

## 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<sup>®</sup> 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.



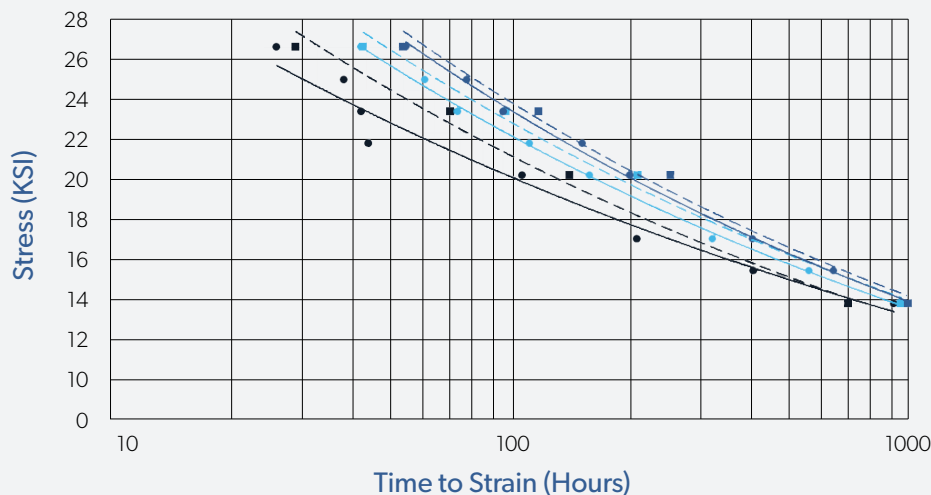
	Sapphire Sapphire 1MZ	Sapphire XC Sapphire XC 1MZ
Typical Volume Rate <sup>1</sup> , cc/hour	60	240
Density, g/cc (lbs/cubic in)	8.28 (0.299)	
Relative Density, percent	99.9+	
Surface Finish <sup>2</sup> , S <sub>a</sub> , µm (µin)	<15 (590)	

## Mechanical Properties at Room Temperature

Property <sup>3</sup>	As Printed		After Heat Treatment & HIP <sup>4</sup>	
	Mean-3σ	Mean	Mean-3σ	Mean
Modulus of Elasticity, GPa (msi)	126 (18.3)	152 (22.0)	186 (27.0)	201 (29.2)
Ultimate Tensile Strength, MPa (ksi)	850 (123)	862 (125)	1141 (165.5)	1158 (168.0)
Yield (0.2% Offset), MPa (ksi)	547 (79.3)	573 (83.1)	711 (103)	743 (108)
Elongation At Break, percent	44.9	47.3	29.3	34.5

**1.** Geometry-dependent. **2.** 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, first 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.

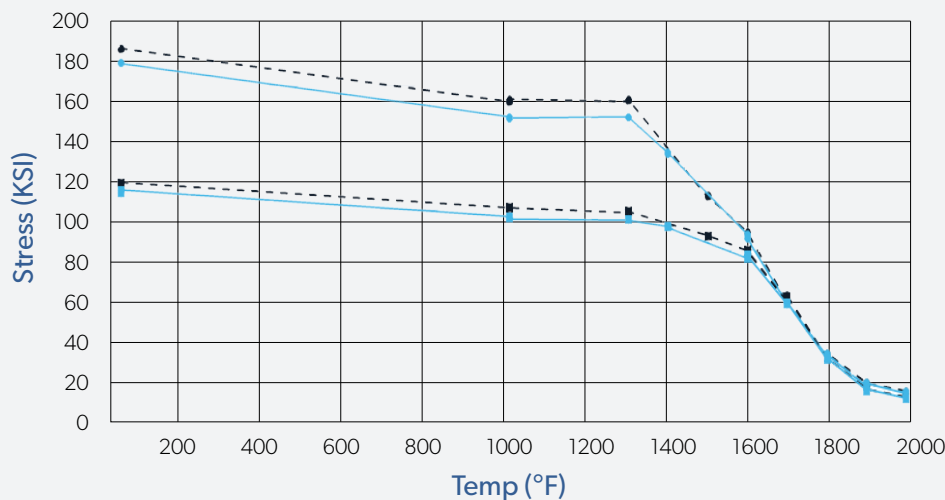
### Creep at 1600°F



Creep Legend

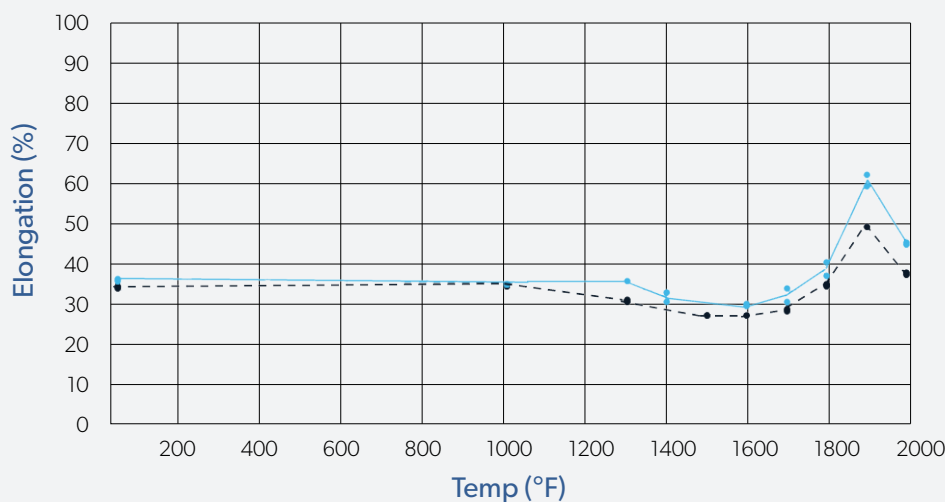
<b>1.0% Strain</b>	—■—	Horizontal
<b>0.5% Strain</b>	—●—	Vertical
<b>0.2% Strain</b>	—■→	Runout

### Tensile Strength vs Temperature



Tensile-Temp Legend

<b>Horizontal</b>	—■—	0.2% Yield
<b>Vertical</b>	—●—	Ultimate



Tensile-Temp Legend

<b>Horizontal</b>	—■—	0.2% Yield
<b>Vertical</b>	—●—	Ultimate