Bearing Life and Load: Understanding the Real-World Connection

The performance and reliability of a rolling bearing are largely determined by the relationship between load capacity and expected life. While the math behind this is important, the goal is practical: predicting how a bearing will perform in your application so you can prevent unexpected downtime and maintenance costs.

Additional formulas and calculation methods are available in the CW Bearing catalog. The intent of this paper is to illustrate the relationship between bearing life and load in a clear, real-world context. Further technical content is available from CW Bearing and our engineering team, who are always ready to assist customers with their design challenges.

Bearing Life in the Field

The relationship between **bearing load** and **bearing life** is more than just a calculation. It's a predictor of performance in the field. For example:

- **Industrial pumps**: Bearings supporting an impeller see steady radial loads and occasional axial thrust from pressure surges. Choosing a bearing with adequate dynamic load capacity ensures years of reliable operation with minimal downtime.
- **Medical robotics**: Precision joints in robotic arms require bearings that can handle light, constant loads without skidding, while still achieving exceptionally long service life in cleanroom environments.
- **Electric motors and gearboxes**: High-speed shafts generate large numbers of revolutions every day. The wrong load-to-life balance can shorten maintenance intervals dramatically.
- **Conveyor systems**: Bearings in rollers face varying loads from uneven product distribution; calculating equivalent loads helps match bearing capacity to actual operating demands.

CW Bearings are engineered to perform under these diverse conditions, whether it's sustaining **hundreds of millions of revolutions** in a manufacturing line or delivering **precise, friction-free motion** in delicate surgical tools. By understanding how load influences life, you can select the right bearing for maximum reliability, and that's where CW's expertise comes in.

Key Concepts Engineers Should Know

1. Basic Rating Life (L_{10})

Defined by ISO 281:2007(E), L_{10} is the number of revolutions 90% of identical bearings can complete before the first signs of fatigue. $L10=(C/P)^3$

- **C** = basic dynamic load rating [N]
- **P** = dynamic equivalent load [N]
- Higher C/P ratio = longer life.

For hours of operation, L_{10} can be converted using operating speed (n in RPM). $L_{10h} = 10^6/(60 \cdot n) \times L_{10}$

2. Dynamic Equivalent Load (P)

Represents the constant radial load that would have the same effect on life as the actual combined radial ($\mathbf{F_r}$) and axial ($\mathbf{F_a}$) loads:

$P = (X \cdot F_r) + (Y \cdot F_a)$

X and Y come from bearing type and Fa/Fr ratio.

3. Temperature and Material Influence

High operating temperatures reduce steel hardness, lowering the dynamic load rating. Correction factors from the catalog should be applied for temperatures above 150 °C.

4. Modified Rating Life (aISO)

Adjusts L_{10} for:

- Lubrication quality
- Contamination level
- Fatigue load limit

  $L_{na} = a_{ISO} \cdot L_{10}$

  In most industrial applications, **aISO** values are modest; often below 3. *However, in very clean, well-lubricated, low-contamination environments (such as certain medical, laboratory, or sealed systems, the factory can reach up to 50. This represents and extreme, best-case, condition and should not be assumed in typical design work.*

5. Static Load Rating (C_0)

Represents resistance to permanent deformation at the most heavily loaded contact point. For most applications, the static safety factor should be ≥1 to prevent premature wear or damage.

6. Minimum Load Requirement

When a ball bearing operates under very light loads, particularly at high speeds or during rapid acceleration, there is a risk of sliding between the balls and raceway instead of true rolling contact. This sliding can significantly reduce bearing life.
To ensure non-slip operation, the minimum recommended load is $P = 0.02 \cdot C$
Where:

- $\mathbf{P_{min}}$ = minimum load [N]
- **C** = basic dynamic load rating [N]

If the application load cannot be increased, consider selecting a bearing with a smaller dynamic load rating and/or using a special low-viscosity grease to improve rolling conditions.

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7. Variable Load and Speed

For applications with changing loads and speeds, life is calculated as a weighted average of each operating condition.

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8. Misalignment, Preload, and Fit

- **Misalignment:** Keep within allowable limits to avoid uneven loading.
- **Preload:** An axial preload can prevent ball skidding; excessive radial preload generates heat and reduces life.
- **Fit:** Tight fits reduce clearance and can unintentionally add preload — factor in thermal expansion.

Example — 6205 Deep Groove Ball Bearing

Specs:
C = 14,000 N, C_0 = 7,850 N
Fr = 500 N, Fa = 50 N
Speed = 3,000 rpm, Temp = 25 °C
Step 1 – Equivalent Load:
P = (1.0 × 500) + (0 × 50) = 500 N
Step 2 – Life in Revolutions:
$L_{10} = (14{,}000 \div 500)^3 \approx 22$ billion rev
Step 3 – Life in Hours:
≈ 122,000 h (≈ 14 years continuous operation)

Safety Check

- **Minimum load needed:** 280 N → OK (we have 500 N)
- **Static safety factor:** 15.7 → Well above safe limit.

✅ **Result:** Under these steady conditions, the bearing easily meets long-life requirements. Clean lubrication and proper mounting will help achieve this in practice.

Practical Takeaways for Design Engineers

1. Choose a **C/P ratio** that supports your target life at the intended speed.
2. Apply correction factors for temperature, contamination, and lubrication.
3. Maintain at least the **minimum load** to prevent skidding.
4. Control preload, fit, and alignment to avoid excess heat or uneven loading.

Tips for Long Life

- Keep lubrication clean and fresh.
- Use correct fits: too tight can overheat, too loose can cause skidding.
- An axial preload can help prevent skidding; avoid high radial preload.
- Protect against dirt, heat, or heavy shock loads.

Conclusion

Understanding the relationship between bearing life and load is essential for achieving reliable, long-term performance in any application, from high-speed industrial motors to precision medical devices. By applying the correct calculations, checking safety margins, and considering real-world factors like lubrication, contamination, and fit, engineers can ensure their bearings deliver maximum value over their service life. CW Bearings' engineering expertise, quality materials, and precision manufacturing provide the confidence that each bearing will meet, and often exceed, the demands of its application.

If you'd like to explore detailed formulas, review your specific application, or solve a design challenge, our engineering team is ready to help. **Contact CW Bearing for expert guidance and support in selecting the right bearing for your needs.**

For more bearing measurement best practices and technical resources, visit CW Bearing's website.

Your Requirements Are Our Standard CW Bearing collaborates with customers to deliver precision, reliability, and innovation. Whether standard or custom-engineered, we are your trusted partner.

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