



stratasys
direct

Selective Absorption Fusion (SAF[®])

Design complex parts with a 3D printing
technology that doesn't require support structures.

SAF
Design Guide



Contents

Introduction	3
What is Selective Absorption Fusion (SAF)?	3
SAF design considerations	4
Advantages of SAF	4
Design guides	5
Complex structures	5
Hollow geometries	5
Hole and negative features	5
Bounding box	6
Bounding density	6
Part hollowing	6
Fine features	7
Upstands and columns	7
Interlocking parts	7
Text and labels	7
Limits and fits	8
Clearance fits	8
Cantilevers and filleting	8
Screw threads	9
Application examples	10
Finishing	11



What is SAF 3D Printing?

Stratasys SAF technology is an industrial-grade additive manufacturing solution that delivers production-level throughput for end-use parts. SAF technology uses industrial-grade piezo-electric printheads that jet high absorption fluid (HAF) onto a powder bed to define the area in which to form the 3d-printed object. The powder bed is then exposed to infrared (IR) energy. The parts of the bed that have HAF have a higher emissivity, which allows it to absorb more IR energy than the surrounding powder. This selectively fuses the parts in a layer-by-layer process.

SAF has a unidirectional print process, meaning that every layer takes the same amount of time between fluid deposition, energy application, and powder recoating regardless of each part's location in the bed or its complexity. The unidirectional print process and advanced thermal control allow for an industry-best nesting density (the total volume of parts divided by the available building space). This enables the manufacturing team to maximize space and put multiple types of geometries together in a build. This makes SAF cost-effective when manufacturing hundreds or thousands of 3D printed end-use parts.

The parts are supported during the printing process by the powder itself, and once the parts have finished building, they must cool to room temperature. The parts are then removed by hand from the powder and cleaned off with compressed air and media blast, and unfused powder is able to be recycled into the next build which helps lower costs.



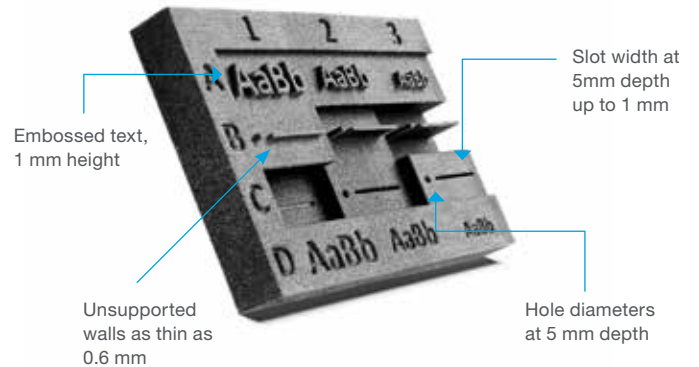


SAF Design Considerations

SAF Feature Capabilities

Made for the manufacturing industry, the entire SAF platform is built around repeatability and reliability. The powder is added to each layer through a proprietary Big Wave process. This ensures that each layer reliably has enough powder regardless of how much is printed on that layer. SAF's unique thermal management powder deposition produces consistent parts even on fine feature details, flat areas and large parts.

The unidirectional print process and advanced thermal control allow for an industry-best nesting density (the total volume of parts divided by the available building space). This enables the manufacturing team to maximize space and put multiple types of geometries together in a build.



Advantages of SAF 3D printing

Production

- **No supports needed:** Create dimensional complexity unconstrained by the need for supports due to the surrounding unfused powder.
- **High nesting density** Leverage batching to produce several parts all at once, nested together tightly in one build.
- **Lower cost per part:** Complexity is free with SAF. Consolidation of assemblies and nesting parts maximizes your budget.

Materials

- **Strong and impact resistant:** Stratasy Direct offers sustainably derived high-performance polymers that produce highly accurate, repeatable parts.

Design

- **Consistent part production:** Each layer is reliably laid down with enough powder regardless of how much is printed while utilizing a thermal control system that guarantees part repeatability with every build.
- **Internal features:** Achieve parts that are difficult using other technologies, including models with internal voids such as manifolds with cooling channels.



SAF Design Guides

Complex Structures

Parts with lattices or complex internal structures may be built without additional difficulty. An example is the gyroid shown here.

SAF technology also allows parts with internal voids, such as parts with cooling channels, to be built. However, when building complex structures or parts with internal features, powder removal must be considered.

As the SAF technology self-supports by using unfused powder, parts must be designed appropriately so that any unfused powder can be removed using compressed air or glass media.

Hollow Geometries

Geometries intended to be hollow must not be completely sealed. Otherwise, powder from within will remain inside the completed part. For example, when designing a hollow box, at least one hole must be included in the design so unfused powder can be removed.

Hole and Negative Features

- **Tubes:** Pay special attention to the width of tubes. If a tube is too narrow, the powder will be difficult to remove. If the tube is large enough, building a removable chain within the tube may help with powder removal. Once removed, the chain will create a channel within the tube through which air or glass beads can flow. This makes powder removal much easier. Typically, once such an airway is established, the powder can be removed.
- **Through Holes:** Powder removal is easier if holes are built using Z as the primary axis. This creates a slight problem as it is not the best orientation for optimum accuracy. It is recommended to build holes with a diameter of at least 1 mm (0.04 in.). If powder cannot be removed by air or glass media, use an appropriately sized drill bit.
- **Blind Holes:** As with through holes, a wider diameter allows for a deeper hole. Powder removal is easier if the primary axis is in the X or Y plane rather than Z. If powder cannot be removed by air or glass media, use an appropriately sized drill bit.



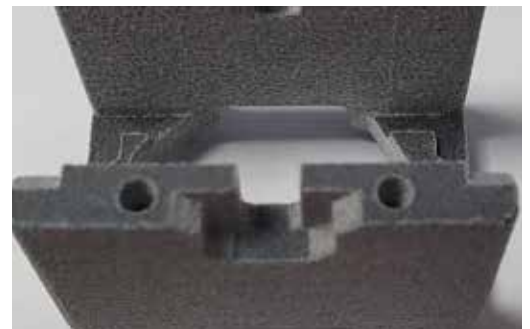
This gyroid has been chemically smoothed and dyed.



Tubes allow for easier powder removal.



Example of through holes.



Example of blind holes



Bounding Box

The bounding box is the maximum part dimension on each axis, and the bounding box is always rectangular. It is possible to overlap the bounding boxes when nesting parts without the parts colliding.

Bounding Density

Build density is the percentage of the build volume occupied by parts. Therefore, the nesting density is highly dependent upon the type of parts. Using single parts with the same volume as an example, a single solid part will have a higher nesting density than single a hollow part.

- Part volume: 13,435.50 mm³
- Bounding box volume: 49,107.50 mm³
- Relative to the bounding box, this part has a density of 27.4% The same principle is applied to all the parts contained in the build volume.
- Maximum Hot Bounding Box: 315 x 208 x 293 mm

$$\text{Build} = \left(\frac{\text{total part volume}}{315 * 208 * \text{build height}} \right) * 100$$

During this stage, two competing effects are present:

- Shrinkage, which makes the parts smaller
- Wall growth, which makes parts bigger

Both must be correctly compensated for to ensure the final parts are dimensionally accurate. Dimensional accuracy is typically best in the XY plane. Thus critical dimensions should be built in the XY plane if possible.

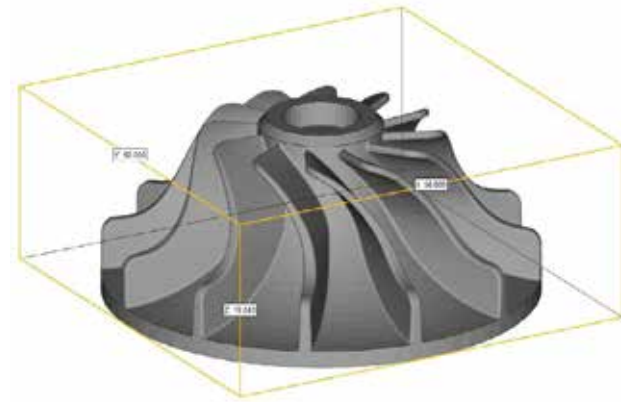
1. Overall part accuracy: X and Y dimensions are typically more accurate than Z. Therefore, critical dimensions should be built in the XY plane if possible. For example, hole to hole centers will be more accurate if built flat.
2. Circularity: Holes and other circular features have a higher degree of circularity when built in the XY plane. This contrasts with orientating for optimum powder removal.

Part Hollowing

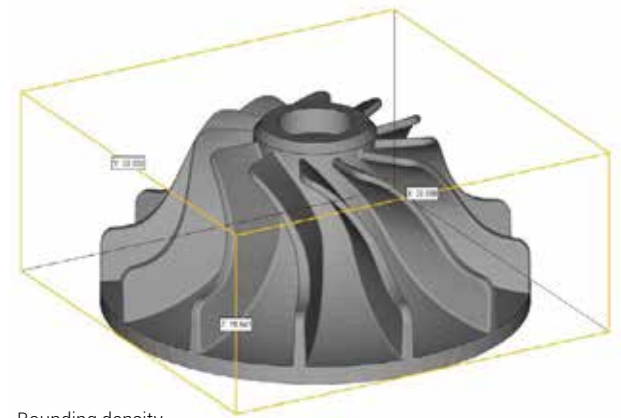
Large, blocky parts can be built as is or may be hollowed to make the part lighter.

- Wall thickness (once the part is hollowed) should be at least 2 mm (0.08 in.).
- Powder removal:
 - A hole should be added so powder from inside the walls can be removed. A single hole will restrict airflow and make powder removal more difficult, so two holes are recommended:
 - First: inlet.
 - Second: outlet.

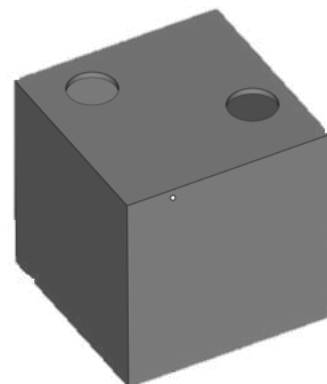
Air or glass beads can now be blown into the inlet hole and out of the second.



Bounding box



Bounding density



Hollow part



Fine Features

Feature resolution is dependent on the part and geometry; however, the following can act as a guide.

Features such as up-stands and columns can be built as small as 0.5 mm (0.02 in.). The key consideration for such small features, depending on the aspect ratio, is whether or not the powder can be removed without the feature breaking.

Although they can be successfully built, small up-stands with a large aspect ratio are very delicate and easily broken. To optimize strength and aesthetics, small features and thin walls should be oriented downward. The width of long walls can be increased to reduce their aspect ratio and make the part more resistant to breaking.

It is important to note that the limiting factor is the powder particle size, not the resolution of the printhead. Average powder particle size is 50 microns. Very small features can be built, but are unlikely to survive unpacking and depowdering.

Upstands and columns

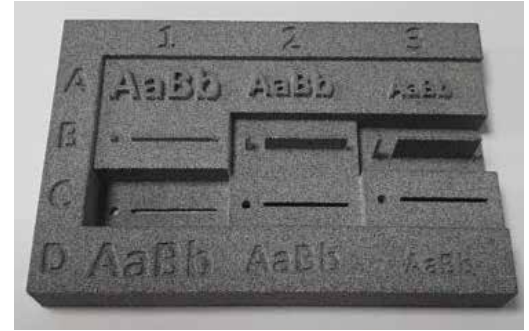
Small features such as upstands and columns can be built as small as 0.6 mm (0.024 in.). The recommended minimum wall thickness is 0.6 mm. Pins and upstand should also have a minimum diameter of 0.6 mm (0.024 in.). To avoid a feature breaking while powder is removed, and to optimize strength and aesthetics, small features and thin walls should be placed upside down.

Interlocking Parts

It is possible to print interlocking, moving, or assembled parts. However, the individual parts that constitute the assembly must have a gap between them. If two parts interlock, the individual components must have a gap of at least 2 mm (0.079 in.). Otherwise, they will fuse.

Text and Labels

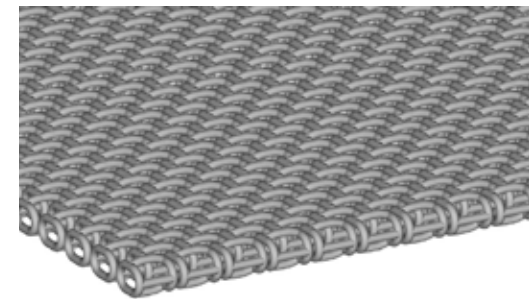
Text or labels that are engraved or embossed may be placed on any surface. A minimum font size of 8 point and a height or depth of 0.5 mm is recommended. Generally, embossed text has the most clear definition when placed on a downward facing surface. Engraved text usually looks best on side walls or upward facing surfaces.



Text and labels



Ducting with walls as thin as 1.5mm



Interlocking parts



Limits and Fits

The application requirements govern the type of fit. Different fit types require different clearances. Ensure an appropriate clearance between parts so they fit together.

Clearance Fits

The clearance on the 2-piece electrical connector shown here is 0.1 mm. This gives an appropriately tight fit when the parts are initially joined together.

Tight fitting parts loosen over time due to repeated use.

The buckle shown here has a clearance of 0.15 mm (0.006 in.) between the male and female parts.

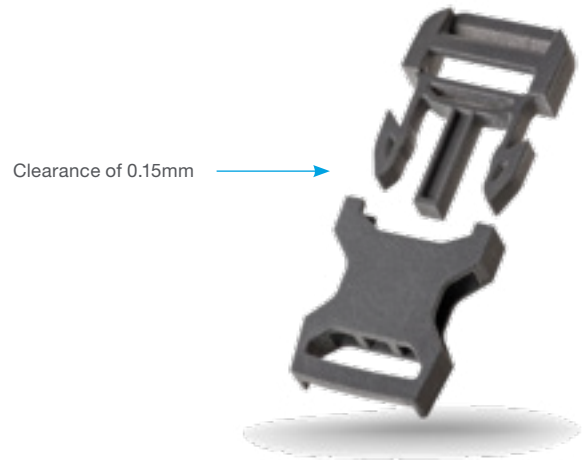
Cantilevers and Filleting

Features such as up-stands and pins are often prone to breaking at the base. This is because stress is concentrated on sharp features. These stresses can be mitigated by adding fillets as shown below. This is a well-known way to strengthen features that are prone to breaking.

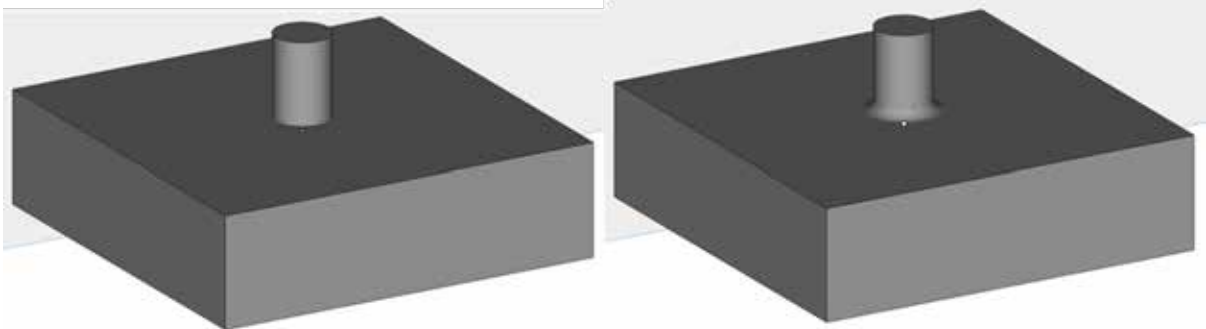
Recommended minimum shaft diameter for 10 mm (0.039 in.) height is 0.75 mm (2.95 in.). Features like this are more robust when built upside down.



← Clearance of 0.1mm



← Clearance of 0.15mm



Upstands and fillets



Screw Threads

SAF is capable of building integral threads size M4 and larger. Place threaded features horizontally if possible. Other design considerations, such as changing feature diameter based on print orientation or modifying the applied offset, might be possible if a threaded feature needs to be printed vertically.

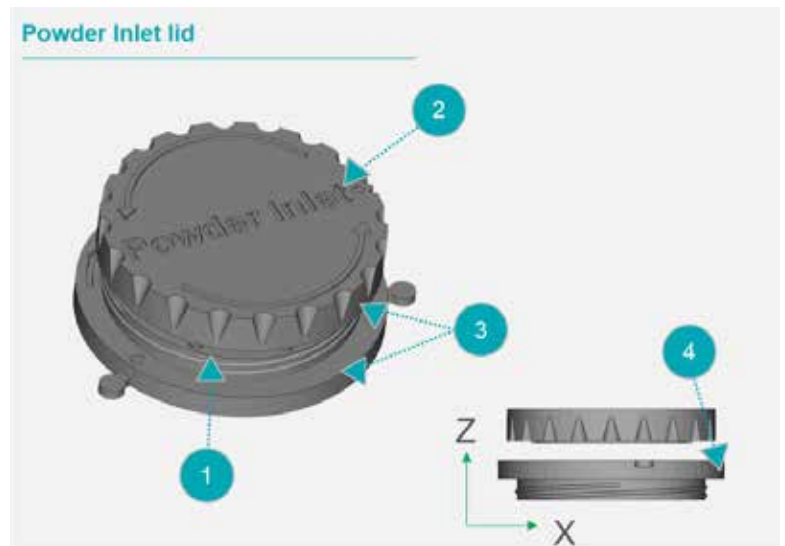
Application requirements:

1. Adequate resolution to print the thread.
2. Top face is the most important surface.
This is where the text and arrows must be well defined and legible to users.
3. Circularity is important for fit and function.
4. Orient the lid and screw base with the text and arrows face down in the build.

The powder lid and screw base are oriented face down in the build volume. This gives a smooth, even surface with well-defined text and arrows, and results in having the required resolution on the side walls to create a well-defined thread. This orientation also gives the best circularity as printing in the XY plane always results in the part being more circular. The two mating parts are positioned concentrically on top of each other. However, due to the accuracy and repeatability of SAF across the build volume, this is not necessary to ensure both parts screw together.



Screw threads



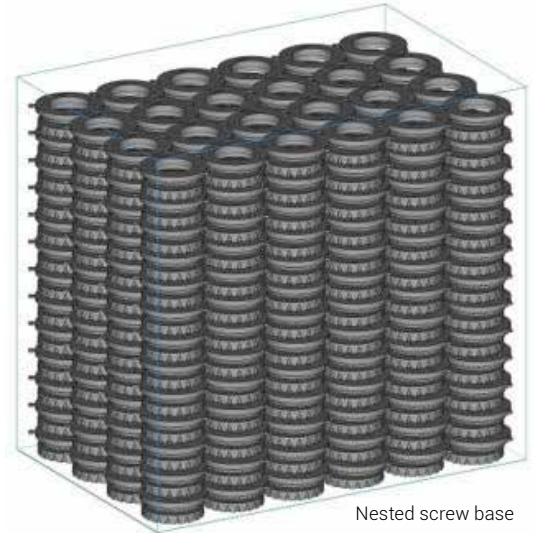
Application Examples



Nesting Example

Nesting refers to arranging parts inside the 3D space of the build chamber. Higher nesting densities are more productive and reduce part cost (per cm³). The primary issue caused by printing very high nesting density builds is degradation of the powder. Very high nesting densities cause a thermal aging of the powder. This affects its colour, flowability, and the mechanical properties of the printed parts.

For the example at right, the part geometry allows packing at a high nesting density of 22%. This is very high for any powder bed fusion technology and is enabled by the unique thermal control of SAF Technology.



Nested screw base

Fine Features Example

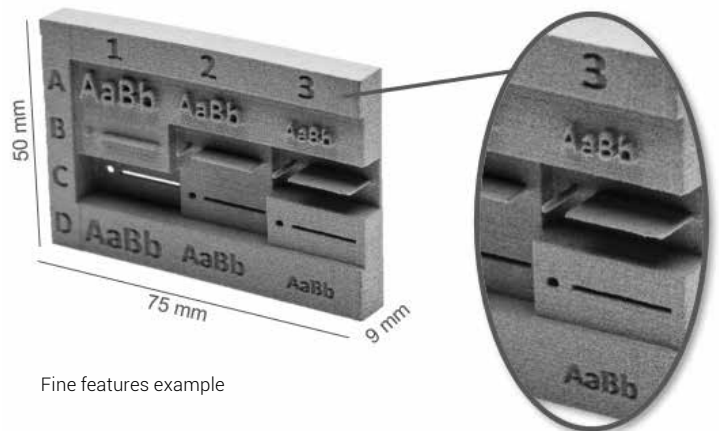
Feature resolution is part, geometry, and material dependent. Under certain conditions, it is possible to go beyond the guidelines shown in the zoom image. The item in the zoom image has a 0.4 mm thick wall, 0.4 mm wide fin, and 0.5 mm wide slot.

- Embossed text: Font calibri, bold, 1 mm height, size 14, 11, 8
- Pin: Ø 1 mm, 1, 3, 5 mm tall Fin: 9.5 x 0.4 mm, 1, 3, 5 mm height
- Hole: Ø 1 mm, 1, 3, 5 mm depth Slot: 9.5 x 0.5mm, 1, 3, 5 mm depth
- Engraved text: Font calibri, bold, 0.5 mm depth, size 14, 11, 8

- 624 parts (312 pairs)
- 22% build density
- 274.5 mm (10.8 in.)
- Volume – 4,016cm³ (245 in³)
- Time for printed layers only ~ 9 hours
- Time taken to nest: 15 minutes

Recommended minimum feature sizes

Minimum font size engraved or embossed	8 pt
Hole diameter at 5 mm depth	1 mm
Slot width at 5 mm depth	1 mm
Minimum shaft diameter at 10 mm height	0.75 mm
Minimum wall thickness	0.6 mm
Clearance between parts	2 mm



Fine features example



Finishing SAF Parts

Finishing a part depends on the application in which the part will be used. Many parts will not require any further finishing. For the parts that require further finishing, many options are available. Finishing can turn a good part in to a great one.



Finishes left to right: Unfinished part, media blasting, dyed, tumbled and vibratory finished

Media Blasting

Smoothing the surface with media propelled by compressed air achieves a more homogeneous surface quality. This can be done using a manual bead blaster or in an automated system such as the DyeMansion Powershot S.

Tumbling and Vibratory Finishing

Parts can be tumbled or vibrated with media such as ceramic, plastic, porcelain, or sand. Both tumbling and vibrating give a very smooth surface finish. However, sharp features may become rounded and fine details may be reduced.

Sanding

If surface texture is rougher than desired, the parts may be smoothed using fine-grit, wet or dry sand paper (or abrasive pads), and lightly sanding the surface.

Drilling

If the diameter of a hole is too narrow, increase the diameter by drilling through the current hole with a larger drill bit. Drilling may also be helpful in removing powder from a negative feature.

Dyeing

Parts may be dyed using commercially available equipment, or they may be dyed using improvised equipment such as a hot water urn or a pressure cooker. If an unfinished part that has not been smoothed is dyed, the final surface will be matte rather than glossy. If a glossy surface is required, the part should be smoothed before dyeing.

A hot water urn similar to the one in the following image, can be an excellent improvised dyeing tank.

Immerse the parts in the boiling liquid for 30 minutes. After this, the parts can be rinsed and dried. After rinsing, dye residue may be left on the surface of the parts. Remove the residue by wiping with an alcohol wipe.

When dyeing parts, it is important that the part surfaces are clean of any unfused powder, debris, grease, oil, or fingerprints.

Vapor Smoothing

Another option for reducing layer lines on SAF parts is a process that exposes part surfaces to vaporized solvent in order to produce a glossy finish. The post-processing solution is ideal for projects where fine features and dimensional accuracy is critical.



Accelerate Your Next Project with Stratasys Direct

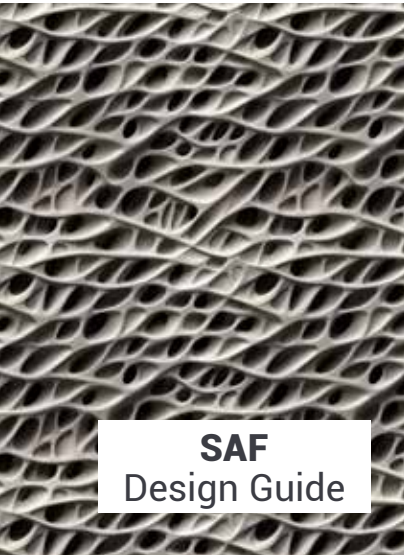
Precise parts result from more than machine operations; they take a team of experts dedicated to the technology. At Stratasys Direct we work to validate all methods and materials in order to ensure perfect parts, every time.

Stratasys Direct has more than thirty years in the industry and a team of engineers ready to assist with every step of your project. Being a part of the family that invented SAF technology means we're backed by Stratasys' strong commitment to R&D. Our in-house SAF experts are constantly exploring new applications and possibilities alongside the Stratasys team.

- AS9100 certified
- ISO9001 certified
- DDTC/ITAR registered

For over 30 years, Stratasys Direct has harnessed cutting-edge AM technologies on real-world use cases, transforming design concepts into reality with precision, excellence, and customization in every 3D print. Through close collaboration with our customers, we are paving new roads that can shape the future of manufacturing.

[Learn more about SAF 3D printing and how our team can find custom solutions for your upcoming project.](#)



LOCATIONS: EDEN PRAIRIE, MN | BELTON, TX | TUSCON, AZ

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SAF
Design Guide

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