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

M2 Series 5 Steel 17-4 PH

Parameters for GE Additive’s Concept Laser M2 Series 5

Data in this material datasheet represent material built with 25, 50 and 80 µm layer thicknesses in an argon atmosphere on a Concept Laser M2 Series 5 single-laser or dual-laser machine. Values listed are typical.

17-4 PH Stainless Steel

17-4 precipitation hardening (PH) stainless steel is used in applications for surgical or orthopedic instruments as well as chemical, oil, and aerospace industries due to high corrosion resistance and high strength and fracture toughness at moderate temperatures. Additive allows for shape freedom of complex geometries not possible with traditional manufacturing processes, in which the high strength and hardness of 17-4 PH steel is difficult to machine. Often additive parts are post-processed with blasting or polishing while traditional machining is minimized with intelligent additive design.

M2 Series 5 Steel 17-4 PH

The 17-4 PH parameters for the Concept Laser M2 Series 5 are developed leveraging the performance of the previous M2 generations. The base parameters deliver good surface quality while maintaining a very good density, mechanical strength and productivity. For highest all-around surface quality, particularly within overhang downskin and upskin regions, the surface parameter has been developed. The hybrid parameter can significantly increase the productivity of parts having a high volume/surface ratio and still meeting highest surface quality requirements. The highest build rate without significant debit of the mechanical properties can be achieved by the productivity parameter having a layer thickness of 80 µm.

M2 Series 5 Steel 17-4 PH

With corresponding approval* 17-4 PH is a widespread precipitation hardening steel which can be used for manufacturing functional components or medical instruments.

Data in this material datasheet represent material built with 25, 50 and 80 µm layer thicknesses in an argon atmosphere on a Concept Laser M2 Series 5 single-laser or dual-laser machine. Values listed are typical.

POWDER CHEMISTRY

Steel 17-4 PH powder chemical composition according to ASTM A564 / A564M - 13 UNS S17400 / SUS 630.

MACHINE CONFIGURATION

- Concept Laser M2 Series 5 (single-laser or dual-laser)
- Argon gas
- Stainless steel or rubber recoater blade

AVAILABLE PARAMETERS

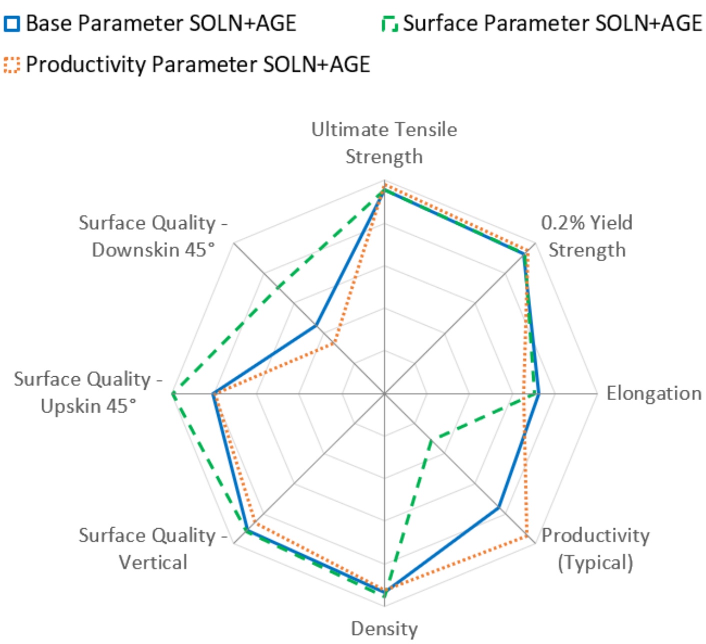
- **Base Parameter 121 / 303****	50 µm layer thickness, rubber recoater
- **Base Parameter 122**	50 µm layer thickness, steel recoater
- **Surface Parameter 123 / 304****	25 µm layer thickness, rubber recoater
- **Hybrid Parameter 192**	25/50 µm layer thickness, rubber recoater
- **Productivity Parameter 246 / 302****	80 µm layer thickness, rubber recoater

**Productivity optimized version (productivity bundle required)

THERMAL STATES

1. As-Built
2. Solution Anneal + Age (SOLN+AGE)
   SOLN: 1040°C, 1 hour, water quench; AGE: 480°C, 45 minutes, rapid cooling

THERMAL STATE 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 **Precipitation Hardening Steels,** the ranges are as follows: UTS: 0-1500 MPa, 0.2%YS: 0-1400 MPa, Elongation: 0-30 %, Density: 99-100 %, Productivity: 5-30 cm³/h, Surface Quality (all): 40-5 µm

TYPICAL BUILD RATE

Base Parameter

	Standard (cm³/h)	Productivity optimized (cm³/h)
Typical build rate[1] w/coating	17.6	22.7
Theoretical melting rate[2] bulk per Laser	18.7	18.7

[1]Using standard Factory Acceptance Test layout and 2 lasers
[2]Calculated (layer thickness x scan velocity x hatch distance)

PHYSICAL DATA AT ROOM TEMPERATURE

Surface Roughness Ra** - Overhang (µm)

	45°	60°	75°
Upskin	12	9	6
Downskin	24	13	7

Surface Roughness Ra** (µm)

H	15
V	9

	Relative Density (%)		Hardness (HV10)		Poisson's Ratio	
Thermal State	H	V	H	V	H	V
As-Built	99.9	99.9	308	--	--	--
SOLN+AGE	99.9	99.9	457	--	--	--

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	187	184	715	705	995	935	17.0	17.5	--	--
SOLN+AGE	195	197	1290	1300	1430	1435	12.5	10.5	--	--

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 therefore deviations might be observed depending on methodology used. Vertical and horizontal sidewalls have been characterized using a tactile system, overhangs using an optical system.

TYPICAL BUILD RATE

	Standard (cm³/h)	Productivity optimized (cm³/h)
Typical build rate[1] w/coating	7.9	9.3
Theoretical melting rate[2] bulk per Laser	9.0	9.0

[1]Using standard Factory Acceptance Test layout and 2 lasers

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

PHYSICAL DATA AT ROOM TEMPERATURE

	Surface Roughness Ra** - Overhang (µm) 45°	60°	75°
Upskin	6	5	5
Downskin	16	6	5

	Surface Roughness Ra** (µm)
H	11
V	8

Thermal State	Relative Density (%) H	V	Hardness (HV10) H	V	Poisson's Ratio H	V
As-Built	99.9	99.9	275	--	--	--
SOLN+AGE	99.9	99.9	--	--	--	--

TENSILE DATA

Tensile testing done in accordance with ASTM E8 and ASTM E21

Test Temperature: RT

Thermal State	Modulus of Elasticity (GPa) H	V	0.2% Yield Strength (MPa) H	V	Ultimate Tensile Strength (MPa) H	V	Elongation (%) H	V	Reduction of Area (%) H	V
As-Built	175	161	780	765	855	805	22.0	22.0	--	--
SOLN+AGE	192	194	1280	1315	1420	1450	12.5	8.0	--	--

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TYPICAL BUILD RATE

Hybrid Parameter

	(cm³/h)
Typical build rate[1] w/coating	8.5 *(8-20)*[3]
Theoretical melting rate[2] bulk per Laser	18.7

[1]Using standard Factory Acceptance Test layout and 2 lasers

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

[3]The hybrid parameter build rate is strongly dependent on application design, in particular wall thickness. For this parameter, a larger increase in productivity (faster build rate) can be expected for parts having high volume/surface ratios.

PHYSICAL DATA AT ROOM TEMPERATURE

	Surface Roughness Ra** - Overhang (µm)		
	45°	60°	75°
Upskin	6	5	5
Downskin	20	6	5

	Surface Roughness Ra** (µm)
H	10
V	8

	Relative Density (%)		Hardness (HV10)		Poisson's Ratio	
Thermal State	H	V	H	V	H	V
As-Built	99.9	99.9	287	--	--	--
SOLN+AGE	99.9	99.9	--	--	--	--

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	181	168	765	775	935	935	18.0	18.5	--	--
SOLN+AGE	190	195	1290	1300	1430	1435	13.0	10.0	--	--

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

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** 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 therefore deviations might be observed depending on methodology used. Vertical and horizontal sidewalls have been characterized using a tactile system, overhangs using an optical system.

TYPICAL BUILD RATE

Productivity Parameter

	Standard (cm³/h)	Productivity optimized (cm³/h)
Typical build rate[1] w/coating	25.9	28.4
Theoretical melting rate[2] bulk per Laser	23.5	23.5

[1]Using standard Factory Acceptance Test layout and 2 lasers

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

PHYSICAL DATA AT ROOM TEMPERATURE

	Surface Roughness Ra** - Overhang (µm)		
	45°	60°	75°
Upskin	13	9	7
Downskin	28	18	11

	Surface Roughness Ra** (µm)
H	11
V	12

	Relative Density (%)		Hardness (HV10)		Poisson's Ratio	
Thermal State	H	V	H	V	H	V
As-Built	99.9	99.9	346	--	--	--
SOLN+AGE	99.9	99.9	464	--	--	--

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	158	164	665	685	1120	1110	15.5	15.5	65.5	66
SOLN+AGE	195	198	1325	1320	1490	1490	13	10	41.5	31

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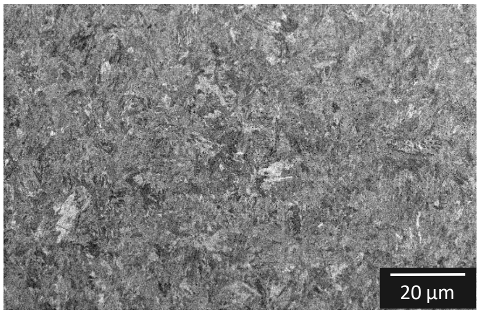
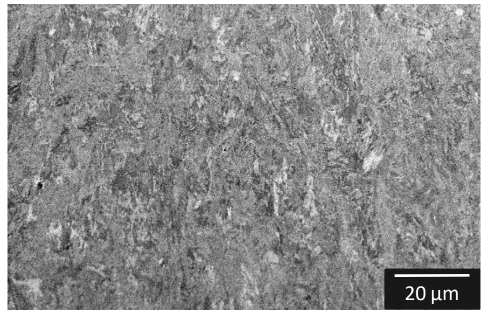
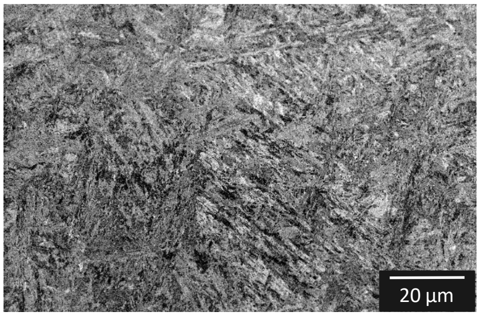
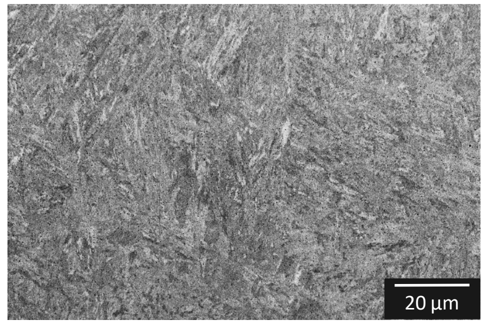
** Roughness measurements have been performed according to DIN EN ISO 4287 and DIN EN ISO 4288. In general analysis of the surface quality is strongly dependent on the methodology used and therefore deviations might be observed depending on methodology used. Vertical and horizontal sidewalls have been characterized using a tactile system, overhangs using an optical system.

	Horizontal	Vertical
As-Built		
SOLN + AGE		

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

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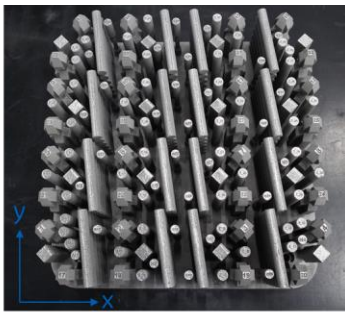
The platform stability build evaluates porosity, roughness and tensile properties across different positions and orientations. To illustrate the position dependency of the M2 Series 5, the samples were homogenously distributed across the platform on 16 different positions. Regarding surface quality all sides of the specimen, so all orientations with respect to gas flow and optical system, are included in the analysis. Data shown below are dependent on part & print layout as well as batch chemistry variations and thus might deviate from “typical values” given on previous pages.

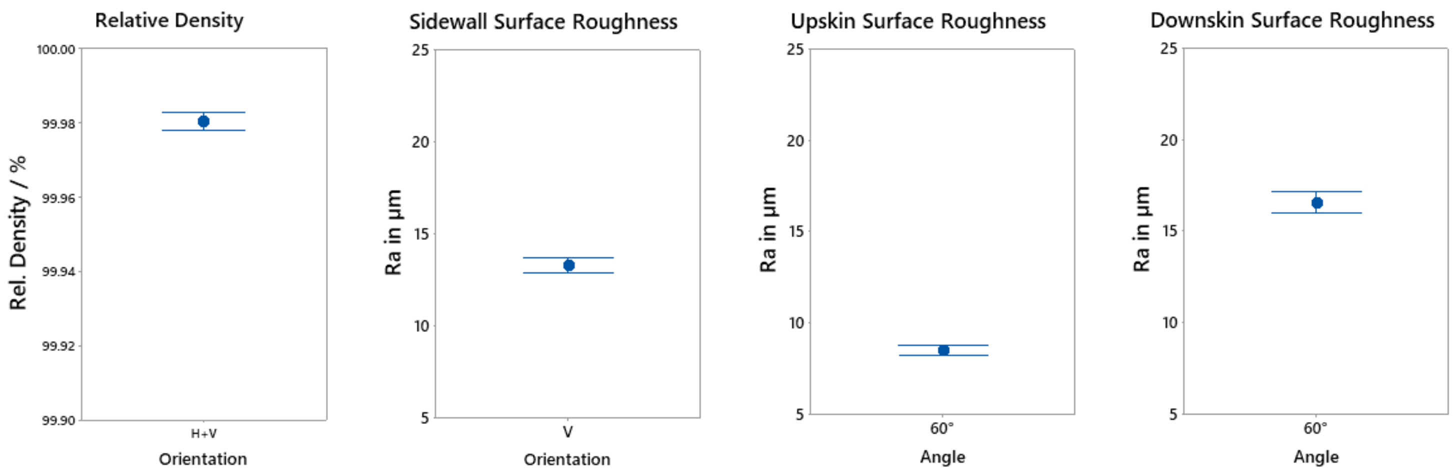
BUILD JOB DESIGN AND SUMMARIZED DATA



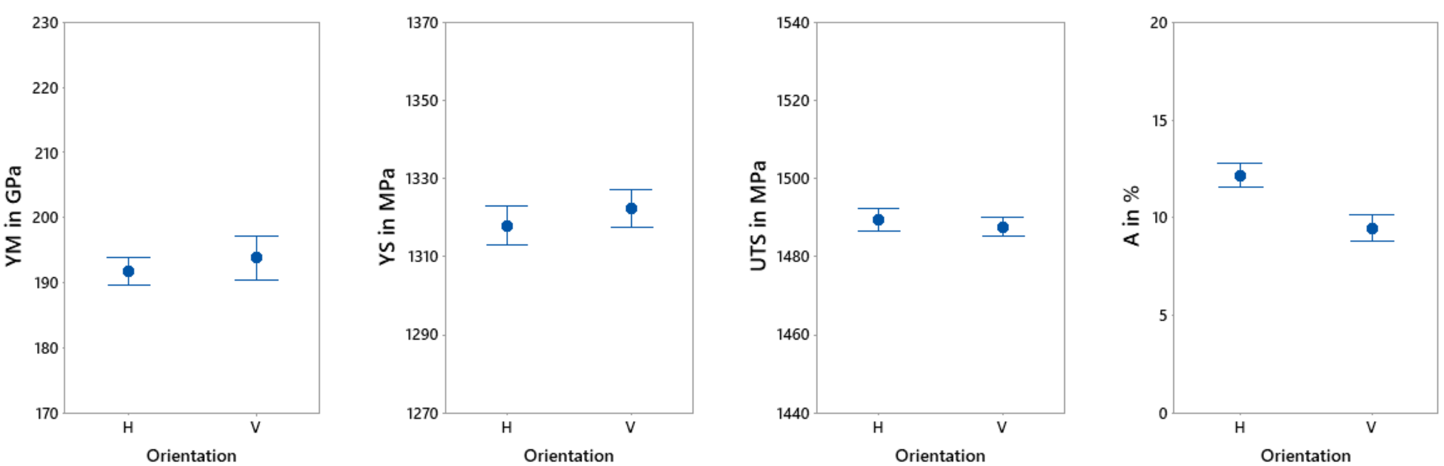
	Sample Size	Mean	St.Dev.
Rel. Density in %	32	99.98	0.01
Sidewall Roughness Ra in µm	128	13	2
Upskin Roughness Ra in µm (60°)	128	8	2
Downskin Roughness Ra in µm (60°)	128	17	3

	Sample Size	Mean	St.Dev.
YM in GPa (H/V)	16/16	192/194	4/6
YS in MPa (H/V)	16/16	1318/1322	10/9
UTS in MPa (H/V)	16/16	1489/1488	5/4
Elongation in % (H/V)	16/16	12.2/9.4	1.2/1.3

RESULTS – RELATIVE DENSITY AND SURFACE QUALITY



RESULTS - MECHANICAL PROPERTIES IN SOLN+AGE CONDITION



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

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