Rolling Bearing Life: ISO 281 Basic and Modified Rating Life

bearing_life_iso281_a ver 1.0 by Tom Irvine

Notation

C basic dynamic load rating, F_r, F_a radial and axial load, X, Y radial and axial factors, e limit ratio, n speed (rpm), p life exponent, a_1 reliability factor, a_{ISO} life modification factor (user entry).

Single load case

1. Equivalent dynamic load — $P = XF_r + YF_a$ $\quad (X = 1,\ Y = 0$ when $e > 0$ and $F_a/F_r \le e)$

2. Life exponent — $p = 3$ ball bearings, $\quad p = 10/3$ roller bearings

3. Basic rating life (90 % reliability) — $L_{10} = \left(\frac{C}{P}\right)^p$ million revolutions

4. Basic rating life in hours — $L_{10h} = \frac{10^6}{60\,n}\,L_{10}$

5. Modified rating life — $L_{nm} = a_1\,a_{ISO}\,L_{10}, \quad L_{nmh} = a_1\,a_{ISO}\,L_{10h}$

Subscript n in L_{nm} = 100 − reliability in % (e.g. L_{1m} at 99 %). Doubling P divides ball life by $2^3 = 8$.

Life modification factor for reliability a_1 (ISO 281:2007)

Reliability %	90	95	96	97	98	99	99.2	99.4	99.6	99.8	99.9	99.92	99.94	99.95
a_1	1	0.64	0.55	0.47	0.37	0.25	0.22	0.19	0.16	0.12	0.093	0.087	0.080	0.077

Values as published for ISO 281:2007 by NSK (bearing life calculation tool help). They replace the ISO 281:1990/Amd 2 values (0.62, 0.53, 0.44, 0.33, 0.21 at 95 to 99 %). Check against the standard.

Duty cycle (Palmgren-Miner)

6. Load in each condition i — $P_i = XF_{r,i} + YF_{a,i}$ $\quad q_i$ = fraction of time, $\sum q_i = 100\,\%$

7. Mean speed — $n_m = \frac{\sum q_i\,n_i}{\sum q_i}$

8. Equivalent load — $P_{eq} = \left[\frac{\sum q_i\,n_i\,P_i^p}{\sum q_i\,n_i}\right]^{1/p}$

9. Combined life — $L_{10} = \left(\frac{C}{P_{eq}}\right)^p, \quad L_{10h} = \frac{10^6}{60\,n_m}\,L_{10} = \left[\sum \frac{q_i}{L_{10h,i}}\right]^{-1}$

10. Damage share of condition i — $100\,q_i\,n_i\,P_i^p\,/\,\sum q_j\,n_j\,P_j^p \quad (\%)$

X, Y and e

Take X, Y, e from the bearing catalog. Example, single-row deep groove ball bearing at $f_0F_a/C_0 = 0.689$:
$e = 0.26$; $F_a/F_r \le e$: $X = 1,\ Y = 0$; $F_a/F_r > e$: $X = 0.56,\ Y = 1.71$ (from public catalog tables).
Enter $e = 0$ to always use the X and Y entered (e.g. roller bearings with their own factors).

Units and assumptions

English: C, F_r, F_a in lbf. **metric**: C in kN (catalog style), F_r, F_a in N. Speed in rpm.
Life does not depend on the unit system (C/P is dimensionless).
a_{ISO} is entered by the user (1 = no adjustment). The ISO 281 a_{ISO} model for lubrication, contamination and fatigue load limit is *not* computed. A warning is shown for $a_{ISO} > 50$ (limit per public summaries).
A warning is shown for $P > 0.5\,C$ (heavy load; consult the manufacturer).

References: ISO 281:2007, *Rolling bearings – Dynamic load ratings and rating life*; ISO/TR 1281-2:2008;
NSK, "Bearing life calculation tool – new life calculation equation" (a_1 table); Shigley, *Mech. Eng. Design*, rolling-contact bearings.