Bearings

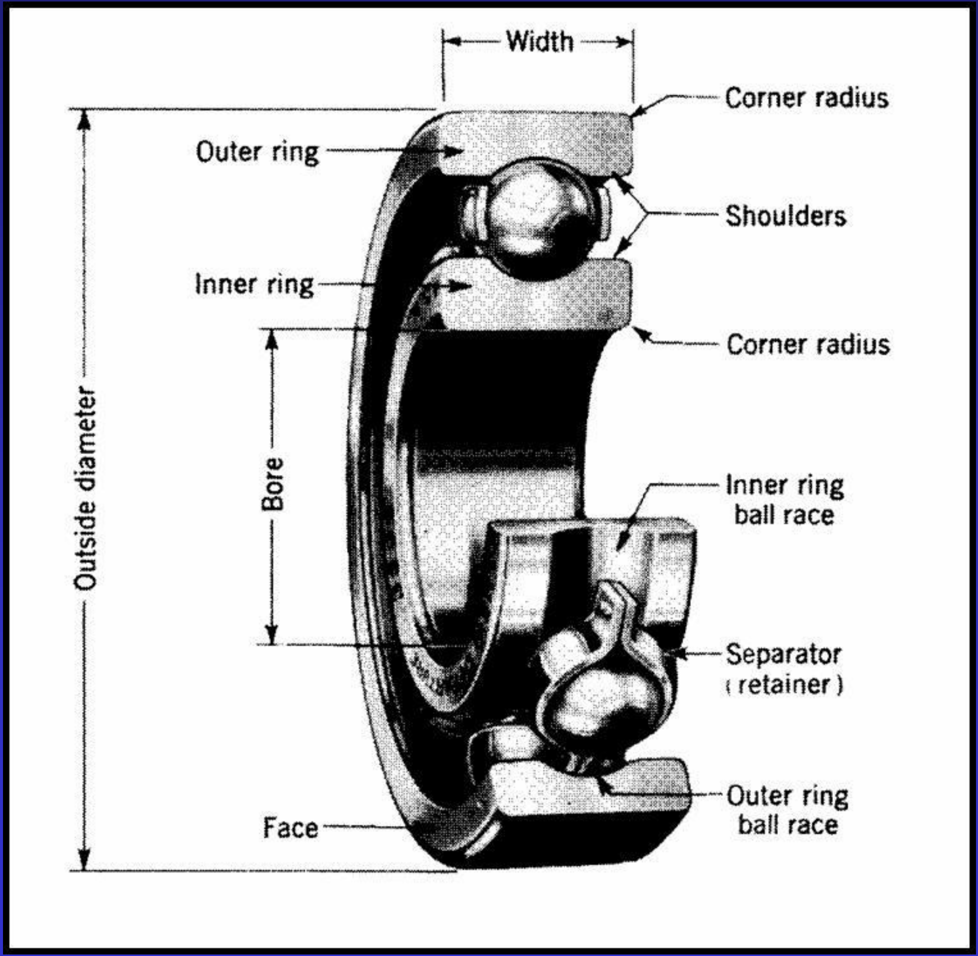
Rolling Contact Bearings – load is transferred through rolling elements such as balls, straight and tapered cylinders and spherical rollers.

Journal (sleeve) Bearings – load is transferred through a thin film of lubricant (oil).

Bearings

Rolling Contact Bearings

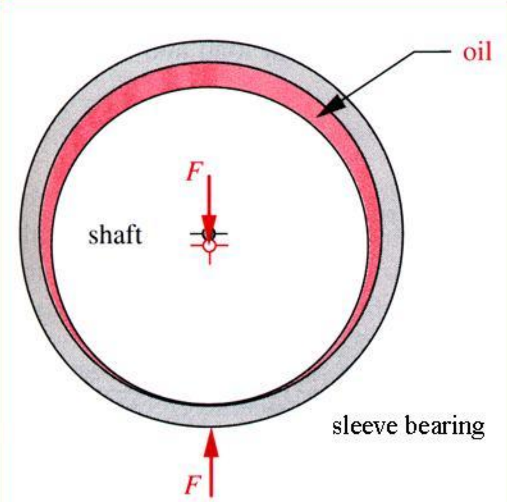
Load is transferred through elements in rolling contact rather than sliding contact.



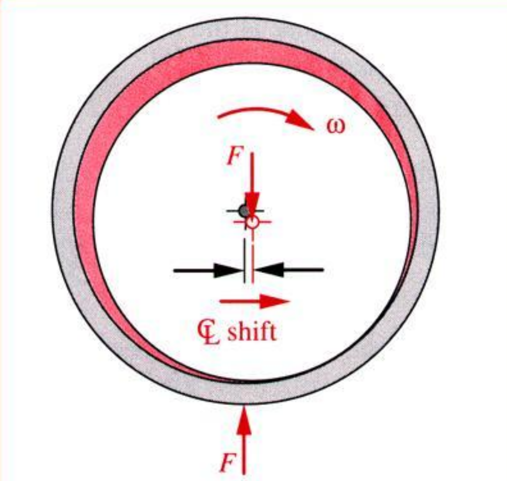
Bearings

Journal (Sleeve) Bearings

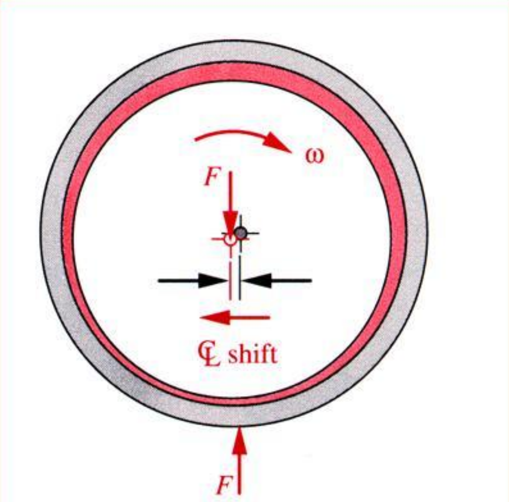
Load is transferred through a lubricant in sliding contact



(a) Shaft stationary - metal contact
- forces and centers in line



(b) Shaft rotating slowly
- boundary lubrication
- contact point leads centerline

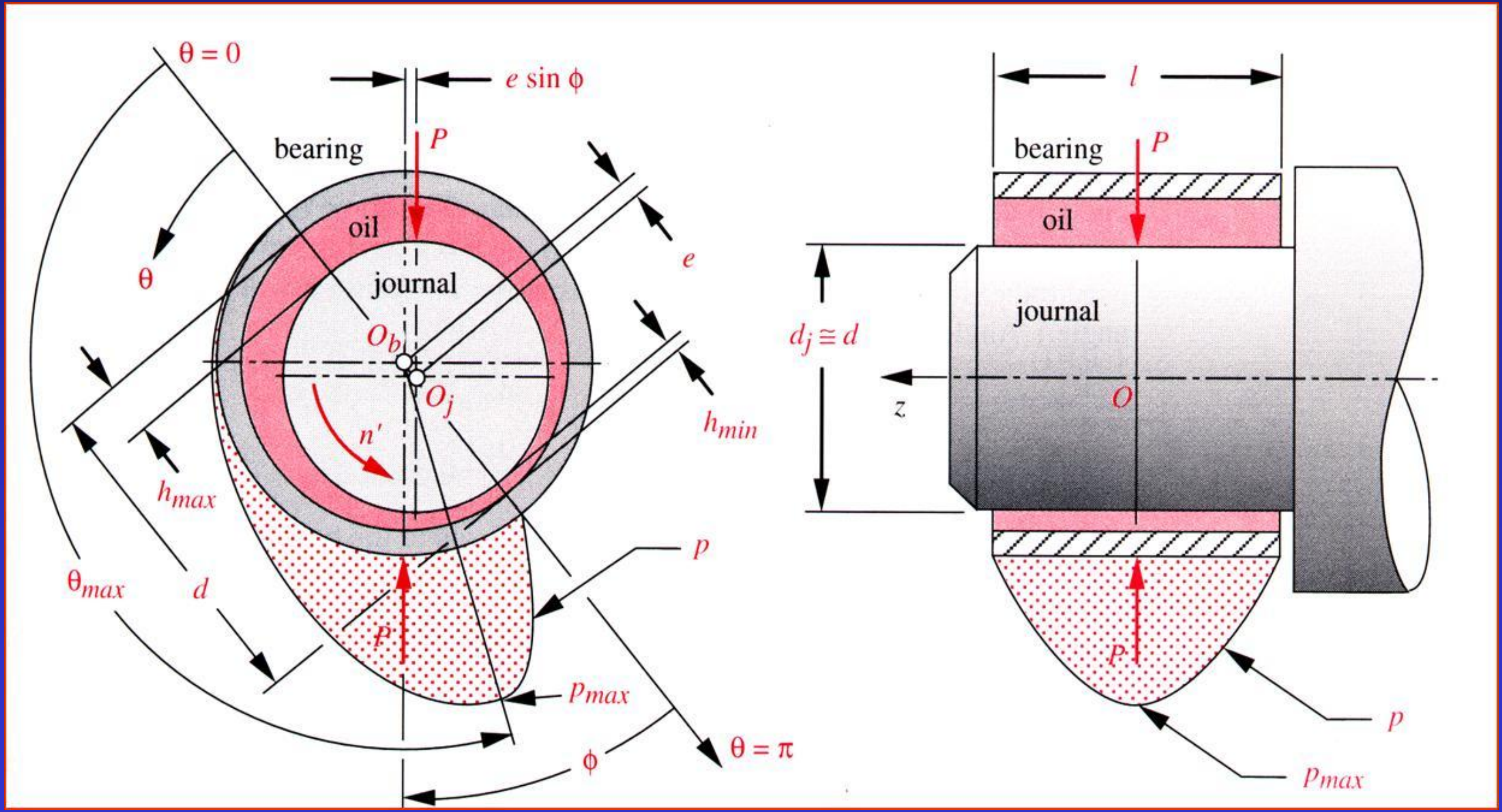


(c) Shaft rotating rapidly
- hydrodynamic lubrication
- no metal contact
- fluid is pumped by shaft
- shaft lags bearing centerline

Journal (Sleeve) Bearings

Thick-film lubrication (hydrodynamic), pressure distribution, and film thickness.

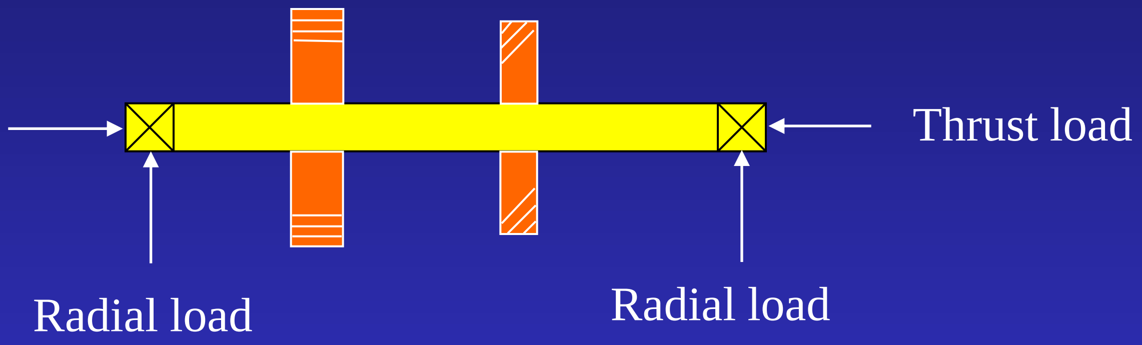
$\boldsymbol{h}_{min}$ = minimum film thickness, c = radial clearance, e = eccentricity



Design Considerations

Bearings are selected from catalogs, before referring to catalogs you should know the followings:

- Bearing load – radial, thrust (axial) or both



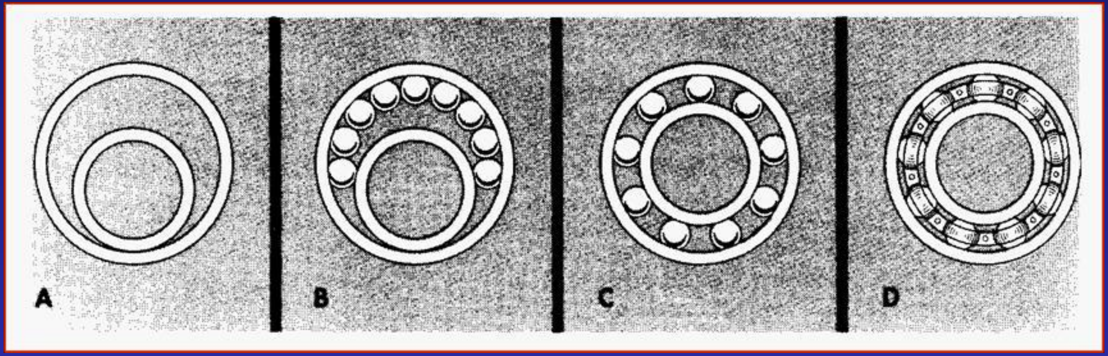
- Bearing life and reliability
- Bearing speed (rpm)
- Space limitation
- Accuracy

Rolling Contact Bearings

1. ***Ball bearings***
   - Deep groove (Conrad) bearing
   - Filling notch ball bearing or maximum capacity bearing
   - Angular contact bearings (AC)
2. ***Roller bearings***
   - Cylindrical bearings
   - Needle bearings
   - Tapered bearings
   - Spherical bearings
3. ***Thrust bearings***
4. ***Linear bearings***

Ball Bearings

1. Deep groove (Conrad) bearing

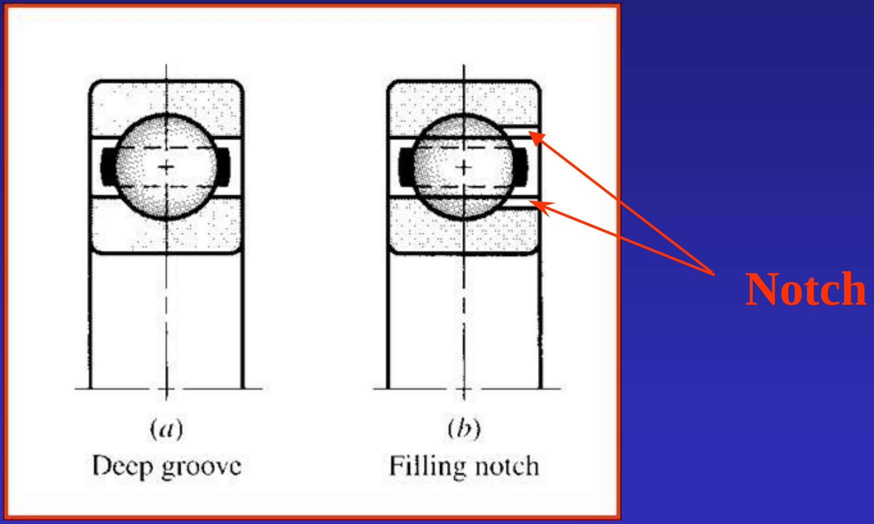


- Load capacity is limited by the number of balls
- Primarily designed to support radial loads, the thrust capacity is about 70% of radial load capacity

Ball Bearings

2. Filling notch or maximum capacity ball bearings

Bearings have the same basic radial construction as Conrad type. However, a ***filling notch*** (loading groove) permits more balls to be used.

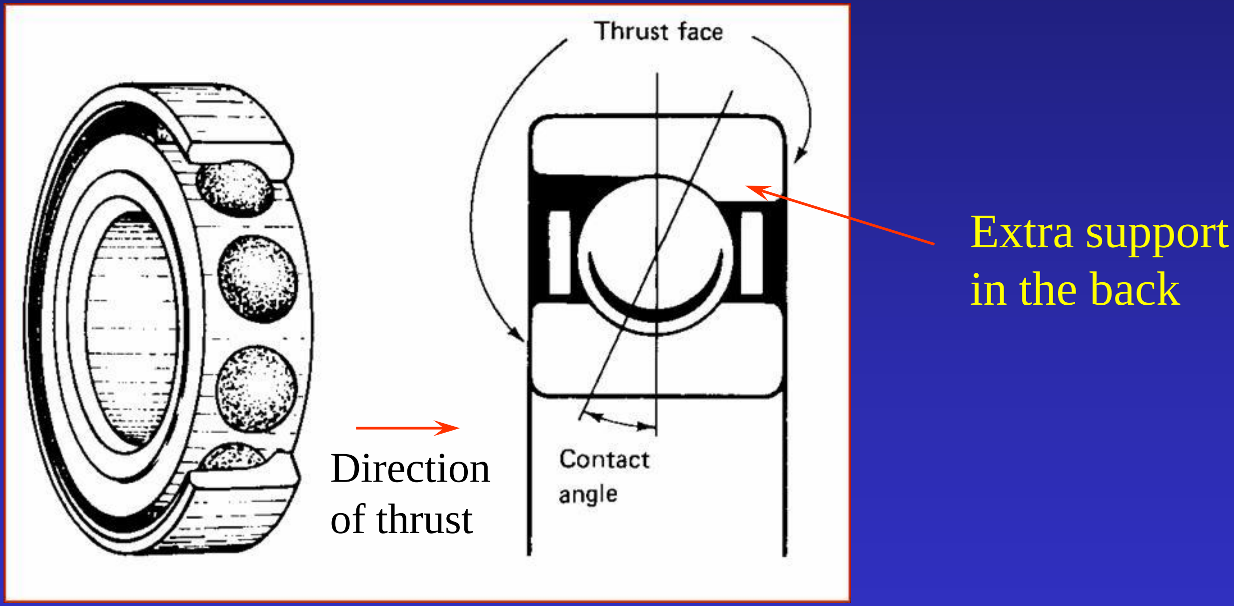


- Radial load capacity is 20 – 40% higher than Conrad type
- Thrust load capacity drops to 20% (2 directions) of radial load capacity.

Ball Bearings

3. Angular contact bearings (AC)

   The centerline of contact between the balls and the raceway is at an angle to the plane perpendicular to the axis of rotation.

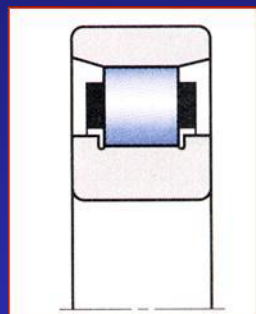


- Used for high radial and thrust load applications

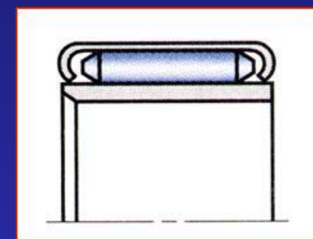
Roller Bearings

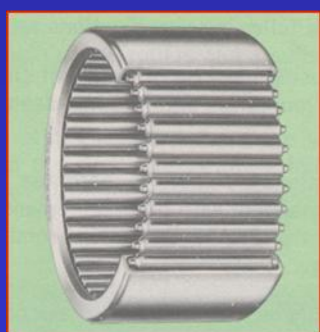
Roller bearings have higher load capacity than ball bearings, load is transmitted through line contact instead of point contact.

Straight cylindrical roller

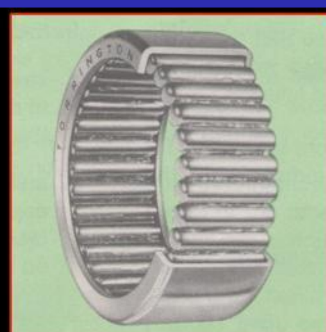


Needle type

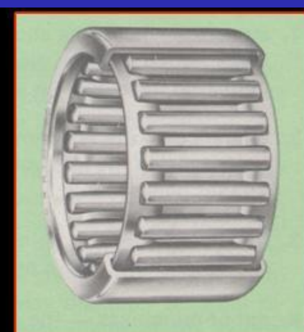




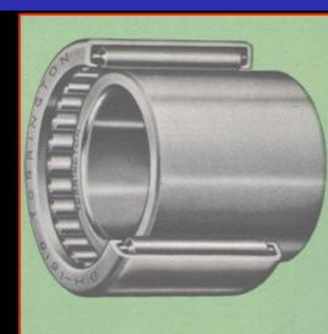
Mechanically retained rollers



Greased retained rollers



Caged

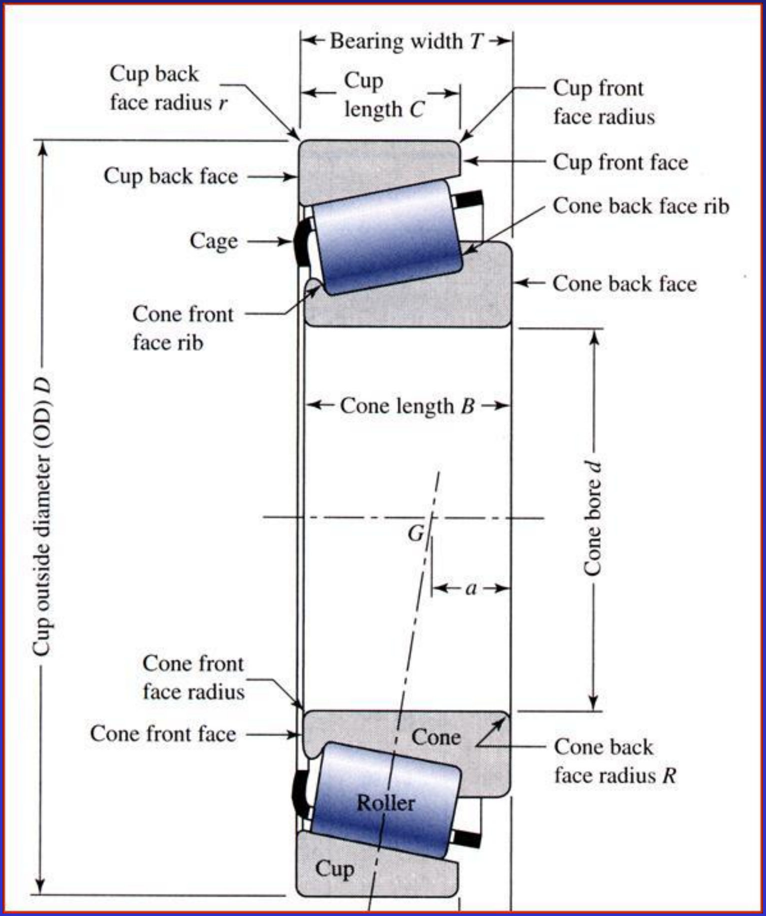


With inner race

Roller Bearings

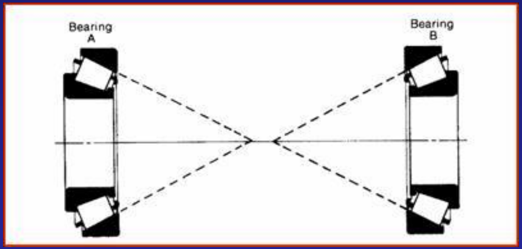
Tapered bearings

Designed to withstand high radial loads, high thrust loads, and combined loads at moderate to high speeds. They can also withstand repeated shock loads.



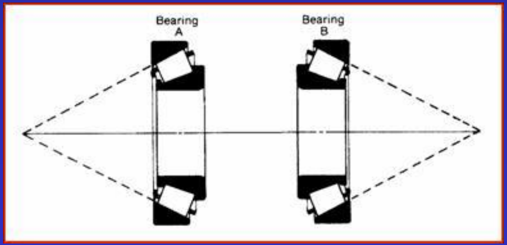
Tapered Bearings

Indirect and *Direct* mounting



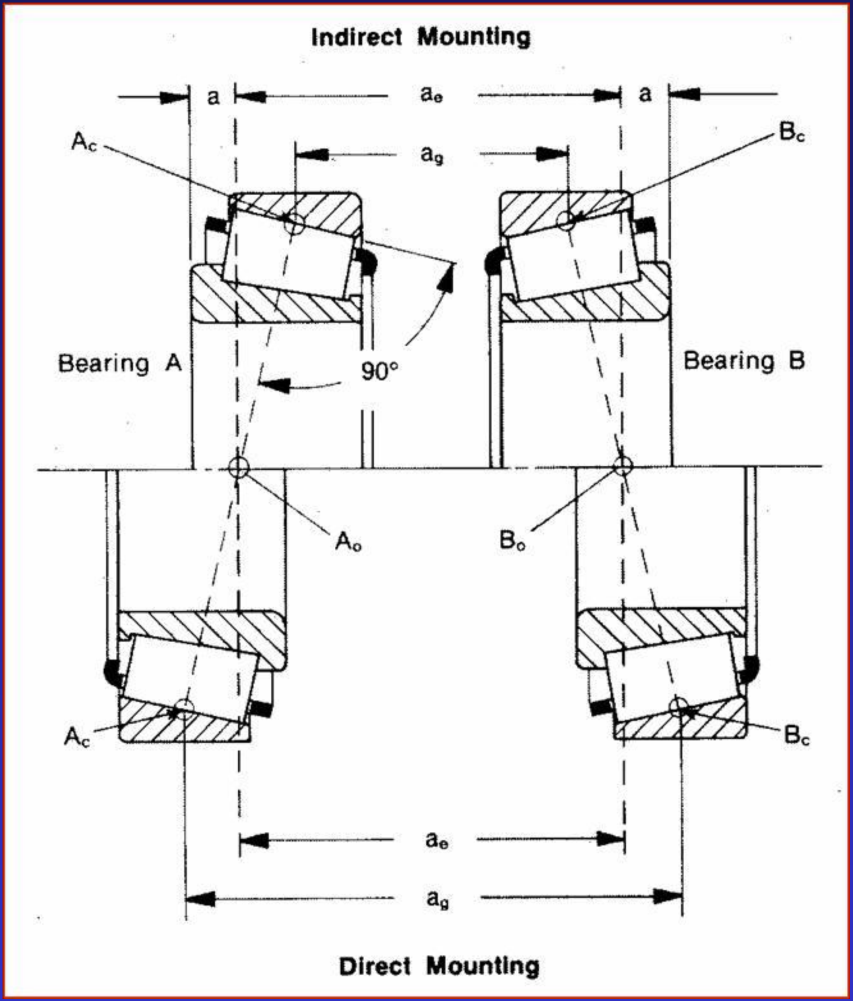
Indirect mounting

Indirect mounting provides greater rigidity when pair of bearings is **closely spaced**: front wheel of a car, drums, sheaves,..



Direct mounting

Direct mounting provides greater rigidity when pair of bearings is **not closely spaced**: transmission, speed reducers, rollers,..



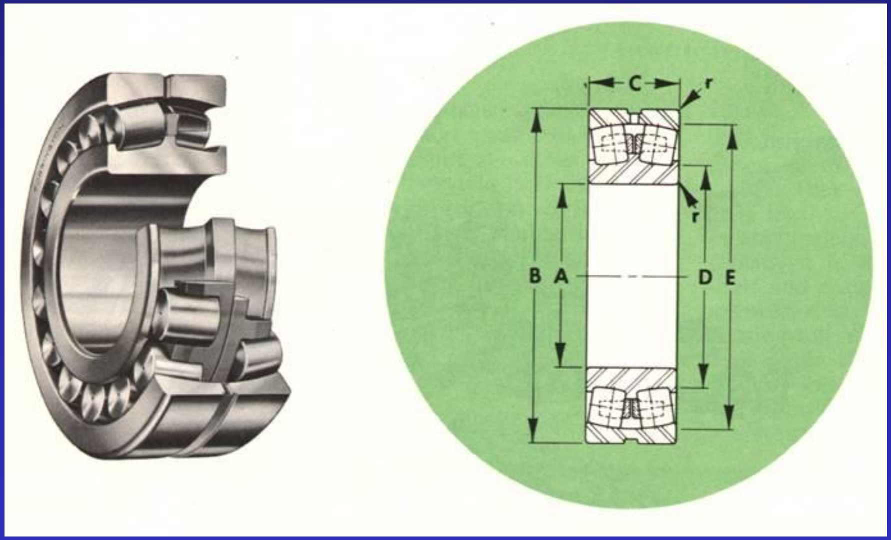
a_a = effective bearing spread

Measure of the rigidity of the bearing mounting

Roller Bearings

Spherical bearings

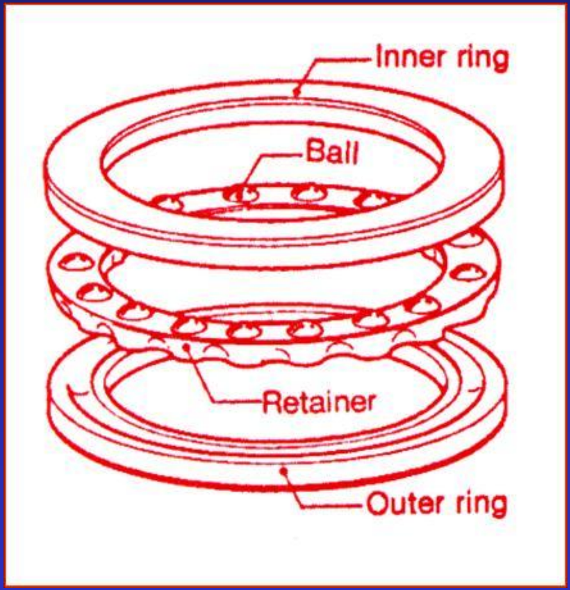
Bearing design uses barrel shaped rollers. Spherical roller bearings combine very high radial load capacity with modest thrust load capacity and *excellent tolerance to misalignment*.



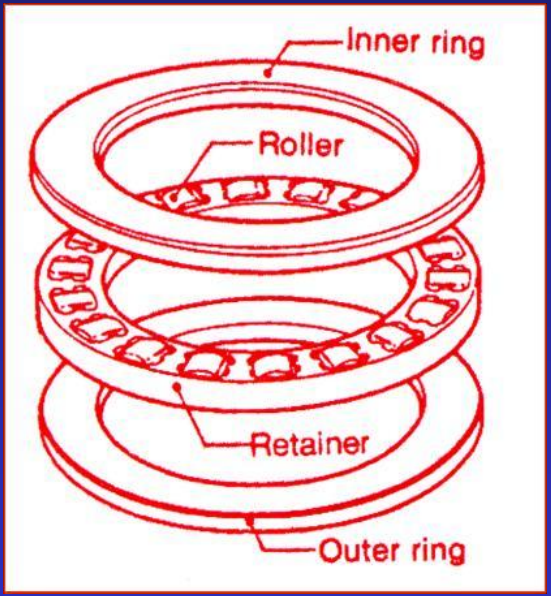
bearing number			nominal bearing dimensions							shoulder dimensions		weight lbs.	basic static capacity	§ approx. limiting speed	†basic dynamic capacity
series 222 straight bore	AFBMA reference number	series 222K tapered bore	A bore		B outside diameter		C width		*r	D max.	E min.	series 222 222K			
			mm	inch	mm	inch	mm	inch	inch	inch	inch		lbs.	rpm	lbs.
22207	35SD22	....	35	1.3780	72	2.8346	23	.9055	.04	1⅞	2 17/32	1.1	9500	5610	**9100**
22208	40SD22	....	40	1.5748	80	3.1496	23	.9055	.04	2	2¾	1.1	11500	5000	**11000**
22209	45SD22	**22209 K**	45	1.7717	85	3.3465	23	.9055	.04	2 3/16	3	1.2	12800	4610	**12300**

Thrust Bearings

Ball thrust bearing

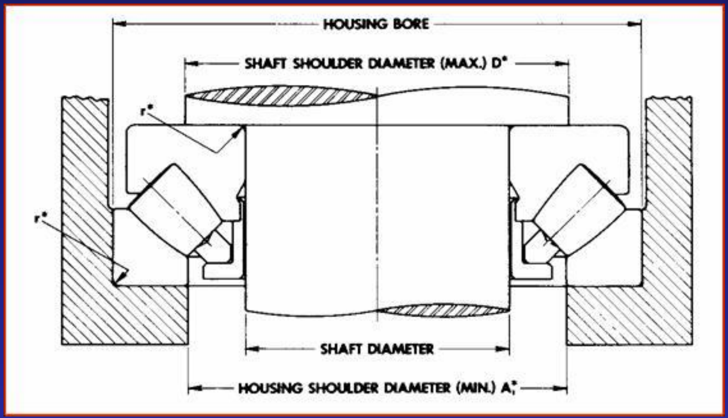


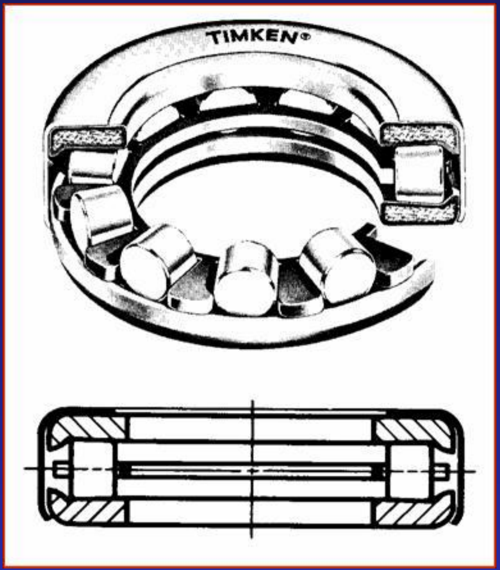
Roller thrust bearing



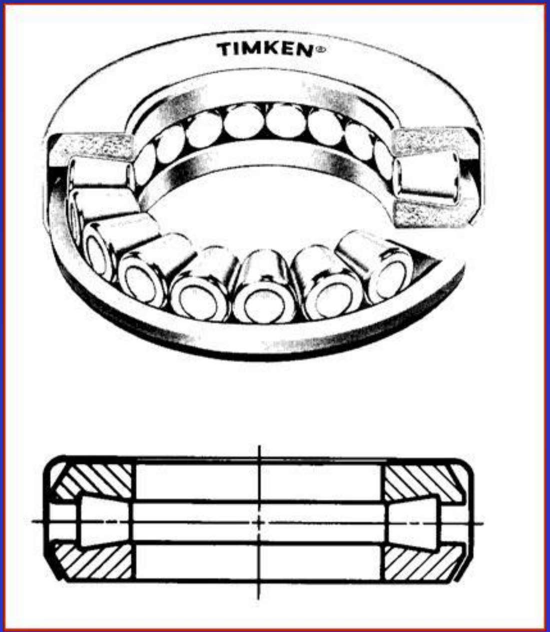
Roller Thrust Bearings

Spherical Thrust Bearings

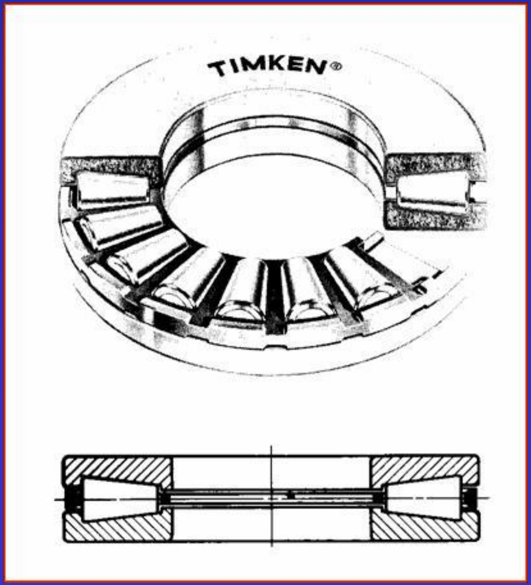




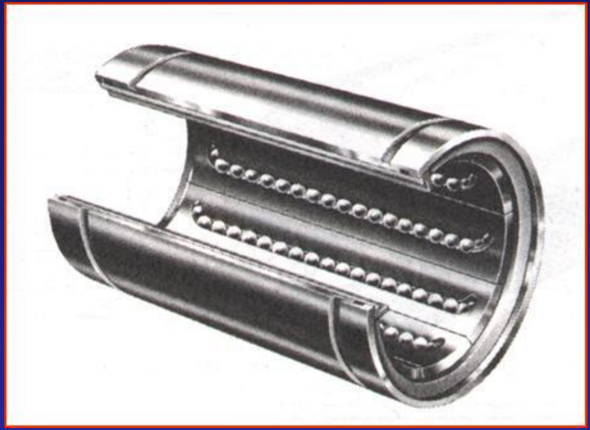
Cylindrical Thrust Bearings

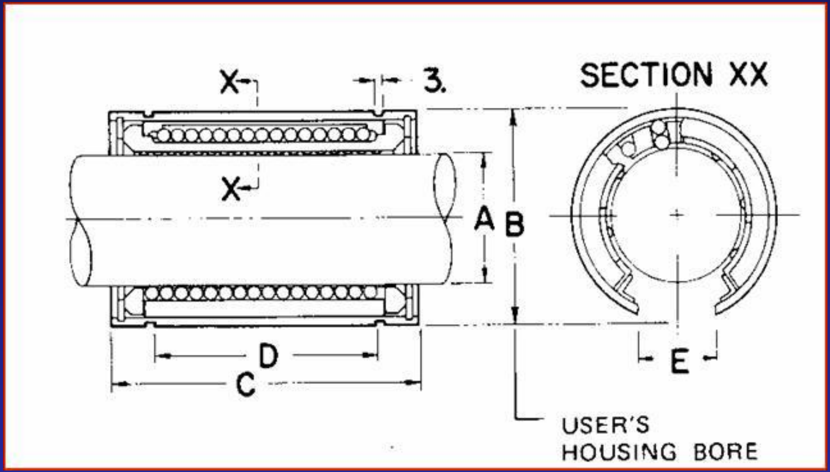


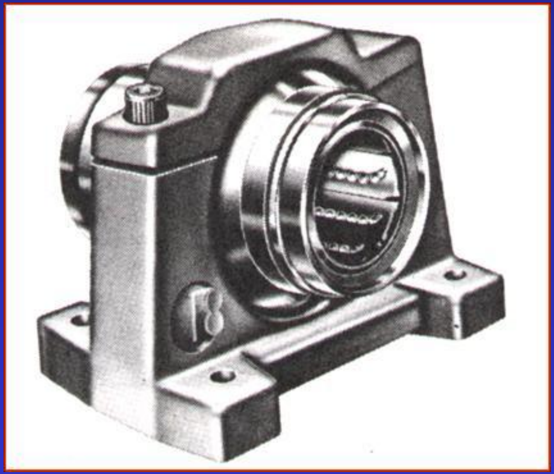
Tapered Thrust Bearings

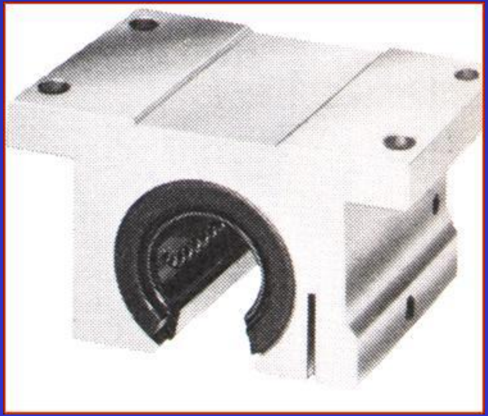


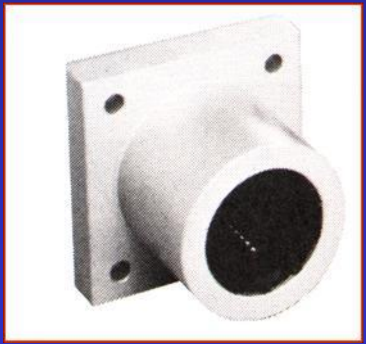
Linear Bearings

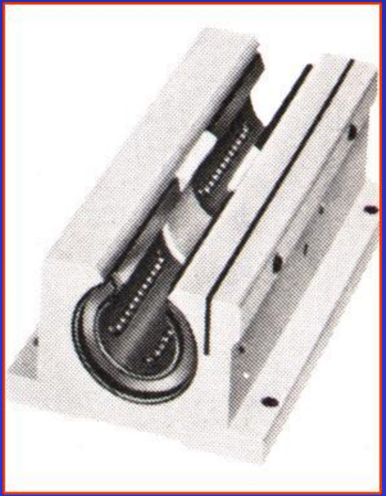






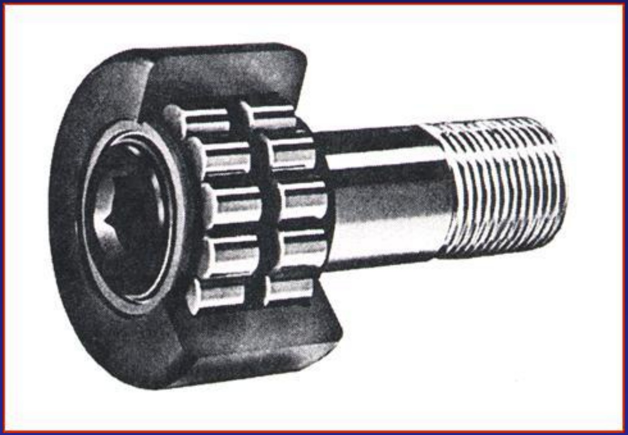




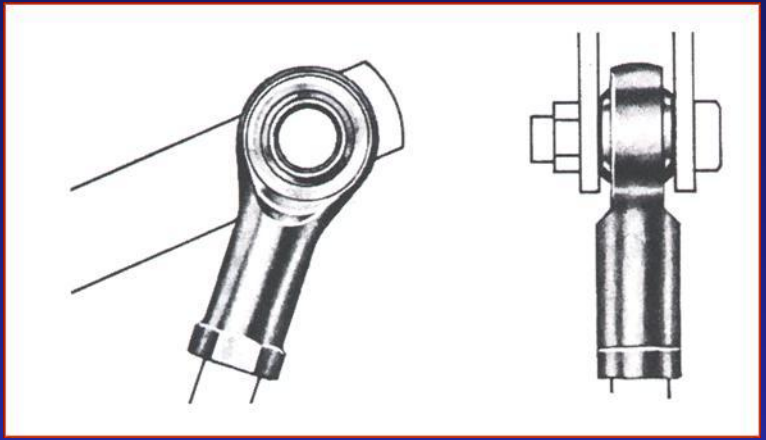


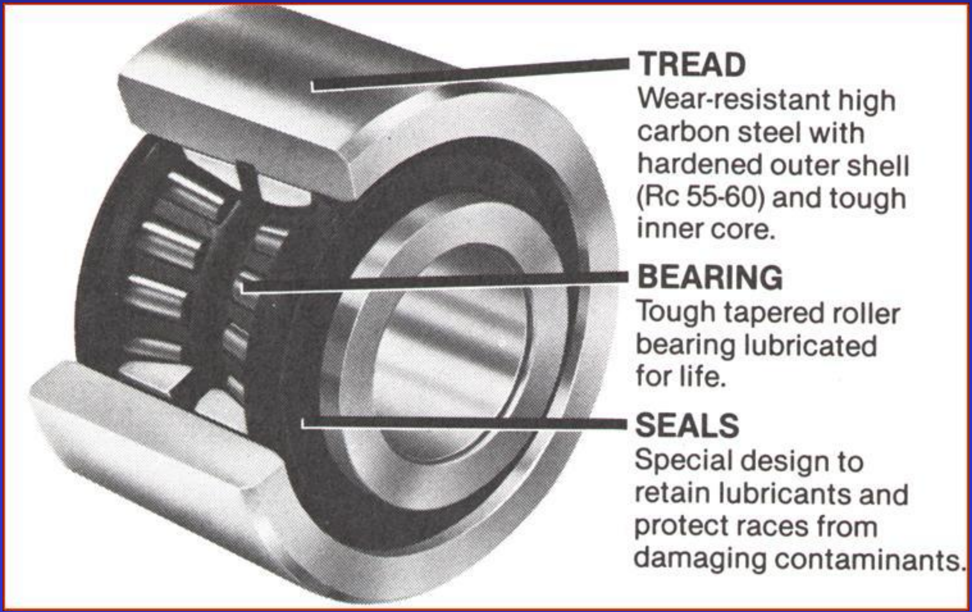
Bearings

Roller bearing cam follower



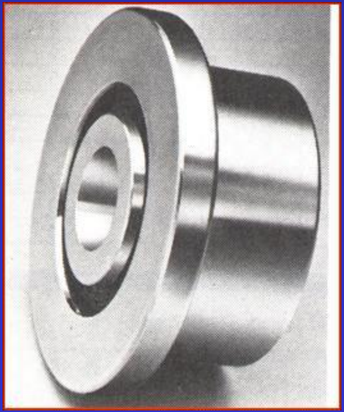
Spherical rod end



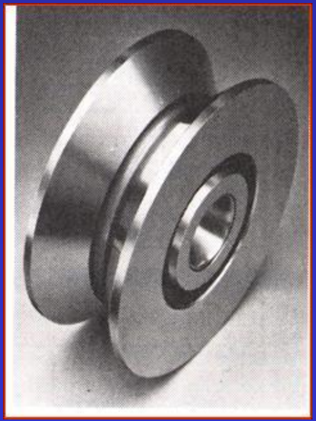


Load runners (idler-rollers)

Flanged

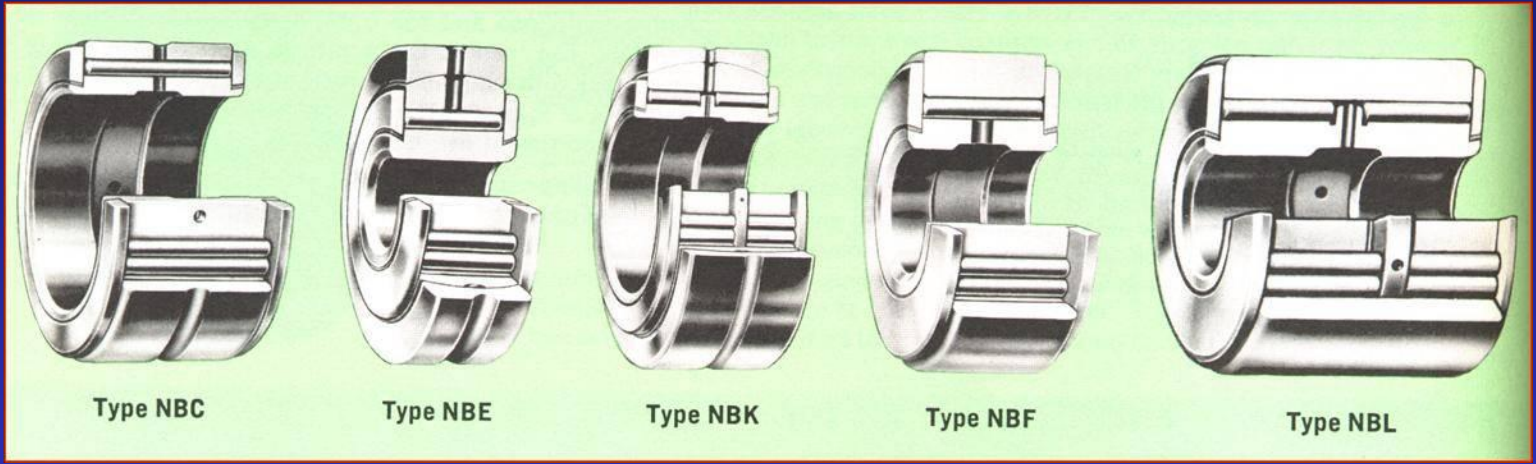


V-Grooved



Bearings

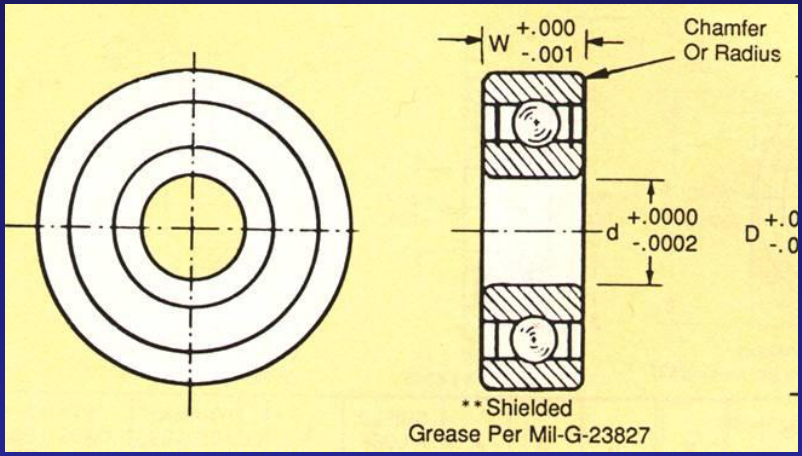
Airframe control bearings – designed to meet the specific needs of the airframe industry, meets military and national standards.



Designed to carry heavy static load and will also handle oscillation or slow rotation.

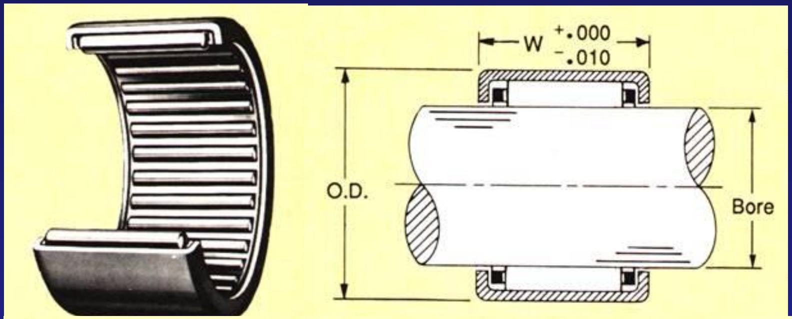
Track rollers, withstand heavy rolling loads.

Precision Bearings



STOCK NUMBER	1-9 PRICE	d	D	W	SHIELD DATA	DYNAMIC LOAD (LBS.)	STATIC LOAD (LBS.)
B1-37	$ 4.25	.0469	.1562	.0625	*	15	4
B1-37-S	5.46			.0937	**		
B1-38	$ 3.97	.0550	.1875	.0781	*	24	9
B1-38-S	5.04			.1094	**		
B1-33	$ 3.69	.0781	.2500	.0937	*	29	11
B1-33-S	4.86			.1406	**		
B1-34	$ 3.69	.0937	.3125	.1094	*	62	24
B1-34-S	5.01			.1406	**		
B1-35	$ 3.69	.1250	.2500	.0937	*	33	13
B1-35-S	4.73			.1094	**		
B1-36	3.59		.3125	.1094	*	62	24
B1-36-S	4.95			.1406	**		
B1-24	3.94		.3750	.1562	*	71	29
B1-5	5.23			.1562	**		
B1-42	$ 4.35	.1562	.3125	.1094	*	44	18
B1-42-S	6.13			.1250	**		
B1-40	$ 4.44	.1875	.3125	.1094	*	35	13
B1-40-S	5.69			.1250	**		
B1-25	3.97		.3750	.1250	*	79	33
B1-27	5.04			.1250	**		
B1-26	4.36		.5000	.1562	*	139	60
B1-7	5.41			.1960	**		
B1-29	$ 4.92	.2500	.3750	.1250	*	38	18
B1-30	5.78			.1250	**		
B1-31	4.40		.5000	.1250	*	128	55
B1-32	5.41			.1875	**		
B1-28	4.59		.6250	.1960	*	159	71
B1-9	5.69			.1960	**		
B1-43	$7.48	.3125	.5000	.1562	*	95	47
B1-43-S	8.38			.1562	**		
B1-39	$ 11.70	.3750	.8750	.2188	*	451	219
B1-13	12.38			.2812	**		
B1-44	$ 17.19	.5000	.8750	.2188	*	203	114
B1-44-S	18.38			.2812	**		

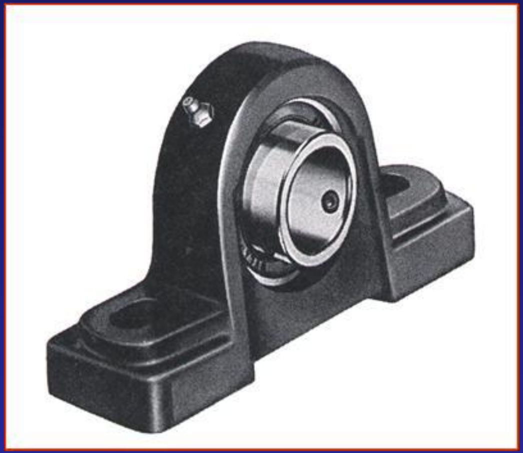
Precision Bearings – High rpm Applications



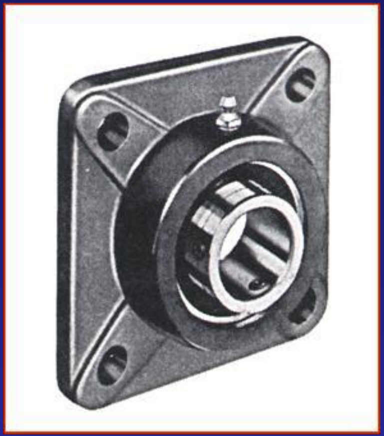
							LOAD CAPACITIES		HARDENED SHAFTING (ORDER SEPARATELY) STOCK LENGTH 12 INCHES OTHER LENGTHS ON REQUEST	
STOCK NUMBER	1-9 PRICE	BORE	BRG. O.D.	HOUSING BORE DIA.	BRG. W	MAX. SPEED RPM	DYNAMIC (LBS.)	STATIC (LBS.)	SHAFTING* STOCK NUMBER	SHAFT DIA.
NRB-24	$ 3.82	1/8	.2500	.2500- .2505	.250	70,000	161	80	—	.1250-.1247
NRB-34	3.30	3/16	.3438	.3432- .3437	.250	70,000	335	185	—	.1875-.1872
NRB-36	3.30	3/16	.3438	.3432- .3437	.375	70,000	540	345	—	.1875-.1872
NRB-44	3.30	1/4	.4375	.4370- .4380	.250	55,000	315	162	—	.2500-.2495
NRB-47	2.30	1/4	.4375	.4370- .4380	.438	55,000	800	540	—	.2500-.2495
NRB-55	2.30	5/16	.5000	.4995- .5005	.312	44,000	570	350	—	.3125-.3120
NRB-59	2.58	5/16	.5000	.4995- .5005	.562	44,000	1,160	880	—	.3125-.3120
NRB-65	2.58	3/8	.5625	.5620- .5630	.312	37,000	600	380	LMS-46-12	.3750-.3745
NRB-610	2.30	3/8	.5625	.5620- .5630	.625	37,000	1,440	1,180	LMS-46-12	.3750-.3745
NRB-86	2.45	1/2	.6875	.6870- .6880	.375	27,000	900	670	LMS-48-12	.5000-.4995
NRB-812	2.56	1/2	.6875	.6870- .6880	.750	27,000	1,930	1,780	LMS-48-12	.5000-.4995
NRB-107	2.56	5/8	.8125	.8120- .8130	.438	22,000	1,290	1,140	LMS-50-12	.6250-.6245
NRB-1012	2.76	5/8	.8125	.8120- .8130	.750	22,000	2,360	2,410	LMS-50-12	.6250-.6245
NRB-126	2.61	3/4	1.0000	.9995-1.0005	.375	18,000	1,390	1,030	LMS-52-12	.7500-.7495
NRB-1212	2.90	3/4	1.0000	.9995-1.0005	.750	18,000	3,000	2,750	LMS-52-12	.7500-.7495
NRB-168	3.22	1″	1.2500	1.2495-1.2505	.500	14,000	2,180	2,060	LMS-56-12	1.0000-.9995
NRB-1616	3.51	1″	1.2500	1.2495-1.2505	1.000	14,000	4,650	5,200	LMS-56-12	1.0000-.9995

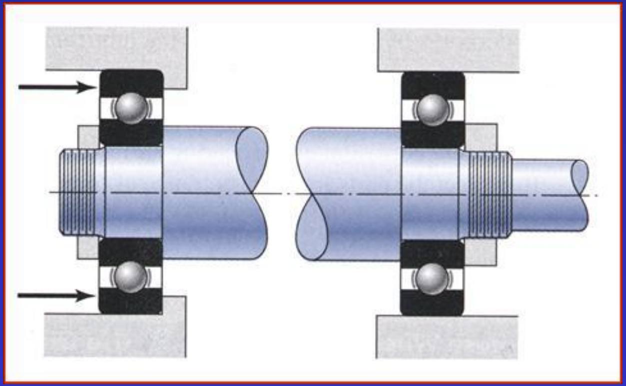
Mounting Bearings

Pillow Block

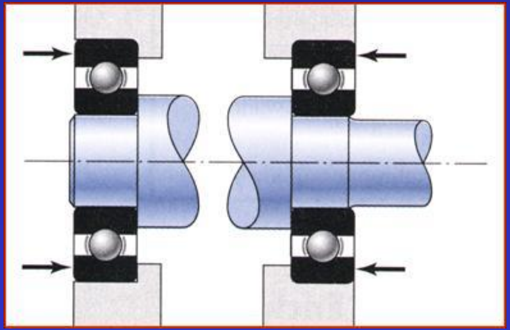


Flange

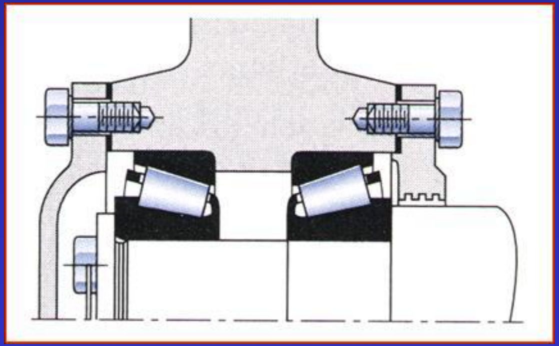




Common mounting, inner ring held in position by nuts threaded onto the shaft.

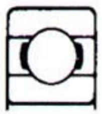
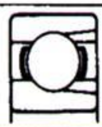
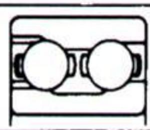
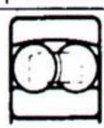


Alternative method, inner ring is press fitted onto the shaft.



Two-bearing mounting

Comparison of Ball Bearings

	Type	Size Range in Inches: Bore	Size Range in Inches: O.D.	Average Relative Ratings: Capacity: Radial	Average Relative Ratings: Capacity: Thrust	Average Relative Ratings: Limiting Speed	Average Relative Ratings: Permissible Misalignment	Available With: Shields	Available With: Seals	Available With: Snap Rings	Dimensions: Metric	Dimensions: Inch
BALL BEARINGS	CONRAD TYPE 	.1181 to 41.7323	.3750 to 55.1181	Good	Fair ↔	Conrad is basis for comparison 1.00	± 0° 8′ Std. Radial Clearance. ± 0° 12′ C3 Clear	X	X	X	X	X
	MAXIMUM TYPE 	.6693 to 4.3307	1.5748 to 8.4646	Excellent	Poor ↔	1.00	± 0° 3′	X		X	X	
	ANGULAR CONTACT 15°/40°  15° / 40°	.3937 to 7.4803	1.0236 to 15.7480	Good	Good (15°) Excellent (40°) ←	1.00 / 0.70	± 0° 2′				X	
	ANGULAR CONTACT 35° 	.3937 to 4.3307	1.1811 to 9.4488	Excellent	Good ←	0.70	0°				X	
	SELF-ALIGNING 	.1969 to 4.7244	.7480 to 9.4488	Fair	Fair ↔	1.00	± 4°				X	

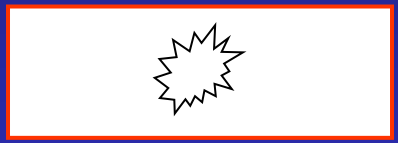
Bearing Comparison

	TYPE	SIZE RANGE IN INCHES		AVERAGE RELATIVE RATINGS				AVAILABLE WITH			DIMENSIONS	
		Bore	O.D.	Capacity: Radial	Capacity: Thrust	Limiting Speed	Permissible Misalignment	Shields	Seals	Snap Rings	Metric	Inch
BALL BEARINGS	CONRAD TYPE	.1181 to 41.7323	.3750 to 55.1181	Good	Fair ↔	Conrad is basis for comparison 1.00	± 0° 8′ Std. Radial Clearance. ± 0° 12′ C3 Clear	X	X	X	X	X
	MAXIMUM TYPE	.6693 to 4.3307	1.5748 to 8.4646	Excellent	Poor ↔	1.00	± 0° 3′	X		X	X	
	ANGULAR CONTACT 15°/40° (15° / 40°)	.3937 to 7.4803	1.0236 to 15.7480	Good	Good (15°) Excellent (40°) ←	1.00 / 0.70	± 0° 2′				X	
	ANGULAR CONTACT 35°	.3937 to 4.3307	1.1811 to 9.4488	Excellent	Good ←	0.70	0°				X	
	SELF-ALIGNING	.1969 to 4.7244	.7480 to 9.4488	Fair	Fair ↔	1.00	± 4°				X	
CYLINDRICAL ROLLER BEARINGS	SEPARABLE INNER RING NON-LOCATING	.4724 to 19.6850	1.2598 to 28.3465	Excellent	0	1.00	± 0° 4′				X	
	SEPARABLE INNER RING ONE DIR. LOCATING	.4724 to 12.5984	1.2598 to 22.8346	Excellent	Poor ←	1.00	± 0° 4′				X	
	SELF-CONTAINED TWO DIR. LOCATING	.4724 to 3.9370	1.4567 to 8.4646	Excellent	Poor ↔	1.00	± 0° 4′				X	
TAPERED ROLLER BEARINGS	SEPARABLE	.6205 to 6.0000	1.5700 to 10.0000	Good	Good →	0.60	± 0° 2′				X	X
SPHERICAL ROLLER BEARINGS	SELF-ALIGNING	.9843 to 12.5984	2.0472 to 22.8346	Good	Fair ↔	0.50	± 4°				X	
	SELF-ALIGNING	.9843 to 35.4331	2.0472 to 46.4567	Excellent	Good ↔	0.75	± 1°				X	
NEEDLE BEARINGS	COMPLETE BEARINGS with or without locating rings & lubricating groove	.2362 to 14.1732	.6299 to 17.3228	Good	0	0.60	± 0° 2′		X		X	X
	DRAWN CUP	.1575 to 2.3622	.3150 to 2.6772	Good	0	0.30	± 0° 2′				X	X
THRUST BEARINGS	SINGLE DIRECTION BALL Grooved Race	.2540 to 46.4567	.8130 to 57.0866	Poor	Excellent →	0.30	0°				X	X
	SINGLE DIRECTION CYL. ROLLER	1.1811 to 23.6220	1.8504 to 31.4960	0	Excellent →	0.20	0°				X	
	SELF-ALIGNING SPHERICAL ROLLER	3.3622 to 14.1732	4.3307 to 22.0472	Poor	Excellent →	0.50	± 3°				X	

Bearing Life

If a bearing is clean, properly lubricated and mounted and is operating at reasonable temp., failure is due to fatigue caused by ***repeated contact stresses*** (Hertzian stress)

Fatigue failure consists of a spalling or pitting of the curved surfaces



Spalling – crack initiates below the curved surface at the location of maximum shear stress, propagates to the surface causing surface damage.

Failure criterion – spalling or pitting of an area of 0.01 in^2,

Timken company (tapered bearings)

Bearing Life

Life – number of revolution or hours of operation, at constant speed, required for the failure criterion to develop.

Rating Life – defines the number of revolution or hours of operation, at constant speed, in such a way that **90%** of the bearings tested (from the same group) will complete or exceed before the first evidence of failure develops. This is known as $\mathbf{L_{10}}$ life.

For ball bearings and spherical bearings:

$L_{10} = 500 \text{ (hours) x } 33.33 \text{ (rpm) x } 60 = 10^6 = 1$ million revolutions

For tapered bearings manufactured by Timken:

$L_{10} = 3000 \text{ (hours) x } 500 \text{ (rpm) x } 60 = 90 \times 10^6 = 90$ million revolutions

Basic Dynamic Load Rating, C – constant radial load that a group of bearings can carry for L_{10} life.

Bearing Life

$L_{10} = (C / F)^a$, a = 3 for ball bearings and a = 10/3 for roller bearings

F = applied radial load

$$C_{10}\,(L_R n_R 60)^{1/a} = F_D\,(L_D n_D 60)^{1/a}$$

- C_{10}: catalog rating
- L_R: rating life in hours
- n_R: rating speed
- F_D: desired radial load, lb or kN
- L_D: desired life, hours
- n_D: desired speed, r/min

Solving for C_{10} gives

$$C_{10} = F_D \left(\frac{L_D n_D 60}{L_R n_R 60} \right)^{1/a}$$

Example

Select a deep groove ball bearing for a desired life of 5000 hours at 1725 rpm with 90% reliability. The bearing radial load is 400 lb.

$$C_{10} = F_D \left(\frac{L_D n_D 60}{L_R n_R 60} \right)^{1/a} = 400 \left[\frac{5000(1725)60}{10^6} \right]^{1/3} = 3211 \text{ lb } = 14.3 \text{ kN}$$

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm		Load Ratings, kN			
						Deep Groove		Angular Contact	
				d_S	d_H	C	C_0	C	C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0

Bearing Reliability

If a machine is assembled with 4 bearings, each having a reliability of 90%, then the reliability of the system is $(.9)^4 = .65 = 65\%$. This points out the need to select bearings with higher than 90% reliability.

The distribution of bearing failure can be best approximated by ***two and three parameter Weibull distribution.***

$$\frac{1}{R} = \exp\left[\left(\frac{L/L_{10} - 0.02}{4.439}\right)^{1.483}\right] \Rightarrow L_{10} = \frac{L}{0.02 + 4.439[\ln(1/R)]^{1/1.483}}$$

$$C_{10} = F_D\left(\frac{L_D n_D 60}{L_R n_R 60}\right)^{1/a} \Rightarrow C_{10} = F_D\left\{\frac{(L_D n_D / L_R n_R)}{0.02 + 4.439[\ln(1/R)]^{1/1.483}}\right\}^{1/a}$$

$$C_{10} = F_D\left\{\frac{(L_D n_D / L_R n_R)}{4.48[\ln(1/R)]^{1/1.5}}\right\}^{3/10}$$

Two parameter Weibull distribution for tapered bearings

C_{10} is the catalog basic dynamic load rating corresponding to L_R hours of life at the speed of n_R rpm.

Example

Select a deep groove ball bearing for a desired life of 5000 hours at 1725 rpm ***with 99% reliability***. The bearing radial load is 400 lb.

For 90% reliability

C_{10} = 14.3 kN $\Longrightarrow$ 30 mm Bore deep groove bearing

Use 99% reliability, R = .99

$$F_R = F_D \left\{ \frac{(L_D n_D / L_R n_R)}{0.02 + 4.439[\ln(1/R)]^{1/1.483}} \right\}^{1/a} = 23.7 \text{ kN}$$

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm d_S	Shoulder Diameter, mm d_H	Load Ratings, kN Deep Groove C	Deep Groove C_0	Angular Contact C	Angular Contact C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0

Select a 35 mm bearing instead of 30 mm for 90% reliability

$L_{new\ D} = L_D$ / .22 = 5000 / .22 = 22,770 hours

Design Life Suggestions and Load Factor

TYPE OF APPLICATION	LIFE, kh
Instruments and apparatus for infrequent use	Up to 0.5
Aircraft engines	0.5–2
Machines for short or intermittent operation where service interruption is of minor importance	4–8
Machines for intermittent service where reliable operation is of great importance	8–14
Machines for 8-h service which are not always fully utilized	14–20
Machines for 8-h service which are fully utilized	20–30
Machines for continuous 24-h service	50–60
Machines for continuous 24-h service where reliability is of extreme importance	100–200

Multiply design load by load factor.

TYPE OF APPLICATION	LOAD FACTOR
Precision gearing	1.0–1.1
Commercial gearing	1.1–1.3
Applications with poor bearing seals	1.2
Machinery with no impact	1.0–1.2
Machinery with light impact	1.2–1.5
Machinery with moderate impact	1.5–3.0

Equivalent Radial Load

Bearings are usually operated with some combination of radial and thrust load. Catalog ratings are based only on radial loads. Follow the guideline in catalogs to obtain the equivalent radial load.

Equivalent Radial Load

$$P = XVF_r + YF_a$$

P = equivalent load

F_r = applied radial load (constant)

F_a = applied thrust load (constant)

Specified by bearing manufacturer:

X = radial factor

Y = thrust factor

V = rotational factor

Equivalent Radial Load

$$\text{if} \quad \frac{F_a}{VF_r} \le e \quad \text{then} \quad X = 1 \text{ and } Y = 0 \qquad (10.22b)$$

Factors V, X, and Y for Radial Bearings

Bearing Type			In Relation to the Load the Inner Ring is: Rotating	Stationary	Single Row Bearings 1): $\frac{F_a}{VF_r} > e$		Double Row Bearings 2): $\frac{F_a}{VF_r} \le e$		$\frac{F_a}{VF_r} > e$		e
			V	V	X	Y	X	Y	X	Y	
Radial Contact Groove Ball Bearings 3)	4) $\frac{F_a}{C_0}$	5) $\frac{F_a}{iZD_w^2}$									
	0.014	25				2.30				2.30	0.19
	0.028	50				1.99				1.99	0.22
	0.056	100				1.71				1.71	0.26
	0.084	150				1.55				1.55	0.28
	0.11	200	1	1.2	0.56	1.45	1	0	0.56	1.45	0.30
	0.17	300				1.31				1.31	0.34
	0.28	500				1.15				1.15	0.38
	0.42	750				1.04				1.04	0.42
	0.56	1000				1.00				1.00	0.44
20°					0.43	1.00		1.09	0.70	1.63	0.57
25°					0.41	0.87		0.92	0.67	1.44	0.68
30°			1	1.2	0.39	0.76	1	0.78	0.63	1.24	0.80
35°					0.37	0.66		0.66	0.60	1.07	0.95
40°					0.35	0.57		0.55	0.57	0.93	1.14
Self-Aligning Ball Bearings			1	1	0.40	0.4 cot α	1	0.42 cot α	0.65	0.65 cot α	1.5 tan α
Self-Aligning and Tapered Roller Bearings			1	1.2	0.40	0.4 cot α	1	0.45 cot α	0.67	0.67 cot α	1.5 tan α

1) For single row bearings, when $\frac{F_a}{VF_r} \leqq e$ use $X = 1$ and $Y = 0$.

For two single row angular contact ball or roller bearings mounted "face-to-face" or "back-to-back" the values of X and Y which apply to double row bearings. For two or more single row bearings mounted "in tandem" use the values of X and Y which apply to single row bearings.

2) Double row bearings are presumed to be symmetrical.

3) Permissible maximum value of $\frac{F_a}{C_0}$ depends on the bearing design.

4) C_0 is the basic static load rating.

5) Units are pounds and inches.

Values of X, Y and e for a load or contact angle other than shown in the table are obtained by linear interpolation.