Beyond Basic Bronze: A Data-Driven Guide to Sliding Bearing Material Selection

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1. The Three Root Causes of Bearing Failure

Over years of analyzing tribological system failures, I have seen countless sliding bearings and bushings fail prematurely. The root cause is almost always the same: a drawing that simply calls out "standard bronze."
There is no universally optimal bearing material. There is only the precise metallurgical match for your specific operating environment.
When an end user experiences bearing seizure, excessive wear, or unplanned downtime, the failure typically traces back to one of three root causes:

1.1 Failure Mode & Application Matrix

Pain Point	Manifestation	Typical Applications
⚠ Starved Lubrication	Collapse of the hydrodynamic oil film leads to friction spikes and seizure	Intermittent duty cycles, inaccessible lubrication points
⚠ Edge Loading & Misalignment	Shaft deflection exceeds bearing conformability, causing scoring	Excavators, presses, heavy machinery
⚠ Corrosive Environments	Simultaneous mechanical wear and chemical attack	Marine pumps, steam valves, chemical processing

1.2 Bronze Alloy Comparison Matrix

The data below reflects continuous casting (CC) values, which provide a denser, superior grain structure for bearing applications.

Application Scenario	Recommended Material	Yield Strength (MPa)	Hardness (HBW)	Self-Lubricating Capability	Key Limitation
High load, well-lubricated	CuSn12-C / C86200	≥150 / ≥310	90 / High	✗ Poor	Requires hardened mating shaft
General machinery, soft shafts	Rg7 (CuSn7Zn4Pb7-C)	≥120	70	⚠ Emergency only	Not suitable for heavy impact
Starved lubrication, misalignment	CuSn7Pb15-C	≥90	65	☑ Excellent	Lead-restricted, ≤120°C
Pumps, valves, aqueous media	Rg5 (CuSn5Zn5Pb5-C)	≥110	65	⚠ Moderate	Not for high sliding loads

☆**Key takeaway:** For high loads, select a high-strength copper alloy—but only with a hardened shaft. For starved-lubrication conditions, high-lead bronze is effective, but environmental regulations favor upgrading to graphite-plugged alternatives.

2. Selecting by Operating Condition

2.1 "My equipment frequently runs with inadequate lubrication. What should I use?"

- **Traditional solution: High-lead bronze (CuSn7Pb15-C)**

With 13–17% free lead, this alloy provides an emergency solid lubricant. Under dry running conditions, lead smears onto the shaft surface, preventing seizure. Its lower yield strength (≥90 MPa) also offers excellent conformability, allowing it to accommodate edge loading and misalignment.

- **Limitations:**
  - Maximum operating temperature: 120°C
  - Increasingly restricted by environmental regulations (RoHS, REACH)
- **Modern alternative:** See Section on Graphite-Plugged Bearings below.

2.2 "Why did my high-strength bronze bearing damage the shaft?"

- **Cause: Hardness mismatch.**

CuSn12-C and C86200 are high-strength alloys with significant hardness. If the mating shaft is not hardened (i.e., its hardness is lower than that of the bearing), the bearing acts as a cutting tool, rapidly wearing the shaft journal.

- **Corrective action:**
  - When using CuSn12-C or C86200, **a hardened shaft is mandatory** (typically ≥45 HRC)
  - If the shaft cannot be hardened, select a softer alloy such as Rg7

2.3 "What material is recommended for pump housings and valves?"

- **Recommendation: Rg5 (CuSn5Zn5Pb5-C)**

Rg5 is formulated for pressure tightness and corrosion resistance rather than pure sliding performance. It is the standard choice for thin-wall castings, pump bodies, and steam fittings operating up to 225°C.

- **Shaft pairing:** In corrosive environments, pair with a hardened stainless steel shaft such as **SAE 430** (16–18% Cr ferritic stainless) to address both corrosion and wear.

3. Self-Lubricating Upgrade: Graphite-Plugged Bearings

When end users demand maintenance-free operation or when environmental regulations restrict lead-containing alloys, **graphite-plugged bearings** represent the most robust m

3.1 Construction Principle

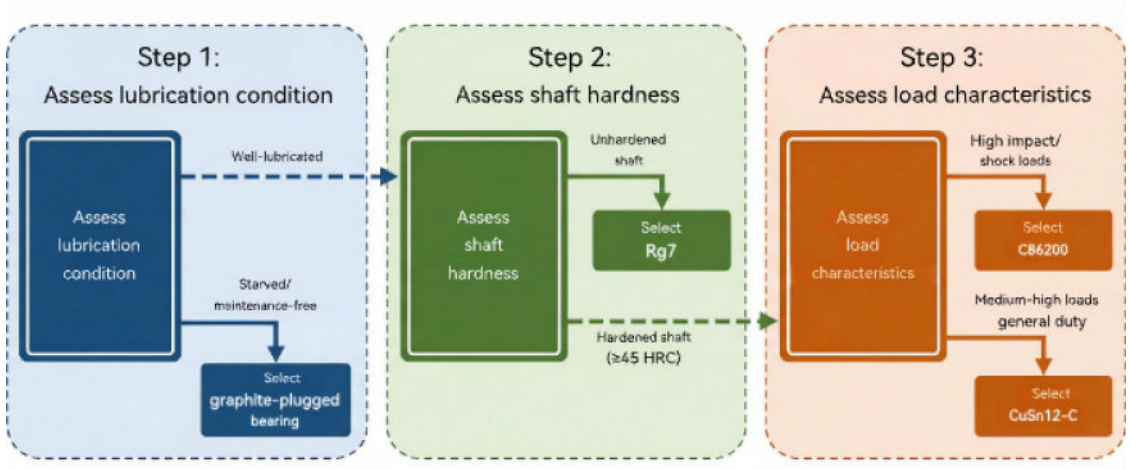
A high-strength copper alloy matrix (such as CuSn12 or C86200) is machined with a precision pattern of pockets on the bearing surface. These pockets are then filled with solid lubricant plugs—typically graphite, PTFE, or MoS_2.

3.2 Technical Advantages

Advantage	Description
☑High load capacity + maintenance-free	Retains the strength of C86200 while eliminating external lubrication systems
☑Transfer film mechanism	Frictional heat causes solid lubricant to expand and transfer onto the shaft, forming a durable low-friction film
☑Environmentally compliant	Replaces lead-containing alloys while exceeding their dry-running performance
☑Wide temperature range	Depending on lubricant formulation, operational from –200°C to +400°C

4. Three-Step Selection Workflow

Use this decision logic to navigate bearing material selection without consulting complex standards:



Step 1: Assess lubrication condition
Well-lubricated → Proceed to Step 2
Starved / maintenance-free → Select **graphite-plugged bearing**

Step 2: Assess shaft hardness
Unhardened shaft → Select **Rg7**
Hardened shaft (≥45 HRC) → Proceed to Step 3

Step 3: Assess load characteristics
High impact / shock loads → **Select C86200**
Medium-high loads / general duty → **Select CuSn12-C**

☆ **Special case:** For corrosive environments (water, steam, chemicals), prioritize Rg5 with a stainless steel shaft, or a graphite-plugged bearing with an appropriately selected lubricant formulation.

5. Frequently Asked Questions

Q1: Can high-lead bronze still be used?

A: In markets with strict environmental regulations (EU, California, etc.), high-lead alloys are being phased out. For equipment destined for these regions or for environmentally sensitive applications, we recommend evaluating graphite-plugged bearings or lead-free copper alloys.

Q2: Do graphite-plugged bearings require lubrication?

A: No. They are designed for “fit-and-forget” maintenance-free operation. In extreme heavy-load or ultra-high-temperature conditions, consult our engineering team to verify whether supplementary lubrication is beneficial.

Q3: When is a hardened shaft mandatory?

A: When the bearing material hardness exceeds approximately 180 HBW. This includes CuSn12-C and C86200. Unhardened shafts (e.g., plain 1045 steel) will experience accelerated wear when paired with these materials.

Q4: Can graphite-plugged bearings be used underwater?

A: Yes. Certain graphite formulations are specifically designed for submerged or humid environments, maintaining stable friction coefficients. Please provide your operating conditions for a tailored recommendation.

Q5: Are the materials listed available as stock items?

A: CuSn12, Rg7, Rg5, C86200, and graphite-plugged bearings are maintained in stock in standard sizes. Custom dimensions are available with typical lead times of 7–15 business days.

6. Summary & Next Steps

6.1 Recommended Bearing Materials by Operating Condition

Operating Condition	Recommended Solution
High load + well-lubricated + hardened shaft	CuSn12-C or C86200
General machinery + unhardened shaft	Rg7
Pumps, valves, aqueous environments	Rg5 + stainless steel shaft
Starved lubrication / maintenance-free / environmentally restricted	Graphite-plugged bearing

☆ **Stop specifying "standard bronze" on your drawings.** Precision metallurgical matching is not about purchasing a bearing—it is about engineering out the risk of catastrophic failure at the design stage.

6.2 Need Assistance with Material Selection?

We offer complimentary application reviews and material recommendations.
Please provide the following information for a tailored recommendation:

- Equipment type and operating duty cycle
- Load magnitude and direction
- Lubrication condition (well-lubricated / starved / maintenance-free)
- Shaft material and hardness (if known)
- Operating temperature and environmental media

Contact our engineering team using the form below or reach out directly.