Material data sheet

# EOS NickelAlloy HX

EOS NickelAlloy HX is a heat and corrosion resistant metal alloy powder intended for processing on EOS M 290 systems.

This document provides information and data for parts built using EOS NickelAlloy HX powder (EOS art.-no. 9011-0023) on the following system specifications:

- EOS M 290 400W with EOSPRINT 1.x and EOS Parameter set HX_Performance 2.0

## Description, application

EOS NickelAlloy HX raw material is a nickel-chromium-iron-molybdenum alloy in fine powder form. Its composition corresponds to UNS N06002. While the wrought and cast versions of the alloy generally are solution annealed, the laser melted material manufactured of this powder has a high strength and good elongation already in the as-built condition. Solution annealing of the laser sintered material will homogenize the microstructure, relax internal stresses and increase the elongation, while slightly decreasing the strength.

This type of alloy is characterized by having high strength and oxidation resistance also at elevated temperatures, and is often used up to 1200°C. Therefore its applications can be found in aerospace technology, gas turbine parts, etc.

Standard laser processing parameters results in full melting of the entire geometry, typically with 40 µm layer thickness. Parts built from EOS NickelAlloy HX can be heat treated and material properties can be varied within specified range. In both as-built and solution heat treated states the parts can be machined, spark-eroded, welded, micro shot-peened, polished, and coated if required. Unexposed powder can be reused.

**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

### General process data

| | EOS NickelAlloy HX |
|---|---|
| Typical achievable part accuracy [1] | |
| - small parts | approx. ±50-80 µm<br>(± 0.0020 – 0.0031 inch) |
| - large parts | approx. ± 0.2 % |
| Min. wall thickness [2] | typ. 0.4 - 0.5 mm<br>(0.016 – 0.020 inch) |
| Layer thickness | 40 µm |
| Surface roughness [3] | |
| - after shot-peening (horizontal / vertical) | $R_a$ 3 – 6.5 µm, $R_z$ 10 - 30 µm<br>$R_a$ 0.12 – 0.25 x $10^{-3}$ inch,<br>$R_z$ 0.39 – 1.18 x $10^{-3}$ inch |
| - after polishing | $R_z$ up to < 0.5 µm<br>$R_z$ up to < 0.02 x $10^{-3}$ inch<br>(can be very finely polished) |
| Volume rate [4] | 4.2 mm³/s (15.2 cm³/h)<br>0.93 in³/h |

[1] 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 ± 80 µm when building a new kind of geometry for the first time. Part accuracy is subject to appropriate data preparation and postprocessing.

[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 the number of layers) and other factors such as DMLS-Start settings.


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

## Physical and chemical properties of parts

| | EOS NickelAlloy HX | | |
|---|---|---|---|
| Material composition | Element | Min | Max |
| | Ni | balance | |
| | Cr | 20.5 | 23.0 |
| | Fe | 17.0 | 20.0 |
| | Mo | 8.0 | 10.0 |
| | W | 0.2 | 1.0 |
| | Co | 0.5 | 2.5 |
| | C | -- | 0.1 |
| | Si | -- | 1.0 |
| | Mn | -- | 1.0 |
| | S | -- | 0.03 |
| | P | -- | 0.04 |
| | B | -- | 0.01 |
| | Se | -- | 0.0050 |
| | Cu | -- | 0.5 |
| | Al | -- | 0.5 |
| | Ti | -- | 0.15 |
| Relative density with standard parameters | approx. 100 % | | |
| Density with standard parameters | min. 8.2 g/cm3<br>min. 0.296 lb/in³ | | |


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

## Mechanical properties of parts (at room temperature)

| | As built |
|---|---|
| Ultimate tensile strength [5] | |
| - in horizontal direction (XY) | typ. 820 ± 50 MPa |
| - in vertical direction (Z) | typ. 675 ±50 MPa |
| Yield strength, Rp0.2% [5] | |
| - in horizontal direction (XY) | typ. 630 ±50 MPa |
| - in vertical direction (Z) | typ. 545 ±50 MPa |
| Young's modulus [5] | |
| - in horizontal direction (XY) | typ. 195 ±20 GPa |
| - in vertical direction (Z) | typ. 175±20 GPa |
| Elongation at break [5] | |
| - in horizontal direction (XY) | typ. 27 ±8 % |
| - in vertical direction (Z) | typ. 39 ±8 % |

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

## Abbreviations

| | |
|---|---|
| typ. | typical |
| min. | minimum |
| approx. | approximately |
| wt | weight |


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

The quoted values refer to the use of these materials with EOS M 290 systems according to current specifications (including the latest released process software PSW and any hardware specified for the relevant material) and operating instructions. All values are approximate. Unless otherwise stated, the quoted mechanical and physical properties refer to standard building parameters and test samples built in vertical orientation. They depend on the building parameters and strategies used, which can be varied by the user according to the application.
The data are based on our latest knowledge and are subject to changes without notice. They are provided as an indication and not as a guarantee of suitability for any specific application.



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

# EOS NickelAlloy HX

EOS NickelAlloy HX is a nickel metal alloy powder intended for processing on EOS DMLS systems.
This document provides information and data for parts built using EOS NickelAlloy HX powder (EOS art.-no. 9011-0023) on the following specifications:

- EOS DMLS system M400-4
- EOSYSTEM: EOSPRINT v.1.5/HCS v.2.4.14
- EOS Parameter set HX FlexLine 40µm

## Description

EOS NickelAlloy HX is a nickel-chromium-iron-molybdenum alloy in fine powder form. Its composition corresponds to UNS N06002. While the wrought and cast versions of the alloy generally are solution annealed, the laser sintered version has a high strength and good elongation already in the as-built condition. Solution annealing of the laser sintered material will homogenize the microstructure, relax internal stresses and increase the elongation, while slightly decreasing the strength.

This type of alloy is characterized by having high strength and oxidation resistance also at elevated temperatures, and is often used up to 1200°C. Therefore its applications can be found in aerospace technology, gas turbine parts, etc.

Parts built from EOS NickelAlloy HX can be heat treated and material properties can be varied within specified range. In both as-built and solution heat treated states the parts can be machined, spark-eroded, welded, micro shot-peened, polished, and coated if required. Unexposed powder can be reused.

**Electro Optical Systems Finland Oy**
Lemminkäisenkatu 36
FIN-20520 Turku
Telephone: +358 20 765 9144
Telefax: +358 20 765 9141

**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 is reported in the table below.

| Material composition | Element | Min | Max |
|---|---|---|---|
| | Ni | | Balance |
| | Cr | 20.5 | 23.0 |
| | Fe | 17.0 | 20.0 |
| | Mo | 8.0 | 10.0 |
| | W | 0.2 | 1.0 |
| | Co | 0.5 | 2.5 |
| | C | - | 0.1 |
| | Si | - | 1.0 |
| | Mn | - | 1.0 |
| | S | - | 0.03 |
| | P | - | 0.04 |
| | B | - | 0.01 |
| | Se | - | 0.0050 |
| | Cu | - | 0.5 |
| | Al | - | 0.5 |
| | Ti | - | 0.15 |
| **Max. particle size** | | | |
| Particles > 63µm [1] | max. 0.5 wt.-% | | |

[1] Sieve analysis according to ASTM B214.



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## General process data

| | |
|---|---|
| Layer thickness | 40 µm |
| Volume rate [2] | 16.8 mm³/s (60.8 cm³/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] | min. 8.2 g/ cm³ |
| Surface roughness after shot peening [4] | $R_a$ 4-6.5 µm; $R_z$ 20-50 µm |

[3] Weighing in air and water according to ISO 3369.
[4] Measurement according to ISO 4287. The numbers were measured at the horizontal (up-facing) and all vertical surfaces of test cubes. 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.

## Tensile data at room temperature [5, 6]

| | As built | Heat treated [7] |
|---|---|---|
| Ultimate tensile strength, $R_m$ | 770 MPa | 710 MPa |
| Yield strength, $R_{p0.2}$ | 610 MPa | 345 MPa |
| Elongation at break, A | 31 % | 45 % |

[5] The numbers are average values and are determined from samples with horizontal and vertical orientation.
[6] 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).
[7] Heat treatment procedure: According to AMS2773 and AMS5390: Solution anneal at 1177°C for 1 hour, followed by rapid air cooling to below 60°C.

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## Abbreviations

| | |
|---|---|
| min. | minimum |
| max. | maximum |
| wt. | weight |

## Legal notes

The quoted values refer to the use of this material with above specified EOS DMLS system, EOSYSTEM software version, parameter set and operation in compliance with parameter sheet and operating instructions. All measured values are average numbers. Part properties are measured with specified measurement methods using defined test geometries and procedures and. 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.



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