MOTION & CONTROL™
NSK

POCKET GUIDE
MAINTENANCE OF BEARINGS

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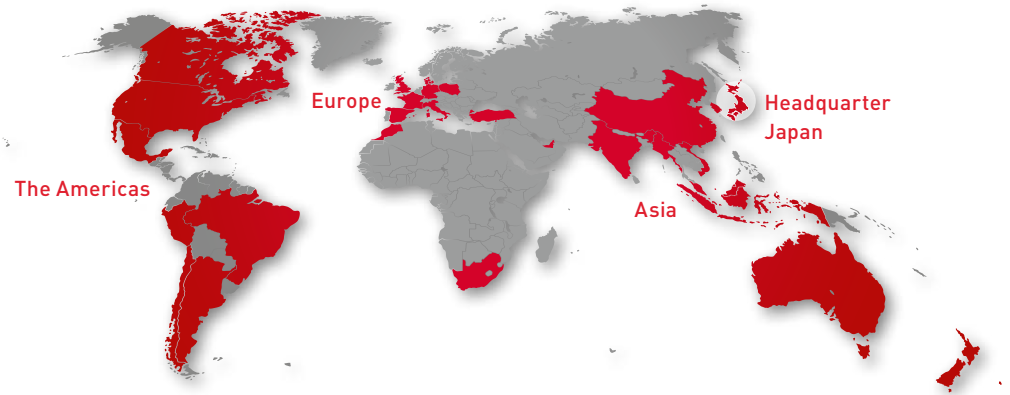
Content

Our most important product: Our customers' statisfaction

We are among the leading manufacturers for rolling bearings, linear technology components and steering systems worldwide. We can be found on almost every continent – with production facilities, sales offices and technology centres – because our customers appreciate short decision-making channels, prompt deliveries and local service.



The NSK Company

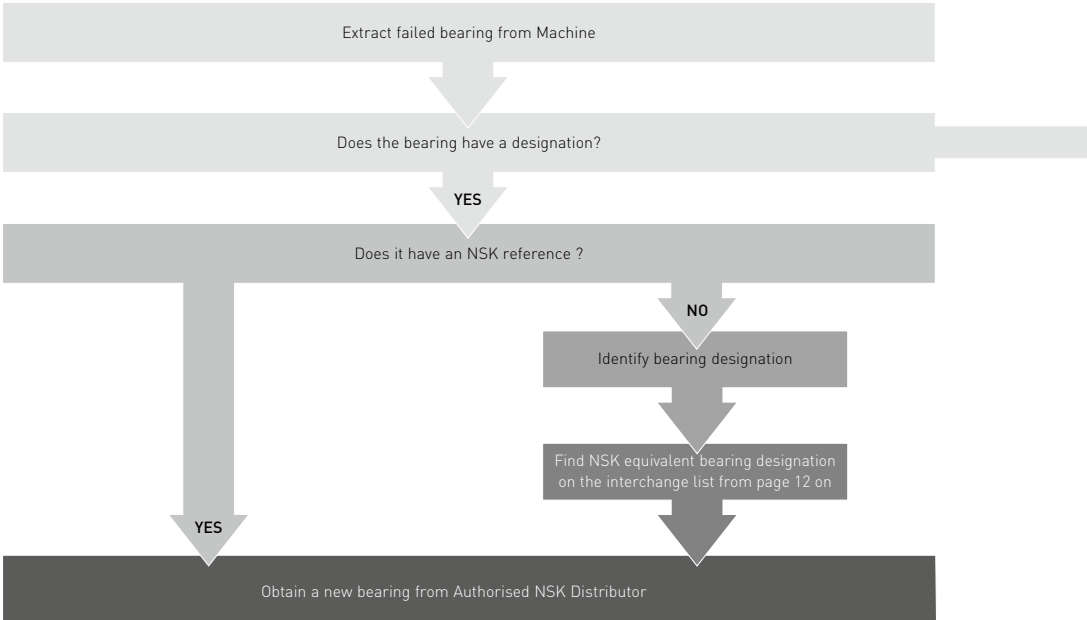
NSK commenced operations as the first Japanese manufacturer of rolling bearings back in 1916. Ever since, we have been continuously expanding and improving not only our product portfolio but also our range of services for various industrial sectors. In this context our worlwide research and production facilities are linked together in a global network. Here we concentrate not only on the development of new technologies, but also on the continuous optimisation of quality – at every process stage. Among other things, our research activities include product design, simulation applications using a variety of analytical systems and the development of different steels and lubricants for rolling bearings.

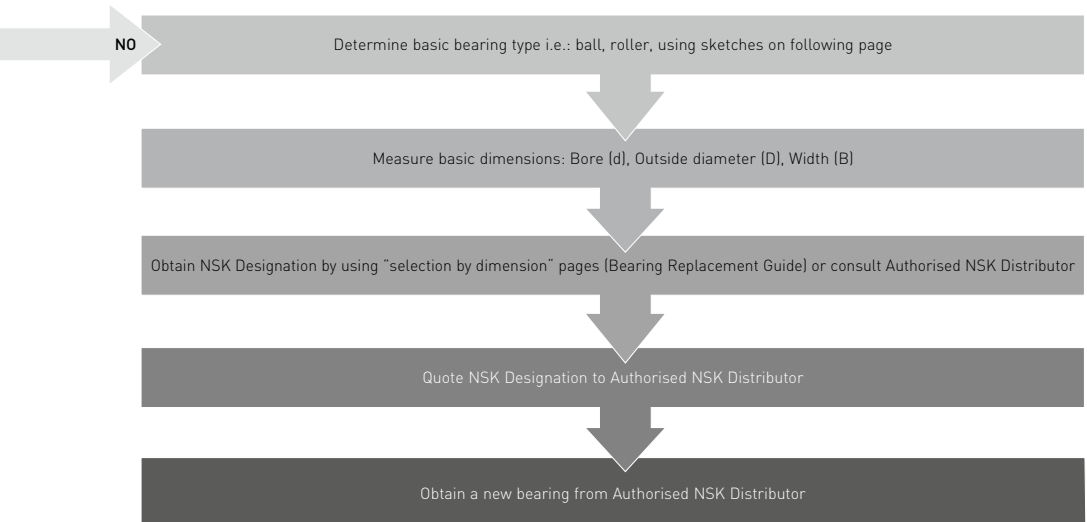
More about NSK under: www.nskeurope.com

General and maintenance dedicated section


NSK

How to order a replacement Bearing




NO
Determine basic bearing type i.e.: ball, roller, using sketches on following page
Measure basic dimensions: Bore (d), Outside diameter (D), Width (B)
Obtain NSK Designation by using "selection by dimension" pages (Bearing Replacement Guide) or consult Authorised NSK Distributor
Quote NSK Designation to Authorised NSK Distributor
Obtain a new bearing from Authorised NSK Distributor

Basic Bearing Types

	Single Row Deep Groove Ball Bearing
	Single Row Angular contact Ball Bearing
	Double Row Angular contact Ball Bearing
	Double Row Self-Aligning Ball Bearing
	Single Row Cylindrical Roller Bearing
	Double Row Spherical Roller Bearing
	Single Row Tapered Roller Bearing
	Single Row Thrust Ball Bearing

If the failed bearing is not on this page, please consult your Authorised NSK Distributor or NSK direct.

Standard Bearings – Interchange

Bearing Type	Manufacturer				
	FAG	SKF	SNR	NTN	NSK
Single row Deep Groove Ball Bearings | 600-6000-6200-6300-6400 Series					
1 or 2 shields	ZR/2ZR	Z/2Z	Z/ZZ	Z/ZZ	Z/ZZ
1 or 2 contact seals	RSR/2RSR	RS1/2RS1	E/EE	LU/LLU	DU/DDU
1 or 2 non contact seals	RSD/2RSD	RZ/2RZ		LB/LLB	V/VV
Groove without / with Snap ring	N/NR	N/NR	N/NR	N/NR	N/NR
Radial Internal Clearance (if different from normal CN clearance)	C2/C3 etc.	C2/C3 etc.	J20/J30 etc.	C2/C3 etc.	C2/C3 etc.
Double row Deep Groove Ball Bearings | 4200-4300 Series					
Polyamide Cage		TN9	Blank		TNG
Without Filling Slots		A	A		B
Radial Internal Clearance (if different from normal CN clearance)		C2/C3 etc.	J20/J30 etc.		C2/C3 etc.
Single row Angular Contact Ball Bearings (standard range) | 7000-7200-7300-7400 Series					
Contact Angle 40°	B	B	B	B	B
Extra Capacity		E			EA
Polyamide Cage	TVP	P	A	T2	T85
Steel Cage		J		J	W
Machined Brass Cage	MP	M	M	L1	Blank
Universal Mounting	UA / UO	CB/G	G	G	G, SU

Bearing Type	Manufacturer				
	FAG	SKF	SNR	NTN	NSK
Double row Angular Contact Ball Bearings | 3200-3300-5200-5300 Series					
Contact Angle 32° and 35° with Filling Slots	Blank	Blank	A	Blank	Blank
Contact Angle 25° and 32° without Filling Slots	B	A	B		B
Polyamide Cage	TVH/TVP	TN9	G15		TNG
Steel Cage	Blank	Blank	Blank	Blank	Blank
Machined Brass Cage	M/MA	M	M	Blank	
1 or 2 shields	ZR/2ZR	Z/2Z			Z/2Z
1 or 2 contact seals	RSR/2RSR	RS/2RS			RSR/2RSR
Radial Internal Clearance (if different from normal CN clearance)	C2/C3 etc.	C2/C3 etc.	J20/J30 etc.	C2/C3 etc.	C2/C3 etc.
Double row Self-Aligning Ball Bearings | 1200-1300-2200-2300-100-11200 | 11300-11500 Series					
Steel Cage		Blank	Blank	Blank	Blank
Polyamide Cage	TV	TN, TN9	G15	Blank	TNG
Machined Brass Cage	M	M	M	M	M
2 contact Seals	2RS	2RS1	EE		2RS
Extra Capacity		E			E
Radial Internal Clearance (if different from normal CN clearance)	C2/C3 etc.	C2/C3 etc.	J20/J30 etc.	C2/C3 etc.	C2/C3 etc.
Tapered Bore 1:12	K	K	K	K	K

Standard Bearings – Interchange

Bearing Type	Manufacturer				
	FAG	SKF	SNR	NTN	NSK
Ball Thrust Bearings, Single and Double Direction | 51100/200/300/400 - 52200/300/400 | 53200/300/400 - 54200/300/400 Series					
Steel Cage	Blank	Blank	Blank	Blank	Blank
Machined Brass Cage	M, MP	Blank		Blank	M
With Seat Washer	U	U		U	U
Duplex Contact Ball Bearings | QJ200 - QJ300 Series					
Polyamide Cage	TVP	TN, TN9			
Machined Brass Cage	MPA	Blank	MA	Blank	Blank
Radial Internal Clearance (if different from normal CN clearance)	C2/C3 etc.	C2/C3 etc.	J20/J30 etc.	C2/C3 etc.	C2/C3 etc.
Single row cylindrical Roller Bearings | N, NU, NUP, NJ / 200-300-400 | N, NU, NUP, NJ / 1000-2200-2300 Series					
Polyamide Cage	TVP2	P	G15	Blank	T, T7
Steel Cage	Blank	J	Blank	Blank	W
Machined Brass Cage	M, M1	M	M	Blank	M
Extra Capacity	E	EC	E	E	E
Radial Internal Clearance (if different from normal CN clearance)	C2/C3 etc.	C2/C3 etc.	J20/J30 etc.	C2/C3 etc.	C2/C3 etc.
Single row tapered Roller Bearings | 30200/300-31300-32000/200/300 | 33000/200 Series					
Steel Cage	Blank	Blank	Blank	Blank	Blank
Extra Capacity	Blank	Blank	A, V		prefix HR

Bearing Type	Manufacturer				
	FAG	SKF	SNR	NTN	NSK
Double row Spherical Roller Bearings | 21300-22200-22300-23000-23100 | 23200-23900-24000-24100 Series					
Polyamide Cage	TVPB				H
Steel Cage	Blank	Blank	A	J	C, CD, EA, J
Machined Brass Cage	M, MA, MB	ECA, ECAC	M, MB	L1	M, MB, CAM
Extra Capacity	E	E, Explorer	E	E	Blank, E
Radial Internal Clearance (if different from normal CN clearance)	C2/C3 etc.	C2/C3 etc.	J20/J30 etc.	C2/C3 etc.	C2/C3 etc.
Tapered Bore 1:12	K	K	K	K	K
Tapered Bore 1:30	K30	K30	K30	K30	K30
Lubrication groove & holes	Blank, S	W33	B33	D1	E4,W33
Heat Stabilized to 200°C	Blank	Blank	Blank	Blank	Blank, S11
Vibrating Equipment Applications	T41A	A15, VA405	F800, F801	UAVS1	U15VS, VB
Spherical Thrust Roller Bearings | 29300-29400 Series					
Steel Cage	Blank	Blank			E
Machined Brass Cage	MB	Blank		Blank	M
Extra Capacity	E	E			Blank

The list identifies the bearing series only. The user should check the relevant table to verify the characteristics and dimensions, and select the exact designation. The list is given in good faith, but no responsibility can be accepted for errors or omissions.

Mounted Units – Interchange

Mounted Units Type	Manufacturer							
	SKF	INA	NTN	ASAHI	SNR	NSK	RHP J-Line	RHP Self-Lube
	SY-TF / SYJ-TF	RASEY	UCP200	UCP200	UCPE/UCP	UCP200D1	UCP200D1	NP
			UCPX00	UCPX00		UCPX00D1		MP
	SY-WF / SYJ-WF	RASE	UELP200	UGP200	EXPE/EXP	UELP200D1	UELP200D1	NP-DEC
	SY-FM / SYJ-FM	PASE	AELP200	UHP200	ESPE/ESP			NP-EC
	SY-RM / SYJ-RM	PASEY	ASP200	BP200	USPE/USP			NP-A
	FY-TF / FYJ-TF	RCJY	UCF200	UCF200	UCFE/UCF	UCF200D1	UCF200D1	SF
			UCFX00	UCFX00		UCFX00D1		MSF
	FY-WF / FYJ-WF	RCJ	UELF200	UGF200	EXFE/EXF	UELF200D1	UELF200D1	SF-DEC
	FY-FM / FYJ-FM	PCJ	AELF200	UHF200	ESFE/ESF			SF-EC
	FY-RM / FYJ-RM	PCJY	ASF200	BF200	USFE/USF			SF-A
	FYTB-TF / FYTJ-TF	RCJTY	UCFL200	UCFL200	UCFLE/UCFL	UCFL200D1	UCFL200D1	SFT
			UCFLX00	UCFLX00		UCFLX00D1		MSFT
	FYTB-WF / FYTJ-TF	RCJT	UELFL200	UGFL200	EXFLE/EXFL	UEFL200D1	UELFL200D1	SFT-DEC
	FYTB-FM / FYTJ-FM	PCJT	AELFL200	UHFL200	ESFLE/ESFL			SFT-EC
	FYTB-RM / FYTJ-RM	PCJTY	ASFL200	BFL200	USFLE/USFL			SFT-A

Mounted Units Type	Manufacturer							
	SKF	INA	NTN	ASAHI	SNR	NSK	RHP J-Line	RHP Self-Lube
	FYC-TF	RMEY	UCFC200	UCFC200	UCFCE/ UCFC	UCFC200D1	UCFC200D1	FC
			UCFCX00	UCFCX00		UCFCX00D1		MFC
	FYC-WM	RME	UELFC200	UGFC200	EXFCE/EXFC	UELFC200D1	UELFC200D1	FC-DEC
	FYC-FM	PME	AELFC200	FHFC200	ESFCE/ESFC			FC-EC
	FYC-RM	PMEY	ASFC200	BFC200	USFCE/USFC			FC-A
		FLCTE	AELFD200	FHLCTE200	ESFD	AELFD200		LFTC-EC
			ASFD200	BLCTE200	USFD	ASFD200		LFTC-A
	SYF-TF / SYFJ-TF	RSHEY	UCUP200	UCPA200	UCPAE/UCPA	UCUP200D1	UCUP200D1	SNP
	SYF-WF / SYFJ-WF	RSHE			EXPAE/EXPA	UELUP200D1	UELUP200D1	SNP-DEC
	SYF-FM / SYFJ-FM	PSHE			ESPAE/ESPA			SNP-EC
	SYF-RM / SYFJ-RM	PSHEY			USPAE/USPA			SNP-A

Mounted Units – Interchange

Mounted Units Type	Manufacturer							
	SKF	INA	NTN	ASAHI	SNR	NSK	RHP J-Line	RHP Self-Lube
			UCFH200	UCFK200		UCFH200D1		
	TU-TF / TUJ-TF	RTUEY	UCT200	UCT200	UCT	UCT200D1	UCT200D1	ST
			UCTX00			UCTX00D1		MST
	TU-WF / TUJ-WF	RTUE	UELT200	UGT200	EXT	UELT200D1	UELT200D1	ST-DEC
	TU-FM / TUJ-FM	PTUE	AELT200	FHT200	EST			ST-EC
	TU-RM / TUJ-RM	PTUEY	AST200	BT200	UST			ST-A
		RHEY	UCHB200	UCEH200	UCEHE	UCHB200D1		SCH / SCHB
		RHE	UELHB200		EXEHE			SCH / SCHB-DEC
		PHE	AELHB200		ESEHE			SCH / SCHB-EC
		PHEY	ASHB200		USEHE			SCH / SCHB-A

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Mounted Units Type	Manufacturer							
	SKF	INA	NTN	ASAHI	SNR	NSK	RHP J-Line	RHP Self-Lube
	P-TF							LPB
	P-WF							LPB-DEC
	P-FM	PB	AELPP200	UHPP200	ESPP	AELPP200	AELPP200	LPB-EC
	P-RM	PBY	ASPP200	BPP200	USPP	ASPP200	ASPP200	LPB-A
	PF-TF	RRY						SLFE
	PF-WF	RR						SLFE-DEC
	PF-FM	RA	AELPF200	FHPF200	ESPF	AELPF200	AELPF200	SLFE-EC
	PF-RM	RAY	ASPF200	BPF200	USPF	ASPF200	ASPF200	SLFE-A
	PFT-TF	RRTY						SLFL
	PFT-WF	RRT						SLFL-DEC
	PFT-FM	RAT	AELPFL200	FHPFL200	ESPFL	AELPFL200	AELPFL200	SLFL-EC
	PFT-RM	RATY	ASPFL200	BPFL200	USPFL	ASPFL200	ASPFL200	SLFL-A
	PFD-TF							SLFT
	PFD-WF	RRTR						SLFT-DEC
	PFD-FM	RATR			ESPFT			SLFT-EC
	PFD-RM	RATRY			USPFT			SLFT-A

Mounted Units Inserts – Interchange

Bearing Type	Manufacturer							
	SKF	INA	NTN	ASAHI	SNR	NSK	RHP J-Line	RHP Self-Lube
	YAR-2F	GYE-KRRB	UC200	UC200	UC200			1000G
			UC200/LIII		UC200L3	UC200D1LLJ	UC200D1L3	T1000G
	YAR2-2RF					UC200D1	UC200D1	1000GFS
	YAT2	GAY-NPPB	AS200	B200	US200	AS200D1	AS200D1	1200G
	YEL2-2F	GE-KRRB	UEL200	UG200+ER	EX200			1000DECG
		GE-KPPB3			EX200L3	UEL200D1LLJ	UEL200D1L3	T1000DECG

Bearing Type	Manufacturer							
	SKF	INA	NTN	ASAHI	SNR	NSK	RHP J-Line	RHP Self-Lube
						UEL200D1W3	UEL200 D1	1000DECGFS
	YET2	GRAE-NPPB	AEL200	KH200+ER	ES200	AEL200D1W3	AEL200D1	1200ECG
	YSA2-2FK	GSH-RRB	UK200	UK200	UK200	UK200D1 +H2300	UK200D1 +H2300	1000-KG
	1726200-2RS	2-NPPB	CS200LLU	CS200ZZ		CS200LLU		1726200-2RS
			UC300	UC300	UC300	UC300 D1		

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Technical section


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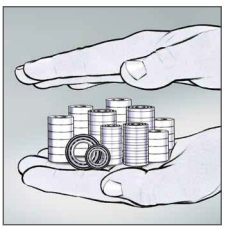
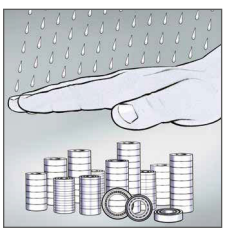
How to handle bearings

Rolling Bearings are high precision machine parts and need to be handled carefully.

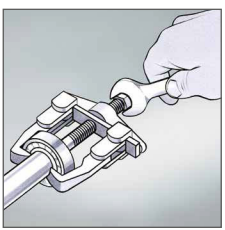
Keep Bearings And Surroundings Clean!



Handle With Care!



Protect Bearings From Corrosion!



Use Proper Tools!

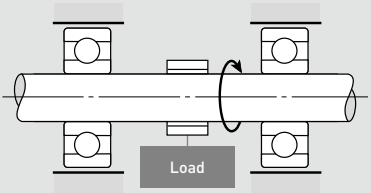
Importance of proper fits

In the case of a rolling bearing with the inner ring fitted to the shaft with insufficient interference, a harmful circumferential slipping may occur between the inner ring and shaft. This slipping of the inner ring, which is called „creep", results in a circumferential displacement of the ring relative to the shaft if the interference fit is not sufficiently tight. When creep occurs, the fitted surfaces become abraded, causing wear and considerable damage to the shaft.

It is important to prevent creep by having sufficient interference to firmly secure that ring which rotates to either shaft or housing. Creep cannot always be eliminated using only axial tightening throughout the bearing ring faces. Generally, it is not necessary, however, to provide interference for rings subjected only to stationary loads. Fits are sometimes made without any interference for either the inner or outer ring, to accommodate certain operating conditions, or to facilitate mounting and dismounting. In this case, to prevent damage to the fitting surfaces due to creep, lubrication or other applicable methods should be considered.

Loading conditions and fits

1



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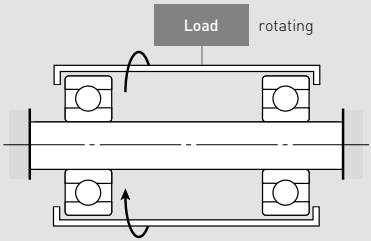

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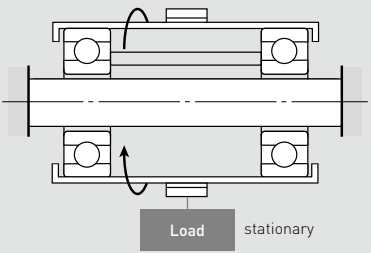

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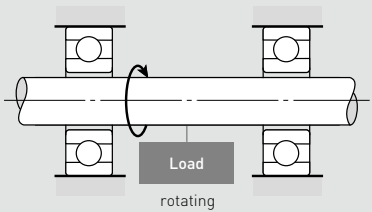


Load Application	Bearing Operation		Load Conditions	Fits	
	Inner Ring	Outer Ring		Inner Ring	Outer Ring
1. Load stationary	Rotating	Stationary	Rotating Inner Ring Load Stationary Outer Ring Load	Tight Fit	Loose Fit
2. Load rotating	Stationary	Rotating			
3. Load stationary	Stationary	Rotating	Rotating Outer Ring Load Stationary Inner Ring Load	Loose Fit	Tight Fit
4. Load rotating	Rotating	Stationary			
Direction of load indeterminate due to variation of direction or unbalanced load	Rotating or Stationary	Rotating or Stationary	Direction of Load Indeterminate	Tight Fit	Tight Fit

Fits between Radial Bearings and Housing Bores

Load Conditions			Examples	Tolerances for Housing Bores	Axial Displacement of Outer Ring	Remarks
Solid Housing	Rotating Outer Ring Load	Heavy loads on bearing in thin-walled housing or heavy shock loads	Automotive wheel hubs (Roller bearings), crane travelling wheels	P7	Impossible	–
		Normal or heavy loads	Automotive wheel hubs (Ball bearing), vibrating screens	N7		
		Light or variable loads	Conveyor rollers, rope sheaves, tension pulleys	M7		
	Direction of Load Indeter-minate	Heavy shock loads	Traction motors			
		Normal or heavy loads	Pumps, crankshaft, main bearings, medium and large motors	K7	Impossible	If axial displacement of the outer ring is not required
Solid or Split Housing		Normal or light loads		JS7 (J7)	Possible	Axial displacement of outer ring is necessary
	Rotating Inner Ring Load	Loads of all kinds	General bearing applications, railway axleboxes	H7	Easily Possible	–
		Normal or high loads	Plummer blocks	H8		
		High temperature rise of inner ring throug shaft	Paper dryers	G7		

Load Conditions			Examples	Tolerances for Housing Bores	Axial Displacement of Outer Ring	Remarks
Solid Housings	Rotating Inner Ring Load	Accurate running desirable under normal or light loads	Grinding spindle rear ball bearings, high-speed centrifugal compressor free bearings	JS6 (J6)	Possible	
	Direction of Load Indeter-minate		Grinding spindle front ball bearings, high-speed centrifugal compressor fixed bearings	K6	Impossible	For heavy loads, interference fit tighter than K is used. When high accuracy is required, very strict tolerances should be used for fitting
	Rotating Inner Ring Load	Accurate running and high rigidity desirable under variable loads	Cylindrical roller bearings for machine tool main spindle	M6 or N6	Impossible	
		Minimal noise is required	Electrical home appliances	H6	Easily Possible	–

Fits between Radial Bearings and Shafts

Load conditions		Examples
Radial Bearings with cylindrical bores		
Rotating Outer Ring Load	Easy axial displacement of inner ring on shaft desirable	Wheels on stationary axles
	Easy axial displacement of inner ring on shaft unnecessary	Tension pulleys rope sheaves
Rotating Inner Load or Direction of Load Indeterminate	Light loads or variable Loads (< 0.06 Cr)	Electrical home appliances, pumps, blowers, transport vehicles, precision machinery, machine tools
	Normal loads (0.06 to 0.13 Cr)	General bearing applications, medium and large motors, turbines, pumps, engine main bearings, gears, woodworking machine

Shaft Diameter (mm)			Tolerance of shaft	Remarks
Ball bearings	Cylindrical roller bearings, tapered roller bearings	Spherical roller bearings		
Radial Bearings with cylindrical bores				
All Shaft Diameters			g6	Use g5 and h5 where accuracy is required. In case of large bearings, f6 can be used to allow easy axial movement
			h6	
⩽18	–	–	js5	–
18~100	⩽40	–	js6 (j6)	
100~200	40~140	–	k6	
–	140~200	–	m6	
⩽18	–	–	js5-6 (j5-6)	k6 and m6 can be used for single-row tapered roller bearings and single-row angular contact ball bearings instead of k5 and m5
18~100	⩽40	⩽40	k5-6	
100~140	40~100	40~65	m5-6	
140~200	100~140	65~100	m6	
200~280	140~200	100~140	n6	
–	200~400	140~280	p6	
–	–	280~500	r6	
–	–	> 500	r7	

Fits between Radial Bearings and Shafts

<table>
<tr><th colspan="2">Load conditions</th><th>Examples</th></tr>
<tr><td colspan="3">Radial Bearings with cylindrical bores</td></tr>
<tr><td>Rotating Inner Load or Direction of Load Indeterminate</td><td>Heavy loads or shock loads (> 0.13 Cr)</td><td>Railway axleboxes, industrial vehicles, traction motors, construction, equipment, crushers</td></tr>
<tr><td colspan="3">Axial Loads Only</td></tr>
<tr><td colspan="3">Radial Bearings with tapered bores and sleeves</td></tr>
<tr><td colspan="2" rowspan="2">All Types of Loading</td><td>General bearing applications, railway axleboxes</td></tr>
<tr><td>Transmission shafts, woodworking spindles</td></tr>
</table>

Shaft Diameter (mm)			Tolerance of shaft	Remarks
Ball bearings	Cylindrical roller bearings, tapered roller bearings	Spherical roller bearings		
Radial Bearings with cylindrical bores				
–	50~140	50~100	n6	Radial internal clearance greater than CN is necessary.
–	140~200	100~140	p6	
–	> 200	140~200	r6	
–	–	200~500	r7	
All Shaft Diameters			js6 (J6)	–
Radial Bearings with tapered bores and sleeves				
All Shaft Diameters			h9/IT5	IT5 and IT7 mean that the deviation of the shaft from its true geometric from, e.g. roundnes and cylindricity should be within the tolerances of IT5 and IT7 respectively.
			h10/IT7	

Tolerances for Shaft Diameters

Diameter Classification (mm) over	incl.	Radial Bearing Bore Diameter (excluding tapered roller bearings)	d6	e6	f6	g5	g6	h5	h6	h7	h8	h9	h10	js5	js6
3	6	0 - 8	- 30 - 38	- 20 - 28	- 10 - 18	- 4 - 9	- 4 - 12	0 - 5	0 - 8	0 - 12	0 - 18	0 - 30	0 - 48	± 2.5	± 4
6	10	0 - 8	- 40 - 49	- 25 - 34	- 13 - 22	- 5 - 11	- 5 - 14	0 - 6	0 - 9	0 - 15	0 - 22	0 - 36	0 - 58	± 3	± 4.5
10	18	0 - 8	- 50 - 61	- 32 - 43	- 16 - 27	- 6 - 14	- 6 - 17	0 - 8	0 - 11	0 - 18	0 - 27	0 - 43	0 - 70	± 4	± 5.5
18	30	0 - 10	- 65 - 78	- 40 - 53	- 20 - 33	- 7 - 16	- 7 - 20	0 - 9	0 - 13	0 - 21	0 - 33	0 - 52	0 - 84	± 4.5	± 6.5
30	50	0 - 12	- 80 - 96	- 50 - 66	- 25 - 41	- 9 - 20	- 9 - 25	0 -11	0 - 16	0 - 25	0 - 39	0 - 62	0 -100	± 5.5	± 8
50	80	0 - 15	- 100 - 119	- 60 - 79	- 30 - 49	- 10 - 23	- 10 - 29	0 - 13	0 - 19	0 - 30	0 - 46	0 - 74	0 - 120	± 6.5	± 9.5
80	120	0 - 20	- 120 - 142	- 72 - 94	- 36 - 58	- 12 - 27	- 12 - 34	0 - 15	0 - 22	0 - 35	0 - 54	0 - 87	0 - 140	± 7.5	± 11

j5	j6	j7	k5	k6	k7	m5	m6	n6	p6	r6	r7	Diameter Classification (mm) over	Diameter Classification (mm) incl.
+ 3 - 2	+ 6 - 2	+ 8 - 4	+ 6 + 1	+ 9 + 1	+ 13 + 1	+ 9 + 4	+ 12 + 4	+ 16 + 8	+ 20 + 12	+ 23 + 15	+ 27 + 15	3	6
+ 4 - 2	+ 7 - 2	+ 10 - 5	+ 7 + 1	+ 10 + 1	+ 16 + 1	+ 12 + 6	+ 15 + 6	+ 19 + 10	+ 24 + 15	+ 28 + 19	+ 34 + 19	6	10
+ 5 - 3	+ 8 - 3	+ 12 - 6	+ 9 + 1	+ 12 + 1	+ 19 + 1	+ 15 + 7	+ 18 + 7	+ 23 + 12	+ 29 + 18	+ 34 + 23	+ 41 + 23	10	18
+ 5 - 4	+ 9 - 4	+ 13 - 8	+ 11 + 2	+ 15 + 2	+ 23 + 2	+ 17 + 8	+ 21 + 8	+ 28 + 15	+ 35 + 22	+ 41 + 28	+ 49 + 28	18	30
+ 6 - 5	+ 11 - 5	+ 15 - 10	+ 13 + 2	+ 18 + 2	+ 27 + 2	+ 20 + 9	+ 25 + 9	+ 33 + 17	+ 42 + 26	+ 50 + 34	+ 59 + 34	30	50
+ 6 - 7	+ 12 - 7	+ 18 - 12	+ 15 + 2	+ 21 + 2	+ 32 + 2	+ 24 + 11	+ 30 + 11	+ 39 + 20	+ 51 + 32	+ 60 + 41 + 62 + 43	+ 71 + 41 + 73 + 43	50	80
+ 6 - 9	+ 13 - 9	+ 20 - 15	+ 18 + 3	+ 25 + 3	+ 38 + 3	+ 28 + 13	+ 35 + 13	+ 45 + 23	+ 59 + 37	+ 73 + 51 + 76 + 54	+ 86 + 51 + 89 + 54	80	120

Tolerances for Shaft Diameters

Diameter Classification (mm) over	incl.	Radial Bearing Bore Diameter (excluding tapered roller bearings)	d6	e6	f6	g5	g6	h5	h6	h7	h8	h9	h10	js5	js6
120	180	0 - 25	- 145 - 170	- 85 - 110	- 43 - 68	- 14 - 32	- 14 - 39	0 - 18	0 - 25	0 - 40	0 - 63	0 - 100	0 - 160	± 9	± 12.5
180	250	0 - 30	- 170 - 199	- 100 - 129	- 50 - 79	- 15 - 35	- 15 - 44	0 - 20	0 - 29	0 - 46	0 - 72	0 - 115	0 - 185	± 10	± 14.5
250	315	0 - 35	- 190 - 222	- 110 - 142	- 56 - 88	- 17 - 40	- 17 - 49	0 - 23	0 - 32	0 - 52	0 - 81	0 - 130	0 - 210	± 11.5	± 16
315	400	0 - 40	- 210 - 246	- 125 - 161	- 62 - 98	- 18 - 43	- 18 - 54	0 - 25	0 - 36	0 - 57	0 - 89	0 - 140	0 - 230	± 12.5	± 18

j5	j6	j7	k5	k6	k7	m5	m6	n6	p6	r6	r7	Diameter Classification (mm) over	Diameter Classification (mm) incl.
+ 7 - 11	+ 14 - 11	+ 22 - 18	+ 21 + 3	+ 28 + 3	+ 43 + 3	+ 33 + 15	+ 40 + 15	+ 52 + 27	+ 68 + 43	+ 88 + 63	+ 103 + 63	120	140
										+ 90 + 65	+ 105 + 65	140	160
										+ 93 + 68	+ 108 + 68	160	180
+ 7 - 13	+ 16 - 13	+ 25 - 21	+ 24 + 4	+ 33 + 4	+ 50 + 4	+ 37 + 17	+ 46 + 17	+ 60 + 31	+ 79 + 50	+ 106 + 77	+ 123 + 77	180	200
										+ 109 + 80	+ 126 + 80	200	225
										+ 113 + 84	+ 130 + 84	225	250
+ 7 - 16	± 16	± 26	+ 27 + 4	+ 36 + 4	+ 56 + 4	+ 43 + 20	+ 52 + 20	+ 66 + 34	+ 88 + 56	+ 126 + 94	+ 146 + 94	250	280
										+ 130 + 98	+ 150 + 98	280	315
+ 7 - 18	± 18	+ 29 - 28	+ 29 + 4	+ 40 + 4	+ 61 + 4	+ 46 + 21	+ 57 + 21	+ 73 + 37	+ 98 + 62	+ 144 + 108	+ 165 + 108	315	355
										+ 150 + 114	+ 171 + 114	355	400

Tolerances for Housing Bore Diameters

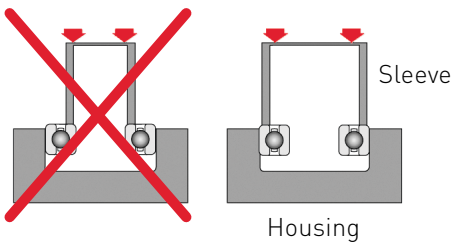
Diameter Classification (mm) over	incl.	Radial Bearing Outside Deviation (excluding tapered roller bearings)	E6	F6	F7	G6	G7	H6	H7	H8	J6	J7	JS6	JS7
10	18	0 - 8	+ 43 + 32	+ 27 + 16	+ 34 + 16	+ 17 + 6	+ 24 + 6	+ 11 0	+ 18 0	+ 27 0	+ 6 - 5	+ 10 - 8	± 5.5	± 9
18	30	0 - 9	+ 53 + 40	+ 33 + 20	+ 41 + 20	+ 20 + 7	+ 28 + 7	+ 13 0	+ 21 0	+ 33 0	+ 8 - 5	+ 12 - 9	± 6.5	± 10.5
30	50	0 - 11	+ 66 + 50	+ 41 + 25	+ 50 + 25	+ 25 + 9	+ 34 + 9	+ 16 0	+ 25 0	+ 39 0	+ 10 - 6	+ 14 - 11	± 8	± 12.5
50	80	0 - 13	+ 79 + 60	+ 49 + 30	+ 60 + 30	+ 29 + 10	+40 + 10	+ 19 0	+ 30 0	+ 46 0	+ 13 - 6	+ 18 - 12	± 9.5	± 15
80	120	0 - 15	+ 94 + 72	+ 58 + 36	+ 71 + 36	+ 34 + 12	+ 47 + 12	+ 22 0	+ 35 0	+ 54 0	+ 16 - 6	+ 22 - 13	± 11	± 17.5
120 150	150 180	0 18 - 0 - 25	+ 110 + 85	+ 68 + 43	+ 83 + 43	+ 39 + 14	+ 54 + 14	+ 25 0	+ 40 0	+ 63 0	+ 18 - 7	+ 26 - 14	± 12.5	± 20
180	250	0 - 30	+ 129 + 100	+ 79 + 50	+ 96 + 50	+ 44 + 15	+ 61 + 15	+ 29 0	+ 46 0	+ 72 0	+ 22 - 7	+ 30 - 16	± 14.5	± 23
250	315	0 - 35	+ 142 + 110	+ 88 + 56	+ 108 + 56	+ 49 + 17	+ 69 + 17	+ 32 0	+ 52 0	+ 81 0	+ 25 - 7	+ 36 - 16	± 16	± 26

K5	K6	K7	M5	M6	M7	N5	N6	N7	P6	P7	Diameter Classification (mm) over	Diameter Classification (mm) incl.
+ 2 - 6	+ 2 - 9	+ 6 - 12	- 4 - 12	- 4 - 15	0 - 18	- 9 - 17	- 9 - 20	- 5 - 23	- 15 - 26	- 11 - 29	10	18
+ 1 - 8	+ 2 - 11	+ 6 - 15	- 5 - 14	- 4 - 17	0 - 21	- 12 - 21	- 11 - 24	- 7 - 28	- 18 - 31	- 14 - 35	18	30
+ 2 - 9	+ 3 - 13	+ 7 - 18	- 5 - 16	- 4 - 20	0 - 25	- 13 - 24	- 12 - 28	- 8 - 33	- 21 - 37	- 17 - 42	30	50
+ 3 - 10	+ 4 - 15	+ 9 - 21	- 6 - 19	- 5 - 24	0 - 30	- 15 - 28	- 14 - 33	- 9 - 39	- 26 - 45	- 21 - 51	50	80
+ 2 - 13	+ 4 - 8	+ 10 - 25	- 8 - 23	- 6 - 28	0 - 35	- 18 - 33	- 16 - 38	- 10 - 45	- 30 - 52	- 24 - 59	80	120
+ 3 - 15	+ 4 - 21	+ 12 - 28	- 9 - 27	- 8 - 33	0 - 40	- 21 - 39	- 20 - 45	- 12 - 52	- 36 - 61	- 28 - 68	120	180
+ 2 - 18	+ 5 - 24	+ 13 - 33	- 11 - 31	- 8 - 37	0 - 46	- 25 - 45	- 22 - 51	- 14 - 60	- 41 - 70	- 33 - 79	180	250
+ 3 - 20	+ 5 - 27	+ 16 - 36	- 13 - 36	- 9 - 41	0 - 52	- 27 - 50	- 25 - 57	- 14 - 66	- 47 - 79	- 36 - 88	250	315

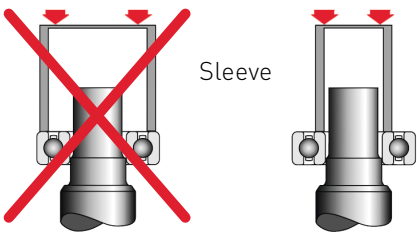
Mounting of Cylindrical Bore Bearings with interence fit

Bearing rings should not be subjected to direct impact – use a tubular drift or hydraulic press! Always apply the mounting force to the correct ring!

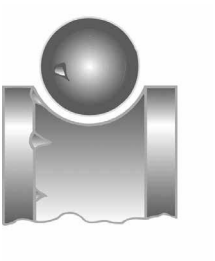
Fitting bearing into housing

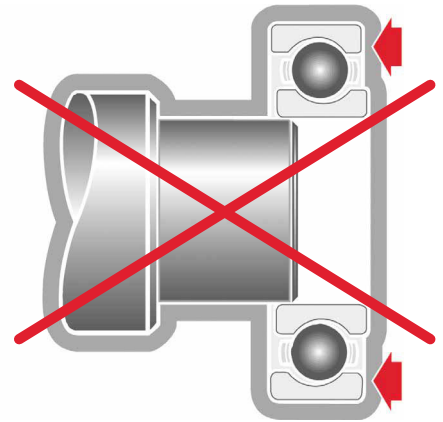


Fitting bearing to shaft



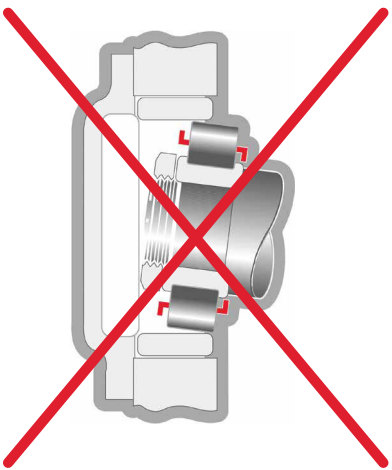
Damage can occur if the mounting force is applied to the incorrect ring during assembly. In particular, the balls or raceways may become indented, also known as "brinelling".



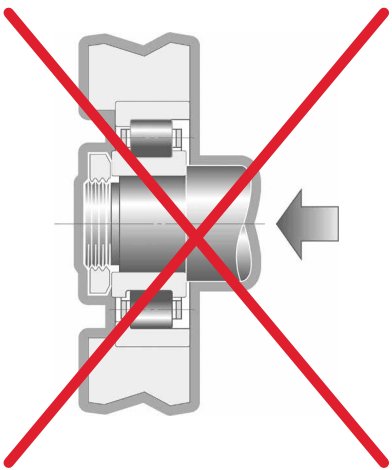


Mounting of Cylindrical Roller Bearings

Ensure that the bearing is correctly aligned to the shaft/housing.



Avoid shock loading on the inner/outer ring ribs.



Fractured rings, due to shock loading during fitting

Shrink fits

Shrink fitting is often used to avoid the large force involved in press fitting large bearings. For shrink fitting, the bearings are first heated in oil, or in an induction heater, to expand them, then mounted and allowed to cool. This amount of expansion of the inner ring for various temperature differences and bearing sizes are shown in Fig. 1.

Some precautions should be considered when using shrink fits:

- Do not heat bearings above 120 °C
- Put bearings on a wire netting or suspend them in the oil tank to prevent them from touching the tank bottom.
- Heat bearing to a temperature 20 to 30 °C higher than the lowest temperature required for mounting, because the inner ring will cool a little during mounting.

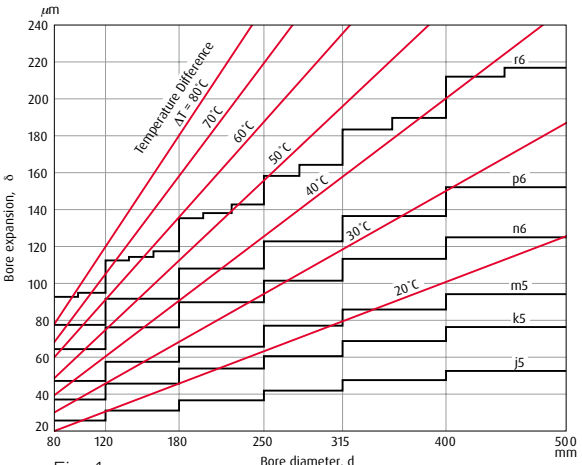
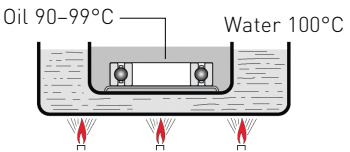


Fig. 1

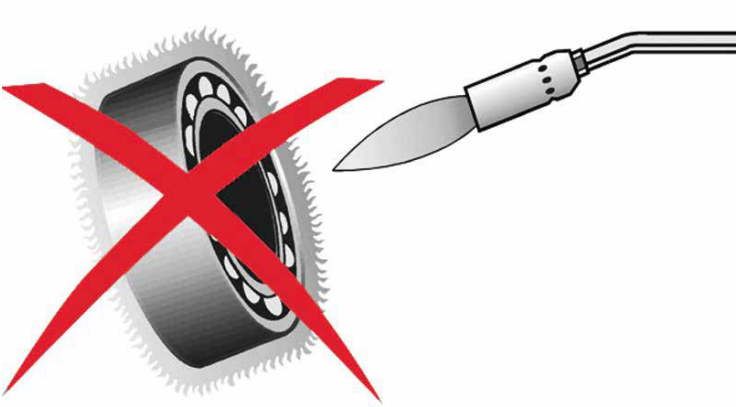
Heating bearing oil



Induction heater

Shrink fits

After mounting, the bearings will shrink in the axial direction as well as the radial direction while cooling. Therefore, while mounting, press the bearing firmly against the shaft shoulder to avoid excessive clearance between the bearing and the shoulder.



Mounting of Spherical Roller Bearings
on adapter sleeves

1. With bearing on bench check clearance using the feeler gauges over the top of the rollers at the top of the bearing as shown in Fig. 1 and note the clearance.

2. Before mounting, smear the thread and the side face of the nut with a molybdenum disulphide paste or similar lubricant.

3. Smear the shaft and outside diameter of sleeve with a light oil.

4. Open the sleeve slightly by inserting and twisting a screw driver into the slit in the sleeve and position the sleeve on the shaft.

5. Slide bearing, lockwasher and locknut onto sleeve and tighten nut with a 'C' spanner until all slackness is removed.

6. Further tighten the nut until the clearance has been reduced by the amount shown in the chart on pages 54/55 but when the bearing is mounted on the shaft the clearance should be checked under the rollers at the bottom of the bearing as shown in Fig. 2.

7. Check the clearance has not been reduced below the minimum permissible residual clearance shown in the chart on pages 54/55 for the size and clearance of bearing.

8. Align one tab on the lock washer with a slot in the locknut and bend it into the slot, if no tabs line up with the slots slightly tighten the locknut until one lines up. **Never back off the nut to line up the tab with the slot.**

9. Check the bearing rotates freely without any binding.

Mounting of Spherical Roller Bearings

on adapter sleeves

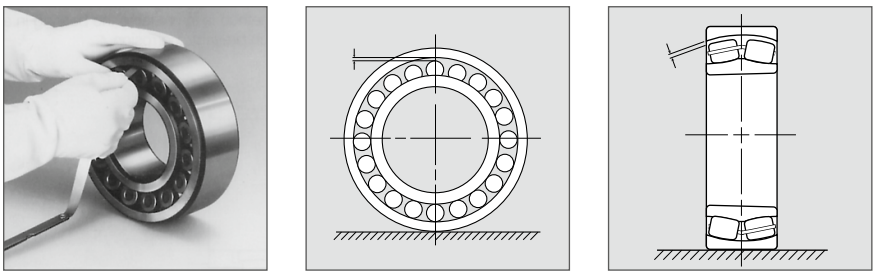


Fig. 1:
Checking bearing clearance with bearing on bench.

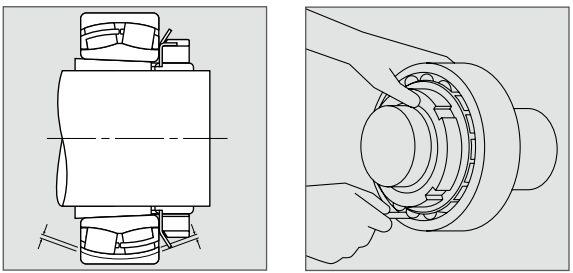


Fig. 2:
Checking bearing clearance with bearing mounted on shaft.

Mounting of Spherical Roller Bearings
on an adapter sleeve using the Axial Drive-Up Method

1. Before mounting, smear the thread and the side face of the nut with a molybdenum disulphide paste or similar lubricant.

2. Smear the shaft and outside diameter of sleeve with a light oil.

3. Open the sleeve slightly by inserting and twisting a screwdriver into the slit in the sleeve and position the sleeve on the shaft.

4. Slide bearing, lockwasher and locknut onto sleeve and tighten nut with a 'C' spanner until all slackness is removed.

5. Measure dimension 'X' as shown in Fig. 3.

6. Tighten the nut and **decrease** dimension 'X' by the amount of axial drive-up shown in the chart on pages 54/55 for the correct size of bearing.

7. Check bearing clearance as shown on pages 50/51 to ensure the clearance is not less than the minimum permissible residual clearance shown in the chart on pages 54/55 for the size and clearance of bearing.

8. Align one tab on the lock washer with a slot in the locknut and bend it into the slot, if no tabs line up with the slots slightly tighten the locknut until one lines up. **Never back off the nut to line up the tab with the slot.**

9. Check the bearing rotates freely without binding.

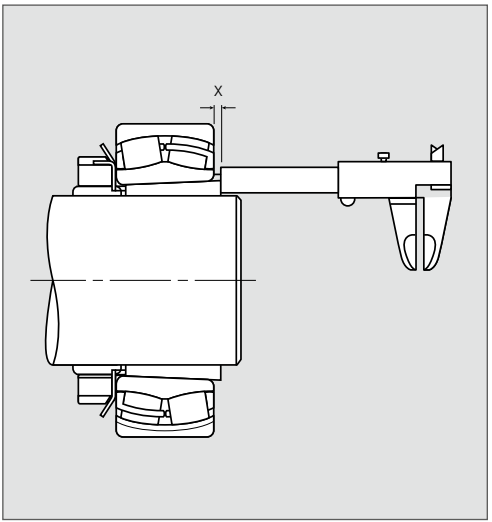


Fig. 3

Mounting of Spherical Roller Bearings

on an adapter sleeve (dimensions in mm) Taper 1:12

Bearing Bore Diameter mm		Initial Radial Internal Clearance						Reduction in Radial Clearance		Axial Drive-Up		Nominal tightening angle	Minimum Permissible Residual Clearance		
		CN		C3		C4									
over	incl.	min	max	min	max	min	max	min	max	min	max	nominal	CN	C3	C4
30	40	0.035	0.050	0.050	0.065	0.065	0.085	0.25	0.030	0.40	0.45	100°	0.010	0.25	0.035
40	50	0.045	0.060	0.060	0.080	0.080	0.100	0.030	0.035	0.45	0.55	120°	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	90°	0.025	0.035	0.060
65	80	0.070	0.095	0.095	0.120	0.120	0.150	0.040	0.040	0.60	0.70	120°	0.030	0.040	0.075
80	100	0.080	0.110	0.110	0.140	0.140	0.180	0.045	0.055	0.070	0.85	140°	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		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	1.10		0.055	0.080	0.130
140	160	0.130	0.180	0.180	0.230	0.230	0.300	0.065	0.080	1.00	1.30		0.060	0.100	0.150

Bearing Bore Diameter mm		Initial Radial Internal Clearance						Reduction in Radial Clearance		Axial Drive-Up		Nominal tightening angle	Minimum Permissible Residual Clearance		
		CN		C3		C4									
over	incl.	min	max	min	max	min	max	min	max	min	max	nominal	CN	C3	C4
160	180	0.140	0.200	0.200	0.260	0.260	0.340	0.070	0.090	1.10	1.40		0.070	0.110	0.170
180	200	0.160	0.220	0.220	0.290	0.290	0.370	0.080	0.100	1.30	1.60		0.070	0.110	0.190
200	225	0.180	0.250	0.250	0.320	0.320	0.410	0.090	0.110	1.40	1.70		0.080	0.130	0.210
225	250	0.200	0.270	0.270	0.350	0.350	0.450	0.100	0.120	1.60	1.90		0.090	0.140	0.230
250	280	0.220	0.300	0.300	0.390	0.390	0.490	0.110	0.140	1.70	2.20		0.100	0.150	0.250
280	315	0.240	0.330	0.330	0.430	0.430	0.540	0.120	0.150	1.90	2.40		0.110	0.160	0.280
315	355	0.270	0.360	0.360	0.470	0.470	0.590	0.140	0.170	2.20	2.70		0.120	0.180	0.300
355	400	0.300	0.400	0.400	0.520	0.520	0.650	0.150	0.190	2.40	3.00		0.130	0.200	0.330

Mounting of Self-Aligning Ball Bearings
on an adapter sleeve

Axial Drive-Up Method

1. Before mounting, smear the thread and the side face of the nut with a molybdenum disulphide paste or similar lubricant.

2. Smear the shaft and outside diameter of sleeve with a light oil.

3. Open the sleeve slightly by inserting and twisting a screw driver into the slit in the sleeve and position the sleeve on the shaft.

4. Slide bearing, lockwasher and locknut onto sleeve and tighten nut wit a 'C' spanner until all slackness is removed.

5. Measure distance from end tapered sleeve to the face of locknut or to the face of the inner ring and note the dimension.

6. From the chart note the required "axial drive up" and tighten the locknut until the bearing has moved the required distance up the taper of the sleeve indicated by the reduction or increase in the measured distance originally noted. If the original dimension was from the end of the tapered sleeve to the face of the locknut then the dimension will increase but if the measurement was from the end of the tapered sleeve to the face of the inner ring the dimension will be reduced.

7. A self-aligning ball bearing with normal clearance when adjusted correctly should rotate freely but should have some resistance to swivelling.

8. Align one tab on the lock washer with a slot in the locknut and bend it into the slot, if no tabs line up with the slots slightly tighten the locknut until one lines up. **Never back off the nut to line up the tab with the slot.**

Mounting of Self-Aligning Ball Bearings
on an adapter sleeve

Tightening Angle Method

1. Before mounting, smear the thread and the side face of the nut with a molybdenum disulphide paste or similar lubricant.

2. Smear the shaft and outside diameter of sleeve with a light oil.

3. Open the sleeve slightly by inserting and twisting a screw driver into the slit in the sleeve and position the sleeve on the shaft.

4. Slide bearing, lockwasher and locknut onto sleeve and tighten nut with a 'C' spanner until all slackness is removed.

5. Tighten locknut through the required angle α, taken from chart, and then reposition the 'C' spanner to 180° from its original position and give it a sharp tap with the hammer to straighten the bearing on its seating.

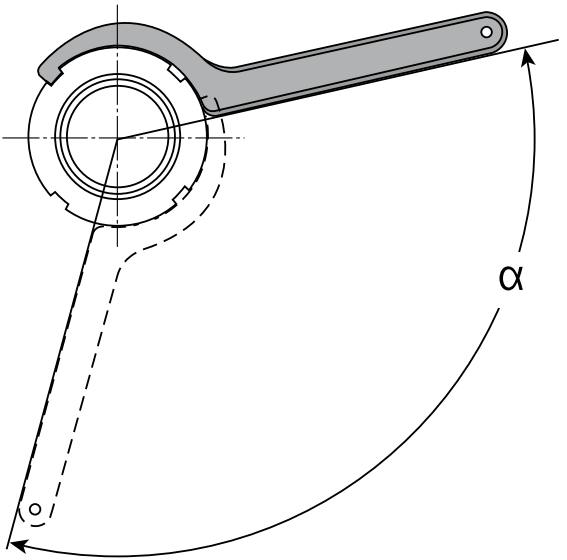
6. A self-aligning ball bearing with normal clearance when adjusted correctly should rotate freely but should have some resistance to swivelling.

7. Align one tab on the lock washer with a slot in the locknut and bend it into the slot, if no tabs line up with the slots slightly tighten the locknut until one lines up. **Never back off the nut to line up the tab with the slot.**

Mounting of Double Row Self-Aligning Ball Bearings

with 1:12 Tapered Bores on to adapter sleeves

Bearing Bore Diameter mm		Tightening Angle (α) degrees	Approximate Axial Drive-Up mm
over	inclusive		
24	30	70	0.22
30	40	70	0.30
40	50	70	0.30
50	65	90	0.40
65	80	90	0.45
80	100	90	0.45
100	120	120	0.55
120	140	120	0.65
140	160	120	0.75


α

Bearing Lubrication

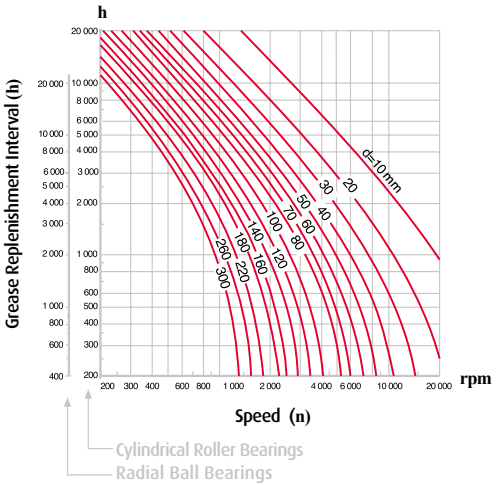
Grease quantity

The quantity of grease in a bearing depends on the application, rotational speed of the bearing, characteristics of the selected grease, and the ambient temperature conditions. These factors are critical to satisfactory performance.

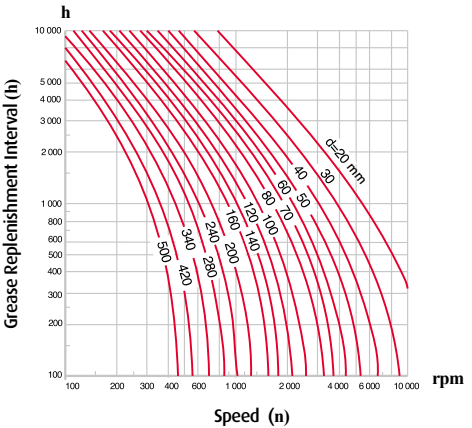
Quantity of grease for standard applications				Replenishment time interval (see graphs on following page)
Conditions	Quantity of Grease	Conditions	Quantity of Grease	Application Conditions
Speed is less than 50% of the bearing limiting speed	Between **1/3** & **2/3** of the free internal space	Speed is more than 50% of the bearing limiting speed	Between **1/3** & **1/2** of the free internal space	These graphs are applicable if the Bearing temperature is < 70°C. If the Bearing temperature exceeds 70°C, the replenishment time interval must be reduced by half for every 15°C temperature rise

Care should be taken to avoid excessive greasing as this will cause bearings to overheat.

Radial Ball Bearings / Cylindrical Roller Bearings



Tapered Roller Bearings / Spherical Roller Bearings



Bearing Doctor Section


12,5 x

Causes and countermeasures for operating irregularities

Irregularities		Possible Causes	Countermeasures
Noise	Loud Metallic Sound	Abnormal load	Correction of fit, internal clearance, preload, position of housing shoulder, etc.
		Incorrect mounting	Correction of alignment of shaft and housing, accuracy of mounting method
		Insufficient or improper lubricant	Replenish lubricant or select proper lubricant.
		Squeaking noise	Replacement by low-noise bearings, selection of small clearance bearings
		Sliding of balls	Adjustment of preload, selection of small clearance bearings, or adoption of softer grease
		Contact of rotating parts	Correction of labyrinth seal, etc.
	Loud Regular Sound	Flaws, corrosion, or scratches on the raceways	Replacement of bearing, cleaning, improvement of seals, and usage of clean lubricant
		Brinelling	Replacement of bearing and careful handling
		Flaking on the raceways	Replacement of bearing
	Irregular Sound	Excessive clearance	Correction of fit and clearance and correction of preload
		Penetration by foreign particles	Replacement of bearing, cleaning, improvement of seals, and relubrication using clean lubricant
		Flaws or flaking on the ball surfaces	Replacement of bearing
		Excessive amount of lubricant	Reduce amount of lubricant, select stiffer grease

Irregularities	Possible Causes	Countermeasures
Abnormal Temperature Rise	Insufficient or improper lubricant	Replenish lubricant or select proper lubricant
	Abnormal load	Correction of fit, internal clearance, preload, position of housing shoulder
	Incorrect mounting	Correction of alignment of shaft and housing, accuracy of mounting, or mounting method
	Creep of fitted surfaces, excessive seal friction	Correction of seals, replacement of bearing, correction of fit or mounting
Vibration	Brinelling	Replacement of bearings and careful handling
	Flaking	Replacement of bearing.
	Incorrect mounting	Correction of squareness between shaft and housing shoulder or side of spacer
	Penetration by foreign particles	Replacement of bearing, cleaning, correction of seals
Leakage or Discoloration of Lubricant	Too much lubrication. Penetration by foreign particles or abrasion chips	Reduce amount of lubricant, select stiffer grease Replace bearing or lubricant Clean housing and adjacent parts

Flaking

Location:
Inner ring of a spherical roller bearing
Symptom:
Flaking of only one raceway over its entire circumference
Cause:
excessive axial load
Countermeasure:
Reconfirm the bearing application and check the load conditions

Scoring

Location:
Rollers of a double-row cylindrical roller bearing

Symptom:
Scoring on the roller end face

Cause:
Poor lubrication and excessive axial load

Countermeasure:
Improve the lubricant and the lubrication method and check the load conditions

Smearing

Location:
Outer ring of a cylindrical roller bearing
Symptom:
Smearing occurs circumferentially on raceway surface
Cause:
Insufficient radial load, roller slipping due to excessive grease filling
Countermeasure:
Improve the bearing clearance, improve the lubrication method, check load condition

Fracture

Location:

Inner ring of a tapered roller bearing

Symptom:

Fracture occurs at the cone back face rib

Cause:

Large shock during mounting

Countermeasure:

Improve the mounting method (shrink fit, use of proper tools)

Cracks

Location:

Inner ring of a spherical roller bearing

Symptom:

Axial cracks occur on raceway surface

Cause:

Large fitting stress due to temperature difference between shaft and inner ring

Countermeasure:

Check the application and use NSK TL series bearings (special steel)

Cage damage

Location:

Cage of an angular contact ball bearing

Symptom:

Pocket pillar fractures in a cast iron machined cage

Cause:

Abnormal load action on cage due to misaligned mounting between inner and outer rings

Countermeasure:

Check the mounting method

Denting

Location:
Inner ring of a tapered roller bearing
Symptom:
Small and large indentations occur over entire raceway surface
Cause:
Debris caught in the surface
Countermeasure:
Improve the sealing mechanism, filter the lubricating oil

Pitting

Location:
Rolling element of a ball bearing
Symptom:
Pitting occurs on the rolling element surface
Cause:
Debris becomes caught in the lubricant
Countermeasure:
Improve the sealing mechanism, filter the lubricating oil

Fretting

Location:

Inner ring of a deep groove ball bearing

Symptom:

Fretting occurs on the bore surface

Cause:

Vibration

Countermeasure:

Check the interference fit

False brinelling

Location:

Inner ring of a deep groove ball bearing

Symptom:

False brinelling occurs on the raceway

Cause:

Vibration from an external source while stationary

Countermeasure:

Secure the shaft and housing during transport, reduce the vibration by preloading, use a suitable lubricant

Creep

Location:
Inner ring of a spherical roller bearing
Symptom:
Creep accompanied by scoring of bore surface
Cause:
Insufficient interference
Countermeasure:
Check the interference and prevent rotation

Seizure

Location:

Inner ring of a spherical roller bearing

Symptom:

Raceway is discolored and melted. Worn particles from the cage were rolled and attached to the raceway

Cause:

Insufficient lubrication

Countermeasure:

Check the lubricant and lubrication method

Electrical corrosion

Location:
Inner ring of a tapered roller bearing
Symptom:
Striped pattern of corrosion occurs on the raceway surface
Cause:
Electrical potential difference between inner and outer rings
Countermeasure:
Insulation of the bearing

Rust and corrosion

Location:

Inner ring of a spherical roller bearing

Symptom:

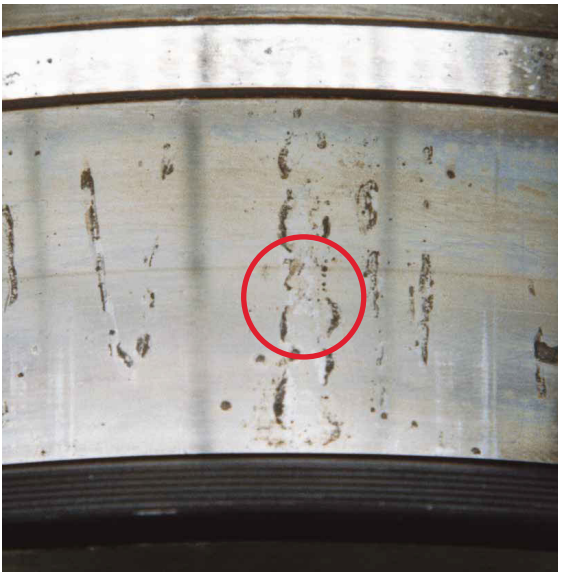
Rust on raceway surface at roller pitch

Cause:

Entry of water into lubricant

Countermeasure:

Improve the sealing mechanism



Mounting flaws

Location:
Inner ring of a cylindrical roller bearing
Symptom:
Axial scratches on raceway surface
Cause:
Inclination of inner and outer rings during mounting
Countermeasure:
Center the relative mating parts during mounting

Discoloration

Location:

Inner ring of a 4-point contact ball bearing

Symptom:

Bluish or purplish discoloration on raceway surface

Cause:

Heat generation due to poor lubrication

Countermeasure:

Improve the lubrication method

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