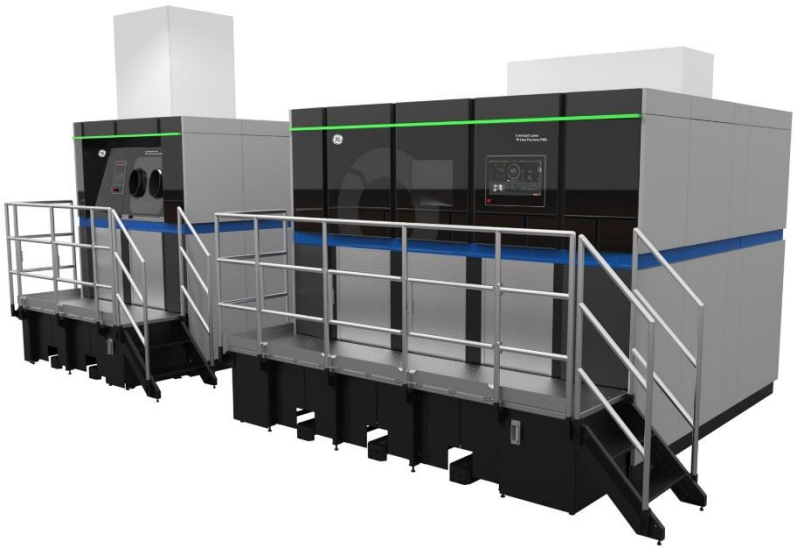
13 Al					
22 Ti	24 Cr	26 **Fe**	27 Co	28 Ni	29 Cu

M Line Steel 316L

Parameters for GE Additive's Concept Laser M Line

Data in this material datasheet represent material built with 50 µm layer thickness in a nitrogen or argon atmosphere on a Concept Laser M Line machine. Values listed are typical.



316L Stainless Steel

316L is a chromium-nickel-molybdenum austenitic stainless steel having a higher corrosion resistance compared to the most common stainless steel 304 without any significant disadvantages in costs. By the addition of molybdenum this steel is particularly suitable for components within harsh chemical environments containing chlorides and other halides. Typical applications can be found across a wide range of industries like plant engineering, oil & gas industry, automotive, medical technology, and jewelry and components for molds. 316L is easily weldable and offers excellent ductility and high creep strength at elevated temperatures.

M Line Steel 316L

The 316L parameter for the Concept Laser M Line is developed leveraging the performance of the previous machine generations. The base parameter delivers good surface quality while maintaining a very good density, mechanical strength and productivity.
All parameters succeed the minimum tensile properties specified in ASTM F3184 for additive manufactured parts in the stress relieved state.

M Line Steel 316L

With corresponding approval* Steel 316L can be used for manufacturing components for acid- and corrosion-resistant applications in the following fields: plant engineering, automotive, medical technology, and jewelry and components for molds.

Data in this material datasheet represents material built with 50 µm layer thickness and in a nitrogen or argon atmosphere on a Concept Laser M Line machine. Values listed are typical.

POWDER CHEMISTRY

316L powder chemical composition according to ASTM F3184 - UNS S31603 / ASTM A276.

MACHINE CONFIGURATION

- Concept Laser M Line
- Nitrogen/Argon gas
- Rubber recoater blade

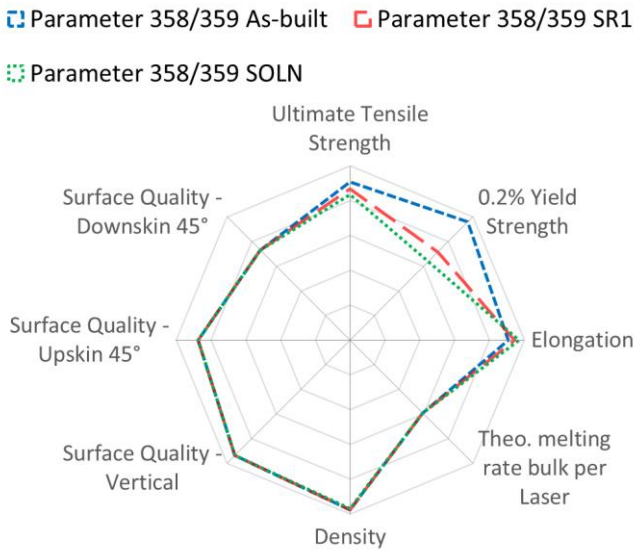
AVAILABLE PARAMETERS

- **Base Parameter 358** — 50 µm layer thickness, rubber recoater, nitrogen
- **Base Parameter 359** — 50 µm layer thickness, rubber recoater, argon

THERMAL STATES

1. As-Built
2. Stress Relief according to AMS2759/11A (SR1)
   SR: 1h at 899°C, with air cooling
3. Solution Anneal according to AMS2759/4D (SOLN)
   SOLN: 1h at 1066°C, with air cooling

PARAMETER COMPARISON



Spider Plot is generated by normalizing typical material data (containing both horizontal and vertical data) against a range defined for each material family. For **Stainless Steels**, the ranges are as follows: UTS: 0-750 MPa, 0.2%YS: 0-600 MPa, Elongation: 0-60 %, Density: 99-100 %, Theo. melting rate bulk per Laser: 5-30 cm^3/h, Surface Quality (all): 50-5 µm

TYPICAL BUILD RATE

	(cm³/h)
Typical build rate w/coating*	10-60
Theoretical melting rate bulk per Laser[1]	17.8

[1]Calculated (layer thickness x scan velocity x hatch distance)

PHYSICAL DATA AT ROOM TEMPERATURE

	Surface Roughness Ra** - Overhang (µm)		
	45°	60°	75°
Upskin	11	8	7
Downskin	18	8	7

	Surface Roughness Ra** (µm)
H	-
V	8

	Relative Density (%)		Hardness (HV10)		Poisson's Ratio	
Thermal State	H	V	H	V	H	V
As-Built	99.9	99.9	222	-	-	-
SR1	-	-	195	-	-	-
SOLN	-	-	183	-	-	-

TENSILE DATA

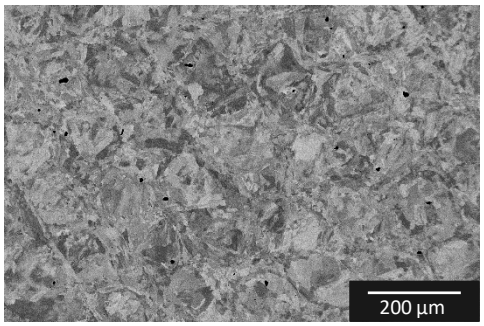
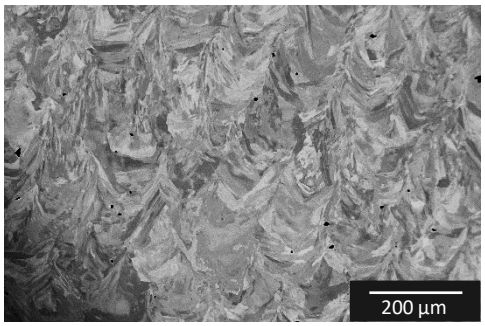
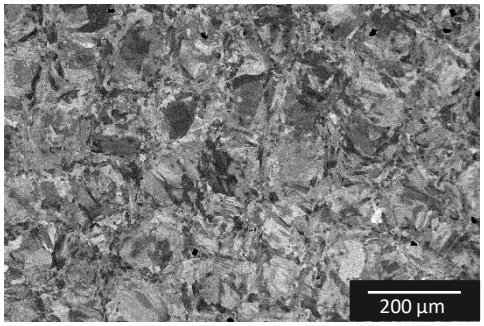
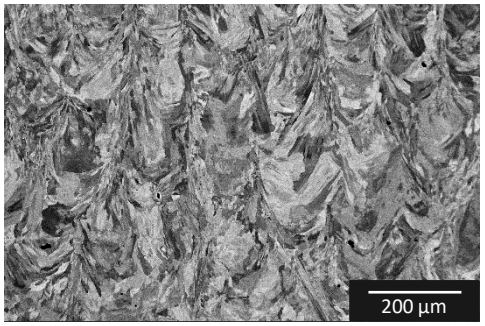
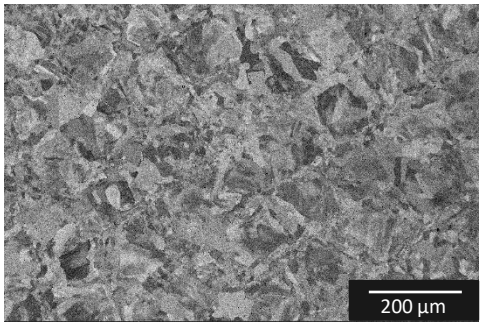
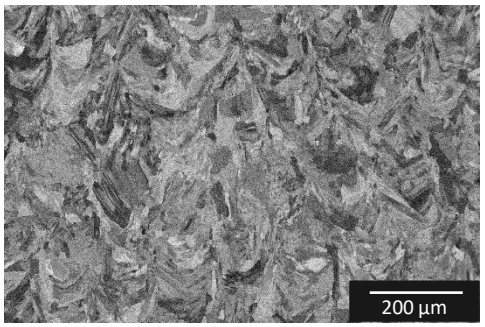
Tensile testing done in accordance with ASTM E8 and ASTM E21

Test Temperature: RT

	Modulus of Elasticity (GPa)		0.2% Yield Strength (MPa)		Ultimate Tensile Strength (MPa)		Elongation (%)		Reduction of Area (%)	
Thermal State	H	V	H	V	H	V	H	V	H	V
As-Built	180	155	600	545	705	655	37.5	44.5	68.0	73.0
SR1	195	185	435	415	670	625	43.5	51.0	65.0	69.5
SOLN	195	200	385	375	645	605	48.5	57.5	65.5	71.5

H: HORIZONTAL (XY) orientation
V: VERTICAL (Z) orientation

* All of the figures contained herein are approximate only. The figures provided are dependent on a number of factors, including but not limited to, process and machine parameters, and the approval is brand specific and/or application specific. The information provided on this material data sheet is illustrative only and cannot be relied on as binding.
** Roughness measurements have been performed according to DIN EN ISO 4287 and DIN EN ISO 4288. In general analysis of the surface quality is strongly dependent on the methodology used and deviations might be caused by different measurement set up. Vertical and horizontal sidewalls have been characterized using a tactile system, overhangs using an optical system.

	Horizontal	Vertical
As-Built		
SR1		
SOLN		

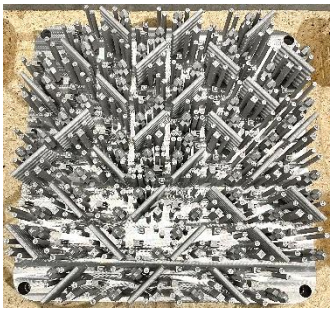
H: HORIZONTAL (XY) orientation
V: VERTICAL (Z) orientation

* All of the figures contained herein are approximate only. The figures provided are dependent on a number of factors, including but not limited to, process and machine parameters, and the approval is brand specific and/or application specific. The information provided on this material data sheet is illustrative only and cannot be relied on as binding.

PLATFORM STABILITY

The platform stability build evaluates porosity, roughness and tensile properties across different positions and orientations. To illustrate the position dependency of the M Line, the samples were homogenously distributed across the platform on 30 different positions. Regarding surface quality all sides of the specimen, so all orientations with respect to gas flow and optical system, are included in the analysis. Data shown below is dependent on part & print layout as well as batch chemistry and thus might deviate from “typical values” given on previous pages.

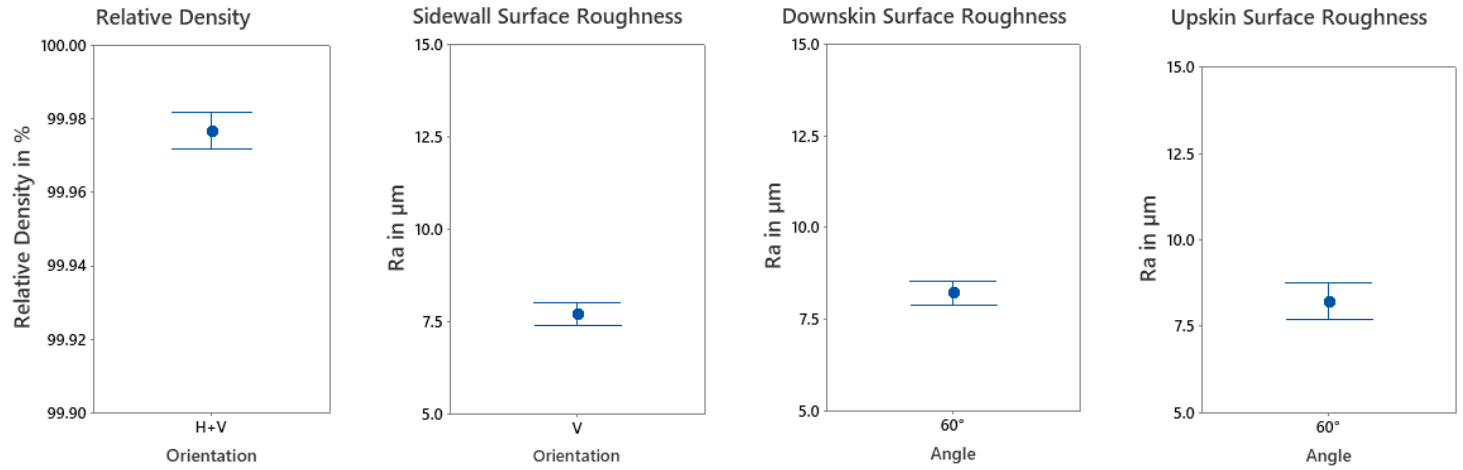
BUILD JOB DESIGN AND SUMMARIZED DATA (AS-BUILT)



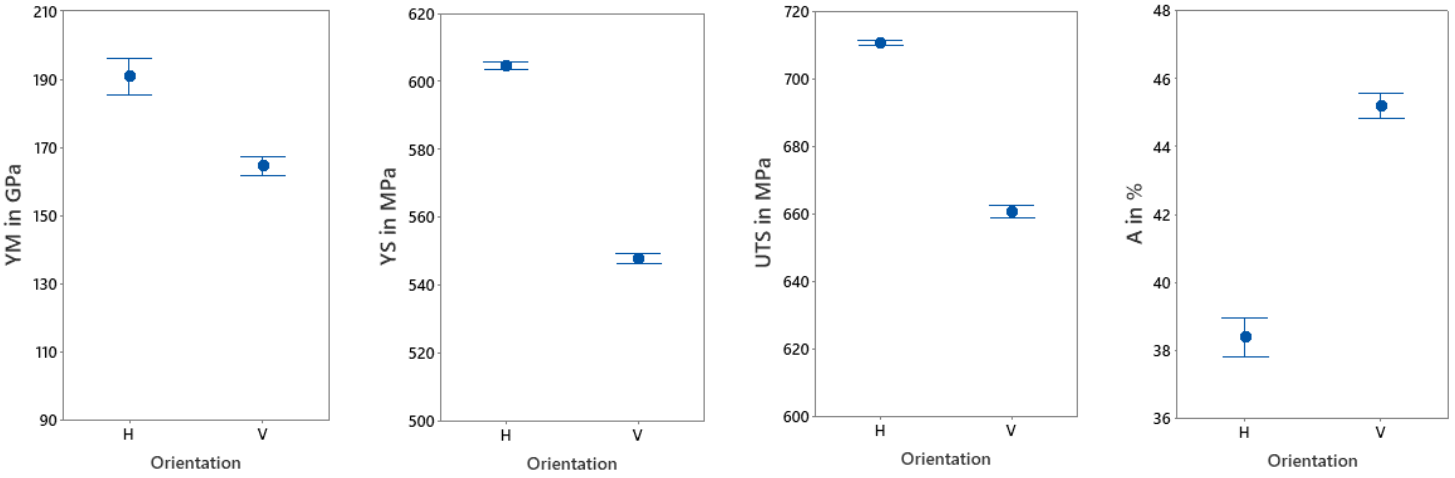
	Sample Size	Mean	St.Dev.
Rel. Density in %	60	99.98	0.02
Sidewall Roughness Ra in µm	30	8	1
Upskin Roughness Ra in µm (60°)	30	9	1
Downskin Roughness Ra in µm (60°)	30	9	1

	Sample Size	Mean	St.Dev.
YM in GPa (H/V)	30/30	190/164	14/8
YS in MPa (H/V)	30/30	604/547	4/5
UTS in MPa (H/V)	30/30	710/660	3/6
Elongation in % (H/V)	30/30	38.3/45.1	1.6/1.0

RESULTS – RELATIVE DENSITY AND SURFACE QUALITY



RESULTS - MECHANICAL PROPERTIES IN AS-BUILT CONDITION



Data points represent the mean value, intervals the 95% confidence level.

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