### Hiperco® Alloy 50

#### Type Analysis
- Carbon: 0.01%
- Manganese: 0.03%
- Silicon: 0.02%
- Cobalt: 48.75%
- Vanadium: 1.90%
- Chrome: 0.05%
- Iron: Balance

#### Description
Hiperco® alloy 50 is an iron-cobalt-vanadium soft magnetic alloy which exhibits high magnetic saturation (24 kilogauss), high D.C. maximum permeability, low D.C. coercive force, and low A.C. core loss. This alloy is produced in strip form only and contains a small niobium addition for grain refinement during milling processing and final heat treatment of strip.

#### Applications
Hiperco® alloy 50 strip has been primarily in the manufacture of rotor and stator laminations in motors and generators for aircraft power generation applications. These laminations are stamped from cold rolled strip and must be annealed in a protective atmosphere or vacuum environment at a temperature which will provide an optimum combination of mechanical and magnetic properties to withstand the high stresses encountered in service.

#### Physical Properties
- Specific gravity: 8.12
- Density: 7.8g/cm³
- Modulus of elasticity: \(10^9\) MPa
- Electrical resistivity: 241 ohm cm
- Electrical resistivity: 400 micromho cm
- Curve temperature: 1724 °C
- Change in unit length: 10⁻⁶ /°C
- Thermal conductivity: 0.208 watts m⁻¹ k⁻¹

Mean coefficient of thermal expansion:

<table>
<thead>
<tr>
<th>Temperature Range (°C)</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room (25 °C)</td>
<td>5.3</td>
</tr>
<tr>
<td>392</td>
<td>5.6</td>
</tr>
<tr>
<td>782</td>
<td>5.8</td>
</tr>
<tr>
<td>1112</td>
<td>6.3</td>
</tr>
<tr>
<td>1472</td>
<td>6.3</td>
</tr>
</tbody>
</table>

#### Magnetic Properties
**Typical D.C. Magnetic Properties - Hiperco Alloy 50**

<table>
<thead>
<tr>
<th>Strip Thickness</th>
<th>@ 10 Oz</th>
<th>@ 50 Oz</th>
<th>@ 100 Oz</th>
<th>@ 200 Oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>.006&quot;</td>
<td>21.2 Kg</td>
<td>23.0 Kg</td>
<td>23.6 Kg</td>
<td>24.4 Kg</td>
</tr>
<tr>
<td>.010&quot;</td>
<td>21.6 Kg</td>
<td>23.5 Kg</td>
<td>23.5 Kg</td>
<td>24.2 Kg</td>
</tr>
<tr>
<td>.014&quot;</td>
<td>21.7 Kg</td>
<td>23.0 Kg</td>
<td>23.6 Kg</td>
<td>24.3 Kg</td>
</tr>
</tbody>
</table>

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Typical A.C. Magnetic Properties - Hiperco Alloy 50

Typical core loss values at frequencies of 60, 400, 800 and 1600 Hz are shown for common lamination strip thicknesses of 0.009" (0.15 mm), 0.010" (0.25 mm) and 0.014" (0.35 mm), heat treated at two different final heat treating temperatures (1600°F [871°C] and 1400°F [756°C]) for 2 hours, cooled at 180°F (100°C)/hr. Typical core loss values cover the induction range of 10 kilogauss (1T) to 20 kilogauss (2T).

The magnetic data was determined on ring laminations 1.50" O.D. x 1.25" I.D. x thickness per ASTM A-697 taking special precautions to assure the retention of a sinusoidal flux wave form.

Core loss vs. induction for 0.006" (0.15 mm) thick strip

- Annealed at 1800°F (982°C) 2 hours, cooled 180°F (100°C) per hour
- Annealed at 1600°F (871°C) 3 hours, cooled 180°F (100°C) per hour
This document is © 1990 by Carpenter Technology and is reproduced with permission. These pages are for general information about the magnetic and mechanical properties, as well as recommendations for annealing, of Hiperco® Alloy 50. Updated magnetic properties can be found on the Magnetic Materials pages of Lamination Steels Third Edition. Please visit the Carpenter Technology web site, www.cartech.com, for the most current material properties. Information on this page is not guaranteed or endorsed by The Electric Motor Education and Research Foundation. Confirm material properties with material producer prior to use. © 2007 The Electric Motor Education and Research Foundation.
Heat Treatment

It is important to avoid any contamination of the finished parts during the heat treatment. All parts must be cleaned thoroughly to remove any surface contaminants prior to annealing. Batch heat treating in a sealed retort or welded box-type furnace is recommended. Thoroughly degreased and cleaned laminations can usually be stacked without an insulating media separation. To obtain the best degree of lamination flatness, a light weight can be placed on top of the stack. It may be necessary to determine the correct amount of weight to assure that there is no sticking of the laminations within the stack height employed.

A dry hydrogen atmosphere or a high vacuum is recommended to minimize oxide contamination of the parts during
annealing. When hydrogen is employed, the entry dew point should be dryer than -40°F (-40°C) and the exit dew point dryer than about -40°F (-40°C) when the inside retort temperature is above 960°F (515°C).

Anneal parts at 1300/1600°F (704/871°C) for 2 to 4 hours in dry hydrogen or vacuum and cool at 150/50°F (83/134°C) per hour until 600°F (316°C) is reached, after which any cooling rate can be employed. The exact heat treat temperature to be employed will depend upon the particular application and the desired compromise between magnetic and mechanical properties. With increasing temperature from 1300 to 1600°F (704 to 871°C), the magnetic properties improve while the yield and tensile strengths decrease. The temperature at no time should exceed 1600°F (871°C) as an upper limit, as the soft magnetic characteristics start to decline due to formation of an austenitic phase.

For certain A.C. applications, improved magnetic characteristics and/or lower core loss are realized by creating a thin oxide layer on the surface of the annealed laminations. The surface oxide layer can be achieved by heating in an oxygen-bearing atmosphere in the range of 600 to 900°F (316 to 482°C) for about 30 to 60 minutes. The exact baking parameters must be determined for the annealing facility employed and the thickness of oxide layer desired.

### Typical Mechanical Properties - Hiperco Alloy 50

<table>
<thead>
<tr>
<th>Hardness</th>
<th>Rockwell C</th>
</tr>
</thead>
<tbody>
<tr>
<td>115</td>
<td>97</td>
</tr>
<tr>
<td>118</td>
<td>63</td>
</tr>
</tbody>
</table>

### Applicable Specifications

ASTM A680 Alloy Type 1

ML-A-47182

### Forms Available

Strip - Up to approximately 5" wide and thicknesses from 0.004" to 0.050" (0.102 to 1.3 mm) in the cold rolled unannealed condition only.