# In-Depth Analysis of CuSn7Pb15-C (CC496K) High-Lead Tin Bronze: A Guide to Its Process, Material Properties, and Applications

In the selection of plain bearings and bushings, EN 1982: CuSn7Pb15-C (CC496K) stands out as a highly specialized high-lead tin bronze material (equivalent to UNS C93800 and BS 1400 LB1). Based on its physical and chemical properties, this material is not engineered for extreme mechanical loads, but rather tailored for harsh operating conditions characterized by poor boundary lubrication, soft journal materials, and corrosive environments. This article provides an in-depth analysis of its material logic, differences in casting processes, and optimal application scenarios.

## 1. The Logic of Material Selection: The Metallurgical Truth of CuSn7Pb15-C

As meticulous engineers, we must look beyond the data sheet to understand the physical principles behind the element composition.

### 1.1 Why Does the Lead Content Reach as High as 13.0% - 17.0%?

Lead (Pb) is virtually insoluble in the copper matrix. Instead, it exists as free particles uniformly distributed at the grain boundaries.
★ **Fail-Safe Lubrication Mechanism:** When the oil film breaks down, leading to dry friction, the low-melting-point lead melts due to frictional heat (thermal conductivity: 50 W/mK, indicating moderate heat dissipation). This forms a solid self-lubricating film on the bushing surface.
★ **Embeddability and Conformability:** With a hardness of only 65 HB, this might seem like a disadvantage. However, from an engineering perspective, this softness allows the material to perfectly "embed" small foreign particles, preventing them from scratching the expensive drive shaft (excellent embeddability).

### 1.2 The Synergistic Balance of Tin (6.0-8.0%) and Nickel (0.5-2.0%)

While lead provides lubrication, it significantly weakens the material's mechanical strength. Therefore, tin is added to form a hard Cu-Sn solid solution, maintaining a base level of load-bearing capacity (Yield Strength: 90 N/mm², Tensile Strength: 200 N/mm²).
★ **Hypothesis & Deduction:** The specification requiring 0.5% - 2.0% nickel (Ni) is highly likely intended to refine the grain structure and inhibit gravity segregation of the high lead content during solidification, thereby ensuring the uniformity of the alloy's microstructure.

### 1.3 Excellent Corrosion Resistance Profile

Data indicates that this material performs exceptionally well in air/fresh water (Grade 5) as well as in seawater, alkaline solutions, and weak acids (all Grade 4). This directly determines its core application areas—wet industrial environments.

## 2. In-Depth Comparison of Manufacturing Processes: GC vs. GZ

For high-lead bronzes, traditional sand casting can easily lead to lead sinking and accumulation. Therefore, specifications primarily recommend Continuous Casting (GC) and Centrifugal Casting (GZ). While their mechanical properties are quite similar, significant differences exist in their practical engineering applications.

### 2.1 Continuous Casting (GC)

• **Performance Difference:** Elongation reaches 8% (slightly higher than GZ's 7%).
• **Process Advantage:** The molten metal undergoes rapid directional solidification in a graphite mold, resulting in an extremely fast cooling rate. This effectively prevents lead segregation and produces an exceptionally dense grain structure.
• **Selection Advice:** Ideal for mass-producing standardized, small to medium-diameter bushings and tubes. This process offers the best material consistency.

### 2.2 Centrifugal Casting (GZ)

• **Performance:** Elongation of 7% with stable overall performance.
• **Process Advantage:** Formed by centrifugal force in a rotating mold. This force pushes the denser, purer molten metal to the outer wall (the material density is high at 9.2 kg/dm³), while forcing inclusions and gases towards the inner diameter, which are subsequently removed by machining.
• **Selection Advice:** The absolute preferred method for manufacturing large-diameter, heavy-duty, non-standard custom flanged plain bearings or liners for heavy machinery.

## 3. Most Common Industrial Application Scenarios (Actionable Use Cases)

Combining the material's characteristics of "low hardness + high lubricity + excellent corrosion resistance," the optimal application scenarios for CuSn7Pb15-C (CC496K) plain bearings can be precisely defined as follows:

★ **Pumps & Marine Equipment**
＞**Logical Match:** Grade 4 resistance to seawater and Grade 5 to fresh water. Suitable for stern tube bearings for ship propellers and guide bearings for deep-well pumps. Even under water-lubricated (oil-free) conditions, the high lead content prevents seizure and scoring.

★ **Mining Machinery & Crushing Equipment**
＞**Logical Match:** Excellent embeddability. In harsh environments prone to dust and sand ingress, the bearing liner can "absorb" hard particles into its soft lead matrix, protecting the main shaft from scoring.

★ **Chemical Processing Equipment (Weak Acids)**
＞**Logical Match:** With Grade 4 resistance to weak acids, it is commonly used in paper machinery and low-speed drives in mildly acidic wastewater treatment equipment.

★ **Boundary-Lubricated Joints Prone to Neglect**
＞**Logical Match:** Suitable for enclosed mechanisms where regular greasing is difficult, or for low-speed, heavy-load (static load) joint bearings where frequent start/stop cycles make it hard to establish a stable oil film.

## 4. Expert Considerations & A Guide to Avoiding Selection Pitfalls (Caveats & Limitations)

As a selection expert, it is crucial to highlight the limitations of this material to prevent engineering failures:

★ **Poor Resistance to Impact Loads:** Yield strength is only 90 N/mm². It is strongly advised not to use this material in equipment subjected to high-frequency impact loads (e.g., crank linkages in heavy stamping presses), as it is highly susceptible to plastic deformation or extrusion-thinning.

★ **Environmental Compliance Risks (RoHS/REACH):** The 13%-17% lead content is a highly restricted substance under modern environmental regulations (such as the EU RoHS). Before selection, the export destination regulations for the final equipment must be verified. If facing environmental restrictions, consider lead-free alternatives like bismuth bronze.

★ **Mating Shaft Hardness Requirements:** Although this material is friendly to soft shafts, for optimal service life, it is recommended that the hardness of the mating steel shaft be slightly higher than that of the bushing (suggested shaft hardness > 200 HB) to form an ideal tribological pair.

## Conclusion

EN 1982 CuSn7Pb15-C (CC496K) is not a universal high-strength material. Instead, it is a "soft-defeating-hard" tactical material. Enhanced by centrifugal or continuous casting processes, it serves as the ultimate compromise solution for addressing issues of poor lubrication, corrosive environments, and the protection of critical shafting.