Technical description EOSINT M 280

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Date: February 2013

1 EOSINT M 280

The machine comprises a process chamber with recoating system, elevator system and platform heating module, an optics system with laser, a process gas management system, a process computer with process control software, and a set of standard accessories. The machine components are integrated into a robust machine frame comprising a stable frame construction. During building the process chamber is secured by a lock. The machine meets the requirements of laser safety class 1. When closed, the switching cabinet complies with IP 54; the machine is supplied with a CE marking.
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1.1 Basic data
- Dimensions (W x D x H) 2200 mm x 1070 mm x 2290 mm
- Weight Approx. 1250kg (without powder filling)
- Power connection (three-phase system) 400 V +6 %/-10 % at 50/60 Hz
- Mains fuse protection 3 x 32 A
- Maximum power consumption (incl. cooling system) 5.5 kW
- Compressed air supply 7,000 hPa, 20 m³/h
- Argon supply 4,000 hPa, 100 l/min
- Minimum argon purity: 99.998 % argon Argon 4.8

For detailed information including the required floor space, connections and environmental conditions (temperature and atmospheric humidity range etc.) please see the Installation Conditions.

1.2 Optics system
The optics system generates and positions the laser beam to melt together and solidify the material. The laser beam emitted by the laser is steered with the aid of a fibre optic, beam expander optics, a scanner mirror and a focussing lens. All optical surfaces have special coatings that ensure effective beam steering.

1.2.1 Laser
- Yb (Ytterbium) fibre laser
- Wavelength 1060 – 1100 nm
- Nominal power 200 W or 400 W (Optional)
1.2.2 Scanner

The scanner is a high speed rotating mirror deflection system comprising precision galvanometer scanners with temperature compensation, actively cooled deflection mirrors of maximum reflectivity, integrated servo electronics and interface electronics, digital data transmission from the control computer and a digital signal processor. It also incorporates an integrated home-in sensor, which detects and corrects any scanner drift at regular intervals. In this way high position stability of the laser beam is maintained, even under varying environmental conditions or in case of high thermal load due to long exposure times or large building jobs.

- Exposure area: 250 mm x 250 mm
- Exposure speed: Up to 7000 mm/s
- Repeatability, scanner position: < 11 µrad

1.2.3 Focussing lens

The focussing lens is a so-called F-Theta lens that focuses the laser beam on a flat plane. Below the F-Theta lens is a window that is kept free of dirt deposits by a lens-clearing nozzle. The laser beam focus is automatically switched between two pre-set sizes during exposure using the dual focus system: a fine focus is typically used for accurate exposure of contours and a broad focus for the fast exposure of larger areas. The sizes are manually pre-selected as a function of the material used.

- Diameter of the laser beam in the building area (variable): 100 – 500 µm
- Focal length of the F-Theta lens (flat plane optic): 410 mm

1.3 Recoating and elevator system

The recoating system produces the layers of powder that are then to be solidified. Its components are a recoating element, a recoater arm and a linear drive that moves the recoater arm in the horizontal direction. Various options are available for the recoating element. For titanium, aluminium and nickel alloy materials we recommend a high-speed steel (HSS) blade, for other materials a wear-resistant ceramic blade.

- Travel speed: 40 – 500 mm/s
The elevator system comprises the dispenser, building and collector systems. The building platform carrier is moved in the vertical direction by the building system. The part is built on the building platform, which is fastened to the building platform carrier.

The building platform carrier permits exact adjustment of the building platform via a three-point mount that can be adjusted using two adjusting motors. Together with a measuring device that can be mounted on the recoater arm, it is possible to quickly and easily align the platform at the start of each job. There are also reference bores integrated into the platform carrier for precise, reproducible positioning of the building platform, which also has corresponding reference bores and can be located using positioning pins.

The building system axis has two parallel guide rails with backlash-free recirculating ball guides that, along with a long service life, ensure the highest positioning accuracy in conjunction with the precision drive.

- Repeatability of the position \( \leq \pm 0.005 \text{ mm} \)
- Maximum building height/325 mm incl. building platform thickness

Note: See section 5 for building platform thicknesses

1.4 Process computer with process software

The process computer with the process software (PSW) controls the building process and the system's measuring and control components.

1.4.1 Process computer

- Industrial PC: Min. Pentium 4 with at least 2 GHz
- Processor Min. 1 GB
- Main memory > 10 GB
- Hard disk 15" flat screen, LCD colour
- Monitor 10/100 Mbit Ethernet
- Data interface Wipe-clean keyboard, mouse
- Other peripherals Microsoft Windows XP
- Operating system
1.4.2 Process software PSW

By using the process software, the building process (job) is prepared, logged and archived. Using this software it is also possible to display data directly on the machine in a graphical layer format. It contains many functions that allow the operator to obtain optimal results from the building process. Further details are available on request.

- Operating system: Microsoft Windows XP
- Data input format: SLI (as per EOS specifications)

1.5 Platform heating module

The platform heating module reduces temperature gradients between the building platform and the part to reduce internal stresses and ensure good bonding of the first layers to the building platform. During interruptions to the building process, the platform heating module also helps to keep the temperature of the part constant and in this way ensures maximum process reliability.

- Operating temperature: Approx. 40 to 100 °C

1.6 Laser cooling system

The laser in the EOSINT M 280 requires cooling. A water-air Cooling system is included as a standard.

- Cooling capacity: 1.4 kW

1.7 Standard accessories

A set of standard equipment for cleaning, as well as tools for job starts and removal of parts is included.
2 Part Property Management (PPM) module

2.1 PPM parameter sets

The so-called Part Property Profiles (PPPs) allow standardisation of the properties of laser sintered parts.

The characteristics of the individual PPPs are derived from typical requirement profiles. In the manufacturing world, each part has different specific quality-related requirements in relation to surface finish quality, accuracy and resolution of detail to meet. As a rule, apart from quality objectives it is also necessary to meet cost objectives. The PPPs, to which parameter sets correspond, therefore address different requirement profiles. In one case the emphasis is on costs, in another case optimal quality characteristics or also carefully balanced compromises.

2.2 Original EOS parameter sets

The following OEPs are available for the EOSINT M materials for the 200 W option:

<table>
<thead>
<tr>
<th>Original EOS parameter sets (200 W)</th>
<th>Layer thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS1_Surface 1.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>MS1_Performance 2.0</td>
<td>40 µm</td>
</tr>
<tr>
<td>GP1_Surface 1.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>PH1_Surface 2.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>MP1_Surface 1.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>MP1_Performance 1.0</td>
<td>40 µm</td>
</tr>
<tr>
<td>Ti64_Performance 2.0</td>
<td>30 µm</td>
</tr>
<tr>
<td>IN718_Surface 1.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>IN625_Surface 1.0</td>
<td>20 µm</td>
</tr>
</tbody>
</table>
2.2.1 “Surface”

Parts with fine, detailed structures and the highest requirements on surface quality are the application for the “Surface” parameter set. This parameter set uses a layer resolution of 20 µm.

2.2.2 “Performance”

“Performance” is the parameter set of high productivity due to the use of thicker layers for building. Mechanical properties and density are identical to the “Surface” parameter set (20µm layers). Compared to the “Surface” parameter set the manufacturing costs are typically reduced by 40 – 50 %.

Note: All these parameter sets produce fully consolidated parts with comparable mechanical properties; please see material data sheets for further details.

2.3 Parameter sets: Usage of 400 W lasers

For the EOSINT M 280 machine the PPP parameter sets called “Speed” and “TopSpeed” have been added.

The following parameter sets are available for the 400 W option:

<table>
<thead>
<tr>
<th>EOS parameter sets (400 W)</th>
<th>Layer thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS1_Performance 1.0</td>
<td>40 µm</td>
</tr>
<tr>
<td>MS1_Speed 1.0</td>
<td>50 µm</td>
</tr>
<tr>
<td>MP1_Performance 1.0</td>
<td>40 µm</td>
</tr>
<tr>
<td>GP1_Surface 1.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>PH1_Surface 2.0</td>
<td>20 µm</td>
</tr>
<tr>
<td>MP1_Speed 1.0</td>
<td>50 µm</td>
</tr>
<tr>
<td>Ti64_Performance 1.0</td>
<td>30 µm</td>
</tr>
<tr>
<td>Ti64_Speed 1.0</td>
<td>60 µm</td>
</tr>
<tr>
<td>AlSi10Mg_Speed 1.0</td>
<td>30 µm</td>
</tr>
<tr>
<td>IN718_Performance 1.0</td>
<td>40 µm</td>
</tr>
<tr>
<td>IN625_Performance 1.0</td>
<td>40 µm</td>
</tr>
</tbody>
</table>
2.3.1 “Speed”

The “Speed” parameter set offers an optimal compromise between building speed and surface finish quality at 400 W.

2.3.2 “TopSpeed”

“TopSpeed” is the highly productive parameter set for the production of parts or tools. 80 µm layer parameter sets offer a high volume rate using the 400 W laser.

Note: All these parameter sets produce fully consolidated parts with comparable mechanical properties; please see material data sheets for further details.

2.4 ExposureEditor

The carefully balanced quality profiles of the PPM and EOS Original Parameter sets cover a wide area of possible laser-sintering applications. In addition, with the ExposureEditor a solution is available to the expert, who seeks a solution, for example for the following special tasks:

- On the basis of long-time experience and with high effort you have developed special parameters for certain applications and/or unusual geometries and would like to use and develop them further on your new EOSINT M system?
- Over and over again you are confronted with new, challenging applications whose special requirements cannot be fulfilled to your or your customers full satisfaction in spite of an expertly use of the EOS standard tools and products of the newest generation?
- You have good reasons for the use of materials which EOS cannot offer to you yet?
- Your main activity field is not the production of prototypes or series production parts, but research and development in the field of laser-sintering?

In all these cases the ExposureEditor is the appropriate platform for your plan.

- The ExposureEditor enables the development and the use of own parameter sets on an EOSINT M system equipped for this purpose and offers therefore a functional editor. On the basis of existing exposure types like
  - „Stripes“ – speed-optimized filling (hatching) of big layer areas
  - „UpDownStripes“ – combination of „Stripes“ for inner areas and
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„UpDown“ for the horizontal upper and the lower surfaces
- „Chess“ – a stress reducing hatch type, e.g. for big layer areas, works with an especially for DMLS optimized chess-board pattern exposure type
- „Contours“ – for geometry optimized contour exposure
- „Skin-Core“ – differentiated parameters for outer (skin) and inner (core) area
- „Edges“ – offer production of finest details like sharp corners and fine structures via exposing single lines with minimum curing width
- „Rot“ – hatch exposure types, Stripes and Chess, can rotate hatch direction from layer to layer in 67° steps, which cause very uniform part properties in XY and Z direction
- „Sli_Hatch“ – for exposure of support structures, e.g. Magics SG+, EOSTYLE exposures can be parameterised regarding speed, laser power and exposure track.

Even the basic version of the ExposureEditor with its default modules and its firmware version is well prepared for all usual development tasks:

- Support of layer thicknesses of 20 µm, 30 µm, 40 µm, 50 µm and 60 µm (see available parameter sets under 2.2 and 2.3)
- Suitable for a wide range of materials which are able to be laser-sintered
- Equipped with multiple proved exposure strategies
- Equipped with the exclusive EOS feature “Edges” as a precondition of the design of finest details
- Optional single or double exposures of contours as well as of edges

Where this range of performances is not succeeding yet, the modular construction of the ExposureEditor guarantees a far-reaching fundamental expandability of its field of application.

Therefore the ExposureEditor allows you to generate, to use and to further develop suitable parameter sets for in principle laser-sinter-capable materials on your EOSINT M system.
2.4.1 Standard configuration
In the standard configuration the license period of the ExposureEditor is unlimited.

2.4.2 For temporary, demand-driven use
If you can foresee the duration of the use of the ExposureEditor and therefore want to keep your investment as flexible as possible, this configuration is interesting for you. The clearly lesser introductory investment in connection with the annual user fee offers more flexibility.
  - Basis software ExposureEditor
    The functional range of the basis software ExposureEditor corresponds to the standard configuration with the exception of additional benefits.
  - Annual licence ExposureEditor
    The annual licence of the ExposureEditor assures you all the additional benefits of the standard configuration for the period of one year.

2.5 ParameterEditor
The modification of existing exposure parameters in order to optimize parts results is possible with the ParameterEditor packages. These parameters are based on an EOS proved parameter set. The start values of the exposure type can be adapted until the results wanted are reached.

ParameterEditor packages include:
  - ExposureEditor licence
  - OEP or PPP parameter sets
  - Start values which can be customized using the ExposureEditors

Following ParameterEditor packages are currently offered for M 280 200 W:
  - MS1 ParameterEditor (20, 40µm)
  - GP1 ParameterEditor (20µm)
  - PH1 ParameterEditor (20µm)
  - MP1 ParameterEditor (20, 40µm)
  - Ti64 ParameterEditor (30µm)
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- IN625 ParameterEditor (20µm)
- IN718 ParameterEditor (20µm)

Following ParameterEditor packages are currently offered for M 280 400 W:
- MS1 ParameterEditor (40, 50µm)
- GP1 ParameterEditor (20µm@200W)
- PH1 ParameterEditor (20µm@200W)
- MP1 ParameterEditor (40, 50µm)
- Ti64 ParameterEditor (30, 60µm)
- AlSi10Mg ParameterEditor (30µm)
- IN625 ParameterEditor (40µm)
- IN718 ParameterEditor (40µm)

The ParameterEditor packages offer the ideal condition for less experienced users, which require optimizing the exposure parameters to manufacture even better parts.

3 IQMS module: EOSTATE

EOSTATE is a status control and reporting software application. With this application the user can monitor the state of building on various machines in parallel in a local network and maintain an overview of production-related data at any time. EOSTATE prepares the production data over freely definable periods in a clearly laid out form. In addition, all relevant process parameters monitored can be clearly presented in reports and allocated to both building tasks and parts. The varying requirements of users and end customers are addressed with the integrated modules, which are to some extent optional: Basic, Quality Assurance, Controlling, Machine Park Management and ERP Interface. They ensure that processes are clearer and therefore easier to control.

3.1 EOSTATE module: Basic

The EOSTATE Basic module is an integral part of each system. It allows job information to be selectively exported for remote diagnostics by EOS support. In this way any problems can be quickly and cost-effectively identified, and solutions found. The export file contains all reporting data for a selected period, however no geometry
data!

The Basic module also includes a status indication that allows any computer on the network to display the current status of the system and any job running on it.

3.2 EOSTATE module: Quality Assurance

The optional Quality Assurance module contains the job report and the part report. Apart from the general building task data and the selected building parameters, these reports provide above all quality-related information, e.g. events during the building process, interruptions and variations from the ideal process conditions. Each report also contains an assessment generated from this information from which it is clear at a glance whether all relevant parameters were in tolerance during the building process.

The job report covers the entire building process and all parts included, while the part report contains detailed information on selected parts. In particular, the assessment generated in the part report only relates to the selected parts and their process conditions so that positive reports can be generated for erroneous jobs for specific parts are not affected. In this way you can efficiently document the production of parts in compliance with quality requirements and standards for your internal and external customers.
In the Statistics tab the Quality Assurance module makes it possible to search by period for all quality-related data, e.g. success rate, building job interruptions, material changes and building temperatures.

3.3 EOSTATE module: Controlling

The EOSTATE Controlling module provides cost-related information in a clear form using a cumulative report and the Statistics tab. The Statistics tab supplies evaluations for defined periods, e.g. weeks, months, quarters and the changes within a selected period. In this way, e.g., powder consumption or machine utilisation is presented graphically and can be used as a quick basis for making decisions.

3.4 EOSTATE module: Machine Park Management

The optional EOSTATE MPM module makes it possible to optimise the control and efficiency of a production facility. Here service-related information, e.g. date of last maintenance, upcoming maintenance, laser hours, machine hours, PSW warnings and error messages are prepared and clearly represented.
4 Materials

Several materials with a wide range of applications for e-manufacturing are available for the EOSINT M 280 systems as summarised below. You will find further details in the related material data sheet. Further materials are also continuously developed. Please request information on the current situation.

4.1 EOS MaragingSteel MS1

EOS MaragingSteel MS1 is a martensitic hardening steel in a fine powder form. Its chemical composition corresponds to the US classification 18 Maraging 300 and the European classification 1.2709 and the German classification X3NiCoMoTi 18-9-5. This type of steel features very high strength with ductility at the same time, can be machined easily after the building process and can be hardened to a hardness of up to approx. 55 HRC by straightforward thermal post-treatment. Conventionally this steel is used for complex tools, as well as for high quality parts in industries such as aerospace.

Typical applications for the material:

- Injection moulding tools and inserts subject to high loads for achievable service lives of up to millions of parts in all the usual plastics using standard injection moulding parameters
- Die cast moulding tools for series production of up to several tens of thousands of alloy parts
- Direct manufacture of parts for industrial applications including functional prototypes, small production runs, customised parts and spare parts

4.2 EOS StainlessSteel GP1

EOS StainlessSteel GP1 is a pre-alloyed stainless steel in fine powder form. Its chemical composition corresponds to the US classification 17-4 and the European classification 1.4542. This type of steel features extraordinary corrosion resistance and mechanical properties, in particular excellent ductility, and is often used in various industrial applications.

Typical applications for the material:

- Industrial applications including functional prototypes, small production runs, customised parts and spare parts
- Parts with high corrosion resistance that can be sterilised etc.
- Parts with high strength and ductility.

4.3 EOS StainlessSteel PH1

EOS StainlessSteel PH1 is a pre-alloyed stainless steel in fine powder form. The chemical composition corresponds to the US classification 15-5 and DIN 1.4540. Even in the state as built it offers very good tensile strength and a high yield strength; all these properties can be significantly improved by straightforward thermal post-treatment.

Typical applications for the material:
- Industrial applications including functional prototypes, small production runs, customised parts and spare parts
- Parts with high strength and/or hardness

4.4 EOS CobaltChrome MP1

EOS CobaltChrome MP1 is a fine mixture of pre-alloyed powders that builds parts in a cobalt-chromium-molybdenum super alloy. This class of super alloys features excellent mechanical properties (strength, hardness etc.), corrosion and temperature resistance.

Typical applications for the material:
- Bio-medical implants, e.g. for the spine, knee, hips etc. [note: the regional requirements on the manufacture of a medical product, e.g. the EU Medical Device Directive 93/42/EEC, are to be checked and met by the manufacturer]
- Parts with high mechanical properties at high temperatures (500 - 1000 °C) and with good corrosion resistance, e.g. turbines and other jet engine parts, cutting tools etc.
- Parts with very small geometric elements such as thin walls, pins etc. that require particularly high strength and/or stiffness

4.5 EOS Titanium Ti64 and EOS Titanium Ti64ELI

EOS Titanium Ti64 is a pre-alloyed Ti6AlV4 alloy in fine powder form. This familiar alloy features excellent mechanical properties and corrosion resistance combined with low weight as well as good bio-compatibility. The ELI version (extra-low
interstitial) has particularly high purity.

Typical applications for the material:
- Lightweight structures and parts where a combination of good mechanical properties with low weight is required, e.g. structural parts and parts for jet engines for aerospace, motor sport applications etc.
- Bio-medical implants
  [note: The regional requirements on the manufacture of a medical product are to be checked and met by the manufacturer]

4.6 EOS NickelAlloy IN718

EOS NickelAlloy IN718 is a nickel-based high temperature-resistant alloy in powder form. The composition corresponds to Inconel™ 718, UNS N07718, AMS 5662, AMS 5664, W.No 2.4668, DIN NiCr19Fe19NbMo3. This type of hardening nickel-chromium alloys features good ageing resistance, tensile strength, high temperature strength and fracture strength at temperatures up to 700 °C. The 718 alloy is also very corrosion-resistant in various corrosive environments.

This material is ideal for many high temperature applications.

Typical applications for the material:
- Parts for airborne and land-based turbines
- Parts for rockets, aerospace
- Parts for the chemical and process industry
- Parts for the oil, petrol and natural gas industries

4.7 EOS NickelAlloy IN625

EOS NickelAlloy IN625 is a heat and corrosion-resistant nickel alloy powder that has been specially optimised for processing in EOSINT M systems.

Parts made of EOS NickelAlloy IN625 correspond in their chemical composition to UNS N06625, AMS 5666F, AMS 5599G, W.No 2.4856 and DIN NiCr22Mo9Nb. This type of alloy features high tensile strength, creep strength and fracture strength. Conventional cast and forged parts made from this nickel alloy typically have excellent (high temperature) fatigue strength, combined with good oxidation resistance.
EOS NickelAlloy IN625 has good corrosion resistance in various corrosive environments. Marine applications in particular require high resistance to pitting corrosion, crevice corrosion and stress cracking corrosion in relation to chlorine ions as well as high tensile strength and fatigue strength. To check the corrosion resistance it is recommended to undertake relevant tests before this material is used in specific corrosive media.

4.8 EOS Aluminium AlSi10Mg

EOS Aluminium AlSi10Mg is a pre-alloyed aluminium powder. AlSi10Mg is a typical casting alloy with good casting properties and is used for cast parts with thin walls and complex geometry.

The alloy combination silicon/magnesium results in a significant increase in the strength and hardness. It also features good dynamic properties and is therefore used for parts subject to high loads.

Typical applications for the material:
- Direct manufacture of functional prototypes, small production runs, user-specific products or spare parts
- Parts that require a combination of good thermal properties with low weight, e.g. for motor sport applications
The operating modes for the EOSINT M materials are listed in the following tables:

<table>
<thead>
<tr>
<th>Powder name</th>
<th>M 280 operating mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOS MaragingSteel MS1</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>EOS StainlessSteel GP1</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>EOS StainlessSteel PH1</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>EOS CobaltChrome MP1</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>EOS Titanium Ti64</td>
<td>Argon</td>
</tr>
<tr>
<td>EOS Titanium Ti64 ELI</td>
<td>Argon</td>
</tr>
<tr>
<td>EOS NickelAlloy IN718</td>
<td>Argon</td>
</tr>
<tr>
<td>EOS NickelAlloy IN625</td>
<td>Argon</td>
</tr>
<tr>
<td>EOS Aluminium AlSi10Mg</td>
<td>Argon</td>
</tr>
</tbody>
</table>

Comment:

All materials in the table are approved, i.e. tested and qualified for EOSINT M 280 systems with the inert gas argon or nitrogen, see table above.

Default parameters are included in the PSW, part properties are documented in a material data sheet, powder is available as a series production product, application support is available.

The majority of the materials available, e.g. the steel alloys can also be processed in argon.
5 Building platforms

The parts are built on the building platform that is either integrated into the part (e.g. on tool inserts) or that can be separated from the parts after the building process. In the latter case the building platforms can be used several times by re-machining the surface. DirectBase building platforms have the dimensions 250 x 250 mm and as a result fill the entire building area. The building platform is fastened in the process chamber to the platform carrier using four bolts. DirectBase platforms are available in various materials and specifications:

<table>
<thead>
<tr>
<th>Name</th>
<th>Material</th>
<th>Nominal thickness</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>DirectBase S22</td>
<td>1.1730 steel</td>
<td>22 mm</td>
<td>Ground surface; 8 mm fastening bores</td>
</tr>
<tr>
<td>DirectBase S36</td>
<td>1.1730 steel</td>
<td>36 mm</td>
<td>Ground surface; 8 mm fastening bores</td>
</tr>
<tr>
<td>DirectBase TS36P</td>
<td>1.2083 steel</td>
<td>36 mm</td>
<td>Ground surface; 8 mm fastening bores; reference via positioning holes, recesses for platform handling</td>
</tr>
<tr>
<td>DirectBase Ti25</td>
<td>Ti6Al4V</td>
<td>25 mm</td>
<td>Milled surface; 8 mm fastening bores</td>
</tr>
<tr>
<td>DirectBase AL30</td>
<td>Aluminium</td>
<td>30 mm</td>
<td>Milled surface; 8 mm fastening bores</td>
</tr>
</tbody>
</table>

Processing notes:

DirectBase Ti25 platforms are recommended for processing EOS titanium materials.
DirectBase AL30 platforms are recommended for processing EOS aluminium AlSi10Mg.
The usage of 1.2083 platforms (DirectBase TS36P) is strongly recommended for processing EOS MaragingSteel MS1 materials and for heat treatment during which the parts remain on the platform.

During the production of very large jobs it is recommended to use the building platforms DirectBase TS36P (with the grooves) combined with the building platform handling truck. See section 6.3.2 for further details on the building platform handling truck.

During the production of large, solid parts, the usage of thick plates is always recommended, e.g. 36 mm.

For building hybrid tools with EOS MaragingSteel MS1 we recommend only 1.2709 steel as the most suitable alloy for preforms.
6 Data preparation

It is necessary to prepare CAD data to produce SLI data to control the building process. The most important requirement during this process is the conversion of a three-dimensional (3D) structure into a sequence of two-dimensional (2D) layers, so-called “slices”. Further requirements are defined by the individual process chain, starting from CAD design to the building process and can include repair, cutting or scaling of 3D structures. If the part is to be separated from the building platform, e.g. typically in DirectPart applications, a support structure is also needed.

The CAD data are normally converted into the so-called STL format in which the part geometry is approximated by a network of triangles. However, various software packages also permit the conversion using other interface formats such as IGES, VDA-FS, STEP, CATIA, PRO/E and many others.

For this data preparation an IBM-compatible PC is required. The equipment should satisfy the following requirements:

- Processor > 1 GHz, Pentium IV recommended
- RAM 512 MB (> 1024 MB recommended)
- Graphic card > 128 MB recommended, open-GL
- Network interface RJ45/100BaseTX
- Network protocol TCP/IP
- Operating system Windows XP
- Drives CD-ROM
- Monitor 17” (1024x768 true colour)

For information on further requirements, e.g. on the processor power and memory, in particular on the simultaneous usage of external data preparation software, please refer to the documentation from the related supplier.
EOS Software available in two variants 32bit and 64bit has to be used stringently in the version according to the MS operating system. This means on a MS 64bit operating system the 64bit version of EOS software has to be used and on a MS 32bit operating system the 32bit version of EOS software has to be used!

Various software packages are, as described in the following, available for the data preparation on the PC.

6.1 EOS RP-Tools - EOS software for generating and editing layer data

EOS RP-Tools is a software package that allows the conversion of part data in the STL or CLI format into the EOS-specific SLI format as is required for the subsequent building process. To make the process optimisation easier, layer data for solid bodies can be divided into skin and core data.

EOS RP-Tools comprises the modules:

- **SLIVIEW**: Graphic user interface for the visualisation of the layer data
- **SLICER**: Generation of two-dimensional layer data from three-dimensional STL data
- **SLIFIX**: Automatic repair of the most common data errors in layer data such as overlaps, double contours and inverted polygon orientations
- **SKINCORE**: Breakdown of solid part data into separate data sets for a definable skin and a core on a two-dimensional basis. Comment: From PSW V3.2 this functionality is also included in the PSW.
- **SLICONV**: Automatic data conversion from CLI to EOS SLI and vice versa (in each case either ASCII or binary)
- **RADIUS**: Generation of a radial transition between platform plane and part to homogenise the internal stresses, as well as the generation of a structure open to the platform on the usage of the skin & core algorithm. Comment: From PSW V3.2 this functionality is also included in the PSW.

Data input format: STL, CLI (ASCII or binary), EOS SLI
Data output format: EOS SLI, CLI (ASCII or binary)

From Version EOS RP Tools 6.0 onwards the software can also be used as a network licence (floating licence). EOS RP Tools is available as 32bit and 64bit
6.2 EOS PSW Offline

PSW Offline is a second licence for the process control software PSW on a separate PC. In this way jobs can be prepared independent of the machine computer. It is then possible to maximise the system utilisation for building parts.

- Operating system: Microsoft Windows 7

From Version PSW 3.5 onwards the PSW Offline software can also be used as a network licence (floating licence) on data preparation computer.

Note: For compatibility reasons, PSW Offline must always be the same version as installed on the machine computer.

6.3 Materialise Magics RP

Magics RP is a software package for data preparation based on STL data. It is available for all common Windows operating systems and covers the requirements for data preparation for EOSINT M systems:

- Parts visualisation in the STL format
- Process-compatible positioning of the parts on the building platform
- Repair and editing functions in the STL format
- Quality assurance on the STL files
- Reinforcement and supports (depending on the parts geometry) with the use of the additional SG module
- Import of IGES, VDA, CATIA and Unigraphics data using additional modules

6.4 Magics modules

6.4.1 Magics SG+ Module

For metal applications, support fulfills a larger purpose than just supporting the part during the build process. A better surface quality on down facing surfaces can be obtained by support structures that allow heat conductivity; they minimize the number of contact points but still allow transferring the heat away from the part. Magics SG+
contains the tools for good anchoring, heat transfer and support, yet taking into account its effects on finishing time.

6.4.2 Volume supports

Magics’s Volume Supports provide a flexible system: automatically generated supports can be adapted and edited to the user’s needs. Such Gap Support (former Feature name from EOSTYLE Module) makes it possible to support certain geometries without contact.

6.4.3 Magics Import Modules

Standard CAD formats (e. g.: .fbx, .step, .acis, .vda, .iges) can be imported into Magics with the following Magics Import Modules:

- CATIA V4.x module
- CATIA V5.x module
- CATIA V6.x module
- IGES module 1200
- VDA module 1200
- ProE module 1400
- UG / Parasolid module
- STEP module 1200
- Acis SAT 1530
- Solidworks module 1530
- JT import 1530

6.4.4 Optional Magics Modules

Materialise offers many other modules in their portfolio. Please contact directly Materialise, if you are interested in the following products:

- Build Processor - integration between Materialise data preparation software and EOS systems
- Structures Module - reduce the weight and material usage in your designs
- FormFit - create packaging STL-files which can be used to produce the optimal support and protection for your parts (or foams milled in EPS based on the generated STL-files).

These products and corresponding trainings can only be ordered directly from Materialise.

6.5 EOSTYLE (only relevant for Magics RP 16)

EOSTYLE is a software package with expanded features for the generation of supports in Magics RP 16 or former versions.

EOSTYLE was written by Materialise exclusively for EOS and is recommended for all EOSINT M customers who want to build positive parts (DirectPart®) or loose parts for tools. EOSTYLE includes the following functions:

- Angled Supports can support overhanging areas from the side
- Improved Tooth Design of minimised surface defects on breaking away support
- Radius Function improves the supports on the platform
- Optimized Block Support with definable orientation and fragmentation for easier and quicker separation
- Advanced Gussets are reinforced by gusset supports with a definable angle
- Gap Support makes it possible to support certain geometries without contact

Hint: Now EOSTYLE features are integrated in Magics 17 SG+ Module, see point 6.4.1.

6.6 EOS Software recommendations

To operate an EOSINT M 280 the following software packages are recommended:

For the production of parts that do not require support structures, e.g. tool inserts:
- EOS RP-Tools (indefinite single user licence)
- EOS PSW Offline (indefinite network licence)

For the production of parts that require support structures, also:
- Materialise Magics RP licence version with additional SG+ module
### 7 Machine modes

EOSINT M 280 systems can be operated in various modes.

#### 7.1 Nitrogen

In this mode the EOSINT M 280 system is designed for the optimal, reliable and cost-effective processing of all EOS StainlessSteel, MaragingSteel and CobaltChrome materials. The materials are processed in a nitrogen atmosphere that is generated by a nitrogen generator integrated into the machine frame. The generator extracts nitrogen from an external compressed air supply.

For details on the connections, please refer to the Installation Conditions for EOSINT M 280.

#### 7.2 Argon

In this mode the EOSINT M 280 machine is operated with an argon inert gas atmosphere. Reactive metals, e.g. EOS titanium, Inconel and aluminium powder can only be processed in this mode. The majority of the other materials available, e.g. the steel alloys can theoretically also be processed in argon.

Due to the higher safety requirements for operation with argon gas and for the processing of reactive metals, the following components are required:

- Connection to external argon gas bottle(s) or battery of bottles that is to be provided by the user (see Installation Conditions),
- Expanded and redundant monitoring of the residual oxygen content at several points, including process chamber, Recirculating filter system and machine frame,
- Expanded safety circuit including automatic interruption of the building process if a defined residual oxygen content is exceeded

For the reactive metals such as EOS titanium or aluminium powder, the Wet separator (a vacuum cleaner filled with water) and the platform handling truck must be used.

For details on the connections, please refer to the Installation Conditions EOSINT M 280.
7.3 Dental package

In this configuration of the EOSINT M 270 the machine is optimally equipped for the production of dental restorations in EOS CobaltChrome SP2 material as per the statutory regulations for the production of class IIa medical products using CE-certified material. The machine hardware is equipped like the standard package, but specially qualified for the usage of EOS CobaltChrome SP2 material.

This package also includes special training for the dental application and a certificate for the licence fee paid for a third-party patent for the manufacture of dental restorations.

The training is mandatory as per statutory regulations for the production of medical products.

EOS recommends the usage of the optional data preparation software CAMbridge with this package.

For details on the connections, please refer to the Installation Conditions EOSINT M 270.
8 Options

Depending on the application, various steps may be necessary for the post-treatment of the parts for which additional equipment may be required. The equipment needed most frequently as well as the contact addresses for manufacturers of this equipment are summarised as follows. Further details and recommendations as well as information on operation are available on request in the EOS application notes, training documents etc.

8.1 Vacuum cleaner

For cleaning the process chamber a vacuum cleaner is used. To ensure safe working, only a vacuum cleaner suitable for this purpose with appropriate accessories should be used that complies with the special requirements and that has been manufactured in accordance with the related safety class.

8.1.1 Standard industrial vacuum cleaner

This is an industrial vacuum cleaner with dust bag, specified for dust class H and with continuously electrically conductive accessories (hose and nozzles).

Fig.: Vacuum cleaner Ruwac WSZ 2210
8.1.2  Wet separator

This vacuum cleaner collects powder and dust etc. drawn up in a liquid and therefore offers the greatest possible safety. It is suitable for usage with all EOS materials, including reactive powders, as well as flammable and even explosive dusts. It is only allowed to use this vacuum cleaner for EOS titanium and aluminium powder materials.

Fig.: Wet separator Ruwac NA35 D1 B1
(required for reactive powder such as titanium and aluminium)

8.2  Accessories for powder handling

8.2.1  Sieving module

Prior to re-usage in the EOSINT M 280, the metal powder should always be sieved to remove agglomerates or other coarse particles. A sieve insert for manually sieving powder inside the process chamber is supplied with the machine.

The Sieving module is used for sieving, mixing and ensuring the even consistency of the metal powder that has been conveyed from the dispenser duct, building duct and collector duct on the machine using the Conveying module. The Sieving module is an external sieve that allows the rapid sieving of larger amounts of powder in a closed unit.

Fig.: Sieving module for EOSINT M 280

- Sieve fabric mesh size  Standard 63 µm, other sizes possible
- Principle of operation  Vibrating sieving with ultrasound cleaning
Conveying module

The Conveying module is used for collecting and conveying metal powder from the dispenser duct, building duct and collector duct on the machine to a powder bin. The Conveying module is a compressed-air operated conveying unit for metal powder; it operates in cycles, the suction time and emptying time can be adjusted to suit the type of metal powder used.

Fig.: Conveying module for EOSINT M

Conveying capacity:

- Conveying performance:
- Vacuum: Max. 91 % (-91 kPa)
- Volumetric flow rate at the connection, suction hose removed: approx. 130 m³/h
- Compressed air setting: 5.5 - 6 bar
- Capacity: 1.5 l
- Suction time: 2 - 30 s
- Emptying time: 2 - 30 s
- Permissible temperature of the metal powder conveyed: 0 - 80 °C
8.2.3 Filling module

This option makes filling the process chamber with sieved metal powder safe and easy. It is recommended particularly for customers who want a quick, contact-free handling, also of large amounts of powder.

Fig.: Filling module for EOSINT M 280

8.2.4 Electrical Lifting truck

The Lifting truck can be equipped with various items of lifting tackle (fork attachments) for the following purposes:
- Removing the building platform from the machine, transporting, setting down
- Picking up the powder bin, transporting and setting down in the Conveying module, in the Sieving module or on a unit for setting down
- Changing the pre-filter on the recirculating filter unit

Fig.: Electrical Lifting truck for EOSINT M 280

Technical data:
- Max. permissible load: 130 kg
- Charging time for the fully discharged rechargeable batteries: 4 - 5 h
- Fuse on the charger: 30 A
- Lift: 2000 mm
8.2.5 CPM - Comfort Powder Module

The Comfort powder module makes it possible to handle powder in a dust-free atmosphere. The Comfort powder module comprises the outer and the inner process chamber door.

The inner process chamber door is equipped with a pair of integrated gloves and storage space for an integrated suction hose. It is possible to transport powder from the dispenser-, building and collector duct with the inner process chamber door closed.

Fig.: Comfort powder module for EOSINT M 280

Hint: The laser is shut down if the outer process chamber door is opened.

8.3 Accessories for building platform handling

8.3.1 Erowa clamping system

This option makes it possible to fasten building platforms using a quick-release clamping system of type Erowa Powerchuck 150 in the EOSINT M 280. In this way a finished job can be quickly and easily unloaded from the machine and immediately fixed for further processing, e.g. on milling or eroding machines that are also equipped with an Erowa Powerchuck 150. For this purpose the building platform is mounted on a pallet that fits the Powerchuck 150 unit.

Fig.: Erowa Powerchuck 150 clamping system
(mounted in an EOSINT M system)
The quick-release clamping system is locked and unlocked using a compressed air connection with quick-release coupling. Additional pallets can be ordered so that several jobs can be processed simultaneously on different machines.

The Erowa clamping system can be removed from the machine at any time and replaced with a standard building platform. On the usage of the Erowa clamping system, the maximum building height is reduced by approx. 98 mm in comparison with the standard arrangement.

- Positioning repetition accuracy of the pallet 0.002 mm

8.3.2 Building platform handling truck

The Lifting truck can be equipped with various items of lifting tackle for the following purposes.

This option makes it possible to safely and easily remove building platforms from the process chamber. It is particularly recommended for users who build heavy jobs and/or use positioning pins or an Erowa clamping system. The truck can also be used for the safe and easy removal or clogged filters from the Recirculating filter system.

- Maximum load 150 kg

Fig.: Lifting truck for the transport of building platforms and filters

8.4 Micro shot-peening
Micro shot-peening is a post-treatment method that makes it possible to very quickly and easily improve the surface quality, both for direct usage and as the basis for further polishing. It can generally be recommended for all materials. Depending on the application, the following packages are recommended. Detailed recommendations for some applications are given in the application note “Surface finishing of DMLS parts”. In applications that require high metallurgical purity, e.g. medical implants, shot-peening medium and handling of the parts must be chosen accordingly.

Please note that EOS does not supply any media or spare parts apart from the packages offered. These products should be ordered directly from Iepco (www.iepco.ch) or a local dealer. Contact addresses can be provided on request.

8.4.1 Micro shot-peening basic package

For the majority of DirectTool® and DirectPart® applications compacting and shot-peening using a basic package is sufficient, this package comprises:

- 2 micro shot-peening machines IEPCO Peenmatic 750S, each with rotating table
- 1 fine shot-peening nozzle Micropeen 250 (integrated in a Peenmatic 750S)
- 5 kg shot-peening medium IEPCONORM A (test quantity)
- 25 kg shot-peening medium IEPCONORM B-4
- 25 kg shot-peening medium IEPCONORM C

8.4.2 Micro shot-peening upgrade package Micropeen 250

For fine slots that are not accessible with Iepconorm B-4, the finer Iepconorm B-2 can be used with a Micropeen 250 fine nozzle. However here caution is required to prevent damage to other surfaces due to the larger amount of material removed. The related upgrade package comprises:

- 1 fine shot-peening nozzle Micropeen 250 + unit for mounting the second Peenmatic 750S micro shot-peening system
- 25 kg shot-peening medium IEPCONORM B-2
8.4.3 Micro shot-peening premium package

For the best quality on injection moulding inserts the work steps cleaning, compaction, shot-peening and smoothing are recommended. For this purpose we recommend the premium package, comprising:

- 3 micro shot-peening machines IEPCO Peenmatic 750S, each with rotating table, two of which with fine shot-peening nozzle Micropeen 250
- 25 kg shot-peening medium IEPCONORM A
- 25 kg shot-peening medium IEPCONORM B-4
- 25 kg shot-peening medium IEPCONORM C

8.4.4 Micro shot-peening dental package

For the best quality dental prosthetic elements the cleaning work step is recommended. For this purpose we recommend the dental package, comprising:

- 1 micro shot-peening machine IEPCO Peenmatic 750S, with rotating table
- 25 kg shot-peening medium IEPCONORM C
8.5 Thermal post-treatment

Depending on the material and application, thermal post-treatment can be recommended, e.g. for post-hardening or stress reduction. In particular with the materials EOS StainlessSteel, MaragingSteel, CobaltChrome and titanium, thermal post-treatment is recommended. More detailed advice is available on request. For all these materials we can recommend the following equipment:

- Electrically heated chamber furnace of type H 41/H with controller C 250
  - Furnace chamber dimensions (W x D x H): 350 x 500 x 250 mm
  - External dimensions (W x D x H): 840 x 1100 x 1320 mm
  - Weight: 260 kg
  - Elec. connection rating: 15.0 kW
  - Connection voltage: 400 V
  - Tmax. 1280 °C

- Inert gas annealing box with inert gas supply
- Loading plate for N 41/H
- Loading truck CW 1

This equipment can be ordered directly from the following supplier:

Nabertherm GmbH
Bahnhofstrasse 20
D-28865 Lilienthal/Bremen
Tel: +49 (0) 4298 922-0
Fax: +49 (0) 4298 922-129

8.6 Brush recoater

The Brush recoater can be used instead of a rigid recoater if parts with very delicate structures are to be manufactured. During recoating the metal powder is applied to the building area using two carbon-fibre brush strips.

Hint: EOS recommends using a rigid recoater blade if process reliability, part dimensional accuracy and surface quality are in the foreground.
8.7 Laser power measurement with PocketMonitor

This option enables the user to measure the laser power directly in the process chamber. The measuring tool is easy to use and very precise, e.g. for a measurement of the laser power before and after a job. The measuring device is inserted into the EOSINT M280 in a bracket and put into an exact centric position with the help of positioning holes on the platform carrier. For the EOSINT M 280 systems and EOSINT M 270 Dual Mode we can recommend the following equipment:

- Laser power measuring device type PocketMonitor PMT 05P
  - Performance range: 25 to 500 W
  - Exactness of measurement within the specified performance range: 4 %
  - Measuring time with 200W laser: 20 sec
  - Measuring time with 400W laser: 10 sec
- Laser-sintered holder for measuring tool (please see above picture)

The PocketMonitor can also be ordered directly from the following supplier (pls. see below).

Note: Please include „PMT 05P – Configuration for EOSINT M 280“ in the order.

PRIMES GmbH
Max-Planck-Str. 2
D - 64319 Pfungstadt
www.primes.de
Tel: +49 (0) 6157 / 9878-0
Fax: +49 (0) 6157 / 9878-128
9 Services

9.1 Installation

9.1.1 EOSINT M 280 system

The system price includes the installation at the customer in accordance with the stipulated regulations. For information on the installation requirements, please see the Installation Conditions. The qualification and commissioning of the system for one material by our service engineers is included in the system price. For the qualification and commissioning of further materials, if ordered at the same time as the system, approx. one day service per material is required. Each material qualification typically uses two building platforms as well as a small amount of the related powder material.

9.1.2 Software

The installation of EOS RP-Tools from CD-ROM is straightforward and can be undertaken in a few minutes. Local administrator rights are necessary to run the installation routine. The following languages can be selected for the software user interface: German, English, French and Italian. The usage of the software is protected with a password that is assigned by EOS as a function of the modules ordered.

During the installation of Magics RP from CD-ROM, the EOSTYLE module is also installed. This installation can be undertaken by the user without problems. The password necessary for the usage of the software is assigned by Materialise as a function of the modules purchased.

9.2 Documentation

9.2.1 EOSINT M 280 system

A complete, CE-compliant documentation is supplied with the system. This documentation includes:

- Installation Conditions
- Operating Instructions
- Troubleshooting, Maintenance and Spare parts
- Software reference PSW
- Accessories and Options
9.2.2 Software

A CE-compliant user manual for EOS RP-Tools is included in the scope of delivery. The user manual can be supplied directly in German, English, French and Italian; for other languages please ask for delivery time and costs.

The scope of delivery for Materialise Magics RP and its modules includes a manual in German or English. The language is selected during the installation. The software has an online help.

The EOSTYLE module in Magics also has an online help.

9.3 Training

9.3.1 EOSINT M 280 system

To ensure the machine is operated correctly, the basic training course for machine operation, machine accessories and software is included in the sale price.

The basic training course includes:

- Basic principles of the technology
- Machine operation
- Handling the accessories
- Process depiction and control*
- Data preparation (EOS RP-Tools)
- Part preparation*
- Finishing the parts

* For one material, e.g. EOSMaragingSteelMS1

The basic training course for up to three participants covers five days and takes place on the premises of EOS GmbH in Krailling. If more than one material is ordered, an additional training course may be required (arranged on request). A training manual in German is provided to the participants.

The basic training course requires basic knowledge of the operation of a PC including Microsoft Windows.

To reinforce and optimise the process chain we would be pleased to offer further training courses (e.g. follow-up training at customer site) or workshops.
9.3.2 Software

The supply of a comprehensive operator manual for EOS RP-Tools makes an additional training course unnecessary. Customers who procure the software together with an EOSINT system will receive an instruction as part of the basic training course.

Training courses for the various Magics modules are offered by Materialise both on its premises and at the customer site. For reasons of efficiency, it is strongly recommended to attend a Magics training course at Materialise prior to starting the EOSINT system basic training course.

Due to the online help in the EOSTYLE module, a separate training course for EOSTYLE is not necessary. Customers who procure the software together with an EOSINT system will receive an instruction as part of the basic training course.

9.4 Service program

To retain the availability of the system, EOS offers numerous contract options in its service program that address the specific requirements of the operating organisation.

For a detailed list of the services in the contract options please see our separate information on this aspect.