PRINTABLE REFERENCE CHART

Bearing life: L10, L10h and reliability (ISO 281)

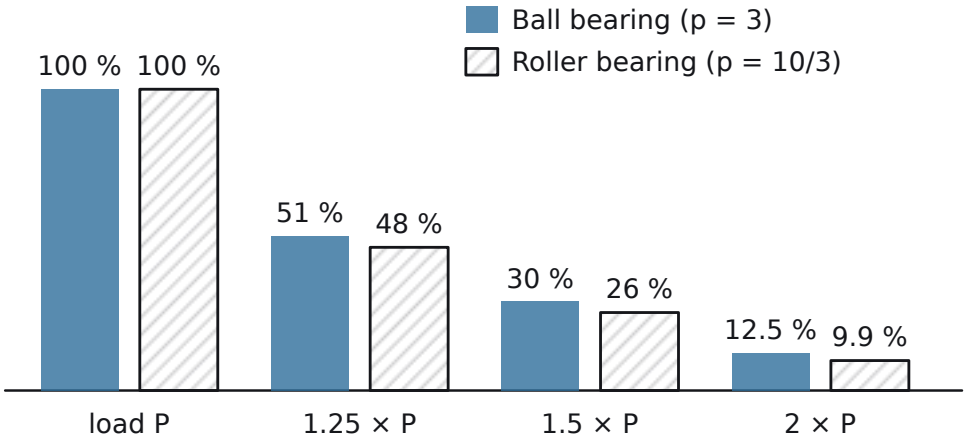
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1. Bearing life formulas

A bearing rotating under load eventually spalls: the balls or rollers and the raceways go through millions of stress cycles until the metal fatigues. ISO 281 gives the basic rating life, written L10: the number of revolutions that 90 % of a large group of identical bearings reach or exceed before the first spall.

Quantity	Formula	Unit
Basic rating life L10	$(C / P)^p$	million revolutions
Exponent p	3 for ball bearings; 10/3 for roller bearings	—
Life in hours L10h	$10^6 \times L10 / (60 \times n)$	hours (n in rpm)
Required basic dynamic load rating	$P \times (60 \times n \times L_h / 10^6)^{1/p}$	same unit as P
Modified rating life L_{nm}	$a_1 \times a_{ISO} \times L10$	million revolutions

C, the basic dynamic load rating, is the constant load under which the bearing reaches L10 = 1 million revolutions. It is listed in the manufacturer's catalogue for each bearing. P and C must be in the same unit (N, kN or lbf): only their ratio matters.



4. Reliability: the a1 and aISO factors

When a failure is costly, a higher reliability is targeted and the life is reduced with the factor a1. Values from ISO 281:2007:

Reliability	Life	a_1	Example: 3,811 h at 90 %
90 %	L_{10m}	1	3,811 h
95 %	L_{5m}	0.64	2,439 h
96 %	L_{4m}	0.55	2,096 h
97 %	L_{3m}	0.47	1,791 h
98 %	L_{2m}	0.37	1,410 h
99 %	L_{1m}	0.25	953 h

These values are the rounded result of $a1 = 0.95 \times (\ln(100/R) / \ln(100/90))^{2/3} + 0.05$, R being the reliability in %, a Weibull law with a minimum life. Earlier editions of the standard (before 2007), without that

minimum term, gave slightly lower values (0.62 at 95 %, 0.21 at 99 %): some software and older catalogues still use them.

5. Worked examples

The basic dynamic load ratings below are example values: for a real bearing, read C in the catalogue of the chosen part.

Case	Calculation	Result
Ball, C = 14,000 N, P = 2,000 N, 1,500 rpm	$(14{,}000 / 2{,}000)^3 = 343$; $343 \times 10^6 / (60 \times 1{,}500)$	**343 million rev; 3,811 h**
Same at 99 % reliability	$0.25 \times 3{,}811$	**953 h**
Same under twice the load (P = 4,000 N)	$(14{,}000 / 4{,}000)^3 = 42.9$	**42.9 million rev; 476 h**
Roller, C = 50,000 N, P = 5,000 N, 1,000 rpm	$10^{10/3} = 2{,}154$; $2{,}154 \times 10^6 / (60 \times 1{,}000)$	**2,154 million rev; 35,907 h**
Required C: 20,000 h at 1,500 rpm, ball, P = 2,000 N	$L10 = 60 \times 1{,}500 \times 20{,}000 / 10^6 = 1{,}800$; $2{,}000 \times 1{,}800^{1/3}$	**C ≥ 24,329 N**
Same at 99 % reliability	$2{,}000 \times (1{,}800 / 0.25)^{1/3}$	**C ≥ 38,620 N**

For a wheel, life is counted in distance: L10 in millions of kilometres = π × D × L10 / 1,000, with D the wheel diameter in metres. A 0.6 m wheel whose bearing makes 343 million revolutions thus covers 0.647 million km.

6. Bearing life in Excel: formulas to copy

With the exponent p in A2 (3 or 10/3), C in B2, P in C2, the speed n in D2 (rpm), the reliability R in E2 (in %, from 90 to 99.9) and the target life in F2 (h), the ball bearing example gives:

Result	Excel formula	Example value
L10 (million rev), in G2	`=(B2/C2)^A2`	343
L10h (hours), in H2	`=G2*10^6/(60*D2)`	3,811.1
a1 factor for R, in I2	`=0.95*(LN(100/E2)/LN(100/90))^(2/3)+0.05`	0.2483 (R = 99)
Life at reliability R (hours)	`=I2*H2`	946.4
C required for F2 hours	`=C2*(60*D2*F2/10^6/I2)^(1/A2)`	38,706 (F2 = 20,000)

The a1 formula gives the exact value (0.2483) where the table rounds to 0.25, hence 946 h instead of 953. Enter 10/3 in A2 as `=10/3`. The same formulas work with C and P in lbf.

Reference values taken from the article https://www.baouch.fr/en/blog/duree-de-vie-roulement-calcul-l10/, which explains the assumptions, formulas and edge cases. For critical use, check the current standard or the manufacturer's documentation. Free to print and share with credit to the source.