VELO 3D

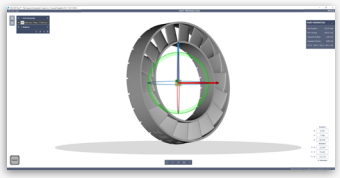
Innovator's Guide to Metal AM Part Selection

How to Select Parts for VELO3D SupportFree™ Manufacturing

The VELO[3D] manufacturing solution is an end-to-end metal additive manufacturing solution centered around the Sapphire® family of printers, and features a fully integrated pre-print software, Flow™, and a layer by layer quality control software, Assure™.

The VELO[3D] manufacturing solution uses the same software, processes, and materials across the entire portfolio of Sapphire® printers.

Complete End-to-End Solution



Flow™

Print Preparation Software

Sapphire®

Metal AM Family of Printers

Assure™

Quality Validation

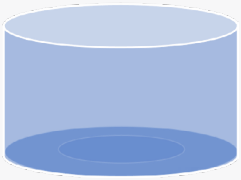
3 Available Build Volumes

Sapphire®

315mm Ø x 400mm z

Sapphire® 1MZ

315mm Ø x 1000mm z



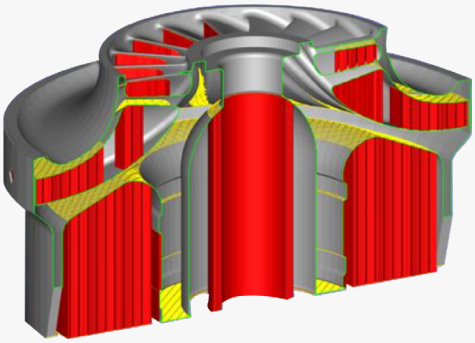
Sapphire® XC

600mm Ø x 550mm z

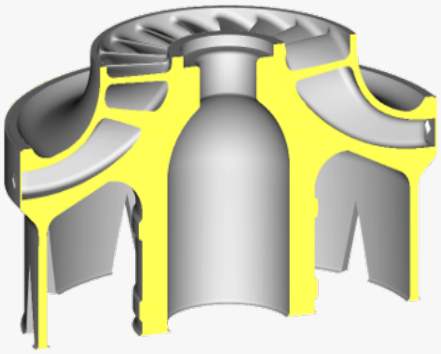
SupportFree Means Design Freedom

Our SupportFree™ process allows for more geometries to be printed with little to no post-processing. Rather than a parameter set that is blind to the specific geometric features of a part, our software intelligently applies the optimal process selected from a library of standardized process recipes.

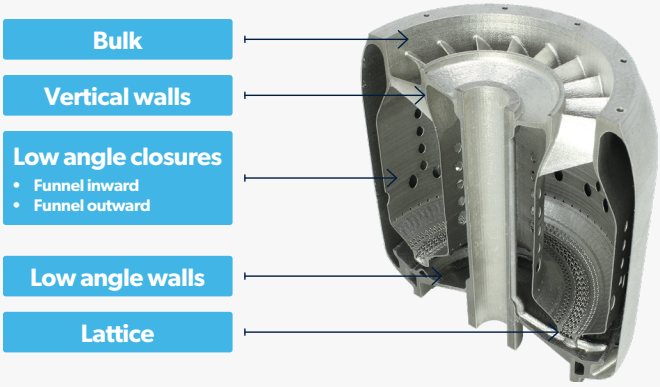
This fully automated analysis breaks down a given part into separate features and categorizes them, assigning the most appropriate process to each geometry. For example: A process that is optimized for a 30-degree overhang is no longer optimal at 20 degrees.

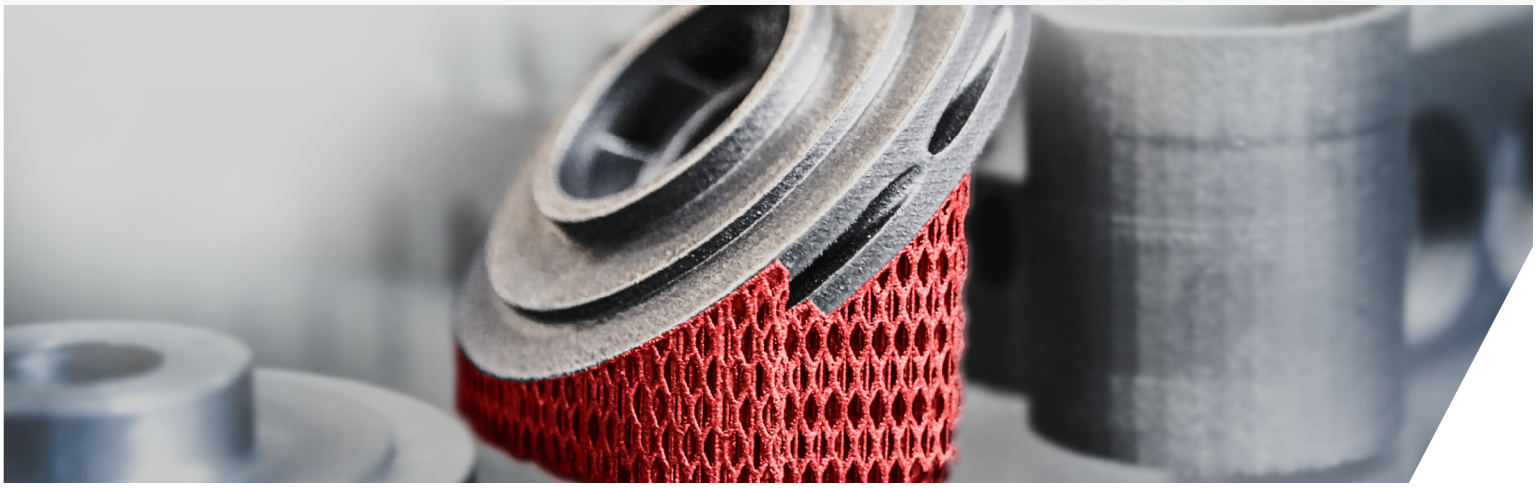


Conventional AM



VELO3D SupportFree™ Process





Opening a New Category of AM Possible Parts

This enables engineers to print more parts without supports, complex orientation rules, or redesign, and without needing to manually customize the parameter set for individual parts.

The biggest problem in metal AM today is that ~95% of parts require support in order to successfully complete the build. For many parts, especially on parts optimized to control fluid flow or heat transfer, support removal becomes its own separate engineering project. In these cases, the machine operations to remove the supports are complex (if even possible). You wouldn't produce parts this way in volume – it introduces too many variables, adds cost, and makes quality control a challenge.

The Market for AM Has Expanded

The VELO^{3D} SupportFree™ system enables manufacturers to print more legacy parts without the need for supports.

Qualified Materials

- **Nickel:** Inconel® 718, Inconel® 625, Hastelloy® C-22, and Hastelloy® X
- **Titanium:** Ti-6Al-4V Grade 23, and Grade 5
- **Aluminum:** F357, Scalmalloy®

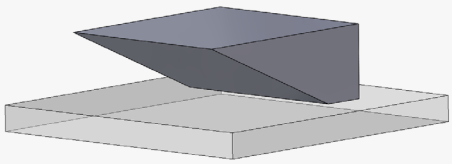
More materials coming soon including:

- **Copper:** GRCop-42
- **Nickel:** Haynes® 282®
- **Stainless Steel:** CA6NM

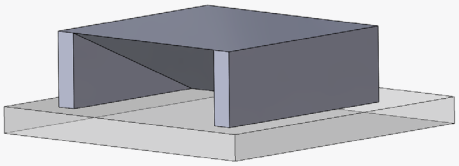
Zero Degree (Horizontal) Overhangs

When evaluating a part for support-free printing, angles matter. Let's look at one type of geometry and see how a seasoned engineer would evaluate it. For an unconstrained plane, if the wedge is above 18 degrees, the part can be printed without supports, regardless of height. Below about 10 degrees, the part is more challenging and should be supported.

However, the case is different for a constrained plane (a plane with more than one wall constraining it). Constrained planes are more stable at lower angles. The need for supports on parts down to zero degrees, can often be eliminated with SupportFree™ process conditions.

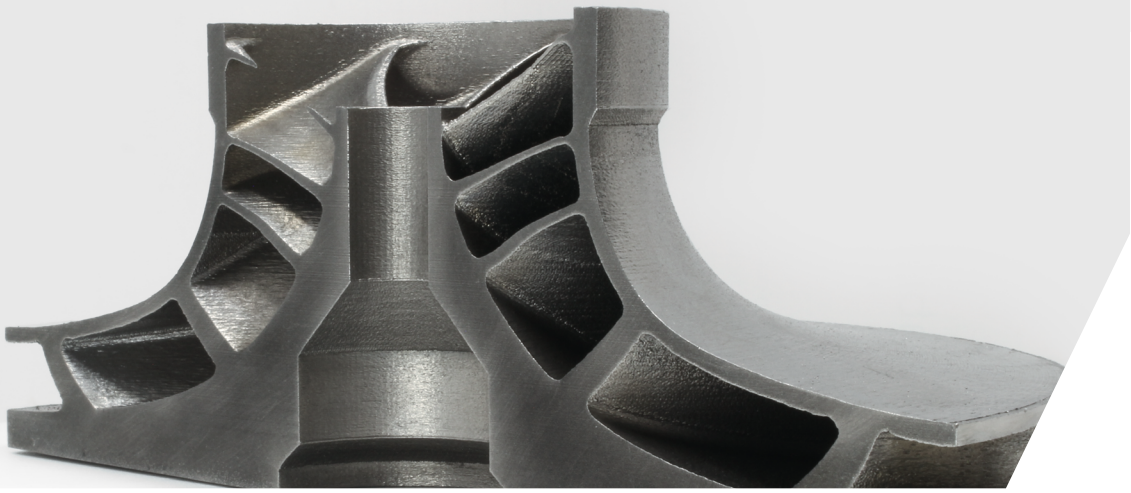


Unconstrained Plane



Unconstrained Plane

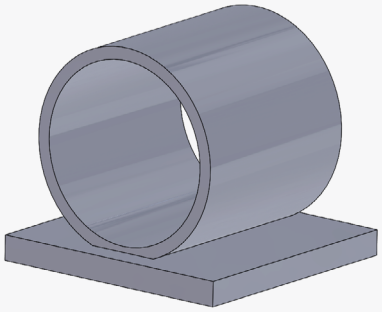
Zero Degree Overhangs



*Qualified materials subject to change; VELO^{3D} regularly introduces new materials. See our website for the most up to date information: velo3d.com/resources

Circular Holes up to 100mm

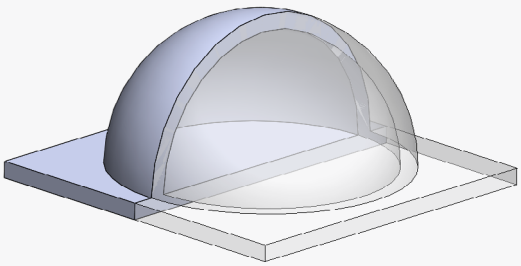
When building a part with a horizontal hole (i.e. the axis of the hole is parallel to the build plate), it is possible to build inner diameters ranging from as large as 100mm all the way down to 500µm with Sapphire®. If the geometry requires a larger inner diameter, the engineer can tilt the part by as little as a few degrees and expand that limit by more than two times. Similarly, once an engineer tilts the part, they can print features down to 300µm inner diameter holes.



Inner Diameters

Domes

Many engineers have learned through experience that domes or similar closures are not worth their time in additive manufacturing. The supports they tend to require can be essentially impossible to remove without compromising the part, putting the manufacturer in a catch-22: if they don't use supports, they suffer build failure, if they do use supports, they suffer from poor surface roughness. Our SupportFree™ processes change that equation. We can create enclosed domes with an interior diameter of more than 150mm without supports. The VELO3D system makes dome closures viable for AM in a way that they simply weren't previously.

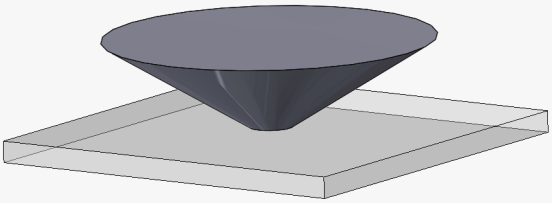


Enclosed Dome

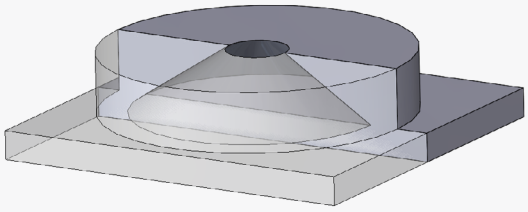
Conical Surfaces

Conical surface stability is more variable than plane stability. When analyzing a downward-facing surface that is conical, the key factor is whether the cone has a smaller diameter at the bottom, or at the top – does it grow inward, or outward. As a layer is printed and the metal cools, the circular cross-section contracts circumferentially. On an outward growing cone (wider on top), this can warp the outer edge upward. This can be problematic starting at around 25 degrees, depending on the height, and can require supports at angles of ten degrees or lower. Above 30 degrees, these cones are stable and can be built without supports.

Inward growing (wider on bottom) cones are more stable and are stable at any angle down to nearly zero degrees. The stress from the circumferential contraction acts as a constraint to the geometry, increasing stability.



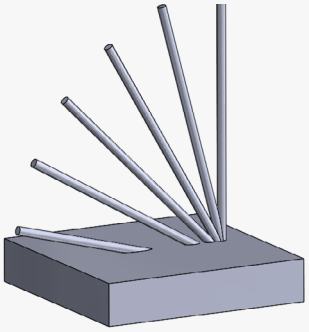
Outward Growing



Inward Growing

Thin Pins and Thin Walls

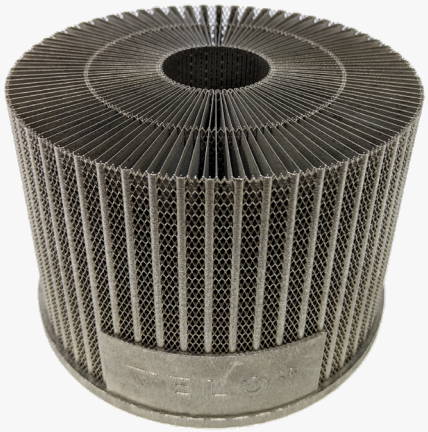
Thin pins and thin walls are common part components, and for parts as elemental as these, every micron matters. For the low angles (15 degrees), we can build pins as thin as 190µm in diameter, but as the part becomes more vertical, it can be thinner, down to 150µm. Thin, leak-tight walls can be as thin as 325µm and down to 150µm – if not leak tight – about half the thickness of a typical playing card.



Low Angle Pins

High Aspect Ratio

One of the benefits of Sapphire®'s recoater is an improved aspect ratio capability. We are able to print very thin walls, down to around 150µm. Importantly, even at this thickness, we have the ability to print to full z-height. This gives the VELO3D Sapphire® the unprecedented ability to print aspect ratios of up to 6000:1.

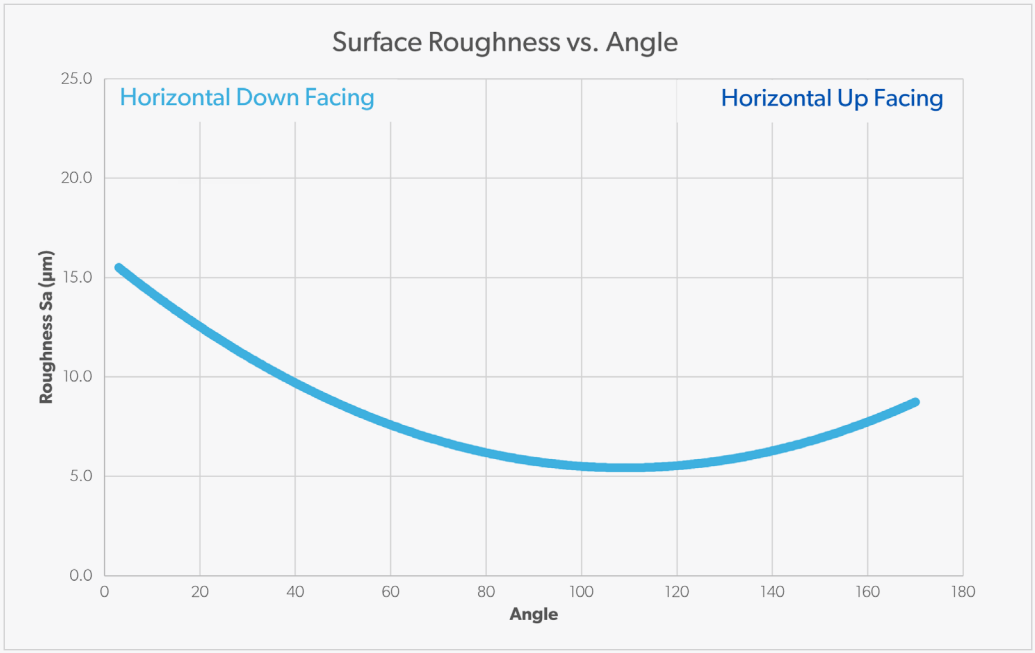


Make More Parts with Less Roughness

The surface finish on SupportFree™ surfaces will almost always be better than surfaces where the supports have been removed. As is true with almost every additive manufacturing modality, surface roughness is a function of surface angle.

While these variations matter, the overall trend is one of control and predictability: roughness is kept within a low, tight range, yielding part consistency to enable post-processing repeatability.

Note: (If you are more accustomed to roughness average (Ra) measurements, Sa is the area analogue to Ra, and produces measurements that are similar or a bit higher than Ra.)

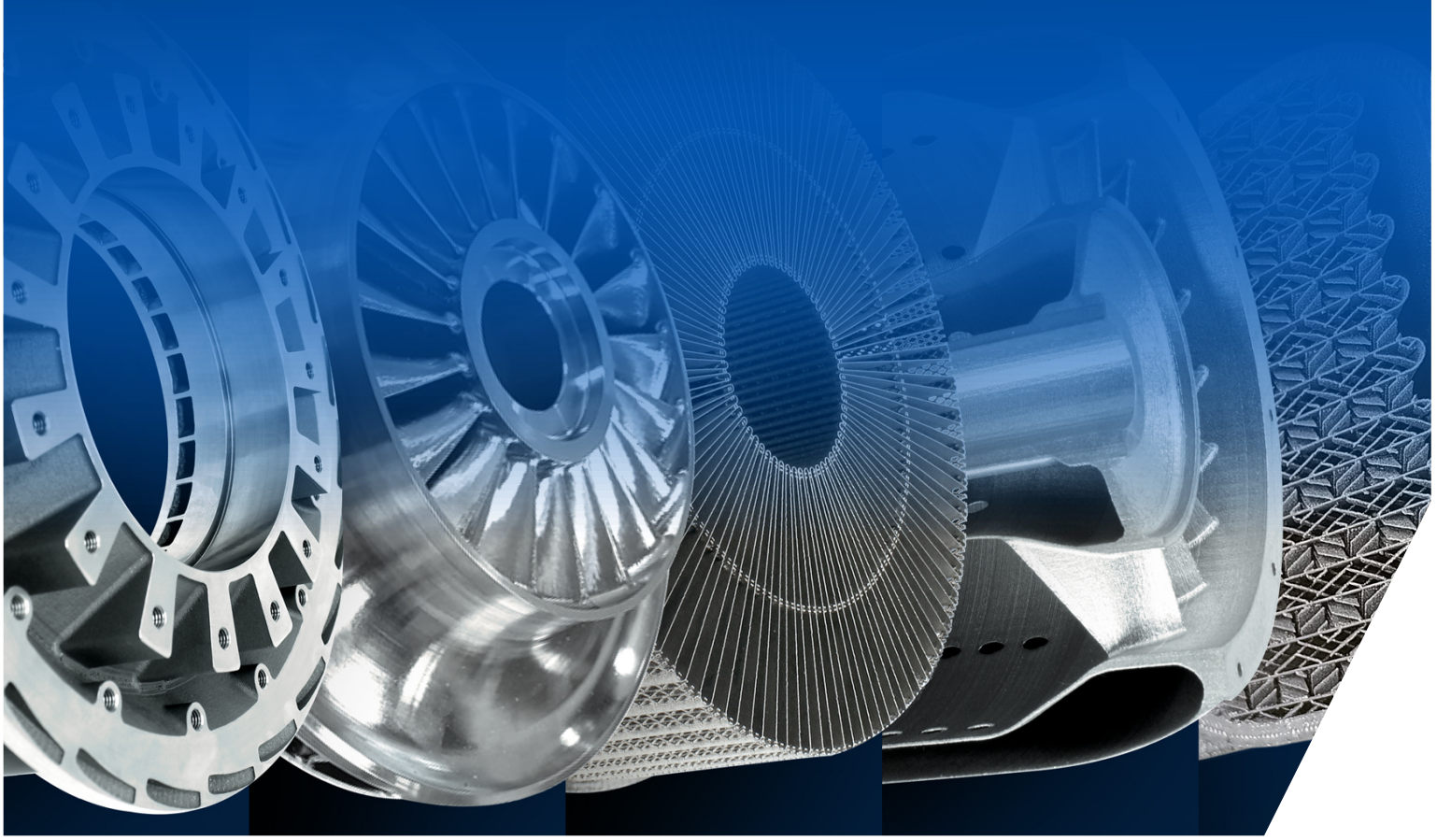


Putting It All Together

By knowing the capabilities of the VELO^{3D} metal additive manufacturing solution using our SupportFree^{TM} technology, engineers can fully optimize their new designs or produce existing designs with a more agile supply chain. Understanding which geometries are more problematic is key. With greater geometric freedom and improved quality control, the move to production AM is inevitable.

SupportFree^{TM} means that you are ready to print faster, with quicker development times and improved quality.

It's easy to unlock Metal AM for your Company. Our proven process can help you find the right, first part to begin production. Contact VELO^{3D} to unlock the power of our SupportFree^{TM} manufacturing solution today.



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