Material data sheet

EOS MaragingSteel MS1

EOS MaragingSteel MS1 is a steel powder which has been optimized especially for processing on EOSINT M systems.

This document provides information and data for parts built using EOS MaragingSteel MS1 powder (EOS art.-no. 9011-0016) on the following system specifications:

- EOSINT M 280 400W
  with PSW 3.6 and EOS Original Parameter Set MS1_Performance 1.0 or MS1_Speed 1.0
- EOS M290 400W
  with EOSPRINT 1.0 and Parameter Set MS1_Performance 1.0 or MS1_Speed 1.0

Description

Parts built in EOS MaragingSteel MS1 have a chemical composition corresponding to US classification 18% Ni Maraging 300, European 1.2709 and German X3NiCoMoTi 18-9-5. This kind of steel is characterized by having very good mechanical properties, and being easily heat-treatable using a simple thermal age-hardening process to obtain excellent hardness and strength.

Parts built from EOS MaragingSteel MS1 are easily machinable after the building process and can be easily post-hardened to more then 50 HRC by age-hardening at 490 °C (914 °F) for 6 hours. In both as-built and age-hardened states the parts can be machined, spark-eroded, welded, micro shot-peened, polished and coated if required. Due to the layerwise building method, the parts have a certain anisotropy, which can be reduced or removed by appropriate heat treatment - see Technical Data for examples.

EOS GmbH - Electro Optical Systems

Robert-Stirling-Ring 1
D-82152 Krailling / München

Telephone: +49 (0)89 / 893 36-0
Telefax: +49 (0)89 / 893 36-285
Internet: www.eos.info

Material data sheet

Technical data

General process data

Typical achievable part accuracy [1], [8]	
- small parts (< 80 x 80 mm)	approx. ± 20 µm approx. ± 0.8 x 10^{-3} inch
- large parts	approx. ± 50 µm approx. ± 0.002 inch
Age hardening shrinkage [2], [8]	approx. 0.08 %
Min. wall thickness [3], [8]	approx. 0.3 - 0.4 mm approx. 0.012 - 0.016 inch
Surface roughness (approx.) [4]	
- as manufactured	
MS1 Performance (40 µm)	R_a 5 µm; Rz 28 µm R_a 0.19 x 10^{-3} inch, R_z 1.10 x 10^{-3} inch
MS1 Speed (50 µm)	R_a 9 µm; Rz 50 µm R_a 0.47 x 10^{-3} inch, R_z 2.36 x 10^{-3} inch
- after shot-peening	R_a 4 - 6.5 µm; R_z 20 - 50 µm R_a 0.16 – 0.26 x 10^{-3} inch R_z 0.78 – 1.97 x 10^{-3} inch
- after polishing	R_z up to < 0.5 µm R_z up to < 0.02 x 10^{-3} inch (can be very finely polished)
Volume rate [5]	
- Parameter set MS1_Performance (40 µm)	4.2 mm³/s (15.1 cm³/h) 0.92 in³/h
- Parameter set MS1_Speed 1.0 (50 µm)	5.5 mm³/s (19.8 cm³/h) 1.21 in³/h

[1] Based on users' experience of dimensional accuracy for typical geometries, as built. Part accuracy is subject to appropriate data preparation and post-processing, in accordance with EOS training.

[2] Ageing temperature 490 °C (914 °F), 6 hours, air cooling

[3] Mechanical stability is dependent on geometry (wall height etc.) and application

[4] Due to the layerwise building, the surface structure depends strongly on the orientation of the surface, for example sloping and curved surfaces exhibit a stair-step effect. The values also depend on the measurement method used. The values quoted here given an indication of what can be expected for horizontal (up-facing) or vertical surfaces.

[5] Volume rate is a measure of build speed during laser exposure of hatched areas. The total build speed depends on the average volume rate, the recoating time (related to the number of layers) and other geometry- and machine setting-related factors.

Physical and chemical properties of parts

Material composition	Fe (balance) Ni (17 - 19 wt-%) Co (8.5 - 9.5 wt-%) Mo (4.5 - 5.2 wt-%) Ti (0.6 - 0.8 wt-%) Al (0.05 - 0.15 wt-%) Cr, Cu (each ≤ 0.5 wt-%) C (≤ 0.03 wt-%) Mn, Si (each ≤ 0.1 wt-%) P, S (each ≤ 0.01 wt-%)
Relative density	approx. 100 %
Density	8.0 - 8.1 g/cm^3 0.289 - 0.293 lb/in^3

Robert-Stirling-Ring 1
D-82152 Krailling / München

Material data sheet

Mechanical properties of parts at 20 °C (68°F) [8]

	As built
Tensile strength [6]	
- in horizontal direction (XY)	typ. 1200 ± 100 MPa typ. 160 ± 15 ksi
- in vertical direction (Z)	typ. 1100± 150 MPa typ. 160 ± 22 ksi
Yield strength (Rp 0.2 %) [6]	
- in horizontal direction (XY)	typ. 1100 ± 100 MPa typ. 1xx ± 22 ksi
- in vertical direction (Z)	typ. 930 ± 150 MPa typ. 145 ± 22 ksi
Elongation at break [6]	
- in horizontal direction (XY)	typ. (12 ± 4) %
- in vertical direction (Z)	x
Modulus of elasticity [6]	
- in horizontal direction (XY)	typ. 150 ± 25 GPa typ. 22 ± 4 Msi
- in vertical direction (Z)	typ. 140 ± 25 GPa typ. 20 ± 4 Msi
Hardness [7]	typ. 33 - 37 HRC

[6] Tensile testing according to ISO 6892-1:2009 (B) Annex D, proportional test pieces, diameter of the neck area 5mm (0.2 inch), original gauge length 25mm (1 inch).

[7] Rockwell C (HRC) hardness measurement according to EN ISO 6508-1 on polished surface. Note that measured hardness can vary significantly depending on how the specimen has been prepared.

[8] Hint: these properties were determined on an EOSINT M 280-400W. Test parts from machine type EOS M 290-400W correspond with these data.

EOS GmbH - Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München

Thermal properties of parts

	As built	After age hardening [2]
Thermal conductivity	typ. 15 ± 0.8 W/m°C typ. 104 ± 6 Btu in/(h ft^2 °F)	typ. 20 ± 1 W/m°C typ. 139 ± 7 Btu in/(h ft^2 °F)
Specific heat capacity	typ. 450 ± 20 J/kg°C typ. 0.108 ± 0.005 Btu/(lb °F)	typ. 450 ± 20 J/kg°C typ. 0.108 ± 0.005 Btu/(lb °F)
Maximum operating temperature		approx. 400 °C approx. 750 °F

Abbreviations

typ.	typical
min.	minimum
approx.	approximately
wt	weight

Notes

The data are valid for the combinations of powder material, machine and parameter sets referred to on page 1, when used in accordance with the relevant Operating Instructions (including Installation Requirements and Maintenance) and Parameter Sheet. Part properties are measured using defined test procedures. Further details of the test procedures used by EOS are available on request. Unless otherwise specified, the data refer to the default job MS1_040_default.job or the equivalent parameter set MS1_Performance 2.0. The corresponding data for the default job MS1_020_default.job or the equivalent parameter set MS1_Surface 1.0 are approximately the same except where otherwise specified.

The data correspond to our knowledge and experience at the time of publication. They do not on their own provide a sufficient basis for designing parts. Neither do they provide any agreement or guarantee about the specific properties of a part or the suitability of a part for a specific application. The producer or the purchaser of a part is responsible for checking the properties and the suitability of a part for a particular application. This also applies regarding any rights of protection as well as laws and regulations. The data are subject to change without notice as part of EOS' continuous development and improvement processes.

EOS GmbH - Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München

Material data sheet

EOS MaragingSteel MS1

EOS MaragingSteel MS1 is a tool steel powder intended for processing on EOS DMLS™ systems.

This document provides information and data for parts built using EOS MaragingSteel MS1 powder (EOS art.-no. 9011-0016) on the following system specifications:

- EOS DMLS™ EOS M290 system
  - Ceramic blade (2200-3013)
  - Grid nozzle (2200-5501)
  - Nitrogen atmosphere
  - IPCM extra sieving module with 63 µm mesh recommended
- EOSYSTEM:
  - EOSPRINT v 1.5 (Build9) or higher
  - HCS v 2.5.22 or higher
- EOS Parameter set: MS1_040_FlexM290_200

Description

Parts built in EOS MaragingSteel MS1 have a chemical composition following US classification 18% Ni Maraging 300, European 1.2709 and German X3NiCoMoTi 18-9-5. This kind of steel is characterized by having very good mechanical properties, and being easily heat-treatable using a simple thermal age-hardening process to obtain excellent hardness and strength.

Parts built from EOS MaragingSteel MS1 are easily machinable after the building process and can be easily post-hardened to more than 50 HRC by age-hardening at 490 °C (914 °F) for 6 hours. In both as-built and age-hardened states the parts can be machined, spark-eroded, welded, micro shot-peened, polished and coated if required. Due to the layerwise building method, the parts have a certain anisotropy, which can be reduced or removed by appropriate heat treatment – e.g. solution treatment at 940 °C (1724 °F) for 2 hours - see Technical Data for examples.

Electro Optical Systems Finland Oy
Lemminkäisenkatu 36
FIN-20520 Turku
Telephone: +358 23358119

EOS GmbH - Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München
Telephone: +49 (0)89 / 893 36-0
Telefax: +49 (0)89 / 893 36-285
Internet: www.eos.info

Technical Data

Powder properties

The chemical composition of the powder (wt-%):

Material composition

Element	Min	Max
Fe	Balance	
Ni	17.00	19.00
Co	8.50	9.50
Mo	4.50	5.20
Ti	0.60	0.80
Al	0.05	0.15
Cr	-	0.50
Cu	-	0.50
C		0.03
Mn		0.10
Si		0.10
P		0.01
S		0.01

Max. particle size

> 63µm [1]	max 0.5 wt.-%

[1] Sieve analysis according to ASTM B214.

Electro Optical Systems Finland Oy
Lemminkäisenkatu 36
FIN-20520 Turku
Telephone: +358 23358119

EOS GmbH – Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München
Telephone: +49 (0)89 / 893 36-0
Telefax: +49 (0)89 / 893 36-285
Internet: www.eos.info

General process data

Layer thickness	40 µm
Volume rate [2]	4.2mm³/s (15.2cm³/h)

[2] The volume rate is a measure of build speed during laser exposure of the skin area. The total build speed depends on this volume rate and many other factors such as exposure parameters of contours, supports, up and downskin, recoating time, Home-In or LPM settings.

Physical and chemical properties of parts

Part density [3]	8.0-8.1 g/cm³
Part accuracy [4]	
Small parts	Approx. ± 50 µm
Large parts	Approx ± 0.1 %
Min. wall thickness [5]	Approx. 0.3 - 0.4 mm
Surface roughness after shot peening [6]	
	Ra 4-6.5 µm; Rz 20-50 µm

[3] Weighing in air and water according to ISO 3369.

[4] Based on users' experience of dimensional accuracy for typical geometries, e.g. ± 50 µm when parameters can be optimized for a certain class of parts or ± 0.1% when building a new kind of geometry for the first time or building larger parts. Part accuracy is subject to appropriate data preparation and postprocessing.

[5] Mechanical stability is dependent on geometry (wall height etc.) and application.

[6] Measurement according to ISO 4287. Due to the layerwise building the roughness strongly depends on the orientation of the surface, for example sloping and curved surfaces exhibit a stair-step effect.

Hardness in heat treated status [7]

Hardness Rockwell C [8]	50-57 HRC

[7] Heat treatment procedure: solution treatment at 940 °C (1724 °F) for 2 hours, air cooling + ageing at 490 °C for 6 hours, air cooling.

[8] Rockwell C (HRC) hardness measurement according to EN ISO 6508-1 on polished surface.

Electro Optical Systems Finland Oy
Lemminkäisenkatu 36
FIN-20520 Turku
Telephone: +358 23358119

EOS GmbH – Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München
Telephone: +49 (0)89 / 893 36-0
Telefax: +49 (0)89 / 893 36-285
Internet: www.eos.info

Tensile properties at room temperature [9, 10, 11]

	Heat treated [7]	
	Horizontal	**Vertical**
Ultimate tensile strength, Rm	2080 MPa	2080 MPa
Yield strength, Rp0.2	2010 MPa	2000 MPa
Elongation at break, A	4 %	4 %

[9] Tensile testing according to. ISO 6892-1 B10, proportional test pieces, diameter of the neck area 5 mm (0.2 inch) , original gauge length 25 mm (1 inch). Results are derived from the validation data made with EOS M290 system and two powder LOTs.

[10] Solution and ageing treatments are needed in order to achieve corresponding mechanical properties. The numbers are average values determined from samples with horizontal and vertical orientation respectively.

[11] Mechanical properties depend on the thermal load of particular job layout as well as the positioning on the platform.

Electro Optical Systems Finland Oy
Lemminkäisenkatu 36
FIN-20520 Turku
Telephone: +358 23358119

EOS GmbH – Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München
Telephone: +49 (0)89 / 893 36-0
Telefax: +49 (0)89 / 893 36-285
Internet: www.eos.info

Abbreviations

Min.	Minimum
Max.	Maximum
Approx.	Approximately
Wt.	Weight

The quoted values refer to the use of this material with above specified type of EOS DMLS system, EOSYSTEM 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.

Electro Optical Systems Finland Oy
Lemminkäisenkatu 36
FIN-20520 Turku
Telephone: +358 23358119

EOS GmbH - Electro Optical Systems
Robert-Stirling-Ring 1
D-82152 Krailling / München
Telephone: +49 (0)89 / 893 36-0
Telefax: +49 (0)89 / 893 36-285
Internet: www.eos.info