Extreme Alloys for Extreme Environments

Elite Bearing Alloys
Material Data

Unique high performance material for bearing applications.

Freerun® SL - Self Lubricating bearing material
Freerun® LW - Long Wearing bearing material
Copper Alloys Ltd has developed a range of materials called Freerun® optimised for use in extreme and aggressive bearing applications.

What is Freerun®?
Why settle for standard bearing material or complicated combinations of material? Freerun is a solid bearing material which comes in a self-lubricating (Freerun® SL) format and a long wearing format (Freerun® LW).

How special is Freerun®?
As a bearing material, these alloys are designed to wear. Freerun® alloys have the benefit of reducing friction, whilst increasing strength. This means will not only last longer, but will be able to take higher loads and perform in more extreme environments.

The metallurgy of Freerun® solid bearing metal
By applying the proprietary process technology called Microfine® unique to Copper Alloys, it is possible to significantly enhance mechanical properties. This unique combination allows previously ‘cast only’ alloys to be manufactured with a fine grain structure. This facilitates the application of mechanical work in order to push the mechanical properties to the extreme.

New material technology
The result is two of the most advanced solid bearing materials.
The benefits of composition

Freerun® SL is a self-lubricating metal. Its composition is designed specifically to enable it to meet a number of national material standards.

**Elite Bearing Alloys**

**Highly Engineered Alloys for Extreme Environments**

Freerun® SL is a Self-Lubricating Alloy ideal when lubrication is difficult or unfeasible, or to be used as a contingency against lubrication failure. This is a Leaded Phosphor Bronze conforming to UNS C93800 and supplied in three grades:

- **SL340** (hard wearing)
- **SL300** (medium wearing)
- **SL240** (soft wearing)

With increasing self-lubrication and reducing yield strength.

**Chemical Composition**

<table>
<thead>
<tr>
<th>Element</th>
<th>As</th>
<th>Q</th>
<th>N</th>
<th>Zn</th>
<th>Sn</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Ni</th>
<th>Fe</th>
<th>Al</th>
<th>Si</th>
<th>S</th>
<th>P</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1-6.3</td>
<td>1/1-4</td>
<td>.6(</td>
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</tr>
</tbody>
</table>

Freerun® SL also meets the following industry standards:

- **EN 1982-2008 C496K**
- **ASTM C93800**
- **BS1400 LB1**
- **SAE 67**

**Engineering Advantages**

- High mechanical strength, three times greater than the all industry standards whilst still retaining good ductility
- Super strength, four-times the strength with reduced ductility
- High fatigue strength
- High lead content gives excellent resistance to seizure
- Increased hardness improves the wear resistance
- Excellent corrosion resistance
- Good machinability at 80% of free machining brass

**Contact Information**

www.copperalloys.net
### Freerun® SL-250 Soft

<table>
<thead>
<tr>
<th>Material Condition</th>
<th>Yield Strength (0.2% N/mm²)</th>
<th>Tensile Strength (0.2% N/mm²)</th>
<th>Elongation (%)</th>
<th>Hardness (HB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half Hard</td>
<td>110</td>
<td>172</td>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td>Hard</td>
<td>120</td>
<td>340</td>
<td>85</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Mechanical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Imperial</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting Point - Liquidus</td>
<td>1730º F</td>
<td>943º C</td>
</tr>
<tr>
<td>Melting Point - Solidus</td>
<td>1570º F</td>
<td>854º C</td>
</tr>
<tr>
<td>Incipient Melting</td>
<td>600º F</td>
<td>316º C</td>
</tr>
<tr>
<td>Density</td>
<td>0.334 lb/in³ @ 68º F</td>
<td>3 g/cm³ @ 20º C</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>9.250</td>
<td>9.25</td>
</tr>
<tr>
<td>Electrical Resistivity</td>
<td>91.10 ohms-cmil/ft @ 68º F</td>
<td>15.15 microhm-cm @ 20º C</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>11 %IACS @ 68º F</td>
<td>0.066 MegaSiemens/cm @ 20º C</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>30.20 Btu • ft/(hr • ft² •°F)</td>
<td>52.3 W/m • °K @ 20º C</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion</td>
<td>10.30 • 10⁻⁶ per °F (68-392º F)</td>
<td>18.5 • 10⁻⁶ per °C (20-200º C)</td>
</tr>
<tr>
<td>Specific Heat Capacity</td>
<td>0.090 Btu/lb/°F @ 68º F</td>
<td>377.1 J/kg • °K @ 293º K</td>
</tr>
<tr>
<td>Modulus of Elasticity in Tension</td>
<td>10500 ksi</td>
<td>72400 MPa</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>18900 psi 130 MPa</td>
<td>18900 psi 130 MPa</td>
</tr>
<tr>
<td>Machinability</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Magnetic Permeability</td>
<td>1.0 µ</td>
<td>1.0 µ</td>
</tr>
</tbody>
</table>

### Elite Bearing Alloys

Highly Engineered Alloys for Extreme Environments

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*Estimated with grease and without against mild steel*
The benefits of composition

Freerun® SL is a lead-free anti-galling bearing metal that is designed to last. Its composition is designed specifically to enable it to meet industry and national material standards.

Long Wearing Alloy

Originally developed for the military aerospace bearings, Copper Alloys' proprietary process technology enables extreme wear resistance and survivability.

Engineering Advantages

• High strength, double industry standards
• Excellent wear resistance whilst maintaining low friction
• Can sustain high load and fatigue resistance
• A fine grain size allowing ultrasonic inspection
• Properties can be adapted to suit specific applications
• Decades of successful operation in critical engineering industries

Chemical Composition

Freerun® LW also meets the following industry standards:

- NF L 14-702
- ASTM C52100
- CW453K
- CW459K

Based on the nominal composition CuSn8P, this is a Phosphor Bronze conforming to UNS C52100 and supplied in several grades including LW-600 (hard wearing) and LW-400 (soft wearing) with increasing tensile strength and reducing friction.

www.copperalloys.net
Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Imperial</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Melting Point - Liquidus</strong></td>
<td>1880º F</td>
<td>1027º C</td>
</tr>
<tr>
<td><strong>Melting Point - Solidus</strong></td>
<td>1620º F</td>
<td>882º C</td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>0.318 lb/in³</td>
<td>8.8 gm/cm³</td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>8.800 8.80</td>
<td>@ 20º C</td>
</tr>
<tr>
<td><strong>Electrical Resistivity</strong></td>
<td>79.80 ohms-cmil/ft @ 68ºF</td>
<td>13.27 µΩcm @ 20º C</td>
</tr>
<tr>
<td><strong>Electrical Conductivity</strong></td>
<td>13 %IACS @ 68º F</td>
<td>0.076 MegaSiemens/cm @ 20º C</td>
</tr>
<tr>
<td><strong>Thermal Conductivity</strong></td>
<td>360 Btu • ft/(hr • ft²•°F) at 68ºF</td>
<td>62.3 W/m • °K at 20º C</td>
</tr>
<tr>
<td><strong>Coefficient of Thermal Expansion</strong></td>
<td>10.10 • 10⁻⁶ per oF (68-392º F)</td>
<td>18.2 • 10⁻⁶ per °C (20-200º C)</td>
</tr>
<tr>
<td><strong>Specific Heat Capacity</strong></td>
<td>0.090 Btu/lb/ºF at 68ºF</td>
<td>377.1 J/kg • °K at 293º K</td>
</tr>
<tr>
<td><strong>Modulus of Elasticity in Tension</strong></td>
<td>16000 ksi</td>
<td>110000 MPa</td>
</tr>
<tr>
<td><strong>Modulus of Rigidity</strong></td>
<td>6400 ksi</td>
<td>41370 MPa</td>
</tr>
</tbody>
</table>

Mechanical Properties

<table>
<thead>
<tr>
<th>Condition</th>
<th>6 of 7</th>
<th>Frerun® LW-400</th>
<th>Hard Wearing</th>
<th>608® LW-600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Strength (0.2% N/mm²)</td>
<td>µ 0.011 - 0.30</td>
<td>µ 0.011 - 0.30</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Tensile Strength (0.2% N/mm²)</td>
<td>µ 0.011 - 0.30</td>
<td>µ 0.011 - 0.30</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Hardness (HB)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Freerun® Long Wearing alloy also meets the following material specification requirements
Fabrication Properties

Joining Technique

Soldering: Excellent
Brazing: Excellent
Oxyacetylene Welding: Fair
Gas Shielded Arc Welding: Good
Coated Metal Arc Welding: Fair
Spot Weld: Good
Seam Weld: Fair
Butt Weld: Excellent

Capacity for Being Cold Worked: Good
Capacity for Being Hot Formed: Poor

Formats

• Available in a range of formats made to order and ex-stock including bar, rings, tubes and sections
• Available in proof machined and finished machine (to print) condition

Elite Bearing Alloys

Highly Engineered Alloys for Extreme Environments

Bearing Material

Load Capacity and Fatigue

Maximum Operating Temp.

Conformability and Embeddability

Resistance to Seizure

Hardness and wear resistance

Tin Bronze

High
High
Moderate
Moderate
High

Freerun® LW

Very High
High
Poor
Very Good

Leaded Bronze

Moderate/High
High
Good
Good
High

Aluminium Bronze

Very High
Very High
Poor
Moderate
Very High

Gunmetal

Moderate/High
High
Good
Moderate/Good
High

Guide to Relative Performance of Bearing Materials

www.copperalloys.net
The Elite Bearing Alloys

Brought to you by Copper Alloys Ltd., creators of the most advanced alloys ever made, including Thermalloy, T-1000 and the game-changing CNC-1.

Visit www.copperalloys.net/elite-alloys to find out more.

Unique high performance material for advanced applications.