# EOS CobaltChrome MP1

EOS CobaltChrome MP1 is a cobalt-chrome-molybdenum-based superalloy powder which has been optimized especially for processing on EOSINT M systems.

This document provides information and data for parts built using EOS CobaltChrome MP1 powder (EOS art.-no. 9011-0012) on the following system specifications:

- EOSINT M 270 Installation Mode *Standard* with PSW 3.3 or 3.4 and default job CC20_MP1_020_default.job or CC20_MP1_040_default.job
- EOSINT M 270 Dual-Mode with PSW 3.5 and EOS Original Parameter Set MP1_Surface 1.0 or MP1_Performance 1.0
- EOSINT M 280 with PSW 3.5 and EOS Original Parameter Set MP1_Surface 1.0, MP1_Performance 1.0 or MP1_Speed 1.0

## Description

Parts built from EOS CobaltChrome MP1 conform to the chemical composition UNS R31538 of high carbon CoCrMo alloy. They are nickel-free (< 0.1 % nickel content) and are characterized by a fine, uniform crystal grain structure. As built EOS CobaltChrome MP1 meets the chemical and mechanical specifications of ISO 5832-4 and ASTM F75 for cast CoCrMo implant alloys, as well as the specifications of ISO 5832-12 and ASTM F1537 for wrought CoCrMo implants alloys except remaining elongation. The remaining elongation can be increased to fulfil even these standards by high temperature stress relieving or hot isostatic pressing (HIP).

Parts made from EOS CobaltChrome MP1 can be machined, spark-eroded, welded, micro shotpeened, polished and coated if required. They are suitable for biomedical applications (note: subject to fulfilment of statutory validation requirements where appropriate), and for parts requiring high mechanical properties in elevated temperatures (500 - 1000 °C) and with good corrosion resistance. 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.

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## Technical data

### General process data

| | |
|---|---|
| Typical achievable part accuracy [1] | |
| - small parts approx. ⌀ 20 – 50 µm | approx. ⌀ 0.8 – 2 x $10^{-3}$ inch |
| - large parts | approx. ⌀ 50 – 200 µm<br>approx. ⌀ 2 – 8 x $10^{-3}$ inch |
| Min. wall thickness [2] | approx. 0.3 mm<br>approx. 0.012 inch |
| Surface roughness [3] | |
| - as built | |
| MP1 Surface (20 µm) | $R_a$ 4 -10 µm; $R_z$ 20 – 40 µm<br>$R_a$ 0.16 – 0.39 x $10^{-3}$ inch,<br>$R_z$ 0.79 – 1.57 x $10^{-3}$ inch |
| MP1 Performance (40 µm) | $R_a$ 7 - 10 µm; $R_z$ 35 – 50 µm<br>$R_a$ 0.28 - 0.39 x $10^{-3}$ inch,<br>$R_z$ 1.37 – 1.96 x $10^{-3}$ inch |
| MP1 Speed (50 µm) | $R_a$ 8 - 12 µm; $R_z$ 38 - 50 µm<br>$R_a$ 0.31 – 0.47 x $10^{-3}$ inch,<br>$R_z$ 1.49 – 1.96 x $10^{-3}$ inch |
| - after polishing $R_z$ up to < 1µm | $R_z$ up to < 0.04 x $10^{-3}$ inch |
| Volume rate [4] | |
| - Parameter set MP1_Surface 1.0 / default job (40 µm layer thickness) | 1.6 mm³/s (5.1 cm³/h) 0.35 in³/h CC20_MP1_020_default.job (20 µm layer thickness) |
| - Parameter set MP1_Performance 1.0 / default job (40 µm layer thickness) | 3.2 mm³/s (11.5 cm³/h) 0.70 in³/h CC20_MP1_040_default.job |
| - Parameter set MP1_Performance 1.0 for M 280 / 400 W (40 µm layer thickness) | 4.2 mm³/s (15.1 cm³/h)<br>0.92 in³/h |


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| | |
|---|---|
| - Parameter set MP1_Speed 1.0 / for M 280 / 400 W (50 µm layer thickness) | 5.5 mm³/s (19.8 cm³/h) 1.21 in³/h |

[1] Based on users' experience of dimensional accuracy for typical geometries, e.g. □ 20 µm ( 0.8 x 10 $^{-3}$ inch) when parameters can be optimized for a certain class of parts or □ 50 µm (2 x 10 $^{-3}$ inch) when building a new kind of geometry for the first time. For larger parts the accuracy can be improved by post-process stressrelieving at 1150 °C (2100 °F) for 6 hours. Part accuracy is subject to appropriate data preparation and postprocessing, in accordance with EOS training.

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

[3] 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.

[4] Volume rate is a measure of build speed during laser exposure. The total build speed depends on the average volume rate, the recoating time (related to number of layers) and other factors such as DMLS-Start settings.

## Physical and chemical properties of parts

| | |
|---|---|
| Material composition | Co (60 - 65 wt-%)<br>Cr (26 - 30 wt-%)<br>Mo (5 - 7 wt-% )<br>Si (□ 1.0 wt-%)<br>Mn (□ 1.0 wt-%)<br>Fe (□ 0.75 wt-%)<br>C (□ 0.16 wt-%)<br>Ni (□ 0.10 wt-%) |
| Relative density | approx. 100 % |
| Density | approx. 8.3 g/cm³<br>approx. 0.30 lb/in³ |

## Mechanical properties of parts at 20 °C (68 °F)

| | As built | Stress relieved [5] |
|---|---|---|
| Tensile strength [6] | | |
| - in horizontal direction (XY) | 1350 ± 100 MPa 196 ± 15 ksi | 1100 ± 100 MPa 160 ± 15 ksi |


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| | | |
|---|---|---|
| - in vertical direction (Z) | 1200 ± 150 MPa 174 ± 22 ksi | 1100 ± 100 MPa 160 ± 15 ksi |
| Yield strength (Rp 0.2 %) [6] | | |
| - in horizontal direction (XY) | 1060 ± 100 MPa 154 ± 15 ksi | 600 ± 50 MPa 87 ± 7 ksi |
| - in vertical direction (Z) | 800 ± 100 MPa 116 ± 15 ksi | 600 ± 50 MPa 87 ± 7 ksi |
| Elongation at break [6] | | |
| - in horizontal direction (XY) | (11 ± 3 ) % | min. 20 % |
| - in vertical direction (Z) | (24 ± 4 ) % | min. 20 % |
| Modulus of elasticity [6] | | |
| - in horizontal direction (XY) | 200 ± 20 GPa 29 ± 3 Msi | 200 ± 20 GPa 29 ± 3 Msi |
| - in vertical direction (Z) | 190 ± 20 GPa 28 ± 3 Msi | 200 ± 20 GPa 29 ± 3 Msi |
| Fatigue life [7] | | |
| - max. stress to reach 10 million cycles | approx. 560 MPa, 81 ksi | |
| - max. stress to reach 1 million cycles | approx. 660 MPa, 96 ksi | |
| Hardness [8] | approx. 35 - 45 HRC | |

[5] High temperature stress relieved, 6 hours at 1150 °C (2100 °F) under inert argon atmosphere

[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] Testing according to ASTM E466:1996, using vertical samples, as built, under 250 MPa (36.3 ksi) stress amplitude and 44 Hz testing frequency

[8] 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.

## Thermal properties of parts

| | |
|---|---|
| | As built |


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| | | |
|---|---|---|
| Coefficient of thermal expansion<br>- over 20 - 500 °C (68 - 932 °F) | | typ. 13.6 x $10^{-6}$ m/m °C<br>typ. 7.6 x $10^{-6}$ in/in °F |
| - over 500 – 1000 °C (932-1832 °F) | typ. 15.1 x $10^{-6}$ m/m °C | typ. 8.4 x $10^{-6}$ in/in °F |
| Thermal conductivity<br>- at 20 °C (68 °F) | | typ. 13 W/m °C typ. 90 Btu in/(h ft² °F) |
| - at 300 °C (572 °F) | | typ. 18 W/m °C<br>typ. 125 Btu in/(h ft² °F) |
| - at 500 °C (932 °F) | typ. 22 W/m °C typ. 153 Btu in/(h ft² °F) | |
| - at 1000 °C (1832 °F) | | typ. 33 W/m °C<br>typ. 229 Btu in/(h ft² °F) |
| Maximum operating temperature | | approx. 1150 °C<br>approx. 2100 °F |
| Melting range | | 1350 - 1430 °C 2460 - 2600 °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 parameter set MP1_Surface 1.0 or the equivalent default job CC20_MP1_020_default.job. The corresponding

data for the parameter set MP1_Performance 1.0 or the equivalent default job CC20_MP1_040_default.job 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.

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