series type is available on some sizes. This type has the same inner ring dimensions, but a larger ball size and outer ring diameter, allowing higher axial loads and stiffness.

Left: extended outer ring BSF type with mounting holes and an extraction groove

Above: conventional BSN type

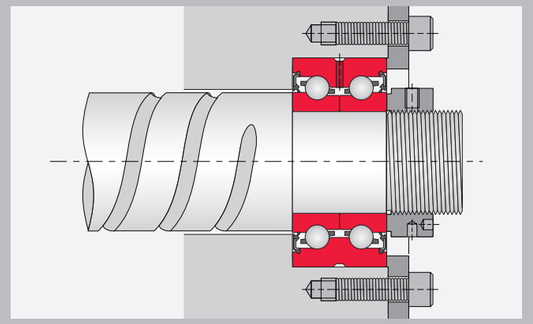
DESIGNATION SYSTEM

NSKHPS BSBD SERIES BALL SCREW SUPPORT BEARINGS

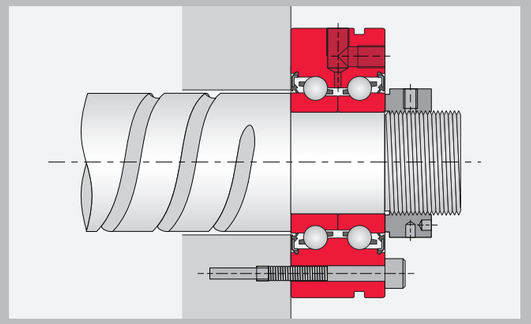
Bearing Type		Nominal Bore Diameter		Closure		Accuracy	
BS	F	30	80	DDU	H	P2B	DT
Flange Design		Nominal Outer Diameter		Preload		Arrangement	

DESIGNATION		ATTRIBUTE
Bearing type	BS	double row ball screw support bearing
Flange design	F	flange type design
	N	no flange
Nominal bore dia.		expressed in millimeters
Nominal outer dia.		expressed in millimeters
Closure	DDU	contact rubber seal

DESIGNATION		ATTRIBUTE
Preload	H	heavy preload standard
Accuracy	P2B	special dimensional accuracy, running accuracy ISO class 2
Arrangement	blank	single bearing
	DT	matched pair



Above: Housing mounting of BSN design type



Above: Direct, face mounting of BSF design type

ROBUSTSLIM HIGH-ACCURACY LOW-PROFILE ANGULAR CONTACT BALL BEARINGS

NSK ROBUSTSLIM angular contact ball bearings are designed specifically for swiveling spindle heads and rotary / tilt tables used in machine tools, and are suitable for high-precision processing with multi-axis machines. The ROBUSTSLIM series of high-accuracy low-profile angular contact ball bearings offer high rigidity on par with conventional crossed roller bearings, with lower torque and consequently, reduced energy loss.

DESIGN FEATURES

- Compact, space-saving design, with a 35% thinner profile than standard angular contact ball bearings
- High accuracy with low NRRO - 0.5µm or lower was achieved with BRSA130
- High moment stiffness on par with crossed roller bearings
- Lower torque than roller bearing alternatives
- Duplex back-to-back arrangement
- Non-contact seal on one side (of each bearing)

Type / Contact Angle	Material - Rings, Balls	Closure	Preload
BRSA 130	S T21	V DB	CP45 P5
Nominal Bore Diameter	Cage	Arrangement	Accuracy

DESIGNATION		ATTRIBUTE
Type / contact angle	BRSA	35° contact angle
Nominal bore dia.		expressed in millimeters
Material - rings / balls	S	SUJ2 or SUJ3 steel rings / SUJ2 balls
Cage	blank	ring guided machined brass
	T21	ring guided resin

DESIGNATION		ATTRIBUTE
Closure	V	non-contact rubber seal, one side
Arrangement	DB	double row, back-to-back
Preload	CP	special preload, in microns
Accuracy	P5	ISO class 5, standard

HIGH-ACCURACY DEEP GROOVE BALL BEARINGS

Delivering low noise operation with low vibration at high speeds, NSK high-accuracy deep groove ball bearings are widely used in high-speed and high-precision motor applications.

DESIGN FEATURES

- Available for dimension series 60, 62 and 63
- With ball guided polyamide cage or inner ring guided phenolic cage - selection depending on the application
- Available with ceramic balls for higher seizure resistance and lower heat generation
- Accuracy classes P2, P3, P4 and P5

Left: with phenolic resin cage (T) and steel balls

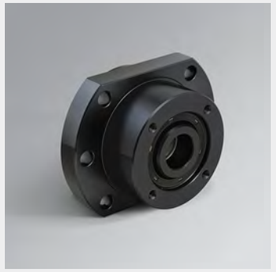
Above: with polyamide resin cage (T1X) and ceramic balls

Dimension Series	Material - Balls	Radial Internal Clearance
62 10	T	CG12 P4
Bore Reference No	Cage	Accuracy

DESIGNATION		ATTRIBUTE
Dimension series	60	10 series
	62	02 series
	63	03 series
Bore reference no.		multiply x 5 for bore diameter in mm
Material - balls	blank	SUJ2 steel balls
	SN24	Si_3N_4 ceramic balls
Cage	T1X	ball guided, polyamide resin
	T	inner ring guided, phenolic resin

DESIGNATION		ATTRIBUTE
Radial internal clearance	blank	normal clearance
	C3	larger than normal clearance
	CGXX	special clearance, in microns
Accuracy	P2	ISO class 2
	P3	dimensional accuracy ISO class 4, running accuracy ISO class 2
	P4	ISO class 4
	P5	ISO class 5

ADDITIONAL MACHINE TOOL BEARING PRODUCTS



BALL SCREW SUPPORT BEARING UNITS

These units for ball screw support in heavy-load and machine tool applications feature NSKTAC C series high-accuracy, high-rigidity angular contact thrust ball bearings. Three types of arrangements - duplex DF, triplex DFD and quadruplex DFF - in an integrated ready-to-install assembly offer considerable advantages:

- Dust-resistant unit allows the user to easily design the support side of the ball screw
- Simplified installation, with preload-controlled and ready-mounted bearings eliminating mounting complexities

MACHINE TOOL GREASES

MTS and MTE are high-performance grease products developed specifically for machine tool applications and sold exclusively by NSK. Each is available in 100 g tubes and 1 kg cans. All NSK super precision sealed angular contact ball bearings come prepacked with MTS and MTE grease.

- **MTS** - heat-resistant grease for high-speed machining centers
- **MTE** - high-load grease for lathes

NSK VERIFY APP

NSK Verify mobile application supports efficient factory automation and IT-based plant management. Scanning 2D barcodes on NSK bearing boxes allows users to assess bearing authenticity and access inspection reports online. Data export functionality empowers users to track usage history and streamline order handling, improve product traceability, and even simplify bearing selection.

- Compatible with iOS and Android devices
- Available on the App Store and Google Play

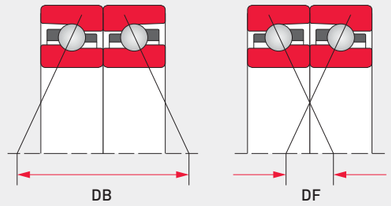
ANGULAR CONTACT BALL BEARING COMBINATIONS

NSK manufactures universal combination bearings that are controlled to have the same amount of stand-out (face offset) on their front and back faces. As such, the specified standard preload is achieved regardless of which combination is chosen. Each universal combination bearing comes with a V-shaped mark on the surface of the outer ring to simplify identification of the correct direction when mounting and to ensure that the correct combination is achieved. The V-shaped mark points to the direction of the axial load that the inner ring supports (vis-à-vis the contact angle).

BACK-TO-BACK ARRANGEMENT, DB

With DB arrangements, axial loads in both directions and radial loads can be sustained. The distance between the effective load centers is large, making this combination suitable if moments are applied. In case of insufficient housing accuracy or shaft misalignment, internal load of the bearings could be large enough to risk premature failure due to the high level of moment stiffness.

Fig.13: Distance between effective load centers



FACE-TO-FACE ARRANGEMENT, DF

Comparatively, the distance between the effective load centers is small, so the capacity to sustain moments is inferior to the DB type. On the other hand, this type is suitable for use with housings that have less accuracy or larger shaft deflections due to low bending stiffness of the shaft.

TANDEM ARRANGEMENT, DT

Axial loads in one direction and combined loads can be sustained. Since axial stiffness of this type is twice the value of a single row type, this arrangement is used when the axial load in one direction is heavy. If preload is required, it needs to be applied by external means such as by use of a spring.

ARRANGEMENTS OF UNIVERSAL COMBINATION BEARINGS - MARKS AND MATCHING

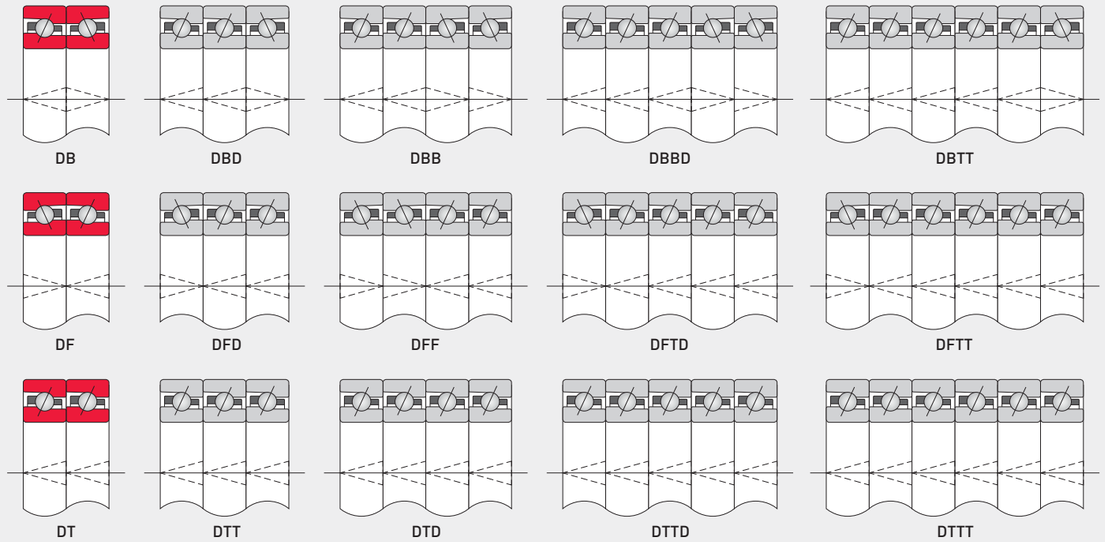


Table 3: Common angular contact ball bearing arrangements and characteristics

CHARACTERISTIC	DB	DF	DT	DBD	DBB
Load direction	↔	↔	→	↔	↔
Moment stiffness	●	○	◍	◉	●
Speed capability	●	●	◉	○	◍
Low heat generation	●	●	◉	○	◍
Stiffness	○	○	◍	◉	●

◉ excellent ● very good ○ good ◍ fair → one direction ↔ two directions

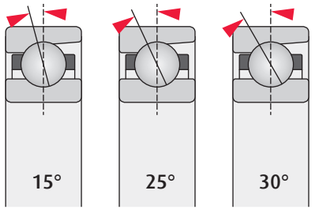
FEATURES OF ANGULAR CONTACT BALL BEARINGS

THE EFFECT OF CONTACT ANGLE

Super precision angular contact ball bearings are available with predetermined contact angles ranging from 15 to 30°. A bearing with a larger contact angle can support higher axial loads. Smaller contact angles, while supporting less axial load, are better suited for high-speed and high radial load applications.

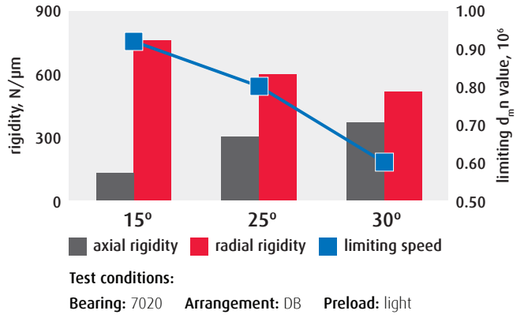
As shown in **Figure 14**, when the preload is constant - in this example light - the bearing with a 30° contact angle delivers axial rigidity roughly three times that of a bearing with a 15° angle.

Conversely, the bearing with a lower contact angle is capable of achieving higher limiting speeds, and does so with lower heat generation for a longer operating life (**Figure 15**).



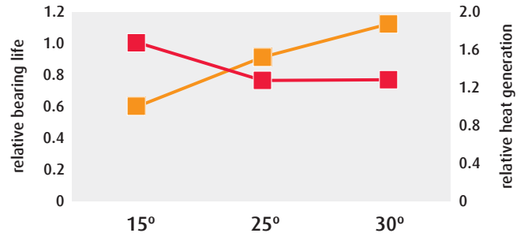
Note: NSKROBUST series bearings are also available with 18° contact angle

Fig.14: Contact angle - rigidity and limiting speed



Test conditions:
Bearing: 7020 **Arrangement:** DB **Preload:** light

Fig.15: Contact angle - heat generation and life



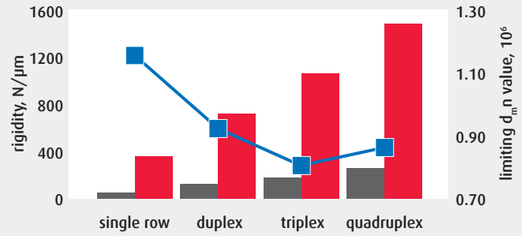
Test conditions:
Bearing: 7020 **Arrangement:** DB **Preload:** light
Speed: 6000 min^{-1}

THE EFFECT OF COMBINATIONS

As previously reviewed on page 26, angular contact ball bearings can be used either as single bearings or in combinations of two or more bearings. There is no limit to the number of rows, although two-row (duplex), three-row (triplex) and four-row (quadruplex) are the most commonly used multiple bearing sets.

As illustrated in **Figure 16**, when the combination is constant - in this example back-to-back - rigidity and load capacity increase with the number of rows of bearings, but limiting speeds decrease. Therefore, higher rigidity can be achieved by sacrificing speed, and conversely higher speeds can be achieved by sacrificing rigidity to a certain extent.

Fig.16: Combinations - rigidity and limiting speed



Test conditions:
Bearing: 7020 **Contact Angle:** 15° **Preload:** light

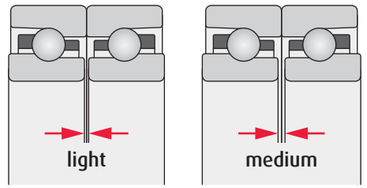
THE EFFECT OF PRELOAD

NSK has defined standard preload levels as extra-light (EL), light (L), medium (M) and heavy (H). Preload affects the performance of angular contact ball bearings in much the same way as the contact angle.

As shown in **Figure 17**, for any predetermined contact angle both radial and axial rigidity can be increased by increasing the preload. Conversely, higher preloads reduce attainable limiting speeds.

In addition to negatively impacting speed, higher preloads result in higher heat generation and declining bearing life (**Figure 18**).

Caution: High speeds combined with higher preload risk bearing seizure.



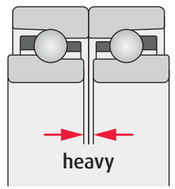
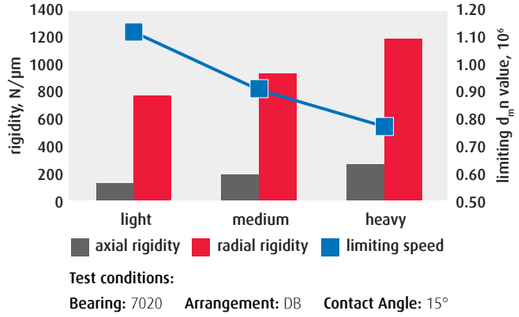
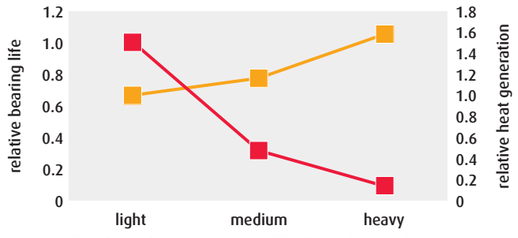


Fig.17: Preload - rigidity and limiting speed

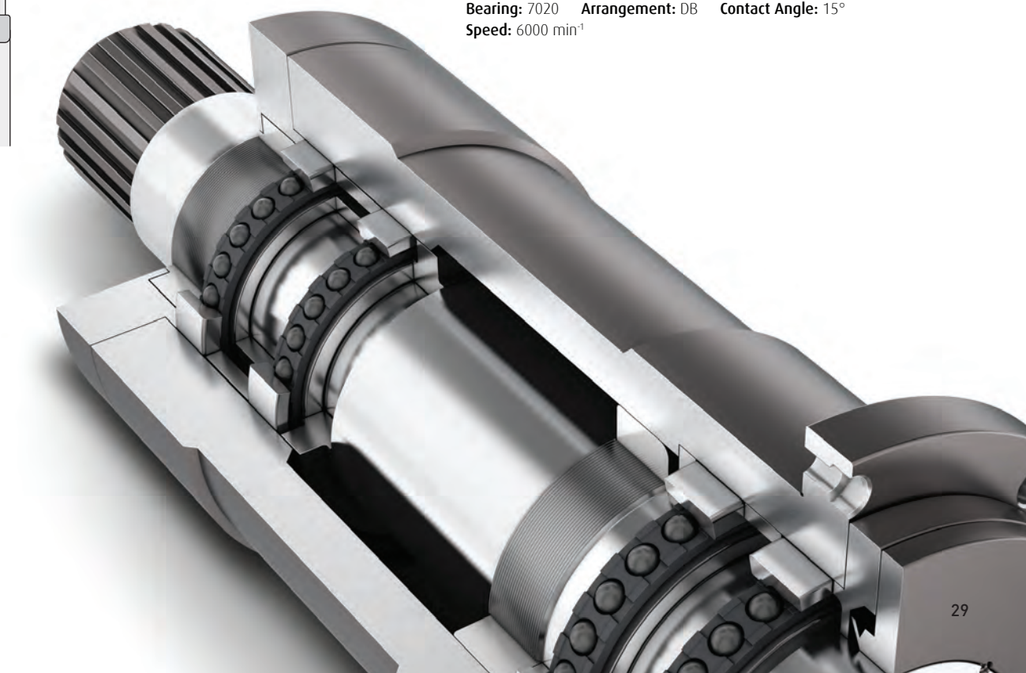


Test conditions:
Bearing: 7020 **Arrangement:** DB **Contact Angle:** 15°

Fig.18: Preload - heat generation and life



Test conditions:
Bearing: 7020 **Arrangement:** DB **Contact Angle:** 15°
Speed: 6000 min^{-1}



Cylindrical roller bearings support only radial loads, but deliver the benefit of a larger radial load capacity than angular contact ball bearings. In general, double row cylindrical roller bearings are used for high rigidity applications such as lathes, while single row cylindrical roller bearings are used in high-speed applications such as machining centers.

THE EFFECT OF INTERNAL RADIAL CLEARANCE

The performance of cylindrical roller bearings is effected by internal radial clearance after mounting. **Figure 19** illustrates that 0 µm to slightly negative clearance is optimal in terms of both rigidity and bearing life.

In order to achieve rigidity for fixed-end bearings, radial clearance is set to slightly below zero. Radial clearance below -3 µm will have negligible increase to rigidity, while bearing life will decline sharply.

Positive clearance of approximately +3 µm is commonly used in free-end bearings. Depending on the bearing size and operating speed, a more detailed examination may be required. Internal radial clearance decreases during operation. This must be taken into account when setting internal radial clearance during mounting, especially with high-speed applications.

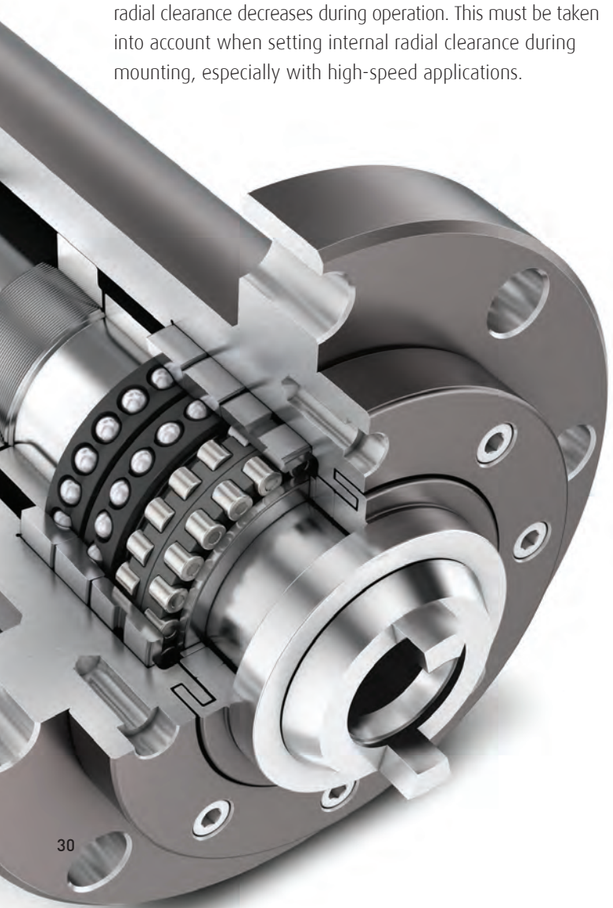
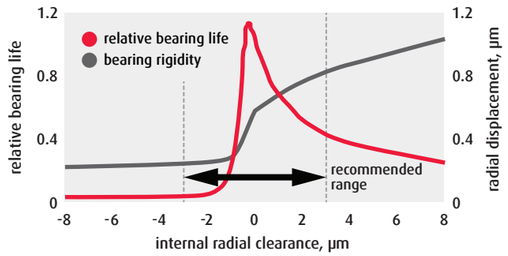
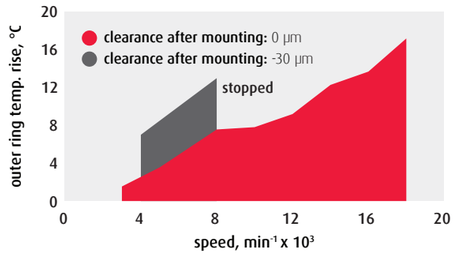


Fig.19: Effect of internal radial clearance



Test conditions:
Bearing: NN3020MBKR **Radial load:** 1000 N

Fig.20: Radial clearance and temperature rise



Test conditions:
Bearing: N1014 with SHX steel rings and rollers
Grease: ISOFLEX NBU15

RADIAL CLEARANCE AND TEMPERATURE RISE

Figure 20 illustrates temperature rise in cylindrical roller bearings after mounting. The bearing with -30 µm internal radial clearance displays a strong temperature rise and a drop in limiting speed. Mounting a bearing with an excessively negative internal radial clearance will not allow that bearing to perform to its potential.

ADJUSTING INTERNAL RADIAL CLEARANCE

Cylindrical bore

Bearing dimensions are matched to those of the shaft and housing. As a result of the shaft and housing fits, internal radial clearance will change from Δr to $\Delta r'$. No further adjustment of the internal radial clearance is possible.

Tapered bore

The distance by which the bearing is driven onto the shaft determines the amount of inner ring expansion; internal radial clearance will change from Δr to $\Delta r'$ to $\Delta r''$ to achieve the desired internal radial clearance.

ISO standards for 1:12 tapered bores have a wide tolerance range for the taper angle. NSK has established its own narrower tolerances for precision cylindrical roller bearings:

› **KR tolerance** has a very narrow range that is positioned towards the lower limit of the standard ISO range. The narrow tolerance of KR tapered bores supports easier clearance control during mounting. NSK applies KR tolerance as standard to bore diameters up to 400 mm

› **K tolerance** is positioned midrange in accordance to the ISO standard. NSK applies K tolerance to bore diameters larger than 400 mm

Fig.21: Cylindrical bore

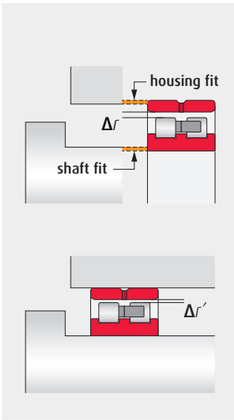
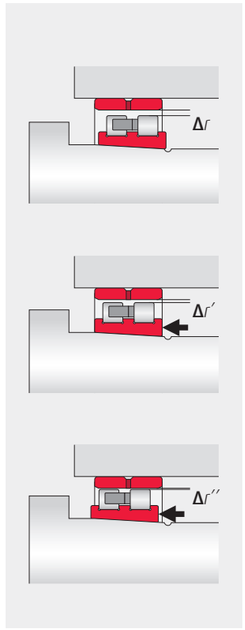


Fig.22: Tapered bore



INTERNAL RADIAL CLEARANCE CLASSES

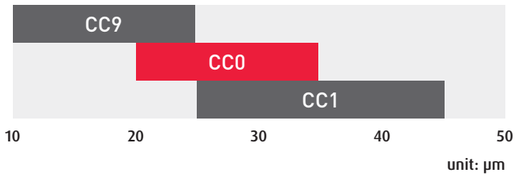
CC0 clearance - NSK recommended

This class offers medium radial clearance, eliminating the upper and lower limits of CC9 and CC1 respectively with a smaller range. NSK recommends CC0 for ease of use in customer applications that target this clearance range.

CC9 clearance

With the lowest internal clearance of the three classes, bearings with CC9 clearance need only to be driven onto the shaft a very short distance, mitigating the negative influence of interference on bearing accuracy or deformation of the shaft bore. However, if the bearing's internal clearance is at the lower end of the CC9 range prior to installation and the drive-up distance to achieve the desired mounted clearance is extremely small, there is an increased risk of creep damage between the shaft and the inner ring of the bearing when under high-speed and/or high-load operation.

Fig.23: Internal clearance example: NN3020TBKR



CC1 clearance

CC1 clearance has been traditionally adopted, in part due to the absence of any risk of creep damage considering the distance that the bearing is driven onto the shaft. However, if the bearing's internal clearance is at the higher end of the CC1 range prior to installation and the drive-up distance to achieve the desired mounted clearance on the tapered shaft is considerable, there is a risk of detrimentally impacting bearing accuracy or causing deformation of the inside shaft bore. This is particularly true in the case of a thin hollow shaft with a large bore diameter.

THE IMPORTANCE OF TOLERANCES

Accuracy classes dictate tolerances that encompass both the running accuracy (runout) and the dimensional accuracy (external tolerances) of bearings.

As illustrated in **Figure 24**, radial runout is the measure by which the rotational axis of the bearing deviates from the centerline axis of the spindle shaft while remaining parallel. Axial runout measures the degree to which the axis of rotation is tilted and deviating from parallelism.

Dimensional accuracies measure the tolerance range of deviations in outer and bore diameters in manufacturing (see **Figure 25**). Appropriate determination and selection are crucial to ensure proper shaft and housing fits. When using bearings in combination arrangements it is important to match the accuracies of the bearings selected. Mismatched bore and outside diameter tolerances in bearing combinations can lead to uneven load sharing and bearing failure.

ACCURACY CLASS P4Y

NSK's proprietary P4Y accuracy standard has a special, tightly controlled range of external tolerances with a Class 4 (P4) running accuracy. Since the variation of bearing bore and outer diameter is minimized (see **Figure 25**), P4Y is particularly well suited for universal combination bearings.

Tables 4 and 5 illustrate the median tolerance range of P4Y relative to all accuracy classes.

SPECIAL WIDTH ACCURACY CLASS P3W

Class 3W is an NSK proprietary standard in which the tolerances for the inner and outer ring width are in a special class, while other tolerances are per Class 3. The width tolerances are the same for the inner and outer rings. This standard can apply to universal arrangement bearings (SU, DU, DUD, and QU). Minimizing differences in width improves assembly and reduces the need for adjustments (see **Figure 25** and **Table 6**).

Fig.24: Running accuracy

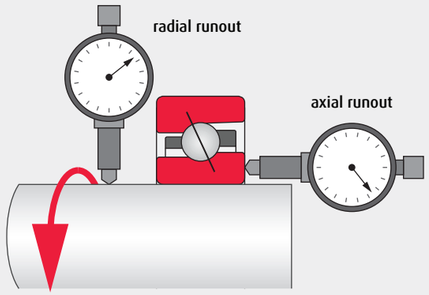
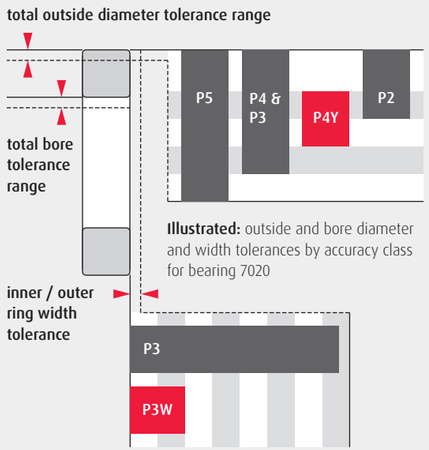


Fig.25: Dimensional accuracy - external tolerances



Illustrated: outside and bore diameter and width tolerances by accuracy class for bearing 7020

Table 4: Inner ring tolerances P4Y

TOLERANCES FOR BORE DIAMETER OF INNER RING											UNIT: µm
Bore diameter (mm)		Class 5		Class 4		Class 4Y		Class 3		Class 2	
over	including	high	low	high	low	high	low	high	low	high	low
30	50	0	-8	0	-6	-1	-3	0	-6	0	-2.5
50	80	0	-9	0	-7	-2	-5	0	-7	0	-4
80	120	0	-10	0	-8	-3	-6	0	-8	0	-5
120	150	0	-13	0	-10	-3	-7	0	-10	0	-7

Table 5: Outer ring tolerances P4Y

TOLERANCES FOR OUTSIDE DIAMETER OF OUTER RING											UNIT: µm
Outside dia. (mm)		Class 5		Class 4		Class 4Y		Class 3		Class 2	
over	including	high	low	high	low	high	low	high	low	high	low
30	50	0	-7	0	-6	-2	-6	0	-6	0	-4
50	80	0	-9	0	-7	-2	-6	0	-7	0	-4
80	120	0	-10	0	-8	-2	-6	0	-8	0	-5
120	150	0	-11	0	-9	-3	-7	0	-9	0	-5
150	180	0	-13	0	-10	-3	-7	0	-10	0	-7
180	200	0	-15	0	-11	-4	-9	0	-11	0	-8
200	215	0	-15	0	-11	-2	-9	0	-11	0	-8

Table 6: Inner / outer ring width tolerances P3W

WIDTH TOLERANCES OF COMBINED BEARINGS UNIT: µm					
Outside dia. (mm)		Class 3		Class 3W	
over	including	high	low	high	low
50	80	0	-250	0	-100
80	120	0	-380	0	-100
120	140	0	-380	0	-100
145	150	0	-380	0	-100
165	170	0	-380	0	-100

The accuracy classes of NSK Super Precision Bearings are specified by ISO 492 as well as ABMA Standard 20 in the case of angular contact ball bearings.

METHODS OF LUBRICATION

Lubrication is essential to machine tool bearings to achieve the level of performance for which they were designed. Optimal selection of lubricant and lubrication methods will ensure reduced friction and wear inside the bearing and thereby prevent seizure. Appropriate lubrication of the rolling contact surfaces extends the rolling fatigue life of bearings. Circulating lubrication can mitigate frictional heat or heat transferred to the bearing, preventing overheating and lubricant deterioration. Adequate lubrication helps to prevent ingress of foreign material and guards against corrosion or rusting.

GREASE LUBRICATION

For grease lubrication of bearings in high-speed machine tool spindles that require low temperature rise and long life, a consistency No.2 or No.3 grease with a synthetic base oil (diester, diester + mineral oil, etc.) is recommended.

Grease life depends, to a large degree, upon operating temperature. It is therefore necessary to maintain a cool running temperature to extend grease life.

Refer to **Table 7** for common brand names and properties of greases widely used in machine tool spindles and ball screw support bearings.

RECOMMENDED GREASE QUANTITIES

The recommended grease fill for operating bearings at high speed ranges from 10% to 30% of internal space depending on bearing type and operation. For ball screw support bearings, which usually operate at slow speed, under high load, and in intermittent operation, NSK recommends a grease quantity of 30% to 55%.

Too much grease will lead to abnormal heat generation, especially during running-in, and may lead to grease deterioration. Based on accumulated experience, NSK determines packing quantities that allow easy running-in and will provide sufficient lubrication.

Table 7: Common grease types and properties

Brand Name / NSK Code	Thickener	Base Oil	Base Oil Viscosity, mm^2/s (40°C)	Dropping Point (°C)	Working Temp. Range (°C) 1)	Applications
NSK MTE Grease / MTE	Barium complex	Mineral oil + Ester oil 3)	23	>260	-20 to +130	Bearings for high-speed spindles
NSK MTS Grease / MTS	Urea 2)	Poly-α-olefin + Ester oil 3)	22	>220	-40 to +130	
Turmogrease Highspeed L252 / YL2	Lithium soap	Poly-α-olefin + Ester oil 3)	25	>250	-50 to +120	
ISOFLEX NBU15 / NB5	Barium complex	Mineral oil + Ester oil 3)	23	>260	-20 to +120	Bearings for spindles
Staburags NBU 8 EP / N8E		Mineral oil	105	>220	-10 to +130	Bearings for high-load spindles
EA7 Grease / EA7	Urea 2)	Poly-α-olefin oil	46	>260	-40 to +160	Bearings for motors
ENS Grease / ENS		Polyol ester oil 3)	30.5	>260	-40 to +160	
Alvania S2 / AS2	Lithium	Mineral oil	130	185	-10 to +110	Ball screw support bearings
NSK WPH Grease / WPH	Urea 2)	Poly-α-olefin oil	95.8	259	-40 to +150	
NSK FS2 Grease / FS2	Lithium soap	Mineral oil	139	205	-10 to +110	Ball screw support bearings, heavy load
Multemp PS No. 2 /PS2		Poly-α-olefin + Diester oil	15.9	190	-50 to +110	Ball screw support bearings, light load
Klüberplex BEM 41-132 / BE4		Mineral oil + Poly-α-olefin oil	120	>250	-40 to +150	Ball screw support bearings, BSBD series

1) For special application environments such as operating temperatures close to the low end or high end of the range, or vacuum, etc., please contact NSK.
2) Caution: Grease containing urea thickener degrades fluorine-based materials.
3) Caution: Ester oil-based grease causes acrylic materials to swell.

OIL MIST LUBRICATION

Oil mist lubrication sprays oil by turning it into a mist using compressed air. With this method it is necessary to adjust the oil quantity to support adequate lubrication at high speeds, as well as to accommodate the effects of the branches in distribution tubing and possible leakage.

As this method involves potential environmental hazards, OSHA regulations should be considered.

OIL-AIR LUBRICATION

Oil-air lubrication feeds oil continuously by injecting oil into a compressed air stream by means of a mixing valve that intermittently discharges the minimum quantity of oil using a constant-quantity piston. The oil flows along the wall of a pipe and approaches a constant flow rate.

Oil-air lubrication is recommended primarily in the main spindles of machine tools and other high-speed applications.

OIL JET LUBRICATION

Jet lubrication is mainly used for high-speed bearings with a d_mn value exceeding one million. Jets of lubricating oil pass through the bearings via one or several nozzles at a constant pressure.

In high-speed applications, the air surrounding the bearing rotates together with the bearing and forms a wall of air. The speed of the jet from each nozzle must exceed the circumferential speed of the inner ring outside surface by at least 20%.

To uniformly cool down bearings and shaft, it proves advantageous to increase the number of nozzles. Enlarging the oil discharge outlet or employing forced discharge should also be considered to improve heat removal.

Table 8 illustrates the various pros and cons associated with selecting each method of lubrication.

Table 8: Comparison of lubricating methods

Lubricating Method	Advantages	Disadvantages
Grease lubrication	› Cost is low › Limitation of temperature rise is possible › Maintenance-free	› If packed grease deteriorates, seizure may occur › May allow penetration of dust or cutting fluid
Oil mist lubrication	› Since new oil is always fed, no fear of oil deterioration › Dust and cutting fluid cannot easily enter	› Pollution of environment › Oil supply quantity varies depending on the oil viscosity and temperature, so controlling of a small flow rate is difficult › It is difficult to confirm that oil is actually fed
Oil-air lubrication	› Since oil quantity control is possible, the optimum quantity of oil is fed and heat generation is low › In addition to little heat generation, there is a cooling effect of the air, so the temperature rise is low › Since new oil is always fed, no fear of oil deterioration › Dust, cutting fluid cannot easily enter › Environmental pollution mist is slight	› Cost is rather high › Confirmation of whether oil is actually fed to bearing is difficult › Environmental pollution mist is slight
Oil jet lubrication	› Since the oil flow rate is high, dust and cutting fluid cannot enter and seizure hardly ever occurs › Because of cooling by oil, the bearing temperature can be controlled to some degree	› Frictional loss is high › Since oil leaks, it is difficult to use for vertical spindles › Cost is high

RUNNING-IN PROCEDURES

If operating speed is suddenly increased after bearings are mounted, bearings may be damaged due to insufficient lubrication, or the lubricant may deteriorate. Proper running-in with gradual increases of operating speed is indispensable, especially for grease-lubricated bearings where grease must be allowed to spread evenly. Spindle assemblies operating under oil mist and oil-air lubrication are at risk of a sudden temperature rise at initial operation or shortly thereafter. Running-in for bearings with these lubricating systems requires much less time than for grease-based systems, and is highly recommended.

CONTINUOUS RUNNING-IN METHOD

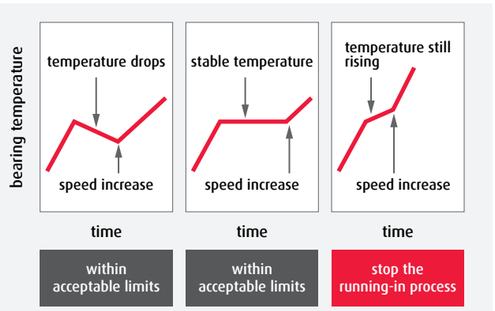
Continuous running-in works by gradually increasing the operating speed from the low-speed zone. Maximum operating speed is commonly divided into ten stages to determine the target speed with incremental increases from stage to stage:

- begin at a reasonably low operating speed
- monitor temperature rise
- when temperature has stabilized, increase speed to the next target speed
- continue repeating steps 2 and 3 until the maximum operating speed is reached

Allow between 30 minutes and 2 hours for the temperature to stabilize before you increase speed to the next stage. **Figure 26** shows patterns of temperature development that help you decide whether speed may be increased.

Determine the target speeds that are optimally suited for your application while monitoring the actual temperature on your spindle. Though somewhat time-consuming, this method helps to detect potential spindle defects and avoid costly damage to the bearings.

Fig. 26: Bearing temperature change during running-in



INTERMITTENT RUNNING-IN METHOD

Initially, run the spindle continuously at about 500 min-1 (100 min-1 for larger machines) for 15 minutes to allow the grease to settle. Take the maximum operating speed and divide it into eight to ten stages to determine the maximum target speed for each stage:

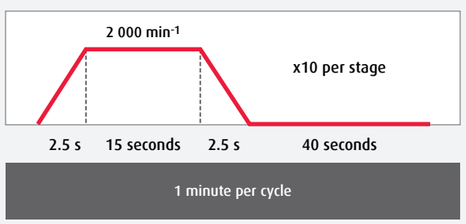
- each stage is divided into 10 cycles of approximately one minute duration
- during each cycle, rapidly accelerate the spindle to the target speed for the current stage > decelerate back to zero > rest for a period of 40 seconds
- repeat this cycle approximately 10 times
- continue to move through the stages, following the above procedures, until the maximum operating speed is reached

After the maximum operating speed is reached, continuously run the spindle at that speed for about 1 hour.

Speed increase causes a sudden supply of grease to the bearing's interior, resulting in a sharp temperature rise. During intermittent running-in, the spindle is stopped to allow the temperature to stabilize. This saves time compared to the continuous running-in method.

The number of target speed stages and cycles to be performed in each speed stage varies according to spindle design and arrangement.

Fig. 27: Cycle structure during intermittent running-in



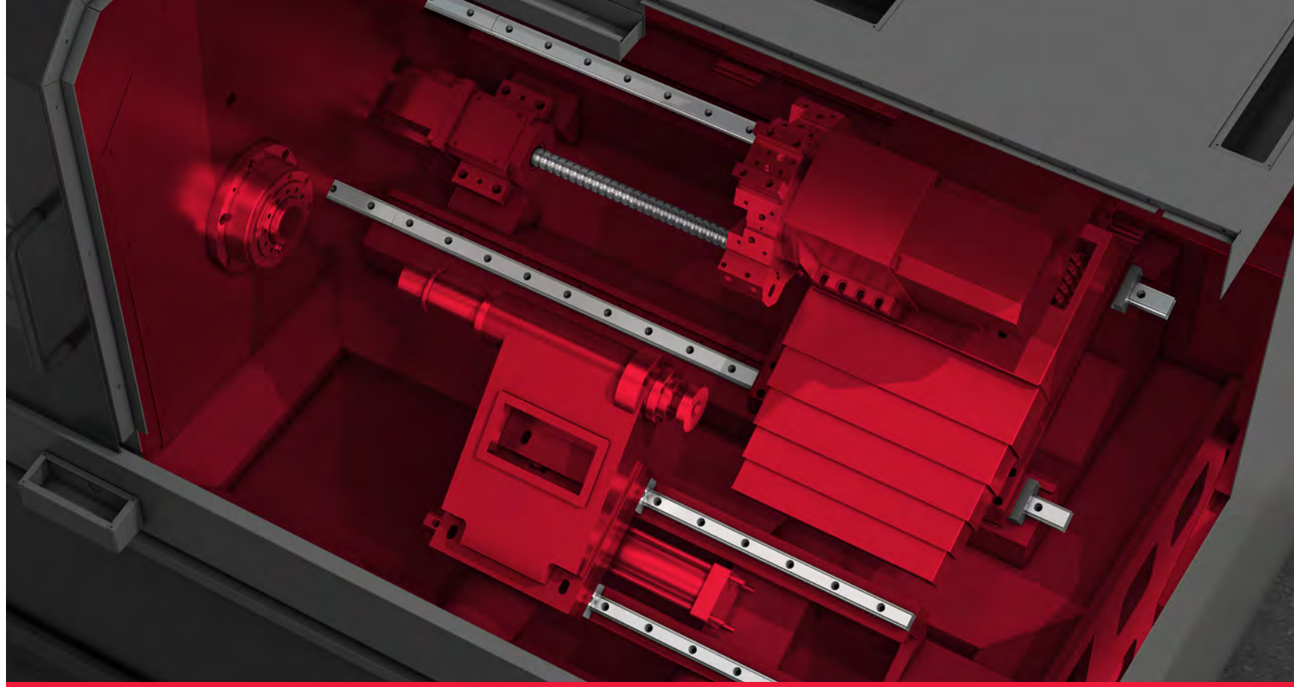
RUNNING-IN PROCEDURE FOR MACHINE TOOL BEARINGS

Lubrication type and running-in method		Grease			Oil
		Continuous	Intermittent	High Speed	Continuous
Process					
		Stair step: increasing speed at each stage	**Quick steps:** short on-off cycles, increasing speed each stage	**ON-OFF:** short on-off cycles, increasing "ON" time each stage	**Slow start:** slow start-up speed, then full speed
Process		**New equipment preferred method**	**Previously run-in spindles**	**When motor speed cannot be varied**	**Spindles using oil lubrication**
Running-in stages	**Stage 1**	10% of maximum rpm	500 rpm 1 cycle = 15 mins.	100% of max. rpm 1 cycle = 20 s ON + 4 mins. OFF x 10 cycles	33% of maximum rpm for 4 min
	Stage 2	20% of maximum rpm	12.5% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles	100% of max. rpm 1 cycle = 30 s ON + 4 mins. OFF x 10 cycles	100% of maximum rpm until "warmed up"
	Stage 3	30% of maximum rpm	25% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles	100% of max. rpm 1 cycle = 40 s ON + 4 mins. OFF x 10 cycles	
	Stage 4	40% of maximum rpm	37.5% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles	100% of max. rpm 1 cycle = 50 s ON + 4 mins. OFF x 10 cycles	
	Stage 5	50% of maximum rpm	50% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles	100% of max. rpm 1 cycle = 60 s ON + 4 mins. OFF x 10 cycles	
	Stage 6	60% of maximum rpm	62.5% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles		
	Stage 7	70% of maximum rpm	75% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles		
	Stage 8	80% of maximum rpm	87.5% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles		
	Stage 9	90% of maximum rpm	100% of max. rpm 1 cycle = 20 s ON + 40 s OFF x 10 cycles		
	Stage 10	100% of maximum rpm	100% of max. rpm 1 cycle = 1 h		
Progression		Move to next stage only after temp. stabilizes. Stage time may vary; allow 30 mins to 2 hrs	Move to next stage only after cycles are completed		Move to next stage only after the previous stage is completed
Total running-in time		**10 to 20 hours**	**2.5 to 3 hours**	**4 to 4.5 hours**	**0.25 to 1 hour**

Caution: Do not attempt to expedite temperature stability by blowing air over the spindle. Excessive cooling of the housing may cause the internal preload of the bearings to increase, which can lead to bearing damage or failure.

For additional technical information about NSK rolling bearing and linear motion products for machine tools, refer to:

- **E1254K - NSK Super Precision Bearings**
- **E3162K - NSK Precision Machine Components**



MORE THAN BEARINGS

NSK LINEAR MOTION PRODUCTS FOR MACHINE TOOL

For the feed drives used in machining centers to position cutting tools and workpieces, positioning accuracy and speed are of equal importance to the quality of finished parts and the productivity of machine tools.

In this regard, NSK expertise extends to precision machine components for machine tools - enabling automation and accuracy at high speeds while contending with myriad machining stresses.

High-speed and high-rigidity ball screws. High-accuracy and long-life linear guides. Material and surface technologies to reduce wear. Advanced seals for dust and contaminant resistance. Lubrication solutions for reduced maintenance.

With our Super Precision bearings and linear motion products, NSK equips machine tool builders and operators with holistic, integrated and ideal motion and control solutions.

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