ONE CLICK METAL

impac SYSTEMS ENGINEERING

BOLDSERIES

DESIGN GUIDE

Contents

Additive Manufacturing 2
Laser Powder Bed Fusion 3
Applications Metal 3D Printing 4
Overview BOLDSERIES 5
Process Chain LPBF 6
Design Guidelines
- CAD-Modelling 8
- Print Optimisation 10
Benchmark Part 12

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Additive Manufacturing

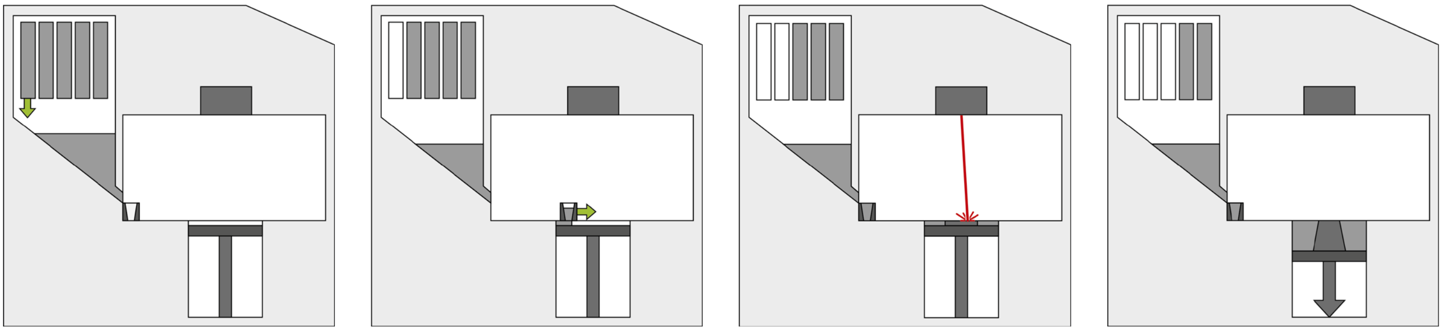
Additive manufacturing is a process in which a component is built up layer by layer based on digital CAD design data (CAD = Computer Aided Design). In contrast to conventional, ablative, or subtractive manufacturing processes, in which a workpiece is milled out of a solid block, additive manufacturing builds up components layer by layer from materials such as fine powder, filament or wire. Possible materials include plastics, composites, and various metals. The additive approach allows highly complex individual components to be created in a shorter time at a lower cost, making additive manufacturing attractive to a wide range of industries.

Laser Powder Bed Fusion

Powder bed based technologies have been in the market the longest, have the largest market share and have the greatest industrial and technical maturity. According to a study, 90-95% of the metal 3D printers sold worldwide are LPBF systems (cf. AMPower study 2018).
The layer-by-layer build-up process of the Laser Powder Bed Fusion process produces high-density, instantly functional components. The shaping and joining happens in one step compared to sintering processes. In sintering processes, on the contrary, the shaping takes place in the printer and the green bodies must then be sintered in a separate oven. In some cases, the binder must be removed thermally or chemically beforehand. With the LPBF method, this reduces the build cycle by more than 50%, which means that this technology offers several advantages:

- Complex component designs
- High degree of customisation
- Accelerated development time
- Cost and time effectiveness

The most common applications of the LPBF process are functional prototypes, individual parts and small series for mostly small to medium-sized components.
The process is shown here in a step-by-step overview:



1. Powder supply

Powder supply using cartridges

2. Coating

Powder deposition with coater

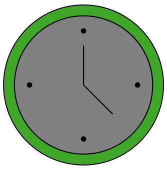
3. Fusing

Fusing process of the powder by the laser

4. Lowering

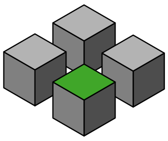
Lowering the building platform & repeat steps one to four until the component height is reached

Applications Metal 3D Printing



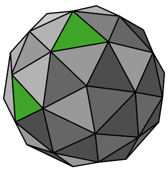
Rapid prototyping

The rapid creation of design samples and functional manufacturing prototypes that can accurately represent the mechanical properties of the final component minimises the time from engineering design to full production. By eliminating the set-up and tooling costs required by traditional manufacturing processes such as casting and machining, metal 3D printing can produce finished prototypes and enable rapid design changes.



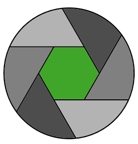
Small series and customised production

Metal 3D printing is ideal for individual and customised production, as it significantly reduces the manufacturing costs and time required for single-use applications, such as the production of tools for injection moulding or die casting. Especially in training departments or universities, metal 3D printing enables rapid printing of student designs.



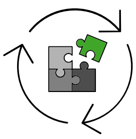
Complex designs

Metal 3D printing enables the production of difficult-to-machine parts, such as components with long or partial through-holes, internal hollow spaces, contours, and conical geometries, as well as metal lattice structures. Form-fitting cooling channels can be printed in tooling. The design should ensure that no supports are required, and that excess powder can be easily removed during the unpacking process.



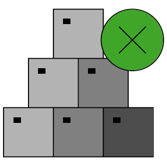
All-in-one-assemblies

Metal 3D printing enables the printing of fully assembled components, eliminating the cost of machining and assembling (often welding) multiple parts.



Decentralised manufacturing

Metal 3D printing enables decentralised manufacturing by allowing critical replacement components to be created on-site from digital CAD files.



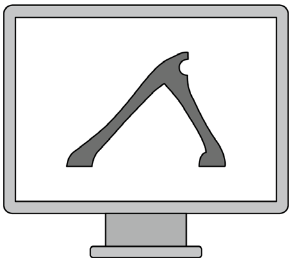
Reduction of physical inventory

Metal 3D printing's process chain replaces the cost and space of physical inventory with digital 3D CAD files. Components are quickly and easily printed on-demand from CAD files.

Overview BOLDSERIES

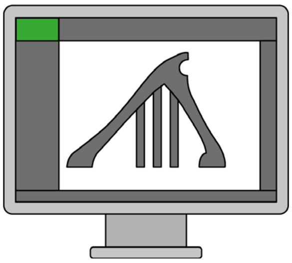
The BOLDseries is the affordable metal 3D printing system consisting of the holistic product solution MPREP, MPRINT+ and MPURE, which enables a perfectly harmonized system chain. The powder and cartridge system ensures simple and safe powder handling. The co-thinking-philosophy includes various features from software tutorials to Poka Yoke principles in operation, which support and accompany the user from start to finish. The low financial entry barrier also makes it easy to get started with the technology.

Process Chain LBPF



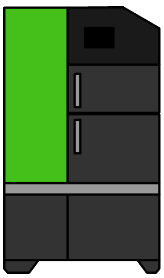
1. Data creation

- **CAD modelling**: No component without a design template. This means designing the component in advance in a 3D-optimised way using CAD software.
- **STL export:** When the design is ready, the model is exported.



2. Data preparation with MPREP

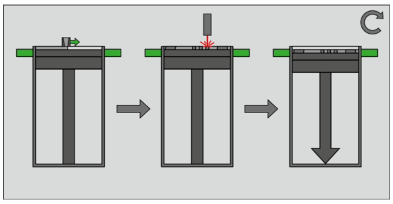
- **Support generation:** Often supports are necessary, e.g., to support overhangs or certain angles or to improve heat dissipation, especially for massive components. See also the column setting options in the MPREP software.
- **Parameter selection:** Parameters are presets optimised to the material and machine. They differ in terms of surface finish and productivity.
- **Slicing & Preview:** As a last step, a layer preview is generated before the file can be exported.



3. Print preparation with MPRINT+

- **Insert powder supply cartridges:** The full powder cartridges are inserted into the cartridge holders provided.
- **Insert the build module:** The build module can be inserted easily using the practical holder rails.
- **Insert overflow cartridge:** The ergonomically shaped powder cartridge catches excess powder.
- **Load print job:** The exported part file is loaded.
- **Inerting:** Gas (nitrogen) is supplied to the process chamber, displacing the oxygen, and thus protecting the materials from oxidising.

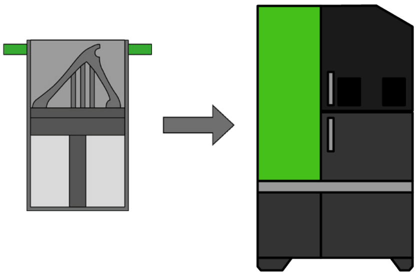
4. Printing process in MPRINT+ with the LPBF-process



- **Supply:** Powder supply through powder cartridges
- **Coating:** Powder application by coater
- **Fusion:** Powder fusion by laser
- **Lowering:** Lowering of the build platform to prepare new layer

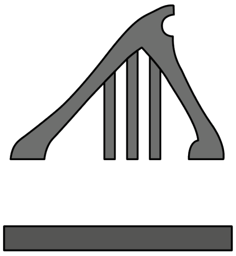
Repeat steps one to four until part height is reached.

5. Unpacking process MPURE



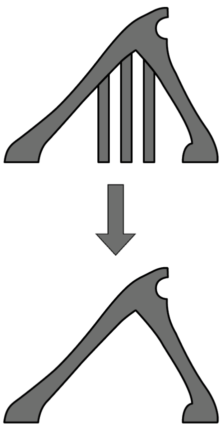
- **Transport build module:** Build module is removed from MPRINT+ and inserted into MPURE with the trolley.
- **Preparing the build platform:** The build platform in MPURE is raised until the desired height is reached.
- **Powder removal:** The gloved interventions are used to roughly remove powder from the component and from gaps and support structures.

6. Separating the component from the platform



- Cutting with band saw, flush cutting tool or wire EDM

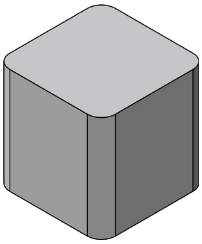
7. Finishing of the component (optional)



- Manual support removal by pliers or side cutter
- Final surface treatment
- Heat treatment for mechanical properties
- Traditional finishing processes such as grinding, polishing, bead blasting, honing of internal channels with abrasive slurry
- Vibratory finishing, wet blasting, and dry blasting
- Finishing processes such as heat treatment
- Renewal of the surface coating of the building panel

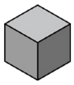
Design Guidelines

CAD-Modelling



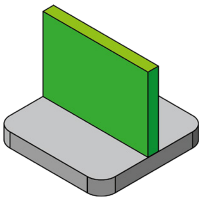
Maximum component size

150 x 150 x 150mm³ with a 20 mm radius



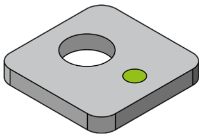
Minimum component size

0.3 x 0.3 x 0.1mm³ (B x T x H)



Minimum wall thickness

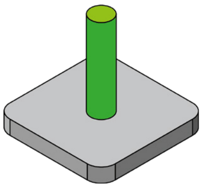
0.3mm



Minimum hole size

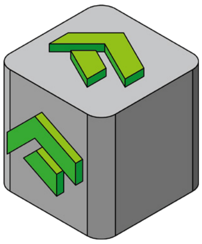
Ø 0.5mm vertical

Ø 0.8mm horizontal



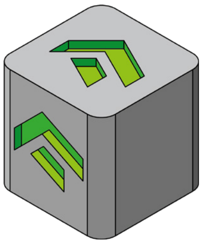
Minimum pin diameter

Ø 0.5mm



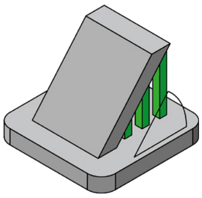
Minimum embossed feature

X/Y	W 0.2mm
	H 0.1mm
Z	W 0.2mm
	H 0.1mm



Minimum debossed feature

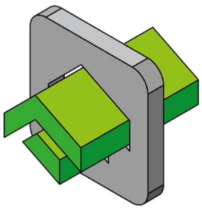
X/Y	W 0.3mm
	H 0.1mm
Z	W 0.3mm
	H 0.2mm



Minimum unsupported overhang angle

0 - 45° degrees: Supports needed

> 45° degrees: No supports needed



Minimum clearance

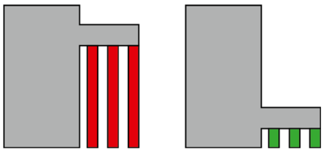
0.5mm

Design Guidelines

Print Optimisation

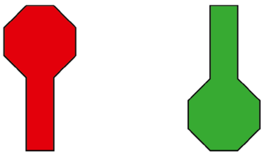
Optimising print orientation

The way the part is oriented on the build plate for printing has an impact on surface quality and manufacturing time. Therefore, the following points should be taken into consideration during component orientation:



Minimise number of supports

The number of supports required should be kept to a minimum to save printing time and material. Therefore, large overhangs resting on support structures should be avoided.

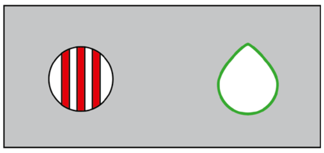


Avoid high centres of gravity

Alignments that shift the centre of gravity of the component upwards should be avoided. This is because the higher the centre of gravity, the more support structures need to be placed to absorb the centre of gravity.

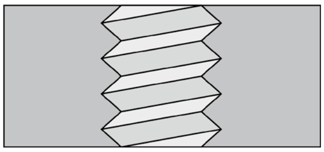
Avoid contact of critical surfaces with supports

Surfaces that meet support structures have a rougher surface quality. Therefore, it is recommended to avoid contact of critical surfaces with support structures.



Holes

Supports may be required for horizontal holes with certain diameters, the support option in MPREP calculates and generates them automatically. The use of support structures for horizontal holes can be avoided by changing the circular hole shape to a teardrop shape, which uses a self-supporting angle. This eliminates the need for additional supports.



Printed threads

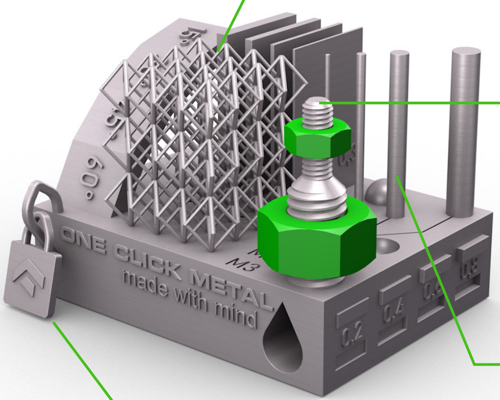
Printing holes and then tapping them is often recommended. The table below serves as a guide:

Thread size	Method
< M3	Print holes, cut threads
≥ M3	Print threads, recut threads

Further recommendations

- Adding fillets reduces stresses during geometry changes.
- Unnecessary blocks of printed material should be avoided.
- If practical, internal holes should be printed parallel to the build direction (Z-axis).

Benchmark Part



LATTICE STRUCTURE 0.3mm

In general, different types of lattice structures are possible in order to implement lightweight construction. On the component, the lattice structure is 0.3mm.

THREAD M3 and M6

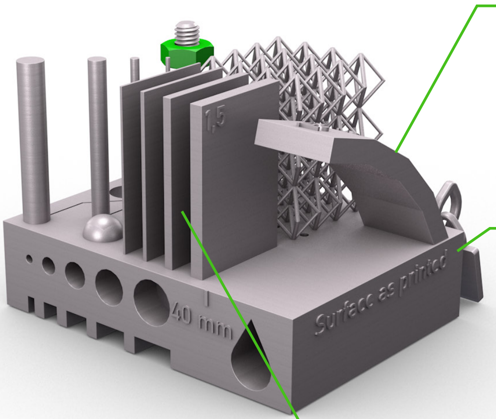
The M3 as well as M6 threads were printed directly and can therefore be used functionally immediately. A nut can be screwed on instantly.

PINS 0.5mm to 3mm

The four pins have a diameter of 0.5mm, 1mm, 2mm and 3mm.

FUNCTION INTEGRATION

Moving elements such as the lock hanger can be printed together in one pass. The movement can be released after support removal.



OVERHANG 15° to 60°

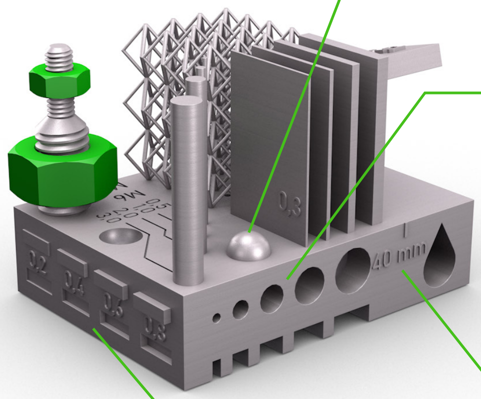
The overhangs on the component are 15°, 30°, 45° and 60°. Support is usually provided up to an angle of 45°.

SURFACE AS PRINTED Ra < 11µm

The unmachined, unblasted surface has a surface roughness of less than 11µm.

WALL THICKNESS 0.3mm to 1.5mm

The four walls have a thickness of 0.3mm, 0.5mm, 1mm and 1.5mm.



STAIR EFFECT

The extent of the stair effect depends on the layer thickness. Basically, the lower the layer thickness, the less the stair effect.

HOLES & HORIZONTAL OVERHANGS 1mm to 5mm

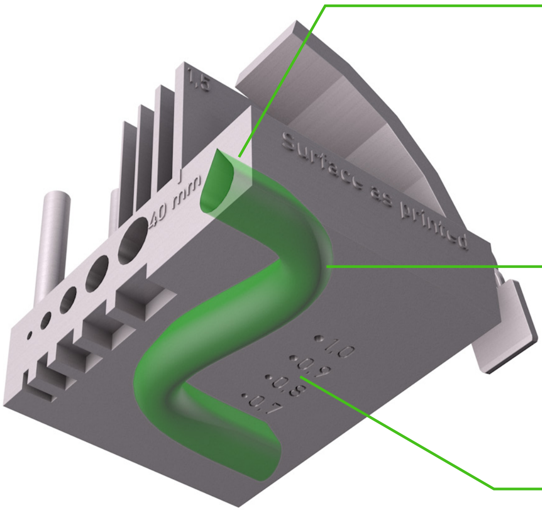
The holes as well as horizontal overhangs have a diameter of 1mm, 2mm, 3mm, 4mm and 5mm. In the horizontal 5mm overhang supports were removed in the finishing process, therefore the overhang surface is finer at this point.

DIMENSIONAL ACCURACY < 0.1mm

With our component length of 40mm, the deviation is less than 0.1mm. A typical deviation is usually between 0.2% and 0.4%.

EMBOSSINGS 0.2mm to 0.8mm

The embossings both inwards and outwards are 0.2mm, 0.4mm, 0.6mm and 0.8mm. Basically, the stronger the embossing, the more critical the overhang.



DROP SHAPE 5mm

The drop-shape of the hole with a diameter of 5mm has a self-supporting function. This means that no support structures are necessary.

PASSAGE CHANNEL 5mm

The drop-shaped and support-free passage channel can be flexibly adapted to any component geometry.

INTERNAL CHANNELS 0.7mm to 1mm

The smallest internal channels have a diameter of 0.7mm, 0.8mm, 0.9mm and 1mm.