

EOS StainlessSteel 316L
Material Data Sheet

EOS StainlessSteel 316L

EOS StainlessSteel 316L is a high performance marine-grade austenitic stainless steel that is molybdenum alloyed for enhanced corrosion resistance in chloride environments. 316L is a standard material for numerous applications in process, energy, paper, transportation and other industries.

Main Characteristics:

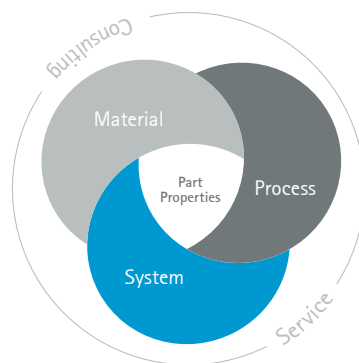
- High ductility and toughness
- High strength
- High corrosion resistance

Typical Applications:

- Chemical industry
- Food processing
- Medical devices

The EOS Quality Triangle

EOS uses an approach that is unique in the AM industry, taking each of the three central technical elements of the production process into account: the system, the material and the process – together simply described as the Quality Triangle. EOS focuses on delivering reproducible part properties for the customer.



All of the data stated in this material data sheet is produced according to EOS Quality Management System and international standards.

Powder Properties

The chemical composition of EOS StainlessSteel 316L corresponds to ASTM F138 material standard for Surgical Implants (UNS S31673).

Powder chemical composition (wt.-%)

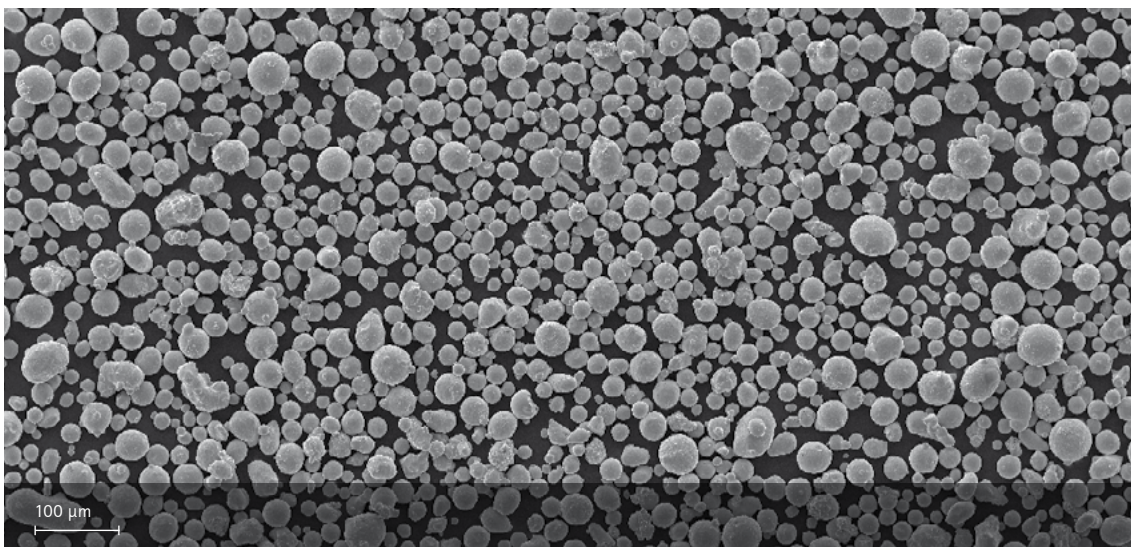
Element	Min.	Max.
Fe	Balance	
Cr	17.00	19.00
Ni	13.00	15.00
Mo	2.25	3.00
C	-	0.03
N	-	0.10

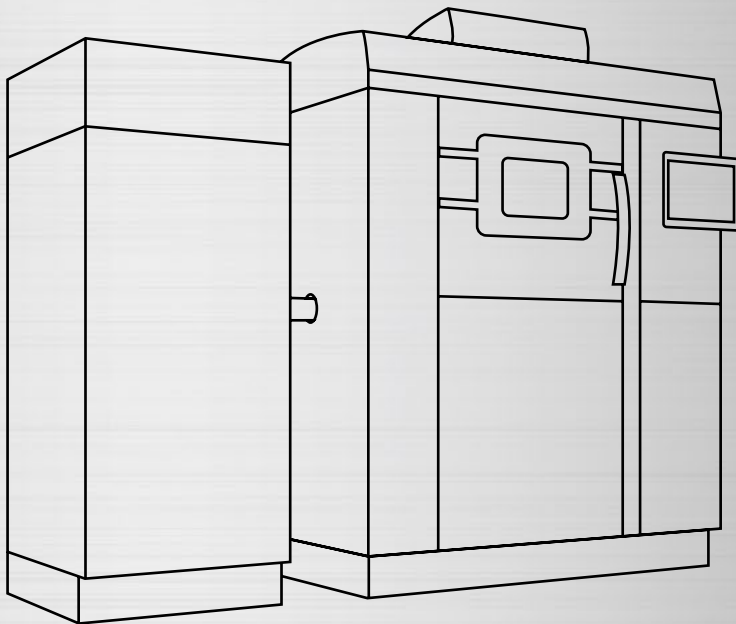
Powder particle size

Generic particle size distribution

20 – 65 μm

SEM picture of EOS StainlessSteel 316L powder.





EOS StainlessSteel 316L for EOS M 290 | 20 μm

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

EOS StainlessSteel 316L for EOS M 290 | 20 µm

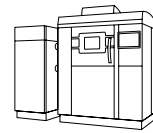
Process Information

This process product is optimized for robustly building parts with EOS M 290 system using EOS StainlessSteel 316L. The mechanical properties have been validated to TRL8 level.

System set-up	EOS M 290
EOS ParameterSet	316L 20µm Surface M290/400W
EOSPAR name	316L_Surface_1.X
Software requirements	EOSPRINT 2.7 or newer EOSYSTEM 2.11 or newer
Powder part no.	9011-0032
Recoater blade	EOS HSS blade
Nozzle	Standard nozzle
Inert gas	Argon
Sieve	63 µm

Additional information

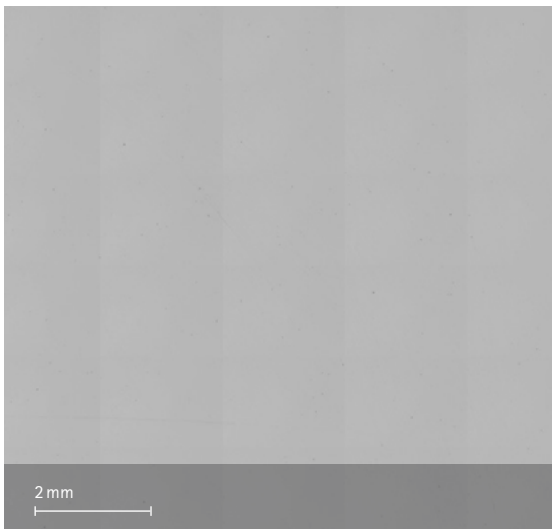
Layer thickness	20 µm
Min. wall thickness	0.3 - 0.4 mm
Typical dimensional change after HT	+0.02 %
Volume rate	2.0 mm ³ /s



Chemical and Physical Properties of Parts

Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

Micrograph of polished surface



Microstructure solution annealed
Etched with etchant Kallings 2



Defects	Result	Number of samples
Average defect percentage	0.018 %	45
Density, ISO3369	Result	Number of samples
Average density	$\geq 7.97 \text{ g/cm}^3$	45

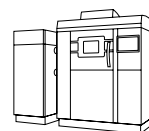
Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

Mechanical Properties as manufactured

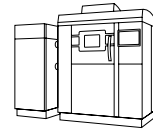


Mechanical properties ISO6892-1

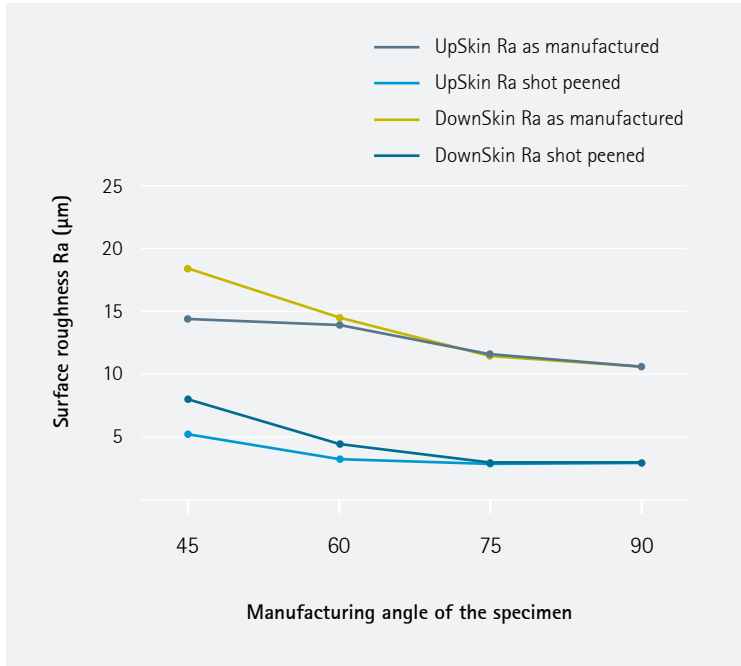
	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]	Number of samples
Vertical	470	540	54	189
Horizontal	530	640	40	162



Additional Data

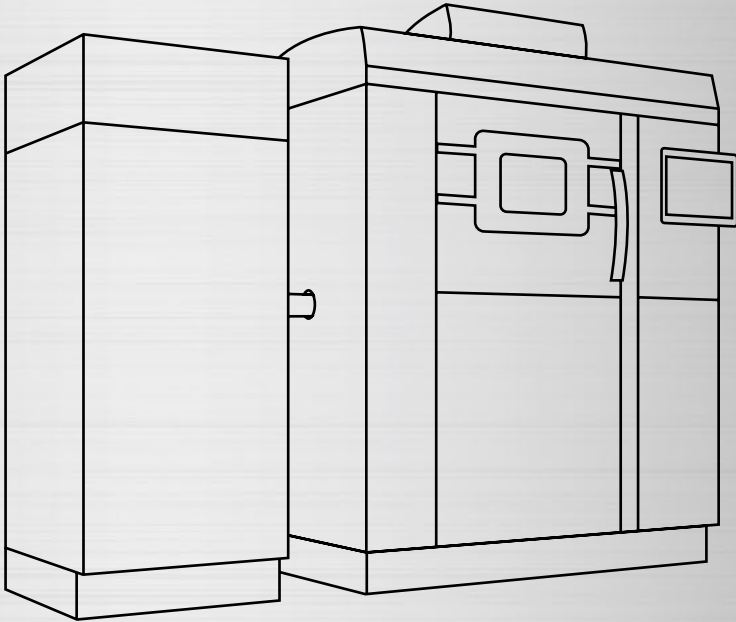


Surface Roughness



Coefficient of Thermal Expansion ASTM E228

Temperature	25-100 °C	25-200 °C	25-300 °C	25-400 °C
CTE	15.72 *10 ⁻⁶ /K	16.75 *10 ⁻⁶ /K	17.27 *10 ⁻⁶ /K	17.70 *10 ⁻⁶ /K



EOS StainlessSteel 316L for EOS M 290 | 40 μm

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

EOS StainlessSteel 316L for EOS M 290 | 40 µm

Process Information

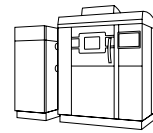
This process product is optimized for building high quality parts with EOS M 290 system reliably using EOS StainlessSteel 316L. Mechanical properties have been validated to TRL7 level.

System set-up	EOS M 290
EOS ParameterSet	316L 40µm FlexLine
EOSPAR name	316L_040_FlexM291_1.X
Software requirements	EOSPRINT 2.7 or newer EOSYSTEM 2.11 or newer
Powder part no.	9011-0032
Recoater blade	EOS HSS blade
Nozzle	EOS grid nozzle
Inert gas	Argon
Sieve	63 µm

Additional information

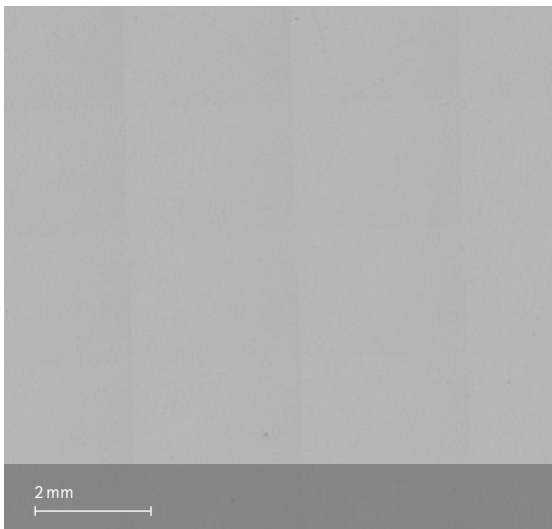
Layer thickness	40 µm
Min. wall thickness	0.1 mm
Typical dimensional change after HT	+0.2 %
Volume rate	3.7 mm ³ /s

Chemical and Physical Properties of Parts



Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

Micrograph of polished surface



Microstructure solution annealed
Etched with etchant Kallings 2



Defects	Result	Number of samples
Average defect percentage	0.015 %	20
Density, ISO3369	Result	Number of samples
Average density	$\geq 7.97 \text{ g/cm}^3$	20

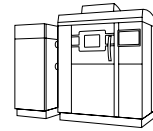
Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

Mechanical Properties as manufactured

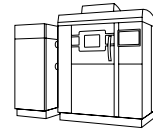


Mechanical properties ISO6892-1

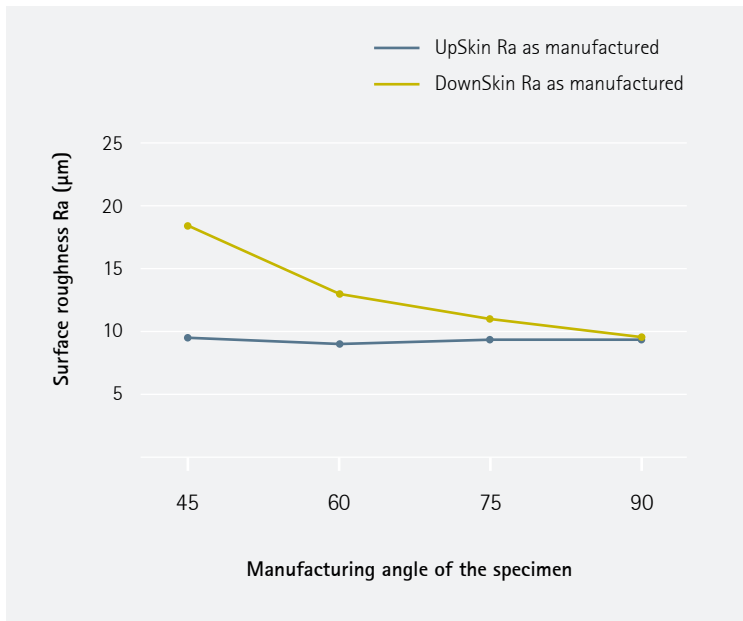
	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]	Number of samples
Vertical	480	570	51	105
Horizontal	540	640	40	90



Additional Data

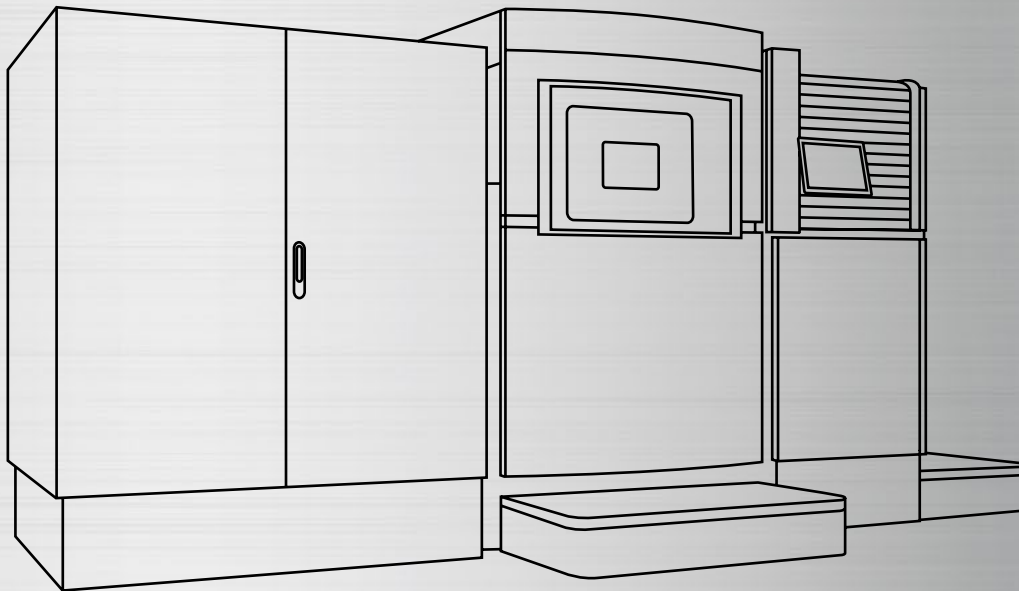


Surface Roughness



Coefficient of Thermal Expansion ASTM E228

Temperature	25-100 °C	25-200 °C	25-300 °C	25-400 °C
CTE	15.72 *10 ⁻⁶ /K	16.75 *10 ⁻⁶ /K	17.27 *10 ⁻⁶ /K	17.70 *10 ⁻⁶ /K



EOS StainlessSteel 316L for EOS M 400-4 | 40 μm

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

EOS StainlessSteel 316L for EOS M 400-4 | 40 µm

Process Information

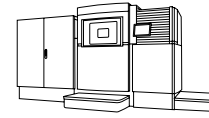
This process product is optimized for building high quality parts with EOS M400-4 system using EOS StainlessSteel.

System set-up	EOS M 400-4
EOS ParameterSet	316L 40µm Flex M 400-4
EOSPAR name	316L_040_FlexM404_1.X
Software requirements	EOSPRINT 2.7 or newer EOSYSTEM 2.11 or newer
Powder part no.	9011-0032
Recoater blade	EOS HSS blade
Inert gas	Argon
Sieve	63 µm

Additional information

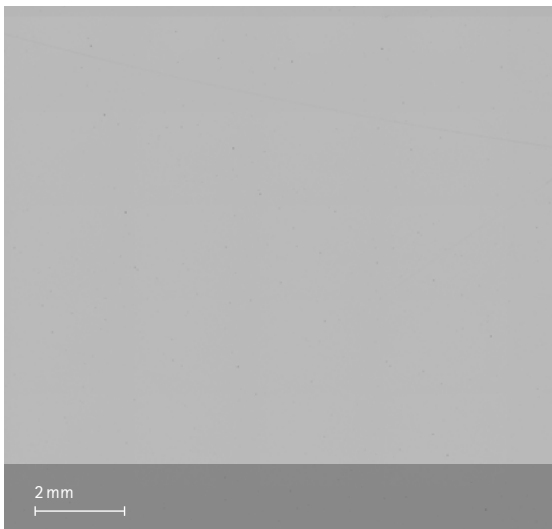
Layer thickness	40 µm
Volume rate	14.8 mm ³ /s

Chemical and Physical Properties of Parts



Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

Micrograph of polished surface



Microstructure solution annealed Etched with etchant Kallings 2



Defects	Result	Number of samples
Average defect percentage	0.015 %	40

Density, ISO3369	Result	Number of samples
Average density	$\geq 7.9 \text{ g/cm}^3$	40

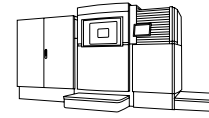
Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

Mechanical Properties as manufactured



Mechanical properties ISO6892-1

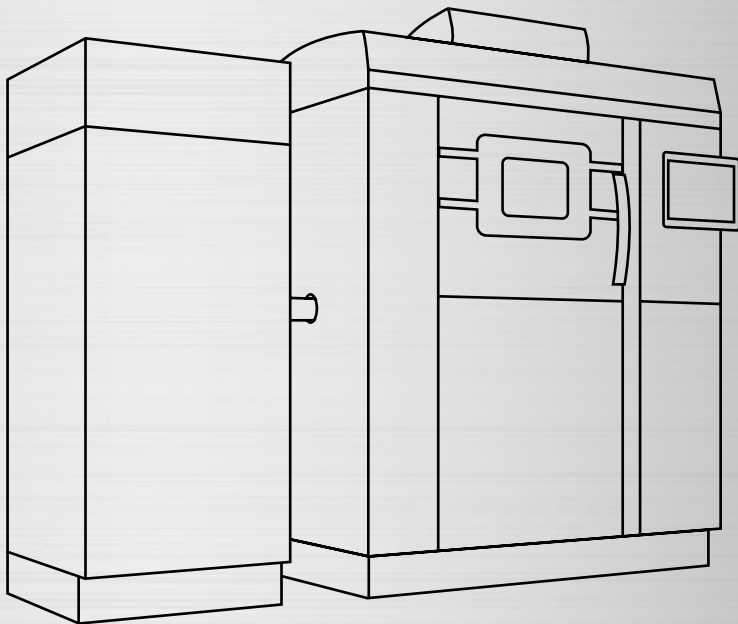
	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]	Number of samples
Vertical	490	590	45	120
Horizontal	550	650	40	96



Additional Data

Coefficient of Thermal Expansion ASTM E228

Temperature	25-100 °C	25-200 °C	25-300 °C	25-400 °C
CTE	$15.72 \cdot 10^{-6}/K$	$16.75 \cdot 10^{-6}/K$	$17.27 \cdot 10^{-6}/K$	$17.70 \cdot 10^{-6}/K$



EOS StainlessSteel 316L for EOS M 290 | 40/80 μm

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

EOS StainlessSteel 316L for EOS M 290 | 40/80 µm Process Information

This process product is optimized for flexible and fast production of 316L parts with the EOS M 290 system. The parameter set has three different layer thickness options that can all be utilized within the same build: 40 µm, 80 µm and 40/80 µm Skin.

The 40µm parameter set is ideal for parts needing great detail resolution and more dense structure. The 80 µm parameter set offers a build rate that is more than double that of the long established 40 µm parameter set.

With the 40/80 µm Skin parameter set, the total build time can be reduced with the same surface quality. The parameter sets are assigned to different sections in the same build job depending on the requirements.

Main characteristics:

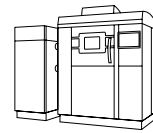
- Parameter set for fast and cost efficient production of 316L parts in small series or serial production
- With 80 µm parameter 100 % increase in productivity compared to the 40 µm FlexLine parameter set
- Faster production without compromising the part quality

System set-up	EOS M 290
EOS ParameterSet	316L 40µm+80µm Core M290/400W
EOSPAR name	316L_040_080_Core M291 1.X
Software requirements	EOSPRINT 2.7 or newer EOSYSTEM 2.11 or newer
Powder part no.	9011-0032
Recoater blade	EOS HSS blade
Nozzle	EOS grid nozzle
Inert gas	Argon
Sieve	63 µm

Additional information

Layer thickness	40 µm, 80 µm & 40/80 µm Skin
Volume rate*	3.7 mm ³ /s (40 µm), 8.4 mm ³ /s (80 µm), 3.7 - 8.4 (40/80 µm Skin)

* Volume rate depends on the part dimensions and skin thickness.



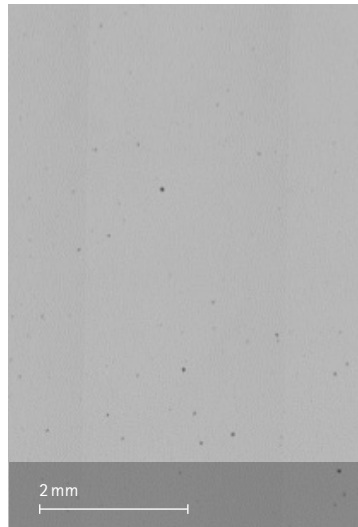
Chemical and Physical Properties of Parts

Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

Micrograph of polished surface (40 μm)



Micrograph of polished surface (80 μm)



Microstructure solution annealed Etched with etchant Kallings 2



Defects	Result
Average defect percentage	0.1 %* (40 μm), < 0.2 %* (80 μm)

* Defect% varies with platform position.

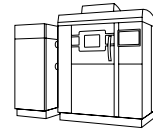
Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 $^{\circ}\text{C}$, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1150 $^{\circ}\text{C}$, hold time minimum 1.5 h when thoroughly heated, water quenching

Mechanical Properties as manufactured



Typical properties as manufactured ISO 6892-1

	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]
40 μm horizontal	500	600	35
40 μm vertical	450	550	50
80 μm horizontal	500	600	35
80 μm vertical	450	550	45

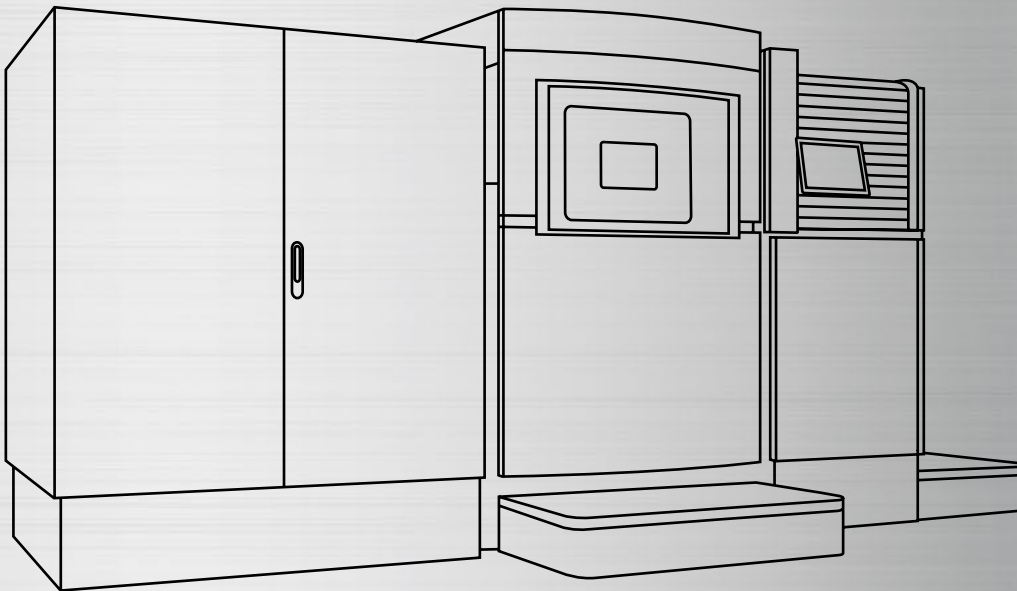
Additional Data

Surface Roughness

Surface roughness	9 - 15 Ra
Surface roughness shot-peened	<5 Ra

Coefficient of Thermal Expansion ASTM E228

Temperature	25-100 °C	25-200 °C	25-300 °C	25-400 °C
CTE	$15.72 \cdot 10^{-6}/\text{K}$	$16.75 \cdot 10^{-6}/\text{K}$	$17.27 \cdot 10^{-6}/\text{K}$	$17.70 \cdot 10^{-6}/\text{K}$



EOS StainlessSteel 316L for EOS M 400-4 | 40/80 μm

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

EOS StainlessSteel 316L for EOS M 400-4 | 40/80 µm Process Information

This process product is optimized for flexible and fast production of 316L parts with the EOS M 400-4 system. The parameter set has three different layer thickness options that can all be utilized within the same build: 40 µm, 80 µm and 40/80 µm Skin.

The 40 µm parameter set is ideal for parts needing great detail resolution and more dense structure. The 80 µm parameter set offers a build rate that is more than double that of the long established 40µm parameter set.

With the 40/80 µm Skin parameter set, the total build time can be reduced with the same surface quality. The parameter sets are assigned to different sections in the same build job depending on the requirements.

Main Characteristics:

- Parameter set for fast and cost efficient production of 316L parts in small series or serial production
- With 80 µm parameter 100 % increase in productivity compared to the 40 µm FlexLine parameter set
- Faster production without compromising the part quality

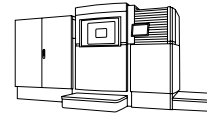
System set-up	EOS M 400-4
EOS ParameterSet	316L 40µm+80µm Core M400-4
EOSPAR name	316L_040_080_Core M404 1.X
Software requirements	EOSPRINT 2.7 or newer EOSYSTEM 2.11 or newer
Powder part no.	9011-0032
Recoater blade	EOS HSS blade
Inert gas	Argon
Sieve	63 µm

Additional information

Layer thickness	40 µm, 80 µm & 40/80 µm Skin
Volume rate*	14.8 mm ³ /s (40µm), 33.6 mm ³ /s (80µm) and 14.8 – 33.6 mm ³ /s (40/80 µm Skin)

* Volume rate depends on the part dimensions and skin thickness.

Chemical and Physical Properties of Parts

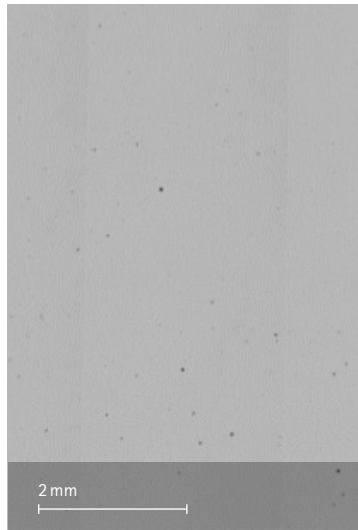


Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

Micrograph of polished surface (40 μm)



Micrograph of polished surface (80 μm)



Microstructure solution annealed Etched with etchant Kallings 2



Defects	Result
Average defect percentage	0.1 %* (40 μm), < 0.2 %* (80 μm)

* Defect% varies with platform position.

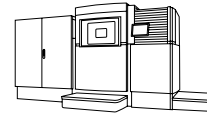
Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 $^{\circ}\text{C}$, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1150 $^{\circ}\text{C}$, hold time minimum 1.5 h when thoroughly heated, water quenching

Mechanical Properties as manufactured



Typical properties as manufactured ISO 6892-1

	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]
40 μm horizontal	500	600	35
40 μm vertical	450	550	50
80 μm horizontal	500	600	35
80 μm vertical	450	550	45

Additional Data

Surface Roughness

Surface roughness	9 - 15 Ra
Surface roughness shot-peened	<5 Ra

Coefficient of Thermal Expansion ASTM E228

Temperature	25-100 °C	25-200 °C	25-300 °C	25-400 °C
CTE	$15.72 \cdot 10^{-6}/\text{K}$	$16.75 \cdot 10^{-6}/\text{K}$	$17.27 \cdot 10^{-6}/\text{K}$	$17.70 \cdot 10^{-6}/\text{K}$

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Status 09/2020

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Cover: This image shows a possible application.

The quoted values refer to the use of this material with above specified type of EOS DMLS system, EOSYSTEM and EOSPRINT software version, parameter set and operation in compliance with parameter sheet and operating instructions. Part properties are measured with specified measurement methods using defined test geometries and procedures. Further details of the test procedures used by EOS are available on request. Any deviation from these standard settings may affect the measured properties. The data correspond to EOS knowledge and experience at the time of publication and they are subject to change without notice as part of EOS' continuous development and improvement processes. EOS does not warrant any properties or fitness for a specific purpose, unless explicitly agreed upon. This also applies regarding any rights of protection as well as laws and regulations.

