Material data sheet

DirectMetal and DirectSteel materials for EOSINT M 250 Xtended

A number of different materials are available for use with EOSINT M 250 Xtended systems, offering a broad range of e-Manufacturing applications. All of the materials were developed and optimised especially for Direct Metal Laser-Sintering (DMLS) on EOSINT M systems and are suitable for manufacturing moulds and tool inserts using the DirectTool process as well as functional prototypes using the DirectPart process.

This document provides brief descriptions of the most commonly used materials and their principle applications, and a table of technical data. For the machine requirements of the various materials please see the information quotes. Coarser versions of some materials are also available, details can be provided on request. Please note that additional materials are available for Direct Metal Laser-Sintering on EOSINT M 270 systems - please refer to the relevant material data sheets for details.

Laser-sintered parts made from these materials can be welded, machined, micro shot-peened, polished and coated if required. Unexposed powder can be reused without restriction or refreshing.

Description, application

DirectMetal 20

DirectMetal 20 is a very fine-grained bronze-based, multi-component metal powder. The resulting parts offer good mechanical properties combined with excellent detail resolution and surface quality. The surfaces can be easily post-processed by shot-peening and can be polished with very little effort. The specially developed powder mixture contains different components which expand during the laser-sintering process, partially compensating for the natural solidification shrinkage and thereby enabling a very high part accuracy to be achieved.

This material is ideal for most prototype injection moulding tooling applications (DirectTool) and for many functional metal prototype applications (DirectPart). It offers the highest building speed so is particularly suitable for larger tools and parts. It also offers a broad window of usable process parameters, e.g. a wide range of achievable mechanical properties and build speeds. Standard parameters use 20 µm layer thickness for the skin and 60 µm layers for the core, but for faster building the entire part can be built using 40 µm layers for the skin and 80 µm layers or the core, or even 60 µm layer thickness for skin and core.

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

Using standard skin parameters the mechanical properties are fairly uniform in all directions, which is especially beneficial for many DirectPart applications. Areas built with core parameters have a porous structure, but the combination of skin and core produces in a strong total part. Parts built from DirectMetal 20 also have good corrosion resistance.

Typical applications:

- injection moulds and inserts for moulding up to tens or even hundreds of thousands of parts in standard thermoplastics using standard injection parameters
- direct manufacture of functional metal prototypes.

DirectSteel 20

DirectSteel 20 is a very fine-grained steel-based, multi-component metal powder. The resulting parts offer fine detail resolution and high accuracy with very good mechanical properties. They have a high density and strength, and can be post-processed by shot-peening, polishing etc. to achieve a high surface quality. The specially developed powder mixture contains different components which expand during the laser-sintering process, partially compensating for the natural solidification shrinkage and thereby enabling a very high part accuracy to be achieved.

This material is suitable for heavier duty applications such as injection moulding of larger quantities of parts or sheet metal stamping (DirectTool), as well as for functional metal prototypes (DirectPart). Standard parameters use 20 µm layer thickness for the outer skin and 60 µm layers for the core, but for faster building the entire part can be built using 40 µm layers for the skin and 80 µm layers for the core or even 60 µm layers for the skin and core. Using standard parameters the mechanical properties in the vertical (build) direction may be significantly lower than in the horizontal (layer) direction, which should be considered especially for DirectPart applications.

Typical applications:

- heavy duty injection moulds and inserts for moulding all standard thermoplastics using standard injection parameters, with achievable tool life of up to hundreds of thousands of parts
- direct manufacturing of functional metal prototypes.

DirectSteel **H**20

DirectSteel H20 is a very fine grained steel-based, multi-component metal powder which offers offers high strength, hardness, wear resistance and surface density. The resulting parts have properties similar to conventional tool steels and can be polished to an excellent, pore-free surface finish. This material is particularly suitable for DirectTool applications such as injection moulds for series production, pressure die-casting tooling and other applications where high strength and wear resistance and/or best possible surface quality are important. It is also suitable for heavy duty DirectPart applications. Standard parameters use 20 µm layer thickness for the outer skin and 60 µm layers for the core, but for faster building thicker layers can be used as for DirectSteel 20. To achieve the high density and hardness, the skin area is completely melted, which results in slower build speed than for DirectSteel 20. This should be considered especially for large tools and parts. Mechanical properties are generally higher in the building plane (XY) than perpendicular to the building plane (Z).

Typical applications:

- heavy duty injection moulds and inserts for moulding all standard thermoplastics using standard injection parameters, with achievable tool life of up to millions of parts
- die casting moulds for small series of up to several thousand parts in light alloys
- metal stamping and other heavy duty tooling applications
- direct manufacturing of heavily loaded functional metal prototypes.

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Material data sheet

Technical data

General process data

	DirectMetal 20	DirectSteel 20	DirectSteel **H**20
Minimum recommended layer thickness	20 µm 0.8 mil	20 µm 0.8 mil	20 µm 0.8 mil
Typical achievable part accuracy [1]	± 50 µm 2.0 mil	± 50 µm 2.0 mil	± 50 µm 2.0 mil
Accuracy specification for qualification [2]	± (0.07 % + 50 µm) ± (0.07 % + 2.0 mil)	± (0.07 % + 50 µm) ± (0.07 % + 2.0 mil)	± (0.07 % + 50 µm) ± (0.07 % + 2.0 mil)
Min. wall thickness [3]	0.6 mm 0.024 in	0.7 mm 0.028 in	0.7 mm 0.028 in
Volume rate [4]			
- standard core parameters	15 mm³/s 3.3 in³/h	7.5 mm³/s 1.6 in³/h	4 mm³/s 0.9 in³/h
- standard skin parameters	2 - 8 mm³/s 0.4 – 1.8 in³/h	1.5 – 2.5 mm³/s 0.3 – 0.5 in³/h	0.5 - 3 mm³/s 0.1 – 0.7 in³/h
- 40 µm layer core parameters	16 mm³/s 3.5 in³/h	8 mm³/s 1.8 in³/h	5 mm³/s 1.1 in³/h
- 40 µm layer skin parameters	4 – 10 mm³/s 0.9 – 2.2 in³/h	2 – 4 mm³/s 0.4 – 0.9 in³/h	1 - 3 mm³/s 0.2 – 0.7 in³/h
- 60 µm layer core parameters	18 mm³/s 4.0 in³/h	10 mm³/s 2.2 in³/h	-
- 60 µm layer skin parameters	6 - 12 mm³/s 1.3 – 2.6 in³/h	2.5 – 5 mm³/s 0.5 – 1.1 in³/h	-

[1] Based on users' experience of dimensional accuracy for typical geometries

[2] Valid for EOS standard qualification part and procedure

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

[4] Volume rate is a measure of build speed during laser exposure. DirectMetal and DirectSteel parts are typically build using Skin & Core strategy, in some cases using inner and outer skins. The average volume rate for a particular part is therefore geometry-dependent. 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.

Material data sheet

Physical and chemical properties of laser-sintered parts

	DirectMetal 20	DirectSteel 20	DirectSteel **H**20
Material composition after laser-sintering	bronze-based matrix containing Ni	steel-based matrix containing Ni	alloy steel containing Cr, Ni, Mo, Si, V, C
Density in skin areas	7.6 g/cm³ 0.27 lb/in³	7.6 g/cm³ 0.27 lb/in³	7.8 g/cm³ 0.28 lb/in³
Density in core areas	6.3 g/cm³ 0.23 lb/in³	6.3 g/cm³ 0.23 lb/in³	7.0 g/cm³ 0.25 lb/in³
Remaining porosity (min.)	8 %	2 %	< 0.5 %

Mechanical properties of laser-sintered parts

	DirectMetal 20	DirectSteel 20	DirectSteel **H**20
Tensile strength (MPIF 10) [5]			
- as laser-sintered (max.)	400 MPa 58 ksi	580 MPa 84 ksi	1100 MPa 159 ksi
- after heat treatment [6]			5 – 10 % higher
Yield strength [5]			
- as laser-sintered (max.)	200 MPa 29 ksi	400 MPa 58 ksi	800 MPa 116 ksi
- after heat treatment [6]			10 – 15 % higher
Transverse rupture strength (MPIF 41) [5]	700 MPa 101 ksi	1000 MPa 145 ksi	2000 MPa 290 ksi
Elongation at break (max.)	2.5 %	1.5 %	4.0 %
Young's modulus	80 GPa 11.6 msi	130 GPa 18.8 msi	180 GPa 26.1 msi

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

	DirectMetal 20	DirectSteel 20	DirectSteel **H**20
Hardness [7]			
- as laser-sintered	110 HB, 115 HV (≅ 65 HRB)	220 HB, 225 HV (≅ 94 HRB)	350 - 420 HV, 35 - 42 HRC
- after micro shot-peening			380 - 420 HV, 38 - 42 HRC
- after nitriding [8]		380 HB, 400 HV (≅ 112 HRB)	500 - 700 HV
- after hard coating [9]	> 2000 HV	> 2000 HV	> 2000 HV
Surface roughness			
- as laser-sintered	R_a 9, R_z 40 - 50 µm R_a 0.35, R_z 1.6 - 2.0 mil	R_a 10, R_z 50 µm R_a 0.39, R_z 2.0 mil	R_a 10, R_z 40 - 50 µm R_a 0.39, R_z 1.6 - 2.0 mil
- after shot-peening	R_a 3, R_z 15 µm R_a 0.12, R_z 0.6 mil	R_a 4, R_z 15 µm R_a 0.16, R_z 0.6 mil	R_a 5, R_z 25 µm R_a 0.2, R_z 1.0 mil
- after polishing	R_z up to < 1 µm, < 0.04 mil	R_z up to < 1 µm, < 0.04 mil	R_z up to < 1 µm, < 0.04 mil

[5] Mechanical properties including strength can vary according to orientation, depending on the material and parameters used. The quoted values are measured parallel to the building plane (X or Y direction), which typically gives the best properties.

[6] Heated to 900 – 1000 °C (1600 – 1800 °F) then quenched in water

[7] Brinell hardness measurement (HB) according to DIN EN ISO 6506-1, abbreviated to HBW 2,5 / 62,5. Vickers hardness measurement (HV) according to DIN EN ISO 6507-1. Rockwell B (HRB) and Rockwell C (HRC) hardness measurement according to DIN EN ISO 6508-1. Values in parentheses are converted in accordance with DIN 50150, which is applicable to cast steels and therefore only gives an indication for laser-sintered materials. Note that depending on the measurement method used, the measured hardness value can be dependent on the surface roughness and can be lower than the real hardness. To avoid inaccurate results, hardness should be measured on a polished surface.

[8] Results for DirectSteel 20 from short-term plasma nitriding, for DirectSteel H20 from Nitroc process (conventional nitriding)

[9] Surface hardness of TiN or CrN coating applied by PVD

Material data sheet

Thermal properties of laser sintered parts

	DirectMetal 20	DirectSteel 20	DirectSteel H20
Coefficient of thermal expansion	18 x 10^{-6} m/m°C 32 x 10^{-6} in/in°F	9 x 10^{-6} m/m°C 16 x 10^{-6} in/in°F	13-15 x 10^{-6} m/m°C [10] 23-27 x 10^{-6} in/in°F [10]
Thermal conductivity	30 W/mK [11] 208 Btu/(h .ft² °F/in)	13 W/mK 90 Btu/(h ft² °F/in)	15 – 18 W/mK [12] 104-125 Btu/(h ft² °F/in)
Maximum operating temperature	400 °C 750 °F	600 °C 1110 °F	800 °C 1470 °F

[10] Lowest value is for 100 - 250 °C (212 - 482 °F), highest value is for 400 - 550 °C (752 - 1022 °F)

[11] At 50 °C (122 °F)

[12] Lowest value is for 50 °C (122 °F), highest value is for 200 °C (392 °F)

The quoted values refer to the use of these materials with EOSINT M 250 Xtended 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, (outer) skin areas and test samples built in horizontal 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.
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