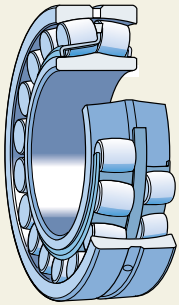
Spherical roller bearings

Spherical roller bearings have two rows of rollers with a common sphered raceway in the outer ring and two inner ring raceways inclined at an angle to the bearing axis (→ **fig** 1). This gives them an attractive combination of design features making them irreplaceable in many demanding applications. They are self-aligning and consequently insensitive to misalignment of the shaft relative to the housing and to shaft deflection or bending.

SKF spherical roller bearings are leading in design and can, in addition to high radial loads, accommodate high axial loads acting in both directions.

Fig 1



Standard bearings

The standard range of SKF spherical roller bearings comprises

- open bearings,
- sealed bearings and
- bearings for vibratory applications.

In addition to the standard range, SKF offers a wide range of special spherical roller bearings adapted for specific applications.

Open bearings

SKF spherical roller bearings are produced in several designs, depending on bearing series and size. The differences are

- the arrangement of the floating guide ring as well as
- the design of the inner ring and the cages,

as described in the following and shown in **fig** 2.

C(J), CC Two window-type steel cages, flangeless inner ring and guide ring centred on the inner ring (**a**).

EC(J), ECC(J) Two window-type steel cages, flangeless inner ring, guide ring centred on the inner ring and reinforced roller complement (**a**).

CA, CAC One-piece machined brass cage of the double-pronged type, retaining flanges on the inner ring and guide ring centred on the inner ring (**b**).

CAF As CA, but with a steel cage

ECA, ECAC One-piece machined brass cage of the double-pronged type, retaining flanges on the inner ring, guide ring centred on the inner ring and reinforced roller complement (**b**).

ECAF As ECA, but with a steel cage

E When bearing bore diameter $d \leq 65$ mm:
Two window-type steel cages, flangeless inner ring and guide ring centred on the inner ring (**c**).
When bearing bore diameter $d > 65$ mm:
Two window-type steel cages, flangeless inner ring and guide ring centred on the cages (**d**).

CAFA One-piece machined steel cage of the double-pronged type centred on the outer ring raceway, retaining flanges on the inner ring and guide ring centred on the inner ring (**e**).

CAMA As CAFA, but with a brass cage

Influence of operating temperature on bearing material

All SKF spherical roller bearings undergo a special heat treatment so that they can be operated at higher temperatures for longer periods, without the occurrence of inadmissible dimensional changes. For example, a temperature of +200 °C for 2 500 h, or for short periods at even higher temperatures is permitted.

Axial load carrying capacity

Because of their special internal design, SKF spherical roller bearings are able to accommodate heavy axial loads and even purely axial loads.

Axial load carrying capacity of bearings mounted on an adapter sleeve

If spherical roller bearings with adapter sleeves are mounted on smooth shafts with no fixed abutment, the magnitude of the axial load that can be supported is determined by the friction between the shaft and sleeve. Provided the bearings are correctly mounted, the permissible axial load can be calculated from

$$F_{ap} = 0{,}003\ B\ d$$

where
F_{ap} = maximum permissible axial load, kN
B = bearing width, mm
d = bearing bore diameter, mm

Minimum load

In order to provide satisfactory operation, spherical roller bearings, like all ball and roller bearings, must always be subjected to a given minimum load, particularly if they are to operate at high speeds or are subjected to high accelerations or rapid changes in the direction of load. Under such conditions the inertia forces of the rollers and cage(s), and the friction in the lubricant, can have a detrimental influence on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the rollers and raceways.

The requisite minimum load to be applied to spherical roller bearings can be estimated using

$$P_{0m} = 0{,}01\ C_0$$

where
P_{0m} = minimum equivalent static load, kN
C_0 = basic static load rating, kN
(→ product tables)

In some applications it is not possible to reach or exceed the requisite minimum load. However, if the bearing is oil lubricated lower minimum loads are permissible. These loads can be calculated when $n/n_r \leq 0{,}3$ from

$$P_{0m} = 0{,}003\ C_0$$

and when $0{,}3 < n/n_r \leq 2$ from

$$P_{0m} = 0{,}003\ C_0 \left(1 + 2\sqrt{\frac{n}{n_r} - 0{,}3}\right)$$

where
P_{0m} = minimum equivalent static bearing load, kN
C_0 = basic static load rating, kN
(→ product tables)
n = rotational speed, r/min
n_r = reference speed, r/min
(→ product tables)

When starting up at low temperatures or when the lubricant is highly viscous, even greater minimum loads than $P_{0m} = 0{,}01\ C_0$ may be required. The weight of the components supported by the bearing, together with external forces, generally exceeds the requisite minimum load. If this is not the case, the spherical roller bearing must be subjected to an additional radial load.

NoWear spherical roller bearings have proven to give reliable operation at very low loads. They can withstand longer periods of insufficient lubrication, sudden variations in load and rapid speed changes (→ **page 939**).

Equivalent dynamic bearing load
For dynamically loaded spherical roller bearings

$P = F_r + Y_1 F_a$ when $F_a/F_r \leq e$
$P = 0{,}67\ F_r + Y_2 F_a$ when $F_a/F_r > e$

The values of the calculation factors e, Y_1 and Y_2 will be found in the product tables.

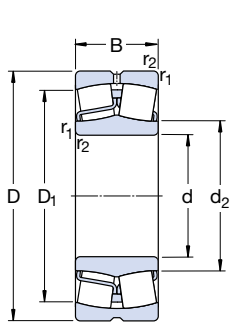
Equivalent static bearing load
For statically loaded spherical roller bearings

$P_0 = F_r + Y_0 F_a$

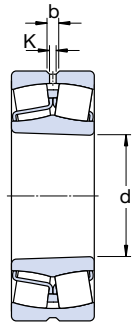
The value of the calculation factor Y_0 will be found in the product tables.

Supplementary designations
The designation suffixes used to identify certain features of SKF spherical roller bearings are explained in the following. The suffixes used to identify bearing (and cage) design, e.g. CC or E, are not included here as they are explained in the section "Standard bearings" on **page 692**.

C2 Radial internal clearance smaller than Normal
C3 Radial internal clearance greater than Normal
C4 Radial internal clearance greater than C3
C5 Radial internal clearance greater than C4
C08 Heightened running accuracy to ISO tolerance class 5
C083 C08 + C3
C084 C08 + C4
2CS Sheet steel reinforced contact seal of acrylonitrile butadiene rubber (NBR) on both sides of the bearing. Annular groove and three lubrication holes in the outer ring covered with a polymer band. Lubricated with an extreme pressure bearing grease according to **table** 1 on **page 694**
2CS2 Sheet steel reinforced contact seal of fluoro rubber (FPM) on both sides of the bearing. Annular groove and three lubrication holes in the outer ring; covered with a polymer band. Lubricated with a polyurea high temperature grease
2CS5 Sheet steel reinforced contact seal of hydrogenated acrylonitrile butadiene rubber (HNBR) on both sides of the bearing. Otherwise as 2CS2
HA3 Inner ring of case-hardening steel
K Tapered bore, taper 1:12
K30 Tapered bore, taper 1:30
P5 Dimensional and running accuracy to ISO tolerance class 5
P6 Dimensional and running accuracy to ISO tolerance class 6
P62 P6 + C2
VA405 Bearings for vibratory applications with surface hardened cages
VA406 VA405 and PTFE-coated bore
VE552(E) Outer ring with three equally spaced threaded holes in one side face to accommodate hoisting tackle; the E indicates that appropriate eye bolts are supplied with the bearings
VE553(E) As VE552 but with threaded holes in both side faces
VG114 Surface hardened pressed steel cage
VQ424 Running accuracy better than C08
VT143 Grease fill with an extreme pressure grease according to **table** 1 on **page 694**
W Without annular groove and lubrication holes in outer ring
W20 Three lubrication holes in the outer ring
W26 Six lubrication holes in the inner ring
W33 Annular groove and three lubrication holes in the outer ring
W64 Solid Oil filling
W77 Plugged W33 lubrication holes
W513 W26 + W33
235220 Inner ring of case-hardened steel with helical groove in bore



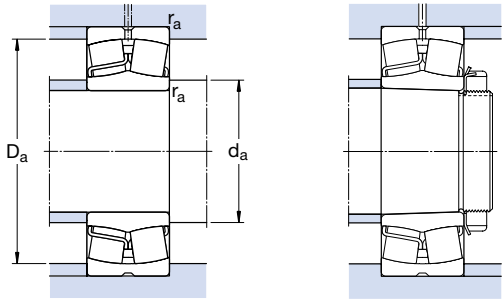
Cylindrical bore



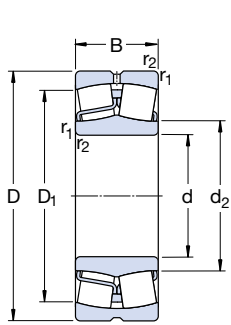
Tapered bore

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Speed ratings** Reference speed	Limiting speed	**Mass**	**Designations** Bearing with cylindrical bore	tapered bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
20	52	18	49	44	4,75	13 000	17 000	0,28	* **22205/20 E**	**–**
25	52	18	49	44	4,75	13 000	17 000	0,26	* **22205 E**	* **22205 EK**
	62	17	41,4	41,5	4,55	8 500	12 000	0,28	**21305 CC**	**–**
30	62	20	64	60	6,4	11 000	14 000	0,29	* **22206 E**	* **22206 EK**
	72	19	55,2	61	6,8	7 500	10 000	0,41	**21306 CC**	**21306 CCK**
35	72	23	86,5	85	9,3	9 000	12 000	0,45	* **22207 E**	* **22207 EK**
	80	21	65,6	72	8,15	6 700	9 500	0,55	**21307 CC**	**21307 CCK**
40	80	23	96,5	90	9,8	8 000	11 000	0,53	* **22208 E**	* **22208 EK**
	90	23	104	108	11,8	7 000	9 500	0,75	* **21308 E**	* **21308 EK**
	90	33	150	140	15	6 000	8 000	1,05	* **22308 E**	* **22308 EK**
45	85	23	102	98	10,8	7 500	10 000	0,58	* **22209 E**	* **22209 EK**
	100	25	125	127	13,7	5 300	7 000	0,99	* **21309 E**	* **21309 EK**
	100	36	183	183	19,6	5 300	7 000	1,40	* **22309 E**	* **22309 EK**
50	90	23	104	108	11,8	7 000	9 500	0,63	* **22210 E**	* **22210 EK**
	110	27	156	166	18,6	5 600	7 500	1,35	* **21310 E**	* **21310 EK**
	110	40	220	224	24	4 800	6 300	1,90	* **22310 E**	* **22310 EK**
55	100	25	125	137	13,7	6 300	8 000	0,84	* **22211 E**	* **22211 EK**
	120	29	156	166	18,6	5 600	7 500	1,70	* **21311 E**	* **21311 EK**
	120	43	270	280	30	4 300	5 600	2,45	* **22311 E**	* **22311 EK**
60	110	28	156	166	18,6	5 600	7 500	1,15	* **22212 E**	* **22212 EK**
	130	31	212	240	26,5	4 800	6 300	2,10	* **21312 E**	* **21312 EK**
	130	46	310	335	36,5	4 000	5 300	3,10	* **22312 E**	* **22312 EK**
65	120	31	193	216	24	4 300	7 000	1,55	* **22213 E**	* **22213 EK**
	140	33	236	270	29	4 300	6 000	2,55	* **21313 E**	* **21313 EK**
	140	48	340	360	38	3 800	5 000	3,75	* **22313 E**	* **22313 EK**
70	125	31	208	228	25,5	5 000	6 700	1,55	* **22214 E**	* **22214 EK**
	150	35	285	325	34,5	3 400	4 500	3,10	* **21314 E**	* **21314 EK**
	150	51	400	430	45	3 400	4 500	4,55	* **22314 E**	* **22314 EK**

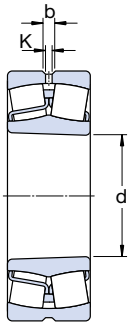
* SKF Explorer bearing



Dimensions						Abutment and fillet dimensions			Calculation factors			
d	d_2 ~	D_1 ~	b	K	$r_{1,2}$ min	d_a min	D_a max	r_a max	e	Y_1	Y_2	Y_0
mm						mm			–			
20	31,2	44,2	3,7	2	1	25,6	46,4	1	0,35	1,9	2,9	1,8
25	31,2	44,2	3,7	2	1	30,6	46,4	1	0,35	1,9	2,9	1,8
	35,7	50,7	–	–	1,1	32	55	1	0,30	2,3	3,4	2,2
30	37,7	53	3,7	2	1	35,6	56,4	1	0,31	2,2	3,3	2,2
	43,3	58,8	–	–	1,1	37	65	1	0,27	2,5	3,7	2,5
35	44,5	61,8	3,7	2	1,1	42	65	1	0,31	2,2	3,3	2,2
	47,2	65,6	–	–	1,5	44	71	1,5	0,28	2,4	3,6	2,5
40	49,6	69,4	5,5	3	1,1	47	73	1	0,28	2,4	3,6	2,5
	59,9	79	–	–	1,5	49	81	1,5	0,24	2,8	4,2	2,8
	49,9	74,3	5,5	3	1,5	49	81	1,5	0,37	1,8	2,7	1,8
45	54,9	74,4	5,5	3	1,1	52	78	1	0,26	2,6	3,9	2,5
	65,3	87,9	5,5	3	1,5	54	91	1,5	0,24	2,8	4,2	2,8
	57,6	83,1	5,5	3	1,5	54	91	1,5	0,37	1,8	2,7	1,8
50	59,9	79	5,5	3	1,1	57	83	1	0,24	2,8	4,2	2,8
	72,6	96	5,5	3	2	61	99	2	0,24	2,8	4,2	2,8
	63,9	91,9	5,5	3	2	61	99	2	0,37	1,8	2,7	1,8
55	65,3	87,9	5,5	3	1,5	64	91	1,5	0,24	2,8	4,2	2,8
	72,6	96	5,5	3	2	66	109	2	0,24	2,8	4,2	2,8
	70,1	102	5,5	3	2	66	109	2	0,35	1,9	2,9	1,8
60	72,6	96,3	5,5	3	1,5	69	101	1,5	0,24	2,8	4,2	2,8
	87,8	115	5,5	3	2,1	72	118	2	0,22	3	4,6	2,8
	77,9	110	5,5	4,5	2,1	72	118	2	0,35	1,9	2,9	1,8
65	80	106	5,5	3	1,5	74	111	1,5	0,24	2,8	4,2	2,8
	94,7	124	5,5	3	2,1	77	128	2	0,22	3	4,6	2,8
	81,6	118	8,3	4,5	2,1	77	128	2	0,35	1,9	2,9	1,8
70	83	111	5,5	3	1,5	79	116	1,5	0,22	3	4,6	2,8
	101	133	5,5	3	2,1	82	138	2	0,22	3	4,6	2,8
	90,3	128	8,3	4,5	2,1	82	138	2	0,33	2	3	2



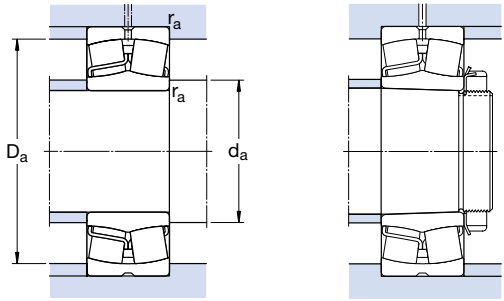
Cylindrical bore



Tapered bore

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations Bearing with cylindrical bore	tapered bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
75	115	40	173	232	28,5	3 800	5 300	1,55	*** 24015 CC/W33**	**–**
	130	31	212	240	26,5	4 800	6 300	1,70	*** 22215 E**	*** 22215 EK**
	160	37	285	325	34,5	4 000	5 600	3,75	*** 21315 E**	*** 21315 EK**
	160	55	440	475	48	3 200	4 300	5,55	*** 22315 E**	*** 22315 EK**
80	140	33	236	270	29	4 300	6 000	2,10	*** 22216 E**	*** 22216 EK**
	170	39	325	375	39	3 800	5 300	4,45	*** 21316 E**	*** 21316 EK**
	170	58	490	540	54	3 000	4 000	6,60	*** 22316 E**	*** 22316 EK**
85	150	36	285	325	34,5	4 000	5 600	2,65	*** 22217 E**	*** 22217 EK**
	180	41	325	375	39	3 800	5 300	5,20	*** 21317 E**	*** 21317 EK**
	180	60	550	620	61	2 800	3 800	7,65	*** 22317 E**	*** 22317 EK**
90	160	40	325	375	39	3 800	5 300	3,40	*** 22218 E**	*** 22218 EK**
	160	52,4	355	440	48	2 800	3 800	4,65	*** 23218 CC/W33**	*** 23218 CCK/W33**
	190	43	380	450	46,5	3 600	4 800	6,10	*** 21318 E**	*** 21318 EK**
	190	64	610	695	67	2 600	3 600	9,05	*** 22318 E**	*** 22318 EK**
95	170	43	380	450	46,5	3 600	4 800	4,15	*** 22219 E**	*** 22219 EK**
	200	45	425	490	49	3 400	4 500	7,05	*** 21319 E**	*** 21319 EK**
	200	67	670	765	73,5	2 600	3 400	10,5	*** 22319 E**	*** 22319 EK**
100	150	50	285	415	45,5	2 800	4 000	3,15	*** 24020 CC/W33**	**–**
	165	52	365	490	53	3 000	4 000	4,55	*** 23120 CC/W33**	*** 23120 CCK/W33**
	165	65	455	640	68	2 200	3 200	5,65	*** 24120 CC/W33**	**–**
	180	46	425	490	49	3 400	4 500	4,90	*** 22220 E**	*** 22220 EK**
	180	60,3	475	600	63	2 400	3 400	6,85	*** 23220 CC/W33**	*** 23220 CCK/W33**
	215	47	425	490	49	3 400	4 500	8,60	*** 21320 E**	*** 21320 EK**
	215	73	815	950	88	2 400	3 000	13,5	*** 22320 E**	*** 22320 EK**
110	170	45	310	440	46,5	3 400	4 300	3,80	*** 23022 CC/W33**	*** 23022 CCK/W33**
	170	60	415	620	67	2 200	3 600	5,00	*** 24022 CC/W33**	*** 24022 CCK30/W33**
	180	56	430	585	61	2 800	3 600	5,75	*** 23122 CC/W33**	*** 23122 CCK/W33**
	180	69	520	750	78	2 200	3 000	7,10	*** 24122 CC/W33**	*** 24122 CCK30/W33**
	200	53	560	640	63	3 000	4 000	7,00	*** 22222 E**	*** 22222 EK**
	200	69,8	600	765	76,5	2 200	3 000	9,85	*** 23222 CC/W33**	*** 23222 CCK/W33**
	240	80	950	1 120	100	2 000	2 800	18,4	*** 22322 E**	*** 22322 EK**

* SKF Explorer bearing



Dimensions						Abutment and fillet dimensions			Calculation factors			
d	d_2 ~	D_1 ~	b	K	$r_{1,2}$ min	d_a min	D_a max	r_a max	e	Y_1	Y_2	Y_0
mm						mm			–			
75	84,1	100	5,5	3	1,1	81	109	1	0,28	2,4	3,6	2,5
	87,8	115	5,5	3	1,5	84	121	1,5	0,22	3	4,6	2,8
	101	133	5,5	3	2,1	87	148	2	0,22	3	4,6	2,8
	92,8	135	8,3	4,5	2,1	87	148	2	0,35	1,9	2,9	1,8
80	94,7	127	5,5	3	2	91	129	2	0,22	3	4,6	2,8
	106	141	5,5	3	2,1	92	158	2	0,24	2,8	4,2	2,8
	98,3	143	8,3	4,5	2,1	92	158	2	0,35	1,9	2,9	1,8
85	101	133	5,5	3	2	96	139	2	0,22	3	4,6	2,8
	106	141	5,5	3	3	99	166	2,5	0,24	2,8	4,2	2,8
	108	154	8,3	4,5	3	99	166	2,5	0,33	2	3	2
90	106	141	5,5	3	2	101	149	2	0,24	2,8	4,2	2,8
	106	137	5,5	3	2	101	149	2	0,31	2,2	3,3	2,2
	112	150	8,3	4,5	3	104	176	2,5	0,24	2,8	4,2	2,8
	113	161	11,1	6	3	104	176	2,5	0,33	2	3	2
95	112	150	8,3	4,5	2,1	107	158	2	0,24	2,8	4,2	2,8
	118	159	8,3	4,5	3	109	186	2,5	0,24	2,8	4,2	2,8
	118	168	11,1	6	3	109	186	2,5	0,33	2	3	2
100	111	132	5,5	3	1,5	107	143	1,5	0,28	2,4	3,6	2,5
	115	144	5,5	3	2	111	154	2	0,30	2,3	3,4	2,2
	113	141	5,5	3	2	111	154	2	0,37	1,8	2,7	1,8
	118	159	8,3	4,5	2,1	112	168	2	0,24	2,8	4,2	2,8
	117	153	8,3	4,5	2,1	112	168	2	0,33	2	3	2
	118	159	8,3	4,5	3	114	201	2,5	0,24	2,8	4,2	2,8
	130	184	11,1	6	3	114	201	2,5	0,33	2	3	2
110	125	151	5,5	3	2	120	160	2	0,23	2,9	4,4	2,8
	122	149	5,5	3	2	120	160	2	0,33	2	3	2
	126	157	8,3	4,5	2	121	169	2	0,30	2,3	3,4	2,2
	123	153	5,5	3	2	121	169	2	0,37	1,8	2,7	1,8
	130	178	8,3	4,5	2,1	122	188	2	0,25	2,7	4	2,5
	130	169	8,3	4,5	2,1	122	188	2	0,33	2	3	2
	143	204	13,9	7,5	3	124	226	2,5	0,33	2	3	2