stratasys direct

Design Guide
FDM

FDM®
Design Guide

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Fused Deposition Modeling
Design Guide

These guidelines are to be used as a starting point in understanding the basic aspects of part design and preparation for FDM® components. FDM extrudes thin layers of molten thermoplastic layer by layer until a part is produced. Various layer heights are available depending on material and part wall thickness.

Design Considerations	Specifications
Max build volume*	Up to 36 x 24 x 36" (914 x 610 x 914 mm)
Layer thickness	0.005 - 0.020" (0.127 - 0.508 mm)

**Parts are not limited to the machine's build volume Stratasys Direct accurately bonds sectioned components together into larger parts and assemblies, saving time while not sacrificing accuracy.*

FDM Design Considerations

The following information builds from conventional plastic part design to explain design considerations for manufacturing high-quality FDM parts. Unlike many traditional manufacturing processes, FDM gives designers the freedom to design for the application, not the manufacturing process.

Warp

Our Stratasys FDM systems utilize a heated chamber, airflow and support material specific to the geometry at hand, warp is not a common problem like other open-air systems. Similar to injection molding, adding ribs will help avoid potential warping when thin-walled sections are present.

Shrinkage

Stratasys Direct engineers account for shrink rates during part processing, so it is not necessary to factor in shrink to the part design. Our in-house engineering staff refine our process to maintain dimensional fidelity. We review each geometry to ensure parts are accurate to the nominal specifications by providing standard quality checks for each part manufactured.

Key Feature Considerations

Holes

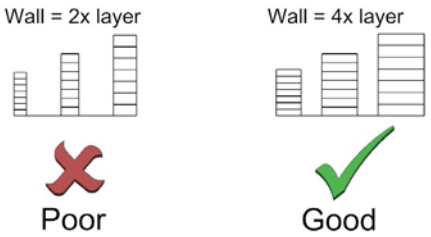
Holes, including those found in bosses, are generally fractionally undersized. Holes may feature an interior seam due to the starting and stopping point of each layer during the FDM build process. If requested or the drawing indicates critical feature tolerances, holes will be bored or reamed during post-processing to ensure accuracy of the diameter.

Columns and pins

Minimum pin and column size is dependent on part orientation, feature length and size of the tip being used on the FDM machine. Stratasys Direct utilizes customized FDM build settings, proprietary software and industry founding knowledge to maximize the build success of fine features. Minimum features can only be achieved in certain instances. Consult with your Stratasys Direct fulfillment service member.

Slice Thickness	Minimum Wall
0.005" (0.127 mm)	0.020" (0.508 mm)
0.007" (0.18 mm)	0.028" (0.72 mm)
0.010" (0.25 mm)	0.040" (1.00 mm)
0.013" (0.33 mm)	0.052" (1.32 mm)
0.020" (0.508 mm)	0.100" (2.54 mm)

**These are standard recommended minimums. Smaller features may be possible on a case-by-case basis. Please consult with a Stratasys Direct estimation engineer about critical features.*

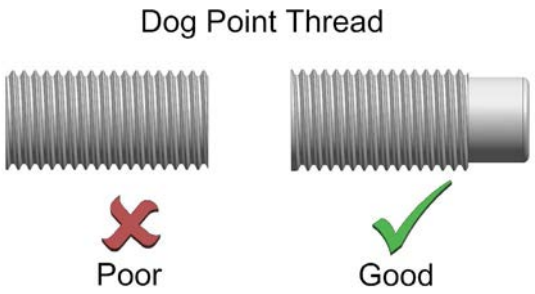


Wall Thickness

Minimum wall thickness for FDM parts varies and is contingent on the slice thickness used to build the part. Stratasys Direct encourages the use of the recommended minimum wall thickness (see chart).

Recommended minimum wall thickness is generally 4x the layer or slice thickness. For example, a part built with 0.010" thick layers would typically have a recommended minimum wall thickness of 0.040".

The wall thickness figures (left) are a general guideline for successful walls. Minimum wall figures will generally provide sufficient thickness for successful inside and outside walls that include interior infill. It is possible to achieve walls thinner than these recommendations on a case-by-case basis, with some geometries or features capable of building as thin as 0.008" (0.2032 mm). Consult with your Stratasys Direct estimation engineer about your project's specific needs and requirements.



Threads

When designing built-in threads, avoid sharp edges and include a radius on the root. Much like injection molding, sharp edges can be stress concentrators in plastic parts. Creating an ACME thread design with rounded roots and crests has been found to work well when using FDM.

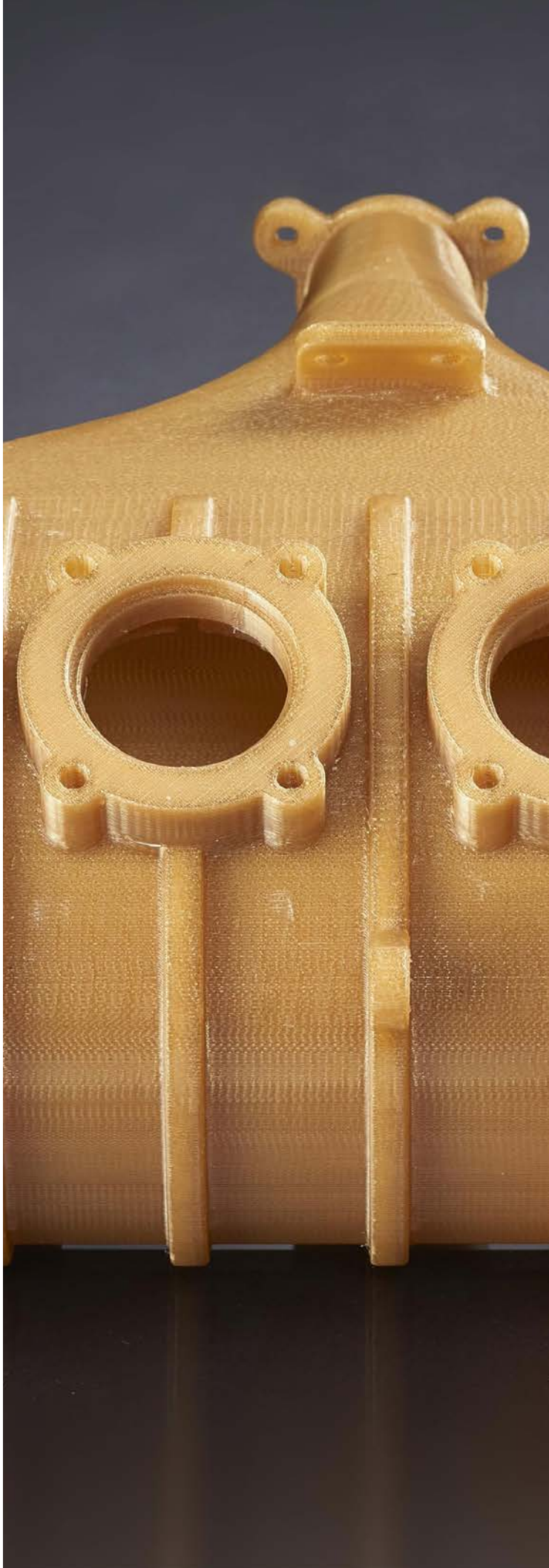
Also, use a **"dog point"** head of around 0.040" (1.0 mm) long. This dog point design makes building the thread easier when the thread is facing downward in the build chamber, encompassed with support. While it is possible to go smaller, a general rule of thumb for manufacturing is to avoid threaded holes smaller than 0.15", or columns/posts smaller than 0.08".

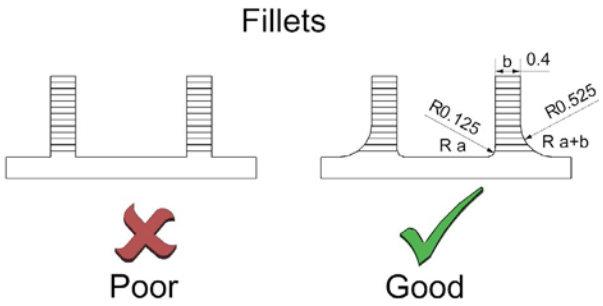
An easy alternative for the Stratasys Direct post-processing team is to use a tap or die to thread holes or posts after the build.

Hinges

Living hinges made from FDM materials can be used for a small number of cycles. If additional cycles are required, consider using a different hinge design.

FDM can build living hinges and multi-piece hinges as a single piece attached to your design in order to consolidate components and reduce part count. Alternatively, living and multi-piece hinges built separate from the main design can be attached during post processing. Hinges including butt, bi-fold, concealed and continuous are buildable due to Stratasys' proprietary soluble support materials, which allow them to be built as a single piece. Hinges are capable of gaining functionality after a short time in a soluble bath that dissolves the support structure, separating the [minimum] 2 components making up the hinge.





Draft angle and fillets

Draft is unnecessary in FDM parts, and is usually only required when parts are used as master patterns for urethane casting. There is no issue if your design already includes draft. FDM parts can be built with or without draft.

Although fillets are not necessary in FDM parts, they can reduce stress concentrations and increase the overall strength of the part.

Undercuts

Because FDM is an additive manufacturing process, undercuts for design features such as **O-ring grooves** are easily handled without causing manufacturing issues. As we like to say, ignore traditional design rules and design your part for its best functionality.

Bosses and ribs

Traditionally designed parts tend to have consistent wall thickness throughout the part, with features such as ribs added for strength. FDM parts can be designed solid rather than using a hollowed-out design supported by bosses and ribs, and this can reduce build time, lowering cost. It is important to use gussets or ribs to support the bosses in FDM parts in order to increase the amount of stress the feature can withstand. It is not necessary to reduce wall thickness of a boss, rib or gusset in FDM parts.

Text

Text is easily incorporated and a simple way to add value to part. Manufacturing jigs and fixtures often incorporate text for quick identification of specific features or for labeling purposes.

Monospace fonts at this size typically produce clear, legible text regardless of material, layer height and surface orientation. In most cases, the supports generated to support text on a vertical wall can be eliminated to save time and material.

We recommend a monospaced fonts

- Courier New,

in a bold font with 24+ point styling.

EX: Courier New

Secondary Operations & Assemblies

Size and orientation

A single, unbonded part can be built as large as:
36" x 24" x 36" (X, Y and Z)
(914 mm x 610 mm x 914 mm)

FDM is a popular choice for large parts and are not limited to these dimensions. Parts that measure beyond the size of the FDM build volume are built in sections and bonded together. To create large sectioned parts, the Stratasys Direct programming team will receive and section the customers' un-sectioned files. Sectioned parts will generally have a dovetail connection. Customers may choose to provide sectioned part files for incorporating custom features such as holes used for reinforcement from metal rods.

Build orientation is determined from many factors including features, required support material and cosmetics, and is usually determined by the Stratasys Direct programming team. Please indicate at the time of the quote if a specific orientation is required during the part build process.

Large FDM parts can also take advantage of lightweight structures inside the part. Internal structures enable light, less expensive and faster building parts, advancing time to market.

Mating assemblies

When creating a consolidated assembly, our estimation engineering team can help determine proper clearances for the project at hand.

Sufficient clearance is required between mating assembly parts to prevent them from fusing together during the build.

Suggested clearance is dependent upon the layer thickness used:

- 0.01" layers used, then use clearance of .01"
- If 0.013" layers are used, the suggested clearance is 0.13".

Consult with the estimation engineering team to determine specific assembly requirements for your project.

Sectioning parts

Parts may be sectioned (prior to manufacturing) in CAD, commercial rapid prototyping software applications or by the Stratasys Direct team. Sectioning can be used to:

- Build parts that are too big for the build chamber (cut parts into sections).
- Eliminate excessive amounts of support structure.
- Cut and separately build certain features to eliminate unnecessary support structures, reduce build time and preserve fragile features.

Fastening hardware

When using fastening hardware, we encourage the use of heat-staked inserts. As general rule of thumb for heat-staked inserts, the wall surrounding the insert should be a minimum of 0.080" beyond the outer diameter of the actual insert.

- **Stratasys Direct uses Dodge® Ultrasert® II** brass inserts unless otherwise indicated by the design.
- **Heli-Coils®** are another viable option for FDM parts when the previously stated wall thickness is not achievable.

Designers may also choose to use cap screws, flanged cap screws and washers. Lock nuts, embedded nuts and metal inserts are all stronger fastening options than adding threads directly to the FDM plastic.

Finishing and secondary operations

Since the FDM process uses engineering-grade thermoplastics, the parts produced are capable of withstanding a number of post-manufacturing processes, including machining operations such as:

- **Drilling and tapping**
- **Sawing**
- **Turning and milling**
- **Smoothing**
- **Burnishing**
- **Sealing**
- **Joining**
- **Bonding and painting.**

Our expert finishing team has decades of finishing experience and employ proven post processing methods to maintain part accuracy.

Design Review & Optimization

Expert Design Review for Manufacturability

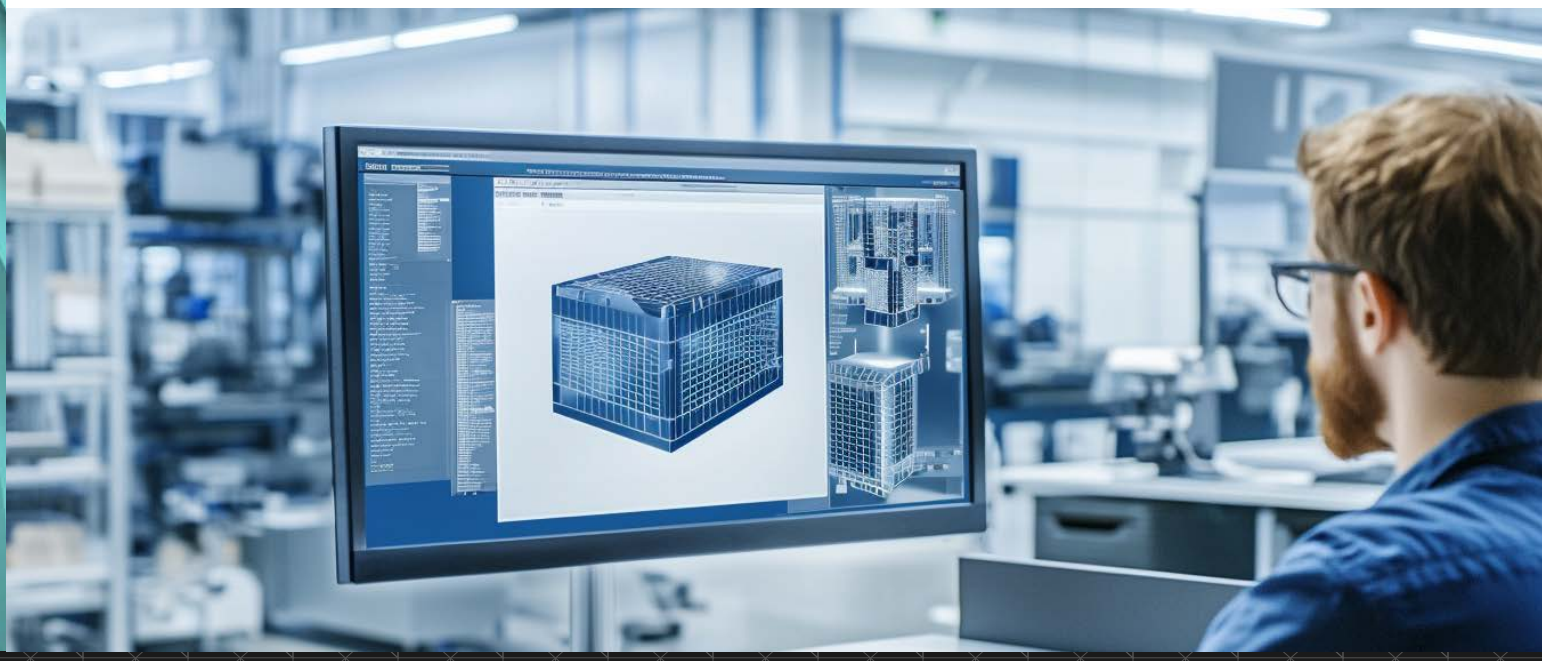
Our dedicated estimation engineers review every submitted part file with a focus on additive manufacturability. They identify potential problem areas and offer recommendations to improve design performance, printability, or efficiency—helping set your project up for success.

Should you choose to implement those changes, our design services team is available to assist with CAD file modifications upon request.

If you need assistance in making these suggested changes to your CAD file, our Design Services team can assist!

Ready with a project?
Get a quote

Talk to a manufacturing expert
Contact Us



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