COLIBRIUM ADDITIVE
a GE Aerospace company

						13 Al
22 Ti	24 Cr	26 Fe	27 Co	28 Ni	29 Cu	

Binder Jet Line Stainless Steel 316L

Parameters and Processes for Colibrium Additive Binder Jet Line

Stainless Steel 316L (1.4404)

316L is an austenitic stainless steel, characterized by significant amounts of chromium, nickel, and molybdenum, while maintaining a low carbon content. It exhibits excellent corrosion & pitting resistance and performs well in forming & welding applications. In the stainless steel family, it is known to have excellent oxidation resistance, creep resistance, and high temperature strength. It is most commonly found in the automotive industry, medical sector, marine environments, as well as jewelry and pharmaceutical applications.

Stainless Steel 316L (1.4404) Binder Jet

Through mechanical testing and bulk material characterization, this parameter and the applied processing cycle demonstrates properties that rival internationally recognized casting standards.

Compared to other powder bed additive manufacturing processes, binder jet offers economy of scale for customers requiring both part quantity and part variation with favorable cost: a build box 0.5 meters per side can be fully printed in approximately 18 hours.

Binder Jet Line Stainless Steel 316L (1.4404)

Machine Configuration

Colibrium Additive Binder Jet Line

Air Atmosphere

Aqueous Binder

Powder Chemistry

316L stainless steel powder conforms to ASTM F3184 and ASTM A276

Parameter Information

This build parameter utilizes a 100 µm layer thickness and green parts are sintered for 360 minutes at 1390°C after a curing step.

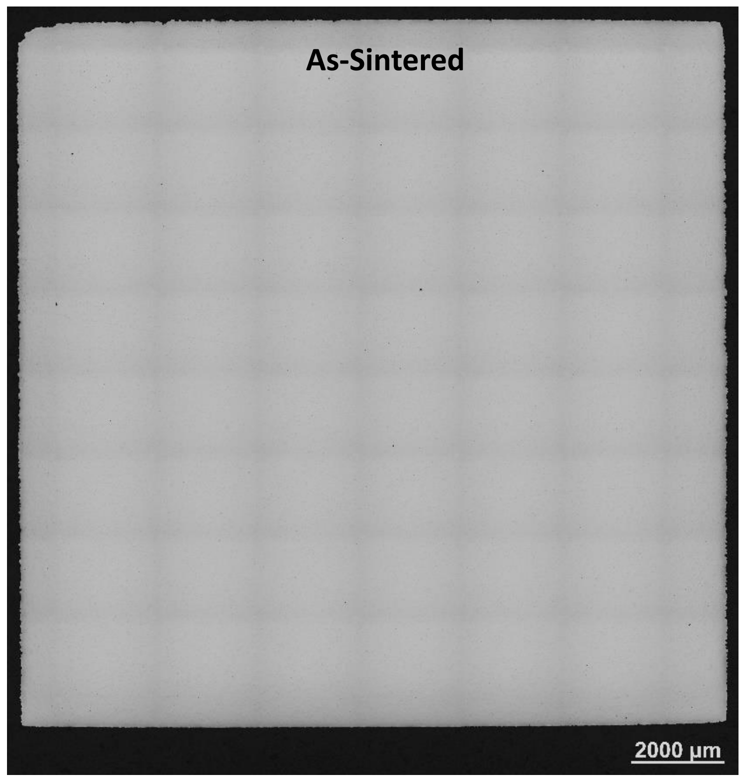
Thermal States

Data for this processing route is presented only in an as-sintered condition.

Residual Carbon & Nominal Chemistry

The carbon concentration after the full heat treatment met both ASTM F3184 and ASTM A276 specification maximums.

Additionally, all other constituents were measured post-sinter and observed to be within ASTM F3184 and ASTM A276 limits.



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Tensile Performance at Room Temperature

	Modulus of Elasticity (GPa)		0.2% Yield Strength (MPa)		Ultimate Tensile Strength (MPa)	
	H	V	H	V	H	V
As-Sintered	154	164	211	204	605	595

	Elongation (%)		Area Reduction (%)	
	H	V	H	V
As-Sintered	70	70	66	65

Tensile Performance at 400°C

	Modulus of Elasticity (GPa)		0.2% Yield Strength (MPa)		Ultimate Tensile Strength (MPa)	
	H	V	H	V	H	V
As-Sintered	82	105	129	130	453	454

	Elongation (%)		Area Reduction (%)	
	H	V	H	V
As-Sintered	41	42	55	54

Tensile Performance at 800°C

	Modulus of Elasticity (GPa)		0.2% Yield Strength (MPa)		Ultimate Tensile Strength (MPa)	
	H	V	H	V	H	V
As-Sintered	59	60	85	83	168	164

	Elongation (%)		Area Reduction (%)	
	H	V	H	V
As-Sintered	77	81	69	68

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Charpy Impact Data

	Impact Energy (J)		Lateral Expansion (mm)	
	H	V	H	V
As-Sintered (Room Temp)	118	118	1.83	1.85
As-Sintered (800°C)	96	100	1.45	1.45

Creep Behavior

The table below indicates the stress at 0.2% iso-strain and 100 hours.

	Temperature (°C)	Stress (MPa)
As-Sintered	650	68
	800	17

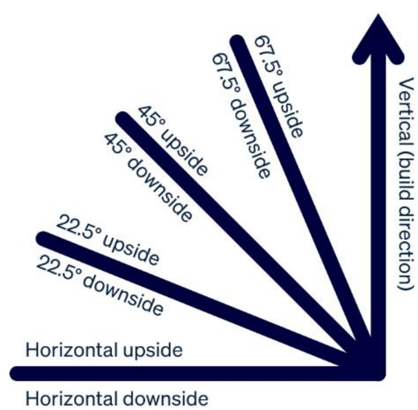
Physical Properties at Room Temperature

	Porosity (%)		Hardness (HRC)		Grain Size (ASTM #)	
	H	V	H	V	H	V
As-Sintered	99.9	99.8	69	69	5	5

As-Sintered Surface Roughness (µm Ra)

Angle/Face	Upside	Downside
H	2.8	14.8
22.5°	17.6	18.1
45°	15.9	15.6
67.5°	16.7	14.2

	Sidewall
V	15.4



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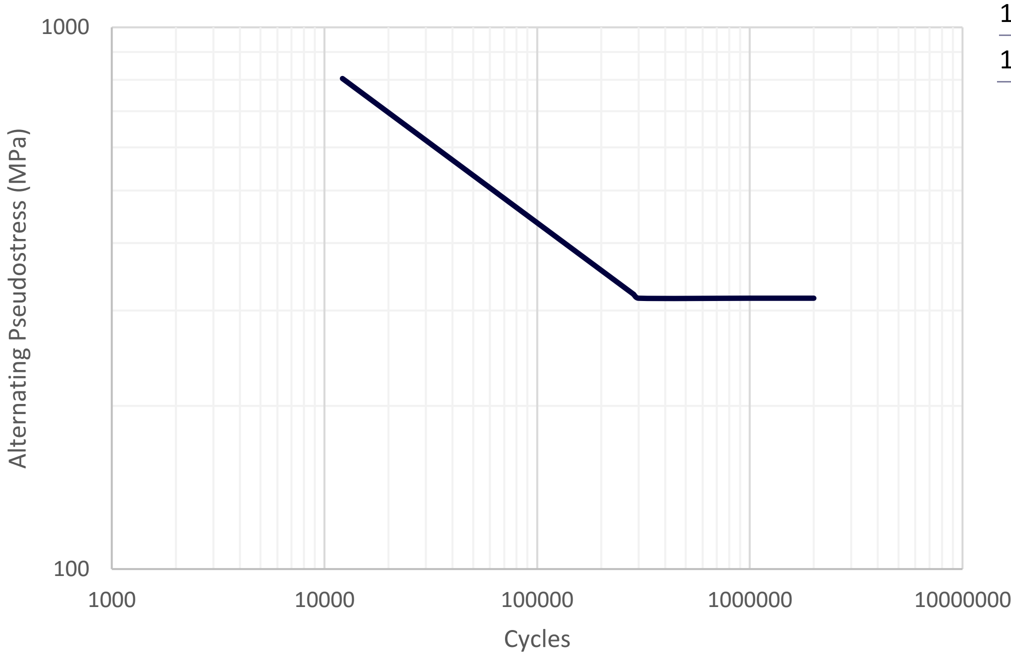
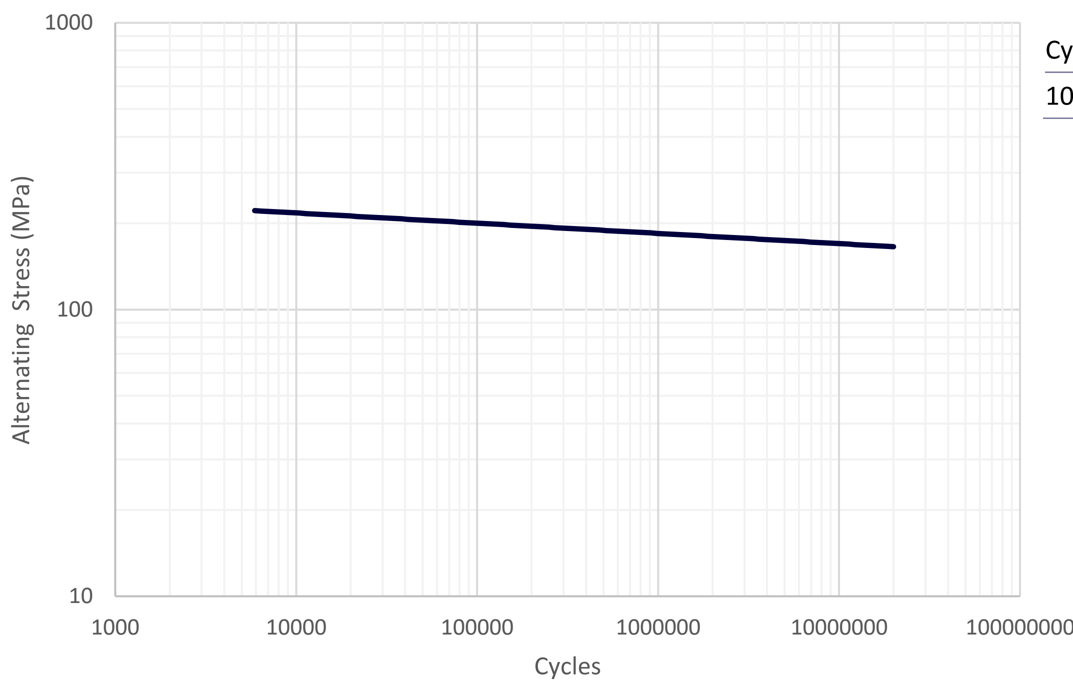
Axial Low-Cycle Fatigue (Machined Surfaces, H + V) at RT and R = -1



Cycles	Alt. Pseudostress (MPa)
10^5	434
10^6	317

Axial High-Cycle Fatigue (Machined Surfaces, H + V) at RT and R = -1



Cycles	Alt. Stress (MPa)
10^7	170

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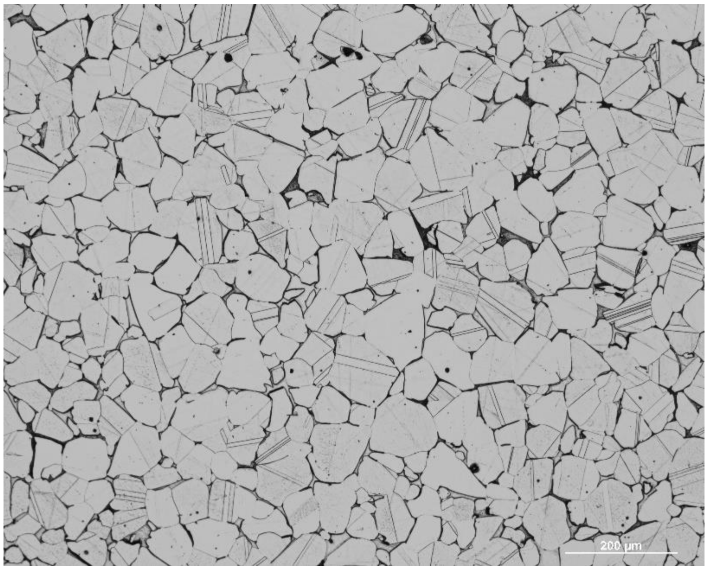
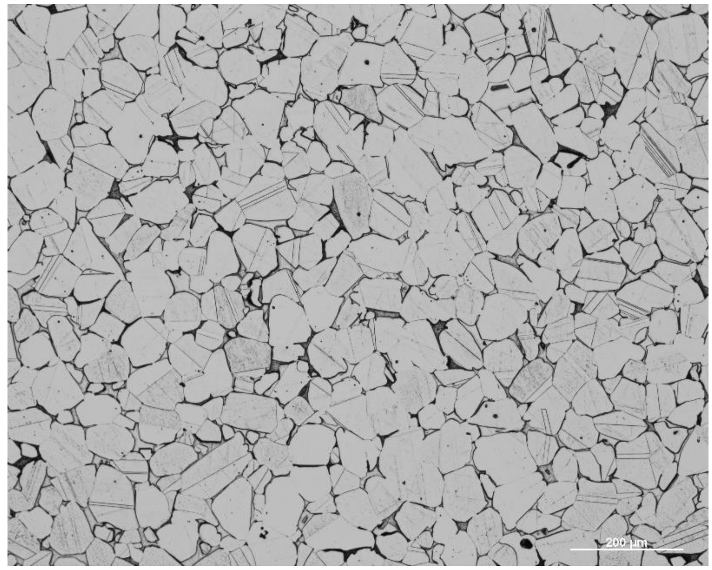
Microstructures (Etched)



Vertical, As-Sintered



Horizontal, As-Sintered

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Data Sheet Nomenclature and Notation

H: Horizontal, X or Y.
V: Vertical, Z.
Other angles are measured from horizontal.

Compositional testing was performed according to ASTM E1447 and E1097.

Roughness measurements have been performed according to DIN EN ISO 4287 and DIN EN ISO 4288. Analysis of surface quality varies as a function of methodology and specific settings, therefore some deviations might be observed depending on the chosen technology.

Hardness was tested according to ASTM E18.

Grain size number was determined after metallographic preparation according to ASTM E3, E407, and E112.

Tensile evaluations were performed per ASTM E8 and E21. All surfaces were machined prior to testing.

Charpy data was generated per ASTM E23. All surfaces were machined prior to testing.

Creep testing was performed in accordance with ASTM E139. All surfaces were machined prior to testing.

Axial low cycle fatigue testing was performed in accordance with ASTM E606. All surfaces were machined prior to testing.

Axial high cycle fatigue testing was performed per ASTM E466. All surfaces were machined prior to testing.