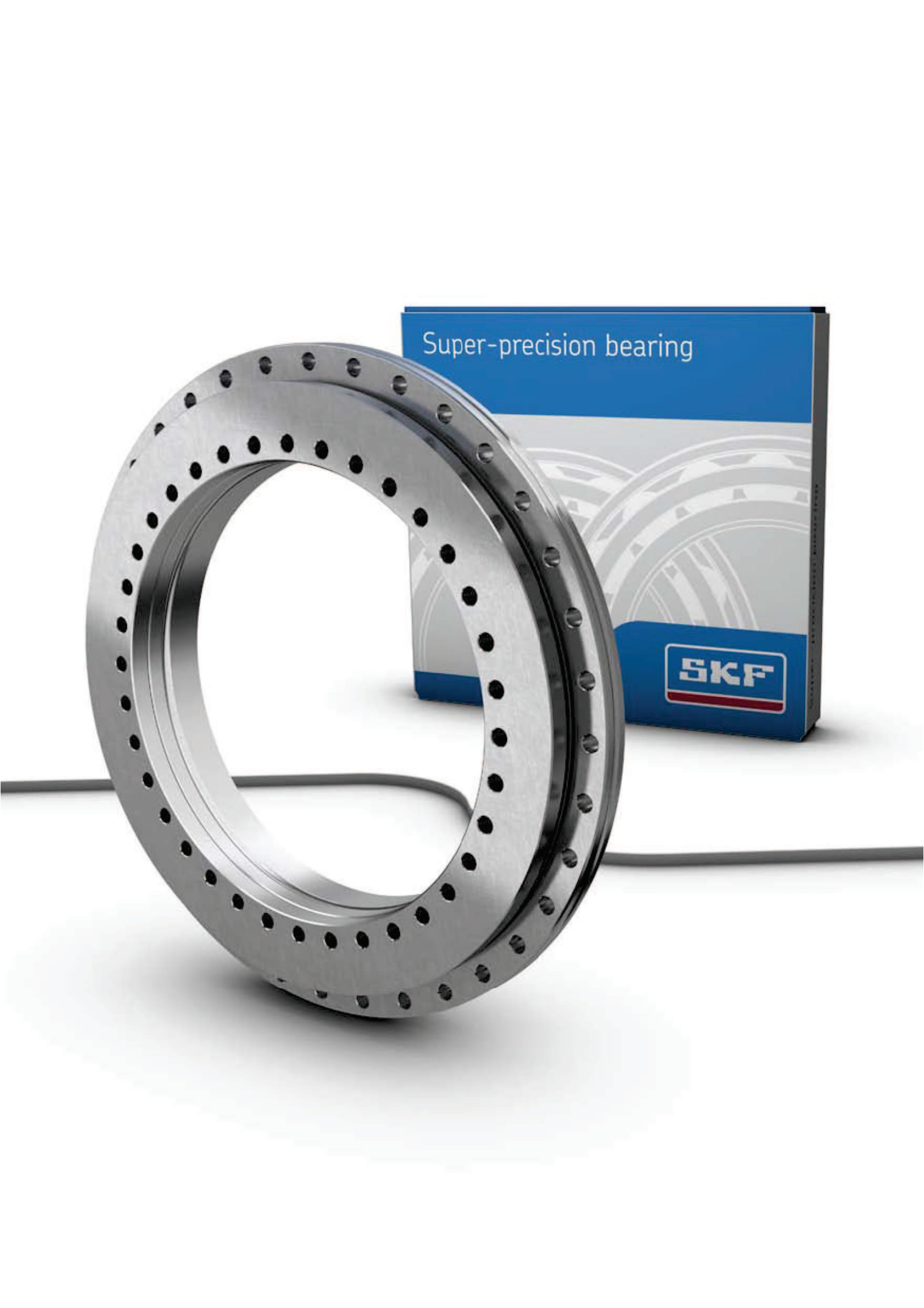
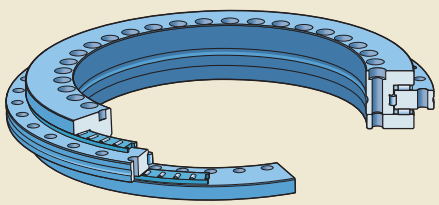

Super-precision bearing
SKF

Axial-radial cylindrical roller bearings

More information

Super-precision axial-radial cylindrical roller bearings are commonly used to support rotary tables, indexing heads and multi-spindle heads on machining centres. SKF manufactures super-precision axial-radial cylindrical roller bearings for shaft diameters from 80 to 850 mm. Their internal design, together with close tolerance manufacturing processes, enables these bearings to attain radial run-out better than, and axial run-out close to, P4 tolerance class.

Fig. 1



Designs and variants

Axial-radial cylindrical roller bearings can accommodate radial loads, axial loads in both directions and moment loads, whether acting singly, or simultaneously, in any combination.

These bearings consist of (→ **fig. 1**):

- Two roller and cage thrust assemblies and a full complement radial roller set.
- An inner ring which has an L-shaped cross section and two raceways. One raceway accommodates the roller and cage thrust assembly and the other accommodates the full complement radial roller set. The inner ring is drilled for attachment bolts.
- A loose flange which acts as a raceway to accommodate the second roller and cage thrust assembly. The flange is held in place to the inner ring with transport bolts that should not be removed until after the bearing has been mounted. The flange is drilled for attachment bolts.
- An outer ring which has three raceways to accommodate both roller and cage thrust assemblies and the full complement radial roller set.

The bearings are supplied standard without grease (no designation suffix) but can also be supplied greased (designation suffix G).

Bearings supplied without grease must be adequately lubricated with either grease or oil through the lubrication holes in the bearing rings. Bearings, greased at the factory, are filled with a grease that is suitable for most applications over the normal speed range for the bearing.

Bearing data

Boundary dimensions	Not standardized
Tolerances For additional information (→ **page 47**)	• manufactured to the tolerances listed in **table 1** • improved radial and axial run-out (50% tighter) on request

Table 1

Tolerances for axial-radial cylindrical roller bearings

Inner ring

d		Δ_{ds}		V_{dp}	V_{dmp}	Δ_{Hs}		Δ_{H1s}		K_{ia}	S_i
over	incl.	high	low	max.	max.	high	low	high	low	max.	max.
mm		µm		µm	µm	µm		µm		µm	µm
50	**80**	0	–9	5	3,5	0	–175	25	–25	3	3
80	**120**	0	–10	6	4	0	–175	25	–25	3	3
120	**150**	0	–13	8	5	0	–175	30	–30	3	3
150	**180**	0	–13	8	5	0	–175	30	–30	4	4
180	**250**	0	–15	9	6	0	–200	30	–30	4	4
250	**315**	0	–18	11	8	0	–400	40	–40	6	6
315	**400**	0	–23	14	10	0	–400	50	–50	6	6
400	**500**	0	–27	17	12	0	–450	60	–60	6	6
500	**630**	0	–33	20	14	0	–500	75	–75	10	10
630	**800**	0	–40	24	16	0	–700	100	–100	10	10
800	**1 000**	0	–50	30	20	0	–850	120	–120	12	12

Outer ring

D		Δ_{Ds}		V_{Dp}	V_{Dmp}		K_{ea}	S_e
over	incl.	high	low	max.	max.		max.	max.
mm		µm		µm	µm			
120	**150**	0	–11	7	5	Values are identical to those for inner ring of the same bearing.		
150	**180**	0	–13	8	5			
180	**250**	0	–15	8	6			
250	**315**	0	–18	10	7			
315	**400**	0	–20	11	8			
400	**500**	0	–23	14	9			
500	**630**	0	–28	17	11			
630	**800**	0	–35	20	13			
800	**1 000**	0	–45	26	17			
1 000	**1 250**	0	–55	34	20			

Tolerance symbols and definitions → **table 4**, **page 48**

Preload and stiffness

Due to the large number of cylindrical rollers in each of the rows, with line contact between them and the raceways, there is a minimal amount of elastic deformation in the bearing under load from any direction.

To provide maximum stiffness the rollers are calibrated during assembly so that a preload is achieved in each row once mounting is complete. Appropriate preload extends bearing service life, improves rigidity and running accuracy, while reducing noise levels.

As a result of the closely controlled preload, stiffness in any direction can be considered constant.

In cases where a heavy axial load acts on an axial-radial cylindrical roller bearing, the loaded roller set can deflect and reduce the preload on the second thrust roller set. In severe cases, the second thrust roller set can become completely unloaded, which can cause the rollers to skid and damage the raceways or subject the cage to impermissible stresses. For additional information, contact the SKF application engineering service.

Preload for the thrust roller sets and stiffness values, together with the axial unloading force, are listed in **table 2**. They are valid for bearings mounted properly and attachment bolts tightened to the recommended torque values (→ **table 7**, **page 332**).

Friction

The frictional losses in axial-radial cylindrical roller bearings, as with other rolling bearings, depend on different factors. For general information, refer to *Friction* (→ **page 37**).

The values for the frictional moment listed in **table 3** were measured in functional tests and are average values. They should be used as guideline values only. The tests were conducted under the following operating conditions:

- lubrication: grease, kinematic viscosity 150 mm^2/s at 40 °C *(105 °F)*
- rotational speed: 5 r/min
- ambient temperature: 30 to 40 °C *(85 to 105 °F)*
- attachment bolts tightened to the recommended torque values (→ **table 7**, **page 332**)

Table 2

Preload and stiffness

Bearing	Axial preload[1]	Axial unloading force[1]	Axial stiffness[2]	Radial stiffness[2]	Moment stiffness[2]
–	kN	kN	kN/µm	kN/µm	kNm/mrad
NRT 80 A	1,3	2,8	4,9	3,1	7
NRT 100 A	1,7	3,8	7,2	3,7	15
NRT 120 A	1,9	4,3	8,1	4,5	22
NRT 150 A	2,2	4,8	9	5,5	35
NRT 180 A	2,5	5,5	10,3	5,8	53
NRT 200 A	2,8	6,2	11,6	6,5	73
NRT 260 A	7,2	16	14,5	8,3	150
NRT 325 A	12	26	28,6	8,9	413
NRT 395 A	14	30	33,6	10,6	672
NRT 460 A	16	34	38,5	12,1	1 036
NRT 580 A	25	55	43,5	18,6	1 838
NRT 650 A	27	59	60	17,2	3 209
NRT 850 A	47	103	77	22,4	7 011

[1] These values are averages.
[2] Stiffness values refer to the roller set.

Table 3

Frictional moment

Bearing	Frictional moment C_{RL}
–	Nm
NRT 80 A	3
NRT 100 A	3
NRT 120 A	6
NRT 150 A	12
NRT 180 A	13
NRT 200 A	14
NRT 260 A	25
NRT 325 A	45
NRT 395 A	55
NRT 460 A	70
NRT 580 A	140
NRT 650 A	200
NRT 850 A	300

Guideline values only

Lubrication

The choice of whether to use grease or oil should be based on the speed and operating temperature of the application. Axial-radial cylindrical roller bearings are typically lubricated by an oil bath or circulating oil system. Grease is normally reserved for lower speed and lower temperature applications.

Grease or oil can be introduced into the bearing via the lubrication holes in the bearing rings. Note that if the bearing is over-lubricated, excessive frictional heat increases bearing operating temperature.

The technical specifications of the standard grease in greased axial-radial cylindrical roller bearings (designation suffix G) are listed in **table 4**.

To achieve the lowest frictional moment and temperature, axial-radial cylindrical roller bearings need to be properly run-in. A typical running-in procedure consists of rotating the bearing for one hour at different speed steps, starting from an initial value of ~ 15% of the maximum operating speed and increasing by steps of 10% each time. During running-in, the bearing operating temperature should not exceed 70 °C *(160 °F)*.

Table 4

Technical specifications of the standard grease in greased bearings (designation suffix G)

Properties	Grease specification
Thickener	Lithium complex soap
Base oil type	Mineral
NLGI consistency class	2
Temperature range [°C] *[°F]*	–30 to +140 *–20 to +285*
Kinematic viscosity [mm²/s] at 40 °C *(105 °F)* at 100 °C *(210 °F)*	185 15

Design considerations

Recommended shaft and housing fits

Shaft and housing seats for super-precision axial-radial cylindrical roller bearings should be manufactured to the following tolerance classes:

- h5Ⓔ for the shaft (→ **table 5**)
- J6Ⓔ for the housing bore (→ **table 6**, **page 326**)

Accuracy of seats and abutments

If a super-precision axial-radial cylindrical roller bearing is to obtain a high degree of running accuracy and low operating temperature, its associated components must be manufactured to similar levels of precision.

Recommendations for the geometrical tolerances and surface roughness are provided in:

- **table 5** for the shaft
- **table 6**, **page 326** for the housing

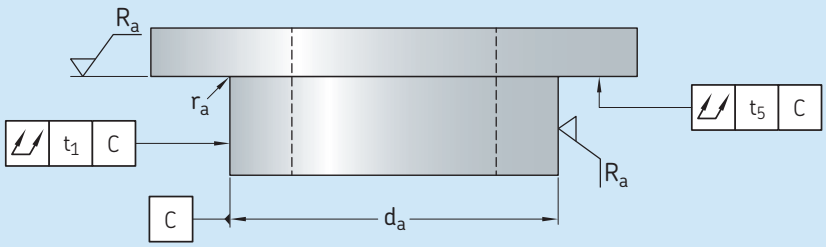
The recommended shaft and housing diameter tolerances, relative to the bearing bore and outside diameter tolerances result in a transition fit, tending towards clearance. In some cases, however, an interference fit may result for either the bearing inner or outer ring. When this occurs, preload on the radial roller set will increase, as will contact stresses, friction and frictional heat.

To optimize operating conditions and running accuracy in applications where there is inner ring rotation, the fit between the shaft and inner ring should be a loose fit that is as close to zero as possible. A near-zero loose fit should be applied to the outer ring and housing when the outer ring rotates.

To help obtain a near-zero loose fit on a shaft, SKF supplies axial-radial cylindrical roller bearings with an inspection report. The report includes the measured deviation from nominal of the inner ring bore diameter. It also includes the measured deviation from nominal of the bearing height and measured running accuracy.

Table 5

Geometrical accuracy for bearing shaft seats



Shaft diameter		Tolerance			Total radial run-out	Total axial run-out	Surface roughness
d_a over	incl.	h5Ⓔ high	low	r_a max.	t_1 max.	t_5 max.	R_a max.
mm		µm		mm	µm	µm	µm
50	**80**	0	–13	0,2	3	3	0,8
80	**120**	0	–15	0,2	4	4	0,8
120	**150**	0	–18	0,2	5	5	0,8
150	**180**	0	–18	0,2	5	5	0,8
180	**250**	0	–20	0,2	7	7	0,8
250	**315**	0	–23	0,5	8	8	0,8
315	**400**	0	–25	0,5	9	9	0,8
400	**500**	0	–27	0,9	10	10	0,8
500	**630**	0	–32	0,9	11	11	0,8
630	**800**	0	–36	1,3	13	13	0,8
800	**1 000**	0	–40	1,3	15	15	0,8

Surface roughness R_a in accordance with ISO 1302

5

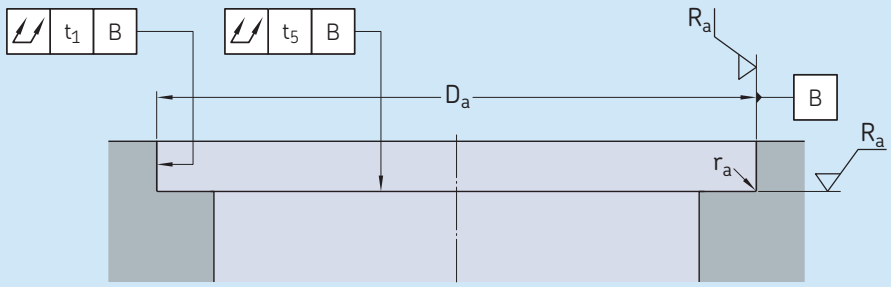
Attachment bolt holes

Axial-radial cylindrical roller bearings require threaded holes for attachment bolts in the shaft and housing. Details about spacing and thread sizes are listed in the product table (→ **page 334**). At the position of retaining bolts and removal threads, no attachment bolt holes are required.

Bearing NRT 80 A should be fixed with 12 attachment bolts each in the inner and outer ring. For this bearing, the retaining bolts and removal threads are positioned between the attachment bolt holes, evenly spaced at 120°.

Table 6

Geometrical accuracy for bearing housing seats



Housing diameter		Tolerance			Total radial run-out	Total axial run-out	Surface roughness
D_a over	incl.	J6Ⓔ high	low	r_a max.	t_1 max.	t_5 max.	R_a max.
mm		µm		mm	µm	µm	µm
120	**150**	18	–7	0,2	5	5	0,8
150	**180**	18	–7	0,5	5	5	0,8
180	**250**	22	–7	0,5	7	7	0,8
250	**315**	25	–7	0,5	8	8	0,8
315	**400**	29	–7	0,5	9	9	0,8
400	**500**	33	–7	0,5	10	10	0,8
500	**630**	34	–10	0,9	11	11	0,8
630	**800**	38	–12	0,9	13	13	0,8
800	**1 000**	44	–12	0,9	15	15	0,8
1 000	**1 250**	52	–14	1,3	18	18	0,8

Surface roughness R_a in accordance with ISO 1302

Load carrying capacity

Axial-radial cylindrical roller bearings can accommodate radial loads, axial loads in both directions and moment loads, whether acting singly, or simultaneously, in any combination. As the bearing is preloaded and normally used to support axial and radial loads acting offset from, or eccentrically to, the bearing axis, the evaluation of the equivalent bearing loads by manual methods can only be approximated. Equivalent bearing loads in the radial and axial directions should be calculated separately. From these, the life ratings can be calculated for each row of rollers. If a more accurate bearing load analysis and and calculation for rated life are required, contact the SKF application engineering service.

Basic load ratings are listed in the product table (→ **page 334**).

Equivalent bearing loads

The equivalent dynamic bearing load can be calculated:

- for the radial roller set using
  $P = F_r$
- for the thrust roller set using
  $P = F_a + 4{,}4\ M/d_1$

The equivalent static bearing load can be calculated:

- for the radial roller set using
  $P_0 = F_r$
- for the thrust roller set using
  $P_0 = F_a + 4{,}4\ M/d_1$

where
P = equivalent dynamic bearing load [kN]
P_0 = equivalent static bearing load [kN]
d_1 = outside diameter of inner ring [mm]
(→ **product table**, **page 334**)
F_a = axial load [kN]
F_r = radial load [kN]
M = moment load [kNmm]

Permissible moment load

Axial-radial cylindrical roller bearings generally rotate slowly, perform slow slewing movements, or are subjected to load when stationary. Under these conditions, the maximum permissible moment load is limited by the static load limit and can be determined using

$$M_{perm} = 0{,}23\ d_1\ (C_{0a}/s_0 - F_a)$$

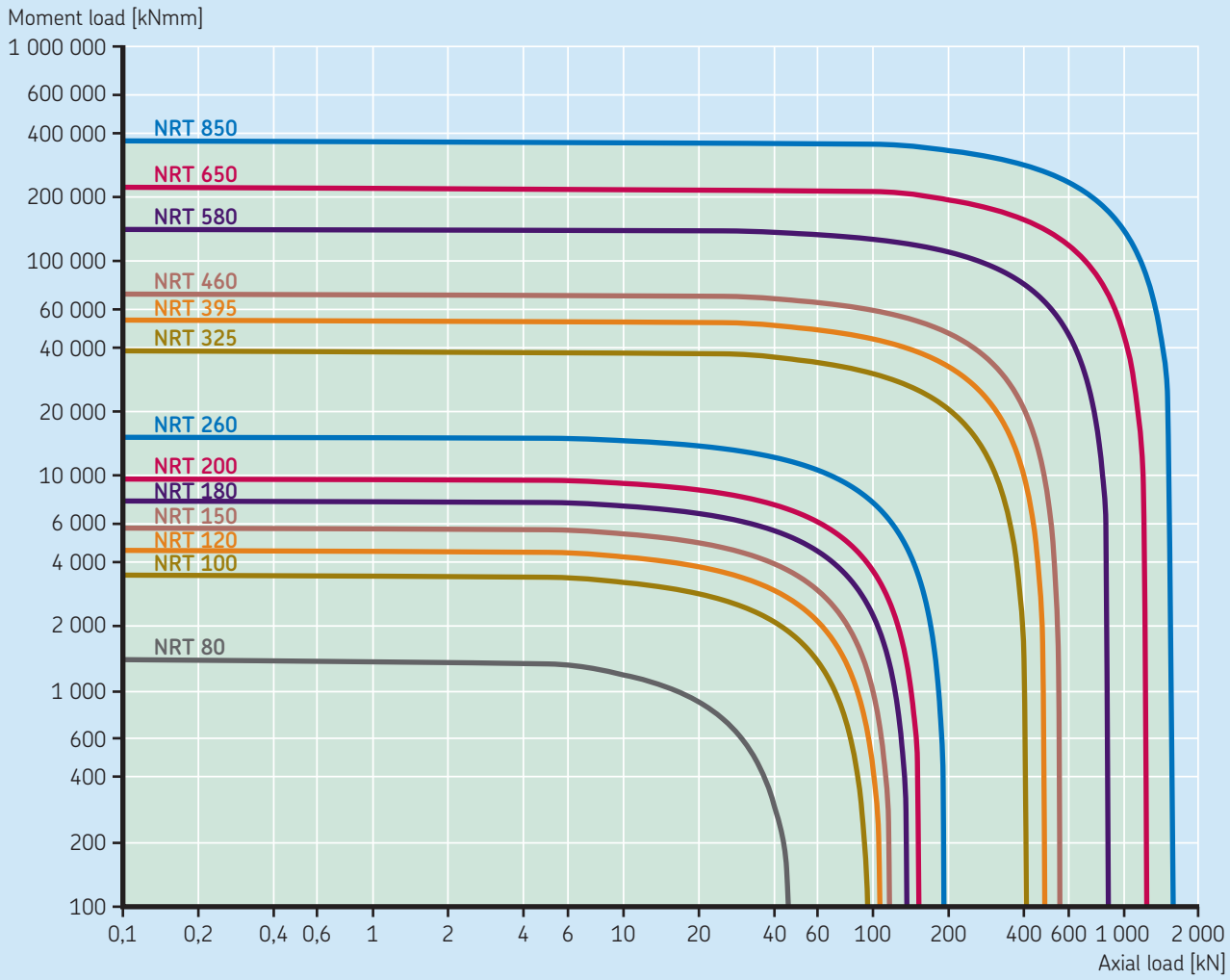
where
M_{perm} = permissible moment [kNmm]
C_{0a} = basic static load rating of thrust roller set [kN] (→ **product table**, **page 334**)
d_1 = outside diameter of inner ring [mm] (→ **product table**)
F_a = centrically acting axial load [kN]
s_0 = safety factor (→ *Permissible static loads*, **page 36**)
= 4

If frequent rotation or oscillation apply, rating life may limit the permissible moment load. In these cases, contact the SKF application engineering service.

Diagram 1 can be used for a quick check of the suitability of the selected bearing size under predominantly static loads.

Diagram 1

Permissible moment load – static limiting load



Mounting

Axial-radial cylindrical roller bearings are precision machine elements that can provide long service life, provided they are mounted and maintained properly. Proper mounting requires experience, accuracy, a clean work environment and the appropriate tools.

Mounting instructions

For general information about mounting bearings, refer to *Mounting and dismounting* (→ **page 123**).

When mounting axial-radial cylindrical roller bearings the inner ring can be unsupported (→ **fig. 2**) or supported (→ **fig. 3**). When a support ring is used, it should support the inner ring over its entire width. The support ring should be approximately twice the thickness of the flange.

CAUTION: To reduce the risk of damaging the bearing, do not apply any force through the rolling elements. Force should only be applied directly through the ring that is being mounted.

Mounting procedure

1. Coat all mating surfaces on the shaft and inner ring with a thin layer of light oil.
2. Loosen the retaining bolts (used to secure the bearing during transportation) 1/2 a turn.
3. Mount the bearing onto the shaft, loose flange first, aligning the attachment bolt holes in the bearing with the tapped holes in the shaft. To facilitate this process, an induction heater can be used and/or a guide stud can be inserted into one of the attachment bolt holes in the shaft. SKF does not recommend heating axial-radial cylindrical roller bearings above 80 °C *(175 °F)*.
4. Once the bearing (and support ring where applicable) is in position against the shaft abutment and the assembly is at ambient temperature, insert the attachment bolts and tighten them “finger tight” while rotating the outer ring. This procedure helps to settle the rollers and centre the inner ring assembly.
5. With the inner ring centred, gradually tighten each attachment bolt in a criss-cross pattern in three stages (→ **fig. 4**), tightening the bolts to 35%, then 70% and then 100% of the recommended torque values listed in **table 7** (→ **page 332**).
6. After the bearing is fitted, the retaining bolts must not be left loose. Either retighten them to the recommended torque values or remove them completely.
7. A similar procedure can be applied for fitting the outer ring. Coat all mating surfaces in the housing and on the outer ring with a thin layer of light oil.
8. Mount the bearing/shaft assembly into the housing (→ **fig. 5**).
9. Insert and tighten the attachment bolts “finger tight” while rotating the bearing/shaft assembly. Tighten each attachment bolt in a criss-cross pattern in three stages (→ **fig. 6**), as described in step **5**.

Checking running accuracy and friction

Once mounting is complete, the running accuracy and friction need to be checked. In cases where friction is particularly high, there are three potential explanations:

- The mating parts are not machined according to specification.
- The attachment bolts are over-tightened.
- There is too much grease in the bearing.

To eliminate possible stresses that may have occurred during mounting, loosen all attachment bolts and retighten them in a criss-cross pattern using the three stage process described above.

Storage/Transport

Axial-radial cylindrical roller bearings should always be stored flat.

Fig. 2

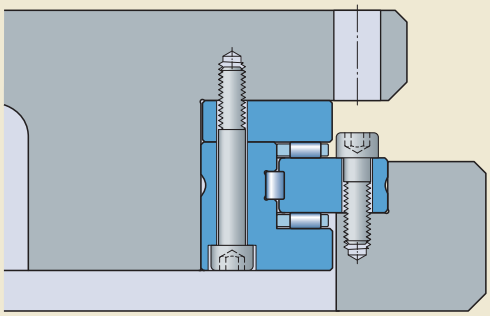


Fig. 3

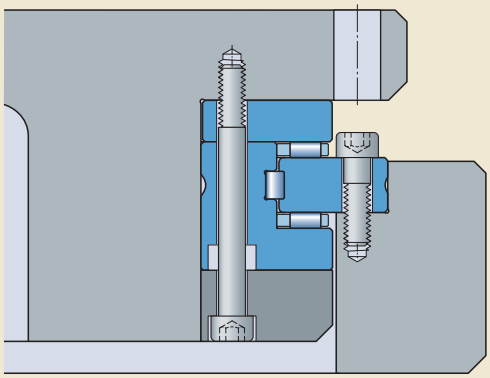


Fig. 4

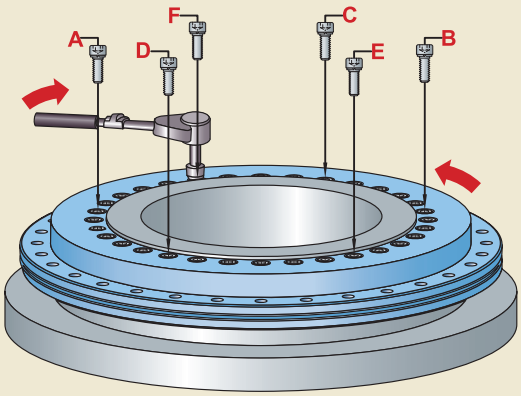


Fig. 5

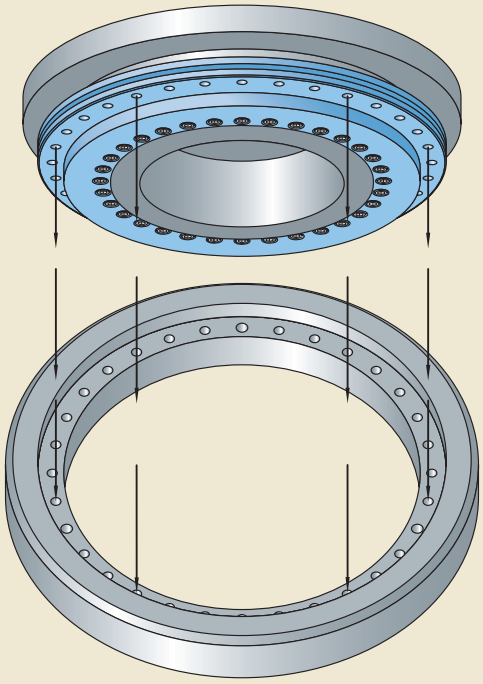


Fig. 6

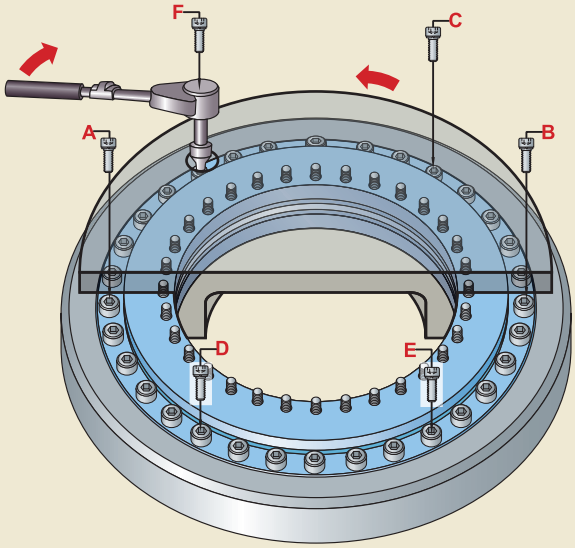


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Table 7

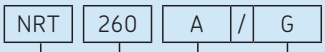
Recommended bolt tightening torque

Bearing	Tightening torque	Bolt size quality 10,9
–	Nm	–
NRT 80 A	4,5	M4
	8,5	M5
NRT 100 A	8,5	M5
NRT 120 A	14	M6
NRT 150 A	14	M6
NRT 180 A	14	M6
NRT 200 A	14	M6
NRT 260 A	34	M8
NRT 325 A	34	M8
NRT 395 A	34	M8
NRT 460 A	34	M8
NRT 580 A	68	M10
NRT 650 A	116	M12
NRT 850 A	284	M16

Do not use a higher torque value which could increase the bearing preload.

Designation system

Example: NRT 260 A/G



Bearing series

NRT Axial-radial cylindrical roller bearing

Bearing size

80
to
850 Bore diameter [mm]

Internal design

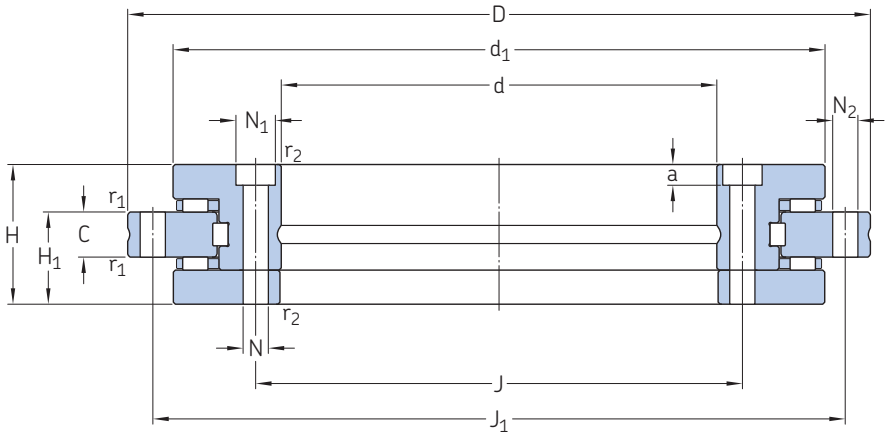
A Basic internal design
B Modified internal design

Other features

G Bearing greased at the factory

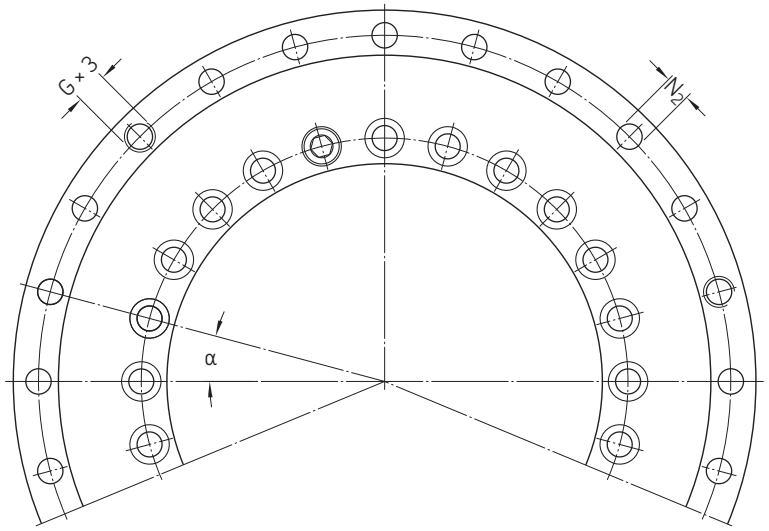
5.1 Axial-radial cylindrical roller bearings

d **80 – 850** mm



Principal dimensions								Basic load ratings				Attainable speeds		Mass	Suitable rotary table	Designation
								radial		axial		Grease lubrication	Oil lubrication			
$d^{1)}$	D	H	H_1	C	d_1	r_1 min.	r_2 min.	dynamic C	static C_0	dynamic C	static C_0					
mm								kN				r/min		kg	mm	–
80	146	35	23,35	12	130	0,3	0,3	55	102	37,5	200	350	700	2,4	200	**NRT 80 A**
100	185	38	25	12	160	0,6	0,3	58,3	116	68	390	280	560	4,1	260	**NRT 100 A**
120	210	40	26	12	184	0,6	0,3	64,4	140	72	440	230	460	5,3	315	**NRT 120 A**
150	240	40	26	12	214	0,6	0,3	67,1	160	75	480	210	420	6,2	350	**NRT 150 A**
180	280	43	29	15	244	0,6	0,3	89,7	236	80	560	190	380	7,7	400	**NRT 180 A**
200	300	45	30	15	274	0,6	0,3	93,5	270	85	630	170	340	9,7	500	**NRT 200 A**
260	385	55	36,5	18	345	0,6	0,6	108	355	95	780	130	260	18,5	630	**NRT 260 A**
325	450	60	40	20	415	0,6	0,6	134	450	153	1 660	110	220	25	700	**NRT 325 A**
395	525	65	42,5	20	486	1	1	147	530	166	1 960	90	180	33	800	**NRT 395 A**
460	600	70	46	22	560	1	1	201	765	180	2 240	80	160	45	1 000	**NRT 460 A**
580	750	90	60	30	700	1	1	229	965	285	3 550	60	120	89	1 250	**NRT 580 A**
650	870	122	78	34	800	1	1	413	1 600	365	5 000	55	110	170	1 450	**NRT 650 A**
850	1 095	124	80,5	37	1 018	1,5	1,5	473	2 120	415	6 400	40	80	253	1 800	**NRT 850 A**

1) Different shaft diameters can be supplied on request. Contact your local SKF representative.



Attachment holes Inner ring					Outer ring					Pitch	Retaining bolts[1]	
J	N	N_1	a	Attachment holes nr.	J_1	N_2	Attachment holes nr.	Removal thread G	Removal thread nr.	nr. x α [°]	Size	nr.
mm				–	mm		–			–	–	
92	5,6	10[2]	4	12	138	4,6	12	M5	3	12x30	M5	3
112	5,6	10	5,4	16	170	5,6	15	M5	3	18x20	M5	2
135	7	11	6,2	22	195	7	21	M8	3	24x15	M6	2
165	7	11	6,2	34	225	7	33	M8	3	36x10	M6	2
194	7	11	6,2	46	260	7	45	M8	3	48x7,5	M6	2
215	7	11	6,2	46	285	7	45	M8	3	48x7,5	M6	2
280	9,3	15	8,2	34	365	9,3	33	M12	3	36x10	M8	2
342	9,3	15[2]	8,2	34	430	9,3	33	M12	3	36x10	M8	2
415	9,3	15	8,2	46	505	9,3	45	M12	3	48x7,5	M8	2
482	9,3	15	8,2	46	580	9,3	45	M12	3	48x7,5	M8	2
610	11,4	18	11	46	720	11,4	42	M12	6	48x7,5	M10	2
680	14	20	13	46	830	14	42	M12	6	48x7,5	M12	2
890	18	26	17	58	1 055	18	54	M16	6	60x6	M16	2

[1] Retaining bolts are screwed into the loose flange.
[2] Milled slots open towards bearing bore.