



INDUSTRIALHUB BD

RELIABILITY & ENGINEERING SERVICE PARTNER

BEARING FUNDAMENTALS & SELECTION GUIDE

Know the bearing types, read the load, life and fit, choose the right rolling bearing and read every bearing number code: a practical guide for plant engineers.



How to use this guide

For engineers and buyers who choose, check or replace rolling bearings: types, selection, fits, lubrication and the meaning of every bearing number code.

A**Know the types**

Structure, load direction, classification, every main bearing type

PAGES 3 to 16

B**Choose and size**

Selection flow, arrangement, loads, life, equivalent load

PAGES 17 to 24

C**Fit and finish**

Fits, clearance, preload, speed, lubricant, seals, examples, checklist

PAGES 25 to 34

D**Standard sizes**

Boundary dimensions, bore sizes, dimension series

PAGES 35 to 37

E**Reading bearing numbers**

Structure, series, prefix, suffix, codes for every type, decoded numbers

PAGES 38 to 53

F**Water pump bearings**

RWF and BWF numbers, sizes and fitting

PAGES 54 to 55

Read this first: a catalogue rating or table is the final word. Use this guide to choose, then confirm the size, fit and number code in the maker's catalogue.

What a bearing does

A rolling bearing carries a rotating shaft with little friction. It puts rolling elements between two rings, so sliding becomes rolling.

■ Parts of a bearing

Part	Job
Inner ring	Fits on the shaft; has the inner raceway
Outer ring	Fits in the housing; has the outer raceway
Rolling elements	Balls or rollers that carry the load between the rings
Cage	Spaces the rolling elements and guides them
Seals or shields	Keep grease in and dirt out (some types)



WHAT A BEARING MUST DO

Support the shaft

Hold its position radially and axially.

Carry the load

Pass radial, axial or combined load to the housing.

Allow rotation

Low friction, low heat, low wear.

WHY ROLLING BEATS SLIDING

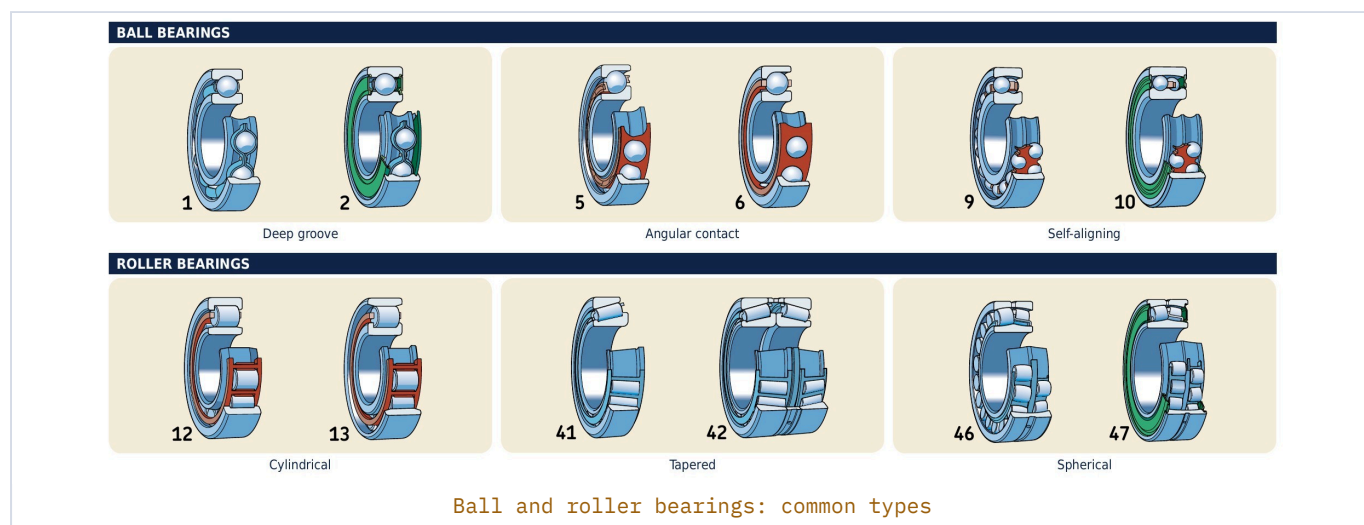
- Starting friction is small, so starting torque is low
- Friction changes little with speed
- Standard sizes are interchangeable between makers
- Bearings need less lubricant and less attention than plain bearings
- Rolling bearings are limited by fatigue life, not by wear alone

Life ends by fatigue. A correctly chosen, fitted and lubricated bearing fails by rolling fatigue after a calculable time; everything else is avoidable.

Ball and roller bearings

The first choice is balls or rollers. It sets load capacity, speed, rigidity and noise.

	Ball bearing	Roller bearing
Contact	Point contact; oval contact surface under load	Line contact; roughly rectangular surface under load
Friction	Little rolling resistance, low torque	Higher torque than ball bearings
Speed	Suited to high speed	Lower limiting speed
Load capacity	Lower; radial types also take axial load	Higher; paired tapered rollers take axial load both ways
Rigidity	Lower	Higher
Noise	Quiet running	Slightly noisier



RULE OF THUMB

GENERAL PRACTICE

Choose balls when

Speed is high, load is light to moderate, torque and noise must be low.

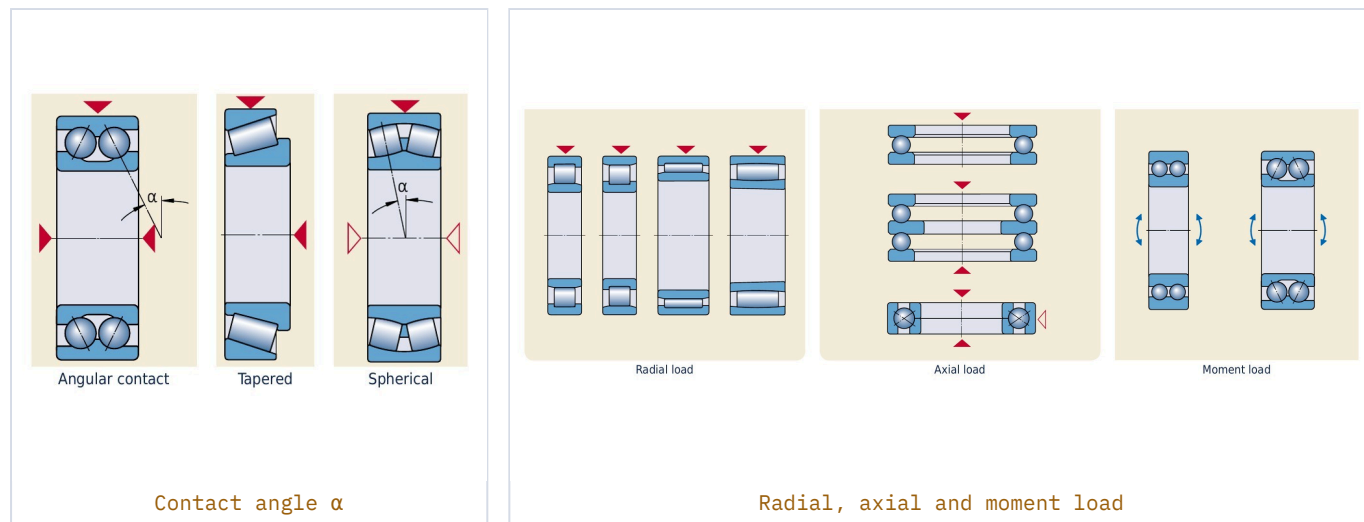
Choose rollers when

Load is heavy or shock is present, rigidity matters, speed is moderate.

Capacity costs speed. Moving from a ball to a roller bearing of the same size raises load capacity but lowers the speed limit.

Contact angle and load direction

The contact angle is the angle between the line of load through the rolling element and the plane of the bearing. A larger angle means more axial capacity and less radial.



LOAD DIRECTIONS

Load	Direction	Suited types
Radial load F_r	At right angles to the shaft axis	Deep groove, cylindrical, needle
Axial load F_a	Along the shaft axis	Thrust bearings; angular contact, tapered
Combined load	Radial and axial together	Angular contact, tapered, spherical roller, deep groove
Moment load	Tilting the shaft; seen in pairs	Paired angular contact or tapered; four-point

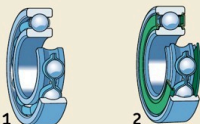
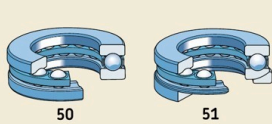
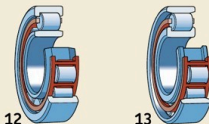
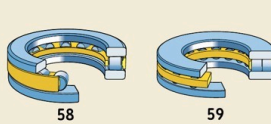
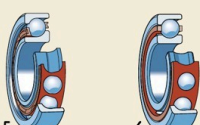
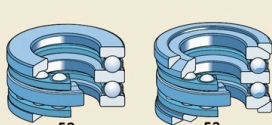
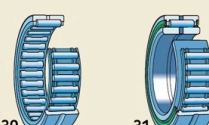
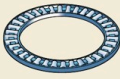
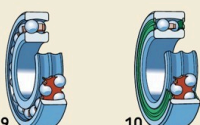
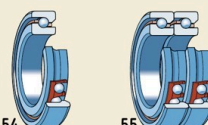
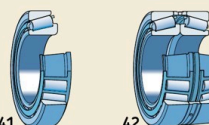
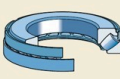
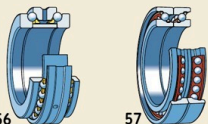
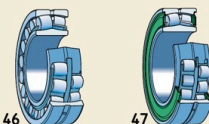
CONTACT ANGLE CODES

Contact angle (angular contact ball)	Code
15°	C
18°	CE1
25°	AD
30°	A (may not be shown)
40°	B

Steeper angle, more thrust. A 40° angular contact bearing takes more axial load than a 15° one but runs slower.

Classification of bearings

Rolling bearings divide first into ball and roller bearings, then by load direction. This tree gives the main types in this guide.

RADIAL BALL	THRUST BALL	RADIAL ROLLER	THRUST ROLLER
 1 2 Deep groove	 50 51 Single direction	 12 13 Cylindrical	 58 59 Cylindrical thrust
 5 6 Angular contact	 52 53 Double direction	 30 31 Needle roller	 60 Needle thrust
 9 10 Self-aligning	 54 55 Angular contact thrust	 41 42 Tapered	 61 Spherical thrust
 8 Four-point contact	 56 57 High-speed double	 46 47 Spherical	 62 63 Tapered thrust

READING THE TREE

Radial ball

Deep groove, angular contact, self-aligning, four-point.

Thrust ball

Single and double direction; high-speed angular contact.

Radial roller

Cylindrical, needle, tapered, spherical.

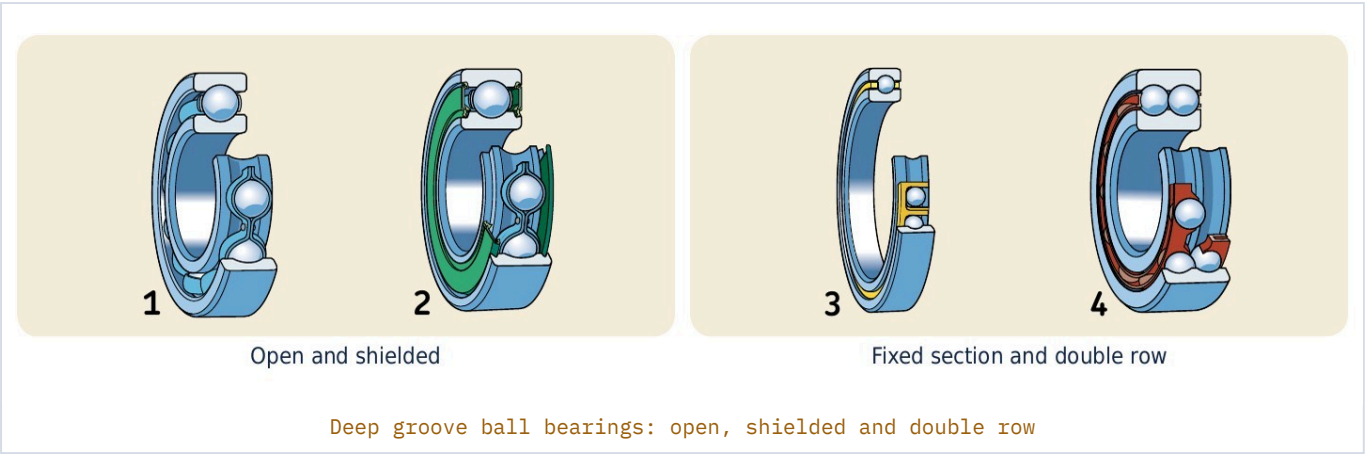
Thrust roller

Cylindrical, needle, tapered, spherical.

Start with the load direction. Radial bearings carry load across the shaft; thrust bearings carry load along it.

Deep groove ball bearings

The most common type. Deep, continuous raceway grooves let it carry radial load and light axial load in both directions at high speed.



FEATURES

Feature	What it means
Load	Radial, plus light axial load in both directions
Speed	High; low friction and low noise
Misalignment	Very small; keep shaft and housing in line
Versions	Open; shield ZZ or removable ZZA; seals LLB (non-contact), LLU (contact), LLH (low torque); snap ring groove N, NR
Cost and range	Widest size range and lowest cost; interchangeable between makers

TYPICAL USES

GENERAL PRACTICE

Electric motors, pumps and fans · Gearbox light-duty shafts · Conveyor idlers and rollers · Appliances and small machines

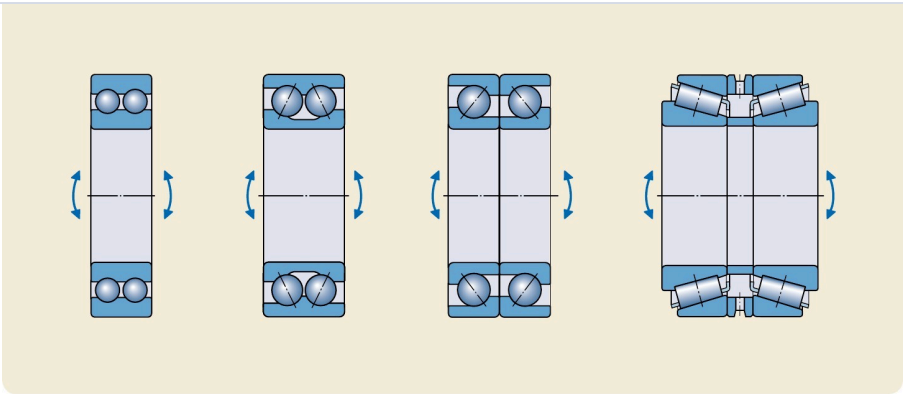
HOW THIS BEARING IS NUMBERED

6205ZZ C3 P5 Series: 68, 69, 60, 62, 63, 64	6	Type: deep groove ball, single row	C3	Clearance greater than normal
	2	Dimension series 2: width (0), diameter 2	P5	Tolerance class 5
	05	Bore number: 05 × 5 = 25 mm	TS2-	Prefix if used: stabilized to 160 °C
	ZZ	Shield on both sides		

Default choice for light to moderate load and speed. If thrust or shaft deflection is large, move to angular contact or a self-aligning type.

Angular contact ball bearings

The raceways are offset so that load acts at an angle. One bearing takes axial load in one direction only, so it is used in pairs or with a stop.



Single and paired angular contact and tapered roller bearings under tilting load

FEATURES

Feature	What it means
Load	Radial plus axial in one direction; pairs take axial both ways
Contact angle	C 15°, CE1 18°, AD 25°, A 30° (code may be omitted), B 40°; larger angle takes more axial load
Speed	High, especially at small angle with good lubrication
Pairs	DB back-to-back, DF face-to-face, DT tandem; set preload and rigidity
Special types	Double row and four-point types handle axial load both ways

TYPICAL USES

GENERAL PRACTICE

Machine tool spindles · Pumps with axial thrust · Gearboxes and worm drives · Compressors

HOW THIS BEARING IS NUMBERED

7014C T1 DB Series: 7, HSE, 5, BST	7	Series: standard angular contact ball	T1	Phenolic cage
	0	Diameter series 0	DB	Pair, back to back (DF face to face, DT tandem)
	14	Bore number: 14 × 5 = 70 mm	5S-	Prefix if used: ceramic balls
	C	Contact angle 15° (AD 25°, A 30°, B 40°)		

Never use a single one alone unless something else holds the shaft in the other direction. Pairing sets stiffness and preload.

Other ball bearings

Three more ball types solve special problems: shaft misalignment, axial load both ways in one bearing, and a combination of both.

SELF-ALIGNING BALL BEARING

Two rows of balls run in a common spherical outer-ring raceway. The bearing tolerates a small tilt between shaft and housing.

FOUR-POINT CONTACT BALL BEARING

The raceways touch each ball at four points. It carries axial load in both directions plus a small radial load, in one compact ring.

DOUBLE ROW ANGULAR CONTACT

Two angular rows in one bearing take radial and axial load both ways. Variants are open, shielded and sealed.

Type	Carries	Use when	Watch
Self-aligning ball	Radial, light axial both ways	Tilt of the shaft or housing out of line	Lower load capacity than roller types
Four-point contact	Axial both ways, small radial	Compact axial location, often with a cylindrical roller bearing	Needs a minimum axial load; speed lower
Double row angular contact	Radial and axial both ways	One bearing for a locating position	Moment capacity limited; seals vary

HOW THESE BEARINGS ARE NUMBERED

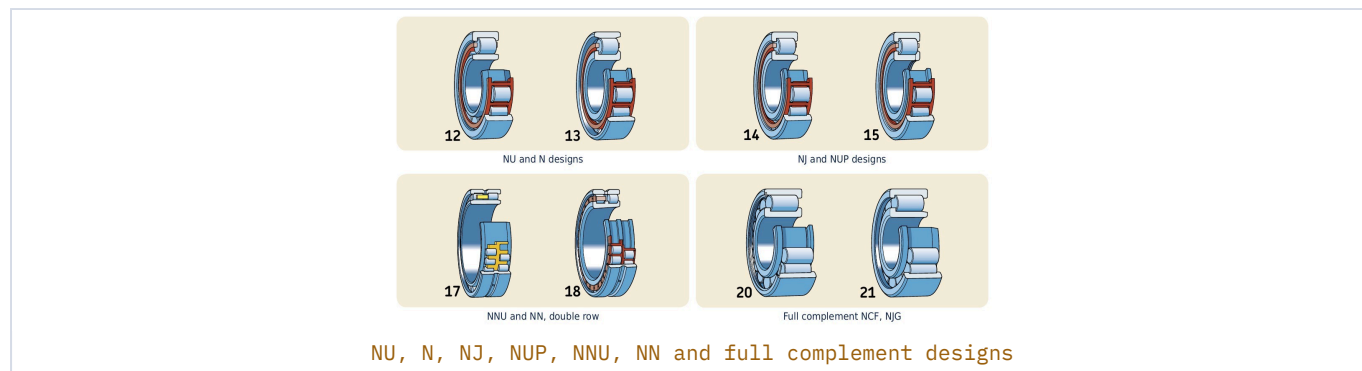
Number	Reading
1210 ETN9	Self-aligning ball: 1 type, (0)2 series, $10 \times 5 = 50$ mm; E optimized design; TN9 polyamide cage
QJ 212 MA	Four-point contact: QJ type, series 2, $12 \times 5 = 60$ mm; MA brass cage, outer ring centred
3210 A	Double row angular contact: series 32, $10 \times 5 = 50$ mm; A without filling slots

GENERAL PRACTICE Use these types where the direct choice (deep groove or a single angular contact) does not meet the duty. Confirm load limits and minimum axial load in the maker's catalogue.

One bearing, one problem. Pick a special ball bearing only for the problem it solves; otherwise it adds cost without benefit.

Cylindrical roller bearings

Line contact between rollers and raceways gives high radial capacity and high rigidity. Ring flanges set how much axial load the bearing can take.



FEATURES

Feature	What it means
Load	Heavy radial; NJ, NUP, NF and NH carry some axial load through the flanges
Speed	Higher than other roller types
Separable	Rings can be fitted apart, so both rings can have tight fits
NU and N	Free axial movement: use as the floating bearing
NUP and NH	Fix the shaft axially in both directions
Limits	Does not tolerate shaft tilt; keep alignment tight

TYPICAL USES

GENERAL PRACTICE

Large electric motors · Gearboxes and rolling-mill roll necks · Pumps and compressors · Machine tools and axles

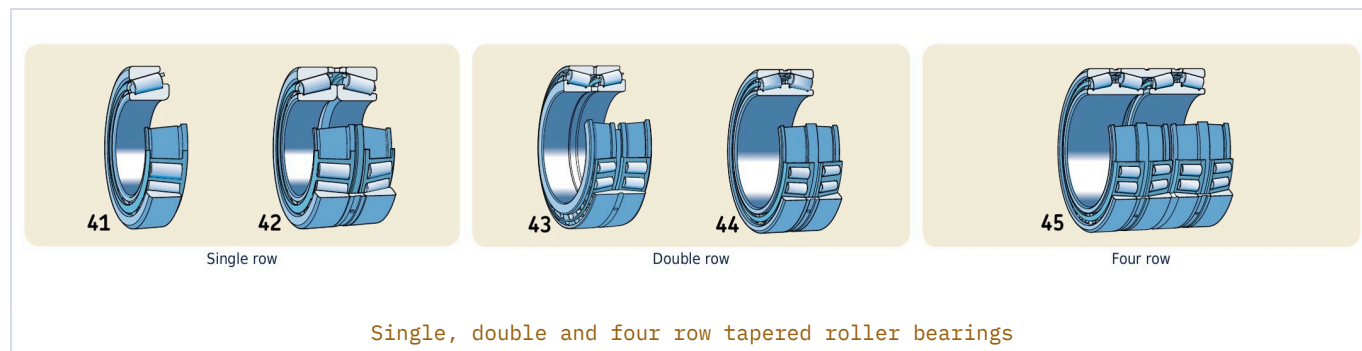
HOW THIS BEARING IS NUMBERED

NU2212 L1 C3 ISO series: 2, 3, 22, 23, 10	NU	Design: outer ring flanged, inner ring without flanges	L1	Machined brass cage
	22	Dimension series 22	C3	Clearance greater than normal
	12	Bore number: $12 \times 5 = 60$ mm	N, NJ, NUP, NF	Other flange layouts; NN, NNU are double row

Floating or locating, by type. NU and N float. NUP locates both ways. NJ and NF locate one way.

Tapered roller bearings

Tapered rollers run between tapered raceways, so one bearing carries combined radial and axial load. A single bearing takes axial load in one direction; pairs take it both ways.



Single row

Radial and one-way axial load. Needs a second bearing to oppose it.

Double and four row

Pre-assembled pairs for heavy machinery; fewer fitting steps.

FEATURES

Feature	What it means
Load	Heavy radial and axial combined; high shock capacity
Contact angle	The steeper the angle, the more axial load it takes
Setting	Must be adjusted to its working clearance or preload
Separable	Cup and cone fit apart; cone and rollers are one assembly
Pairs	Mounted face-to-face or back-to-back in two bearings

TYPICAL USES

GENERAL PRACTICE

Wheel hubs and axle boxes · Gearbox shafts · Rolling-mill and heavy machinery · Construction equipment

HOW THIS BEARING IS NUMBERED

32210 P5

ISO series: 302, 303, 322, 323, 330, 332

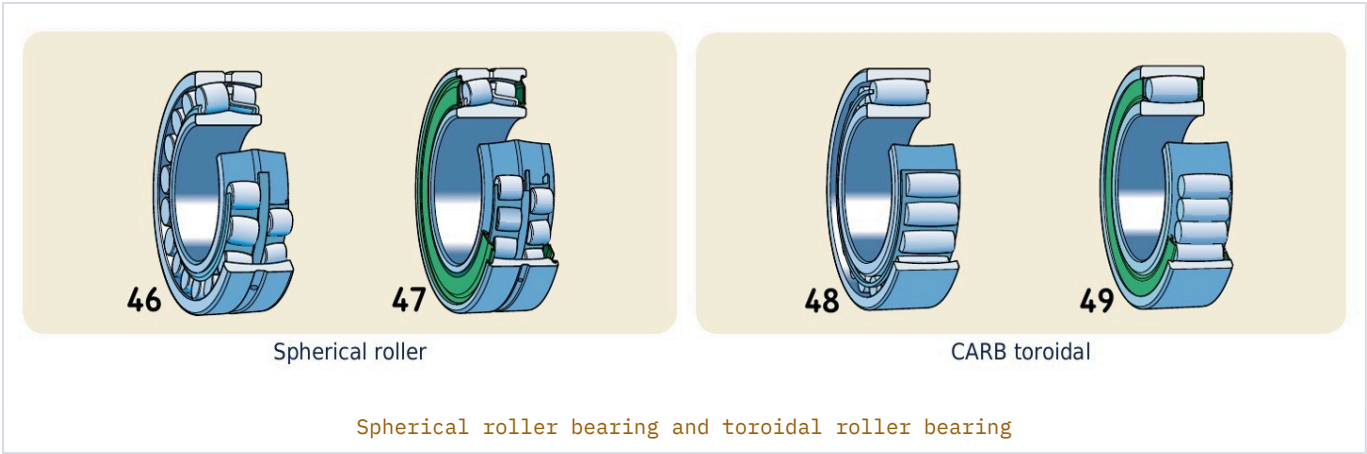
3 Type: tapered roller
22 Dimension series 22
10 Bore number: $10 \times 5 = 50$ mm

P5 Tolerance class 5
Inch series Cone and cup carry separate numbers, written as a pair

Adjustment is part of the bearing. Set end play or preload after fitting and check it again when hot.

Spherical roller bearings

Two rows of barrel rollers run in a spherical outer-ring raceway. They carry very heavy radial load and axial load both ways, and they tolerate misalignment.



FEATURES

Feature	What it means
Load	Very heavy radial, axial both ways, shock load
Misalignment	Self-aligning; accepts shaft deflection and mounting error
Speed	Moderate; sets limit by heat
Bore	Cylindrical or tapered; tapered bore uses an adapter or withdrawal sleeve
Cage	Steel or brass; the type differs by series

TYPICAL USES

GENERAL PRACTICE

Mine, quarry and steel plant machinery · Paper machines and fans · Gearboxes, crushers and screens · Large pumps

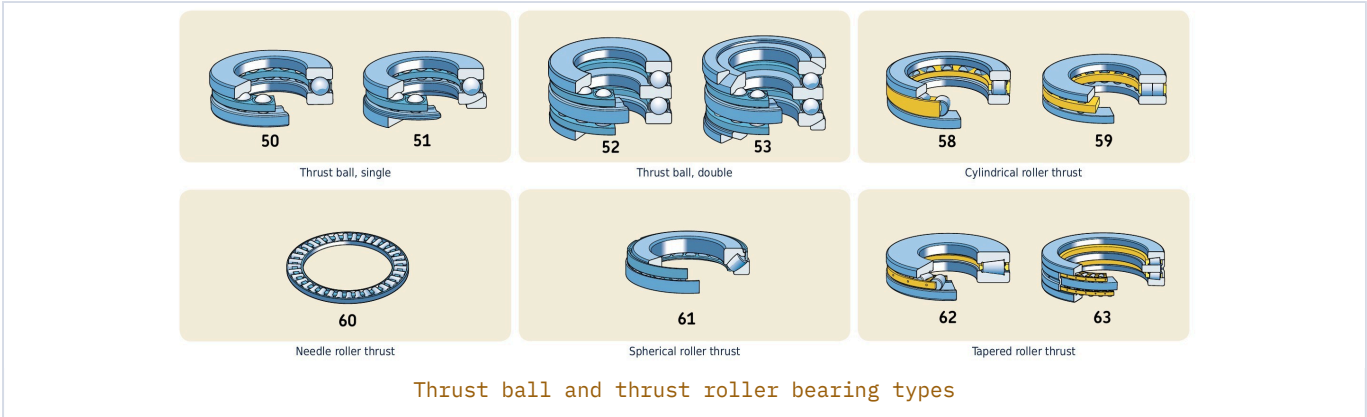
HOW THIS BEARING IS NUMBERED

22212K C3 ISO series: 222, 223, 230, 231, 232, 240, 241	2 Type: spherical roller 22 Dimension series 22 12 Bore number: 12 × 5 = 60 mm	K Tapered bore, taper 1:12 C3 Clearance greater than normal
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The heavy-duty general choice. Where load, shock and misalignment all appear, spherical roller bearings are usually the first candidate.

Thrust bearings

Thrust bearings carry axial load only. A radial bearing alongside must carry any radial load and hold the shaft.



FEATURES

Feature	What it means
Single direction thrust ball	Axial load one way; light load, low speed
Double direction thrust ball	Axial load both ways; a middle ring locates the shaft
Thrust cylindrical roller	High axial capacity; no speed or tilt tolerance
Thrust needle roller	Very compact; axial height is small
Spherical thrust roller	Heavy axial load; tilt tolerance; also takes some radial load
Rule	Needs a minimum axial load; not for radial load

TYPICAL USES

GENERAL PRACTICE

Vertical pumps and cranes · Hooks and swivels · Gearbox and screw-down thrust positions · Extruders

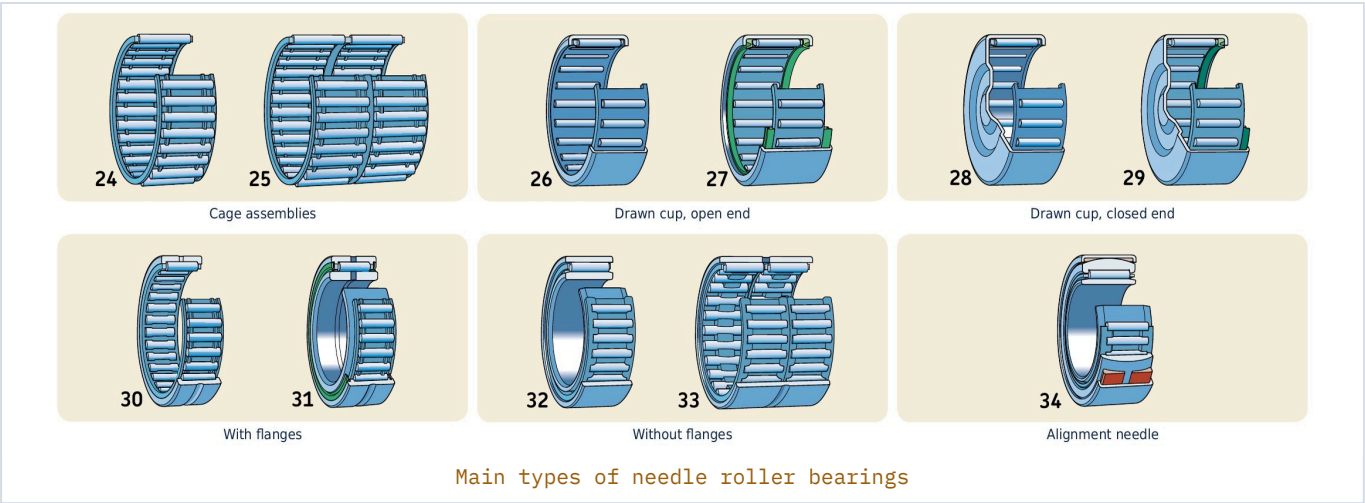
HOW THIS BEARING IS NUMBERED

51210 Series: 511 to 514	5	Type: thrust ball	522, 523, 524	Double direction series: 52210
	12	Series: height 1, diameter 2	292, 293, 294	Spherical roller thrust: 29412
	10	Bore code: 10 × 5 = 50 mm	811, 812	Cylindrical roller thrust: 81212

A thrust bearing carries axial load only. Do not rely on it for the radial position of the shaft.

Needle roller bearings

Needle rollers are thin and long, so a needle roller bearing is very light and thin in section. It carries heavy radial load in a small radial space.



FEATURES

Feature	What it means
Load	High radial load for its size; no axial load unless a thrust type
Section	Thin ring or no inner ring; saves radial space
Types	With cage, full complement, with or without inner ring, drawn cup
Speed	Moderate; oscillating motion suits needles well
Fit	Shaft or housing seat often acts as the raceway: hardness and finish matter

TYPICAL USES

GENERAL PRACTICE

Universal joints and rocker arms · Gearboxes and compact drives · Pumps and compressors · Oscillating mechanisms

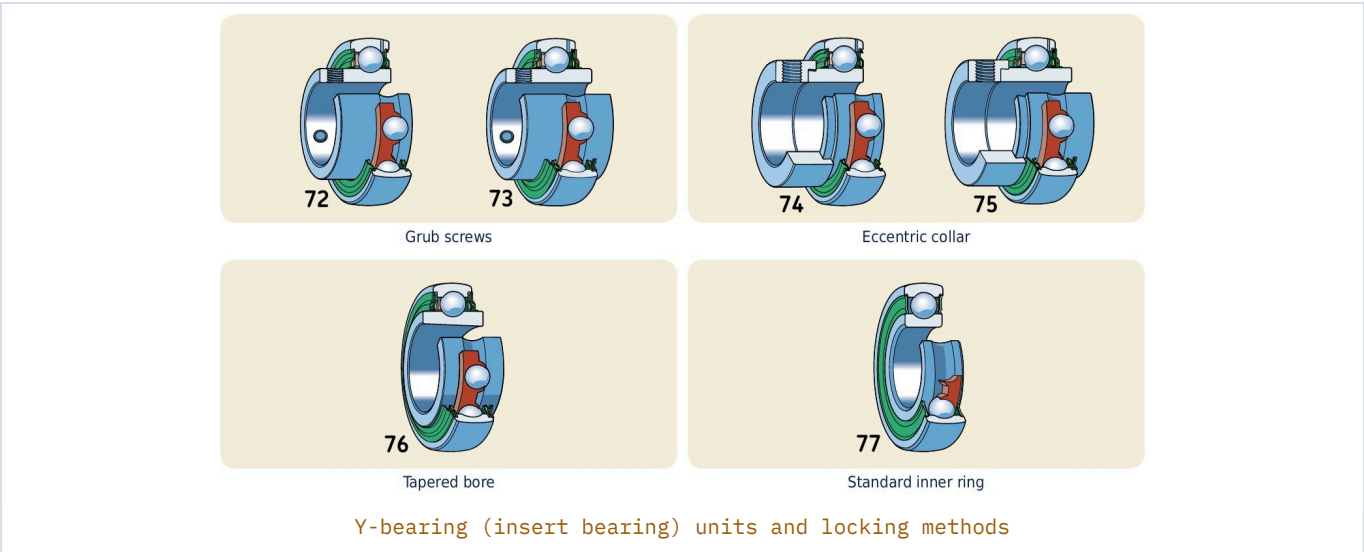
HOW THIS BEARING IS NUMBERED

NA 4910 Confirm in the maker's needle catalogue	NA	Needle roller bearing with inner ring	10	Bore code: 10 × 5 = 50 mm
	RNA	Same series without inner ring: RNA 4910	HK 2016	Drawn cup: shaft 20 mm, length 16 mm
	49	Dimension series 49		

Accurate seats are part of the bearing. When the shaft is the inner raceway, it must be hardened, ground and true.

Bearing units

A bearing unit is a ball bearing with a spherical outside diameter, mounted in a cast or pressed housing. It is a ready-fitted, greased and sealed assembly.



FEATURES

Feature	What it means
Parts	Insert bearing, housing, seals, and often a grease fitting
Alignment	Self-aligning insert fits the housing; absorbs small shaft misalignment
Fixing	Set screw, eccentric collar or adapter on the shaft
Housing types	Pillow block, flange, take-up and others
Benefit	Fast to fit and to replace; sealed against dirt

TYPICAL USES

GENERAL PRACTICE

Conveyors and belt drives · Agricultural and food machinery · Fans and light industrial shafts · Packaging equipment

HOW THIS BEARING IS NUMBERED

YAR 208-2F Confirm in the maker's unit catalogue	YAR 2 Insert bearing, set screw locking, series 2 YET 2 Eccentric collar locking	08 Bore code: 08 × 5 = 40 mm -2F Seals on both sides
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The easy fit for the ordinary shaft. Choose a unit for speed of maintenance; choose a plumber block and spherical roller for heavy duty.

Choosing the type

This table compares the main types on the points that decide the choice. Marks give general guidance; use the maker's catalogue for any real duty.

GENERAL PRACTICE

Type	Radial	Axial	Speed	Tilt	Remark
Deep groove ball	•••	•	••••	•	Low cost; first choice
Angular contact ball	•••	•••	••••	•	Pair for axial both ways
Self-aligning ball	••	•	•••	••••	Misalignment, light load
Cylindrical roller	••••	◦ to •	•••	•	NU floats; high radial
Tapered roller	••••	••••	••	•	Must be adjusted
Spherical roller	•••••	•••	••	••••	Heavy duty, misalignment
Needle roller	••••	–	••	•	Compact radial space
Thrust ball	–	•••	•	–	Axial only, low speed
Thrust roller	–	•••••	•	◦ to •••	Axial only, heavy

• more marks means more capability. – means not suited. ◦ means little or none.

SHORTLISTING

If the duty is	Start with
Radial load only	Deep groove, cylindrical, needle
Radial and axial together	Angular contact, tapered, spherical roller
Misalignment likely	Self-aligning ball, spherical roller, unit
Axial only	Thrust types with a radial bearing
Heavy shock	Tapered, spherical roller

A table narrows the list; it does not choose. Final choice comes from load, life, speed, space and cost, as the next pages show.

Selection flow

Choose in order. Each step narrows the next, so skipping one costs a re-selection later.

GENERAL PRACTICE

1 Duty data Load, speed, temperature, space	2 Type Load direction, tilt, rigidity	3 Arrangement Fixed and floating bearings	4 Size Life and load rating
5 Fits Shaft and housing	6 Clearance Initial and working	7 Lubricant Grease or oil, sealing	8 Confirm Speed, temperature, mounting

WHAT EACH STEP DECIDES

Step	Decides
Duty data	Everything below depends on it; collect it first
Type	Ball or roller, single or paired, tilt capacity
Arrangement	Which bearing locates the shaft and which floats
Size	Rated load against required life
Fits	How tight the rings are held; changes clearance
Clearance	Internal clearance after fit and heat
Lubricant and seal	Speed limit, heat and contamination protection
Confirm	Speed limit, temperature, mounting method and tools

Size comes late. A bearing picked by bore alone is picked before its duty is known.

Collect the duty data

Write the duty on one sheet. Missing data is the largest cause of wrong selection.

GENERAL PRACTICE

Item	What to write down
Machine and position	Drive end, non-drive end, pump, gearbox, roll neck
Space	Shaft diameter, housing bore, width, shoulders
Radial and axial load	Size, direction, whether it changes; shock and vibration
Speed	Normal, maximum and minimum, in min^{-1}
Duty cycle	Continuous, intermittent, stop-start, oscillating
Temperature	Ambient and bearing, ring-to-ring difference
Environment	Dust, water, chemicals, washdown, vacuum
Alignment	Shaft deflection, mounting error, thermal growth
Rotating ring	Does the shaft or the housing rotate?
Required life	Hours of service, maintenance interval
Maintenance	Access, lubrication method, replacement time

WHY THE ROTATING RING MATTERS

The ring that turns against a fixed load direction sees the load go round its whole circumference (rotating load) and needs a tight fit. The other ring sees a fixed spot (stationary load) and can be a looser fit. Fits on page 25 start from this.

Collect the duty before the catalogue. A one-page duty sheet turns a buyer's request into an engineer's answer.

Fixed and floating arrangement

A shaft needs two bearings. One locates it axially; the other lets it move with heat. Without a floating bearing, thermal growth loads the bearings.

GENERAL PRACTICE

■ Fixed bearing

- Locates the shaft axially
- Carries radial and axial load
- Ring fits tight on both rings
- Examples: deep groove, paired angular contact, NUP, spherical roller

■ Floating bearing

- Carries radial load only
- Moves axially with shaft growth
- One ring free to slide in the seat
- Examples: NU or N cylindrical, deep groove with a free outer ring

COMMON ARRANGEMENTS

Arrangement	How it works	Use
Deep groove at each end	Fixed at one end, outer ring free at the other	Light to moderate load
Cylindrical (NU) + angular or deep groove	NU floats, the other locates	Heavy radial, thermal growth
Paired tapered, face to face or back to back	Two tapered bearings locate both ways	Adjust clearance or preload
Spherical roller + spherical roller	One locates, one floats	Heavy duty and misalignment
Paired angular contact	Pair locates both ways	Spindles, high rigidity

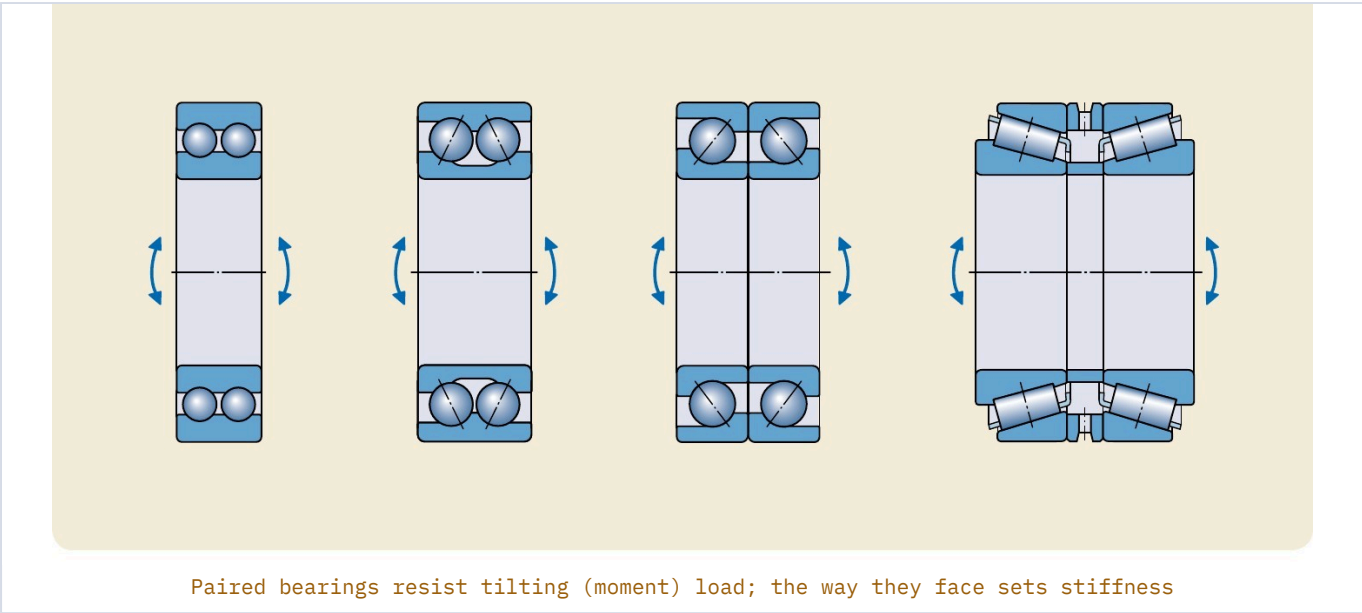
SELF - CHECK

- Is there exactly one locating bearing for each axial direction?
- Can the shaft grow with temperature without loading a bearing?
- Is the floating ring free to slide: right fit, clean seat?

One bearing locates; the other floats. Two locating bearings load each other as the shaft heats up.

Duplex and paired bearings

Angular contact and tapered bearings are often fitted in pairs. The way they face sets stiffness, tilt resistance and how the load is shared.



Arrangement	What it does	Note
DB: back to back	Load lines spread apart; high stiffness against tilt; takes axial both ways	Tilt (moment) resistance; shaft thermal growth adds preload
DF: face to face	Load lines converge; takes axial both ways; some tilt tolerance	Less moment stiffness than DB
DT: tandem	Both bearings take axial load in the same direction	Doubles the axial capacity one way; needs a third to oppose

MATCHING

- Buy matched pairs from the maker; do not mix single bearings
- Preload and clearance come with the pair code
- Fit both bearings with the same fits and the same lubricant

Back to back for stiffness; face to face for tolerance. Tandem for axial capacity in one direction.

Loads on a bearing

Real loads exceed the calculated load. Shock, vibration and the drive itself add to it. Multiply by a factor, then use the result as the bearing load.

GENERAL PRACTICE

LOAD FACTOR f_w

Condition	Examples	f_w
Smooth running, little shock	Electric motors, small pumps, air conditioners	1.0 to 1.2
Normal, some shock	Gearboxes, conveyors, machine tools	1.2 to 1.5
Heavy shock and vibration	Crushers, rolling mills, vibrating screens	1.5 to 3.0

DRIVE LOADS

Drive	Formula	Notes
Gear drive: tangential force	$K_t = 19.1 \times 10^6 \times P \div (n \times d)$	P kW, n min ⁻¹ , d pitch dia. mm; radial component = $K_t \times \tan \alpha$, about 0.36 K_t for a 20° spur gear
Gear accuracy factor k_g	Precision gears 1.05 to 1.1; ordinary 1.1 to 1.3	Multiply the calculated gear force
Belt drive: effective tension	$F_b = 19.1 \times 10^6 \times P \div (n \times d)$	Tension radial load $\approx k_b \times F_b$; V-belt k_b about 1.5 to 2; flat belt about 2.5 to 4

MEAN LOAD, WHEN LOAD CHANGES

For a load that changes steadily between F_{min} and F_{max} , a close estimate of the mean load is $F_m \approx (F_{min} + 2 F_{max}) \div 3$. For stepped loads use the cube-root mean for ball bearings and the 10/3 power mean for roller bearings.

Calculated load times the right factor. Without it, a gearbox on paper lasts twice as long as in the plant.

Bearing life

Rolling fatigue limits bearing life. Basic rating life L10 is the life that 90 % of a group of identical bearings reach or exceed.

GENERAL PRACTICE

BASIC RATING LIFE

Quantity	Formula	Meaning
In millions of revolutions	$L_{10} = (C \div P)^p$	C: basic dynamic load rating, P: equivalent dynamic load
In hours	$L_{10h} = 10^6 \div (60 n) \times (C \div P)^p$	n: speed in min^{-1}
Exponent p	3 for ball bearings	10/3 for roller bearings

HOW MUCH LIFE IS ENOUGH?

Machine duty	Typical required L10h
Household appliances, light duty	2 000 to 4 000 h
Intermittent use: hand tools, lifts	4 000 to 8 000 h
Short or occasional full load: motors, conveyors	8 000 to 15 000 h
Daily 8-hour service: gearboxes, machine tools	15 000 to 30 000 h
Continuous 24-hour service: pumps, fans, rolling mills	40 000 to 60 000 h
Critical, no stop: paper machines, mine fans	100 000 h and more

QUICK CONVERSIONS

- Doubling the load cuts ball bearing life to one eighth, roller bearing life to about one tenth
- Doubling speed halves the life in hours, not in revolutions
- Required $C = P \times (L_{10} \div 1 \text{ million rev.})^{(1/p)}$

Load matters more than speed. A 20 % load increase takes about 40 % off ball bearing life.

Adjusted life and reliability

The basic rating life assumes 90 % reliability and ordinary conditions. The adjusted rating life changes that for higher reliability, material and operating conditions.

GENERAL PRACTICE

ADJUSTED RATING LIFE

Form	Meaning
$L_{nm} = a_1 \times a_2 \times a_3 \times L_{10}$	Older form: a_1 reliability, a_2 material, a_3 operating conditions
$L_{nm} = a_1 \times a_{ISO} \times L_{10}$	ISO 281 form: a_{ISO} combines lubrication, contamination and fatigue load limit

RELIABILITY FACTOR a_1

Reliability	Life	a_1
90 %	L10	1.00
95 %	L5	0.64
96 %	L4	0.55
97 %	L3	0.47
98 %	L2	0.37
99 %	L1	0.25

WHAT MOVES a_2 , a_3 AND a_{ISO}

Factor	Effect
Material	Cleaner steel and heat treatment raise a_2 ; ordinary bearing steel is 1.0
Lubrication	Oil film thickness against surface roughness; viscosity ratio κ raises or lowers a_{ISO}
Contamination	Dirt and particles lower a_{ISO} ; sealed and filtered systems lower this loss
Load	Light load in clean conditions can reach fatigue limit; life then exceeds the calculation

A bad lubricant or dirty oil can cut calculated life by half or more. Life depends on the film, not only on the load.

Equivalent load

Combined radial and axial load is converted to one equivalent load P that does the same fatigue damage. The factors X and Y come from the maker's table for each bearing.

GENERAL PRACTICE

EQUIVALENT DYNAMIC LOAD

Case	Formula
$P = F_r$	When $F_a \div F_r$ is small ($\leq e$); only the radial load counts
$P = X F_r + Y F_a$	When $F_a \div F_r$ is larger than e ; use the X and Y for that bearing
Thrust bearing	$P = F_a$ for a pure thrust bearing; the table gives the formula for the type
Cylindrical roller	$P = F_r$ for most types; check the table when axial load acts on flanged types

STEPS

- Find $F_a \div F_r$ and compare with the limit e for the bearing
- Read X and Y from the maker's table (they change with the bearing and with $f_0 F_a \div C_0 r$ for ball bearings)
- Compute P , then multiply by f_w if the load factor was not already used

STATIC SAFETY FACTOR

Quantity	Value
$s_0 = C_0 \div P_0$	C_0 : basic static load rating; P_0 : equivalent static load
Smooth, low noise	s_0 of 2 or more
Normal	s_0 about 1 to 1.5
Heavy shock	s_0 of 1.5 to 3; check the maker's guidance

Axial load costs more than radial. A small axial load can multiply P once it passes the limit e .

Shaft and housing fits

The fit holds the ring against creep. Rotating load needs a tight fit; stationary load can be looser. Too tight a fit uses up internal clearance; too loose a fit lets the ring creep and wear the seat.

GENERAL PRACTICE

WHICH RING GETS THE TIGHT FIT

Case	Load on the ring	Fit
Inner ring rotates, load direction fixed	Rotating inner-ring load	Inner ring tight on the shaft; outer ring looser
Outer ring rotates, load direction fixed	Rotating outer-ring load	Outer ring tight in the housing; inner ring looser
Load rotates with the inner ring (unbalance)	Stationary inner-ring load	Inner ring may be looser; outer ring tight

SHAFT TOLERANCES, ROTATING INNER RING

Cylindrical bore, steel shaft; ISO symbols.

Load	Shaft tolerance
Light load, $P \leq 0.06 C$	h5 to j6 (up to about 40 mm bore)
Normal load, 0.06 C to 0.12 C	j5 to k5, m5 as size rises
Heavy load, over 0.12 C; shock	m5 to n6, p6 for larger bores

TYPICAL HOUSING TOLERANCES

Condition	Housing tolerance
Stationary outer ring, normal use	H7 (G7 for a floating bearing)
Rotating outer-ring load, light to normal	M7 to N7
Rotating outer-ring load, heavy or thin housing	N7 to P7

FIT QUALITY

- Check roundness, taper and surface finish of seats; accurate seats matter as much as the tolerance class
- Raise the fit grade for heavy load, hollow shafts and thin housings
- Contact the maker for a tapered bore, split housing or very high speed

Tight for the ring that turns against the load. A creeping ring wears its seat and cannot be repaired by a new bearing.

Internal clearance

Internal clearance is the total distance one ring can move against the other. A tight fit and a temperature difference between the rings both reduce it in service.

GENERAL PRACTICE

CLEARANCE CLASSES

Class	Size	Use
C2	Smaller than normal	Precision, low noise, with light fits
CN (normal)	Standard	Normal fits and normal temperature
C3	Larger than normal	Tight fits, heat from the shaft, most motors
C4	Larger than C3	Very tight fits, big temperature difference
C5	Larger than C4	Special cases; confirm with maker

FROM INITIAL TO WORKING CLEARANCE

Step	Effect
Initial clearance	As supplied, before fitting
Less: interference fit	A tight fit expands the inner ring or shrinks the outer ring
Less: temperature difference	The inner ring usually runs hotter than the outer ring
= Working clearance	Aim for a small positive value, near zero for many ball bearings

WHEN TO CHOOSE C3

- Inner ring with interference fit and a hot shaft
- Electric motors and fans
- Bearing in a housing with a large temperature difference
- Spherical and cylindrical roller bearings with tight fits

No clearance, no life. A bearing that runs with negative working clearance heats and fails in hours, not years.

Preload

Preload is a deliberate axial or radial load that removes working clearance. It raises stiffness and running accuracy and holds the rolling elements in place.

GENERAL PRACTICE

WHY PRELOAD

Benefits Higher stiffness; lower shaft run-out; better positioning; less noise and vibration; less skidding of rolling elements at light load.	Cost More friction and heat; shorter life if overdone; speed limit falls; needs accurate seats and matched parts.
--	---

METHODS

Method	How it works	Use
Constant (spring) preload	Springs press the outer ring; load stays steady as parts grow with heat	Grinders, spindles, high speed
Fixed (position) preload	Spacers or ring offsets set the position; stiffer; load rises with temperature	Machine tools, gearboxes
Matched duplex pairs	Preload built into the pair code (light, medium, heavy)	Spindles, ready to fit
Tapered roller set-up	Adjust nut or shim to end play or preload	Hubs, pinions

RULES

- Do not preload without a reason; it is a precision tool
- Check preload at running temperature, not only cold
- Never mix single bearings in a preloaded set

Preload trades life for stiffness. Use the least preload that meets the accuracy requirement.

Speed and temperature

Speed limit is set by heat, not only by strength. Friction heats the bearing until heat leaves at the same rate it is made.

GENERAL PRACTICE

SPEED INDEX $dm \cdot n$

Quantity	Meaning
$dm = (d + D) \div 2$	Mean diameter in mm; d bore, D outside diameter
$dm \cdot n$	$dm \times$ speed n in min^{-1} ; a rough measure of the sliding speed in the bearing
Compare with the catalogue limit	Catalogue limits differ by lubricant, cage, seal and precision class

WHAT LOWERS THE SPEED LIMIT

Factor	Effect
Contact seals	Friction from the seal lip
Heavy load	More rolling resistance and heat
Poor lubrication	Too much or too little grease; wrong viscosity
Preload or tight fit	Extra friction from the loss of clearance
High ambient temperature	Less margin for bearing heat

TEMPERATURE LIMITS

Part	Guide
Standard bearing steel ring	About 120 °C continuous; special stabilisation above
Grease	Check dropping point and useful range of the grease
Seals and cages	Rubber, plastic cages and seals set lower limits than the steel

Temperature is the bearing's report. Measure the housing at start-up and again at steady state; a rising trend means a problem.

Grease or oil

The lubricant forms the film that keeps the rolling elements and raceways apart. Grease is the usual choice. Oil is used where speed, heat or the machine design demand it.

GENERAL PRACTICE

	Grease	Oil
Method	Grease, packed in the housing	Oil bath, circulation or mist
Speed	Low to moderate	Moderate to high
Heat removal	Poor	Good with circulation
Maintenance	Top up or replace at intervals	Check level and condition; filter or change
Sealing	Needs seals to keep grease in	Needs leak-tight housing
Use	Motors, pumps, fans, units	Gearboxes, high-speed and hot shafts

GREASE

- Fill 30 to 50 % of the free space in the bearing and housing
- Overfilled grease churns, heats and shortens life
- Do not mix greases with different thickeners without checking compatibility
- Relubricate by interval or by condition

OIL

- Pick viscosity for the speed and temperature; a higher viscosity gives a thicker film
- Oil bath level reaches the centre of the lowest rolling element when still
- Keep oil clean and dry; filter circulation systems

Grease where you can, oil where you must. Oil removes heat; grease is simpler and seals better.

Seals, cages and materials

Seals keep lubricant in and dirt out. The cage and the steel complete the bearing.

GENERAL PRACTICE

SEALING

Seal	Features
Shield (ZZ, removable ZZA)	Metal; non-contact; low friction; keeps large particles out
Contact seal (LLU)	Rubber; better sealing; more friction; lower speed limit
Non-contact seal (LLB), low torque (LLH)	Low friction with good protection
External seals	Labyrinth, V-ring, lip seal; for dirty or wet duty

CAGES

Cage	Use
Pressed steel	Light, low cost, widely used
Machined brass	Strong; suits heavy load, vibration and shock
Polyamide (plastic)	Light, quiet; limit on temperature and some greases

MATERIALS

Material	Use
High-carbon chromium bearing steel	Standard rings and rolling elements; hardened
Case-hardened steel	Tough rings for heavy shock and roller bearings
Stainless steel	Corrosion; lower load capacity
Ceramic balls	Electrical insulation, high speed; hybrid bearings
Heat-stabilised steel	Operation above standard temperature

Seal and cage are part of the rating. Changing either changes the speed limit and the temperature limit of the bearing.

Accuracy and bearing numbers

The bearing number and the accuracy class fix the dimensions and the quality. Read both before buying a replacement.

GENERAL PRACTICE

ACCURACY CLASSES

Class	Use
Normal (ISO Class 0)	General machinery; standard
Class 6	Better rotation accuracy; some motors and spindles
Class 5	Machine tools and instruments
Class 4 and 2	Precision spindles and the most demanding duty

A higher class means tighter dimension and run-out limits and a higher price. Many makers use their own names for the classes.

READING THE NUMBER: 6205ZZ C3

6 Type: deep groove ball bearing	2 Series: width and diameter	05 Bore code: $05 \times 5 = 25$ mm	ZZ C3 Shield both sides; clearance larger than normal
--	--	---	---

COMMON TYPE CODES

Prefix	Type
6xxx	Deep groove ball
7xxx	Angular contact ball
1xxx, 2xxx	Self-aligning ball
NU, NJ, NUP, N, NF	Cylindrical roller
3xxxx	Tapered roller
22xxx, 23xxx	Spherical roller
5xxxx	Thrust ball

Same number, different maker, same size. Suffix meaning, clearance class and cage can still differ, so compare codes before an interchange.

Worked example: ball bearing

Check a 6205 deep groove ball bearing on a fan shaft.

GENERAL PRACTICE

GIVEN

Item	Value
Bearing	6205, bore 25 mm, outside diameter 52 mm, width 15 mm
Dynamic load rating C	About 14 kN (catalogue value; confirm in your maker's table)
Radial load Fr	2.0 kN, smooth running
Axial load Fa	None
Speed n	1 500 min ⁻¹
Required life	Continuous, 24 h a day

CALCULATION

Step	Result
1. Equivalent load	$P = F_r = 2.0 \text{ kN}$ (no axial load)
2. Load factor	$f_w = 1.1$ for smooth running $\rightarrow P = 2.2 \text{ kN}$
3. Rating life	$L_{10} = (14 \div 2.2)^3 = 258$ million revolutions
4. Life in hours	$L_{10h} = 10^6 \times 258 \div (60 \times 1\,500) = \text{about } 2\,870 \text{ h}$

JUDGEMENT

About 2 900 h is only four months of continuous running. For 40 000 h at 1 500 min⁻¹ the bearing would need $C \geq P \times (3\,600)^{(1/3)} = 2.2 \times 15.3 \approx 34 \text{ kN}$. Move to a larger series (for example a 6305 or 6405) or a roller type, then check the speed and fit again.

Always convert to hours and compare with the duty. A bearing that fits the shaft can still be too small for the life you need.

Worked example: roller bearing

Choose a roller bearing for a gearbox shaft that must last 20 000 h.

GENERAL PRACTICE

GIVEN

Item	Value
Radial load F_r	3.0 kN after the load factor
Speed n	1 000 min^{-1}
Required L_{10h}	20 000 h
Bore	Not more than 40 mm on the shaft

CALCULATION

Step	Result
1. Required life	$L_{10} = 60 \times 1\,000 \times 20\,000 \div 10^6 = 1\,200$ million revolutions
2. Ball bearing check	$C \geq 3.0 \times (1\,200)^{(1/3)} = 3.0 \times 10.6 = 32$ kN
3. Roller bearing check	$C \geq 3.0 \times (1\,200)^{(0.3)} = 3.0 \times 8.4 = 25$ kN
4. Compare	A cylindrical or tapered roller bearing with C of 25 kN or more is enough

WHAT THIS SHOWS

- For the same life, the roller bearing needs a smaller rated load than a ball bearing of the same size, as its exponent is lower
- Choose the type from the load direction first, then check size against the catalogue rating
- Confirm fit, clearance and speed limit for the bearing you chose

Work backwards from the life you need. The required rating C tells you which size to look up in the catalogue.

Selection checklist

Run this list before you order. Each “no” is a question for the maker or for your engineer.

GENERAL PRACTICE

Check	What to confirm
Duty	Load, speed, temperature, space and environment are written down
Type	Load direction and tilt match the type
Arrangement	One locating and one floating bearing; thermal growth allowed
Life	L10h is calculated with a load factor and meets the required hours
Static load	Static safety factor is adequate for shock
Fits	Rotating ring is tight; seats are round and true
Clearance	Working clearance stays positive after fit and heat
Lubricant	Grease or oil chosen, quantity and interval set
Sealing	Seal fits the dirt, water and speed
Speed and heat	Speed limit and temperature checked
Fitting	Method, tools and heating are planned
Records	Number, supplier, fitting date and lubricant are logged

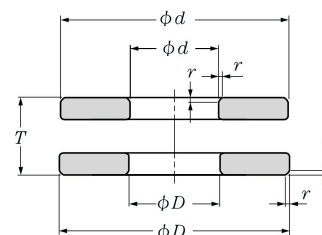
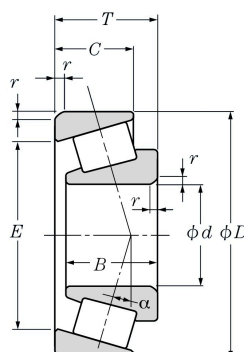
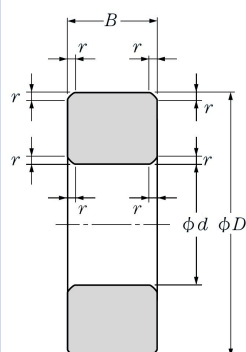
WHAT TO SEND YOUR SUPPLIER

- Existing bearing number, or the bore, outside diameter and width
- Machine, position, load, speed and temperature
- Seal, clearance class and any special code on the old bearing
- Quantity, delivery place and required date

A good order carries its own duty. The more the supplier knows about the job, the less the chance of the wrong bearing.

Boundary dimensions

Boundary dimensions are the outside sizes that decide whether a bearing fits the shaft and the housing. They are standardised, so bearings from different makers can be exchanged.



Radial bearing • tapered roller bearing • single-direction thrust bearing: d , D , B or T , chamfer r

90

standard bore diameters

0.6–2 500

bore range, mm

22

chamfer sizes, 0.05 to 19 mm

4

sizes fixed: d , D , B or T , r

STANDARDS

Bearing group	Standard
Radial, not tapered	ISO 15
Tapered roller	ISO 355
Thrust	ISO 104
Chamfer r (min.)	ISO 582
National (Japan)	JIS B 1512

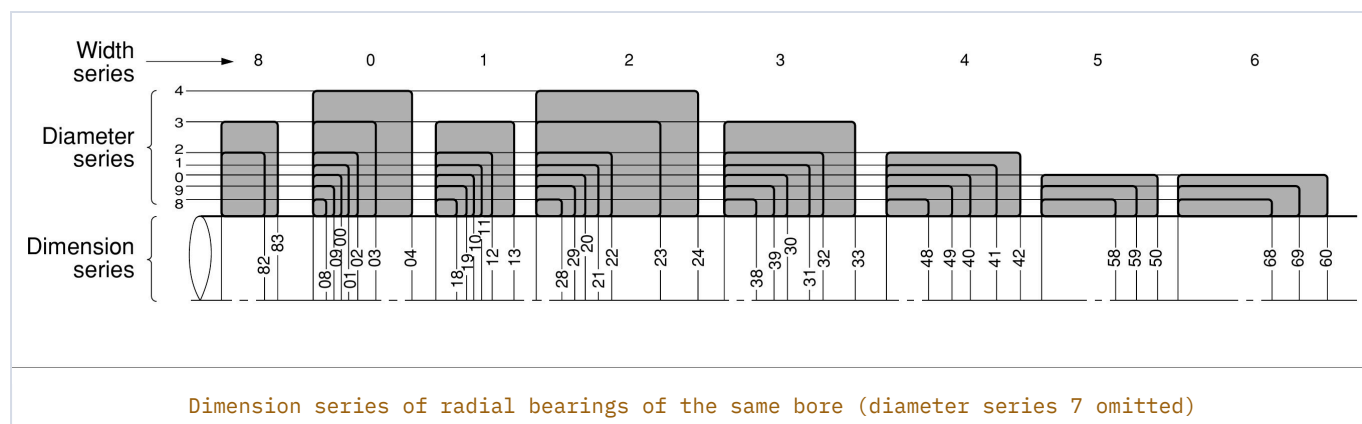
STANDARD BORE STEPS

Bore d , mm	Standard sizes, mm
to 1	0.6
1 to 3	1, 1.5, 2.5: steps of 0.5
3 to 10	3, 4 ... 9: steps of 1
10 to 20	10, 12, 15, 17
20 to 35	20, 22, 25, 28, 30, 32
35 to 110	35, 40 ... 105: steps of 5
110 to 200	110, 120 ... 190: steps of 10
200 to 500	200, 220 ... 480: steps of 20
500 to 2 500	500, 530 ... 2 500

Not every standard size is made. Internal construction is not covered by these standards, so confirm the load rating and clearance in the catalogue.

Dimension series: radial bearings

For one bore diameter there are eight outside diameters and eight widths. The diameter series and the width series together form the dimension series.



DIAMETER SERIES (outside diameter)

smallest to largest



WIDTH SERIES (ring width)

narrowest to widest



HOW TO READ A SERIES NUMBER

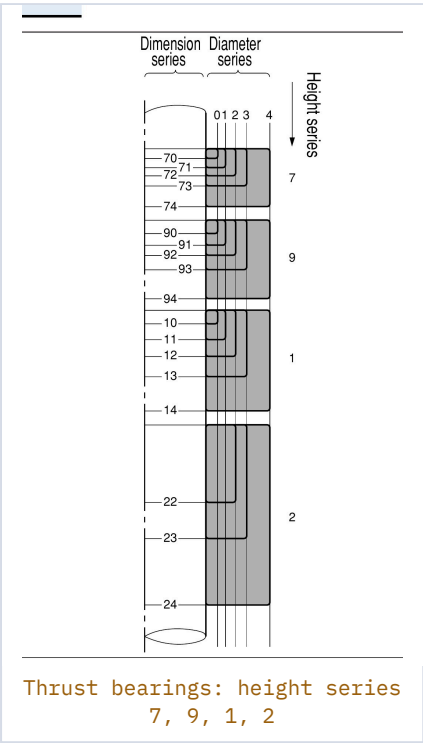
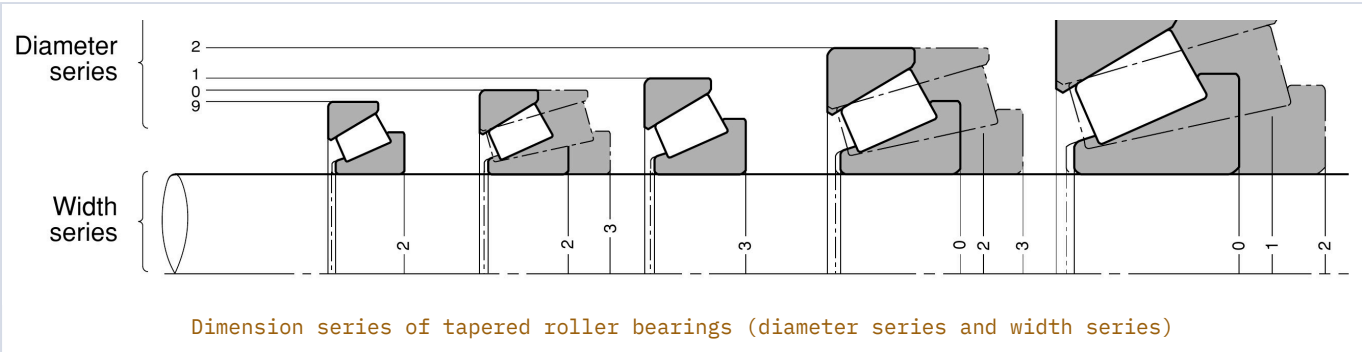
SERIES	SERIES	SERIES	SERIES
62	63	23	30
width (0), diameter 2	width (0), diameter 3	width 2, diameter 3	width 3, diameter 0

The first digit of a two-digit series is the width series, the second is the diameter series. Width series 0 and 1 are often not written; the type letters or digits come first.

Same bore, different series, different bearing. A bigger diameter series gives a bigger outside diameter; a bigger width series gives a wider ring.

Dimension series: tapered and thrust

Tapered roller bearings and thrust bearings have their own series. Tapered bearings add a contact angle series; thrust bearings use a height series instead of a width series.



TAPERED ROLLER

Series	Values
Diameter series	9, 0, 1, 2, 3
Width series	0, 1, 2, 3
Letter system	Diameter B to G; width B to E
Contact angle series	2 to 7, small to large angle
Example	2FB: angle series 2, diameter F, width B

THRUST

Series	Values
Diameter series	0, 1, 2, 3, 4
Height series	7, 9, 1, 2
Width series	None

A larger letter or number means a larger size. Tapered bearing numbers such as 302, 322 and 303 carry the width and diameter series in the last two digits.

Tapered and thrust bearings do not follow the radial series. Look up their dimensions in the catalogue table for the exact series.

How a bearing number is built

A bearing number is a code. It states the bearing type, size, internal construction, tolerance and other features. It has a basic number, then supplementary prefix and suffix codes.

GENERAL PRACTICE

ORDER OF THE NUMBER (DEEP GROOVE AND MINIATURE BALL BEARINGS)

Prefix code	Basic number	Suffix code
• Special application code • Material or heat treatment code	• Type symbol and dimension series: width or height series, diameter series • Bore diameter number	• Internal modification • Cage • Seal or shield • Ring configuration • Duplex arrangement • Tolerance • Lubrication

WORKED EXAMPLE: TS2-6205ZZ C3 P5

PREFIX	TYPE	SERIES	BORE	SEAL	CLEARANCE	TOLERANCE
TS2- Stabilized to 160 °C	6 Deep groove ball, single row	2 Width (0), diameter 2	05 $05 \times 5 = 25$ mm	ZZ Shield, both sides	C3 Greater than normal	P5 Class 5

HOW TO READ IT

- Basic number first: type 6, series 62, bore 25 mm. That fixes the boundary dimensions.
- Suffix codes follow in a set order: cage, seal or shield, ring configuration, clearance, tolerance.
- The prefix, when present, comes first and tells you about material or heat treatment.
- A code that is not shown has its normal meaning: no clearance code means normal (CN) clearance.

Bearing series, prefix and suffix codes not listed in a maker's table should be confirmed with the maker.

Basic number = what it is. Suffix = how it is made. Two bearings with the same basic number but different suffixes are not always interchangeable.

Series symbol and bore number

The series symbol gives the type and the size series. The bore number gives the shaft diameter. Together they make the basic number.

GENERAL PRACTICE

BEARING SERIES SYMBOL: SINGLE ROW DEEP GROOVE BALL

Series	Type symbol	Width series	Diameter series
68	6	(1)	8
69	6	(1)	9
60	6	(1)	0
62	6	(0)	2
63	6	(0)	3
64	6	(0)	4

A width series in brackets is left out of the number: series 62 is type 6, width (0), diameter 2.

BORE DIAMETER NUMBER

Number	d mm	Number	d mm	Number	d mm
/0.6	0.6	/22	22	09	45
/1.5	1.5	/28	28	10	50
/2.5	2.5	/32	32	11	55
1 to 9	1 to 9	04	20	12	60
00	10	05	25	16	80
01	12	06	30	20	100
02	15	07	35	24	120
03	17	08	40	96	480

- A slash before the number means the bore is written in millimetres: /0.6, /22.
- Single figures 1 to 9 are the bore in millimetres, with no slash.
- From 04 up, multiply the number by 5 to get the bore: 05 × 5 = 25 mm.

SAME BORE, DIFFERENT SERIES

Number	Series	d × D × B
6005	Series 60	25 × 47 × 12 mm
6205	Series 62	25 × 52 × 15 mm
6305	Series 63	25 × 62 × 17 mm

The last two figures are the bore; the figures before them are the series. Same bore, higher series: larger outside diameter and width, and more load capacity.

Prefix, cage and seal codes

Supplementary prefix codes describe material and heat treatment. Suffix codes describe the cage and the seal or shield. Not every code is available on every bearing.

GENERAL PRACTICE

PREFIX CODES

Prefix	Meaning
F-	Stainless steel bearing
TS2-, TS3-, TS4-	Dimension stabilized for high temperature: to 160, 200 and 250 °C
TM-, CS-	Special heat-treated, long-life bearing
ES-	Special heat treatment and material, extra long life
EC-	Expansion compensating bearing
AC-	Creep preventing bearing

CAGE CODES

Code	Meaning
L1	Machined brass cage
F1	Machined steel cage
G1	Machined brass cage, rivetless
G2	Pin-type steel cage
J	Pressed steel cage
T1	Phenolic cage
T2	Plastic cage, nylon or PTFE

SEAL AND SHIELD CODES

Code	Meaning
ZZ	Shield, both sides
ZZA	Removable shield
LLB	Synthetic rubber seal, non-contact type
LLU	Synthetic rubber seal, contact type
LLH	Synthetic rubber seal, low-torque type

Seal code sets speed and protection. A contact seal (LLU) protects best and runs hotter; a shield (ZZ) or non-contact seal (LLB) runs freer.

Clearance, preload and tolerance codes

The rest of the suffix covers the outer ring, internal clearance, preload, tolerance class and lubricant. They follow the cage and seal codes.

GENERAL PRACTICE

RING CONFIGURATION

Code	Meaning
N	Snap ring groove in the outer ring, without snap ring
NR	Snap ring groove with snap ring fitted
D	Bearing with oil holes

INTERNAL CLEARANCE

Code	Meaning
C2	Radial clearance smaller than normal
CN	Normal clearance; usually not shown in the number
C3	Radial clearance greater than normal
C4	Radial clearance greater than C3
CM	Clearance for electric motor bearings
NA	Non-interchangeable clearance, shown after the clearance code

PRELOAD

Code	Meaning
/GL	Light preload
/GN	Normal preload
/GM	Medium preload
/GH	Heavy preload

TOLERANCE CLASS

Code	Meaning (JIS class)
P6	Class 6
P5	Class 5
P4	Class 4
P2	Class 2

Lubrication is coded after the tolerance, for example /2AS or /5C: each code names a grease type. Check the maker's table.

No code means the standard. If a number shows no clearance code, it is normal clearance; if it shows no tolerance code, it is a normal class.

Angular contact ball bearing codes

Angular contact ball bearings add ball and ring material, contact angle and matching codes. The order is shown below.

GENERAL PRACTICE

WORKED EXAMPLE: 5S-7014C T1 DB G /GL P4

BALLS 5S- Si ₃ N ₄ ceramic	SERIES 7 Standard type	DIAMETER 0 Series 0	BORE 14 14 × 5 = 70 mm	ANGLE C 15°
CAGE T1 Phenolic	MATCH DB Back to back	GROUND G Flush ground	PRELOAD /GL Light	TOLERANCE P4 Class 4

Code group	Codes
Ball material	5S- Si ₃ N ₄ ceramic balls; blank: bearing steel balls
Ring material	F- stainless steel; blank: bearing steel
Bearing series	7 standard; HSE high speed; BST thrust angular contact (60°); 5 double row
Diameter series	9, 0 or 2
Contact angle	C 15°; CE1 18°; AD 25°; A 30° (may not be shown); B 40°
Cage	T1 phenolic; blank: nylon
Matching	DB back to back; DF face to face; DT tandem; DBT tandem and back to back (three); DTBT (four)
Flush grinding	G flush ground; blank: not flush ground
Preload or clearance	/GL light; /GN normal; /GM medium; /Gxx special preload; /CSxx special clearance
Tolerance	P5; P4; P4X special bore and outside diameter; P42 class 4 dimensions with class 2 running; P2

A matched set is bought as a set. The matching, flush grinding and preload codes only work when the bearings are ground together and kept together.

Bearing numbers by type

Other bearing types have their own series numbers. Add the bore number and you have the basic number. Series below are common ISO and JIS series; check the exact series with the maker.

GENERAL PRACTICE

Bearing type	Series in the number	Example, bore
Deep groove ball, single row	68, 69, 60, 62, 63, 64	6205 = 25 mm bore
Self-aligning ball	12, 13, 22, 23	1210 = 50 mm; 2308 = 40 mm
Angular contact ball	70, 72, 73 (standard type 7)	7014 = 70 mm
Double row angular contact ball	Type 5 (5S- is ceramic balls)	Check series with the maker
Four-point contact ball	QJ 2, QJ 3	QJ 212 = 60 mm
Cylindrical roller	NU, NJ, NUP, N, NF; series 2, 3, 22, 23, 10	NU2212 = 60 mm
Tapered roller (metric)	302, 303, 313, 320, 322, 323, 329, 330, 331, 332	32210 = 50 mm
Spherical roller	213, 222, 223, 230, 231, 232, 239, 240, 241	22212 = 60 mm; 23022 = 110 mm
Thrust ball, single direction	511, 512, 513, 514	51210 = 50 mm
Thrust ball, double direction	522, 523, 524	52210 = 50 mm
Spherical roller thrust	292, 293, 294	29412 = 60 mm
Cylindrical roller thrust	811, 812	81212 = 60 mm
Needle roller	NA 49 with inner ring; RNA 49 without	NA4910 = 50 mm
Bearing units	UC, UCP and similar insert series	Check the unit catalogue

The same suffix codes apply across types where the maker offers them: cage (L1, J, T1), clearance (C2, C3, C4), tolerance (P6, P5, P4) and seal or shield. Letters for special features differ by type and by maker: confirm them before ordering.

First figures give the type; the last two give the bore. A thrust bearing 51210 and a deep groove 6210 share a bore number but are different bearings.

Series, width and diameter digits

The series number is built from the type code, a width or height digit and a diameter digit. A digit in brackets is normally left out of the number, so 62 means type 6, width (0), diameter 2.

GENERAL PRACTICE

HOW THE SERIES IS BUILT

TYPE 6 Deep groove ball	WIDTH (0) Normal: not written	DIAMETER 2 Light series	BORE 08 $8 \times 5 = 40 \text{ mm}$
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SERIES TABLE: TYPE CODE, WIDTH OR HEIGHT, DIAMETER

Bearing type	Series	Type code	Width or height digit	Diameter digit
Deep groove ball	68, 69, 60, 62, 63	6	(1), (1), (1), (0), (0)	8, 9, 0, 2, 3
Angular contact ball	79, 70, 72, 73	7	(1), (1), (0), (0)	9, 0, 2, 3
Self-aligning ball	12, 13, 22, 23	1 or 2	(0), (0), 2, 2	(0), (0), 2, 2
Cylindrical roller, NU	NU10, NU2, NU22, NU3, NU23, NU4	NU	1, (0), 2, (0), 2, (0)	0, 2, 2, 3, 3, 4
Cylindrical roller, NJ, NUP	NJ2, NJ22, NJ3, NJ23, NJ4	NJ, NUP	(0), 2, (0), 2, (0)	2, 2, 3, 3, 4
Cylindrical roller, N	N10, N2, N3, N4	N	1, (0), (0), (0)	0, 2, 3, 4
Cylindrical roller, NF	NF2, NF3, NF4	NF	(0), (0), (0)	2, 3, 4
Double row cylindrical	NNU49, NN30	NNU, NN	4, 3	9, 0
Needle roller	NA48, NA49, NA59, NA69	NA	4, 4, 5, 6	8, 9, 9, 9
Tapered roller	329, 320, 330, 331, 302, 322, 332, 303, 323	3	2, 2, 3, 3, 0, 2, 3, 0, 2	9, 0, 0, 1, 2, 2, 2, 3, 3
Spherical roller	230, 231, 222, 232, 213, 223	2	3, 3, 2, 3, 0, 2	0, 1, 2, 2, 3, 3
Thrust ball, flat seat	511, 512, 513, 514, 522, 523, 524	5	1, 1, 1, 1, 2, 2, 2	1, 2, 3, 4, 2, 3, 4
Spherical roller thrust	292, 293, 294	2	9, 9, 9	2, 3, 4

Series 213 would be 203 by logic; it is numbered 213 by custom. Read each series left to right: type code, width or height digit, diameter digit.

Width digit up means wider; diameter digit up means a bigger outside diameter for the same bore. A 6308 is heavier and stronger than a 6208 with the same 40 mm bore.

Cylindrical and tapered roller codes

Roller bearings use the same order as ball bearings: type letters or digits, series, bore number, then suffix codes. The front letters name the ring layout; the back letters name the build.

GENERAL PRACTICE

CYLINDRICAL ROLLER: NU 2212 E T C3

LAYOUT	SERIES	BORE	DESIGN	CAGE	CLEAR.
NU	22	12	E	T	C3
Flanges on outer ring only	Width 2, diameter 2	12 × 5 = 60 mm	High capacity	Polyamide cage	Larger than normal

Code	Meaning
N, NU	Flanges on one ring only: N on the inner ring, NU on the outer. Free axial movement; use as floating bearing
NJ, NF	Two flanges on one ring, one on the other: takes axial load in one direction
NUP, NH	Flanges and loose rib: takes axial load in both directions; NH is NJ with a loose rib
NN, NNU	Double row; NN 30 and NNU 49 are the usual series
2, 3, 4, 22, 23	Series: the digit is the diameter series, 22 and 23 are wider
M, MA, MB	Machined brass cage. W: pressed steel. T, T7: polyamide
KR	Tapered bore 1:12 (precision double row)
E44 (E2)	Oil groove and holes in the outer ring
CC, CM, CT	Radial clearance for non-interchangeable (CC, CM) or interchangeable (CT) rings
R NU 207	R prefix: outer ring with rollers and cage, no inner ring

TAPERED ROLLER: HR 32210 J

PREFIX	TYPE	SERIES	BORE	SUFFIX
HR	3	22	10	J
Higher load rating	Tapered roller	Angle 2, width 2	10 × 5 = 50 mm	ISO dimensions

Code	Meaning
ISO 355: T 2 C D 025	Type letter (T tapered), contact angle code (2 to 7), diameter series letter, width series letter, bore in mm (025 = 25 mm)
J, X	J: sizes follow ISO 355. X: external dimensions changed to meet the standard
Inch series	Prefix letters (EH, HH, H, HM, M, LM, L, LL, EL) give the size range of the cone. The first digits of the number give the bore; cone and cup carry separate numbers
DF, DB + KR	Matched pair: face to face or back to back, spacer between outer rings (+KR)
CA	Axial clearance of the pair; the number is the mean value in µm

Metric tapered numbers read like ISO 355; inch numbers do not. An inch cone and cup are chosen as a pair by number, not by bore code.

Spherical and thrust codes

Spherical roller and thrust bearings carry heavy and axial loads. Their numbers add letters for the tapered bore, the cage and the oil groove.

GENERAL PRACTICE

SPHERICAL ROLLER: 22212 EA K C3

TYPE 2 Spherical roller	SERIES 22 Width 2, diameter 2	BORE 12 $12 \times 5 = 60$ mm	DESIGN EA Extra capacity	BORE K Taper 1:12	CLEAR. C3 Larger than normal
--------------------------------------	--	--	---------------------------------------	--------------------------------	---

Code	Meaning
CA, CAM	Floating guide ring; CA pressed or machined steel cage, CAM solid brass cage
C, CD	Floating guide ring, pressed steel cage
EA, EJ	Higher load rating, pressed steel cage. EVB: solid brass cage
MB	Brass cage guided by the inner ring
K, K30	Tapered bore: K is 1:12, K30 is 1:30 (series 240, 241)
E4, E2	Oil groove and lubrication holes in the outer ring
G	Case hardened steel. G2 outer ring, G3 inner ring, G5 both rings
S11	Thermally stabilised for up to 200 °C
W31, VS	Vibration service (screens): often C3 clearance
213, 222, 223, 230, 231, 232, 239, 240, 241	Series in use; the first digit 2 marks the spherical roller

THRUST BEARINGS

Code	Meaning
511 to 514	Single direction thrust ball. Third digit is height series, last digit the diameter series
522 to 524	Double direction thrust ball
U	Spherical housing washer and seat washer
X	External dimensions changed to meet the standard (51226 X)
292, 293, 294	Spherical roller thrust. E and M: pressed or machined cages
811, 812	Cylindrical roller thrust; the bore number is read as for ball bearings
P5	Tolerance class 5

Example: 51210 = single direction thrust ball, 12 series, $10 \times 5 = 50$ mm bore. 29412 = spherical roller thrust, 94 series, 60 mm bore.

K at the end means a tapered bore. A K bearing mounts on an adapter or withdrawal sleeve and needs a smaller clearance reduction check.

Prefix, needle and unit codes

Prefixes appear on special bearings and on parts of a bearing. Needle roller bearings and units follow their own conventions. Always confirm these numbers in the maker's catalogue.

GENERAL PRACTICE

PREFIX CODES

Prefix	Meaning
B	Bearing with special dimensions
F	Bearing with flanged outer ring (F 684 ZZ)
HR	Higher load rating (tapered roller and deep groove)
R	Outer ring with rollers and cage, no inner ring (R NU 207); or inch miniature bearing (R 4 ZZ)
MR, MF	Miniature metric bearing with special dimensions; MF has a flanged outer ring
-H-	Extra corrosion resistant steel (608-H-20 ZZ)
T	Mounted unit insert with triple lip seal
J	Insert with lubrication hole on the screw side

NEEDLE ROLLER BEARINGS

Number	Reading
NA 4910	Needle roller bearing with inner ring · 49 series · $10 \times 5 = 50$ mm
RNA 4910	Same size without inner ring
HK 2016	Drawn cup, open ends · shaft 20 mm · length 16 mm
BK	Drawn cup with closed end
K 20×26×13	Needle roller and cage assembly: shaft, outer and width in mm
NK, NKI	Machined ring needle bearing without or with inner ring

BEARING UNITS AND INSERTS

Number	Reading
UC 208	Insert with set screws · 2 series · $08 \times 5 = 40$ mm
UCP 208	Insert in a pillow block housing
UCF 208, UCFL 208	Insert in a square or oval flange housing
UCT 208	Insert in a take-up housing
Number + G	Grease fill type; +E or FS for flinger seal on the insert

Prefix and suffix letters are not universal. A letter that means one thing on a ball bearing can mean another on a needle roller or unit.

Seal, noise and grease codes

For deep groove ball bearings the suffix after the bore number carries the seal, ring groove, clearance, noise grade, heat treatment and grease fill. Read them left to right.

GENERAL PRACTICE

SEAL, SHIELD AND SNAP RING GROOVE

Code	Meaning
Z, ZZ	Shield one side, both sides (6208 ZZ)
DU, DDU	Contact seal one side, both sides
V, VV	Non-contact seal one side, both sides
D, DD	Seal for bores under 10 mm (608 DD)
N, NR	Snap ring groove in outer ring; NR with the ring fitted
ZNR, DUNR	Shield or seal on one side, groove and ring on the other
ZZS	Removable shields

INTERNAL CLEARANCE AND NOISE

Code	Meaning
C2, CN, C3, C4, C5	Radial clearance: smaller than normal, normal, then larger steps
CM	Reduced normal range for electric motors, low noise
CG14	Special clearance; the number is the mean in μm
MC1 to MC6	Miniature bearings under 10 mm bore; MC3 is the normal grade
E, ER, EF	Low noise grades, rising in strictness; E follows the clearance code (6303 C3 E)

HEAT STABILISATION AND GREASE FILL

Code	Meaning
X26, X28, X29	Stabilised for up to 150, 200 and 250 °C
No code	Normal stabilisation for up to 120 °C
Grease code	Three letters at the end of the number name the grease (6203 DDU C3E AS2S). Ask the maker for the table
K, L, S, M, F	Fill amount as a share of free space: K 20 %, L 20 to 30 %, S 30 to 55 % (standard), M 55 to 70 %, F 85 to 90 %

Example: 6208 VV CM NS7S = deep groove, bore 40 mm, non-contact seals both sides, low noise motor grade, a named grease with the standard fill.

Check the grease and temperature codes before you swap. A replacement with a different grease code may not suit the speed or the heat of the motor.

Matched set and precision codes

Spindle and precision angular contact bearings are supplied in matched sets. The number states the contact angle, cage, arrangement, preload and tolerance class.

GENERAL PRACTICE

PRECISION ANGULAR CONTACT: 7014 C TYN DB L P4

SERIES 70 Angular contact	BORE 14 14 × 5 = 70 mm	ANGLE C 15°	CAGE TYN Polyamide 46	SET DB Back to back	PRELOAD L Light	CLASS P4 Class 4
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Code	Meaning
A, A5, B, C	Contact angle: 30° (A), 25° (A5), 40° (B), 15° (C)
T, TR, TYN, TNG	Cage: phenolic (T, TR), polyamide 46 (TYN), polyamide 66 snap cage (TNG)
W, M	Pressed steel cage (W), brass cage (M)
DB, DF, DT	Pair: back to back, face to face, tandem
DBD, DBB, DFD, DFF, DBT, DTT	Sets of three or four bearings combined from DB, DF and DT
DU, SU	Universal pair (DU) or single (SU): can be matched in any way
L, M, H	Preload: light, medium, heavy (DUL, SUM, SUH)
+KL, +KR	Spacers between inner rings (KL) or outer rings (KR); the number is the width

TOLERANCE AND SPECIAL ACCURACY

Code	Meaning
P6, P5, P4, P2	Tolerance classes to ISO 492
P3	Outside diameter as P4, running accuracy as P2
PA5, PA7, PA9	ABEC 5, 7, 9 classes
P4A, P2A	Special classes for thrust angular contact bearings

OTHER PRECISION SERIES

Code	Meaning
BNR, BER, BSR	Spindle bearings with 18°, 25° and 15° contact angle
BAR, BTR	Thrust angular contact bearings: 30° (BAR), 40° (BTR)
32, 33 series	Double row angular contact: 32°. B is 25°. 2RS or 2Z for seals
QJ	Four-point contact

Matched sets are not loose bearings. Keep the set together and in the order marked by the V on the outer rings; do not mix numbers.

Prefix codes: material

Prefix letters tell you the material, the heat treatment or a special design. They are maker-specific and different makers use the same letters differently.

GENERAL PRACTICE

HIGH TEMPERATURE AND MATERIAL

Prefix	Meaning
TS2-	Dimension stabilised, to 160 °C
TS3-	Dimension stabilised, to 200 °C
TS4-	Dimension stabilised, to 250 °C
LH-	Long life at high temperature, stable to 250 °C
F-	Stainless steel bearing
M-	Plated (hard chrome) bearing
H- or N-	High speed steel or special material
5S-	Ceramic rolling elements (Si3N4)

HEAT TREATMENT AND LIFE

Prefix	Meaning
TM-, CS-	Special heat-treated, long life
ES-	Special heat treatment and material, extra long life
TA-	Nitride-treated bearing steel
E-	Case-hardened steel
EA-	Nitride-treated case-hardened steel
EC-	Expansion compensating bearing
AC-	Creep preventing bearing

SPECIAL TAPERED AND ROLLER DESIGNS

Prefix	Meaning
4T-	Special design tapered roller bearing; example 4T-30208
ET-	Special design tapered roller bearing
ETA-	ET design plus special heat treatment
ECO-	Long-life tapered roller bearing
HL-	Special roller bearing, maker design

MATERIAL CODES IN ANGULAR CONTACT BALL BEARINGS

Ball material

5S- Si3N4 ceramic balls. Blank: bearing steel (SUJ2).

Ring material

F- stainless steel (SUS440C). Blank: bearing steel (SUJ2).

Why it matters

Ceramic balls and stainless rings change speed, life and corrosion limits.

A prefix changes the bearing. Two numbers that differ only in the prefix are not interchangeable. Confirm the code in the maker's list.

Special suffix codes

These suffix codes describe tapered bores, paired bearings, special clearance and preload, special tolerance and the grease fitted. Common cage, seal and clearance codes are on pages 40 and 41.

GENERAL PRACTICE

INTERNAL MODIFICATION

Code	Meaning
U	Tapered roller, internationally interchangeable
R	Tapered roller, not interchangeable
ST	Low-torque tapered roller bearing
HT	Cylindrical roller, high axial load

TAPERED BORE AND RING

Code	Meaning
K	Tapered bore, taper 1:12
K30	Tapered bore, taper 1:30
D1	Lubrication hole and groove in the outer ring

PAIRS AND SETS

Code	Meaning
DB	Back-to-back pair
DF	Face-to-face pair
DT	Tandem pair
DBT	Three-row: tandem plus back-to-back
DTBT	Four-row set
D2	Two matched, paired bearings
G	Flush ground faces
+α	Spacer of width α mm

SPECIAL CLEARANCE AND PRELOAD

Code	Meaning
C5	Clearance greater than C4
CM	Clearance for electric motors
NA	Non-interchangeable clearance
/Gxx	Special preload
/CSxx	Special clearance

SPECIAL TOLERANCE

Code	Meaning
P6X	Class 6X, tapered roller
P4X	Class 4, special bore and outside diameter
P42	Class 4 dimensions, class 2 running accuracy
2, 3, 0, 00	Inch tapered roller classes (ABMA)

GREASE CODES

Code	Meaning
/2A, /3A	Multi-purpose grease No. 2 and No. 3
/8A	Extreme-pressure grease No. 2
/5K	Low-torque, wide-temperature grease
/LX11	High-temperature fluorinated grease
/LP03	Thermosetting grease, polymer-filled bearings

Read the suffix from left to right. The order is fixed: modification, cage, seal, ring, pair, clearance, preload, tolerance, grease.

Reading real bearing numbers (1)

Read each number from the left: prefix, basic number, then the suffix codes in order. Four real numbers decoded.

GENERAL PRACTICE

6205ZZC3/2A Deep groove ball bearing, shielded, greater clearance, grease fitted

TYPE 6 Deep groove ball	SERIES 2 Diameter series 2	BORE 05 $5 \times 5 = 25 \text{ mm}$	SHIELD ZZ Both sides	CLEARANCE C3 Greater than normal	GREASE /2A Grease code
---	--	--	--	--	--

23034BD1 Spherical roller bearing, 170 mm bore

SERIES 230 Width 3, diameter 0	BORE 34 $34 \times 5 = 170 \text{ mm}$	DESIGN B Internal design B	OIL D1 Lubrication hole and groove
--	--	--	--

7012CDB/GMP4 Angular contact ball bearing pair, 60 mm bore

SERIES 70 Angular contact, diameter 0	BORE 12 $12 \times 5 = 60 \text{ mm}$	ANGLE C Contact angle 15°	PAIR DB Back-to-back	PRELOAD /GM Medium preload	CLASS P4 Class 4
---	---	--	--	--	--------------------------------------

NU320G1C3 Cylindrical roller bearing, 100 mm bore

TYPE NU Outer ring ribs, inner ring ribless	SERIES 3 Diameter series 3	BORE 20 $20 \times 5 = 100 \text{ mm}$	CAGE G1 Machined brass, rivetless	CLEARANCE C3 Greater than normal
---	--	--	---	--

Bore code times five. For codes 04 to 96 the bore is the code $\times 5 \text{ mm}$. Codes 00 to 03 are 10, 12, 15 and 17 mm.

Reading real bearing numbers (2)

The same reading rule on tapered bore, thrust, tapered roller and precision numbers.

GENERAL PRACTICE

240/750BK30 Spherical roller bearing, tapered bore, 750 mm bore

SERIES 240 Width 4, diameter 0	BORE /750 Slash: bore 750 mm	DESIGN B Internal design B	BORE TAPER K30 Tapered bore 1:30
--	--	--	--

51120L1P5 Single-direction thrust ball bearing, 100 mm bore

TYPE 511 Thrust ball; height 1, diameter 1	BORE 20 $20 \times 5 = 100$ mm	CAGE L1 Machined brass	CLASS P5 Class 5
--	--	--	--------------------------------------

4T-30208 Tapered roller bearing, special design, 40 mm bore

PREFIX 4T- Special design	SERIES 302 Width 0, diameter 2	BORE 08 $8 \times 5 = 40$ mm
---	--	--

5S-7014C T1 DB G /GL P4 Ceramic ball angular contact pair, 70 mm bore

BALLS 5S- Si3N4 ceramic	SERIES 70 Angular contact	BORE 14 $14 \times 5 = 70$ mm	ANGLE C 15°	CAGE T1 Phenolic	PAIR DB G Back-to-back, flush ground	PRELOAD /GL Light	CLASS P4 Class 4
---	---	---	--	--------------------------------------	--	---------------------------------------	--------------------------------------

A code that is not shown has its normal meaning. No clearance code is normal clearance; no tolerance code is the normal class.

Water pump bearing numbers

A water pump bearing combines the bearing and the shaft in one unit. Its number is built differently from a standard bearing.

GENERAL PRACTICE

EXAMPLE: RWF35-41aR2R6g3

TYPE	OUTER RING	SERIAL	CHAMFER	FRONT SEAL	REAR SEAL	MATERIAL
RWF Ball and roller	35 Outside diameter, mm	41 Serial number	a Special chamfer	R2 Seal symbol	R6 Seal symbol	g3 Carburised shaft

RWF and BWF

RWF: ball and roller type; the groove marks the roller side. BWF: ball and ball type.

Omitted symbols

No chamfer symbol: standard chamfer. No rear seal symbol: rear seal same as front. No material symbol: bearing steel (SUJ2).

0 / -13 µm

outside diameter and shaft diameter

±150 µm

outer ring width and assembled width

±250 µm

shaft length

0.010 to 0.040 mm

usual radial clearance

Life, ball type

$$L_h = 10^6 / (60 n) \times (C / P)^3$$

Life, roller type

$$L_h = 10^6 / (60 n) \times (C / P)^{10/3}$$

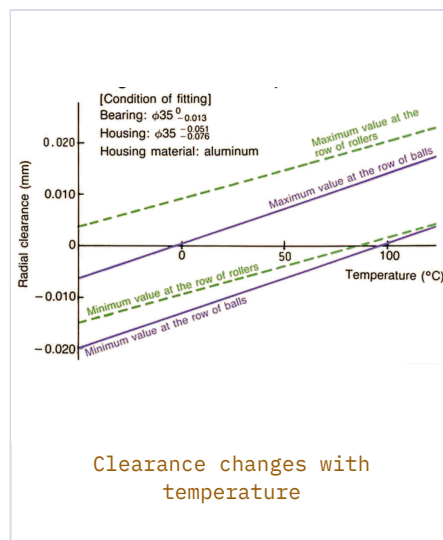
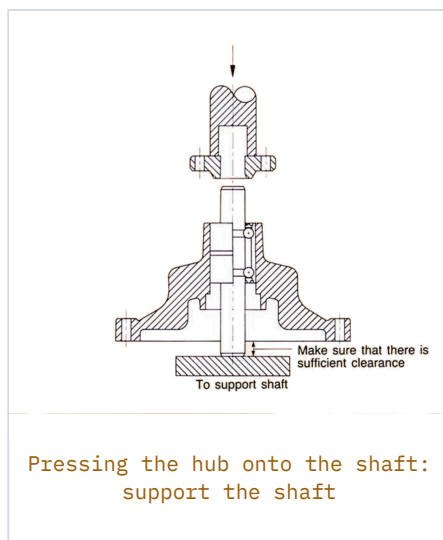
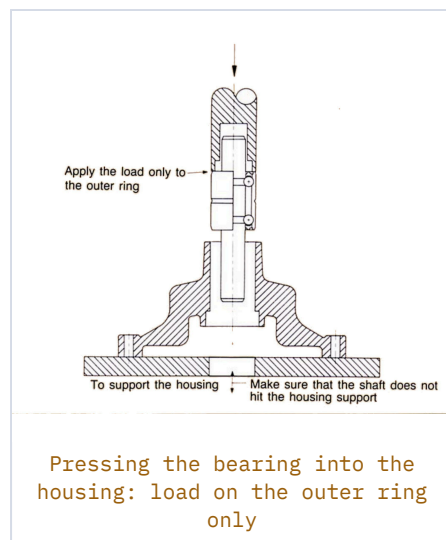
L_h rating life (h) with 10 % failure; P load (N); C basic dynamic load rating (N); n speed (rpm). If the load is off-centre, check shaft tilt and edge load with the maker.

Water pump bearings are ordered by their full number. Quote the number, the seal symbols and the shaft ends; do not substitute by outside diameter alone.

Water pump bearing sizes

Typical water pump bearing sizes and the way to fit them. Press only the ring that is being fitted, and keep the load off the rolling elements.

GENERAL PRACTICE



Series	D mm	W mm	Shaft A mm	C _r roller row, N	C _r ball row, N
RWF26	26	30, 39	12	12 800 to 13 200	3 950
RWF28	28	20	17.2	6 300	5 100
RWFS30	30	30	17.2	13 200	6 000
RWF30	30	29.9 to 46	15.918	14 600 to 17 000	6 600
RWF35	35	38.84 to 56	18	18 500	8 150
RWF41	41	38.9	20	28 000	9 800
RWF42	42	46, 56	22	24 900	11 600
BWF24	24	15, 31.5	10	—	3 300
BWF26	26	30, 39	12	—	3 950
BWF28	28	15.9, 20	17.2	—	5 100
BWFS30	30	23	17.2	—	6 000
BWF30	30	30 to 45.9	15.918	—	6 000
BWF35	35	29.9 to 46	17.5, 18	—	8 150
BWF40	40	46	19	—	9 800

D outer ring diameter, W outer ring width, A main shaft diameter, C_r basic dynamic radial load rating. Maximum shaft length 150 mm. Typical catalogue data: confirm the exact number in the maker's table.

Zero or slightly positive clearance is best. A shaft that hits the support or a press on the wrong ring damages the raceway before the pump runs.



REQUEST A QUOTATION

Plant and maintenance teams: send the bearing number, machine, load, speed and what you want to do. You get the right bearing and fit advice, the price and the delivery time, and an engineer who stays with you after delivery.

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