



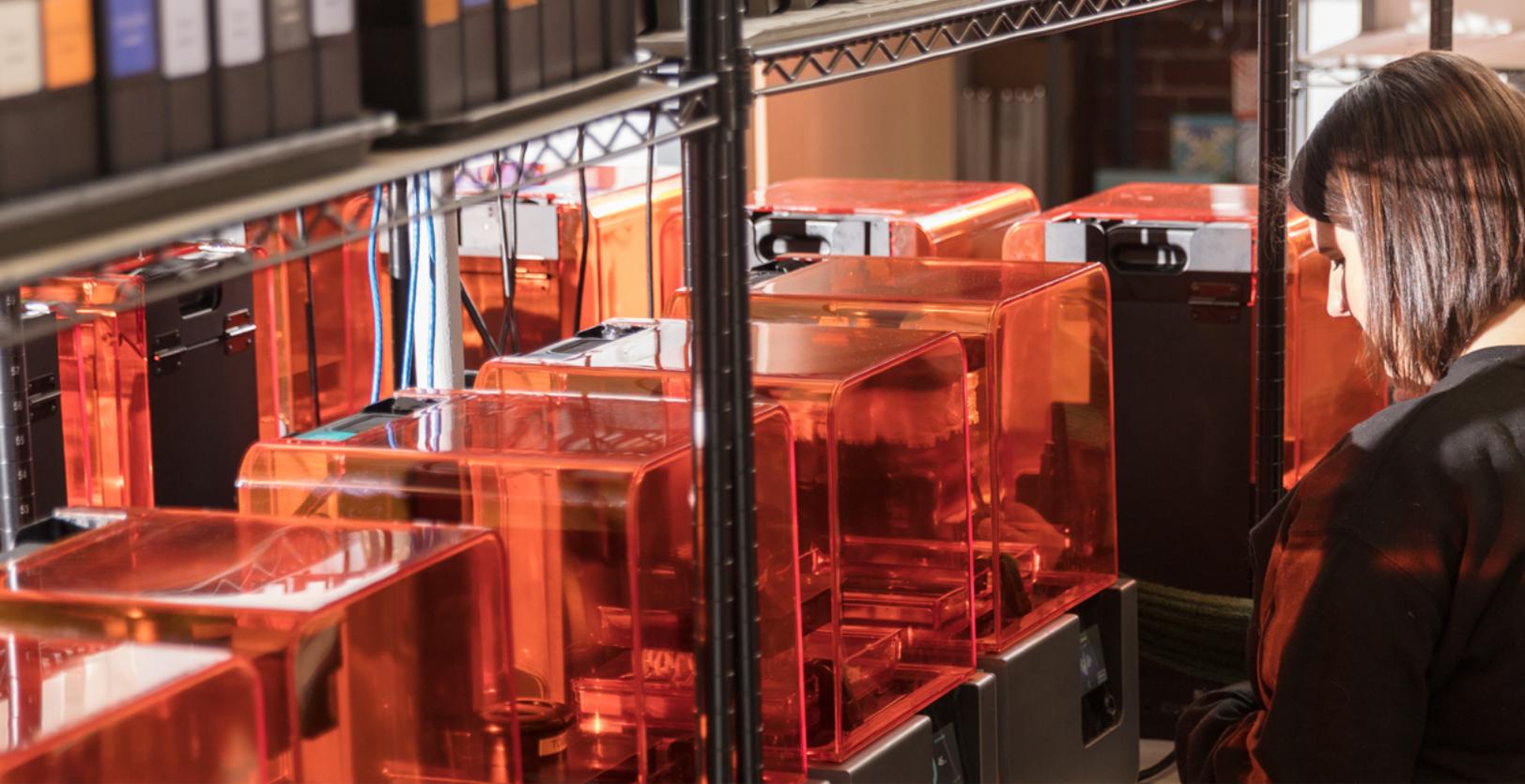
FORMLABS WHITE PAPER:

Managing Multiple 3D Printers

How to Create an In-House Facility for Rapid Prototyping and Low-Volume Production

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Introduction

With a small facility of stereolithography (SLA) desktop 3D printers, small businesses, labs, and entrepreneurs can affordably produce high fidelity prototypes and low-volume batches of parts and products in-house.

Using multiple 3D printers overcomes the traditional barriers of costly prototyping and manufacturing processes and opens the door for affordable in-house production, especially for highly customized products.

This document will review the end-to-end 3D printing process and cover design and management considerations, including tips from professional users and our own in-house print farm, for a minimum-investment setup of six or more desktop 3D printers. It also includes a list of everything you need to get started.

“Anyone that has a passion and a vision to create a product can get started with just one printer. Then, once you’re ready to scale up, start using multiple printers to ramp up production.”

Eduardo Salcedo

Researcher at Indiana University–
Purdue University Indianapolis (IUPUI)

Why Create a Multi-Printer Facility?

When used for short run or bridge manufacturing, a multi-printer facility delivers substantial cost and time savings compared to outsourcing or traditional production methods, such as injection molding, making limited runs of hundreds of parts accessible.

When used for prototyping, having multiple 3D printers facilitates rapid iteration of multi-component designs and allows companies to support multiple design projects and teams without bottlenecks.

FOR SHORT RUN PRODUCTION

We chose a commonly printed part to compare costs for a short production run using multiple Form 2 printers, outsourcing to a service bureau, and injection molding. The part is an enclosure for a small electrical component, consisting of a main housing and a top cover.



Main housing:
2.8 in x 2.7 in x 2.8 in

Top cover:
3.1 in x 0.3 in x 2.4 in

COST COMPARISON

Short Run Production		Form 2	Service Bureau	Injection Molding
100 pc	Cost Per Part	\$25.21	\$136.87	\$436.13
	Total Cost	\$2,521.00	\$13,687.00	\$43,613.00

FORM 2

Printing one enclosure on the Form 2 costs \$25.21. This includes consumables (materials, tanks, post-processing, accessories), maintenance, and factors in accounting depreciation of the machine over five years. However, this estimate excludes labor cost, which will vary from user to user. Assuming the use of six printers in parallel, printing and post-processing each enclosure requires approximately 0.5 hours for a technician. These costs remain constant regardless of the number of parts being printed.

One Form 2 printer can print a complete enclosure in single build within 7 hours and 41 minutes. By printing one build during the day and one overnight, six printers can produce 100 enclosures in 9 days.

SERVICE BUREAUS

Service bureaus tend to offer discounts on short run production over one-off prototyping, but costs still grow mostly linearly depending on the number of parts. A popular online 3D printing service provided an estimate of \$136-\$137 per part for a run of 100 pieces.

Lead time for a 100 part production run ranges between 2-4 weeks.

INJECTION MOLDING

Injection molding requires a substantial investment in tooling, which generally makes it prohibitively expensive for short run production. In this case, an online custom part service provided an estimate of \$43,509 for tooling. This means that for a 100 piece run, part cost is \$436 per piece.

For this specific enclosure, printing on the Form 2 is cost-competitive with injection molding for up to 1,700 pieces.

Lead times for injection molded parts are generally between 10-15 weeks, inclusive of tooling and production.

FOR PROTOTYPING

The ability to simultaneously print multiple components of a product prototype can significantly accelerate development timelines, and can make it cost efficient to test multiple design options at once. For instance, if a prototype consists of two separate 3D printed components, the ability to print them in parallel, overnight, rather than in sequence, effectively cuts cycle time by half.

For design teams working on several projects at once, multiple printers prevent costly bottlenecks in the prototyping process, which can cause significant delays when more than one team relies on 3D printing in their workflow.

End-to-End 3D Printing in 7 Steps

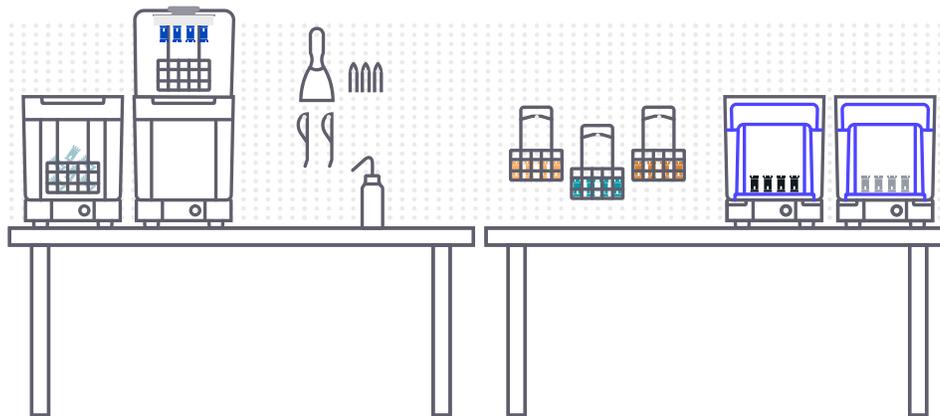
Understanding the full 3D printing process will help you think through the setup and management of your space. Below, find an overview of the steps involved in the printing process with Formlabs' Form 2 3D printers.

For more in-depth information on the 3D printing process, [visit the support pages](#) on [formlabs.com](#).



1. DESIGN IN CAD 2. PREFORM

3. 3D PRINTING



4. WASHING

5. DRYING

6. POST-CURING



7. FINISHING

Understanding the 3D Printing Process

1. DESIGN IN CAD

The Form 2 can print .OBJ and .STL files. These are standard file types that can be exported from your preferred CAD program. More advanced users may consider [specifically designing for SLA](#), or taking steps like [hollowing parts](#) to conserve material.

2. PREPARING PRINT JOBS IN PREFORM

Set up your print job using Formlabs' free PreForm software, with the ability to print multiple files at once. Our One-Click Print feature allows you to quickly, automatically set up 3D models in an optimal orientation. If you plan to print the same file multiple times, it's worth taking the time to use PreForm's advanced settings to carefully orient your part and optimize support settings to minimize material usage and required cleanup. Once a part is set up, you can save it as a .FORM file for future use in PreForm.

Download [PreForm](#) for free.

3. 3D PRINTING

Once the file has been sent to the printer (by USB, Ethernet, or Wi-Fi), you must physically confirm the print by pressing the start button on the 3D printer. You'll be able to see the estimated print time on the touch screen on the front of the printer, or via [Dashboard](#), Formlabs' cloud-based tool that helps monitor print progress.

Formlabs' [Dashboard](#) allows you to remotely manage printers and queued prints and track material usage. [Visit our website](#) to learn more and register.

4. WASHING

Remove the build platform,* then remove the part from the platform using the tools provided in Formlabs' Finish Kit.

Note: When removing the build platform, the resin tank catches any drips of resin that would otherwise fall onto the printer's optical window. Always have a tank in place before removing or inserting the build platform.

Transfer the parts to an isopropyl alcohol (IPA) bath. Once submerged, agitate for 30-60 seconds. Then let sit in IPA for 20 minutes. To conserve IPA, use two rinse buckets: one for the first 10 minutes and one for the next 10 minutes. The first wash will clean most of the residual resin from the part, allowing the IPA in the second bucket to stay cleaner for a longer length of time.

Use [Form Wash](#) to streamline and automate the print cleaning process. Form Wash automatically agitates parts in IPA, and raises them out of IPA once a wash cycle is complete.

5. DRYING

After removing prints from IPA, set them out to dry. We strongly recommend allowing prints to air-dry completely, as touching a print while still damp can leave marks or fingerprints. Drying can take up to a day.

6. POST-CURING

Post-curing helps parts to reach their highest possible strength and stability. This step is optional for Formlabs' Standard Resins, but highly recommended for Engineering Resins and required for Dental SG and Castable.

Learn more about the post-curing process in our [white paper](#).

7. FINISHING

For some prints, it is possible to simply peel off the supports. For parts that are complicated or fragile, use the Flush Cutters included in the Finish Kit to carefully cut the supports from the model. Sand off support marks from the print to achieve a smooth finish. Additional items, such as mineral oil, can also be helpful in polishing your final part. Find [additional recommendations](#) on our website.

Design and Equipment Considerations

This list is created to reflect the equipment, design, and space considerations for setting up six Formlabs Form 2 3D printers.

We estimate that, using the list below, setting up a basic production space for 6 Form 2 3D printers will cost approximately \$500-1,000, in addition to the cost of the printers and Pro Service Plans.

What You'll Need

Tech & Accessories	Organization
6 Formlabs desktop 3D printers	1 Label maker for labeling printers, resin tanks, and cords
Formlabs printing consumables , including tanks, cartridges, and build platforms *	1 Sturdy industrial 48" x 24" x 72" wire shelf , with flat boards cut to size
6 Formlabs Finish Kits , 6-quart polypropylene buckets , or Form Washes	Additional storage for printing consumables
6 Formlabs Pro Service Plans (per printer)	6 Wire mesh baskets
2 Form Cures , or 2 other post-curing units**	1 8-port Ethernet switch
	6 Cat 6 cables for Ethernet connection
Post Processing	Essentials
Sandpaper (a few grits between 100 and 400, and as high as 1500 - consider a set with many different grits)	Disposable gloves
1 Set microfiber cloths	Paper towels
1 Bottle mineral oil	Isopropyl alcohol (IPA)
1 Set needle files	
1 Large pack Q-tips	Recommended Cleaning Supplies
1 Set compressed air cans	1 Bottle Novus 1
1 Pair shatter-proof eye goggles	100 Count PEC pads
1 Pack dust masks	

* *Consumables will need to be replenished over time and will vary based on production volume. Note that the more types of resin used, the more complex your setup may be.*

** *If primarily printing with materials requiring post-curing, you may need more than two units. Learn more about how to determine which [type of post-curing unit](#) is best for your application.*

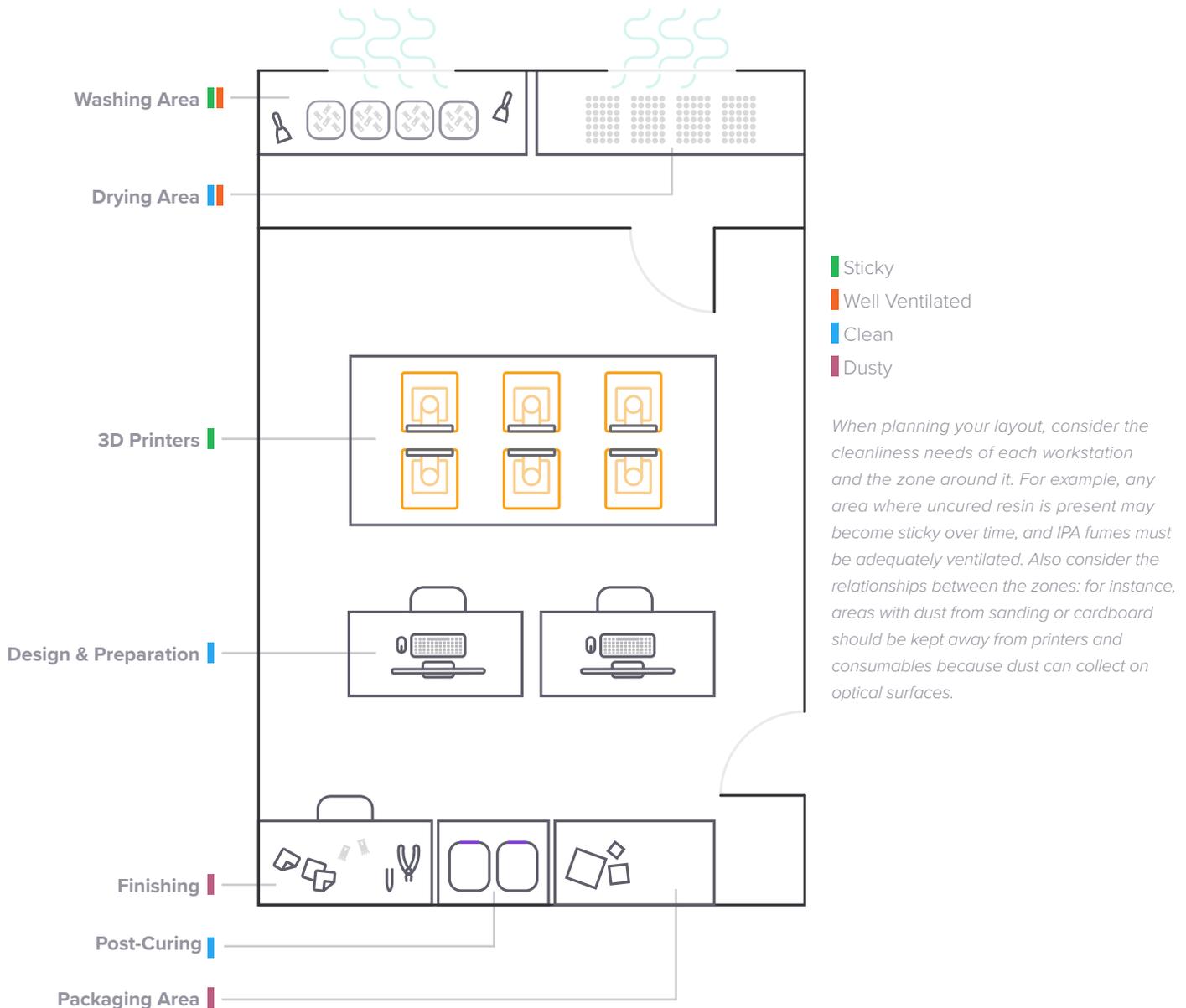
Setup and Management

In general, it's best to come up with an organizational layout or floor plan beforehand to minimize confusion later. Ideally, set up in a space away from direct sunlight, UV lights, and dust.

"It's kind of like an assembly line. It's an amazing iterative process that's real-time. The transition between workstations to printing capabilities within the same room is just amazing."

Lyman Connor

Handsmith (producer of custom bionic prostheses)



Computer Station

Dedicate a space near your 3D printer setup for a computer or laptop station. That way, you can easily upload over USB (if needed) and start your prints as soon as they are uploaded.

3D Printer Setup

LABELING

In order to send a file to a printer in PreForm you must select the serial name of the printer from a dropdown list. Dashboard also refers to printers by name. Each printer's name is listed on its backside, but it is easier to remember (especially when sending prints over WiFi) which printers are which if you identify each printer by name with a sticker on the front.

Similarly, labeling resin tanks makes it easy to see at a glance which material is in a printer or on a shelf.

If you are producing identical parts in large quantity, we recommend labeling batches of parts with the date, printer name, resin type, and, in particularly high volume situations, a tank number. This allows prints to be traced back to a specific print job on a specific printer, which makes it much easier to troubleshoot if a defective print is found. Internally, we use paper labels, which follow a print batch from build platform to QC.



To prevent cross-contamination of resin types, the simplest approach is to buy multiple build platforms and dedicate one to each material, labeling for clarity.

SHELVING

Place your printers on a sturdy, flat surface. Tables and shelves work well. If using shelves, be sure there is room to fully open the printers' lids and remove and replace resin cartridges – 30.5 inches clear between shelves. Allow for 32 lbs per printer.

The footprint of a Form 2 is 13.5 x 13 inches. The printers can be close together, but a little space between them makes it easier to access any cables plugged in from behind. Each printer should have 4 inches of clear space behind it to allow the lid to fully open.



A shelf that is 72" tall and 24" deep fits the Form 2 well; 48" wide fits six printers.

We recommend sturdy industrial wire shelves with a flat board cut to size.

If setting up multiple shelves, be sure that there is adequate room for two people to work and pass each other in front of the printers. In most workspaces, 42 inches is sufficient. This is especially important when working in teams or if there are many people using the printers.

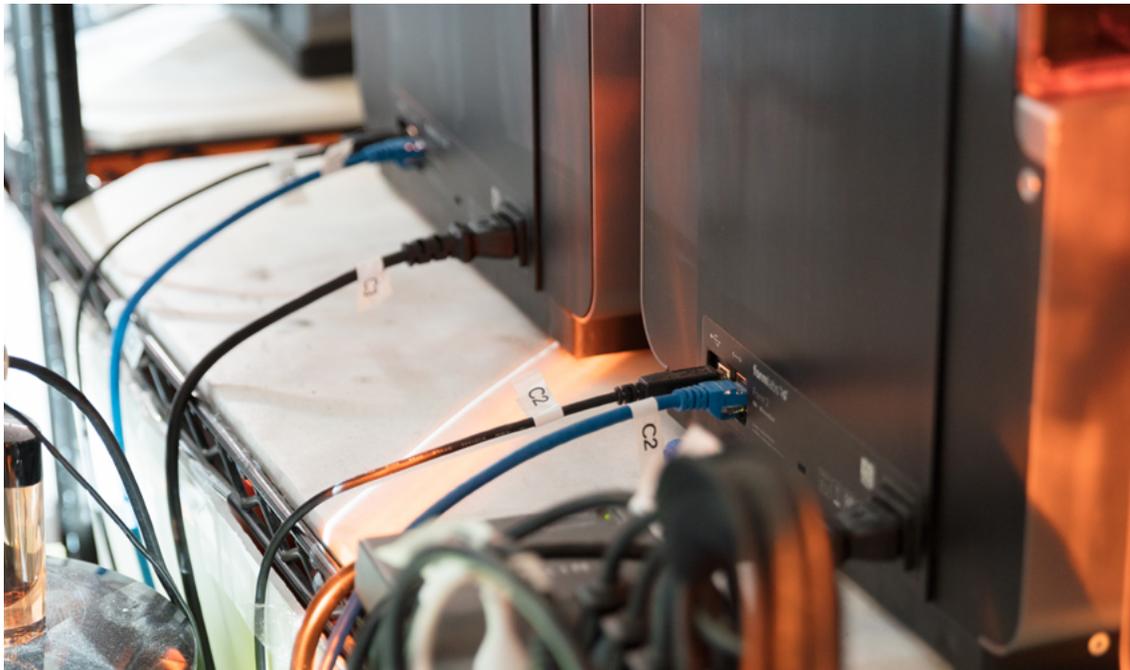
If you use multiple printers every day, consider using a wheeled cart to collect and transport completed prints on their build platforms from the printers to the cleaning station. If using a cart to collect prints, adjust your walkways to accommodate the cart moving through the space.

We also recommend an additional shelving unit for storing printing consumables (tanks, resin cartridges, build platforms), disposable gloves, and other supplies.

CABLE MANAGEMENT

Matching cords to machines can get confusing in a facility with multiple 3D printers. To help, label all cords (power, Ethernet, USB) at both ends based on the name and/or location of the printer. If you have to change your setup, it'll be easy to know which cables belong to which printers.

You may want to have an Ethernet switch, depending on your wireless bandwidth and the number of other devices on the network. For the most reliable access, we recommend an ethernet connection for three or more printers, using Cat 6 cables.



To more easily stay organized, it can be helpful to label cords connected to each printer. At Formlabs, we use a numbered system so we can move printers around without having to rewire everything.

Consumables Management

Tanks must be covered whenever they are outside of a printer to prevent ambient light from curing the resin inside. In order to keep dust or reflected light from reaching the bottom of the optical surface of the tank while in storage, stack tanks on top of each other or on a spare tank lid.

Each printer purchase includes one build platform, but additional build platforms are available for purchase from Formlabs. To prevent cross-contamination of resin types, the simplest approach is to buy multiple build platforms and dedicate one to each material, labeling for clarity. If using a single build platform for multiple resins, be sure to clean it thoroughly with IPA and let it dry before switching materials.



Keep dust or reflected light from reaching the bottom of the optical surface of resin tanks by stacking on top of each other or on a spare tank lid.

CLEANING AND PERSONAL PROTECTIVE EQUIPMENT

Cleanliness and personal safety are the most important factors in the success of your setup. Always keep a surplus stock of disposable gloves and paper towels on hand. Always wear gloves when handling resin or IPA. Use [Novus 1](#) or a similar acrylic cleaner (instead of IPA) and [PEC Pads](#) to clean your printer's cover and tanks. Keep microfiber cloths on hand for cleaning printed parts.

When handling IPA, **always** wear gloves and protective glasses. If you do get resin on your skin, do not use IPA or hand sanitizer to remove. Instead, use soap and water. You may also want an apron to shield your clothes from IPA and discoloration.

Wash Area

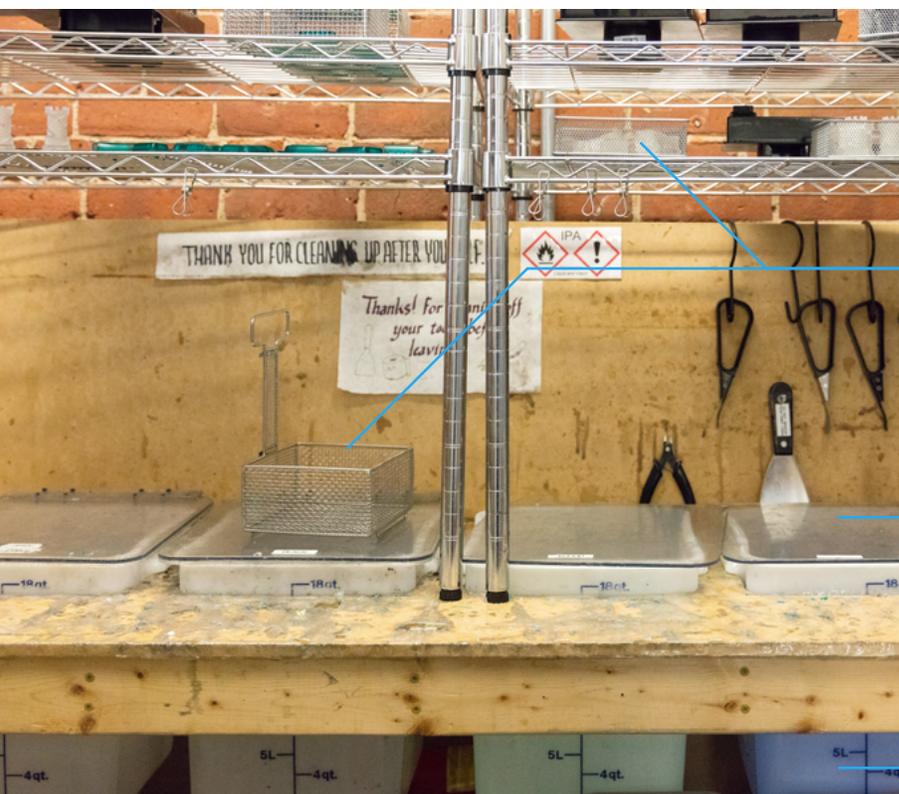
Washing areas can be set up on tables in the same space as your 3D printers. Removal of parts from the build platform should also take place at this station. Be sure to wipe down tools thoroughly with IPA after use.

You can use the Rinse Buckets included in the Formlabs Finish Kit, or larger buckets, based on the volume of prints you'll be washing at the same time. Formlabs Finish Kits each take up approximately 17 inches of space in width, and 9 inches in depth. Form Wash is 10.3 inches in width, 11.5 inches in depth, and 13.4 inches in height (accounting for clearance when parts are raised out of IPA).

HANDLING IPA

If parts are still sticky after 24 hours of air-drying, the IPA used to wash them needs to be changed. If this happens the parts can be rescued by a wash in fresh IPA. With intensive use, IPA may need to be changed as frequently as once a week. Disposal of used IPA varies by location; make sure your method of disposal is safe and appropriate, and in line with any local regulations. Visit our [support site](#) to learn more about our recommendations for buying, handling, and disposing of IPA.

Dental SG Resin can not be washed in the same IPA as other materials. Contamination would compromise its biocompatibility. We also recommend that Castable Resin have a dedicated IPA wash.



Mesh wire baskets with handles help achieve the best IPA flow around a part for washing, and are easy to hang for optimal air flow while drying.

If you choose not to use the buckets that come with the Finish Kit, we recommend using 6 quart polypropylene buckets. Make sure all IPA containers have lids that close securely.

If you have a high volume of prints in different resins, use different Rinse Buckets to separate prints based on the color/type of the resin. This will help prevent used IPA from staining light-colored or clear prints.

Drying Area

Once washed, place prints in a well-ventilated area where they can air dry for up to 24 hours. At Formlabs, we place parts on cafeteria trays or in mesh wire baskets that allow for more air flow.



At Formlabs, we place some parts on cafeteria trays to dry.

Post-Curing Area

If producing parts that need to be post-cured, we [recommend](#) using heat with a 405 nm light source, such as our own [Form Cure](#). Nail salon gel drying boxes, such as [USpicy](#) or [Salon Sundry](#), can also work exceptionally well. If using Dental SG Resin, be sure to use a cure box designed for use with dental applications. Post-curing units can be in the same space as the washing or finishing stations.

Several Formlabs customers have made their own cure boxes.

Visit the Formlabs [support page](#) for ideas from the Formlabs forum and more technical specifications.

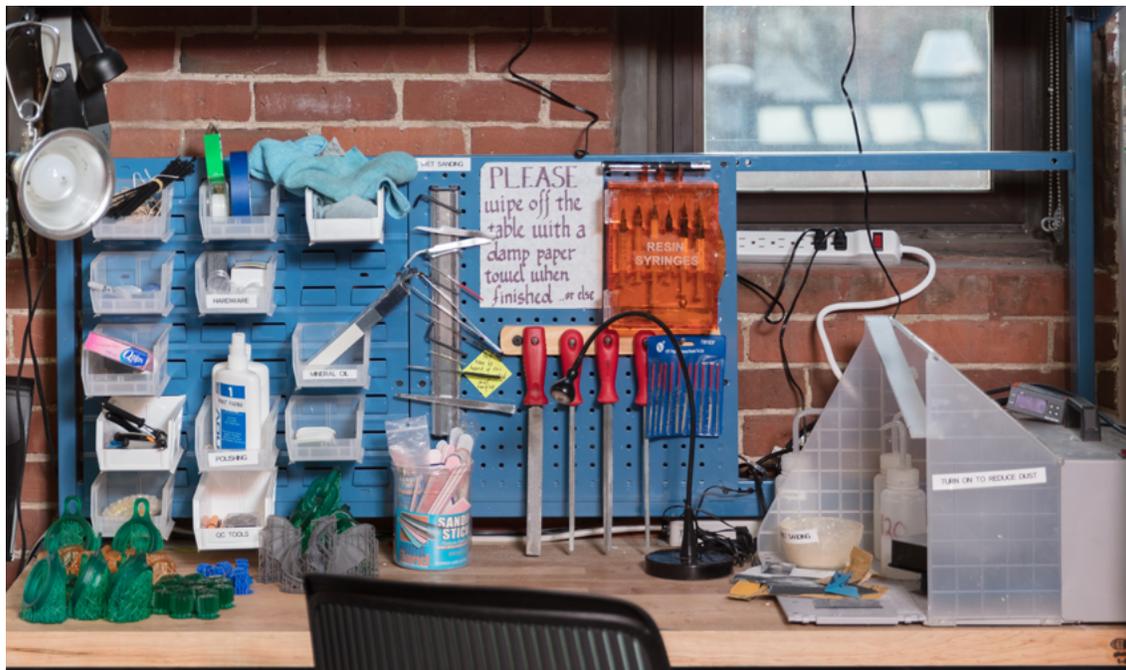
Finishing Station

At the finishing station, you'll want room for all your tools and a person (or several people) to sit down at the table and work on finishing parts. To avoid getting resin dust on the optical surfaces of the 3D printers, either keep the finishing area at a distance from the printers or use a dust collector.

Items we include in our Finishing Station are: tools included in the Finish Kit, sandpaper (a few grits between 150 and 400, and as high as 1500 for a fine polish), [mineral oil](#), a set of [needle files](#), a microfiber cloth dedicated to cleaning up resin dust, Q-tips for cleaning small areas, and cans of [compressed air](#).

Personal protective equipment should always be included in a finishing station. Keep shatter-proof eye goggles within easy reach for finishing brittle resins. Resin dust is similar to acrylic dust, so keep dust masks on hand.

Wetting the sandpaper or file with tap water helps keep resin dust to a minimum. It also polishes prints beautifully.



Formlabs finishing stations are equipped with a variety of tools, such as needle files and mineral oil, that help give prints a smooth, polished finish.

Quality Control

We visually inspect every single part we print. Transfer finished parts to a well-lit area where you can check for smaller failures that may not have been noticeable when the print was first removed, such as scratches, particulate stuck to the surface, or small holes.

