BEARINGS · L10 LIFE · LOAD RATING · FITS · LUBRICATION · REFERENCE DOCUMENT · PUBLIC

Bearing selection guide

Choosing and sizing a bearing — rolling vs plain, the L10 life calculation, mounting fits and the locating/floating arrangement, lubrication, and the failure modes to design against.

REVISION	ISSUED	OWNER	COMPANION
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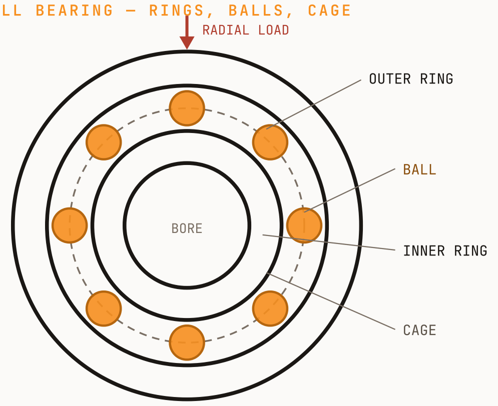
ABSTRACT

A bearing carries load between moving parts with low friction. Getting it right is a sequence: the load direction and speed choose the bearing type, the dynamic load rating and the L10 life equation set the size, and the mounting fits, arrangement and lubrication determine whether it reaches that life.

Section 1 covers bearing types and when to use each. Section 2 is load, rating and the L10 life calculation. Section 3 is speed and lubrication. Section 4 is mounting fits and the locating/floating arrangement. Section 5 covers plain bearings and the PV limit. Section 6 is failure modes and a selection checklist.

DEEP-GROOVE BALL BEARING — RINGS, BALLS, CAGE



A DEEP-GROOVE BALL BEARING — THE VERSATILE DEFAULT. SELECTION IS A CHAIN: LOAD AND SPEED SET THE TYPE, THE L10 LIFE EQUATION SIZES IT, AND THE SHAFT/HOUSING FITS PLUS THE LOCATING/FLOATING ARRANGEMENT MAKE IT RUN.

CONTENTS

1. Bearing types and when to use each

The first split is **rolling-element** (low friction, defined life, needs space and cleanliness) vs **plain/bushing** (cheap, quiet, shock-tolerant, friction- and PV-limited). Within rolling bearings, the load direction picks the type.

TYPE	RADIAL	AXIAL	SPEED	SELF-ALIGN	USE WHEN
Deep-groove ball	high	moderate	high	no	Versatile default, combined loads
Angular-contact ball	high	high (1 dir)	high	no	Spindles; mount in preloaded pairs
Cylindrical roller	very high	~none	high	no	Heavy radial, axial float
Tapered roller	high	high	moderate	no	Wheels, gearboxes; pairs
Needle roller	high	none	moderate	no	Tight radial envelope
Spherical roller	very high	moderate	low–mod	yes	Heavy load + misalignment
Thrust ball	none	high	low	no	Pure axial load
Plain bushing	PV-limited	flanged	low–mod	slight	Low cost, quiet, shock, dirty

1.1 Terms

`C`	Basic dynamic load rating — load giving 10^6 rev L10 life (from the catalogue)
C_0	Basic static load rating — limits permanent raceway deformation (brinelling)
`P`	Equivalent dynamic load = X·F_radial + Y·F_axial
`L10`	Life 90% of bearings reach before fatigue spalling
`ndm`	Speed factor = speed × mean diameter — a proxy for lubrication/thermal limit
`Preload`	Built-in negative clearance (angular-contact/taper) for stiffness and running accuracy

2. Load, rating and L10 life

Rolling bearings fail by **subsurface fatigue** — so life is statistical, quoted as L10 (the life 90% survive):

`L10 = (C / P)ᵖ` million revolutions, with **p = 3 for ball, p = 10/3 for roller** bearings.

In hours: `L10h = L10 × 10⁶ / (60 · n)` where n is rpm.

Example: ball bearing, C = 30 kN, equivalent load P = 3 kN, at 1500 rpm → L10 = $(30/3)^3$ = 1000 million rev → L10h = $1000 \times 10^6 / (60 \cdot 1500)$ ≈ **11,000 h**.

- **Equivalent load P combines radial and axial via catalogue factors X, Y (which depend on the axial/radial ratio and the bearing's contact angle).**
- **Reliability: L10 is 90% survival. For higher reliability multiply by a_1 (≈0.62 for 95%, ≈0.21 for 99%); modern ratings add an aISO factor for lubrication and contamination.**
- **Static check: also verify C_0/P_0 ≥ ~1–2 so shock or standstill loads don't brinell the raceways.**

3. Speed and lubrication

- **Limiting speed is set by heat and lubricant; compare ndm (speed × mean diameter, mm·rpm) to the catalogue limit. Grease is simpler and sealed-for-life up to moderate ndm; oil (bath, mist, jet) for high speed or heat.**
- **Grease for most applications**
  choose base-oil viscosity for the speed/temperature and an NLGI grade (typically 2). Re-greasing interval falls with speed and temperature.
- **Plain bearings run in a lubrication regime:**
  boundary
  (start/stop, metal-to-metal, needs additives or self-lube liner),
  mixed
  , then
  hydrodynamic
  (a full oil film at speed
  near-zero wear). Design journal bearings to reach hydrodynamic at running speed.

4. Mounting fits and arrangement

The ring that sees a **rotating load must be an interference fit** or it creeps and wears its seat; the ring with a stationary load can be looser.

- **Rotating inner ring (most common): interference on the shaft (k5 / k6 / m6 by size and load), looser in the housing (H7 / J7).**
- **Rotating outer ring: interference in the housing, looser on the shaft.**
- **Locating / floating: fix**
  one
  bearing axially (both rings clamped) to locate the shaft; let the
  other
  float (one ring free to slide) so thermal expansion doesn't preload the pair. Cylindrical-roller and deep-groove bearings make good floating bearings.
- **Preload angular-contact and tapered pairs for stiffness and running accuracy**
  but over-preload kills life and overheats.
- **Provide square, supported shoulders and the catalogue fillet/chamfer clearance.**

5. Plain bearings and the PV limit

Plain bushings are limited by frictional heat, captured by the **PV value** (contact pressure × sliding velocity). Stay under the material's PV limit and check P and V individually:

MATERIAL	MAX P (MPA)	MAX V (M/S)	NOTES
Oil-impregnated sintered bronze	~14	~6	Self-lubricating, low cost
PTFE-lined metal (e.g. DU)	~250 (static)	~2	Dry/marginal lube, thin
Filled PTFE / composite	~100	~2	Chemical, dry running
Acetal / nylon	~10	~3	Cheap, quiet, moulded
Carbon-graphite	~4	~5	High temperature

Prefer a plain bearing for **low speed, oscillating or shock loads, quiet running, dirty environments, or cost** — and a rolling bearing for **defined life, high speed, low starting friction, or precise location**.

6. Failure modes and checklist

MODE	CAUSE	FIX
Fatigue spalling	normal end of L10 life	size for required L10; reduce load/speed
Contamination dents / wear	dirt, debris (the #1 premature cause)	better sealing, clean assembly, filtration
Brinelling	static overload / impact at standstill	check C_0; cushion shock; handle carefully
False brinelling / fretting	vibration while not rotating	preload, secure in transit, lubricate
Smearing / skidding	too light load at high speed	minimum load, lighter preload
Lubrication failure	wrong/insufficient lube, overheat	correct grease/oil, re-lube interval, cooling
Electrical fluting	shaft currents (VFD drives)	insulated bearing or shaft grounding ring
Misalignment wear	shaft/housing not coaxial	self-aligning type, tighter alignment

6.1 Selection checklist

- **Load**
  direction (radial / axial / combined / moment) and magnitude, including shock.
- **Speed**
  rpm and ndm vs the limiting speed.
- **Life & reliability**
  required L10h and survival % (apply a_1).
- **Environment**
  temperature, contamination, moisture, electrical.
- **Constraints**
  envelope, precision/runout, stiffness/preload, noise.
- **Then: pick the type (table), size to L10, choose fits and the locating/floating arrangement, select lubrication and sealing, and specify mounting (shoulders, clamping, fits) on the drawing.**