

Bearings for Papermaking Machines

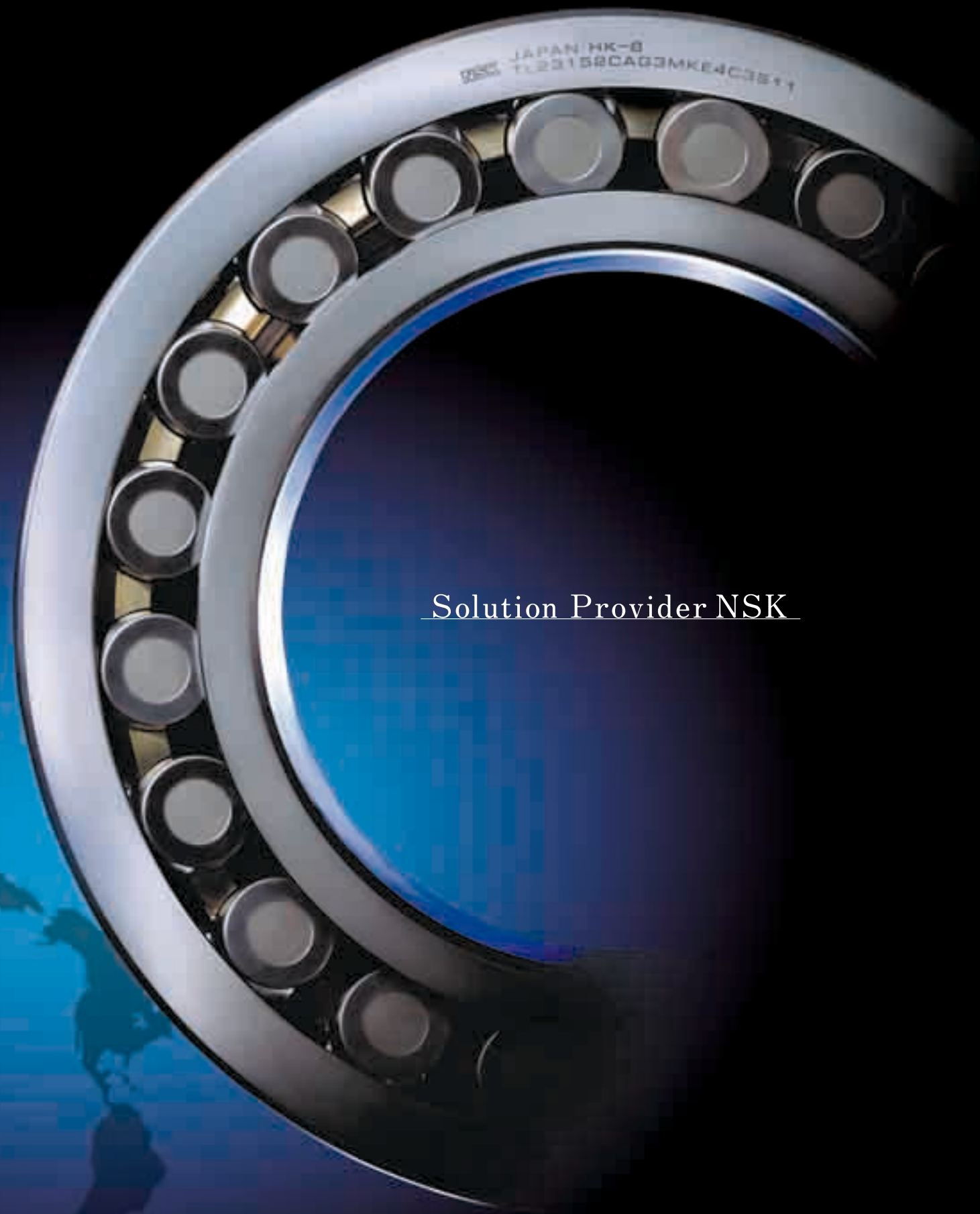
Excellent durability under high-temperature conditions including moisture and dust laden environments, resulting in longer life, higher limiting speed and dramatically enhanced productivity.

**Choose
NSK**



The NSK brand, recognized around the world

From home electric appliances, automobiles, and large-scale equipment to the aerospace industry—NSK bearings are used in an extensive range of fields. NSK established its global-scale enterprise on technology that has met the exacting requirements of Japanese industry. We have also established R&D systems and support services to meet the diverse needs of our customers throughout the world. As a brand recognized around the world, NSK continues to lead the industry with its technical prowess.



Solution Provider NSK

NSK is on the move, across the globe

Headquarters

- Japan**
 - Tokyo
- North and South America**
 - Ann Arbor
- Europe**
 - Maidenhead
- Asia**
 - Shanghai
 - Singapore

Technical offices

- Japan**
 - Fujisawa
 - Maebashi
- North and South America**
 - Ann Arbor
- Europe**
 - Newark
 - Kielce
- Asia**
 - Kunshan

Plants

- Japan**
 - Fujisawa
 - Hanyu
 - Otsu
 - Konan
 - Takasaki
 - Haruna
 - Maebashi
 - Tanakura
 - Ukiha
- North America**
 - Ann Arbor
 - Clarinda
 - Franklin
 - Liberty
 - Bennington
- South America**
 - Suzano
- Europe**
 - Peterlee
 - Newark
 - Kielce
 - Munderkingen
 - Torino
- Asia**
 - Kunshan
 - Anshun
 - Dongguan
 - Zhangjiagang
 - Suzhou
 - Changshu
 - Chennai
 - Jakarta
 - Changwon
 - Balakong
 - Chonburi
 - Chachoengsao

Sales offices

- Japan**
 - Tokyo
 - Nagoya
 - Osaka
 - 27 other offices
- North America**
 - Ann Arbor
 - Indianapolis
 - Chicago
 - San Jose
 - Los Angeles
 - Bennington
 - Miami
 - Atlanta
 - Montreal
 - Toronto
 - Vancouver
- South America**
 - Buenos Aires
 - Sao Paulo
 - Belo Horizonte
 - Joinville
 - Porto Alegre
 - Recife
 - Mexico City
- Europe**
 - Maidenhead
 - Newark
 - Coventry
 - Paris
 - Dusseldorf
 - Stuttgart
 - Leipzig
 - Milano
 - Tilburg
 - Barcelona
 - Warsaw
 - Istanbul

Africa

- Johannesburg

Asia

- Beijing
- Shanghai
- Guangzhou
- Anshun
- Chengdu
- Hong Kong
- Taipei
- Taichung
- Tainan
- Seoul
- Chennai
- Jakarta
- Manila
- Bangkok
- Kuala Lumpur
- Prai
- Johor Bahru
- Kota Kinabalu
- Singapore

Oceania

- Melbourne
- Sydney
- Brisbane
- Adelaide
- Perth
- Auckland

The high quality and toughness of NSK bearings reduce maintenance costs in the papermaking industry.

Papermaking machine bearings operating under high-temperature conditions are vulnerable to problems such as fracturing of the inner ring, which can result in work stoppages. NSK bearings, with their long service life, superior resistance to inner ring fractures, outstanding hardness, and excellent dimensional stability under high temperatures, produce solutions for a host of paper mill applications and operating environments.



Key to Bearing Specifications:

① Bearing type SR: Spherical Roller Bearing TR: Tapered Roller Bearing B: Ball Bearing	③ Bearing series
② Bearing inner ring bore diameter	④ Internal clearance / tolerance class
	⑤ Lubrication
	⑥ Heat treatment, material

The Papermaking Process and Spherical Roller Bearing Specifications

- Suction Couch Roll**
- | Front | Back | Back-internal |
|---|--|---|
| ① SR
② 320-1000
③ 239, 230XX
④ C3 / P55
⑤ Oil circulation | ① SR
② 260-420
③ 230, 231XX
④ C3 / P55
⑤ Oil circulation | ① SR
② 100-200
③ 223XX
④ C3 / P0
⑤ Grease |

- Felt Roll**
- ① SR
 - ② 60.325-146.05
 - ③ Inch series
 - ④ Normal / P0
 - ⑤ Grease

- Press Roll (1P-4P)**
- ① SR
 - ② 300-480
 - ③ 230, 231, 232XX
 - ④ Normal / P0 or P55
 - ⑤ Grease or oil circulation
 - ⑥ CCR: Triple Ring Bearing

- Canvas Roll**
- ① SR
 - ② 50-110
 - ③ 223XX
 - ④ C3 / P0
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL or S11

- Paper Roll**
- ① SR
 - ② 50-70
 - ③ 223XX
 - ④ C3 / P0
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL or S11

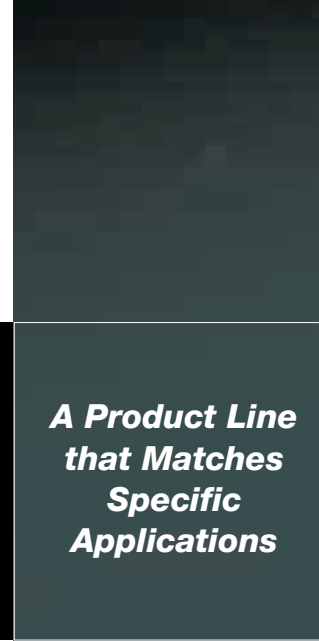
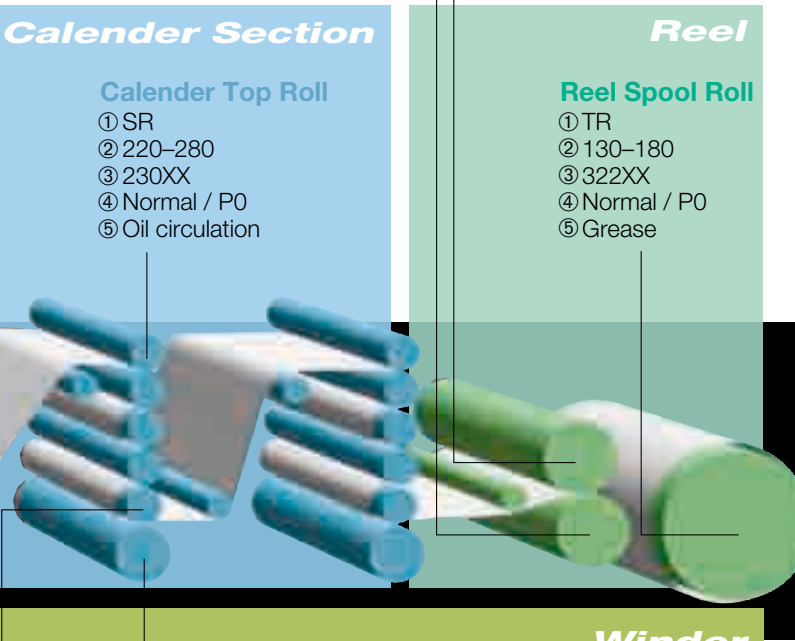
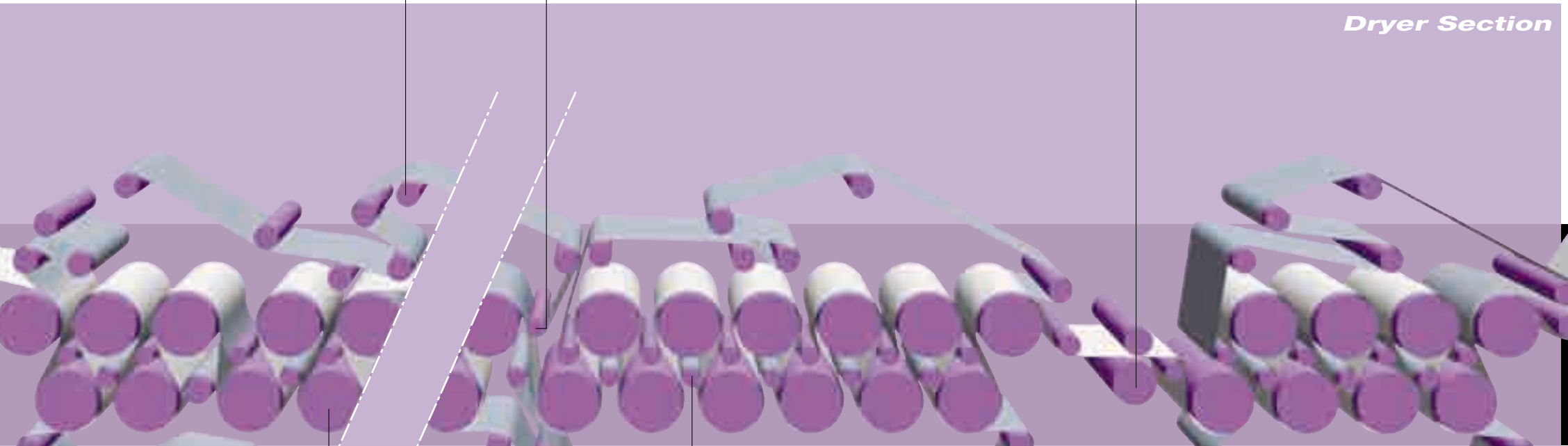
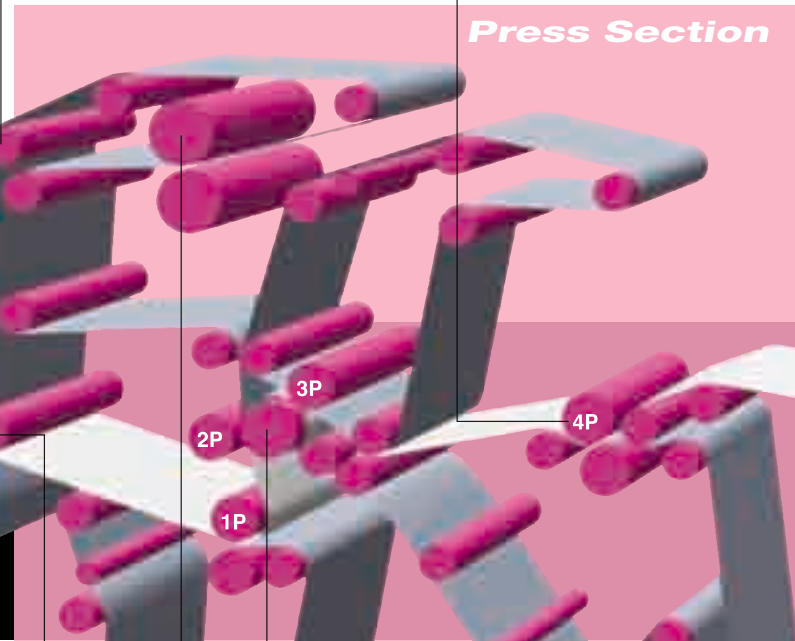
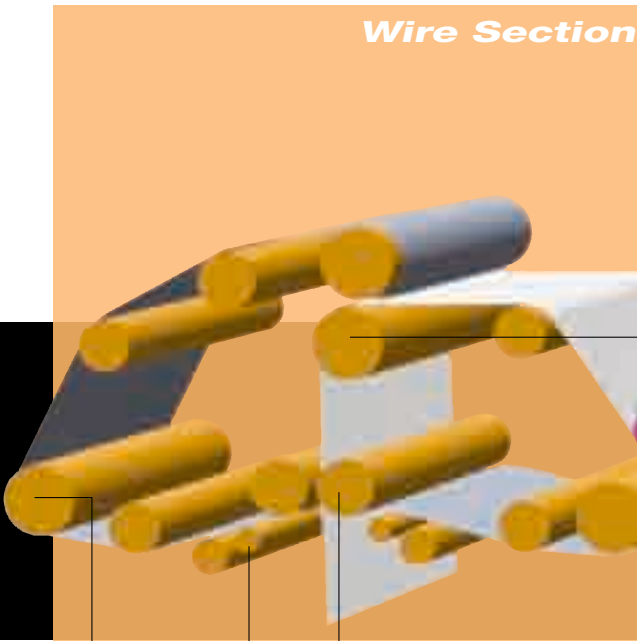
- Breaker Stack Bottom Roll**
- ① SR
 - ② 320
 - ③ 231XX
 - ④ C3 / P55
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL or S11

- Soft Calender**
- ① SR
 - ② 400-600
 - ③ 232, 241XX
 - ④ C3 or C4 / P0 or P55
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL or S11 or carburized steel + S11

- Reel Spreader Roll**
- ① SR
 - ② 60-70
 - ③ 223XX
 - ④ Normal / P0
 - ⑤ Grease

- Reel Drum Roll**
- ① SR
 - ② 190
 - ③ 222, 223XX
 - ④ C3 / P0
 - ⑤ Oil bath

- Reel Spool Roll**
- ① TR
 - ② 130-180
 - ③ 322XX
 - ④ Normal / P0
 - ⑤ Grease



- Breast Roll**
- ① TR (or SR)
 - ② 101.6-177.8
 - ③ Inch series (or 223XX)
 - ④ Normal or C3 / P0
 - ⑤ Grease

- Press Center Roll**
- ① SR
 - ② 300-480
 - ③ 230, 231, 232XX
 - ④ Normal / P0
 - ⑤ Oil circulation

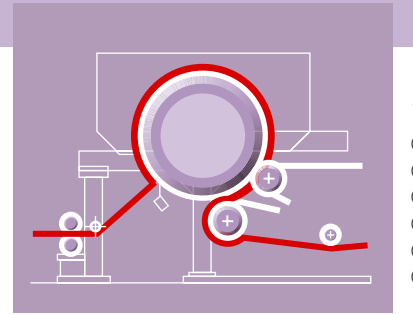
- Expander Roll**
- ① B
 - ② 75-190
 - ③ 60, 62XX
 - ④ Special / P0
 - ⑤ Grease

- Wringer Roll**
- ① SR
 - ② 190-380
 - ③ 231, 232, 223XX
 - ④ Normal or C3 / P0
 - ⑤ Oil circulation

- Turning Roll**
- ① TR (or SR)
 - ② 101.6-177.8
 - ③ Inch series (or 223XX)
 - ④ Normal or C3 / P0
 - ⑤ Grease

- Suction Pick-Up Roll**
- | Front | Back | Back-internal |
|---|--|---|
| ① SR
② 320-480
③ 239, 230, 231XX
④ C3 / P55
⑤ Oil circulation | ① SR
② 260-400
③ 230, 231XX
④ C3 / P55
⑤ Oil circulation | ① SR
② 110-130
③ 232XX
④ C3 / P0
⑤ Grease |

- Drying Cylinder**
- ① SR
 - ② 160-300
 - ③ 230, 231, 222, 232XX
 - ④ C3 or C4 / P0
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL



- Yankee Dryer**
- ① SR
 - ② 400-600
 - ③ 230, 231XX
 - ④ C3 or C4 / P0
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL or S11 or carburized steel + S11

- PV Roll**
- ① SR
 - ② 90-380
 - ③ 239, 231, 222, 223XX
 - ④ C3 / P0
 - ⑤ Oil circulation
 - ⑥ Heat treatment: TL or S11

- Calender Bottom Roll**
- ① SR
 - ② 240-530
 - ③ 232XX
 - ④ C3 / P0
 - ⑤ Oil circulation
 - CCR: Triple Ring Bearing

- Calender Queen Roll**
- ① SR
 - ② 160-320
 - ③ 231XX
 - ④ C3 / P0
 - ⑤ Oil circulation

- Paper Roll**
- ① SR
 - ② 60-95
 - ③ 223XX
 - ④ C3 / P6
 - ⑤ Oil bath or grease

- Unwinding Stand**
- ① SR
 - ② 80-130
 - ③ 222XX
 - ④ C3 / P6 or P0
 - ⑤ Oil bath

- Rider Roll**
- ① SR
 - ② 60-80
 - ③ 222, 223XX
 - ④ C3 / P6
 - ⑤ Oil bath

- Winder Drum Roll**
- ① SR
 - ② 130-160
 - ③ 223XX
 - ④ C3 / P6
 - ⑤ Oil bath

A Product Line that Matches Specific Applications



TL Series Spherical Roller Bearings
Ideal for high temperature equipment, with resistance to inner ring fracture. Tough, long-life TL bearings boost productivity and lower costs.
Major applications: dryer rolls, canvas rolls, PV rolls, and calender rolls



HPS™ Spherical Roller Bearings
Next-generation standard bearings utilizing innovative materials and technologies benefit from NSK's experience and expertise to deliver longer life and higher limiting speed.
Major applications: small diameter rolls such as canvas rolls, paper rolls, felt rolls, and rider rolls



Molded-Oil™ Bearings
Excellent performance in environments exposed to moisture or paper dust, without oil leakage. Molded oil with optimal composition and molding method provides higher speed operation, is easy to handle, and safe for the environment.
Major applications: raw material conveyors, carrier rope sheaves, suction rolls



EM Series Cylindrical Roller Bearings
Bearings with integrated machined cages offer enhanced performance by combining the advantages of the conventional M series bearings and the high-load EMA1 series.
Major applications: motors and pumps



Triple Ring Bearings
Uniquely structured bearing for ease of use and no creep while offering high precision and long life.
Major applications: press rolls, breaker stack rolls



CA Series Spherical Roller Bearings
Superior radial load capacity and alignment, featuring high load capacity and excellent strength; equipped with a machined cage. This product line includes the high-precision P55.
Major applications: large diameter rolls such as suction rolls, press rolls, calender rolls and reel drum rolls.



Deep Groove Ball Bearings
Designed for high-speed expander rolls, these bearings dramatically suppress friction torque. Product line includes contact seal bearings with superior sealing and low-noise bearings for motors.
Major applications: expander rolls, dandy rolls, table rolls, and motors

NSK offers other advantageous products for various rolls and conveyors, including the HR series of high load capacity tapered roller bearings and easy-to-handle ball bearing units.

TL Series Spherical Roller Bearings

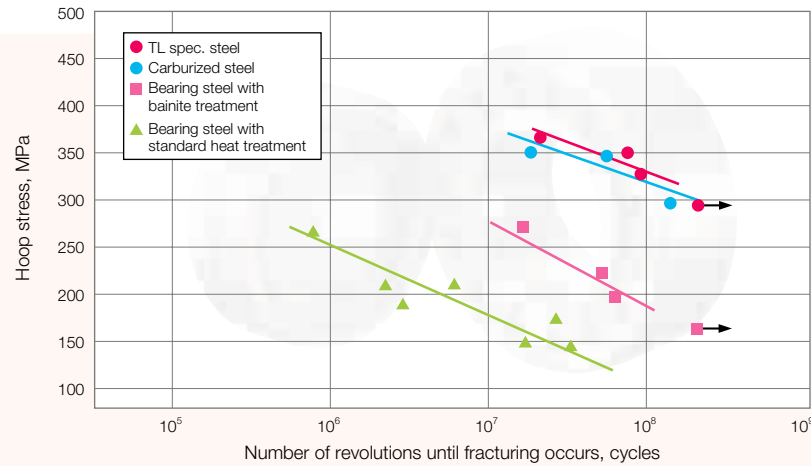
Dryer rolls are generally used under high-temperature conditions, which can lead to fracturing of the bearing inner ring, and in the worst case, result in work stoppage. NSK's solution is the TL (Tough and Long-life) bearing, which features sufficient strength to resist inner ring fractures, superior dimensional stability under high-temperature conditions, and long life due to superior hardness. All these characteristics mean improved productivity.



Features

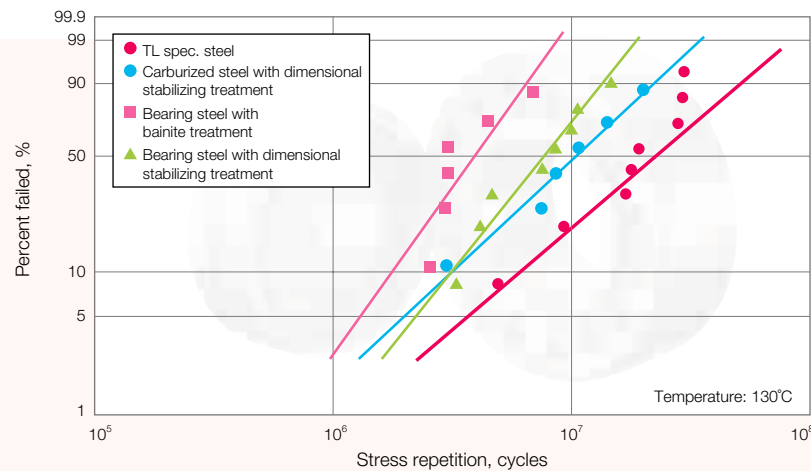
Enhanced inner ring strength

Adoption of a special steel and surface hardening heat treatment, developed by NSK, dramatically enhance inner ring strength against increasing hoop stress caused by rising shaft temperature.



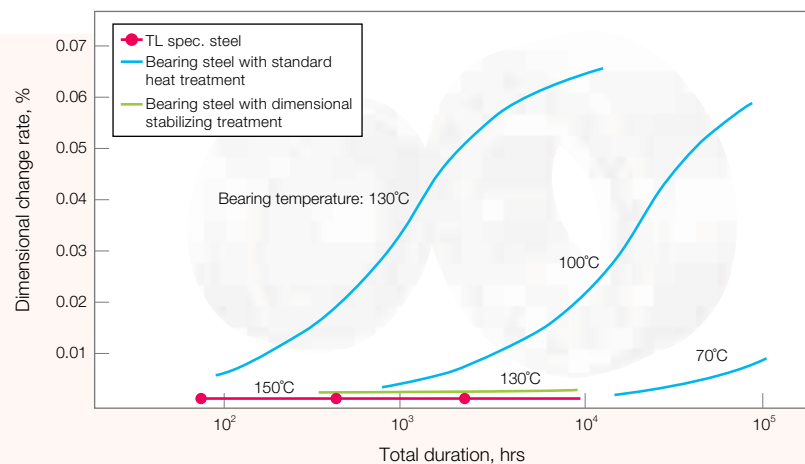
Longer life

Increased hardness of raceway surface provides longer life when foreign debris is present than that of other bearings.



Dimensional stability under high temperatures

Dimensional stability under high temperatures is adopted as a standard specification. (Max. 200°C)



Catalog No. E1205

HPS™ Spherical Roller Bearings

Bearings for all types of equipment are expected to contribute to lower maintenance costs and improved product performance. NSK developed its next-generation HPS spherical roller bearing using state-of-the-art materials and advanced technologies as well as its wealth of experience and expertise. As a leading bearing manufacturer, NSK is confident that this latest standard bearing, HPS, will deliver unprecedented advances in longer life and higher limiting speeds.



Features

Compared to the conventional EA series:

Bearing life
Maximum **2 times**
Increased dynamic load rating to maximum of 25%

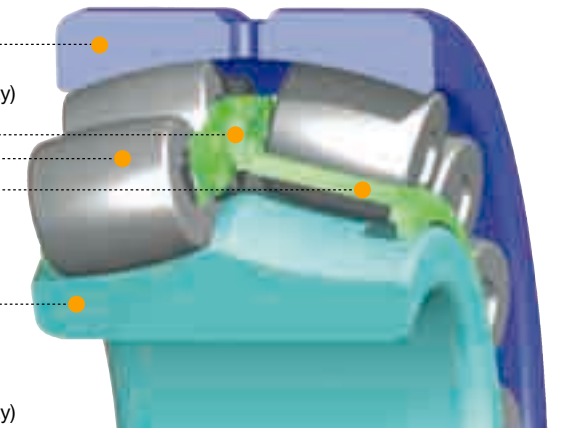
Optimal design for internal specification, combined with improved press technology for significantly boosting dynamic load rating by a 25% maximum. In addition, high-cleanliness Z steel is used for the bearing material. As a result, bearing life is doubled resulting in reduced maintenance costs and extending equipment service life.

Limiting speed
Maximum **20% higher**

The cage is strengthened against friction to achieve a maximum of 20% higher limiting speed, and thereby supports high speeds and longer operation, as well as extended flexibility in various applications.

Series offers bearing inner bore dimensions ranging from 40 mm to 130 mm

- Outer Ring** High-temperature operability (dimensional stability) and lubrication groove and holes
- Cage Flange** High limiting speed
- Rollers** Increased size and number
- Cage** High-strength pressed steel with special surface treatment
- Inner Ring** High-temperature operability (dimensional stability)



Catalog No. E1259

CA Series Spherical Roller Bearings

CA series bearings have high load capacity, superior durability, and wear resistance featuring a brass cage and larger rollers than that of the conventional M series. The CA series is available in a wide selection of sizes and other specifications, such as bearings with a lubrication hole and groove provided in the outer ring (E4), high heat-resistant bearings capable of withstanding up to 200°C (S11), and high-precision bearings (P55), for various types of large rolls.



Deep Groove Ball Bearings

Deep Groove Ball Bearings are characterized by high performance and quality, displaying NSK's technological excellence. This top of the line design includes special bearings for high-speed expander rolls with low friction torque that minimize surface damage such as smearing, maintenance-free sealed ball bearings with high-performance seals, and silent ball bearings suitable for motors and pumps.



Molded-Oil™ Bearings

Molded-Oil™ bearings are lubricated with NSK's own oil-impregnated material, Molded-Oil™ consists of lubricating oil and polyolefin resin that has an affinity for oil. Oil slowly seeping from this material provides ample lubrication to the bearing for extended periods.



Features

Excellent performance in water- and dust-contaminated environments

The bearings are designed to prevent liquids such as water, which can wash out the lubricating oil, and dust from getting inside the bearings. Sealed types can be used in environments exposed to water and dust.
*Water and dust dramatically accelerate bearing damage. In order to realize stable operation, we recommend using seals to prevent water and dust from getting in the bearing.

Optimal composition and molding methods enable high-speed operation

Optimization of composition and molding method of Molded-Oil™ improves strength and enables high-speed operation.

Low torque

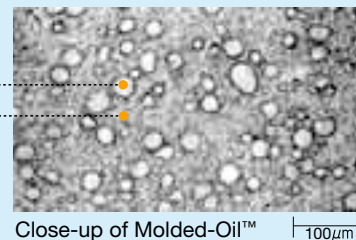
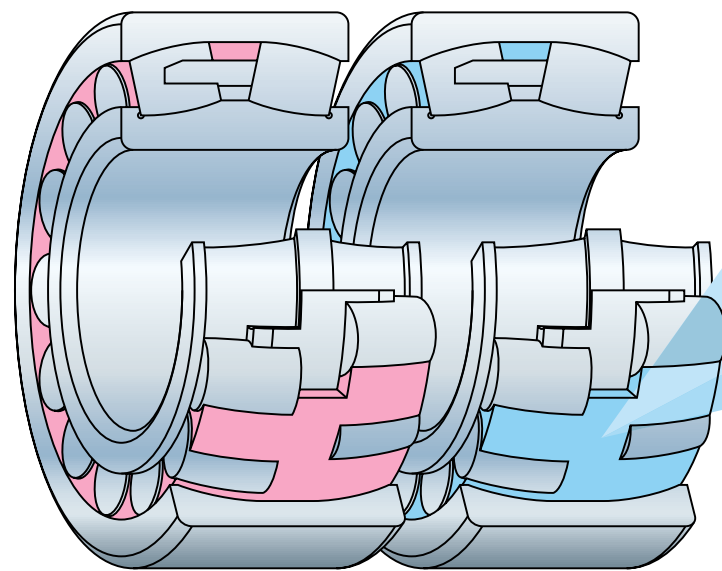
Packing with Molded-Oil™ after providing the bearing surface with special treatment realizes smooth rotation of rolling elements.

Environmentally friendly

The bearings are lubricated by minute quantities of oil exuded by Molded-Oil™, which consequently minimizes oil leakage.

Applications

Material processing equipment (conveyers, agitators), paper mill line equipment (support for wire part rolls), maintenance facilities (carrier rope sheave pulley), and carrier line equipment



Portion containing mostly lubricating oil
The lubricating oil is mineral oil-based.

Portion containing mostly polyolefin
Polyolefin is an environmentally sound material used for packaging food in supermarkets, replacing dioxin-generating vinyl chloride.

For applications in which bearings are exposed to large quantities of liquids such as water, corrosion resistance and operating life can be further enhanced by using long-life, corrosion-resistant stainless steel (ESI).

Catalog No. E1216

EM Series Cylindrical Roller Bearings

The high-load capacity standard cylindrical roller bearing delivers outstanding performance across a wide range of applications. High-load capacity is achieved by using more rollers than conventional bearings based on an innovative NSK concept. We also offer standard cylindrical roller bearings for today's needs that provide longer service life and low-noise and low-vibration performance through an optimally designed one-piece cage with high rigidity and low wear.



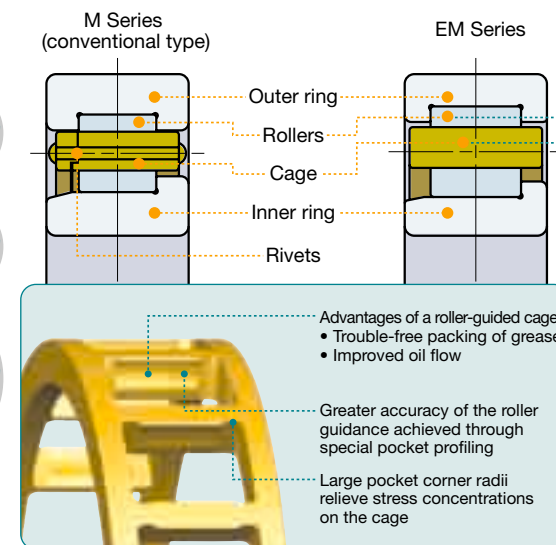
Features Series are available in bearing inner bore dimensions ranging from 25 mm to 200 mm

Compared to the conventional M Series:

Bearing life approximately **2 times**

Low vibration and noise **50% to 60% less**

Cage strength dramatically enhanced (generated stress cut in half)



High load rating
Greater number of larger rollers

Low vibration and noise
One-piece cage provides greater accuracy. Roller-guided cage achieves lower running temperature and quieter operation

High-strength and wear-resistant cage
Well-balanced one-piece design

Catalog No. E1237

Triple Ring Bearings

Combination tapered roller bearings have typically been used for the outside of controlled crown rolls (CCR) and spherical roller bearings for the inside. Switching to high-precision, high load capacity triple ring bearings prevents creep, facilitates easier mounting, and extends operating life.



Features

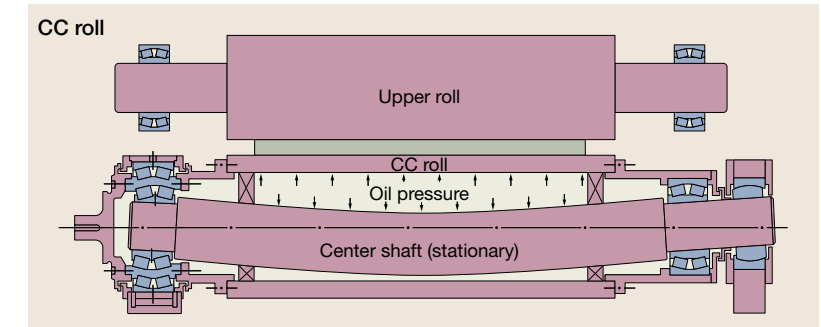
High-load capacity design

Long life
(uses vacuum melted, carburized steel)

High precision
(dimensional and rotational precision)

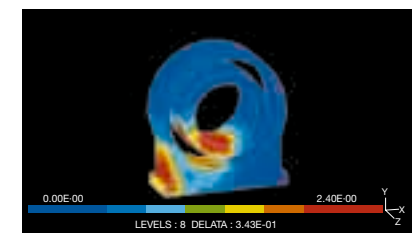
Optimal inner ring design for lubrication

Lubrication hole and groove provided on inner and outer rings



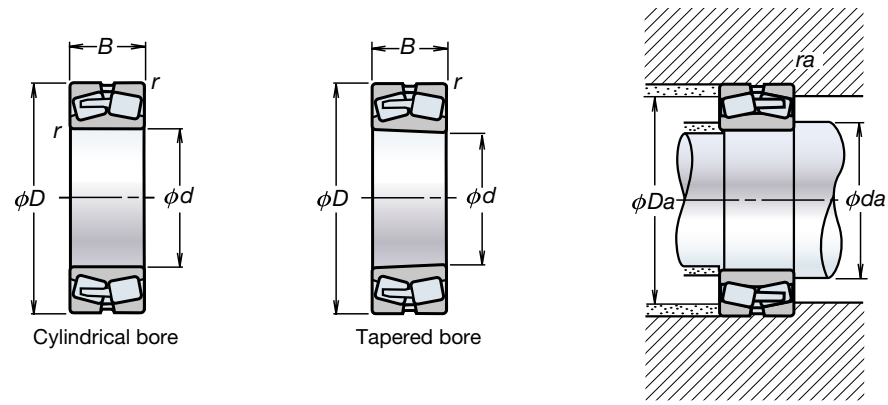
Finite element analysis of housing design for triple ring bearings.

Bearing load distribution is minimized by finite element method (FEM) analysis, thereby contributing to optimal structural design of the housing for paper machine manufacturers.



Maximum principle stress distribution

TL Series Spherical Roller Bearings



Dynamic equivalent load

$$P = XF_r + YF_a$$

$F_a / F_r \leq e$		$F_a / F_r > e$	
X	Y	X	Y
1	Y_3	0.67	Y_2

Static equivalent load

$$P_0 = F_r + Y_0 F_a$$

The values for e , Y_2 , Y_3 and Y_0 are given in the table below.

Bearing Nomenclature

Example : **TL 23152 CA g3 M K E4 C3 S11**

Spherical roller bearings (Bearing type);
Width series 3 (Bearing series symbols);
Diameter series 1 (Bearing series symbols);
Bearing bore 260 mm (Bore number)

Machined brass cage (Cage type symbol)

Max. operating temperature: less than 200°C
(Special specification symbol)

Radial clearance C3 (Internal clearance symbol)

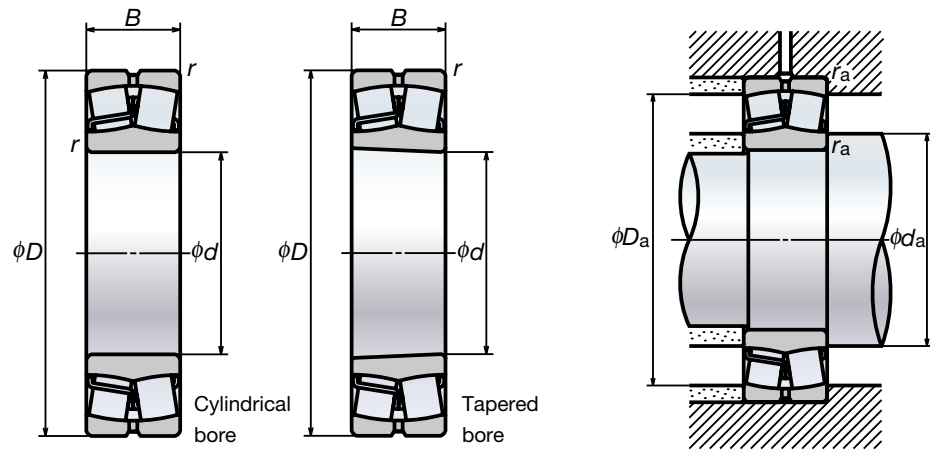
Outer ring with oil groove and oil holes (External features symbol)

Tapered bore (External features symbol)

TL spec. Inner ring. (Special spec, material symbol) g5: Inner and outer ring

Boundary dimensions (mm)				Basic load ratings (N)		Limiting speeds (min ⁻¹)		Bearing numbers		Abutment and fillet dimensions (mm)				Constant	Axial load factors			Mass	
d	D	B	r (min)	C_r	C_{or}	Grease	Oil	Cylindrical bore	Tapered bore (1)	(min) d_a	(max) d_a	(max) D_a	(min) D_a	r_a (max)	e	Y_2	Y_3	Y_0	(kg) approx
65	140	48	2.1	375 000	380 000	3 200	4 000	TL22313EAE4	TL22313EAKE4	77	84	128	119	2	0.33	3.0	2.0	2.0	3.52
70	150	51	2.1	425 000	435 000	3 000	3 800	TL22314EAE4	TL22314EAKE4	82	91	138	129	2	0.33	3.0	2.0	2.0	4.28
90	190	64	3	665 000	705 000	2 400	3 000	TL22318EAE4	TL22318EAKE4	104	115	176	163	2.5	0.33	3.1	2.1	2.0	8.56
100	215	73	3	860 000	930 000	2 000	2 600	TL22320EAE4	TL22320EAKE4	114	130	201	184	2.5	0.33	3.0	2.0	2.0	12.7
110	170	45	2	293 000	465 000	2 000	2 400	TL23022CDE4	TL23022CDKE4	120	124	160	153	2	0.24	4.2	2.8	2.8	3.76
110	200	69.8	2.1	515 000	760 000	1 500	1 900	TL23222CE4	TL23222CKE4	122	130	188	170	2	0.34	3.0	2.0	1.9	9.54
110	240	80	3	825 000	1 120 000	1 700	2 200	TL22322EAE4	TL22322EAKE4	124	145	226	206	2.5	0.30	3.1	2.1	2.0	17.6
120	260	86	3	955 000	1 320 000	1 600	2 000	TL22324EAE4	TL22324EAKE4	134	157	246	222	2.5	0.32	3.1	2.1	2.0	22.2
130	280	93	4	995 000	1 350 000	1 300	1 600	TL22326CAE4	TL22326CAKE4	148	—	262	236	3	0.34	2.9	2.0	1.9	27.8
140	210	53	2	420 000	715 000	1 600	1 900	TL23028CDE4	TL23028CDKE4	150	157	200	190	2	0.22	4.5	3.0	2.9	6.49
140	250	68	3	645 000	930 000	1 400	1 700	TL22228CDE4	TL22228CDKE4	154	167	236	219	2.5	0.25	4.0	2.7	2.6	14.5
140	250	88	3	835 000	1 300 000	1 100	1 500	TL23228CE4	TL23228CKE4	154	163	236	213	2.5	0.35	2.9	1.9	1.9	18.8
150	225	56	2.1	470 000	815 000	1 400	1 800	TL23030CDE4	TL23030CDKE4	162	168	213	203	2	0.22	4.6	3.1	3.0	7.90
150	250	80	2.1	725 000	1 180 000	1 100	1 400	TL23130CAE4	TL23130CAKE4	162	—	238	218	2	0.30	3.4	2.3	2.2	15.8
150	270	73	3	765 000	1 120 000	1 300	1 600	TL22230CDE4	TL22230CDKE4	164	179	256	236	2.5	0.26	3.9	2.6	2.5	18.4
150	320	108	4	1 220 000	1 690 000	1 100	1 400	TL22330CAE4	TL22330CAKE4	168	—	302	270	3	0.35	2.9	1.9	1.9	41.5
160	240	60	2.1	540 000	955 000	1 300	1 700	TL23032CDE4	TL23032CDKE4	172	179	228	216	2	0.22	4.5	3.0	2.9	9.66
160	290	80	3	910 000	1 320 000	1 200	1 500	TL22232CDE4	TL22232CDKE4	174	190	276	255	2.5	0.26	3.8	2.6	2.5	23.1
160	290	104	3	1 100 000	1 770 000	1 000	1 300	TL23232CE4	TL23232CKE4	174	189	276	245	2.5	0.34	2.9	2.0	1.9	30.5
170	230	45	2	350 000	660 000	1 400	1 800	TL23934BCAE4	TL23934BCAKE4	180	—	220	213	2	0.17	5.8	3.9	3.8	5.38
170	260	67	2.1	640 000	1 090 000	1 200	1 600	TL23034CDE4	TL23034CDKE4	182	191	248	233	2	0.23	4.3	2.9	2.8	13.0
170	280	88	2.1	940 000	1 570 000	1 000	1 300	TL23134CAE4	TL23134CAKE4	182	—	268	245	2	0.29	3.5	2.3	2.3	21.0
170	360	120	4	1 580 000	2 110 000	1 000	1 200	TL22334CAE4	TL22334CAKE4	188	—	342	304	3	0.35	2.9	1.9	1.9	57.9
180	280	74	2.1	750 000	1 270 000	1 200	1 400	TL23036CDE4	TL23036CDKE4	192	202	268	249	2	0.24	4.2	2.8	2.8	17.1
180	320	112	4	1 300 000	2 110 000	850	1 100	TL23236CAE4	TL23236CAKE4	198	—	302	274	3	0.35	2.9	1.9	1.9	38.5
190	290	75	2.1	775 000	1 350 000	1 100	1 400	TL23038CAE4	TL23038CAKE4	202	—	278	261	2	0.24	4.2	2.8	2.8	17.6
190	320	104	3	1 190 000	2 020 000	850	1 100	TL23138CAE4	TL23138CAKE4	204	—	306	276	3.5	0.31	3.2	2.2	2.1	34.0
190	340	92	4	1 140 000	1 730 000	1 000	1 200	TL22238CAE4	TL22238CAKE4	208	—	322	296	3	0.26	3.8	2.6	2.5	35.5
190	340	120	4	1 440 000	2 350 000	800	1 100	TL23238CAE4	TL23238CAKE4	208	—	322	288	3	0.35	2.9	1.9	1.9	46.5
190	400	132	5	1 890 000	2 590 000	900	1 100	TL22338CAE4	TL22338CAKE4	212	—	378	338	4	0.34	2.9	2.0	1.9	77.6
200	310	82	2.1	940 000	1 700 000	1 000	1 300	TL23040CAE4	TL23040CAKE4	212	—	298	279	2	0.25	4.0	2.7	2.6	22.6
200	340	112	3	1 360 000	2 330 000	800	1 000	TL23140CAE4	TL23140CAKE4	214	—	326	293	2.5	0.32	3.2	2.1	2.1	41.5
200	360	98	4	1 300 000	2 010 000	950	1 200	TL22240CAE4	TL22240CAKE4	218	—	342	315	3	0.26	3.8	2.6	2.5	42.6
200	360	128	4	1 660 000	2 750 000	750	1 000	TL23240CAE4	TL23240CAKE4	218	—	342	307	3	0.35	2.9	1.9	1.9	57.0
220	340	90	3	1 090 000	1 980 000	950	1 200	TL23044CAE4	TL23044CAKE4	234	—	326	302	2.5	0.24	4.1	2.8	2.7	29.7
220	370	120	4	1 570 000	2 710 000	710	950	TL23144CAE4	TL23144CAKE4	238	—	352	320	3	0.31	3.2	2.2	2.1	52.0
220	400	108	4	1 570 000	2 430 000	850	1 000	TL22244CAE4	TL22244CAKE4	238	—	382	348	3	0.27	3.7	2.5	2.4	59.0
220	400	144	4	2 010 000	3 400 000	670	900	TL23244CAE4	TL23244CAKE4	238	—	382	337	3	0.36	2.8	1.9	1.8	79.5
220	460	145	5	2 350 000	3 400 000	750	950	TL22344CAE4	TL22344CAKE4	242	—	438	391	4	0.33	3.0	2.0	2.0	116
240	320	60	2.1	635 000	1 300 000	950	1 200	TL23948CAE4	TL23948CAKE4	252	—	308	298	2	0.17	6.0	4.0	3.9	13.3
240	360	92	3	1 160 000	2 140 000	850	1 100	TL23048CAE4	TL23048CAKE4	254	—	346	324	2.5	0.24	4.2	2.8	2.7	32.6
240	400	128	4	1 790 000	3 100 000	670	850	TL23148CAE4	TL23148CAKE4	258	—	382	347	3	0.31	3.3	2.2	2.2	64.5
240	500	155	5	2 600 000	3 800 000	670	850	TL22348CAE4	TL22348CAKE4	262	—	478	423	4	0.32	3.2	2.1	2.1	147
260	360	75	2.1	930 000	1 870 000	850	1 000	TL23952CAE4	TL23952CAKE4	272	—	348	333	2	0.19	5.4	3.6	3.5	23.0
260	400	104	4	1 430 000	2 580 000	800	950	TL23052CAE4	TL23052CAKE4	278	—	382	356	3	0.25	4.1	2.7	2.7	46.6
260	440	144	4	2 160 000	3 750 000	600	800	TL23152CAE4	TL23152CAKE4	278	—	422	380	3	0.32	3.2	2.1	2.1	88.2
280	380	75	2.1	925 000	1 950 000	800	950	TL23956CAE4	TL23956CAKE4	292	—	368	351	2	0.18	5.7	3.9	3.8	24.5
280	420	106	4	1 540 000	2 950 000	710	900	TL23056CAE4	TL23056CAKE4	298	—	402	377	3	0.24	4.2	2.8	2.7	50.5
280	460	146	5	2 230 000	4 000 000	560	750	TL23156CAE4	TL23156CAKE4	302	—	438	400	4	0.30	3.3	2.2	2.2	94.3
280	500	176	5	2 880 000	4 900 000	530	670	TL23256CAE4	TL23256CAKE4	302	—	478	425	4	0.35	2.9	1.9	1.9	147
300	420	90	3	1 230 000	2 490 000	710	900	TL23960CAE4	TL23960CAKE4	314	—	406	386	2.5	0.19	5.2	3.5	3.4	38.2
300	460	118	4	1 920 000	3 700 000	670	850	TL23060CAE4	TL23060CAKE4	318	—	442	413	3	0.24	4.2	2.8	2.7	70.5
300	500	160	5	2 670 000	4 800 000	500	670	TL23160CAE4	TL23160CAKE4	322	—	478	433	4	0.31	3.3	2.2	2.2	125
300	540	192	5	3 400 000	5 900 000	480	630	TL23260CAE4	TL23260CAKE4	322	—	518	458	4	0.35	2.9	1.9	1.9	189
320	540	176	5	3 050 000	5 500 000	480	600	TL23164CAE4	TL23164CAKE4	342	—	518	466	4	0.31	3.2	2.1	2.1	162
340	520	133	5	2 280 000	4 400 000	560	710	TL23068CAE4	TL23068CAKE4	362	—	498	465	4	0.24	4.2	2.8	2.8	101
340	580	190	5	3 600 000	6 600 000	430	560	TL23168CAE4	TL23168CAKE4	362	—	558	499	4	0.31	3.2	2.1	2.1	206
360	540	134	5	2 390 000	4 700 000	530	670	TL23072CAE4	TL23072CAKE4	382	—								

HPS Spherical Roller Bearings



Dynamic equivalent load
 $P = X F_r + Y F_a$

$F_a / F_r \leq e$		$F_a / F_r > e$	
X	Y	X	Y
1	Y_3	0.67	Y_2

Static equivalent load
 $P_0 = F_r + Y_0 F_a$

The values for e , Y_2 , Y_3 and Y_0 are given in the table below.

Bearing Nomenclature

Example: **22318 EA E4 C3**

Spherical roller bearings (Bearing type);
 Width series 2 (Bearing series symbols);
 Diameter series 3 (Bearing series symbols);
 Bearing bore 90 mm (Bore number)

Radial clearance C3
 (Internal clearance symbol)
 Outer ring with oil groove and oil holes
 (External features symbol)

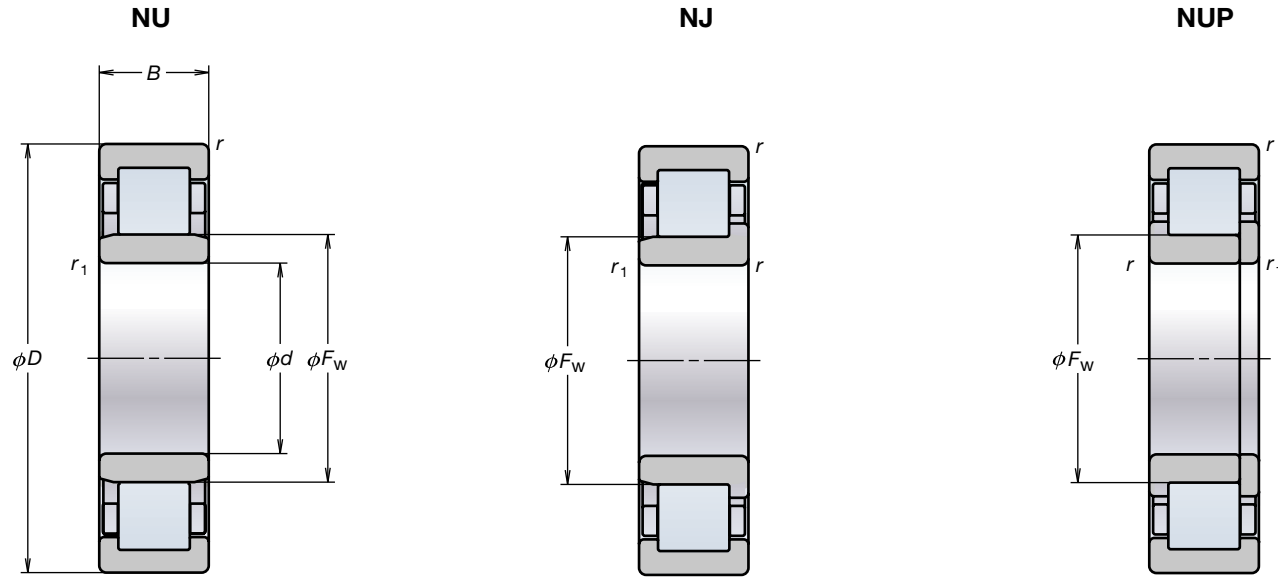
High load capacity HPS series pressed steel cage
 (Internal symbol)

Boundary dimensions (mm)				Basic load ratings (N)		Limiting speeds (min ⁻¹)		Bearing numbers		Abutment and fillet dimensions (mm)				Constant	Axial load factors			Mass	
d	D	B	r (min)	C_r	C_{Or}	Grease	Oil	Cylindrical bore	Tapered bore (1)	(min) d_a	(max)	(max) D_a	(min)	r_a (max)	e	Y_2	Y_3	Y_0	(kg) approx
40	80	23	1.1	113 000	99 500	6 700	8 500	22208EAE4	22208EAKE4	47	49	73	70	1	0.28	3.6	2.4	2.4	0.50
	90	23	1.5	118 000	111 000	6 000	7 500	21308EAE4	21308EAKE4	49	54	81	75	1.5	0.25	3.9	2.7	2.6	0.73
	90	33	1.5	170 000	153 000	5 300	6 700	22308EAE4	22308EAKE4	49	52	81	77	1.5	0.35	2.8	1.9	1.9	0.98
45	85	23	1.1	118 000	111 000	6 000	7 500	22209EAE4	22209EAKE4	52	54	78	75	1	0.25	3.9	2.7	2.6	0.55
	100	25	1.5	149 000	144 000	5 000	6 300	21309EAE4	21309EAKE4	54	65	91	89	1.5	0.23	4.3	2.9	2.8	0.96
	100	36	1.5	207 000	195 000	4 500	5 600	22309EAE4	22309EAKE4	54	59	91	86	1.5	0.34	2.9	2	1.9	1.34
50	90	23	1.1	124 000	119 000	5 600	7 100	22210EAE4	22210EAKE4	57	60	83	81	1	0.24	4.3	2.9	2.8	0.61
	110	27	2	178 000	174 000	4 500	5 600	21310EAE4	21310EAKE4	60	72	100	98	2	0.23	4.4	3	2.9	1.21
	110	40	2	246 000	234 000	4 300	5 300	22310EAE4	22310EAKE4	60	64	100	93	2	0.35	2.8	1.9	1.9	1.78
55	100	25	1.5	149 000	144 000	5 300	6 700	22211EAE4	22211EAKE4	64	65	91	89	1.5	0.23	4.3	2.9	2.8	0.81
	120	29	2	178 000	174 000	4 500	5 600	21311EAE4	21311EAKE4	65	72	110	98	2	0.23	4.4	3	2.9	1.58
	120	43	2	292 000	292 000	3 800	4 800	22311EAE4	22311EAKE4	65	73	110	103	2	0.34	2.9	2	1.9	2.30
60	110	28	1.5	178 000	174 000	4 800	6 000	22212EAE4	22212EAKE4	69	72	101	98	1.5	0.23	4.4	3	2.9	1.10
	130	31	2.1	238 000	244 000	3 800	4 800	21312EAE4	21312EAKE4	72	87	118	117	2	0.22	4.5	3	3	1.98
	130	46	2.1	340 000	340 000	3 600	4 500	22312EAE4	22312EAKE4	72	79	118	111	2	0.34	3	2	1.9	2.89
65	120	31	1.5	221 000	230 000	4 300	5 300	22213EAE4	22213EAKE4	74	80	111	107	1.5	0.24	4.2	2.8	2.7	1.51
	140	33	2.1	264 000	275 000	3 600	4 500	21313EAE4	21313EAKE4	77	94	128	126	2	0.22	4.6	3.1	3	2.45
	140	48	2.1	375 000	380 000	3 200	4 000	22313EAE4	22313EAKE4	77	84	128	119	2	0.33	3	2	2	3.52
70	125	31	1.5	225 000	232 000	4 000	5 300	22214EAE4	22214EAKE4	79	84	116	111	1.5	0.23	4.3	2.9	2.8	1.58
	150	35	2.1	310 000	325 000	3 200	4 000	21314EAE4	21314EAKE4	82	101	138	135	2	0.22	4.6	3.1	3	3.00
	150	51	2.1	425 000	435 000	3 000	3 800	22314EAE4	22314EAKE4	82	91	138	129	2	0.33	3	2	2	4.28
75	130	31	1.5	238 000	244 000	4 000	5 000	22215EAE4	22215EAKE4	84	87	121	117	1.5	0.22	4.5	3	3	1.64
	160	37	2.1	310 000	325 000	3 200	4 000	21315EAE4	21315EAKE4	87	101	148	134	2	0.22	4.6	3.1	3	3.64
	160	55	2.1	485 000	505 000	2 800	3 600	22315EAE4	22315EAKE4	87	97	148	137	2	0.33	3	2	2	5.26
80	140	33	2	264 000	275 000	3 600	4 500	22216EAE4	22216EAKE4	90	94	130	126	2	0.22	4.6	3.1	3	2.01
	170	39	2.1	355 000	375 000	3 000	3 800	21316EAE4	21316EAKE4	92	109	158	146	2	0.23	4.4	3	2.9	4.32
	170	58	2.1	540 000	565 000	2 600	3 400	22316EAE4	22316EAKE4	92	103	158	145	2	0.33	3	2	2	6.23
85	150	36	2	310 000	325 000	3 400	4 300	22217EAE4	22217EAKE4	95	101	140	135	2	0.22	4.6	3.1	3	2.54
	180	41	3	360 000	395 000	3 000	4 000	21317EAE4	21317EAKE4	99	108	166	142	2.5	0.24	4.3	2.9	2.8	5.20
	180	60	3	600 000	630 000	2 400	3 200	22317EAE4	22317EAKE4	99	110	166	155	2.5	0.33	3.1	2.1	2	7.23
90	160	40	2	360 000	395 000	3 200	4 000	22218EAE4	22218EAKE4	100	108	150	142	2	0.24	4.3	2.9	2.8	3.30
	190	43	3	415 000	450 000	2 800	3 600	21318EAE4	21318EAKE4	104	115	176	152	2.5	0.24	4.3	2.9	2.8	6.10
	190	64	3	665 000	705 000	2 400	3 000	22318EAE4	22318EAKE4	104	115	176	163	2.5	0.33	3.1	2.1	2	8.56
95	170	43	2.1	415 000	450 000	3 000	3 800	22219EAE4	22219EAKE4	107	115	158	152	2	0.24	4.3	2.9	2.8	4.04
	200	67	3	735 000	780 000	2 200	2 800	22319EAE4	22319EAKE4	109	121	186	172	2.5	0.33	3.1	2.1	2	9.91
100	180	46	2.1	455 000	490 000	2 800	3 600	22220EAE4	22220EAKE4	112	119	168	160	2	0.24	4.3	2.9	2.8	4.84
	215	73	3	860 000	930 000	2 000	2 600	22320EAE4	22320EAKE4	114	130	201	184	2.5	0.33	3	2	2	12.7
110	200	53	2.1	605 000	645 000	2 600	3 200	22222EAE4	22222EAKE4	122	129	188	178	2	0.25	4	2.7	2.6	6.99
	240	80	3	1 030 000	1 120 000	1 900	2 400	22322EAE4	22322EAKE4	124	145	226	206	2.5	0.33	3.1	2.1	2	17.6
120	215	58	2.1	685 000	765 000	2 400	3 000	22224EAE4	22224EAKE4	132	142	203	190	2	0.25	3.9	2.7	2.6	8.80
	260	86	3	1 190 000	1 320 000	1 700	2 200	22324EAE4	22324EAKE4	134	157	246	222	2.5	0.32	3.1	2.1	2	22.2
130	230	64	3	820 000	940 000	2 200	2 600	22226EAE4	22226EAKE4	144	152	216	204	2.5	0.26	3.8	2.6	2.5	11.0

Note (1) The suffix K indicates that the bearing has a tapered bore (taper 1:12).

Remarks 1. The maximum operating temperature of standard HPS spherical roller bearings is 200°C.
 2. The suffix E4 indicates that the bearing has an oil groove and holes.

EM Series Cylindrical Roller Bearings



Bearing Nomenclature

Example : **NU210 EM C3**

Cylindrical roller bearings (Bearing type) NU type;
Diameter series 2 (Bearing series symbols);
Bearing bore 50 mm (Bore number)

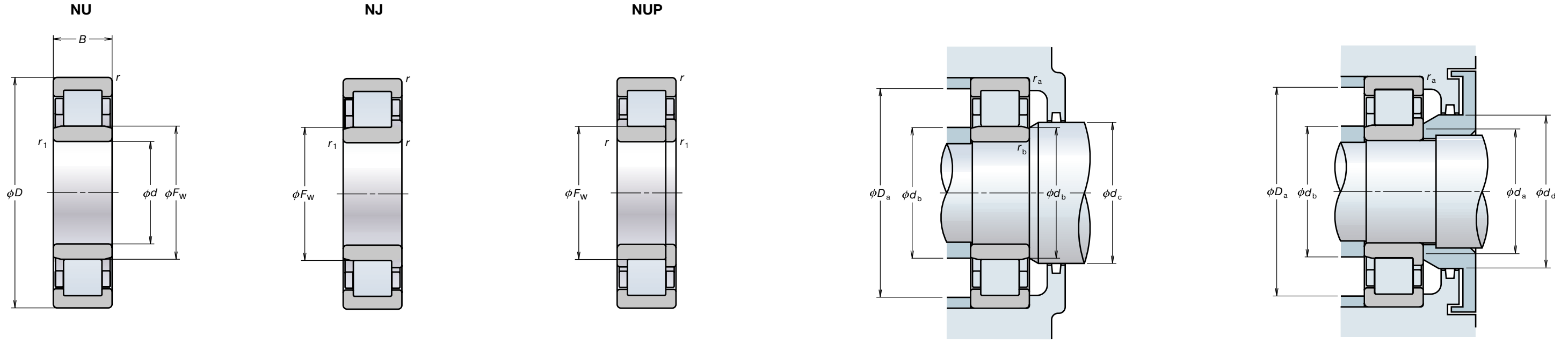
Radial clearance C3
(Internal clearance symbol)

High capacity machined brass cage
(Internal, cage type symbol)

Boundary dimensions (mm)						Basic load ratings (N)		Limiting speeds (min ⁻¹)		Bearing numbers			Abutment and fillet dimensions (mm)						Permissible axial movement S (mm)		
d	D	B	r	r ₁	F _w	C _r	C _{or}	Grease	Oil	NU	NJ	NUP	d _a	d _b		d _c	d _d	D _a		r _a	r _b
			min	min									min	min	max	min	min	max		max	max
25	52	15	1	0.6	31.5	29 300	27 700	13 000	16 000	NU205EM	NJ	NUP	30	29	30	34	37	47	1	0.6	1.2
	62	17	1.1	1.1	34	41 500	37 500	10 000	13 000	NU305EM	NJ	NUP	31.5	31.5	32	37	40	55.5	1	1	1.2
30	62	16	1	0.6	37.5	39 000	37 500	11 000	13 000	NU206EM	NJ	NUP	35	34	36	40	44	57	1	0.6	1.2
	72	19	1.1	1.1	40.5	53 000	50 000	8 500	11 000	NU306EM	NJ	NUP	36.5	36.5	39	44	48	65.5	1	1	1.2
35	72	17	1.1	0.6	44	50 500	50 000	9 500	11 000	NU207EM	NJ	NUP	41.5	39	42	46	50	65.5	1	0.6	1.2
	80	21	1.5	1.1	46.2	66 500	65 500	8 000	9 500	NU307EM	NJ	NUP	43	41.5	44	48	53	72	1.5	1	1.2
40	80	18	1.1	1.1	49.5	55 500	55 500	8 500	10 000	NU208EM	NJ	NUP	46.5	46.5	48	52	56	73.5	1	1	1.2
	90	23	1.5	1.5	52	83 000	81 500	6 700	8 500	NU308EM	NJ	NUP	48	48	50	55	60	82	1.5	1.5	1.2
45	85	19	1.1	1.1	54.5	63 000	66 500	7 500	9 000	NU209EM	NJ	NUP	51.5	51.5	52	57	61	78.5	1	1	1.2
	100	25	1.5	1.5	58.5	97 500	98 500	6 300	7 500	NU309EM	NJ	NUP	53	53	56	60	66	92	1.5	1.5	1.4
50	90	20	1.1	1.1	59.5	69 000	76 500	7 100	8 500	NU210EM	NJ	NUP	56.5	56.5	57	62	67	83.5	1	1	1.7
	110	27	2	2	65	110 000	113 000	5 600	6 700	NU310EM	NJ	NUP	59	59	63	67	73	101	2	2	1.4
55	100	21	1.5	1.1	66	86 500	98 500	6 300	7 500	NU211EM	NJ	NUP	63	61.5	64	68	73	92	1.5	1	1.2
	120	29	2	2	70.5	137 000	143 000	5 000	6 300	NU311EM	NJ	NUP	64	64	68	72	80	111	2	2	1.4
60	110	22	1.5	1.5	72	97 500	107 000	6 000	7 100	NU212EM	NJ	NUP	68	68	70	75	80	102	1.5	1.5	1.2
	130	31	2.1	2.1	77	150 000	157 000	4 800	5 600	NU312EM	NJ	NUP	71	71	75	79	86	119	2	2	1.5
65	120	23	1.5	1.5	78.5	108 000	119 000	5 300	6 300	NU213EM	NJ	NUP	73	73	76	81	87	112	1.5	1.5	1.4
	140	33	2.1	2.1	82.5	181 000	191 000	4 300	5 300	NU313EM	NJ	NUP	76	76	80	85	93	129	2	2	1.5
70	125	24	1.5	1.5	83.5	119 000	137 000	5 000	6 300	NU214EM	NJ	NUP	78	78	81	86	92	117	1.5	1.5	1.4
	150	35	2.1	2.1	89	205 000	222 000	4 000	5 000	NU314EM	NJ	NUP	81	81	86	92	100	139	2	2	1.5
75	130	25	1.5	1.5	88.5	130 000	156 000	4 800	6 000	NU215EM	NJ	NUP	83	83	86	90	96	122	1.5	1.5	1.4
	160	37	2.1	2.1	95	240 000	263 000	3 800	4 800	NU315EM	NJ	NUP	86	86	92	97	106	149	2	2	1.4
80	140	26	2	2	95.3	139 000	167 000	4 500	5 300	NU216EM	NJ	NUP	89	89	92	97	104	131	2	2	1.4
	170	39	2.1	2.1	101	256 000	282 000	3 600	4 300	NU316EM	NJ	NUP	91	91	98	105	114	159	2	2	1.5
85	150	28	2	2	100.5	167 000	199 000	4 300	5 000	NU217EM	NJ	NUP	94	94	98	104	110	141	2	2	1.3
	180	41	3	3	108	291 000	330 000	3 400	4 000	NU317EM	NJ	NUP	98	98	105	110	119	167	2.5	2.5	2
90	160	30	2	2	107	182 000	217 000	4 000	4 800	NU218EM	NJ	NUP	99	99	104	109	116	151	2	2	1.4
	190	43	3	3	113.5	315 000	355 000	3 200	3 800	NU318EM	NJ	NUP	103	103	111	117	127	177	2.5	2.5	1.5
95	170	32	2.1	2.1	112.5	220 000	265 000	3 800	4 500	NU219EM	NJ	NUP	106	106	110	116	123	159	2	2	1.4
	200	45	3	3	121.5	335 000	385 000	3 000	3 600	NU319EM	NJ	NUP	108	108	118	124	134	187	2.5	2.5	1.5
100	180	34	2.1	2.1	119	249 000	305 000	3 600	4 300	NU220EM	NJ	NUP	111	111	116	122	130	169	2	2	1.4
	215	47	3	3	127.5	380 000	425 000	2 800	3 400	NU320EM	NJ	NUP	113	113	124	132	143	202	2.5	2.5	1.8
105	190	36	2.1	2.1	125	262 000	310 000	3 400	4 000	NU221EM	NJ	NUP	116	116	121	129	137	179	2	2	1.4
	225	49	3	3	133	425 000	480 000	2 600	3 200	NU321EM	NJ	NUP	118	118	131	137	149	212	2.5	2.5	1.8
110	200	38	2.1	2.1	132.5	293 000	365 000	3 200	3 800	NU222EM	NJ	NUP	121	121	129	135	144	189	2	2	1.4
	200	53	2.1	2.1	132.5	385 000	515 000	2 800	3 400	NU222EM	NJ	NUP	121	121	129	135	144	189	2	2	1.4
	240	50	3	3	143	450 000	525 000	2 600	3 000	NU322EM	NJ	NUP	123	123	139	145	158	227	2.5	2.5	3.8

The following are also available: 1. N and NF type bearings 2. Cages with an outside diameter of less than 650 mm (Please contact NSK for details.)

EM Series Cylindrical Roller Bearings



Boundary dimensions (mm)						Basic load ratings (N)		Limiting speeds (min ⁻¹)		Bearing numbers			Abutment and fillet dimensions (mm)						Permissible axial movement S (mm)		
d	D	B	r	r ₁	F _w	C _r	C _{or}	Grease	Oil	NU	NJ	NUP	d _a	d _b		d _c	d _d	D _a		r _a	r _b
			min	min									min	min	max	min	min	max		max	max
120	215	40	2.1	2.1	143.5	335 000	420 000	3 000	3 400	NU224EM	NJ	NUP	131	131	140	146	156	204	2	2	1.5
	215	58	2.1	2.1	143.5	450 000	620 000	2 600	3 200	NU2224EM	NJ	NUP	131	131	140	146	156	204	2	2	2
	260	55	3	3	154	530 000	610 000	2 200	2 800	NU324EM	NJ	NUP	133	133	150	156	171	247	2.5	2.5	1.8
	260	86	3	3	154	795 000	1 030 000	2 000	2 600	NU2324EM	NJ	NUP	133	133	150	156	171	247	2.5	2.5	2.8
130	230	40	3	3	153.5	365 000	455 000	2 600	3 200	NU226EM	NJ	NUP	143	143	150	158	168	217	2.5	2.5	1.5
	230	64	3	3	153.5	530 000	735 000	2 400	3 000	NU2226EM	NJ	NUP	143	143	150	158	168	217	2.5	2.5	3
	280	58	4	4	167	615 000	735 000	2 200	2 600	NU326EM	NJ	NUP	146	146	163	169	184	264	3	3	2.3
	280	93	4	4	167	920 000	1 230 000	1 900	2 400	NU2326EM	NJ	NUP	146	146	163	169	184	264	3	3	2.3
140	250	42	3	3	169	395 000	515 000	2 400	3 000	NU228EM	NJ	NUP	153	153	165	171	182	237	2.5	2.5	1.5
	250	68	3	3	169	550 000	790 000	2 200	2 800	NU2228EM	NJ	NUP	153	153	165	171	182	237	2.5	2.5	2.5
	300	62	4	4	180	665 000	795 000	2 000	2 400	NU328EM	NJ	NUP	156	156	176	182	198	284	3	3	3.3
	300	102	4	4	180	1 020 000	1 380 000	1 700	2 200	NU2328EM	NJ	NUP	156	156	176	182	198	284	3	3	2.8
150	270	45	3	3	182	450 000	595 000	2 200	2 800	NU230EM	NJ	NUP	163	163	177	184	196	257	2.5	2.5	1.5
	270	73	3	3	182	635 000	930 000	2 000	2 600	NU2230EM	NJ	NUP	163	163	177	184	196	257	2.5	2.5	3
	320	65	4	4	193	760 000	920 000	1 800	2 200	NU330EM	NJ	NUP	166	166	188	195	213	304	3	3	3.2
	320	108	4	4	193	1 160 000	1 600 000	1 600	2 000	NU2330EM	NJ	NUP	166	166	188	195	213	304	3	3	2.2
160	290	48	3	3	195	500 000	665 000	2 200	2 600	NU232EM	NJ	NUP	173	173	190	197	210	277	2.5	2.5	1.8
	290	80	3	3	193	810 000	1 190 000	1 900	2 400	NU2232EM	NJ	NUP	173	173	188	197	210	277	2.5	2.5	3.3
	340	68	4	4	204	860 000	1 050 000	1 700	2 000	NU332EM	NJ	NUP	176	176	199	211	228	324	3	3	3.2
	340	114	4	4	204	1 310 000	1 820 000	1 500	1 900	NU2332EM	NJ	NUP	176	176	199	211	228	324	3	3	2.7
170	310	52	4	4	207	605 000	800 000	2 000	2 400	NU234EM	NJ	NUP	186	186	202	211	223	294	3	3	3.8
	310	86	4	4	205	925 000	1 330 000	1 800	2 200	NU2234EM	NJ	NUP	186	186	200	211	223	294	3	3	2.8
	360	72	4	4	218	930 000	1 150 000	1 600	2 000	NU334EM	NJ	NUP	186	186	213	223	241	344	3	3	1.7
	360	120	4	4	216	1 490 000	2 070 000	1 400	1 800	NU2334EM	NJ	NUP	186	186	210	223	241	344	3	3	6.2
180	320	52	4	4	217	625 000	850 000	1 900	2 200	NU236EM	NJ	NUP	196	196	212	221	233	304	3	3	2.2
	320	86	4	4	215	1 010 000	1 510 000	1 700	2 000	NU2236EM	NJ	NUP	196	196	210	221	233	304	3	3	2.7
	380	75	4	4	231	985 000	1 230 000	1 500	1 800	NU336EM	NJ	NUP	196	196	226	235	255	364	3	3	2.2
	380	126	4	4	227	1 560 000	2 220 000	1 300	1 700	NU2336EM	NJ	NUP	196	196	222	235	255	364	3	3	6.2
190	340	55	4	4	230	695 000	955 000	1 800	2 200	NU238EM	NJ	NUP	206	206	225	234	247	324	3	3	1.7
	340	92	4	4	228	1 100 000	1 670 000	1 600	2 000	NU2238EM	NJ	NUP	206	206	223	234	247	324	3	3	1.7
	400	78	5	5	245	1 060 000	1 340 000	1 400	1 700	NU338EM	NJ	NUP	210	210	240	248	268	380	4	4	1.7
	400	132	5	5	240	1 770 000	2 520 000	1 300	1 600	NU2338EM	NJ	NUP	210	210	235	248	268	380	4	4	6.2
200	360	58	4	4	243	765 000	1 060 000	1 700	2 000	NU240EM	NJ	NUP	216	216	238	247	261	344	3	3	2.2
	360	98	4	4	241	1 220 000	1 870 000	1 500	1 800	NU2240EM	NJ	NUP	216	216	235	247	261	344	3	3	2.2
	420	80	5	5	258	1 140 000	1 450 000	1 300	1 600	NU340EM	NJ	NUP	220	220	252	263	283	400	4	4	1.2
	420	138	5	5	253	1 910 000	2 760 000	1 200	1 500	NU2340EM	NJ	NUP	220	220	247	263	283	400	4	4	7.7

The following are also available: 1. N and NF type bearings 2. Cages with an outside diameter of less than 650 mm (Please contact NSK for details.)

Triple Ring Bearings

Bearing Nomenclature

Example : **2SL 180-2 UPA**

Triple ring bearings
(Spherical roller bearings)

Bearing bore 180 mm

Special accuracy (Tolerance class symbol)

Molded-Oil™ Spherical Roller Bearings

Bearing Nomenclature

Example : **22212 L12 CAM C3**

Spherical roller bearings (Bearing type);
Width series 2 (Bearing series symbols);
Diameter series 3 (Bearing series symbols);
Bearing bore 90 mm (Bore number)

Radial clearance C3
(Internal clearance symbol)
Machined brass cage
(Cage type symbol)

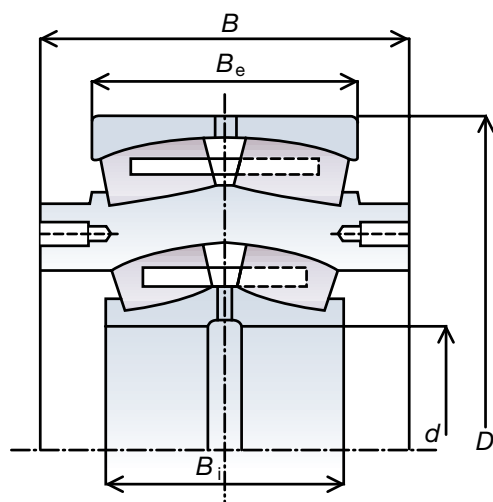
Molded-Oil for high-speed (L11 is for general use)

Bearing numbers	Boundary dimensions (mm)					Mass (kg)
	d	D	B_i	B_e	B	
2SL180-2 UPA	180	480	140	160	215.9	175
2SL200-2 UPA	200	520	160	180	241.3	230
2SL220-2 UPA	220	600	180	200	279.4	330
2SL240-2 UPA	240	620	200	200	279.4	410
2SL260-2 UPA	260	680	218	218	317.5	490
2SL280-2 UPA	280	720	218	218	317.5	525
2SL300-2 UPA	300	780	243	250	342.9	735
2SL320-2 UPA	320	820	258	258	368.3	840
2SL340-2 UPA	340	870	280	272	393.7	1 050
2SL380-3 UPA	380	980	240	308	431.8	1 370
2PSL240-1 UPA	240	600	205	160	225	285

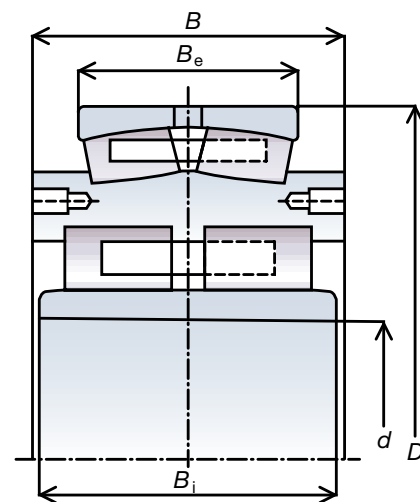
Bearing numbers	Boundary dimensions (mm)				Basic load ratings (N)	
	Bore diameter	Outside diameter	Width	Chamfer dimension (min)	C_r	C_{or}
21307L12CAM	35	80	21	1.5	71 000	76 000
21308L11ACAM	40	90	23	1.5	82 000	93 000
22308L11CAM	40	90	33	1.5	122 000	129 000
22209L11CAM	45	85	23	1.1	78 000	88 000
22309L12CAM	45	100	36	1.5	148 000	167 000
22210L11CAM	50	90	23	1.1	82 000	93 000
22311L12CAM	55	120	43	2	209 000	241 000
22212L12CAM	60	110	28	1.5	127 000	154 000
22213L11CAM	65	120	31	1.5	152 000	190 000
22313L11CAM	65	140	48	2.1	265 000	315 000
22313L12CAM	65	140	48	2.1	265 000	315 000
22214L11CAM	70	125	31	1.5	163 000	205 000
22315L12CAM	75	160	55	2.1	340 000	415 000
22216L11CAM	80	140	33	2	181 000	232 000
22217L12CAM	85	150	36	2	215 000	276 000
22218L12CAM	90	160	40	2	256 000	340 000
22219L12CAM	95	170	43	2.1	296 000	395 000
23120L11CAM	100	165	52	2	345 000	530 000
22320L11CAM	100	215	73	3	600 000	785 000
22222L12CAM	110	200	53	2.1	425 000	585 000
23024L11CAM	120	180	46	2	315 000	525 000
23124L12CAM	120	200	62	2	465 000	720 000
22226L11CAM	130	230	64	3	565 000	815 000
23932L11CAM	160	220	45	2	360 000	675 000

Bearing numbers other than those given in the table can also be produced.

2SL Type



2PSL Type



Molded-Oil™ Deep Groove Ball Bearings (Steel bearings)

Molded-Oil™ Deep Groove Ball Bearings (Stainless steel)

Bearing Nomenclature

Example : **6208 L11 -H-20 DDU C3**

Single-row deep groove ball bearings
(Bearing type):
Diameter series 2 (Bearing series symbols):
Bearing bore 40 mm (Bore number)

Molded-Oil for general use
(L12 is for high-speed operation)

Long-life, corrosion-resistant stainless steel (material symbol)

Radial clearance C3
(Internal clearance symbol)

Double seals (seal symbol)

Bearing numbers			Boundary dimensions (mm)				Basic load ratings (N)	
	Shielded type	Sealed type	Bore diameter	Outside diameter	Width	Chamfer dimension (min)	C_r	C_{or}
6900L11	ZZ1	DD1	10	22	6	0.3	2 700	1 270
6000L11	ZZ	DD	10	26	8	0.3	4 550	1 970
6200L11	ZZ	DDU	10	30	9	0.6	5 100	2 390
6901L11	ZZ2	DD1	12	24	6	0.3	2 890	1 460
6001L11	ZZ	DDU	12	28	8	0.3	5 100	2 370
6201L11	ZZ	DDU	12	32	10	0.6	6 800	3 050
6902L11	ZZ1	DD1	15	28	7	0.3	4 350	2 260
6002L11	ZZ	DDU	15	32	9	0.3	5 600	2 830
6202L11	ZZ	DDU	15	35	11	0.6	7 650	3 750
6903L11	ZZ	DDU	17	30	7	0.3	4 600	2 550
6003L11	ZZ	DDU	17	35	10	0.3	6 000	3 250
6203L11	ZZ	DDU	17	40	12	0.6	9 550	4 800
6904L11	ZZ	DDU	20	37	9	0.3	6 400	3 700
6004L11	ZZ	DDU	20	42	12	0.6	9 400	5 000
6204L11	ZZ	DDU	20	47	14	1	12 800	6 600
6905L11	ZZ	DDU	25	42	9	0.3	7 050	4 550
6005L11	ZZ	DDU	25	47	12	0.6	10 100	5 850
6205L11	ZZ	DDU	25	52	15	1	14 000	7 850
6906L11	ZZ	DDU	30	47	9	0.3	7 250	5 000
6006L11	ZZ	DDU	30	55	13	1	13 200	8 300
6206L11	ZZ	DDU	30	62	16	1	19 500	11 300
6907L11	ZZ	DDU	35	55	10	0.6	10 600	7 250
6007L11	ZZ	DDU	35	62	14	1	16 000	10 300
6207L11	ZZ	DDU	35	72	17	1.1	25 700	15 300
6908L11	ZZ	DDU	40	62	12	0.6	13 700	10 000
6008L11	ZZ	DDU	40	68	15	1	16 800	11 500
6208L11	ZZ	DDU	40	80	18	1.1	29 100	17 900
6909L11	ZZ	DDU	45	68	12	0.6	14 100	10 900
6009L11	ZZ	DDU	45	75	16	1	20 900	15 200
6209L11	ZZ	DDU	45	85	19	1.1	31 500	20 400
6910L11	ZZ	DDU	50	72	12	0.6	14 500	11 700
6010L11	ZZ	DDU	50	80	16	1	21 800	16 600
6210L11	ZZ	DDU	50	90	20	1.1	35 000	23 200

Bearing numbers other than those given in the table can also be produced.
Not applicable to bearings with plastic cage.

Bearing numbers			Boundary dimensions (mm)				Basic load ratings (N)	
	Shielded type	Sealed type	Bore diameter	Outside diameter	Width	Chamfer dimension (min)	C_r	C_{or}
6900L11-H-20	ZZ1	DD1	10	22	6	0.3	2 290	1 020
6000L11-H-20	ZZ	DD	10	26	8	0.3	3 900	1 580
6200L11-H-20	ZZ	DDU	10	30	9	0.6	4 350	1 910
6901L11-H-20	ZZ2	DD1	12	24	6	0.3	2 460	1 170
6001L11-H-20	ZZ	DDU	12	28	8	0.3	4 350	1 890
6201L11-H-20	ZZ	DDU	12	32	10	0.6	5 800	2 440
6902L11-H-20	ZZ1	DD1	15	28	7	0.3	3 700	1 810
6002L11-H-20	ZZ	DDU	15	32	9	0.3	4 750	2 270
6202L11-H-20	ZZ	DDU	15	35	11	0.6	6 500	2 980
6903L11-H-20	ZZ	DDU	17	30	7	0.3	3 900	2 040
6003L11-H-20	ZZ	DDU	17	35	10	0.3	5 100	2 600
6203L11-H-20	ZZ	DDU	17	40	12	0.6	8 150	3 850
6904L11-H-20	ZZ	DDU	20	37	9	0.3	5 400	2 940
6004L11-H-20	ZZ	DDU	20	42	12	0.6	7 950	4 000
6204L11-H-20	ZZ	DDU	20	47	14	1	10 900	5 250
6905L11-H-20	ZZ	DDU	25	42	9	0.3	5 950	3 600
6005L11-H-20	ZZ	DDU	25	47	12	0.6	8 550	4 650
6205L11-H-20	ZZ	DDU	25	52	15	1	11 900	6 300
6906L11-H-20	ZZ	DDU	30	47	9	0.3	6 150	4 000
6006L11-H-20	ZZ	DDU	30	55	13	1	11 300	6 600
6206L11-H-20	ZZ	DDU	30	62	16	1	16 500	9 050
6907L11-H-20	ZZ	DDU	35	55	10	0.6	9 000	5 800
6007L11-H-20	ZZ	DDU	35	62	14	1	13 600	8 200
6207L11-H-20	ZZ	DDU	35	72	17	1.1	21 800	12 200
6908L11-H-20	ZZ	DDU	40	62	12	0.6	11 600	8 000
6008L11-H-20	ZZ	DDU	40	68	15	1	14 200	9 250
6208L11-H-20	ZZ	DDU	40	80	18	1.1	24 800	14 300
6909L11-H-20	ZZ	DDU	45	68	12	0.6	12 000	8 700
6009L11-H-20	ZZ	DDU	45	75	16	1	17 800	12 200
6209L11-H-20	ZZ	DDU	45	85	19	1.1	26 600	16 300
6910L11-H-20	ZZ	DDU	50	72	12	0.6	12 400	9 400
6010L11-H-20	ZZ	DDU	50	80	16	1	18 500	13 300
6210L11-H-20	ZZ	DDU	50	90	20	1.1	29 800	18 600

Bearing numbers other than those given in the table can also be produced.
Not applicable to bearings with plastic cage.

	NSK Bearings for Papermaking Machines
	★ TL Bearings (★: Dryer cylinder)
	● Scope of application for TL Bearings (●: Delivered products)
	HPS Spherical Roller Bearings

Bore number	239			230			231			222			232			213			223			
	PM	TL	HPS	PM	TL	HPS	PM	TL	HPS	PM	TL	HPS	PM	TL	HPS	PM	TL	HPS	PM	TL	HPS	
05																						
06																						
07																						
08																						
09																						
10																						
11																						
12																						
13																						
14																						
15																						
16																						
17																						
18																						
19																						
20																						
22																						
24																						
26																						
28																						
30																						
32																						
34																						
36																						
38																						
40																						
44																						
48																						
52																						
56																						
60																						
64																						
68																						
72																						
76																						
80																						
84																						
88																						
92																						
96																						
/500																						
/530																						
/560																						
/600																						
/630																						
/670																						
/710																						
/750																						
/800																						
/850																						
/900																						
/950																						
/1000																						
/1060																						
/1120																						

Bearings with tapered bores are directly mounted onto tapered shafts or onto cylindrical shafts with adapters or withdrawal sleeves (Fig. 1).

Large bearings are often mounted using hydraulic pressure. Fig. 2 shows a bearing mounting utilizing a sleeve and hydraulic nut. Another mounting method is to drill holes in the sleeve which are used to feed oil under pressure to seat the bearing. As the bearing expands radially, the sleeve is inserted axially with adjusting bolts. The bearing should be mounted with a suitable interference fit by checking residual clearance while measuring their radial-clearance reduction and referring to the amount of axial movement listed in Table 1. Radial clearance must be measured using clearance

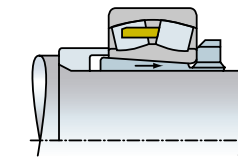


Fig. 1 Mounting with adapter

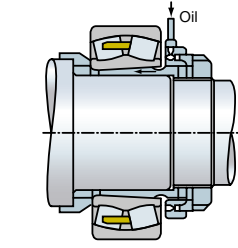


Fig. 2 Mounting with hydraulic nut

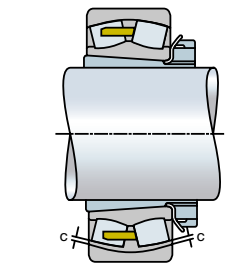


Fig. 3 Clearance measurement of spherical roller bearing

gauges. As shown in Fig 3, radial clearance for both rows of rollers must be measured simultaneously, and those two values should be kept roughly the same.

When a large bearing is mounted on a shaft, the outer ring may be deformed into an oval shape by its own weight. If radial clearance is measured at the lowest part of the deformed bearing, the measured value may be greater than the true value. If an incorrect radial internal clearance is obtained in this manner and the value in Table 1 are used, then the interference fit may become too tight and the true residual clearance may become too small. In this case, as shown in Fig. 4, one half of the total clearance at points a and b (which are on a horizontal line passing through the bearing center) and c (which is the lowest position of the bearing) may be used as the residual clearance.

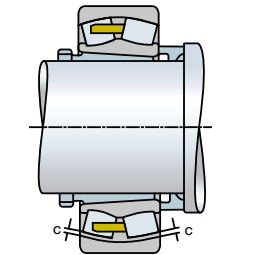
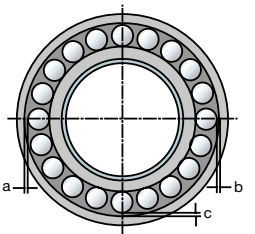


Fig. 4 Measuring clearance in large spherical roller bearing

Table 1 Radial Clearance in Spherical Roller Bearings with Tapered Bores

(Unit: mm)

Bearing bore diameter <i>d</i>	Clearance in bearings with tapered bores								Reduction in radial clearance		Axial movement				Minimum permissible residual clearance		
	CN		C3		C4		Taper 1:12				Taper 1:30		CN	C3	C4		
	over	incl	min	max	min	max	min	max	min	max	min	max					
30	40	0.035	0.050	0.050	0.065	0.065	0.085	0.025	0.030	0.40	0.45	—	—	0.010	0.025	0.035	
40	50	0.045	0.060	0.060	0.080	0.080	0.100	0.030	0.035	0.45	0.55	—	—	0.015	0.030	0.045	
50	65	0.055	0.075	0.075	0.095	0.095	0.120	0.030	0.035	0.45	0.55	—	—	0.025	0.035	0.060	
65	80	0.070	0.095	0.095	0.120	0.120	0.150	0.040	0.045	0.60	0.70	—	—	0.030	0.040	0.075	
80	100	0.080	0.110	0.110	0.140	0.140	0.180	0.045	0.055	0.70	0.85	1.75	2.15	0.035	0.050	0.085	
100	120	0.100	0.135	0.135	0.170	0.170	0.220	0.050	0.060	0.75	0.90	1.9	2.25	0.045	0.065	0.110	
120	140	0.120	0.160	0.160	0.200	0.200	0.260	0.060	0.070	0.90	1.1	2.25	2.75	0.055	0.080	0.130	
140	160	0.130	0.180	0.180	0.230	0.230	0.300	0.065	0.080	1.0	1.3	2.5	3.25	0.060	0.100	0.150	
160	180	0.140	0.200	0.200	0.260	0.260	0.340	0.070	0.090	1.1	1.4	2.75	3.5	0.070	0.110	0.170	
180	200	0.160	0.220	0.220	0.290	0.290	0.370	0.080	0.100	1.3	1.6	3.25	4.0	0.070	0.110	0.190	
200	225	0.180	0.250	0.250	0.320	0.320	0.410	0.090	0.110	1.4	1.7	3.5	4.25	0.080	0.130	0.210	
225	250	0.200	0.270	0.270	0.350	0.350	0.450	0.100	0.120	1.6	1.9	4.0	4.75	0.090	0.140	0.230	
250	280	0.220	0.300	0.300	0.390	0.390	0.490	0.110	0.140	1.7	2.2	4.25	5.5	0.100	0.150	0.250	
280	315	0.240	0.330	0.330	0.430	0.430	0.540	0.120	0.150	1.9	2.4	4.75	6.0	0.110	0.160	0.280	
315	355	0.270	0.360	0.360	0.470	0.470	0.590	0.140	0.170	2.2	2.7	5.5	6.75	0.120	0.180	0.300	
355	400	0.300	0.400	0.400	0.520	0.520	0.650	0.150	0.190	2.4	3.0	6.0	7.5	0.130	0.200	0.330	
400	450	0.330	0.440	0.440	0.570	0.570	0.720	0.170	0.210	2.7	3.3	6.75	8.25	0.140	0.220	0.360	
450	500	0.370	0.490	0.490	0.630	0.630	0.790	0.190	0.240	3.0	3.7	7.5	9.25	0.160	0.240	0.390	
500	560	0.410	0.540	0.540	0.680	0.680	0.870	0.210	0.270	3.4	4.3	8.5	11.0	0.170	0.270	0.410	
560	630	0.460	0.600	0.600	0.760	0.760	0.980	0.230	0.300	3.7	4.8	9.25	12.0	0.200	0.310	0.460	
630	710	0.510	0.670	0.670	0.850	0.850	1.090	0.260	0.330	4.2	5.3	10.5	13.0	0.220	0.330	0.520	
710	800	0.570	0.750	0.750	0.960	0.960	1.220	0.280	0.370	4.5	5.9	11.5	15.0	0.240	0.390	0.590	
800	900	0.640	0.840	0.840	1.070	1.070	1.370	0.310	0.410	5.0	6.6	12.5	16.5	0.280	0.430	0.660	
900	1 000	0.710	0.930	0.930	1.190	1.190	1.520	0.340	0.460	5.5	7.4	14.0	18.5	0.310	0.470	0.730	
1 000	1 120	0.770	1.030	1.030	1.300	1.300	1.670	0.370	0.500	5.9	8.0	15.0	20.0	0.360	0.530	0.800	

Bearing Maintenance and Inspection

Maintenance

Bearings and operating conditions must be periodically inspected and maintained to maximize bearing life to prevent mechanical failure, ensure reliable operation, raise productivity, and enhance cost performance.

Maintenance should be performed regularly according to work standards that may vary according to machine operating conditions. Operating conditions should be monitored, lubricant replenished or changed, and the machine periodically disassembled and overhauled.

1. Inspection under operating conditions

Review lubricant properties, check operating temperatures, and inspect for any vibrations and bearing noise to determine bearing replacement periods and replenishment intervals of the lubricant.

2. Inspection of the bearing

Be sure to thoroughly examine the bearings during periodic machine inspections and part replacement. Check the raceway for any damage and confirm if the bearing can be reused or should be replaced.

Inspection points

Items to be checked while the machine is running should include bearing noise, vibrations, temperature, and lubricant condition.

1. Bearing noise

Sound detection instruments can be used during operation to ascertain the volume and characteristics of bearing rotation noise through sound patterns that are readily distinguishable, which can reveal the presence of bearing damage such as slight flaking. Three typical noise conditions are described in Table 1.

2. Bearing vibration

Bearing irregularities can be analyzed by performing a quantitative analysis of vibration amplitude and frequency using a frequency spectrum analyzer. Measured data varies depending on the operating conditions of the bearing and the location of the vibration pick-up. Therefore, this method requires the determination of evaluation standards for each measured machine.

Table 1 Bearing irregularity causes and countermeasures

Irregularities		Possible causes	Countermeasures
Noise	Loud metallic sound	Abnormal load	Improve the fit, internal clearance, preload, or position of housing shoulder.
		Incorrect mounting	Improve machining accuracy, alignment accuracy or mounting accuracy of shaft and housing, or use the correct mounting method.
		Insufficient or improper lubricant	Replenish the lubricant or select another lubricant.
		Contact of rotating parts	Modify the labyrinth seal.
	Loud regular sound	Flaws, corrosion, or scratches on raceways caused by foreign particles	Replace or clean the bearing, improve sealing conditions, or use clean lubricant.
		Brinelling	Replace the bearing and use care when handling.
		Flaking on raceway	Replace the bearing.
	Irregular sound	Excessive clearance	Improve the fit, clearance, or preload.
		Contamination by foreign particles	Replace or clean the bearing, improve the seals, and use clean lubricant.
Flaws or flaking on balls		Replace the bearing.	
Abnormal temperature rise	Excessively small clearance	Improve the fit, clearance, or preload.	
	Excessive amount of lubricant	Reduce amount of lubricant and select stiffer grease.	
	Insufficient or improper lubricant	Replenish lubricant or select a proper one.	
	Abnormal load	Improve the fit, internal clearance, preload, or position of housing shoulder.	
	Incorrect mounting	Improve machining accuracy, alignment accuracy or mounting accuracy of shaft and housing, or use the correct mounting method.	
Vibration (Axial runout)	Creep on fitted surface, or excessive seal friction	Correct the seals, replace the bearing, and correct the fitting or mounting.	
	Brinelling	Replace the bearing, and use care when handling bearings.	
	Flaking	Replace the bearing.	
	Incorrect mounting	Correct the squareness between the shaft and housing shoulder or side of spacer.	
Leakage or discoloration of lubricant	Penetration of foreign particles	Replace or clean the bearing components and improve sealing.	
	Too much lubricant, or contamination by foreign particles or wear debris	Reduce the amount of lubricant. Select a stiffer grease. Replace the bearing or lubricant. Clean the housing and adjacent parts.	

Running Traces and Applied Loads

As the bearing rotates, the raceways of the inner ring and the outer ring make contact with the rolling elements. This results in a darkening of both the rolling elements and raceways. It is normal for the running trace to be marked on the raceway, and the extent and shape of this running trace provides a useful indication of loading conditions.

It is possible to determine from careful observation of the running traces whether the bearing is carrying a radial load,

a large axial load, or a moment load, or if there are extreme rigidity variations of the housing. Unexpected load applied to the bearing, excessive mounting error, or others can also be determined, providing a clue to the investigation of causes for bearing failure.

Typical running traces of deep groove ball bearings are shown in Fig. 1, and representative running traces of roller bearings are shown in Fig. 2.

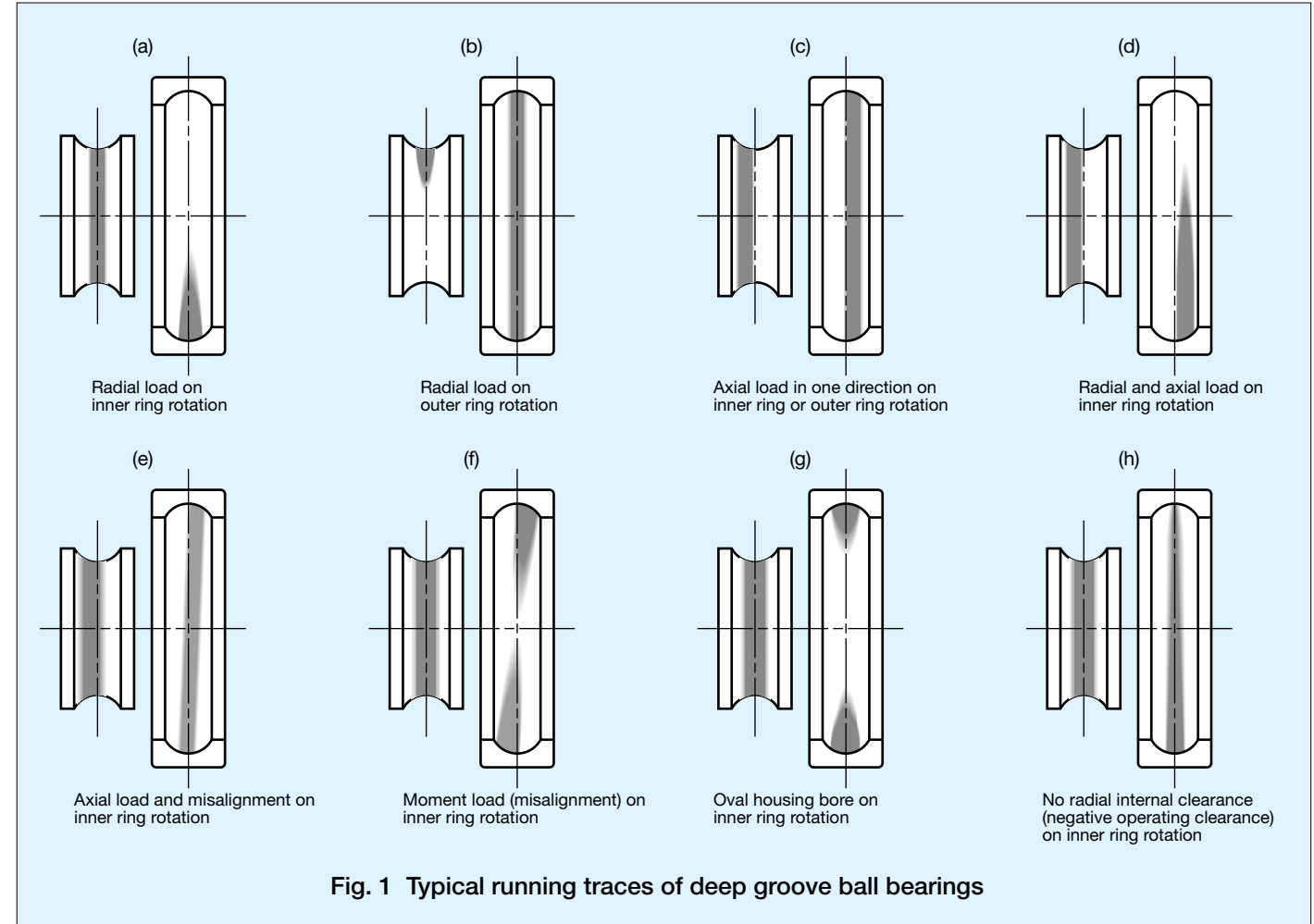


Fig. 1 Typical running traces of deep groove ball bearings

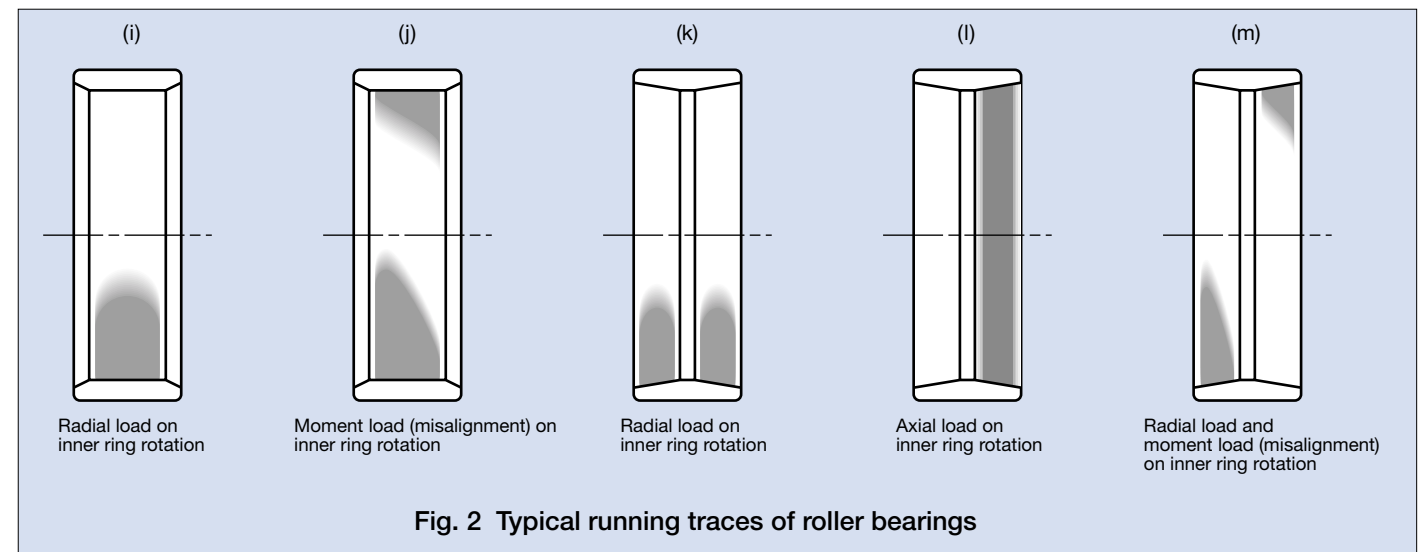


Fig. 2 Typical running traces of roller bearings

Examples of Bearing damage and countermeasures for papermaking machines



Creep

Bearing type	Application	Cause of damage	Countermeasures
Tapered Roller Bearing	Press CC roll	<ul style="list-style-type: none"> • Insufficient interference fit 	<ul style="list-style-type: none"> • Tighten interference fit
Spherical Roller Bearing	Dryer canvas roll	<ul style="list-style-type: none"> • Dimensional variation at high temperatures 	<ul style="list-style-type: none"> • Use TL steel • Use HPS bearing • Apply high-temperature dimensional stabilizing treatment (S11)



Inner ring fracture

Bearing type	Application	Cause of damage	Countermeasures
Spherical Roller Bearing	Dryer cylinder roll	<ul style="list-style-type: none"> • Excessive force applied during mounting • Defective bore face contact • High hoop stress 	<ul style="list-style-type: none"> • Control residual clearance • Adjust with taper gauge • Use TL steel



Rust and corrosion

Bearing type	Application	Cause of damage	Countermeasures
Spherical Roller Bearing	Wire suction roll	<ul style="list-style-type: none"> • Insufficient oil film formation due to water entry 	<ul style="list-style-type: none"> • Reinforce lubricating oil control • Improve bearing housing • Anti-rust treatment for idle periods
	Press suction roll	<ul style="list-style-type: none"> • Rust formed while stationary or being stored 	



Flaking

Bearing type	Application	Cause of damage	Countermeasures
Spherical Roller Bearing	Wire suction roll	<ul style="list-style-type: none"> • Insufficient oil film formation due to water entry 	<ul style="list-style-type: none"> • Reinforce lubricating oil control • Improve bearing housing
	Dryer cylinder roll	<ul style="list-style-type: none"> • Insufficient oil film formation at high temperatures 	<ul style="list-style-type: none"> • Use TL steel • Increase oil viscosity • Increase volume and reinforce control of lubricating oil temperature • Use thermal insulation sleeve
	Dryer canvas roll	<ul style="list-style-type: none"> • Excessive axial loading due to expansion of outer ring on the free-end bearing 	<ul style="list-style-type: none"> • Use TL steel • Use HPS bearing • Apply high temperature dimensional stabilizing treatment (S11)



Smearing

Bearing type	Application	Cause of damage	Countermeasures
Spherical Roller Bearing	Calender CC roll (triple ring)	<ul style="list-style-type: none"> • Insufficient oil film formation 	<ul style="list-style-type: none"> • Increase oil viscosity • Increase oil volume and reinforce control of lubricating oil temperature • Add additives to lubricating oil



Electrical corrosion

Bearing type	Application	Cause of damage	countermeasures
Deep Groove Ball Bearing Cylindrical Roller Bearing	Motor	<ul style="list-style-type: none"> • Sparks produced by flow of current where rolling elements contact the raceway 	<ul style="list-style-type: none"> • Design electric circuit which prevents current flow through the bearings • Insulate the bearing