Material & Process Capability

This powder is produced by Höganäs under license from Haynes International Inc. It is a vacuum induction melted, argon gas atomized, spherical powder for additive manufacturing. Velo3D has qualified this powder, produced by Höganäs AB, a world leader in metal powder production, under license from Haynes International, for use in the Sapphire® family of printers. The Velo3D fully integrated metal AM solution uniquely enables companies to build the parts they need without compromising design or quality - resulting in complex parts higher in performance than casting or other methods. This alloy is a gamma-prime strengthened nickel-chromium-cobalt superalloy for high temperature applications and shows a good balance of creep strength at high temperatures, thermal stability, weldability, and fabricability.

General Process

In addition to its strength, the alloy is characterized by its superb fatigue, creep, and corrosion resistance under extreme conditions; it is ideal for high temperature applications such as gas turbine and power/process industry parts.

This data sheet specifies the expected mechanical properties and characteristics of this alloy when manufactured on a Velo3D Sapphire System. All data is based on parts built using Velo3D standard 50 µm layer thickness parameters. Parts built with this alloy on a Sapphire System can be heat treated like those manufactured by other methods.

Mechanical Properties at Room Temperature

<table>
<thead>
<tr>
<th>Property</th>
<th>As Printed</th>
<th>After Heat Treatment &amp; HIP¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean-3σ</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>Modulus of Elasticity, GPa (msi)</td>
<td>126 (18.3)</td>
<td>152 (22.0)</td>
</tr>
<tr>
<td>Ultimate Tensile Strength, MPa (ksi)</td>
<td>850 (123)</td>
<td>862 (125)</td>
</tr>
<tr>
<td>Yield (0.2% Offset), MPa (ksi)</td>
<td>547 (79.3)</td>
<td>573 (83.1)</td>
</tr>
<tr>
<td>Elongation At Break, percent</td>
<td>44.9</td>
<td>47.3</td>
</tr>
</tbody>
</table>

² Geometry-dependent. ¹ For angles >25° from horizontal, actual finish depends on orientation and process selected. ³ Mechanical & test samples printed in vertical orientation, machined to ASTM E8 (round specimen #3). ⁴ Hot Isostatic Pressing at 1175°C (2150°F) & 14750 psi +/-250 psi for 4 hours, rapid cool. Vacuum Solution Heat Treat at 1135°C (2075°F) for 30 min. Two-step vacuum age, fast at 1010°C (1850°F) for two hours followed by rapid air cool, then at 790°C (1450°F) for eight hours, followed by rapid air cool.

Density, g/cc (lbs/cubic in) 8.28 (0.299)  Relative Density, percent 99.9+  Surface Finish², Sμ, µm (µin) <15 (590)

Sapphire Sapphire IMZ Sapphire XC Sapphire XC IMZ

Typical Volume Rate¹, cc/hour 60 240

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Creep at 1600°F

Creep Legend

- 1.0% Strain — — — Horizontal
- 0.5% Strain — — Vertical
- 0.2% Strain — — — Runout

Tensile Strength vs Temperature

Tensile-Temp Legend

- Horizontal — — — 0.2% Yield
- Vertical — — Ultimate

- 0.2% Yield
- Ultimate

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