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NICKEL 625X

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Griffin Armament developed, custom patent-pending powder additive alloy, Nickel 625X offers excellent mechanical strength, creep resistance, and corrosion resistance at high temperatures. This is accomplished via a nickel base, proprietary sound suppressor optimized material ~40% composed of several high melting point refractory metals and including only ~1.5% iron. This novel alloy is ~87% similar in composition to Inconel 625 - it's closest counterpart, and is approximately 68% stronger at 1200°F.

A microalloying element acting as a grain boundary modifier reduces the volume fraction of laves phase by ~80%, freeing niobium for Gamma double prime (γ'') phase strengthening, and molybdenum for solid-solution strengthening. Grain size of SLM produced Nickel 625X is ~43-83% smaller than Inconel 625 SLM material, and porosity is reduced, enhancing strength and stability, while providing superior 40.5RC hardness to the SLM material*. Yield strength after an incredibly short, low temperature heat treatment is 68% higher than 625 SLM additive material at 1200°F, and yield strength of Nickel 625X at 1472°F is approximately identical to 625 Inconel sheet material at room temperature.

Maximum environmental temperature- a function of corrosion resistance and stability at temperature - is approximately 1950°F, which is significantly higher than the 1300°F recommended maximum mechanical service temperature of 718 Inconel. Maximum mechanical service temperature is approximately 1400°F, delivering a 100°F advantage over 718 Inconel. A 2 hour 1200°F post-build heat treat reduces heat treating costs ~93% vs 718 Inconel. This ~93% reduction of heat treating costs reduces energy consumption requirements and improves environmental sustainability of additive manufacturing.

*Hardness measured after 2 hour stress relief at 1200°F, followed by cooling to room temperature. Inconel® is a registered trademark of Special Metals Corporation. Griffin Armament has no affiliation with Special Metals Corporation, and the use of "Inconel" in this document is only for purposes of comparison between materials.

Material Properties

- Extremely High Strength with ~93% Reduced Heat Treatment Cost
- Extremely High Creep Resistance
- Extremely High Corrosion Resistance
- High Fatigue Strength in Seawater
- Excellent Welding Characteristics
- Non-Magnetic
- Near-Zero Dimensional Change during Heat Treatment

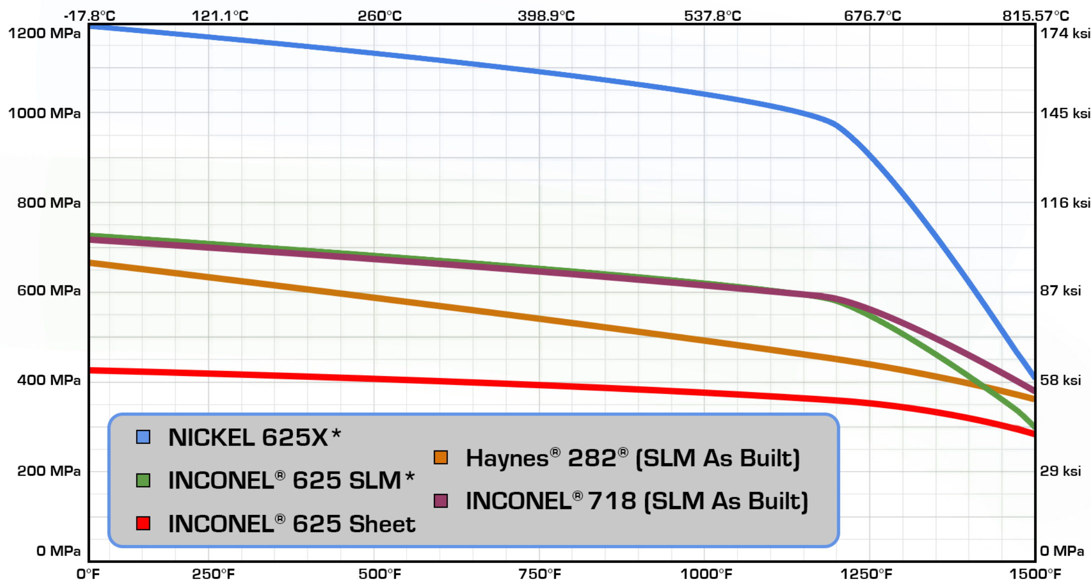
Potential Applications

- Sound Suppressors for Firearms
- Defense/Missile Disks, Compressor Cases, Housings
- Rocket Combustion Chamber Jackets
- Deep Water Drilling Tool Bodies
- Industrial Gas Turbine Parts
- Chemical Processing

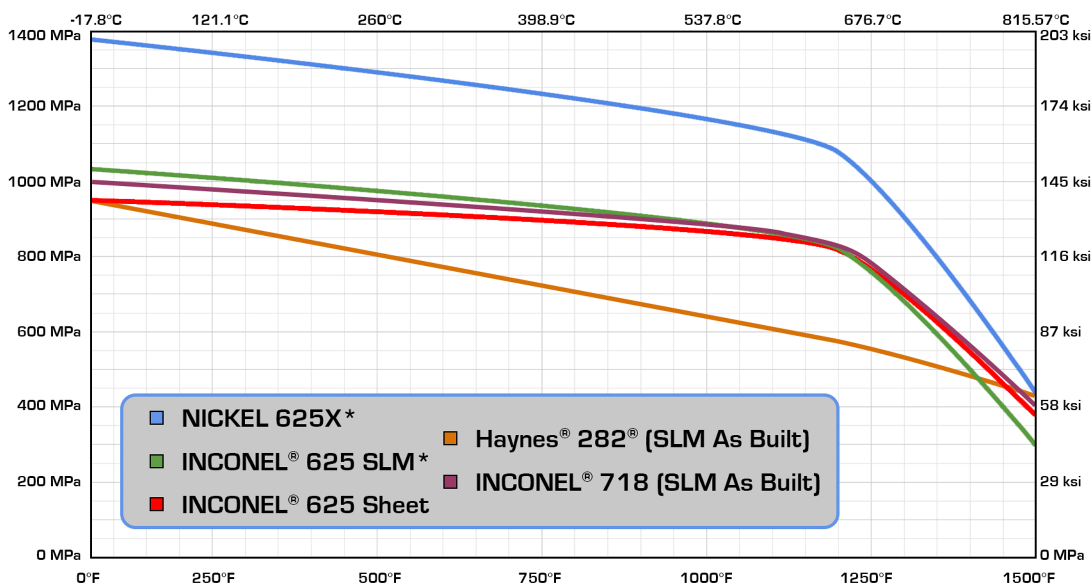
NICKEL 625X

Strength Comparison to Other Market Suppressor Materials

YIELD STRENGTH



TENSILE STRENGTH



*Data for Nickel 625X and Inconel 625 SLM came from ASTM E8M laboratory testing. Specimens were printed at 60 micron layer thickness on NIKON SLM additive machines, and machined to E8M & E21M specifications, and heat treated at 1200°F for 2 hours prior to testing. Data points are the average of horizontal and vertical tested specimens. The curves are implied between the three tested data points (68°F, 1200°F, and 1472°F). The actual curve between 1200°F and 1472°F will not match the graph exactly, and the curves are illustrative only as a result. This unfortunately cannot completely illustrate service temperature differences between the two alloys. E21M requires a 1/2 hour hold to "stabilize" an alloy before testing. This reduces the 1472°F data point in a way that wouldn't directly apply to short-term elevated temperature use of a sound suppressor.

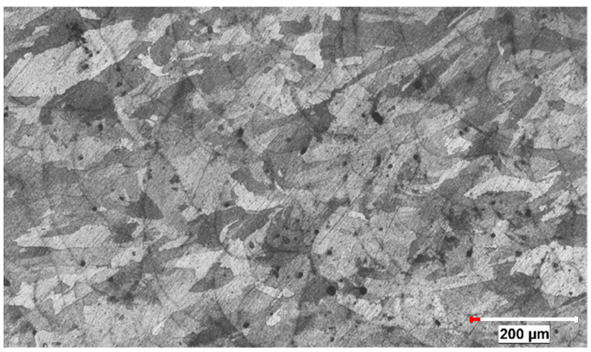
Microstructure

Grain microstructure analysis at 100X magnification revealed a more uniform and refined microstructure in the nickel alloy of the disclosure. Grain size was reduced approximately 50-80% from approximately ~100-250 μm (particularly large grains in the horizontal orientation) in standard SLM Inconel 625 to ~30-175 μm for the alloy of the disclosure. In the vertical orientation, grain size decreased from approximately ~30-175 μm in standard 625 to ~5-100 μm (43-83% reduction) for Nickel 625X.

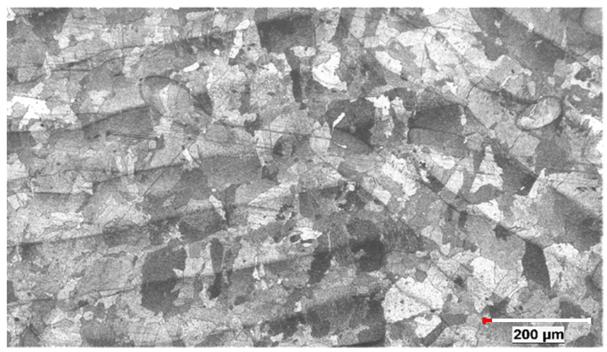
Nickel 625X exhibited a characteristic 'haze' of evenly dispersed subgrains, cellular dendrites, and fine precipitates (likely γ'' or vanadium carbides). These micrograins showed increased frequency—approximately 2x in the horizontal direction and 6x in the vertical direction—relative to standard SLM INCONEL® 625. Overall, Nickel 625X displayed a more homogeneous microstructure with more refined and equiaxed grains—indicators of enhanced strength, toughness, and isotropy—compared to standard SLM INCONEL® 625, which displayed more obvious phase segregation and larger, elongated grains.

INCONEL® 625 SLM

Horizontal in 100x

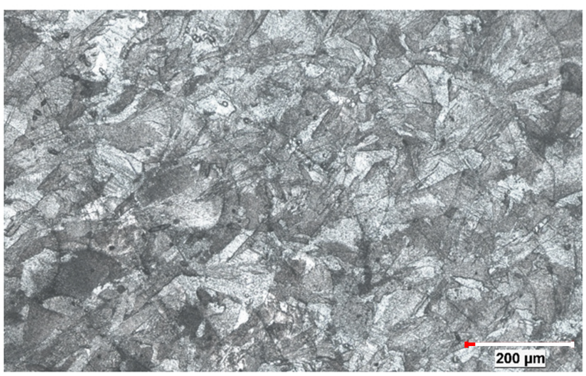


Vertical in 100x

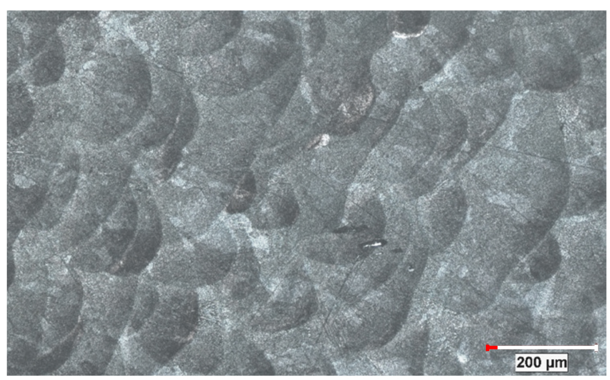


NICKEL 625X SLM

Horizontal in 100x



Vertical in 100x



NICKEL 625X

Mechanical Properties

Nickel 625X was stress-relieved for 2 hours at 1200°F in a box furnace for laboratory test comparaibility to Griffin's manufacturing process for Nickel 625X.

Hardness

Hardness (RC):	C40.5

Ultimate Tensile Strength (UTS)

UTS was tested at three temperature ranges, and is displayed in MPA and ksi measurements for °F and °C temperature values, and is shown as an average value of the horizontal and vertical planes.

Temperature	68°F (20°C)	1200°F (649°C)	1472°F (800°C)
UTS in ksi (MPA)	200 ksi (1379 MPA)	156.8 ksi (1081 MPA)	74.1 ksi (511 MPA)

0.2% Yield Strength

UTS was tested at three temperature ranges, and is displayed in MPA and ksi measurements for °F and °C temperature values, and is shown as an average value of the horizontal and vertical planes.

Temperature	68°F (20°C)	1200°F (649°C)	1472°F (800°C)
0.2% YS in ksi (MPA)	173.3 ksi (1195 MPA)	141.1 ksi (973 MPA)	67.9 ksi (468 MPA)

Coefficient of Thermal Expansion (CTE)

CTE per ASTM E228 shows elongation in 2" taking an average of 2 vertical and 2 horizontal examples and is shown in 200°C increments with corresponding °F values.

Temperature	68 - 392°F (20-200°C)	68 - 752°F (20-400°C)	68 - 1112°F (20-600°C)	68 -1472°F (20-800°C)
CTE - 2" ASTM E228	12.25 ppm/°F(°C)	13.24 ppm/°F(°C)	13.92 ppm/°F(°C)	14.95 ppm/°F(°C)