REPORT

Form 3 Dimensional Accuracy Report

formlabs

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Introduction

For many designers and creators across a wide array of professions, such as engineering, manufacturing, dental labs hospitals, and more, Formlabs printers represented their first foray into the world of in-house stereolithography (SLA) 3D printing. In line with other manufacturing processes, it is important to understand the limits of 3D printing before beginning production.

The quality of end use parts in additive manufacturing can be evaluated with several metrics, one of which is dimensional accuracy. For some applications, such as dental surgical guides or jigs and fixtures, dimensional accuracy is paramount to whether the part is usable.

Formlabs created an internal test to determine the dimensional accuracy of the Form 3 and Form 3B. We tested two models, one with features under 50mm and one with features over 50mm. Importantly, we printed multiple parts per printer across multiple printers to highlight the Form 3's efficacy in repeatedly creating accurate parts.

The topline results are as follows:

The average deviations from the ideal, or exact, print size are small, ranging from 0 to 100 microns. The Form 3, printing in Grey Resin, demonstrates consistent accuracy across multiple prints and sizes, meeting the requirements for various manufacturing applications.

TEST PRINT SETUP	
Printers Used	Four Form 3s
Model Printed	Test models (photos below)
Layer Height	50 microns
Post Processing	Form Wash + Form Cure
Material Used	Grey V4 Resin
Software	Preform 3.9
Measurement Tool	Hexagon CMM with CMM Manager (Nikon Metrology)

Addressing Dimensional Accuracy

What impacts dimensional accuracy?

1. The 3D printer used to create the part (ex: there may be accuracy variations between printers).
2. The materials selected for the part.
3. How the supports are placed and removed on the part.
4. The post-curing steps taken after the parts are cleaned.

There are four ways Formlabs addresses dimensional accuracy:

1. **We developed Low Force Stereolithography (LFS)**, which powers the Form 3, Form 3B, Form 3L, and Form 3BL. LFS 3D printing uses a flexible resin tank to significantly reduce peel forces during printing, reducing stress on your part and enabling more accurate prints. Additionally, the light Processing Unit (LPU), our custom-designed enclosed optics engine, ensures a uniform laser spot size across the entire resin tank, producing consistent, accurate prints. For users, LFS delivers prints with impressive surface detail and fine features once impossible to achieve on the desktop.
2. **A portfolio of materials developed specifically for our SLA printers.** Formlabs offers a suite of engineering materials tailored to individual workflows, delivering professional level parts made to withstand extensive testing and perform under stress. Our materials are made by a team of renowned chemical engineers and rigorously tested to work across applications.
3. **Removal of supports can damage or leave markings on parts.** Formlabs has taken significant effort to make support removal easy and give users tools to reduce and customize supports in PreForm.
4. **Offer a consistent, automated workflow for peak performance.** Due to the importance of post-processing, Formlabs developed the Form Wash and Form Cure to automate 3D printing from beginning to end. Form Cure can be set to the optimal time for each material, ensuring they reach the desired mechanical properties.

Test Results: 1mm to 50mm Results

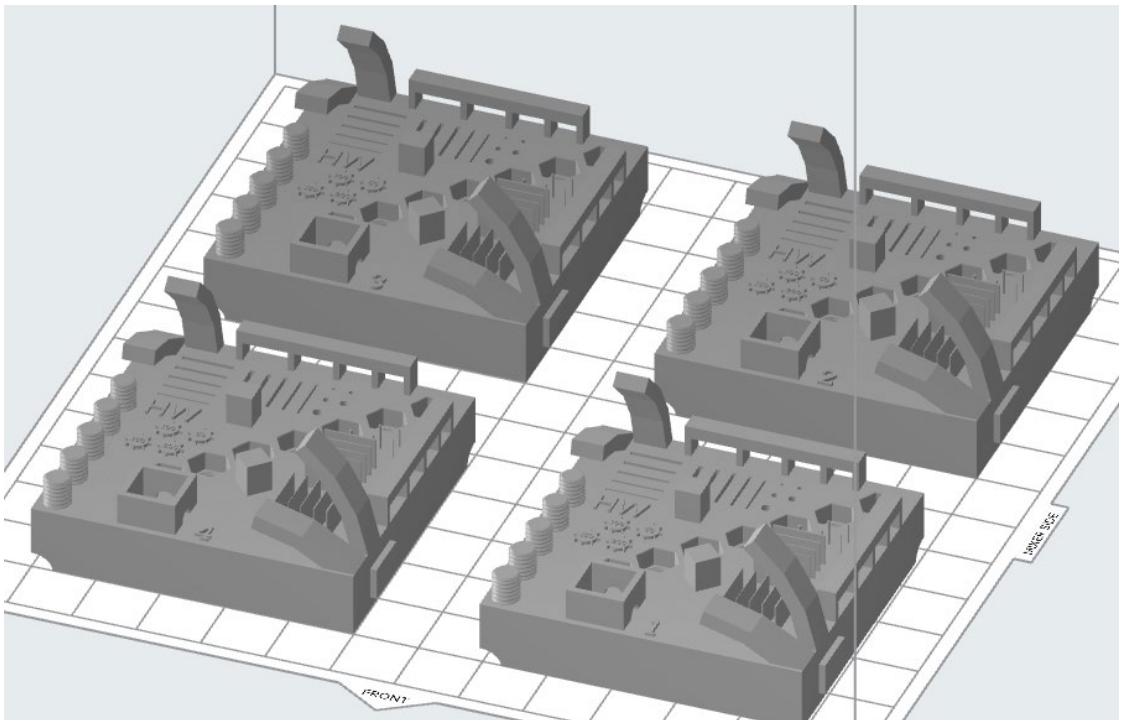

Figure 1

Figure 1 represents the first test print: a model of varying geometries with features ranging from 1mm to 50mm. These sizes represent the majority of parts printed on Formlabs printers.

Figure 1 shows the test print in PreForm. Each test contains two features for each 1 mm, 4 mm, 9 mm, 27 mm, and 50 mm dimension, measured in the XY direction. The table 1 details the average deviation from the ideal, or perfect, print for each intended feature size.

INTENDED FEATURE SIZE	AVERAGE DEVIATION FROM IDEAL (MM)	STANDARD DEVIATION (MM)
1mm	-0.02	0.03
4mm	-0.01	0.03
9mm	-0.01	0.03
27mm	-0.04	0.04
50mm	0	0.07

Table 1: Average size deviation and standard deviation results binned by intended feature size (n = 160 for 1 mm, 9 mm, 27 mm, and 50 mm features, n = 320 for 4 mm).

Table 1 shows how the Form 3 meets the accuracy requirements required for 3D printing applications. These results represent data accumulated over 160 test prints, meaning the printers are reliably accurate over a range of prints. Repeatability and stability are core requirements for manufacturing and dental workflows, and this result confirms the Form 3's suitability for these popular print sizes.

Test Results: 60mm to 130mm Results

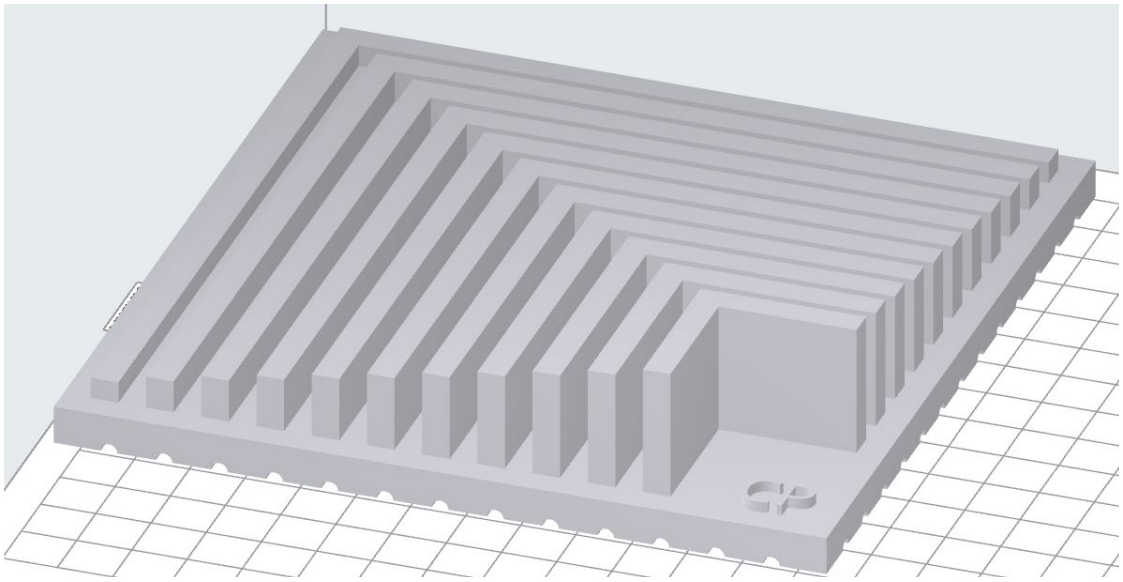

Figure 2

Figure 2 offers a look at a range of larger sizes, from 30mm to 130mm, increasing in increments of 10mm.

Our results are similar to those obtained by the smaller test print size in figure 1: the Form 3, printing in Grey Resin, shows little to no variation in size tolerance across a range of sizes. When these results are grouped by size, the data shows that the average deviations from the ideal are small, ranging from 0 to 100 microns.

INTENDED FEATURE SIZE	AVERAGE DEVIATION FROM IDEAL (MM)	STANDARD DEVIATION (MM)
60 mm	0.03	0.04
70 mm	0.00	0.04
80 mm	-0.01	0.06
90 mm	-0.01	0.07
100 mm	-0.05	0.09
110 mm	-0.1	0.1
120 mm	-0.1	0.1
130 mm	-0.1	0.1

Table 2: Average size deviation and standard deviation results binned by intended feature size (n=10 for every size feature).

Post Processing And Dimensional Accuracy

Every test print was washed for two 10 minute cycles in the Form Wash. Each wash was filled with previously used IPA to simulate a more realistic washing environment (>10% saturated with resin in wash one, <5% saturated with resin in wash two).

Following the final wash, the surfaces and voids were rinsed with clean IPA from a spray bottle and the parts dried using compressed air. Once clean and dry, each part was then post cured per Formlabs' recommendation for Grey Resin V4 (30 min, 60 °C in a Form Cure). The cured parts were then allowed to cool to room temperature prior to measuring. It is recommended that all engineering resins are cured to reach their ideal dimensional accuracy.

To find the correct cure time for each Formlabs resin, click here.

Caveats and Questions

The data presented in this report is only for the printed parts as shown in Figure 1 and Figure 2. It is not possible to extrapolate from this data that all prints of the same size will perform exactly the same, but Formlabs is confident in the accuracy of its printers across all available Formlabs resins.

As noted, all prints in this report were created in Grey Resin. All Formlabs resins go through a rigorous testing process before being released, and we would expect to see similar results across our material portfolio. However, variations may occur, especially depending on part geometry.

Not all printers will output exactly the same results. Some printers, by the nature of mass production, will skew larger or smaller on average, which may result in variations. This phenomenon can be observed in our dataset, with some printers creating parts slightly larger than average, and others slightly below average. This is normal print variance present in 3D printing. Additionally, degrees of freedom that cause distortions and anisotropic shrinking have the potential to contribute significantly to dimensional inaccuracies. Formlabs calibrates all 3D printers before shipping, resulting in a much tighter distribution of variations. Calibration reduces, but does not totally eliminate, these inaccuracies.

If you have additional questions about the accuracy of our printers, please contact a sales expert.

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