

The following table shows the principal dimensions for radial ball bearings.

Table 27.1. Principal dimensions for radial ball bearings.

<i>Bearing No.</i>	<i>Bore (mm)</i>	<i>Outside diameter</i>	<i>Width (mm)</i>
200	10	30	9
300		35	11
201	12	32	10
301		37	12
202	15	35	11
302		42	13
203	17	40	12
303		47	14
403		62	17
204	20	47	14
304		52	14
404		72	19
205	25	52	15
305		62	17
405		80	21
206	30	62	16
306		72	19
406		90	23
207	35	72	17
307		80	21
407		100	25
208	40	80	18
308		90	23
408		110	27
209	45	85	19
309		100	25
409		120	29
210	50	90	20
310		110	27
410		130	31
211	55	100	21
311		120	29
411		140	33
212	60	110	22
312		130	31
412		150	35

<i>Bearing No.</i>	<i>Bore (mm)</i>	<i>Outside diameter</i>	<i>Width (mm)</i>
213	65	120	23
313		140	33
413		160	37
214	70	125	24
314		150	35
414		180	42
215	75	130	25
315		160	37
415		190	45
216	80	140	26
316		170	39
416		200	48
217	85	150	28
317		180	41
417		210	52
218	90	160	30
318		190	43
418		225	54

Table 27.3. Life of bearings for various types of machines.

<i>S. No.</i>	<i>Application of bearing</i>	<i>Life of bearing, in hours</i>
1.	Instruments and apparatus that are rarely used (a) Demonstration apparatus, mechanism for operating sliding doors (b) Aircraft engines	500 1000 – 2000
2.	Machines used for short periods or intermittently and whose breakdown would not have serious consequences <i>e.g.</i> hand tools, lifting tackle in workshops, and operated machines, agricultural machines, cranes in erecting shops, domestic machines.	4000 – 8000
3.	Machines working intermittently whose breakdown would have serious consequences <i>e.g.</i> auxillary machinery in power stations, conveyor plant for flow production, lifts, cranes for piece goods, machine tools used frequently.	8000 – 12 000
4.	Machines working 8 hours per day and not always fully utilised <i>e.g.</i> stationary electric motors, general purpose gear units.	12 000 – 20 000

5.	Machines working 8 hours per day and fully utilised <i>e.g.</i> machines for the engineering industry, cranes for bulk goods, ventilating fans, counter shafts.	20 000 – 30 000
6.	Machines working 24 hours per day <i>e.g.</i> separators, compressors, pumps, mine hoists, naval vessels.	40 000 – 60 000
7.	Machines required to work with high degree of reliability 24 hours per day <i>e.g.</i> pulp and paper making machinery, public power plants, mine-pumps, water works.	100 000 – 200 000

Table 27.2. Values of X_0 and Y_0 for radial bearings.

S.No.	Type of bearing	Single row bearing		Double row bearing	
		X_0	Y_0	X_0	Y_0
1.	Radial contact groove ball bearings	0.60	0.50	0.60	0.50
2.	Self aligning ball or roller bearings and tapered roller bearing	0.50	$0.22 \cot \theta$	1	$0.44 \cot \theta$
3.	Angular contact groove bearings :				
	$\alpha = 15^\circ$	0.50	0.46	1	0.92
	$\alpha = 20^\circ$	0.50	0.42	1	0.84
	$\alpha = 25^\circ$	0.50	0.38	1	0.76
	$\alpha = 30^\circ$	0.50	0.33	1	0.66
	$\alpha = 35^\circ$	0.50	0.29	1	0.58
	$\alpha = 40^\circ$	0.50	0.26	1	0.52
	$\alpha = 45^\circ$	0.50	0.22	1	0.44

Table 27.4. Values of X and Y for dynamically loaded bearings.

Type of bearing	Specifications	$\frac{W_A}{W_R} \leq e$		$\frac{W_A}{W_R} > e$		e
		X	Y	X	Y	
Deep groove ball bearing	$\frac{W_A}{C_0} = 0.025$				2.0	0.22
	= 0.04				1.8	0.24
	= 0.07				1.6	0.27
	= 0.13	1	0	0.56	1.4	0.31
	= 0.25				1.2	0.37
	= 0.50				1.0	0.44
Angular contact ball bearings	Single row		0	0.35	0.57	1.14
	Two rows in tandem		0	0.35	0.57	1.14
	Two rows back to back	1	0.55	0.57	0.93	1.14
	Double row		0.73	0.62	1.17	0.86
Self-aligning bearings	Light series : for bores					
	10 – 20 mm		1.3		2.0	0.50
	25 – 35	1	1.7	6.5	2.6	0.37
	40 – 45		2.0		3.1	0.31
	50 – 65		2.3		3.5	0.28
	70 – 100		2.4		3.8	0.26
	105 – 110		2.3		3.5	0.28
	Medium series : for bores					
	12 mm		1.0	0.65	1.6	0.63
	15 – 20		1.2		1.9	0.52
	25 – 50		1.5		2.3	0.43
	55 – 90		1.6		2.5	0.39
Spherical roller bearings	For bores :					
	25 – 35 mm		2.1		3.1	0.32
	40 – 45	1	2.5	0.67	3.7	0.27
	50 – 100		2.9		4.4	0.23
Taper roller bearings	For bores :					
	30 – 40 mm				1.60	0.37
	45 – 110	1	0	0.4	1.45	0.44
	120 – 150				1.35	0.41

Selection of Radial Ball Bearings

In order to select a most suitable ball bearing, first of all, the basic dynamic radial load is calculated. It is then multiplied by the service factor (KS) to get the design basic dynamic radial load capacity. The service factor for the ball bearings is shown in the following table.

Table 27.5. Values of service factor (K_s).

S.No.	Type of service	Service factor (K_s) for radial ball bearings
1.	Uniform and steady load	1.0
2.	Light shock load	1.5
3.	Moderate shock load	2.0
4.	Heavy shock load	2.5
5.	Extreme shock load	3.0

After finding the design basic dynamic radial load capacity, the selection of bearing is made from the catalogue of a manufacturer. The following table shows the basic static and dynamic capacities for various types of ball bearings.

Table 27.6. Basic static and dynamic capacities of various types of radial ball bearings.

Bearing No.	Basic capacities in kN							
	Single row deep groove ball bearing		Single row angular contact ball bearing		Double row angular contact ball bearing		Self-aligning ball bearing	
	Static (C_0)	Dynamic (C)	Static (C_0)	Dynamic (C)	Static (C_0)	Dynamic (C)	Static (C_0)	Dynamic (C)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
200	2.24	4	—	—	4.55	7.35	1.80	5.70
300	3.60	6.3	—	—	—	—	—	—
201	3	5.4	—	—	5.6	8.3	2.0	5.85
301	4.3	7.65	—	—	—	—	3.0	9.15
202	3.55	6.10	3.75	6.30	5.6	8.3	2.16	6
302	5.20	8.80	—	—	9.3	14	3.35	9.3
203	4.4	7.5	4.75	7.8	8.15	11.6	2.8	7.65
303	6.3	10.6	7.2	11.6	12.9	19.3	4.15	11.2
403	11	18	—	—	—	—	—	—
204	6.55	10	6.55	10.4	11	16	3.9	9.8
304	7.65	12.5	8.3	13.7	14	19.3	5.5	14
404	15.6	24	—	—	—	—	—	—

205	7.1	11	7.8	11.6	13.7	17.3	4.25	9.8
305	10.4	16.6	12.5	19.3	20	26.5	7.65	19
405	19	28	—	—	—	—	—	—
206	10	15.3	11.2	16	20.4	25	5.6	12
306	14.6	22	17	24.5	27.5	35.5	10.2	24.5
406	23.2	33.5	—	—	—	—	—	—
207	13.7	20	15.3	21.2	28	34	8	17
307	17.6	26	20.4	28.5	36	45	13.2	30.5
407	30.5	43	—	—	—	—	—	—
208	16	22.8	19	25	32.5	39	9.15	17.6
308	22	32	25.5	35.5	45.5	55	16	35.5
408	37.5	50	—	—	—	—	—	—
209	18.3	25.5	21.6	28	37.5	41.5	10.2	18
309	30	41.5	34	45.5	56	67	19.6	42.5
409	44	60	—	—	—	—	—	—
210	21.2	27.5	23.6	29	43	47.5	10.8	18
310	35.5	48	40.5	53	73.5	81.5	24	50
410	50	68	—	—	—	—	—	—

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
211	26	34	30	36.5	49	53	12.7	20.8
311	42.5	56	47.5	62	80	88	28.5	58.5
411	60	78	—	—	—	—	—	—
212	32	40.5	36.5	44	63	65.5	16	26.5
312	48	64	55	71	96.5	102	33.5	68
412	67	85	—	—	—	—	—	—
213	35.5	44	43	50	69.5	69.5	20.4	34
313	55	72	63	80	112	118	39	75
413	76.5	93	—	—	—	—	—	—
214	39	48	47.5	54	71	69.5	21.6	34.5
314	63	81.5	73.5	90	129	137	45	85
414	102	112	—	—	—	—	—	—
215	42.5	52	50	56	80	76.5	22.4	34.5
315	72	90	81.5	98	140	143	52	95
415	110	120	—	—	—	—	—	—
216	45.5	57	57	63	96.5	93	25	38
316	80	96.5	91.5	106	160	163	58.5	106
416	120	127	—	—	—	—	—	—
217	55	65.5	65.5	71	100	106	30	45.5
317	88	104	102	114	180	180	62	110
417	132	134	—	—	—	—	—	—
218	63	75	76.5	83	127	118	36	55
318	98	112	114	122	—	—	69.5	118
418	146	146	—	—	—	—	—	—
219	72	85	88	95	150	137	43	65.5
319	112	120	125	132	—	—	—	—
220	81.5	96.5	93	102	160	146	51	76.5
320	132	137	153	150	—	—	—	—
221	93	104	104	110	—	—	56	85
321	143	143	166	160	—	—	—	—
222	104	112	116	120	—	—	64	98
322	166	160	193	176	—	—	—	—

Example 27.3. Select a single row deep groove ball bearing for a radial load of 4000 N and an axial load of 5000 N, operating at a speed of 1600 r.p.m. for an average life of 5 years at 10 hours per day. Assume uniform and steady load.

Solution. Given : $W_R = 4000 \text{ N}$; $W_A = 5000 \text{ N}$; $N = 1600 \text{ r.p.m}$

Since the average life of the bearing is 5 years at 10 hours per day, therefore life of the bearing in hours,

$$L_H = 5 \times 300 \times 10 = 15\,000 \text{ hours} \quad \dots \text{(Assuming 300 working days per year)}$$

and life of the bearing in revolutions,

$$L = 60 N \times L_H = 60 \times 1600 \times 15\,000 = 1440 \times 10^6 \text{ rev}$$

We know that the basic dynamic equivalent radial load,

$$W = X.V.W_R + Y.W_A \quad \dots(i)$$

In order to determine the radial load factor (X) and axial load factor (Y), we require W_A/W_R and W_A/C_0 . Since the value of basic static load capacity (C_0) is not known, therefore let us take $W_A/C_0 = 0.5$. Now from Table 27.4, we find that the values of X and Y corresponding to $W_A/C_0 = 0.5$ and $W_A/W_R = 5000/4000 = 1.25$ (which is greater than $e = 0.44$) are

$$X = 0.56 \quad \text{and} \quad Y = 1$$

Since the rotational factor (V) for most of the bearings is 1, therefore basic dynamic equivalent radial load,

$$W = 0.56 \times 1 \times 4000 + 1 \times 5000 = 7240 \text{ N}$$

From Table 27.5, we find that for uniform and steady load, the service factor (K_S) for ball bearings is 1. Therefore the bearing should be selected for $W = 7240 \text{ N}$.

We know that basic dynamic load rating,

$$\begin{aligned} C &= W \left(\frac{L}{10^6} \right)^{1/k} = 7240 \left(\frac{1440 \times 10^6}{10^6} \right)^{1/3} = 81\,760 \text{ N} \\ &= 81.76 \text{ kN} \quad \dots (\because k = 3, \text{ for ball bearings}) \end{aligned}$$

From Table 27.6, let us select the bearing No. 315 which has the following basic capacities,

$$C_0 = 72 \text{ kN} = 72\,000 \text{ N} \quad \text{and} \quad C = 90 \text{ kN} = 90\,000 \text{ N}$$

$$\text{Now} \quad W_A/C_0 = 5000/72\,000 = 0.07$$

\therefore From Table 27.4, the values of X and Y are

$$X = 0.56 \quad \text{and} \quad Y = 1.6$$

Substituting these values in equation (i), we have dynamic equivalent load,

$$W = 0.56 \times 1 \times 4000 + 1.6 \times 5000 = 10\,240 \text{ N}$$

\therefore Basic dynamic load rating,

$$C = 10\,240 \left(\frac{1440 \times 10^6}{10^6} \right)^{1/3} = 115\,635 \text{ N} = 115.635 \text{ kN}$$

From Table 27.6, the bearing number 319 having $C = 120 \text{ kN}$, may be selected. **Ans.**

Solution. Given : $W_R = 2500 \text{ N}$; $W_A = 1500 \text{ N}$

From Table 27.4, we find that for single row angular contact ball bearing, the values of radial factor (X) and thrust factor (Y) for $W_A/W_R = 1500/2500 = 0.6$ are

$$X = 1 \quad \text{and} \quad Y = 0$$

Since the rotational factor (V) for most of the bearings is 1, therefore dynamic equivalent load,

$$W = X.V.W_R + Y.W_A = 1 \times 1 \times 2500 + 0 \times 1500 = 2500 \text{ N}$$

From Table 27.5, we find that for light shock load, the service factor (K_S) is 1.5. Therefore the design dynamic equivalent load should be taken as

$$W = 2500 \times 1.5 = 3750 \text{ N}$$

From Table 27.6, we find that for a single row angular contact ball bearing number 310, the basic dynamic capacity,

$$C = 53 \text{ kN} = 53\,000 \text{ N}$$

We know that rating life of the bearing in revolutions,

$$L = \left(\frac{C}{W} \right)^k \times 10^6 = \left(\frac{53\,000}{3750} \right)^3 \times 10^6 = 2823 \times 10^6 \text{ rev } \mathbf{Ans.}$$

... ($\because k = 3$, for ball bearings)

Example 27.5. Design a self-aligning ball bearing for a radial load of 7000 N and a thrust load of 2100 N. The desired life of the bearing is 160 millions of revolutions at 300 r.p.m. Assume uniform and steady load,

Solution. Given : $W_R = 7000 \text{ N}$; $W_A = 2100 \text{ N}$; $L = 160 \times 10^6 \text{ rev}$; $N = 300 \text{ r.p.m.}$

From Table 27.4, we find that for a self-aligning ball bearing, the values of radial factor (X) and thrust factor (Y) for $W_A / W_R = 2100 / 7000 = 0.3$, are as follows :

$$X = 0.65 \quad \text{and} \quad Y = 3.5$$

Since the rotational factor (V) for most of the bearings is 1, therefore dynamic equivalent load,

$$W = X.V.W_R + Y.W_A = 0.65 \times 1 \times 7000 + 3.5 \times 2100 = 11\,900 \text{ N}$$

From Table 27.5, we find that for uniform and steady load, the service factor K_S for ball bearings is 1. Therefore the bearing should be selected for $W = 11\,900 \text{ N}$.

We know that the basic dynamic load rating,

$$C = W \left(\frac{L}{10^6} \right)^{1/k} = 11\,900 \left(\frac{160 \times 10^6}{10^6} \right)^{1/3} = 64\,600 \text{ N} = 64.6 \text{ kN}$$

... ($\because k = 3$, for ball bearings)

From Table 27.6, let us select bearing number 219 having $C = 65.5 \text{ kN}$ **Ans.**

Example 27.6. Select a single row deep groove ball bearing with the operating cycle listed below, which will have a life of 15 000 hours.

Fraction of cycle	Type of load	Radial (N)	Thrust (N)	Speed (R.P.M.)	Service factor
1/10	Heavy shocks	2000	1200	400	3.0
1/10	Light shocks	1500	1000	500	1.5
1/5	Moderate shocks	1000	1500	600	2.0
3/5	No shock	1200	2000	800	1.0

Assume radial and axial load factors to be 1.0 and 1.5 respectively and inner race rotates.

Solution. Given : $L_H = 15\ 000$ hours ; $W_{R1} = 2000$ N ; $W_{A1} = 1200$ N ; $N_1 = 400$ r.p.m. ; $K_{S1} = 3$; $W_{R2} = 1500$ N ; $W_{A2} = 1000$ N ; $N_2 = 500$ r.p.m. ; $K_{S2} = 1.5$; $W_{R3} = 1000$ N ; $W_{A3} = 1500$ N ; $N_3 = 600$ r.p.m. ; $K_{S3} = 2$; $W_{R4} = 1200$ N ; $W_{A4} = 2000$ N ; $N_4 = 800$ r.p.m. ; $K_{S4} = 1$; $X = 1$; $Y = 1.5$

We know that basic dynamic equivalent radial load considering service factor is

$$W = [X.V.W_R + Y.W_A] K_S \quad \dots(i)$$

It is given that radial load factor (X) = 1 and axial load factor (Y) = 1.5. Since the rotational factor (V) for most of the bearings is 1, therefore equation (i) may be written as

$$W = (W_R + 1.5 W_A) K_S$$

Now, substituting the values of W_R , W_A and K_S for different operating cycle, we have

$$W_1 = (W_{R1} + 1.5 W_{A1}) K_{S1} = (2000 + 1.5 \times 1200) 3 = 11\ 400 \text{ N}$$

$$W_2 = (W_{R2} + 1.5 W_{A2}) K_{S2} = (1500 + 1.5 \times 1000) 1.5 = 4500 \text{ N}$$

$$W_3 = (W_{R3} + 1.5 W_{A3}) K_{S3} = (1000 + 1.5 \times 1500) 2 = 6500 \text{ N}$$

and $W_4 = (W_{R4} + 1.5 W_{A4}) K_{S4} = (1200 + 1.5 \times 2000) 1 = 4200 \text{ N}$

We know that life of the bearing in revolutions

$$L = 60 N L_H = 60 N \times 15\ 000 = 0.9 \times 10^6 N \text{ rev}$$

\therefore Life of the bearing for 1/10 of a cycle,

$$L_1 = \frac{1}{10} \times 0.9 \times 10^6 N_1 = \frac{1}{10} \times 0.9 \times 10^6 \times 400 = 36 \times 10^6 \text{ rev}$$

Similarly, life of the bearing for the next 1/10 of a cycle,

$$L_2 = \frac{1}{10} \times 0.9 \times 10^6 N_2 = \frac{1}{10} \times 0.9 \times 10^6 \times 500 = 45 \times 10^6 \text{ rev}$$

Life of the bearing for the next 1/5 of a cycle,

$$L_3 = \frac{1}{5} \times 0.9 \times 10^6 N_3 = \frac{1}{5} \times 0.9 \times 10^6 \times 600 = 108 \times 10^6 \text{ rev}$$

and life of the bearing for the next 3/5 of a cycle,

$$L_4 = \frac{3}{5} \times 0.9 \times 10^6 N_4 = \frac{3}{5} \times 0.9 \times 10^6 \times 800 = 432 \times 10^6 \text{ rev}$$

We know that equivalent dynamic load,

$$W = \left[\frac{L_1 (W_1)^3 + L_2 (W_2)^3 + L_3 (W_3)^3 + L_4 (W_4)^3}{L_1 + L_2 + L_3 + L_4} \right]^{1/3}$$

$$= \left[\frac{36 \times 10^6 (11\,400)^3 + 45 \times 10^6 (4500)^3 + 108 \times 10^6 (6500)^3 + 432 \times 10^6 (4200)^3}{36 \times 10^6 + 45 \times 10^6 + 108 \times 10^6 + 423 \times 10^6} \right]^{1/3}$$

$$= \left[\frac{1.191 \times 10^8 \times 10^{12}}{621 \times 10^6} \right]^{1/3} = (0.1918 \times 10^{12})^{1/3} = 5767 \text{ N}$$

and

$$L = L_1 + L_2 + L_3 + L_4$$

$$= 36 \times 10^6 + 45 \times 10^6 + 108 \times 10^6 + 432 \times 10^6 = 621 \times 10^6 \text{ rev}$$

We know that dynamic load rating,

$$C = W \left(\frac{L}{10^6} \right)^{1/k} = 5767 \left(\frac{621 \times 10^6}{10^6} \right)^{1/3}$$

$$= 5767 \times 8.53 = 49\,193 \text{ N} = 49.193 \text{ kN}$$

From Table 27.6, the single row deep groove ball bearing number 215 having $C = 52 \text{ kN}$ may be selected. **Ans.**