CARPENTER ADDITIVE®

DATASHEET

PowderRange 625

Applicable specifications: ASTM F3056

Associated specifications: UNS N06625, AMS5666F, AMS5599G, DIN NiCr22Mo9Nb

Type analysis

Single figures are nominal except where noted.

Nickel	Balance	**Chromium**	20.00–23.00 %	**Molybdenum**	8.00–10.00 %
Iron	5.00 %	**Niobium**	3.15–4.15 %	**Cobalt**	1.00 %
Manganese	0.50 %	**Silicon**	0.50 %	**Aluminum**	0.40 %
Titanium	0.40 %	**Carbon**	0.10 %	**Oxygen**	0.030 %
Nitrogen	0.020 %	**Phosphorus**	0.015 %	**Sulfur**	0.015 %

Description

PowderRange 625 is a non-magnetic, corrosion and oxidation resistant, nickel-base superalloy. Its outstanding strength and toughness in the temperature range cryogenic to 2000°F (1093°C) are derived primarily from the solid solution effects of the refractory metals, niobium and molybdenum, in a nickel-chromium matrix. The alloy has excellent fatigue strength and stress-corrosion cracking resistance to chloride ions.

PowderRange 625 has excellent weldability in laser and electron-beam additive manufacturing processes. Parts built from PowderRange 625 can be heat treated and material properties can be varied within a specified range. Parts can be finished by all conventional means, including but not limited to machining, EDM, shot-peening, grit-blast, vibratory polishing, and coatings in both as-built and in heat treated conditions.

Key Properties:

- Outstanding strength and toughness in the temperature range cryogenic to 2000°F (1093°C)
- Corrosion and oxidation resistant
- Non-magnetic

Markets:

- Aerospace
- Automotive
- Marine

Applications:

- Heat shields
- Furnace hardware
- Combustion liners and spray bars
- Gas turbine engine ducting
- Chemical plant hardware
- Special marine and seawater applications

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Powder properties

PART NUMBER	PowderRange 625 F	PowderRange 625 E
APPLICATION	L-PBF[1]	EB-PBF or DED[1]
MAXIMUM PARTICLE SIZE	Max 1 wt% > 53 µm[2]	Max 10 wt% > 106 µm[2]
MINIMUM PARTICLE SIZE	Max 10 vol% < 15 µm[3]	Max 10 wt% < 45 µm[2]
LSD PERCENTILE	D10, D50, D90[3], reported	
ATOMIZATION	Vacuum Induction Melted, Argon Gas Atomized	
APPARENT DENSITY (G/CM³)	Measured according to ASTM B212[4] and reported	
HALL FLOW (S/50G)	Measured according to ASTM B213[5] and reported	

[1] ASTM/ISO 52900: Laser—Powder Bed Fusion (L-PBF), Electron-Beam Powder Bed Fusion (EB-PBF), Directed Energy Deposition (DED)
[2] ASTM B214 Standard Test Method for Sieve Analysis for Metal Powders
[3] ASTM B822 Standard Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering
[4] ASTM B212 Standard Test Method for Apparent Density of Free-Flowing Metal Powders Using the Hall Flowmeter Funnel
[5] ASTM B213 Standard Test Method for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel
Testing of powder will fulfill certification requirements to Nadcap Materials Testing and ISO/IEC 17025 Chemical, per relevant ASTM procedures

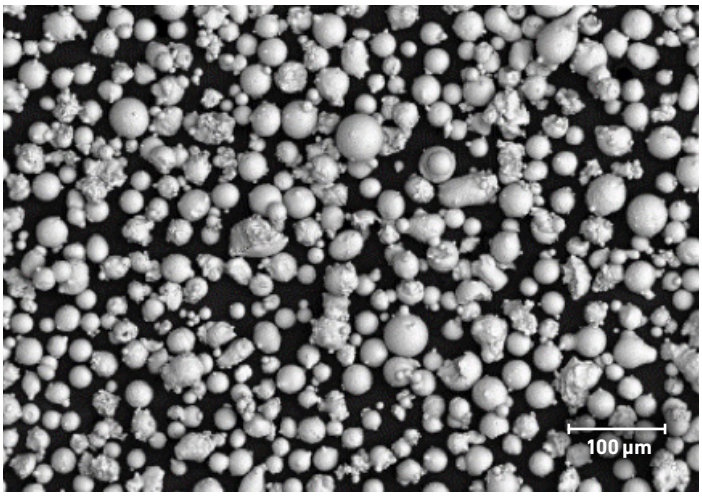

FIGURE 1—SEM IMAGE OF TYPICAL PowderRange 625 POWDER

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Additive manufacturing process guidance

ASTM F3056: ADDITIVE MANUFACTURING NICKEL (UNS N06625) WITH POWDER BED FUSION	
Laser-Powder Bed Fusion (L-PBF)	PowderRange 625 for additive manufacturing is compatible with all commercially available L-PBF equipment. To achieve mean, as-built density >99.9%, 20 to 60 µm layer thicknesses and Specific Energy ≥ 65 J/mm^3 is recommended.
Stress relief or anneal (SR or AN)	Stress relief, typically performed at the annealing temperature, may be performed per AMS2774, i.e. 1900°F (1038°C) for 1 hour followed by air cooling, or substitute Solution Annealing per AMS2774, i.e. 2150°F (1177°C) followed by rapid air cooling or faster for higher ductility.
Hot Isostatic Pressed condition (HIP)	We recommend HIP as standard practice for microstructure homogenization; removal of residual spatter-induced voids, trapped gas porosity in powder and keyhole porosities; as well as to heal any shrinkage-induced micro-cracks in the material. **To achieve up to full density (100%):** Process components per ASTM F3056 section 13: minimum pressure of 14.5 ksi (100 MPa) at a temperature of approximately 2087°F (1141°C) for 240 minutes in argon.
Machinability	Low cutting speeds, rigid tools and work piece, heavy equipment, ample coolant, and positive feeds are general recommendations.

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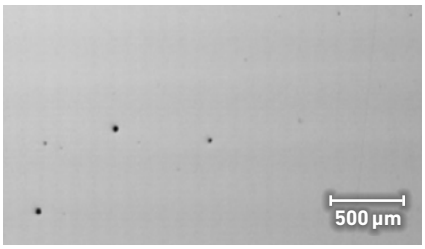
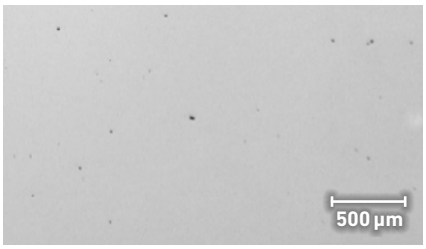
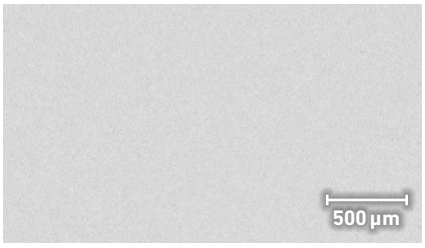
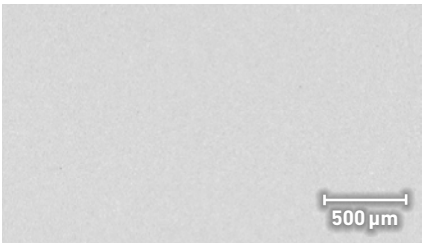
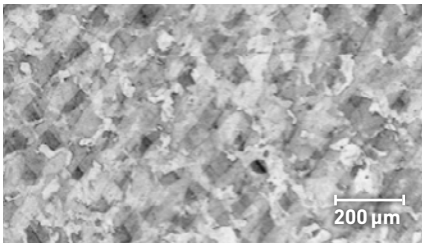
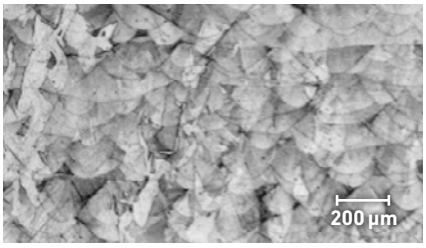
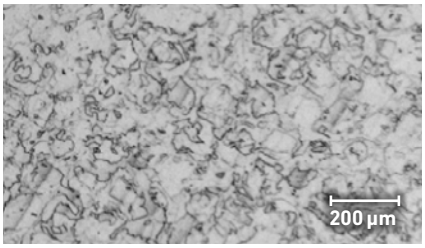
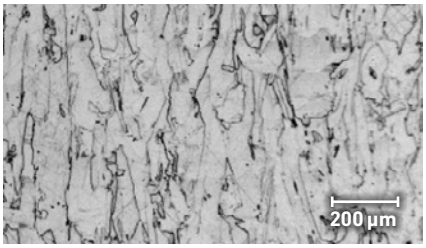
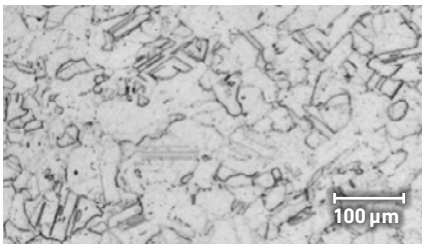
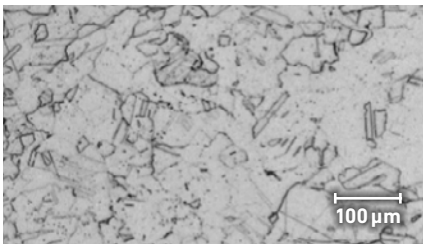
TYPICAL MICROSTRUCTURES

CONDITION	TRANSVERSE (X-Y PLANE)	LONGITUDINAL (Y-Z PLANE)	NOTES
As-built			Mean densities greater than 99.9%
HIP			Up to 100% density
As-built, etched[6]			Clean weld tracks visible Minimal spatter porosity
SR, etched[6]			Non-equiaxed / anisotropic features and properties with grains aligned along z-axis Grain size ASTM 4-6 (average 5)[7]
HIP, etched[6]			Equiaxed grains Grain size ASTM 4-5[7]

[6] Etched with Waterless Kalling's Reagent
[7] ASTM E112-13 Standard Test Method for Determining Average Grain Size

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Typical achievable mechanical properties

ROOM TEMPERATURE MECHANICAL PROPERTIES[8]									
FORM	ORIENTATION	0.2% YIELD STRENGTH $\sigma_{0.2\%}$		ULTIMATE TENSILE STRENGTH σ_{UTS}		ELONGATION IN 4D	REDUCTION OF AREA	IMPACT ENERGY	
		ksi	MPa	ksi	MPa	%	%	FT-LBS	J
As-built	X and Y	108	745	147	1014	40	59	80	108
	Z	89	614	132	910	49	68	99	134
SR	X and Y	94	648	146	1007	41	51	73	99
	Z	86	593	131	903	50	59	90	122
HIP	X and Y	57	393	130	896	60	62	97	132
	Z	54	372	128	883	62	60	98	133
ASTM Spec.[9]	X and Y	40	275	70	485	30	30	—	—
	Z	40	275	70	485	30	30	—	—

[8] Average of a minimum of 5 samples taken from across the extents of a build plate in each orientation and for each heat treatment. Testing performed in accordance with ASTM E8/E8M-16a (tensile), ASTM E23-18 (impact energy) and ASTM E18-19 (hardness). Additional data may be available through a wide range of consortia and other collaborations. Please contact Carpenter Additive for additional information.

[9] ASTM F3056-14 Room Temperature Classification "A, B, and C" Minimum Tensile Properties

Corrosion resistance

PowderRange 625 withstands many corrosive environments. In alkaline, saltwater, fresh water, neutral salts, and in the air, almost no attack occurs. The nickel and chromium provide resistance to oxidizing environments. Nickel and molybdenum provide for resistance to nonoxidizing atmospheres. Pitting and crevice corrosion are prevented by molybdenum. Chloride stress-corrosion cracking resistance is excellent. The alloy resists scaling and oxidation at high temperatures.

IMPORTANT NOTE:
The following 4-level rating scale (Excellent, Good, Moderate, Restricted) is intended for comparative purposes only and is derived from experiences with wrought product. Additive manufactured material may perform differently; corrosion testing is recommended. Factors that affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish, and dissimilar metal contact.

Nitric Acid	Good	**Sulfuric Acid**	Good
Phosphoric Acid	Excellent	**Acetic Acid**	Excellent
Sodium Hydroxide	Excellent	**Salt Spray (NaCl)**	Excellent
Sea Water	Excellent	**Sour Oil/Gas**	Excellent
Humidity	Excellent		

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Similar materials

COMPANY	ALTERNATIVE TITLE
Other Generic Names	Inconel 625, Alloy 625, Nickel 625
3D Systems	LaserForm Ni625
GE (Concept Laser)	Nickel 625
EOS	NickelAlloy IN625
DMG Mori (Realizer)	—
Renishaw	In625-0402
SLM Solutions	IN625

For additional information, please contact your nearest sales office:
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The mechanical and physical properties of any additively-manufactured material are strongly dependent on the processing conditions used to produce the final part. Significantly differing properties can be obtained by utilizing different equipment, different process parameters, different build rates and different geometries. The properties listed are intended as a guide only and should not be used as design data.

The information and data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his/her own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes. There is no representation that the recipient of this literature will receive updated editions as they become available.

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