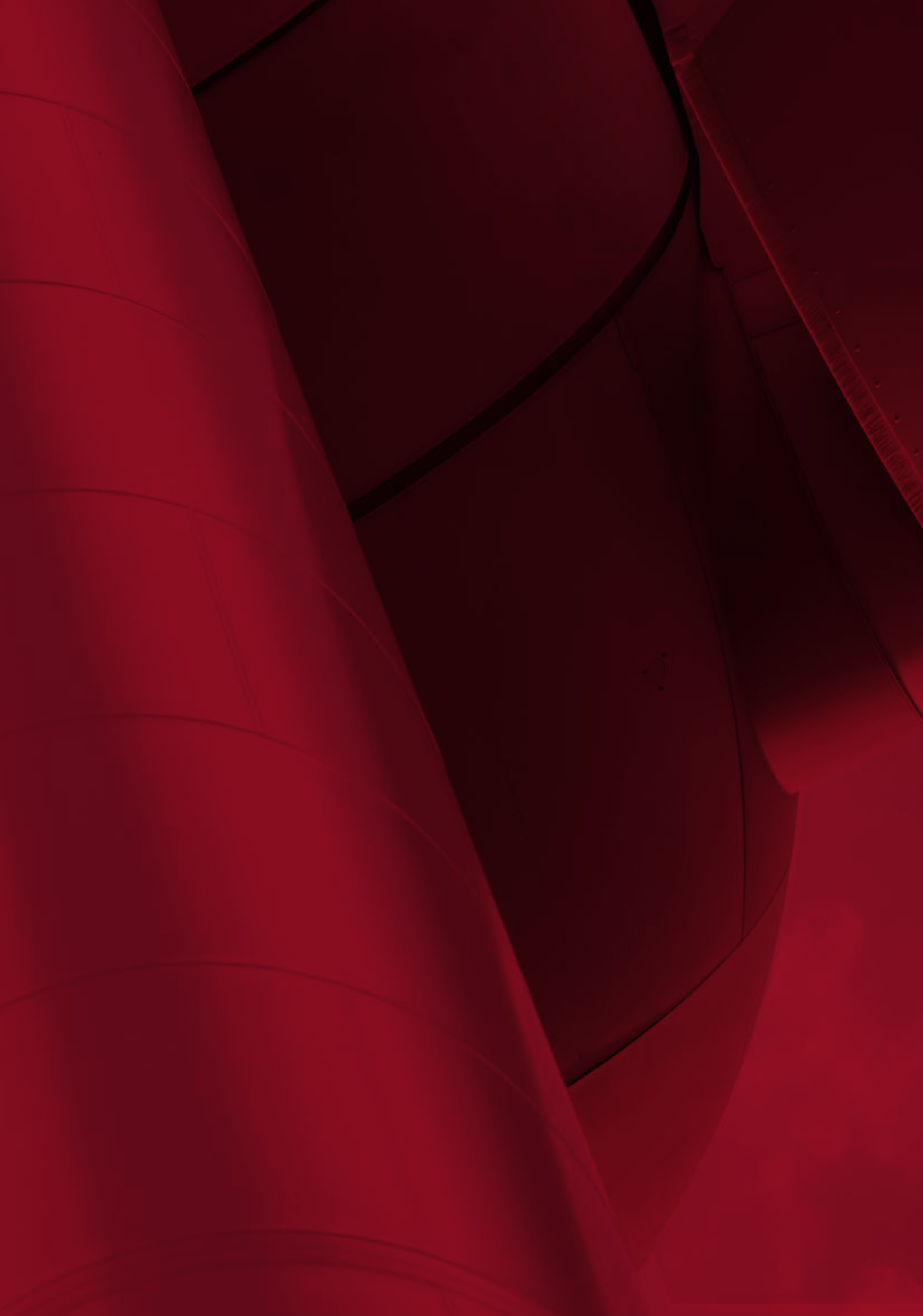


ADVANCED BEARING SOLUTIONS FOR THE WIND INDUSTRY





Wind turbines generate electricity under adverse and constantly changing conditions, both on and offshore. Efficient power generation from wind turbines demands high performance from every component – particularly the bearings used in the main shaft, gearbox, and generator.

NSK rolling bearings for these applications perform with robust resistance to seizure, wear, flaking and unique challenges such as white etching cracks (WEC) to deliver advanced product design solutions for a reliable and sustainable operating life. NSK has been producing bearings for wind turbines for over 30 years.



A GLOBAL PARTNER AND SOLUTIONS PROVIDER



As a leading manufacturer of rolling bearings, linear technology components and steering systems, NSK can be found on almost every continent – with production facilities, sales offices and technology centers – providing our customers with responsive decision-making channels, effective logistics and local service.



THE NSK COMPANY:

NSK commenced operations as the first Japanese manufacturer of rolling bearings in 1916. From the outset, we have been continuously expanding and improving not only our product portfolio but also our range of services for various industrial sectors. In this context, we develop technologies in the fields of rolling bearings, linear systems, components for the automotive industry and mechatronic systems. Our research and production facilities in the Americas, Europe and Asia are linked together in a global technology network. Here we concentrate not only on the development of new technologies, but also on the continuous optimization of quality – at every process stage.

NSK has a long tradition in patent applications for machine parts. In our worldwide research centers, we not only concentrate on our development of new technologies, but also on the continual improvement of quality based on the integrated technology platform of tribology, material technology, numerical simulation and mechatronics.

TRIBOLOGY:

Improving Performance by Optimizing Friction. Tribology is the study of friction and wear of contact surfaces in relative motion, such as rotating parts that endure enormous forces with a thin oil film. Severe operating conditions are optimized through lubrication and surface treatments developed by NSK, resulting in superior performance for applications requiring low friction, high-speed rotation, quiet operation or enhanced durability.

MATERIALS:

Superior Performance for Any Application. Materials research and development affects nearly every aspect of product performance. Through careful selection of material composition, heat treatment and use of alternative materials, NSK enables optimization of application performance. This may be through improvements in product function, endurance, and reliability or through improvements in production and process cost efficiency.

NUMERICAL SIMULATION:

Turning Blind Risk Into Trusted Reliability. In the past, accuracy and reliability in product development were achieved with experience-based design and longer testing periods. NSK's simulation technology allows for virtual validation to accelerate design and production. Extreme conditions or innovative designs that defy previous expectations can also be evaluated and analyzed.

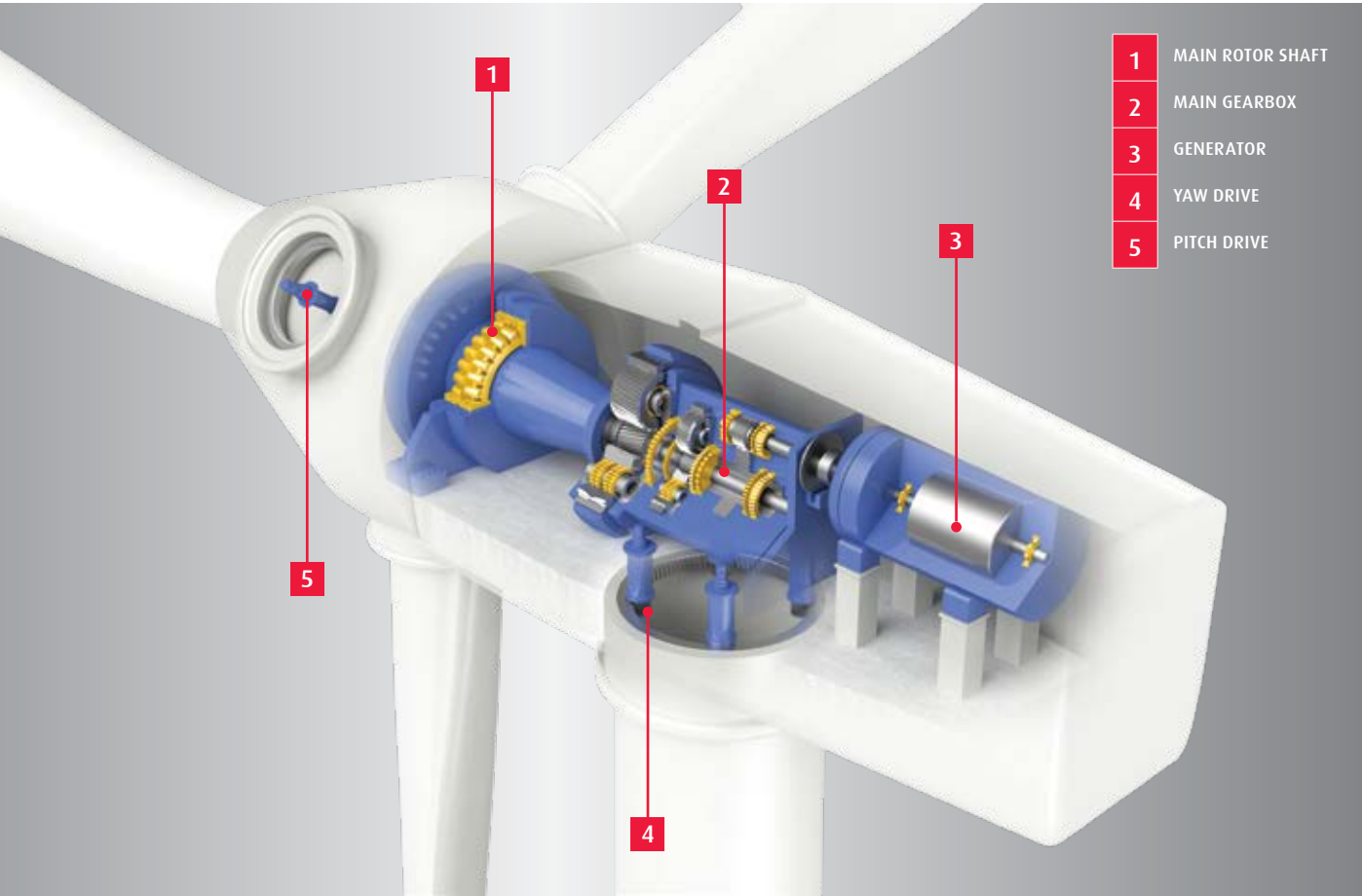
MECHATRONICS:

Technology for a Safe and Comfortable Future. Mechatronics refers to the combination of mechanics and control technologies. NSK has cultivated knowledge of mechanics through years of product development and production. This knowledge is used in conjunction with motors, sensors and circuits to develop mechatronic systems that add new functions, improve reliability and increase performance in various industries while also improving convenience and safety in our daily lives.

CORE TECHNOLOGIES

EVERY SOLUTION CALLS FOR THE RIGHT PRODUCTS

Whether for the main drive stage or other components, our broad range of rolling bearing products deliver reliable and sustainable operating life across wind turbine applications.



MAIN ROTOR SHAFT

The rotor induces high axial and radial loads in the main bearings, which occur both statically and dynamically. Given these loads, high bearing stiffness is indispensable. Spherical roller bearings used in the 3-point and 4-point drivetrains, or cylindrical and tapered roller bearings used in the 4-point drivetrain, are particularly well-suited for this application.

MAIN GEARBOX

A variety of gearbox arrangements have been implemented for wind turbines in recent years. Megawatt-class systems often combine planet gear stage(s) with multiple parallel gear stages. Deep groove ball bearings, spherical roller bearings, cylindrical roller bearings, tapered roller bearings and four-point contact ball bearings are used, depending on location.

	SPHERICAL ROLLER BEARINGS	CYLINDRICAL ROLLER BEARINGS - SINGLE ROW	CYLINDRICAL ROLLER BEARINGS - DOUBLE ROW	TAPERED ROLLER BEARINGS - SINGLE ROW	TAPERED ROLLER BEARINGS- DUPLEX / WITHOUT OUTER RING	TAPERED ROLLER BEARINGS - DOUBLE ROW / ASYMMETRICAL ARRANGEMENTS	DEEP GROOVE BALL BEARINGS	FOUR-POINT BEARINGS
MAIN ROTOR SHAFT	■	■		■		■		
MAIN GEARBOX	■	■	■	■	■	■	■	■
GENERATOR		■					■	
PITCH / YAW GEARBOX	■	■		■			■	

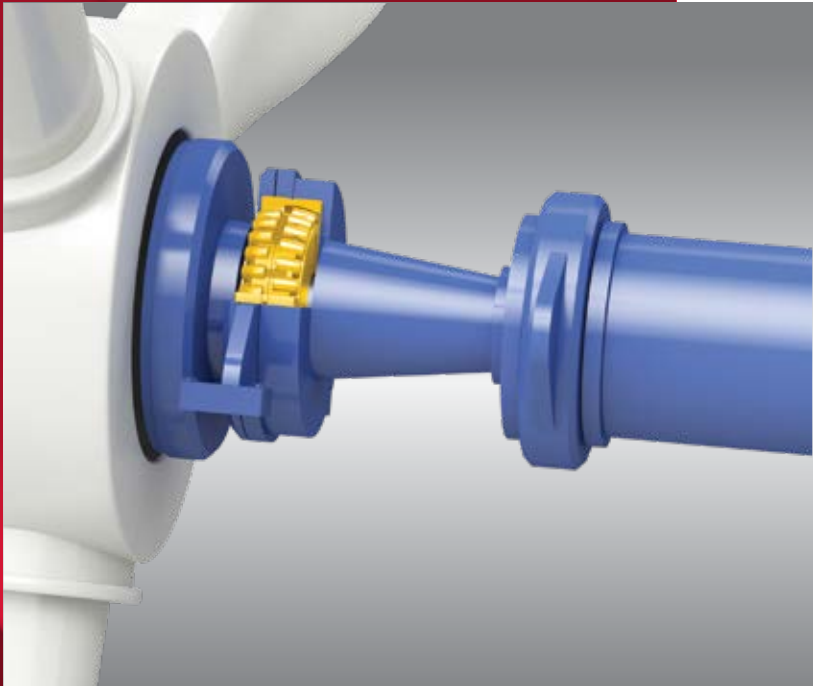
GENERATOR

Generators primarily use deep groove ball bearings and cylindrical roller bearings. Transmission of electrical current can damage the rolling bearings and shorten their service life. In order to avoid this damage, NSK offers coated rolling bearings where an insulating coating has been applied to the outer rings.

PITCH AND YAW GEARBOX

Yaw gearboxes turn the nacelle into the wind or away from it. Pitch gearboxes are required for rotor blade adjustment. Deep groove ball bearings, cylindrical roller bearings, spherical roller bearings and tapered roller bearings are typically installed in these gearboxes.

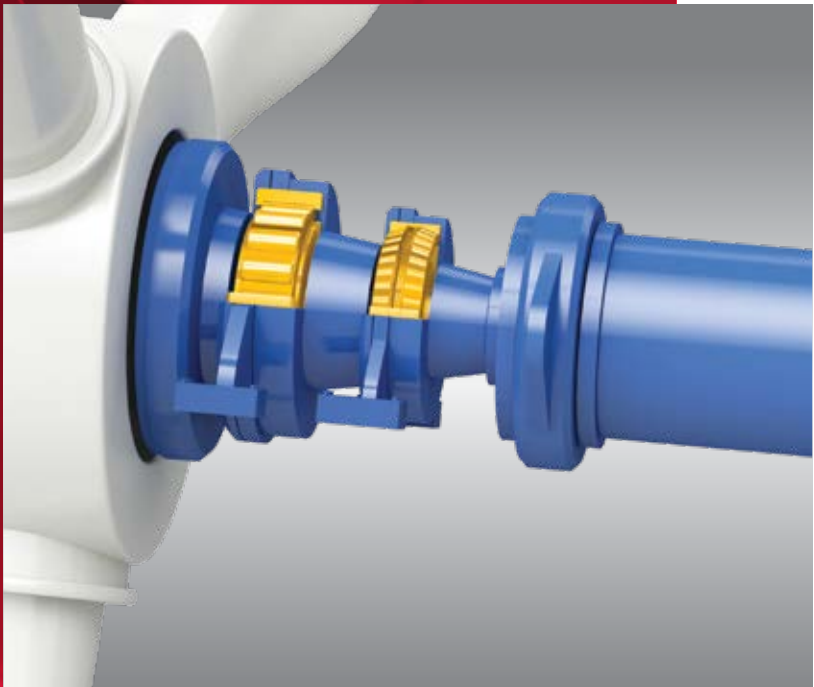
MAIN SHAFT BEARINGS



3-POINT SUSPENSION

One of the most common wind turbine architectures is the 3-point suspension. In this configuration, a single spherical roller bearing is used to support the main shaft and wind loading. The other end of the main shaft is rigidly mounted to the input shaft of the gearbox and relies on the gearbox's flexible trunion system to share the loading through the gearbox's input shaft bearings. All of the wind loading generated by the rotor, as well as its torque, must be safely transmitted through the gearbox structure and mounting system to the wind turbine's frame.

Bearing Selection: Spherical Roller Bearing



4-POINT SUSPENSION MODULAR DRIVETRAIN

The architecture is a typical configuration consisting of two main bearings that support a separate main shaft. This main shaft is also rigidly connected to the gearbox input shaft. The bearings supporting the main shaft isolate the wind loading from the gearbox and its bearings. Only deflections and tolerances may cause additional reaction loads in the gearbox bearings. Often the reaction loads at the bearings cannot easily be calculated in this statically indeterminate drivetrain configuration.

Bearing Selection: Tapered Roller Bearing,
Single Row or
Double Row KDH or KH Design

Cylindrical Roller Bearing
Single Row NU, NJ or NF Design

Spherical Roller Bearing



SPHERICAL ROLLER BEARINGS

Spherical roller bearings use heavy-duty machined brass cages with extremely high load capacity and superior durability. Extra-capacity ECA bearings offer an optimized internal design for higher load ratings and a roller-guided cage that eliminates the need for a guide ring, reducing sliding friction and wear. Available with Super-TF long life steel applied to rings, and DLC coating applied to rollers to resist wear and peeling as option.



TAPERED ROLLER BEARINGS DOUBLE-ROW

NSK double-row tapered roller bearings are designed with a single inner ring, 2 roller/cage sets and 2 outer rings with spacer. Optimized large-size rollers guided by high strength, wear resistant cages deliver high capacity for combined heavy radial loads and axial loads in both directions. In inch and metric dimensions with normal contact angle (KH design) or with steep angle races (KDH design) for increased axial load capacity. Available with Super-TF long-life steel applied to rings as option.



CYLINDRICAL ROLLER BEARINGS SINGLE ROW

Optimized size and profile of rollers guided by high precision machined cages deliver higher load ratings and smooth rotation in main shaft applications, even at very low speeds. With heavy duty precision machined brass cage or pin-type cages. Available with Super-TF long-life steel applied to rings as option.



TAPERED ROLLER BEARINGS SINGLE ROW

Tapered roller bearings can carry both radial and axial loads. The rigidity of main shaft can be increased by combining two single-row tapered roller bearings and applying preload. Both inch and metric series are available. And available with Super-TF long-life steel applied to rings as option.

SPHERICAL ROLLER BEARINGS

APPLICATIONS FOR SPHERICAL ROLLER BEARINGS

Spherical roller bearings have self-aligning capabilities and high load capacity in both radial and axial directions. These features account for their wide use in applications where mounting errors and shaft misalignment are likely, bearing spans are long, shaft deflection is high, or large radial or impact loads are applied.



SPHERICAL ROLLER BEARINGS FOR WIND TURBINE MAIN SHAFTS

Spherical roller bearings used in main shafts face low speeds and high loads conditions from blades which can lead to surface damage such as peeling and wear due to insufficient oil film formation between the rolling elements and ring raceways.

To solve these surface damages, NSK provides solutions with material technology, analysis and design technology, and coating technology.



MATERIAL TECHNOLOGY

Standard Material: High-Cleanliness Steel

The rolling fatigue life of bearings is highly dependent on the quantity of non-metallic inclusions in the bearing material. NSK uses high cleanliness bearing steel as standard material, in which oxygen content is kept as low as possible and other impurities are greatly reduced in order to reduce non-metallic inclusions. This ensures longer rolling fatigue life.

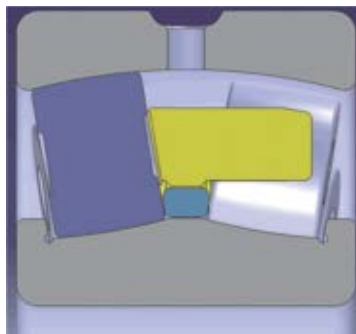
Advanced Material: Super-TF

Super-TF offers excellent resistance to wear and peeling, providing long life even in environments with poor lubrication or contaminants. (See pages 18-20 for details.)

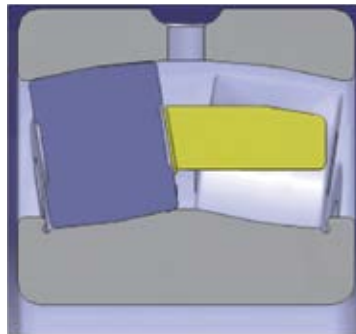
EXTRA-CAPACITY ECA BEARINGS (ROLLER-GUIDED CAGE)

Conventional (CA type) spherical roller bearings require a guide ring between the cage and inner ring. Conversely, extra-capacity ECA bearings feature a roller-guided cage with specially shaped pockets that eliminate the need for a guide ring. The optimized design of these pockets reduces stress on the cage columns even with thinner columns, supporting a higher quantity of rollers and larger roller sizes to increase load capacity.

CA Type

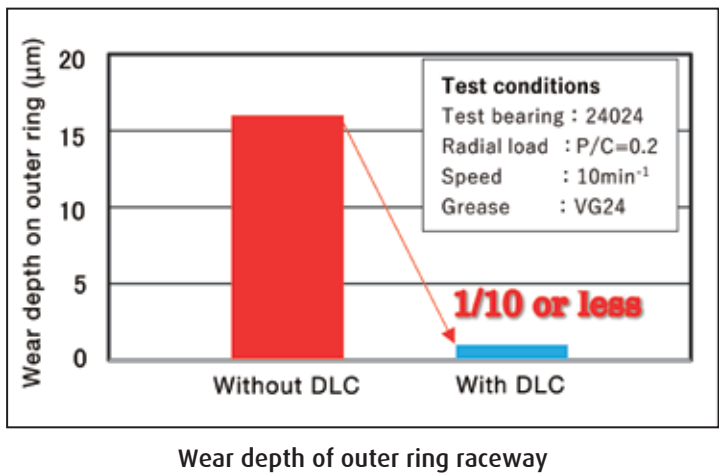


ECA Type

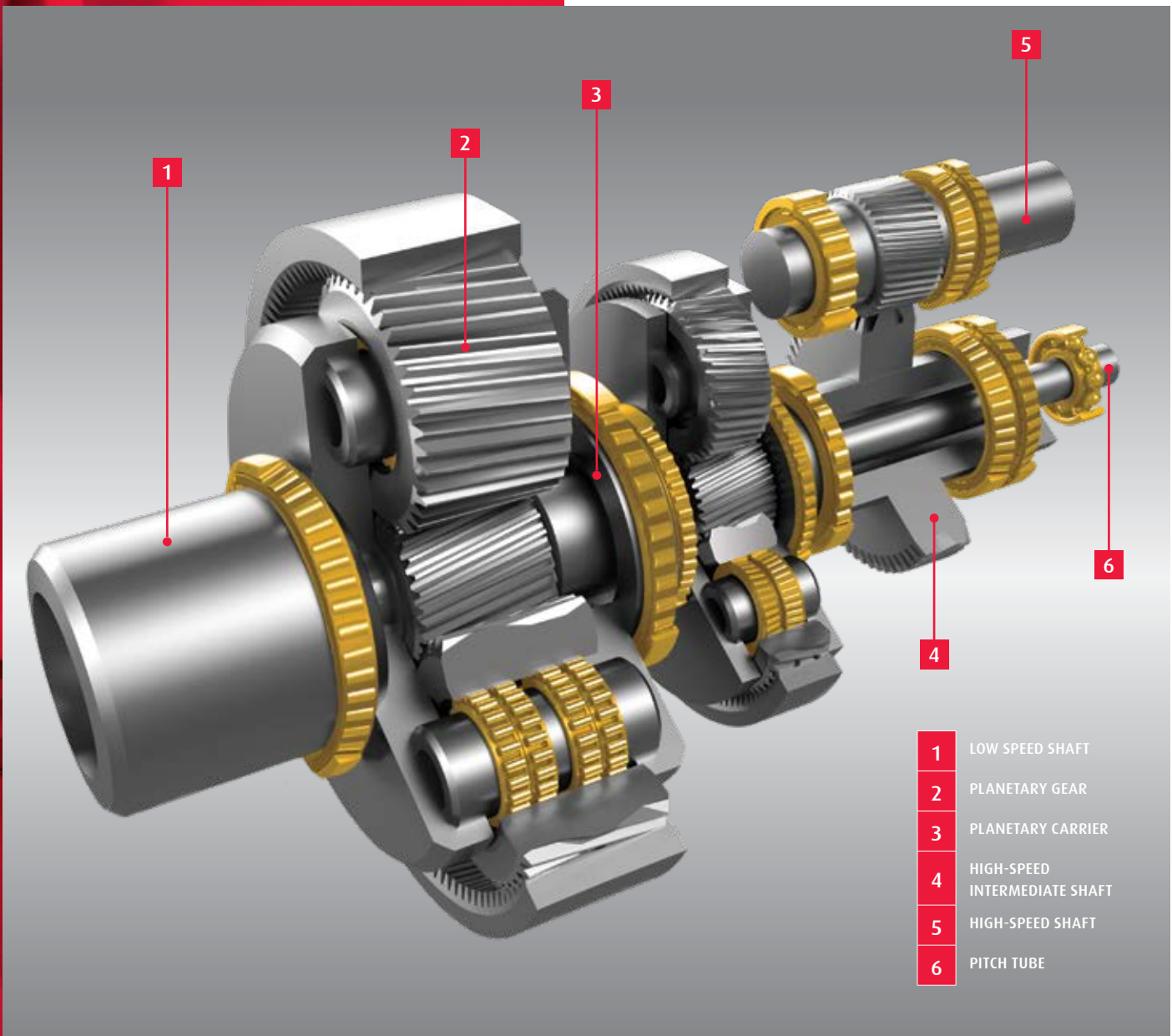


DLC COATING

Applying a high-hardness diamond-like carbon (DLC) coating to the rollers helps to prevent the deterioration of roller surface conditions, even from metal-to-metal contact of the rolling elements with the ring raceways due to insufficient oil film formation. The DLC coating reduces tangential forces acting from the rolling elements on the ring raceways, resulting in superior wear/peeling resistance and longer life.



MAIN GEARBOX BEARINGS



Through close collaboration with our wind industry partners, NSK has gained tremendous insight into the complex conditions that impact wind turbine operation – none more profoundly than within the gearbox. Our advanced product development takes into consideration the continuous variation and fluctuation of factors such as lubrication, load, stress, vibration and temperature to deliver reliable and cost-effective operating life.



CYLINDRICAL ROLER BEARINGS FULL COMPLEMENT

Cageless full complement cylindrical roller bearings have the maximum possible number of rollers and can sustain much heavier loads than cylindrical roller bearings of the same size with cages. In single row NCF and double row NNCF series. Available with Super-TF long-life steel applied to rings and black oxide coating applied to rings and rollers as option.

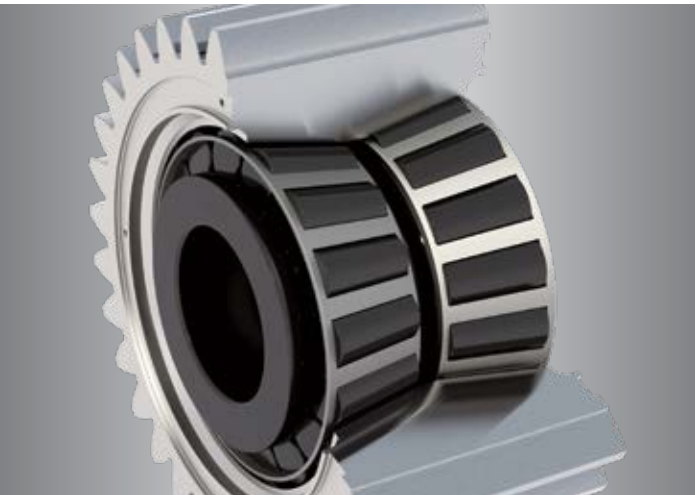
Bearing Location: Planetary Carriers
Planetary Gears



TAPERED ROLLER BEARINGS SINGLE-ROW

Single row tapered roller bearings have high radial and axial rigidity, and are capable of taking high radial loads and moment loads as well as axial loads in one direction. NSK offers a range of large size, dimensionally specialized single row tapered roller bearings for main gearbox applications in both metric and inch configurations. Available with Super-TF long-life steel applied to rings and black oxide coating applied to rings and rollers as option.

Bearing Location: Planetary Carriers



TAPERED ROLLER BEARINGS DUPLEX WITHOUT OUTER RING

Duplex tapered roller bearings without outer ring comprise 2 single-row bearings combined into a single unit. In gearbox applications, the outer ring is integrated into the gear, allowing the quantity and size of rollers to be increased for higher load capacity. In addition, planetary gear rigidity can be increased by adjusting the preload with a spacer. Available with Super-TF long-life steel applied to rings, and black oxide coating applied to rings and rollers and special crowning applied to rollers as option.

Bearing Location: Planetary Gears



TAPERED ROLLER BEARINGS DOUBLE-ROW/ASYMMETRICAL ARRANGEMENTS

Double-row tapered roller bearings can accommodate heavy radial loads and axial loads in both directions. Available in normal contact angle (KH design) or with steep angle races (KDH design) for increased axial load capacity. Available with Super-TF long-life steel applied to rings, and black oxide coating applied to rings and rollers, and special crowning applied to rollers as option.

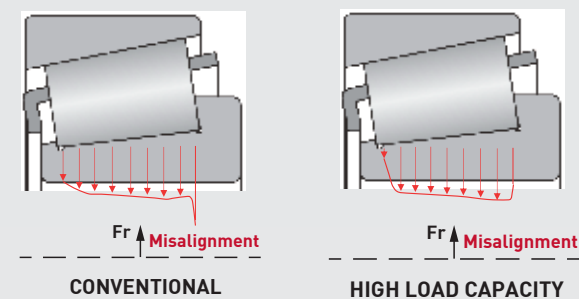
Bearing Location: Low-Speed Intermediate Shafts

Asymmetrical tapered roller bearing arrangements use bearings of different widths to suit the axial load. Available with Super-TF long-life steel applied to rings, black oxide coating applied to rings and rollers and special crowning applied to rollers as option.

**Bearing Location: High-Speed Intermediate Shafts
High-Speed Shafts
Low-Speed Intermediate Shafts**

TAPERED ROLLER BEARINGS WITH HIGH LOAD CAPACITY

Applying a special crowning to the rolling surfaces of tapered roller bearings reduces and equalizes the contact pressure generated under load. As a result, longer life and higher reliability have been achieved.

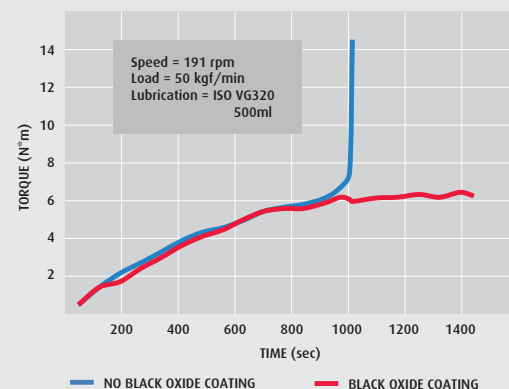


BLACK OXIDE COATING (BOC)

Applying a black oxide coating (BOC) to bearings helps to prevent damage from slippage during startup. It also serves as an effective countermeasure for white etching cracks (see page 21).

BOC can be applied to all bearings in the gearbox and is a standard specification for high-speed shafts.

FALEX TEST



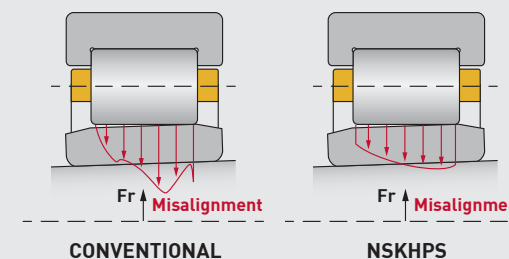
CYLINDRICAL ROLLER BEARINGS, SINGLE ROW

Featuring NSKHPS high performance standard for increased load capacity and speed ratings, NSK single row cylindrical roller bearings deliver high strength and radial rigidity for high loads and speeds. Optimized internal geometry promotes lower running temperature and quiet operation. Cylindrical roller bearings without outer rings are also available for planetary gears. And available with Super-TF long-life steel applied to rings, and black oxide coating applied to rings and rollers as option.

**Bearing Location: High-Speed Intermediate Shafts
High-Speed Shafts
Planetary Gears**

NSKHPS CYLINDRICAL ROLLER BEARINGS (WITH EM CAGE)

- › Bearing life increased up to 2x compared to conventional designs
- › Up to 23% higher basic dynamic load ratings
- › High strength and maximum rigidity for high loads and high speeds
- › Higher permissible misalignment



	Cr	LIFE	PERMISSIBLE MISALIGNMENT	
			22XXE, 23XXE	2XXE, 3XXE
Conventional	1	1	2'	4'
NSKHPS	1.23	2	4'	4'

DEEP GROOVE BALL BEARINGS

NSK deep groove ball bearings are designed to deliver unsurpassed performance for a wide variety of applications. Precision high-grade balls and super-finished raceways provide smooth and quiet operation. For low to medium radial loads and smaller axial loads in both directions. Advanced lubricant technology and sealing designs ensure optimum performance and reliability. Available in NSKHPS series with pressed steel cage or machined brass cage.

Bearing Location: Pitch Tubes



GENERATOR BEARINGS



CERAMIC-COATED
INSULATED BEARINGS

NSK ceramic coated bearings provide superior insulation to prevent electrical erosion or arcing in bearings used in turbine generators. An optimized alumina-based ceramic material combined with a blend of additives is used to coat the outer ring, offering high resistance to the flow of electrical current. The coating is tough and durable when impacted on its corner surfaces, and excellent heat dissipation properties. Boundary dimensions are identical to a standard bearing, enabling easy replacement without the need for modifications.

Bearing Location: Generators

SPECIFICATION	NSK CERAMIC INSULATION HD2
Application	Generator
Insulating material	Al ₂ O ₃
Insulation resistance (1000VDC)	Over 100MΩ
Breakdown voltage	Over 4kV
Boundary dimensions	ISO standard

ADVANCED SOLUTIONS – NSK TOUGH STEEL(TF)

The valuation of a wind turbine includes one major maintenance cycle during its over 20-year life expectancy. As such, the need for improved durability in bearing performance is a critical consideration to achieve the greatest reliability and total cost performance – even in uniquely demanding operating conditions. In response, NSK has applied our Tough Steel (TF) technology to bearing solutions that set a new standard for long service life.



NSK’s Super-TF (STF) series bearings are designed to deliver outstanding durability in operating environments subject to contamination. Utilizing advanced material engineering and heat treatment technology, they perform with superior resistance to wear and seizure under contaminated lubrication conditions.

Outstanding toughness, performance, and total cost-savings: NSK technology sets a new standard for long service life.



In its quest for longer bearing service life, NSK has spent many years analyzing the mechanisms of fatigue in bearings and researching and developing materials, heat treatment processes and operating conditions. The range of approaches to achieving longer service life taken by our research team are shown in Fig. 1. Super-TF bearings are designed to maximize service life under conditions where bearings are subject to hydrogen-induced embrittlement and contamination-induced surface-originating flaking.

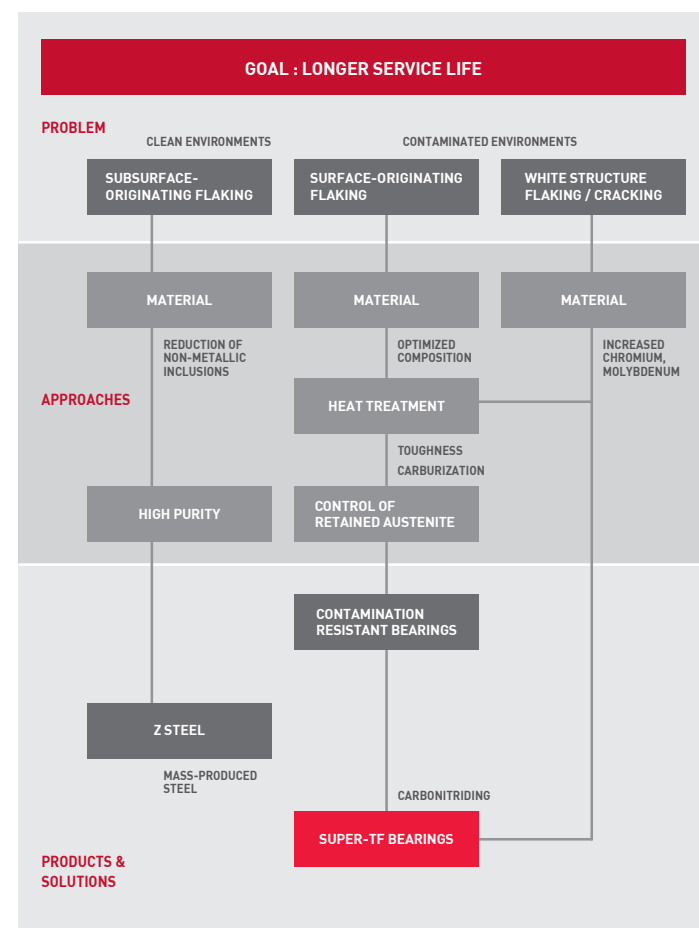
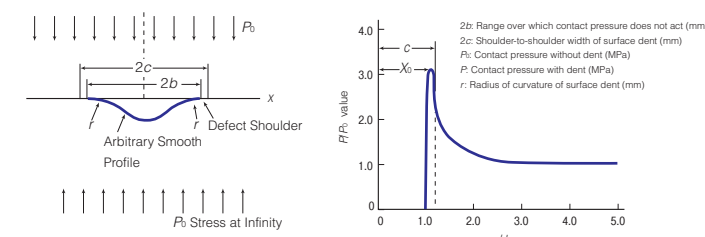


FIG. 1 APPROACHES TO ACHIEVING LONGER SERVICE LIFE FROM BEARINGS



SUPER-TF AND SURFACE-ORIGINATING FLAKING

Bearings can be required to operate under conditions where lubrication is easily contaminated. Metal particles or casting sand in the lubricant create dents in the rolling contact surfaces, and stress concentrated around these dents eventually leads to cracking and surface-originating flaking. Reducing the concentration of stress around the shoulders of surface dents is a direct approach to achieving longer bearing life.

NSK research and development of material properties has revealed that a high level of retained austenite is an extremely effective means of maximizing the r/c value around surface dents in the bearing material (see Fig. 2) - the greater the r/c value, the smaller the stress concentration. TF technology in general is a unique heat treatment process developed by NSK to optimize the level of retained austenite in bearing materials.

However, austenite itself has a soft microstructure, reducing the hardness of the bearing material. To meet needs for greater hardness with a higher level of retained austenite, NSK adopts a technique that promotes the uniform distribution and reduce the diameter of carbide and carbonitride particles in the bearing material. Super-TF bearing steel contains appropriate amounts of chrome and molybdenum to optimize the formation of carbides.

Figures 3 and 4 illustrate how Super-TF Bearings have a greater amount of fine-size carbide and carbonitride particles than ordinary carburized bearings, giving them a greater degree of hardness and higher retained austenite for a long service life.

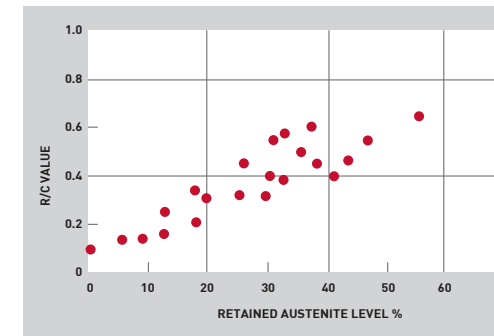


FIG. 2 RELATIONSHIP OF R/C VALUE TO RETAINED AUSTENITE LEVEL

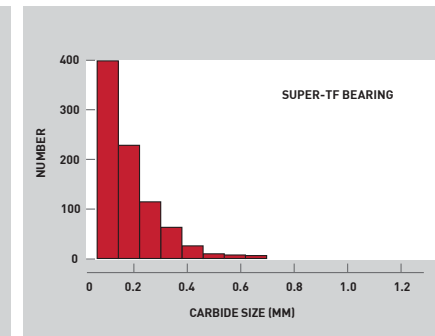


FIG. 3 AVERAGE DIAMETER OF CARBIDE AND CARBONITRIDE PARTICLES IN A SUPER-TF BEARING

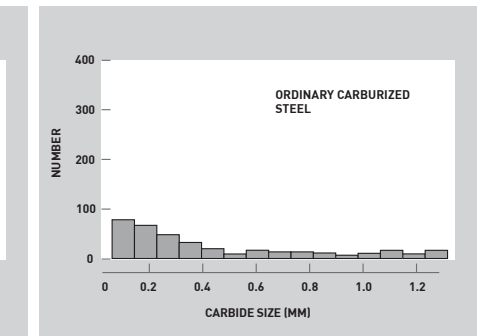


FIG. 4 AVERAGE DIAMETER OF CARBIDE PARTICLES IN AN ORDINARY CARBURIZED STEEL BEARING

SERVICE LIFE UNDER BOUNDARY LUBRICATION CONDITIONS

Under boundary lubrication conditions where there is an insufficient EHL film, metal-to-metal contact occurs, thus reducing bearing life. Fig. 5 shows the results of service life tests conducted under conditions where oil film parameter Λ , which represents the ratio of the thickness of the oil film to the roughness of the surface, is very small ($\Lambda=0.3$). At this very small ratio, peeling damage occurs (Fig. 6), but in Super-TF bearings, the concentration of stress around the projections of the contact area is reduced, giving a service life approximately 5.5 times greater than that of ordinary carburized steel bearings.

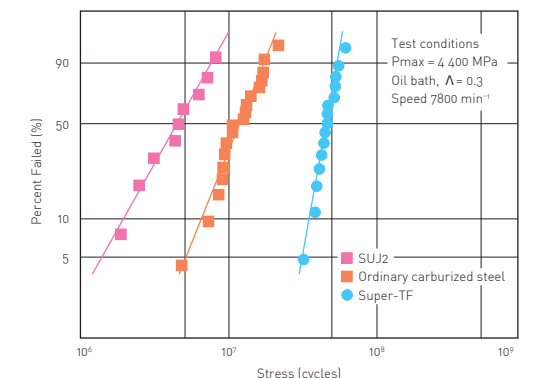


FIG. 5 Service Life Tests Under Boundary Lubrication Conditions

WEAR AND SEIZURE RESISTANCE

Besides extending service life under contaminated lubrication conditions, Super-TF increases the bearing's resistance to wear and seizure by ensuring the dispersion of a large number of fine carbides and nitrides in the bearing material. Fig. 7 presents the results of a Sawin wear test that shows the degree of wear and the seizure limit for different types of bearing material. The test reveals that Super-TF bearings have superior wear resistance to SUJ2 steel. Super-TF bearings are also 40 % more resistant to seizure than SUJ2 steel bearings.

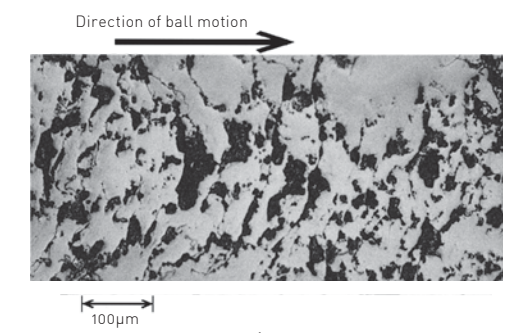


FIG. 6 Peeling Damage

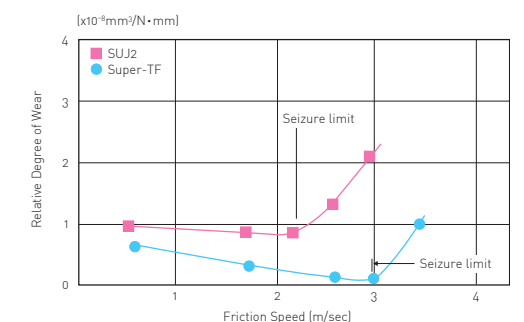
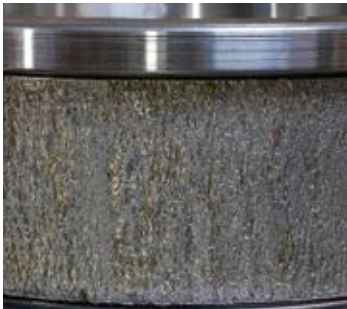


FIG. 7 Comparison of Wear Resistance

BEARING FAILURE MODES

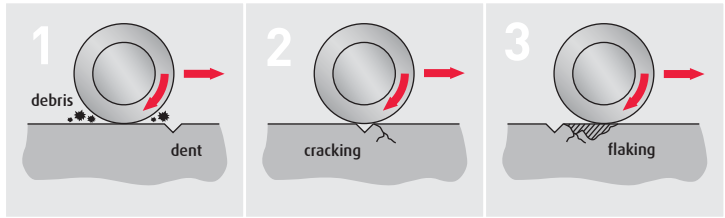
Abbreviations
HSS: High-speed shaft
HSIMS: High-speed intermediate shaft
LSIMS: Low-speed intermediate shaft
3PT: Three-point suspension (1 bearing)
4PT: Four-point suspension (2 bearings)

SURFACE-ORIGINATING FLAKING



Location:
Gearbox - All bearing locations
Main Shaft

Solution:
Super-TF (STF) Long-life Steel

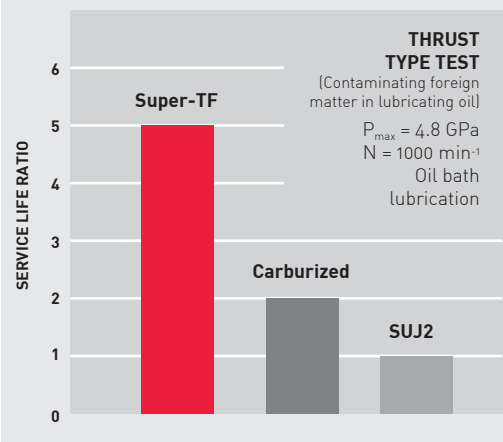


Foreign debris leads to the formation of dents

Stress concentrations around dents develop into cracks

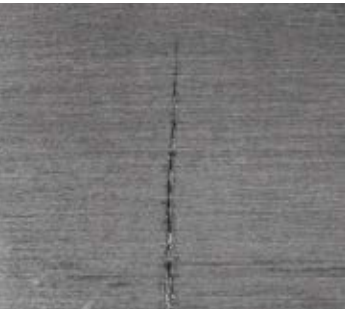
Cracks propagate under the load of each passing roller and develop into flaking

COMPARISON OF SERVICE LIFE



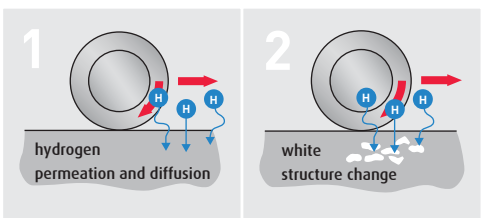
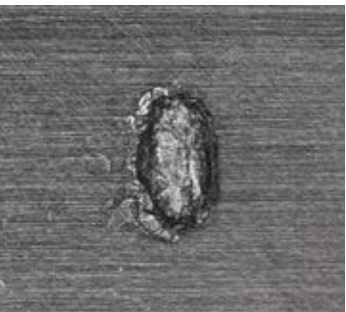
Super-TF delivers 5 times the life of standard steel (SUJ2)

WHITE ETCHING CRACKS / FLAKING



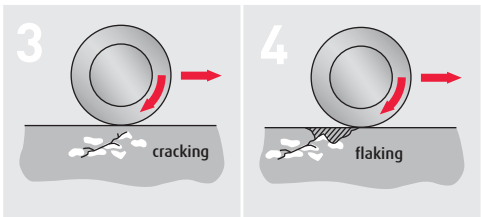
Location:
Gearbox - HSIMS, HSS

Solution:
Super-TF (STF) Long-life Steel
Black oxide coating



Hydrogen permeates the bearing steel, causing it to weaken

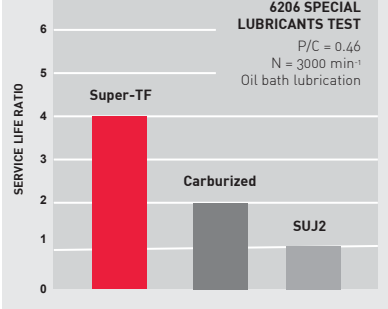
White structure forms below the surface of the bearing



Cracks form along the boundary of the white structure from repeated stress

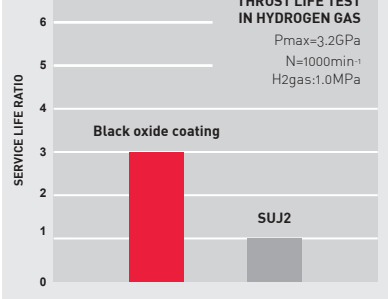
Cracks propagate under the load of each passing roller and develop into flaking

COMPARISON OF SERVICE LIFE



Super-TF delivers 4 times the life of standard steel (SUJ2)

COMPARISON OF SERVICE LIFE



Black oxide coating delivers 3 times the life of standard steel (SUJ2)

SKIDDING

Location:
Gearbox - LSS, HSIMS, HSS

Solution:
Black oxide coating

ELECTRICAL EROSION

Location:
Generator - Rotor

Solution:
Ceramic coating

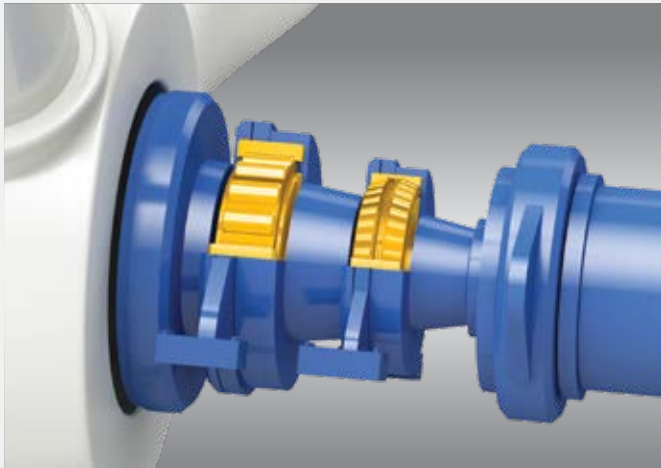
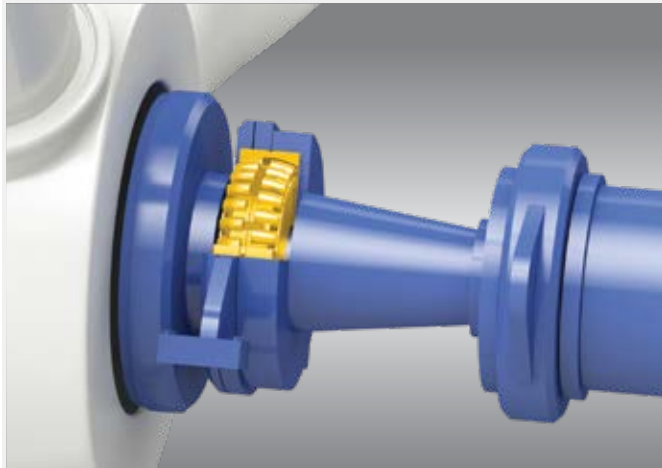
ADHESIVE WEAR

Location:
Main Shaft - 3 point suspension
Planetary Carrier, Planetary Gear

Solution:
Super-TF (STF) Long-life Steel
DLC Coating (Roller)
ECA (cage)

EXAMPLES: BEARING NOMENCLATURE

Abbreviations
HSS: High-speed shaft
HSIMS: High-speed intermediate shaft
LSIMS: Low-speed intermediate shaft
3PT: Three-point suspension (1 bearing)
4PT: Four-point suspension (2 bearings)



SPHERICAL ROLLER BEARING - 3 PT SUSPENSION (1 BEARING), - 4 PT SUSPENSION (2 BEARINGS)

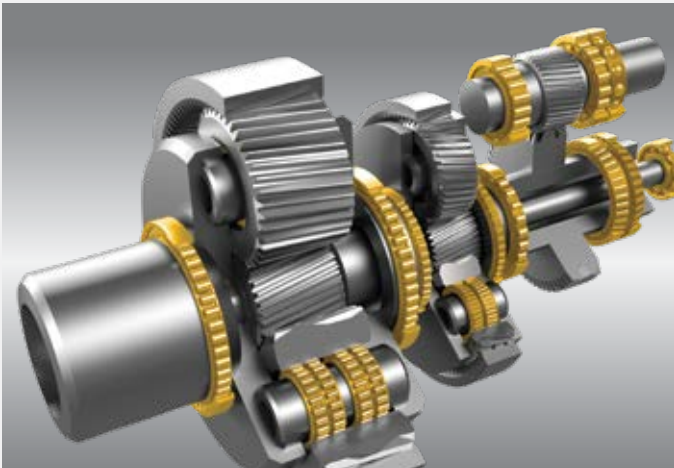
	STF	240	/750	ECA	g5	S4WC	M	E4	CG400	U22	U303W
STF	Super-TF long-life steel							M	machined brass cage		
240	spherical roller bearing, width series 4, diameter series 0							E4	lubrication groove and holes in outer ring		
/750	bore diameter equals 750 mm							CG400	greater than normal radial internal clearance		
ECA	high capacity roller-guided cage							U22	special surface finish		
g5	case-hardened inner and outer rings (multiple options available)							U303W	special process control for wind turbine bearings and special wrapping		
S4WC	DLC roller										

CYLINDRICAL ROLLER BEARING - MODULAR DRIVETRAIN

	STF	NJ	28	/710	g5	M	CCG338	U303
STF	Super-TF long-life steel							
NJ	single-row cylindrical roller bearing - 2 outer ring ribs, one inner ring rib							
28	dimension series (width series 2, diameter series 8)							
/710	bore diameter equals 710 mm							
g5	case hardened inner and outer rings (multiple options available)							
M	machined brass cage							
CCG338	special radial internal clearance							
U303	special process control for wind turbine bearings							

TAPERED ROLLER BEARING, DOUBLE ROW - MODULAR DRIVETRAIN

	STF	460	KDH	65	01	g5	SA	+K	CA450	U303
STF	Super-TF long-life steel									
460	bore diameter equals 460 - 460.999 mm									
KDH	double-row tapered roller bearing, steep angle race									
65	outer diameter equals 650 - 659.999 mm									
01	tolerance for metric bearing									
g5	case-hardened inner and outer rings (multiple options available)									
SA	special tolerance									
+K	outer ring spacer (controls preload)									
CA450	special axial clearance									
U303	special process control for wind turbine bearings									



TAPERED ROLLER BEARING, DOUBLE ROW - LSIMS

	431	KH	57	55	SA	+K	CA640	U303
431	bore diameter equals 431 - 431.999 mm							
KH	double row tapered roller bearing							
57	outer diameter equals 570 - 579.999 mm							
55	tolerance for inch bearing							
SA	special tolerance							
+K	outer ring spacer							
CA640	special axial clearance							
U303	special process control for wind turbine bearings							

CYLINDRICAL ROLLER BEARING, SINGLE ROW - HSIMS, HSS

	NU	23	26	E	/S/	M	C3	&	U303
NU	single row cylindrical roller bearing - 2 outer ring ribs, no inner ring ribs								
23	dimension series (width series 2, diameter series 3)								
26	bore diameter equals 130 mm (reference number x 5)								
E	high capacity internal design								
/S/	black oxide coating								
M	machined brass cage								
C3	greater than normal radial internal clearance								
&	NSKHPS - High Performance Standard								
U303	special process control for wind turbine bearings								

TAPERED ROLLER BEARING, SINGLE ROW - PLANETARY CARRIER

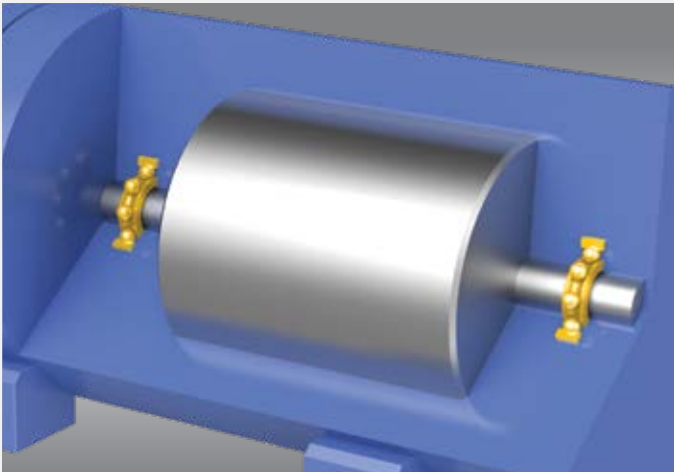
R	1025	-2	/S/	E	U303
R	single row tapered roller bearing, special dimensions				
1025	bore diameter equals 1024.875 - 1025 mm				
-2	serial number				
/S/	black oxide coating				
E	notch in the outer ring				
U303	special process control for wind turbine bearings				

TAPERED ROLLER BEARING, ASYMMETRICAL ARRANGEMENT - HSIMS, HSS, LSIMS

HR	303	26	J	g5	/	HR	313	26	J	g5	DF	+KR	U303
HR	high capacity							g5	case hardened inner and outer rings (multiple options available)				
303	medium width series 0. diameter series 3							DF	bearing arrangement is face to face				
313	steep angle width series 1. diameter series 3							+KR	outer ring spacer (controls preload)				
26	bore diameter equals 130 mm (reference number x 5)							U303	special process control for wind turbine bearings				
J	ISO conformance												

CYLINDRICAL ROLLER BEARING, FULL COMPLEMENT – PLANETARY CARRIER AND GEAR

NNCF	50	44	/S/	V	C3	DR	U303
NNCF	full-complement cylindrical roller bearing, double row						
50	dimension series (width series 5, diameter series 0)						
44	bore diameter equals 220 mm (reference number x 5)						
/S/	black oxide coating						
V	no cage						
C3	greater than normal radial internal clearance						
DR	controlled size variation arrangement						
U303	special process control for wind turbine bearings						



FOUR-POINT CONTACT BALL BEARING – HSIMS, HSS

QJ	3	28	M	E	C3	U303
QJ	four-point contact ball bearing					
3	dimension series 3					
28	bore diameter equals 140 mm (reference number x 5)					
M	machined brass cage					
E	notch in outer ring					
C3	greater than normal radial internal clearance					
U303	special process control for wind turbine bearings					

DEEP GROOVE BALL BEARING, CERAMIC COATED - GENERATOR

63	30	HD2	MR	C3	X26	U303
63	deep groove ball bearing, diameter series 3					
30	bore diameter equals 150 mm (reference number x 5)					
HD2	ceramic insulated coating on outer ring					
MR	ball-guided machined brass cage					
C3	greater than normal radial internal clearance					
X26	dimensional stabilizing treatment					
U303	special process control for wind turbine bearings					

DEEP GROOVE BALL BEARING - PITCH TUBE

60	26	DDU	C3	&	AS2S
60	single row deep groove ball bearing, dimension series 0				
26	bore diameter equals 130 mm (reference number x 5)				
DDU	contact seal (non-contact seal and shielded closures available)				
C3	greater than normal radial internal clearance				
&	NSKHPS symbol - High Performance Standard				
AS2S	grease type and fill				

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