CARPENTER ADDITIVE®

DATASHEET

PowderRange 17-4 AR

Applicable specifications: AMS7012

Associated specifications: UNS S17400, AMS5643, ASME SA564, ASTM A564/A564M, ASTM A705, DIN 1.4548 (X5CrNiCuNb17-4-4), DIN 1.4542 (X5CrNiCuNb16-4), AISI 630

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Chromium**	15.00–17.50 %	**Copper**	3.00–5.00 %
Nickel	3.00–5.00 %	**Manganese**	1.00 %	**Silicon**	1.00 %
Molybdenum	0.50 %	**Niobium + Tantalum**	0.15 –0.45 %	**Cobalt**	0.40 %
Carbon	0.070 %	**Aluminum**	0.050 %	**Oxygen**	0.040 %
Phosphorus	0.040 %	**Nitrogen**	0.030 %	**Sulfur**	0.030 %
Tin	0.020 %				

Description

PowderRange 17-4 AR stainless steel is a martensitic precipitation/age-hardening stainless-steel offering high strength and hardness, along with excellent corrosion resistance, up to 600°F (316°C). It has good fabricating characteristics and can be age-hardened by a single-step, low-temperature treatment, which can be chosen to achieve specific strength and toughness combinations. Due to this balanced combination of performance and ease of use in AM, PowderRange 17-4 AR for additive manufacturing has been used for a wide variety of applications, including rapid tooling functional components in nearly every market, and prototyping.

Key Properties:

- Good strength, toughness, hardness, and ductility
- Good corrosion resistance

Markets:

- Aerospace
- Food processing
- Petrochemical
- Medical

Applications:

- Surgical instruments and tools
- Valves and fittings
- Pumps and impellers
- Manifolds
- Industrial and chemical processing equipment
- Tooling

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Powder properties

PART NUMBER	PowderRange 174AR F
APPLICATION	L-PBF[1]
MAXIMUM PARTICLE SIZE	Max 1 wt% > 53 µm[2]
MINIMUM PARTICLE SIZE	Max 10 vol% < 15 µm[3]
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

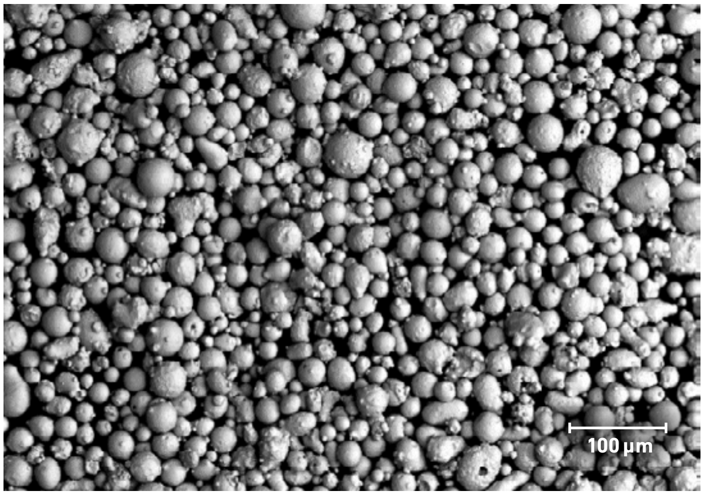

FIGURE 1 — SEM IMAGE OF TYPICAL PowderRange 17-4PH AR POWDER

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Additive manufacturing process guidance

ASTM/ISO 52900: LASER-POWDER BED FUSION (L-PBF)	
Laser-Powder Bed Fusion L-PBF As-built	PowderRange 17-4PH AR 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 ≥ 50 J/mm^3 is recommended.
Stress relief	Stress relieve at 1250°F (677°C) for 1 hour per inch of thickness (minimum 2 hours) up to 4 hours.
Homogenization Hom	Carpenter Technology recommends a homogenization treatment at 2000°F (1093°C) for 1 hour followed by an air cool to minimize anisotropy. If performing a HIP step, a separate homogenization is not required.
Hot Isostatic Press HIP/Sol/H900	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 under argon at not less than 14.5 ksi (100 MPa) at a temperature of approximately 2087°F (1141°C); hold at the selected temperature for approximately 240 min, then cool under inert atmosphere to below 800°F (427°C). Follow with Solution Anneal and Age treatment as described below.
Solution Anneal and Age Condition Hom/Sol/H900	After either homogenization or HIP, Solution Anneal at 1900°F (1038°C) per ASTM A564/A564M for 0.5 hours, cool to below 90°F (32°C) to achieve complete transformation to martensite. Sections under 3 in. (76 mm) can be quenched in a suitable liquid quenchant (e.g. water or oil) and sections over 3 in. (76 mm) should be rapidly air cooled. It is recommended not use this Solution Annealed condition, without age hardening, for the final product due to susceptibility to stress-corrosion cracking. After Solution Anneal, age material as desired per ASTM A564/A564M, e.g. 900°F (482°C) for 1 hour and air cool, per ASTM A564/A564M.
Machinability	PowderRange 17-4PH AR is readily machined in both the solution-treated and various age-hardened conditions. In the solution-treated condition, it machines similarly to stainless steel types 302 and 304. When using carbide tools, surface speed feet/minute (SFPM) can be increased between 2 and 3 times over the high-speed suggestions. Feeds can be increased between 50 and 100%.

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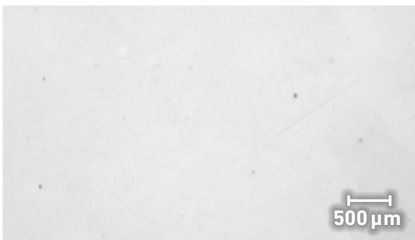
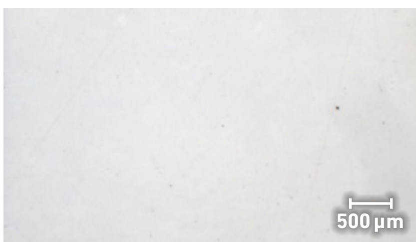
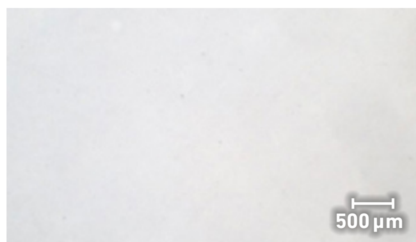
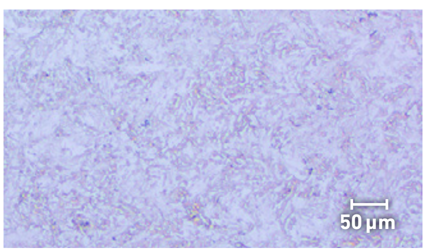
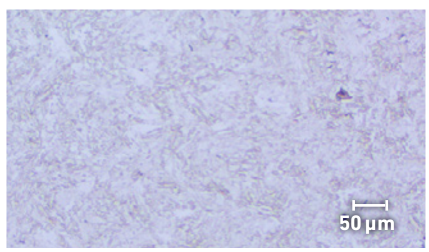
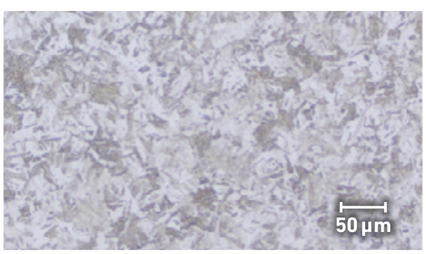
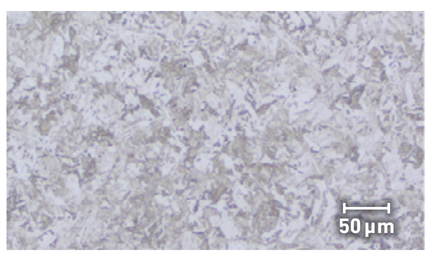
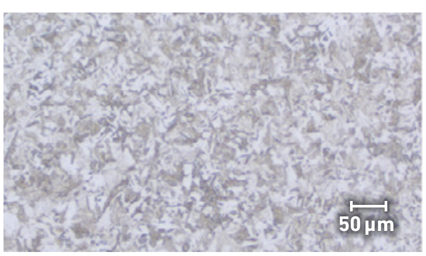
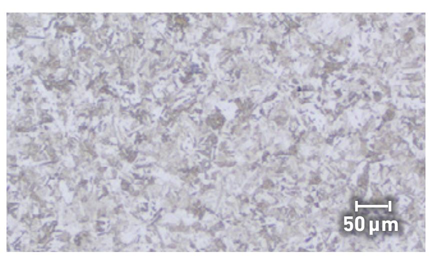
TYPICAL MICROSTRUCTURES

CONDITION	TRANSVERSE (X-Y PLANE)	LONGITUDINAL (Y-Z PLANE)	NOTES
As-built			Mean densities greater than 99.9%
HIP/Sol/ H900			Up to 100% density
As-built, etched[6]			Typical pre-solutionized PowderRange 17-4PH AR microstructure, consisting of martensite with minimal carbide precipitates
HIP/Sol/ H900, etched[6]			Average grain size ASTM 7-8[7] Typical PowderRange 17-4PH AR aged martensitic microstructure
HIP/Sol/ H900, etched[6]			Average grain size ASTM 7-8[7] Typical PowderRange 17-4PH AR aged martensitic microstructure

[6] Etched with Ralph's etchant
[7] ASTM E112 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		HARDNESS
		ksi	MPa	ksi	MPa	%	%	FT-LBS	J	HRB
As-built	X and Y	110	758	165	1136	15	62	85	115	35
	Z	108	747	166	1145	15	64	74	100	
Sol	X and Y	175	1209	195	1342	17	54	21	29	42
	Z	175	1208	195	1343	15	50	17	23	
HIP/Sol	X and Y	175	1207	194	1338	18	56	22	30	42
	Z	175	1207	194	1340	17	54	16	22	
ASTM Spec.[9]	—	170	1170	190	1310	10	40	—	—	40

[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 A564/A564M-13 Mechanical Test Requirements After Age Hardening Heat Treatment (Type 630, Condition H900), minimum values

Corrosion resistance

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

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Similar materials

COMPANY	ALTERNATIVE TITLE
Other Generic Names	1.4542, 17-4PH
3D Systems	LaserForm 17-4PH
GE (Concept Laser)	17-4PH
EOS	GP1
DMG Mori (Realizer)	—
Renishaw	Stainless Steel 17-4
SLM Solutions	17-4PH (1.4542)

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.