



Hybrid bearings

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Hybrid bearings

Hybrid bearings have rings of bearing steel and rolling elements of bearing grade silicon nitride (Si_3N_4). In addition to being excellent electric insulators, hybrid bearings have a higher speed capability and will provide longer service life than all-steel bearings in most applications.

The very good electrical insulating property is one of the essential features of the silicon nitride. This protects the rings from electric current damage and thus increases bearing service life.

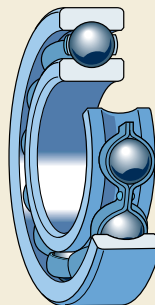
The density of silicon nitride is only 40 % of the density of bearing steel. Thus the rolling elements weigh less and have lower inertia. This means less cage stresses during rapid starts and stops and also significantly lower friction at high speeds as explained in the section “Friction” on **page 87**. Lower friction means cooler running and longer lubricant service life. Hybrid bearings are thus suitable for high rotational speeds.

Under insufficient lubrication conditions there is no smearing between silicon nitride and steel. This enables hybrid bearings to last much longer in applications operating under severe dynamic conditions or lubrication conditions with low operating viscosity ($\kappa < 1$). For hybrid bearings it is common to apply $\kappa = 1$ for running conditions with $\kappa < 1$ to estimate life under such conditions. Hybrid bearings may perform well, when lubricated with ultra thin film forming media, such as refrigerants, enabling oil-free designs but care needs to be taken in design and material selection. In such cases it is recommended to consult the SKF application engineering service before deciding upon design and ordering.

Silicon nitride has a higher hardness and higher modulus of elasticity than steel, resulting in increased bearing stiffness and longer bearing service life in contaminated environments.

Silicon nitride rolling elements have a lower thermal expansion than steel rolling elements of similar size. This means less sensitivity to temperature gradients within the bearing and more accurate preload control. When designing bearing arrangements for very low temperature and as to estimate reductions in bearing clearance of hybrid bearings, please contact the SKF application engineering service.

Fig. 1



SKF hybrid deep groove ball bearings

The SKF standard range of hybrid bearings essentially comprises hybrid single row deep groove ball bearings (→ **fig. 1**). The reason for it is clear: deep groove ball bearings are the most widely used bearing type, especially in electric motors, and are very useful for simple designs utilizing greased-for-life bearings. Deep raceway grooves and the close conformity between the raceways and the balls enable the accommodation of radial loads as well as of axial loads in both directions.

SKF hybrid deep groove ball bearings are available from 5 up to 80 mm bore diameter. They meet most application needs. Larger bearings can also be manufactured by SKF on request.

Bearings up to 45 mm bore diameter, for example, are most suitable for electrical motors in the power range of 0,15 up to 15 kW as well as generators, power tools and high-speed drives.

There is a wide application field for hybrid deep groove ball bearings, consequently SKF produces

- sealed and greased-for-life bearings
- open design bearings.

Sealed and greased-for-life bearings

Sealed and greased-for-life SKF hybrid deep groove ball bearings (→ **fig. 2**) are protected on both sides, either by

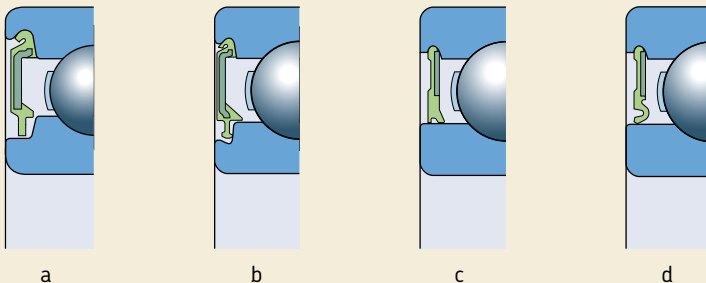
- a low-friction seal of the RSL design (**a**) fitted to bearings with an outside diameter up to 25 mm, designation suffix 2RSL
- a low-friction seal of the RSL design (**b**) fitted to bearings with an outside diameter over 25 mm and up to and inclusive 52 mm, designation suffix 2RSL
- a low-friction seal of the RZ design (**c**) fitted to bearings with an outside diameter above 52 mm, designation suffix 2RZ
- a contact seal of the RS1 design (**d**), designation suffix 2RS1.

Details about the suitability of the different seals for various operating conditions can be found in the section “Deep groove ball bearings”, starting on **page 287**.

The seals are made of acrylonitrile-butadiene rubber (NBR) with sheet steel reinforcement. The permissible operating temperature range for these seals is -40 to $+100$ °C and up to $+120$ °C for brief periods.

Sealed bearings are filled as standard with a premium quality grease, synthetic ester oil based using polyurea thickener, bearing designation suffix WT. It has excellent lubrication properties in the temperature range from about $+70$ to $+120$ °C, offers extremely long life unattainable with other sealed and greased-for-life bearing designs and fits the needs of electrical

Fig. 2



Hybrid bearings

machinery. The most important properties of the WT grease are listed in **table 1**.

Regarding the suitability for high temperatures, the permissible temperature ranges of the cage and seals have to be taken into consideration. For SKF hybrid bearings with seals of fluoro rubber, which withstand temperatures up to 180 °C please contact the SKF application engineering service.

Open design bearings

In addition to sealed and greased-for-life bearings larger SKF hybrid deep groove ball bearings are also available in open basic design without seals. If smaller open design bearings are required and the quantity is small, SKF recommends ordering sealed hybrid bearings and removing the seals, which can be done quite simply.

Other SKF hybrid bearings

Hybrid high-precision bearings

The SKF product range also includes a selection of

- hybrid high-precision angular contact ball bearings
- hybrid high-precision cylindrical roller bearings
- hybrid high-precision angular contact thrust ball bearings, single and double direction.

Detailed information about these hybrid bearings can be found in the SKF catalogue "High-precision bearings".

In addition, hybrid single or double row angular contact ball bearings and hybrid four-point contact ball bearings can be manufactured to special order. In such cases the SKF application engineering service should be contacted for further information.

Hybrid ball and roller bearings, hybrid bearing units

SKF also designs and manufactures a variety of other hybrid bearings in standard sizes on special order for certain size ranges including

- angular contact ball bearings
- cylindrical roller bearings
- bearing units.

Such designs enable a combination of optimal performance, simplicity in handling and economy. For more information, please contact the SKF application engineering service.

Hybrid bearings with special steel rings and coatings

SKF hybrid bearings are made as standard of the same steel as the equivalent all-steel bearing. The standard stabilization temperatures are 120 °C for deep groove ball bearings and 150 °C for angular contact ball bearings. For continuous operation above these temperatures it is recommended to use bearings with rings that are dimensionally stabilized for use at higher operating temperatures e.g.

Table 1

Properties of WT grease

DIN 51825 code	K2P-40
Thickener	Polyurea (Di-urea)
Base oil type	Synthetic ester
NLGI consistency class	2-3
Temperature range, °C¹⁾	-40 to +160
Base oil viscosity, mm²/s	
at 40 °C	70
at 100 °C	9,4

¹⁾ For safe operating temperature, → section "Temperature range – the SKF traffic light concept", starting on page 232

- up to +150 °C, suffix S0
- up to +200 °C, suffix S1.

Hybrid deep groove ball bearings stabilized to S0 or S1 etc. are normally not stocked.

On request hybrid bearings can be manufactured with through-hardened rings of stainless bearing steels with good corrosion, wear and oxidation resistance and good high temperature properties. Such bearings can operate at temperatures up to 300 °C.

For custom-made hybrid bearings with rings of special stainless steels for cryogenic temperatures or of high temperature tool steels please contact the SKF application engineering service.

The rings may be coated for corrosion protection e.g. with zinc chromate or thin dense chromium. Low friction coatings of molybdenum base can be applied for vacuum and gas applications.

Bearing data – general

Dimensions, tolerances, internal clearance

SKF hybrid deep groove ball bearings are standardized bearings and are manufactured as standard with

- boundary dimensions to ISO 15:1998
- Normal tolerances to ISO 492:2002
- C3 radial internal clearance to ISO 5753:1991 (→ table 2).

Misalignment

Hybrid deep groove ball bearings have only limited ability to accommodate misalignment. The permissible angular misalignment between inner and outer rings, which will not produce inadmissibly high additional stresses in the bearing, depends on

- the radial internal clearance of the bearing in operation
- the bearing size
- the forces and moments acting on the bearing.

Depending on the various influences of the factors, the permissible angular misalignment lies between 2 and 10 minutes of arc. Any misalignment will result in increased bearing noise and reduced bearing service life.

Table 2

Radial internal clearance			
Bore diameter d		Radial internal clearance C3	
over	incl.	min	max
mm		µm	
10	10	8	23
18	18	11	25
	30	13	28
30	40	15	33
40	50	18	36
50	65	23	43
65	80	25	51
80	100	30	58
100	120	36	66

Hybrid bearings

Cages

Depending on the bearing size, SKF hybrid deep groove ball bearings are fitted with

- an injection moulded snap-type cage of glass fibre reinforced polyamide 6,6, ball centred, designation suffix TN9 (→ **fig. 3a**)
- a riveted cage of pressed steel, ball centred, no designation suffix (→ **fig. 3b**).

Hybrid bearings with a cage of glass fibre reinforced polyamide 6,6 can be operated at temperatures up to +120 °C.

Minimum load

In order to provide satisfactory operation, hybrid deep groove ball bearings, like the standard bearings, must always be subjected to a given minimum load. Please refer to the section "Minimum load" of standard deep groove ball bearings on **page 298**.

However, hybrid bearings are generally more resistant to skidding and smearing damages of raceways caused by too light loads. This makes hybrid bearings a good alternative for bearing arrangements subjected to variable load cycles that include light loads.

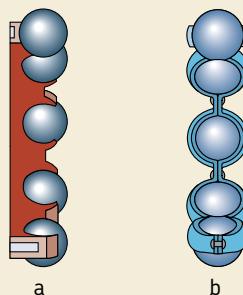
Axial preloading

In order to provide low noise and good high-speed operation it is normal to apply an axial preload to a bearing arrangement comprising two hybrid deep groove ball bearings. A particular simple method to apply the axial preload is by using spring washers, as described in the section "Preloading by springs", starting on **page 216**. The recommended axial preloads can be calculated as provided in this section. For additional information please refer to the section "Bearing preload", starting on **page 206**.

Axial load carrying capacity

If hybrid deep groove ball bearings are subjected to purely axial load, this axial load should generally not exceed the value of $0,5 C_0$. Small bearings (bore diameter up to approx. 12 mm) and bearings in the light Diameter Series 0 should not be subjected to an axial load greater than $0,25 C_0$. Excessive axial loads can lead to a considerable reduction in bearing service life.

Fig. 3



Equivalent dynamic bearing load

$$P = F_r \quad \text{when } F_a/F_r \leq e$$

$$P = 0,46 F_r + Y F_a \quad \text{when } F_a/F_r > e$$

The factors e and Y depend on the relationship $f_0 F_a/C_0$, where f_0 is a calculation factor (\rightarrow product tables), F_a the axial component of the load and C_0 the basic static load rating.

In addition, the factors are influenced by the magnitude of the radial internal clearance. For bearings with C3 internal clearance mounted with the usual fits as listed in **tables 2, 4** and **5** on **pages 169** to **171**, the values for e and Y are listed in **table 3** below.

Equivalent static bearing load

$$P_0 = 0,6 F_r + 0,5 F_a$$

If $P_0 < F_r$, $P_0 = F_r$ should be used.

Speed capability

Hybrid deep groove ball bearings fitted with a polymeric cage can be operated at speeds in excess of the ratings given for all-steel bearings. The limiting speeds listed in the product tables are valid for bearings with the standard cage, seal and grease according to the bearing designation. Hybrid bearings fitted with a cage of polyetheretherketone (PEEK) can be operated at higher speeds and temperatures. For more information please contact the SKF application engineering service.

The values for "Reference speed" shown with the sealed bearings are valid for open basic design bearings and demonstrate the speed capability of these bearings. For sealed bearings the values listed for "Limiting speed" should not be exceeded.

Hybrid bearings perform excellently under vibrating or oscillating conditions. It is therefore not usually necessary to apply special greases or preloads for these conditions.

Silicon nitride properties

The properties of the bearing grade silicon nitride (Si_3N_4) are presented in the section "Materials for rolling bearings", starting on **page 138**.

Electrical properties

Hybrid bearings provide effective protection against electric arc damage to the grease and raceways caused by both AC and DC currents. The impedance for a hybrid bearing is high, even for very high frequencies, providing extremely good protection against high frequency current and peaks through the ball/raceway contacts. For small hybrid bearings equipped with a sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR), the voltage level when the first arcing occurs through the seal/bearing contact is beyond 2,5 kV DC. For additional information please contact the SKF application engineering service.

Table 3

Calculation factors for hybrid deep groove ball bearings with C3 radial internal clearance

$f_0 F_a/C_0$	e	Y
0,172	0,29	1,88
0,345	0,32	1,71
0,689	0,36	1,52
1,03	0,38	1,41
1,38	0,40	1,34
2,07	0,44	1,23
3,45	0,49	1,10
5,17	0,54	1,01
6,89	0,54	1,00

Intermediate values are obtained by linear interpolation

Hybrid bearings

Supplementary designations

The designation suffixes used to identify certain features of SKF hybrid deep groove ball bearings are explained in the following.

C3	Radial internal clearance greater than Normal
F1	Grease filling grade: 10–15 % of the free space in the bearing
HC5	Rolling elements of silicon nitride
2RS1	Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing
2RSH2	Sheet steel reinforced contact seal of fluoro rubber (FKM) on both sides of the bearing
2RSL	Sheet steel reinforced low-friction seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing
2RZ	Sheet steel reinforced low-friction seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing
TNH	Injection moulded snap-type cage of glass fibre reinforced polyetheretherketone (PEEK), ball centred
TN9	Injection moulded snap-type cage of glass fibre reinforced polyamide 6,6, ball centred
WT	Grease with polyurea thickener of consistency 2–3 to the NLGI Scale for a temperature range –40 to +160 °C (normal filling grade)

Selection of bearing size

When selecting the necessary bearing size of hybrid deep groove ball bearings please follow the procedure for all-steel bearings in the section "Selection of bearing size", starting on **page 49**. Due to the higher modulus of elasticity of ceramic balls the static safety factor s_0 should be increased by

$$s_{0 \text{ hybrid}} = 1,1 s_{0 \text{ all-steel}}$$

The recommended values of s_0 for all-steel bearings can be found in **table 10** on **page 77**.

Lubrication

Most of the SKF hybrid deep groove ball bearings are sealed and greased-for-life. In the case of open bearings and grease lubrication SKF recommends the SKF grease LGHP 2 for electrical motors. For very high-speed applications at temperatures below +70 °C the use of SKF grease LGLT 2 is recommended. More about the SKF greases can be found in the section "Lubrication", starting on **page 229**.

Applications requiring long service life at extremely high speeds have to be oil-lubricated. The two recommended lubrication methods in this case are

- oil jet lubrication
- oil-air lubrication.

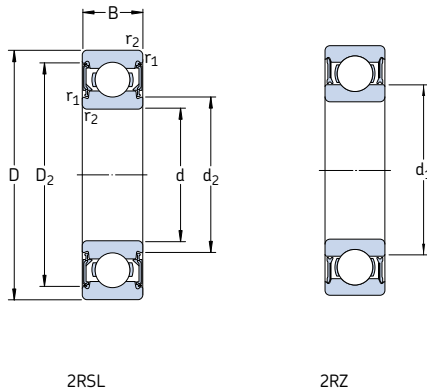
Oil-air lubrication, e.g. by the VOGEL OLA oil + air systems (→ **fig. 4**), enables reliable lubrication to be achieved with extremely small quantities of oil, which lowers the operating temperatures, enables higher speeds and reduces oil emission to the environment.

For more information about the design of oil-air lubrication arrangements, please refer to the VOGEL publication 1-5012-3 "Oil + Air Systems", or please visit www.vogelag.com.

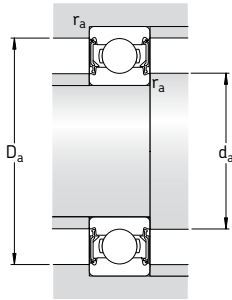


Fig. 4

**Sealed and greased-for-life
hybrid deep groove ball bearings**
d 5 – 45 mm

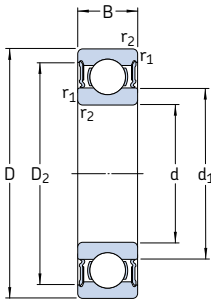


Principal dimensions			Basic load ratings		Fatigue load limit P_u	Speed ratings		Mass	Designation
d	D	B	dynamic C	static C_0		Reference speed	Limiting speed		
mm			kN		kN	r/min		kg	–
5	16	5	1,14	0,38	0,016	130 000	85 000	0,0050	625-2RZTN9/HC5C3WTF1
6	19	6	2,34	0,95	0,04	110 000	70 000	0,0080	626-2RSLTN9/HC5C3WTF1
7	19 22	6 7	2,34 3,45	0,95 1,37	0,04 0,057	110 000 95 000	70 000 63 000	0,0070 0,012	607-2RSLTN9/HC5C3WTF1 627-2RSLTN9/HC5C3WTF1
8	22	7	3,45	1,37	0,057	95 000	63 000	0,012	608-2RSLTN9/HC5C3WTF1
10	26 30	8 9	4,75 5,4	1,96 2,36	0,083 0,1	85 000 75 000	56 000 50 000	0,018 0,032	6000-2RSLTN9/HC5C3WT 6200-2RSLTN9/HC5C3WT
12	28 32	8 10	5,4 7,28	2,36 3,1	0,1 0,132	75 000 67 000	50 000 45 000	0,022 0,037	6001-2RSLTN9/HC5C3WT 6201-2RSLTN9/HC5C3WT
15	32 35	9 11	5,85 8,06	2,85 3,75	0,12 0,16	63 000 60 000	43 000 40 000	0,030 0,044	6002-2RSLTN9/HC5C3WT 6202-2RSLTN9/HC5C3WT
17	35 40	10 12	6,37 9,95	3,25 4,75	0,137 0,2	56 000 53 000	38 000 34 000	0,038 0,059	6003-2RSLTN9/HC5C3WT 6203-2RSLTN9/HC5C3WT
20	42 47	12 14	9,95 13,5	5 6,55	0,212 0,28	48 000 45 000	32 000 30 000	0,062 0,097	6004-2RSLTN9/HC5C3WT 6204-2RSLTN9/HC5C3WT
25	47 52	12 15	11,9 14,8	6,55 7,8	0,275 0,335	40 000 38 000	28 000 26 000	0,073 0,12	6005-2RSLTN9/HC5C3WT 6205-2RSLTN9/HC5C3WT
30	55 62	13 16	13,8 20,3	8,3 11,2	0,355 0,475	34 000 32 000	24 000 22 000	0,11 0,18	6006-2RZTN9/HC5C3WT 6206-2RZTN9/HC5C3WT
35	62 72	14 17	16,8 27	10,2 15,3	0,44 0,655	30 000 28 000	20 000 18 000	0,15 0,26	6007-2RZTN9/HC5C3WT 6207-2RZTN9/HC5C3WT
40	68 80	15 18	17,8 32,5	11,6 19	0,49 0,8	28 000 24 000	18 000 16 000	0,19 0,34	6008-2RZTN9/HC5C3WT 6208-2RZTN9/HC5C3WT
45	85 100	19 25	35,1 55,3	21,6 31,5	0,915 1,34	22 000 20 000	14 000 4 500	0,42 0,77	6209-2RZTN9/HC5C3WT 6309-2RS1TN9/HC5C3WT

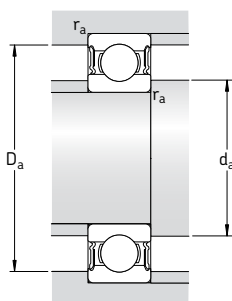


Dimensions					Abutment and fillet dimensions				Calculation factor
d	d ₁	d ₂	D ₂	r _{1,2} min	d _a min	d _a max	D _a max	r _a max	f ₀
mm					mm				-
5	8,4	-	13,3	0,3	7,4	-	13,6	0,3	8,4
6	-	9,5	16,5	0,3	8,4	9,4	16,6	0,3	13
7	-	9,5	16,5	0,3	9	9,4	17	0,3	13
	-	10,6	19,2	0,3	9,4	10,5	19,6	0,3	12
8	-	10,6	19,2	0,3	10	10,5	20	0,3	12
10	-	13	22,6	0,3	12	12,5	24	0,3	12
	-	15,2	24,8	0,6	14,2	15	25,8	0,6	13
12	-	15,2	24,8	0,3	14	15	26	0,3	13
	-	16,6	27,4	0,6	16,2	16,5	27,8	0,6	12
15	-	18,7	28,2	0,3	17	18,5	30	0,3	14
	-	19,4	30,4	0,6	19,2	19,4	30,8	0,6	13
17	-	20,7	31,4	0,3	19	20,5	33	0,3	14
	-	22,2	35	0,6	21,2	22	35,8	0,6	13
20	-	24,9	37,2	0,6	23,2	24,5	38,8	0,6	14
	-	26,3	40,6	1	25,6	26	41,4	1	13
25	-	29,7	42,2	0,6	28,2	29,5	43,8	0,6	14
	-	31,8	46,3	1	30,6	31,5	46,4	1	14
30	38,2	-	49	1	34,6	-	50,4	1	15
	40,4	-	54,1	1	35,6	-	56,4	1	14
35	43,8	-	55,6	1	39,6	-	57,4	1	15
	46,9	-	62,7	1,1	42	-	65	1	14
40	49,3	-	61,1	1	44,6	-	63,4	1	15
	52,6	-	69,8	1,1	47	-	73	1	14
45	57,6	-	75,2	1,1	52	-	78	1	14
	62,2	-	86,7	1,5	54	-	91	1,5	13

**Sealed and greased-for-life
hybrid deep groove ball bearings**
d 50 – 75 mm

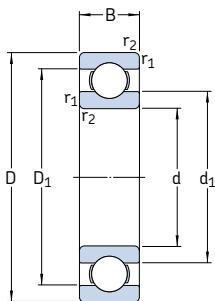


Principal dimensions			Basic load ratings		Fatigue load limit P_u	Speed ratings		Mass	Designation
d	D	B	dynamic C	static C_0		Reference speed	Limiting speed		
mm			kN		kN	r/min		kg	–
50	90	20	37,1	23,2	0,98	20 000	4 800	0,44	6210-2RS1/HC5C3WT
	110	27	65	38	1,6	18 000	4 300	0,92	6310-2RS1/HC5C3WT
55	100	21	46,2	29	1,25	19 000	4 300	0,59	6211-2RS1/HC5C3WT
	120	29	74,1	45	1,9	17 000	3 800	1,20	6311-2RS1/HC5C3WT
60	110	22	55,3	36	1,53	17 000	4 000	0,71	6212-2RS1/HC5C3WT
	130	31	85,2	52	2,2	15 000	3 400	1,50	6312-2RS1/HC5C3WT
65	120	23	58,5	40,5	1,73	16 000	3 600	0,92	6213-2RS1/HC5C3WT
	140	33	97,5	60	2,5	14 000	3 200	1,85	6313-2RS1/HC5C3WT
70	125	24	63,7	45	1,9	15 000	3 400	1,00	6214-2RS1/HC5C3WT
75	130	25	68,9	49	2,04	14 000	3 200	1,05	6215-2RS1/HC5C3WT

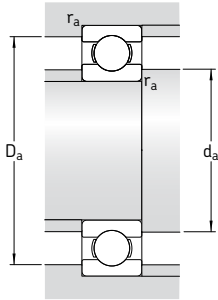


Dimensions				Abutment and fillet dimensions			Calculation factor
d	d ₁ ~	D ₂ ~	r _{1,2} min	d _a min	D _a max	r _a max	f ₀
mm				mm			-
50	62,5	81,6	1,1	57	83	1	14
	68,8	95,2	2	61	99	2	13
55	69,1	89,4	1,5	64	91	1,5	14
	75,3	104	2	66	109	2	13
60	75,5	98	1,5	69	101	1,5	14
	81,9	112	2,1	72	118	2	13
65	83,3	106	1,5	74	111	1,5	15
	88,4	121	2,1	77	128	2	13
70	87,1	111	1,5	79	116	1,5	15
75	92,1	117	1,5	84	121	1,5	15

Hybrid deep groove ball bearings
d 65 – 80 mm



Principal dimensions			Basic load ratings		Fatigue load limit P_u	Speed ratings		Mass	Designation
d	D	B	dynamic C	static C_0		Reference speed	Limiting speed		
mm			kN		kN	r/min		kg	–
65	120	23	58,5	40,5	1,73	16 000	8 500	0,92	6213/HC5C3
70	110 125	20 24	39,7 63,7	31 45	1,32 1,9	16 000 15 000	9 000 8 500	0,57 0,99	6014/HC5C3 6214/HC5C3
80	170	39	130	86,5	3,25	12 000	6 300	2,80	6316/HC5C3



Dimensions				Abutment and fillet dimensions			Calculation factor
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$d_{a, \min}$	D_a max	r_a max	f_0
mm				mm			-
65	83,3	106	1,5	74	111	1,5	15
70	82,9 87,1	99,9 111	1,1 1,5	76 79	104 116	1 1,5	16 15
80	108	147	2,1	92	158	2	13