HIGH PERFORMANCE
Pfinodal®
COPPER ALLOY STRIP

AMETEK
SPECIALTY METAL PRODUCTS
**SPINODAL Metallurgy**
- Spinodal strengthening occurs spontaneously during aging and results from submicroscopic chemical composition fluctuations.
- For Spinodal, the alloying elements are homogeneous throughout the strip prior to aging due to the wrought powder metallurgy process.
- Spinodal hardening is a distinctly different metallurgy process.
- The amount of cold rolling, aging temperature and time all affect the strength and formability of Spinodal.

**PFINODAL Properties and Benefits**
- Excellent high-temperature stress relaxation resistance.
- High strength and excellent formability.
- Lack of distortion during aging.
- Available in mill hardened and age hardenable tempers.
- Excellent solderability and resistance to intermetallic formation at high temperature.
- Excellent corrosion resistance and ease of cleaning. In moist ammonia, it resists corrosion for over 500 hrs. at 40°C.
- Lower initial cost and cost savings during processing.

**PFINODAL CHEMICAL COMPOSITION**
- **NICKEL**: 14.5-15.5%
- **TIN**: 7.5-8.5%
- **COPPER**: BALANCE
- **COPPER AND NAMED ELEMENTS**: 99.90%
- **OTHER ELEMENTS**: 3.10% MAXIMUM

*C72900 is CDX-LNS designation for Cu-15 Ni-4 Sn alloy. ASTM B-740 standard specification for Copper-Nickel-Tin Spinodal alloy strip.*

**PHYSICAL PROPERTIES OF PFINODAL C72900**
- Electrical Conductivity at 68°F (20°C): 7.8 % IACS
- Electrical Conductivity at 382°F (200°C): 7.3 % IACS
- Thermal Conductivity: 17 BTU/ft²•hr•°F at 68°F (30±10°F) W/m•K at 28°C
- Coefficient of Thermal Expansion: 9.1x10⁻⁶ in/in°F 68°F - 572°F
- 16.4x10⁻⁶ in/in°F 20°C 20°C - 280°C
- Modulus of Elasticity (Tension): 10.5x10⁶ psi (127x10³ MPa)
- Modulus of Rigidity: 7.5x10⁶ psi (52x10³ MPa)
- Density: 0.323 lb/in³ (8.39 g/cc)

**Available in Age Hardenable Tempers**

**MECHANICAL PROPERTIES OF PFINODAL ALLOY C72900**

**Age Hardenable (annealed and cold worked)**

<table>
<thead>
<tr>
<th>Standard Designation</th>
<th>Temper Name</th>
<th>0.2% YS ksi (MPa)</th>
<th>UTS ksi (MPa)</th>
<th>Elongation (%)</th>
<th>Hardness VHN</th>
<th>Minimum Bend Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB00</td>
<td>Solution</td>
<td>25-45 (172-310)</td>
<td>64-85 (441-586)</td>
<td>32-60</td>
<td>100-150</td>
<td>0 0</td>
</tr>
<tr>
<td>TD01</td>
<td>¾ Hard</td>
<td>32-75 (358-517)</td>
<td>75-100 (517-689)</td>
<td>16-35</td>
<td>150-235</td>
<td>0 0</td>
</tr>
<tr>
<td>TD02</td>
<td>½ Hard</td>
<td>75-100 (517-689)</td>
<td>95-110 (666-750)</td>
<td>8-20</td>
<td>190-275</td>
<td>0 0.05t 3.5-11t</td>
</tr>
<tr>
<td>TD03</td>
<td>¾ Hard</td>
<td>90-115 (620-750)</td>
<td>95-120 (665-827)</td>
<td>3-12</td>
<td>210-290</td>
<td>0.5-1t 1.5-2t</td>
</tr>
<tr>
<td>TD04</td>
<td>Hard</td>
<td>95-125 (655-862)</td>
<td>100-130 (689-960)</td>
<td>1-10</td>
<td>220-300</td>
<td>2-3t 3-4t</td>
</tr>
</tbody>
</table>

**Age Hardened (annealed and cold worked, parts age hardened)**

<table>
<thead>
<tr>
<th>Standard Designation</th>
<th>Spinodal Hardening Treatment</th>
<th>0.2% YS ksi (MPa)</th>
<th>UTS ksi (MPa)</th>
<th>Elongation (%)</th>
<th>Hardness VHN</th>
<th>Minimum Bend Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX00</td>
<td>700°F/2 hr. (370°C/2 hr.)</td>
<td>100-130 (619-896)</td>
<td>120-150 (827-1034)</td>
<td>6-20</td>
<td>275-350</td>
<td></td>
</tr>
<tr>
<td>TS01</td>
<td>700°F/2 hr. (370°C/2 hr.)</td>
<td>115-145 (733-1000)</td>
<td>130-160 (936-1183)</td>
<td>4-16</td>
<td>290-365</td>
<td></td>
</tr>
<tr>
<td>TS02</td>
<td>700°F/2 hr. (370°C/2 hr.)</td>
<td>135-165 (831-1138)</td>
<td>145-175 (1000-1206)</td>
<td>3-12</td>
<td>315-390</td>
<td></td>
</tr>
<tr>
<td>TS03</td>
<td>700°F/2 hr. (370°C/2 hr.)</td>
<td>145-175 (1000-1206)</td>
<td>155-185 (1069-1275)</td>
<td>2-9</td>
<td>325-400</td>
<td></td>
</tr>
<tr>
<td>TS04</td>
<td>675°F/2 hr. (360°C/2 hr.)</td>
<td>155-185 (1069-1275)</td>
<td>165-195 (1138-1344)</td>
<td>2-6</td>
<td>335-410</td>
<td></td>
</tr>
</tbody>
</table>

**Available in Mill Hardened Tempers**

**MILL HARDENED TEMPER DESIGNATIONS FOR PFINODAL C72900**

(cold worked and hardened)

<table>
<thead>
<tr>
<th>Standard Designation</th>
<th>0.01% YS ksi (MPa)</th>
<th>0.2% YS ksi (MPa)</th>
<th>UTS ksi (MPa)</th>
<th>Elongation (%)</th>
<th>Hardness VHN</th>
<th>Minimum Bend Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM00</td>
<td>65-90 (448-620)</td>
<td>75-95 (517-655)</td>
<td>95-115 (655-792)</td>
<td>22-36</td>
<td>190-230</td>
<td>0 0.5t</td>
</tr>
<tr>
<td>TM02</td>
<td>75-100 (517-669)</td>
<td>90-110 (620-750)</td>
<td>105-125 (723-922)</td>
<td>15-30</td>
<td>215-315</td>
<td>0 0.5t 3.5-1t</td>
</tr>
<tr>
<td>TM04</td>
<td>90-115 (620-729)</td>
<td>105-125 (723-922)</td>
<td>115-135 (759-930)</td>
<td>10-24</td>
<td>245-345</td>
<td>0-1t 0.8-1.5t</td>
</tr>
<tr>
<td>TM06</td>
<td>100-125 (689-862)</td>
<td>126-145 (921-999)</td>
<td>130-150 (896-1034)</td>
<td>6-16</td>
<td>270-370</td>
<td>0.5-6.0X 2-3t</td>
</tr>
<tr>
<td>TM08</td>
<td>115-140 (792-965)</td>
<td>146-170 (995-1171)</td>
<td>150-178 (1031-1326)</td>
<td>2-10</td>
<td>305-430</td>
<td><em>—</em></td>
</tr>
</tbody>
</table>

*Minimum bend radius measured in 3 point bending in an unsupported die.*
No Distortion

Pi nodal parts can be age hardened with a simple heat treatment and no distortion of parts will occur. No fixturing is required. Age hardenable Pi nodal is recommended for part geometries requiring the highest strength with excellent formability.

Other age hardenable alloys, such as beryllium-copper, can severely distort during the hardening heat treatment. This distortion, caused by differential shrinkage, can result in parts with poor dimensional accuracy. Fixture heat treating of beryllium-copper parts can be used in some cases to restrain this distortion but at significantly higher processing costs.
Stress/Thermal Relaxation

The significance of high temperature stress (thermal) relaxation resistance of Pfinodal is the maintenance of contact spring pressure over a long period of time at high temperature. When a contact engages the mating members are deflected and elastic stress and strain forms along the length of the beam. Over a long period of time at room temperature, essentially none of this stress or strain is lost. As the temperature increases, some of the elastic stress in ordinary alloys relaxes and the elastic strain is converted to permanent deflection. As the temperature and time increases, so does the amount of permanent deflection. Upon removal of the deflection member, the spring no longer returns to its original position, but remains partially open. Upon reinserting the mating member, the amount of spring pressure is less because the elastic deflection is less. Lower spring pressure can cause intermittent or no electrical contact between the spring and the mating member.

STRESS (THERMAL) RELAXATION

All Tests Run at Initial Stress of 80% of the 0.2% Offset Yield Strength
**Equipment and Atmosphere**

Aging of Pfinodal is best performed in recirculating ovens having excellent temperature uniformity. Vacuum or muffle type furnaces may be used, and as with all furnaces or ovens, furnace loading and temperature control should be taken into consideration to be certain that all parts attain the proper temperature.

Any common inert or reducing atmosphere can be used. To take advantage of the excellent surface characteristics of Pfinodal, a slightly reducing atmosphere such as nitrogen-3% hydrogen (forming gas) is preferred. This will generally result in post-heat treated parts exhibiting excellent solderability without the need for surface cleaning or acid pickling.

The use of salt pots is not recommended because of the need to post-clean all copper base alloys. If salt pots are used, thorough cleaning to remove all residual salts from parts is required.

**Heat Treating Parameters for PFINODAL Parts**

Recommended aging cycle ranges to achieve peak or near peak strength in Pfinodal are shown in table below:

<table>
<thead>
<tr>
<th>TEMPER</th>
<th>TEMPERATURE / TIME</th>
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</thead>
<tbody>
<tr>
<td>TB00</td>
<td>675°F - 700°F (357°C - 371°C) / 2 hours</td>
</tr>
<tr>
<td>TD01</td>
<td>655°F - 675°F (343°C - 357°C) / 2 hours</td>
</tr>
<tr>
<td>TD02</td>
<td>655°F - 675°F (343°C - 357°C) / 2 hours</td>
</tr>
<tr>
<td>TD03</td>
<td>675°F - 700°F (357°C - 371°C) / 2 hours</td>
</tr>
<tr>
<td>TD04</td>
<td>675°F - 700°F (357°C - 371°C) / 2 hours</td>
</tr>
</tbody>
</table>

Alternative time/temperature cycles may be used to suit individual requirements while maintaining good mechanical properties.

It is recommended that the furnace temperature be below 200°F (93°C) before removal of parts to avoid surface tarnish.

**HEAT TREATING CURVES FOR PFINODAL PARTS**

![Heat Treating Curves for PFINODAL Parts](image)

**Special Consideration for Heat Treatment of PFINODAL Parts**

To optimize the performance of Pfinodal in any particular application one may wish to consider using alternate heat treatments.

1. In part geometries where the maximum stressed area has been heavily formed, a 25°F (14°C) lower aging temperature is recommended. This would result in peak strength in the critically stressed area.

2. In parts requiring some ductility after aging to accommodate a limited forming operation (bending, twisting, crimping, etc.), a 25°F (14°C) lower aging temperature is recommended. This heat treatment would result in a slight decrease in as-aged strength and more ductility.

3. In parts undergoing severe forming operations after aging (such as restamping or 90° solder tail twisting), an even lower aging temperature may be required [50°F (28°C) or more below the peak aging temperature].

4. Overaging is not recommended. Upon overaging, the loss in strength and ductility can be significant. For a given ductility requirement, underaging will result in higher strengths and ductility than overaging.

5. For specific recommendations for your part, please consult AMETEK. We can also provide assistance in obtaining sources for heat treating parts.
Burn-In and Elevated Temperature Applications

Pfinodal C72900 Copper-Nickel-Tin Spinodal Alloy provides high reliability at an economical cost for applications at normal temperatures as well as for higher temperature usage. For burn-in and elevated temperature applications in the range from 125°C to 225°C, Pfinodal delivers superior resistance to stress relaxation for long life, in addition to excellent surface characteristics which simplify processing. Pfinodal exhibits good shelf life and good solderability and is easily plated or inlaid. For plating and soldering, milder cleaning solutions and less aggressive fluxes can be used. When soldering high temperature components, careful cleaning to remove flux residues is extremely important.

SOLDERING

All copper-base alloys can react at high temperatures with the tin in tin-containing solders to form intermetallic phases. In order to insure good, long-term solder joint properties at a high temperature, proper selection of a solder is required.

Good engineering practice suggests the use of a solder having a melting point of about 50°C above the operating temperature of the parts being soldered.

For Temperatures Above 150°C

At these very high temperatures, in order to minimize intermetallic phase formation that can occur with any copper alloy, it is necessary to use a high lead solder containing a maximum of 10% tin. Excellent field experience has been obtained with the 10% Sn-88%Pb-2%Ag solder. Laboratory data also shows excellent compatibility of this solder with Pfinodal at 225°C. The 10% Sn-90%Pb solder is not recommended for temperatures above 200°C.

For Temperatures Up to 150°C

All tin-lead solders can be used in this temperature range.