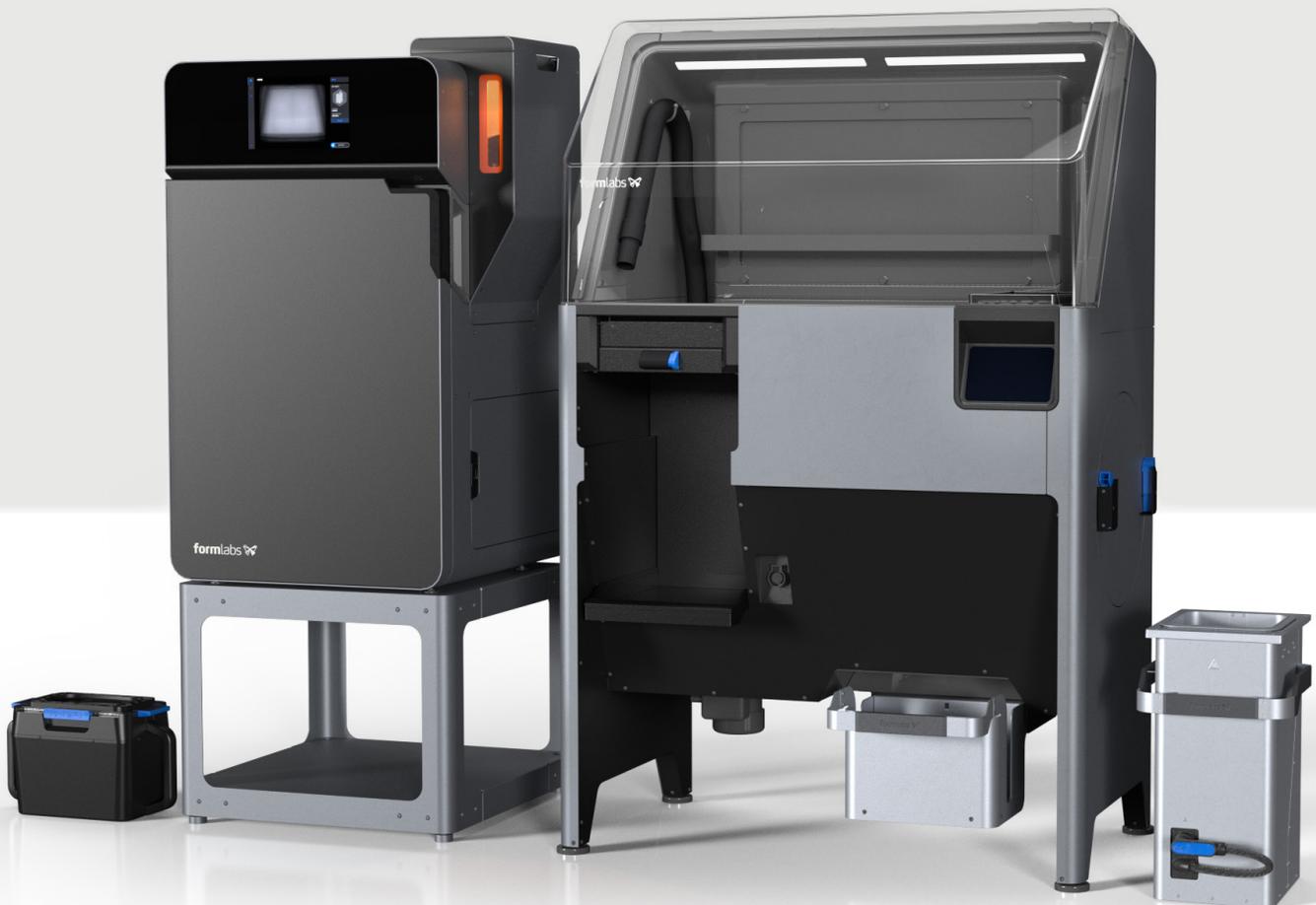


Fuse 1

Technology and Workflow Overview



Thank you for your early support of the Fuse 1!

We know many of you have been waiting for a long time, and we're excited to finally deliver on the potential of bringing the Formlabs experience to benchtop SLS as we begin to ship printers over the next several months. We're excited to see how intuitive, high quality, low-cost SLS changes the way people work, and hope you're excited to be at the forefront of expanding this technology.

What follows is a sneak peek of the Formlabs SLS experience. As someone who placed their order well in advance, we want you to be the first to see it. In this guide, you'll find an overview of what it will be like to print on the Fuse 1, setup requirements, and what you'll need to get up and running. Please reach out to us if you have any questions.

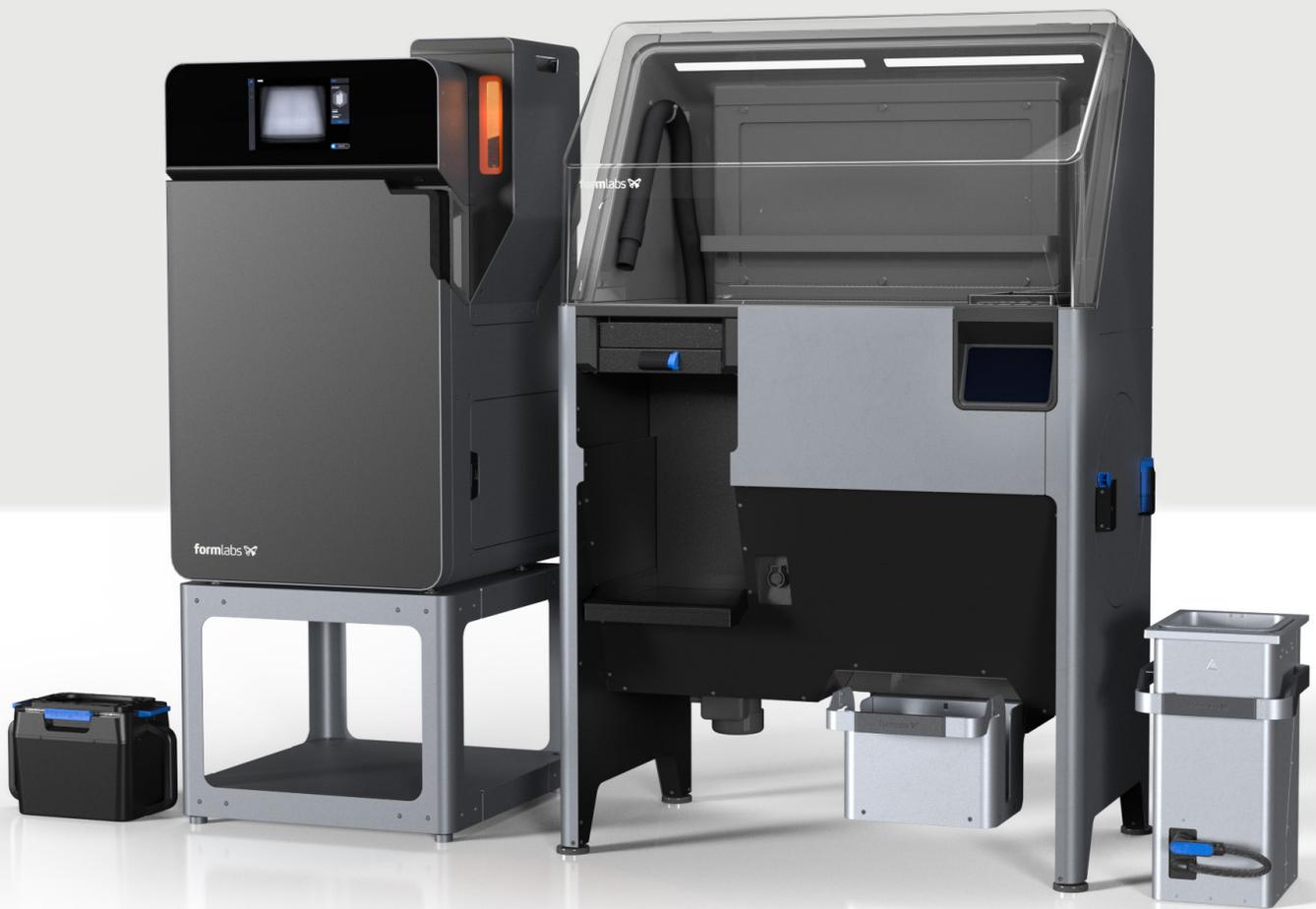
Thank you!
Formlabs and the Fuse 1 Team

What's new with the Fuse 1?

A lot has happened since we first announced the Fuse 1 back in 2017. In fact, so much has changed that the platform itself is almost a second generation machine compared to what we originally launched. As a result, we are proud to offer a complete ecosystem that brings the intuitive and affordable Formlabs 3D printing experience to Selective Laser Sintering (SLS).

SOME OF OUR LATEST IMPROVEMENTS INCLUDE:

- **Fuse Sift:** Fuse Sift is an efficient, enclosed system for initial post-processing of Fuse 1 prints and reclaiming powder. Move the build chamber directly from Fuse 1 to Fuse Sift after printing for a contained, efficient workflow.
- **30% refresh rate:** Our Nylon 12 Powder can produce robust, fully-functional parts using a mere 30% refresh rate—with unlimited cycles thanks to significant advancements with our print process. This means you can print with up to 70% reclaimed powder, indefinitely. Fuse Sift will dose and mix used and new powder automatically so you can reduce waste and control your powder supply.
- **Live video feed:** Keep an eye on your print job from the large touchscreen display on the front of the printer. Measure the accuracy or completion of your job in real time. Using computer vision, the Fuse 1 can even identify, track, and classify print failures and proactively pause prints if issues are detected.
- **Efficient, low-labor workflow:** Every step of operating the Fuse 1 system, from our PreForm print preparation software to automated powder reclamation with the Fuse Sift, has been comprehensively designed for an intuitive workflow that minimizes hands-on operator time. You can download the latest version of PreForm for free on our website to try setting up parts on a virtual Fuse 1 printer.



INTRODUCING **THE FUSE 1** PRODUCT LINE

The Fuse 1 and the accompanying Fuse Sift post-processing station demonstrate what Formlabs does best: bringing powerful, advanced technology to the masses in a cost-effective, intuitive, and compact format.

Fuse 1

The Fuse 1 is poised to set a new standard for SLS printing. It brings production-ready technology once reserved for service bureaus to your benchtop at a tenth of the cost of industrial SLS alternatives without compromising print quality.

With an industry-leading refresh rate of just 30% for efficient powder reclaiming, the Fuse 1 produces fully-functional parts using our custom Nylon 12 Powder, with additional materials in development. A spacious build volume of 165 x 165 x 300 mm means you can print everything from full-sized prototypes to large batches of end-use parts, all in a single print.



TECH SPEC HIGHLIGHTS

BUILD VOLUME (W X D X H)	165 x 165 x 300 mm (6.5 x 6.5 x 11.8 in)
LAYER THICKNESS	110 microns (0.0043 in)
STARTUP TIME	60 minutes
LASER TYPE	Ytterbium Fiber
LASER SPECIFICATIONS	EN 60825-1: 2014 1065 nm Maximum 10 Watts 4.01 mrad beam divergence (nominal, full angle) Class 1 Laser Product
LASER SPOT SIZE (FWHM)	200 microns (0.0079 in)
HOPPER CAPACITY	8.5 kg (18.7 lbs) of Nylon 12
MATERIAL REFRESH RATE	30 – 50 %
BUILD CHAMBER	Modular, compatible with Fuse 1 and Fuse Sift

Fuse Sift

The Fuse Sift is the best sidekick an SLS printer could ask for, combining powder reclamation with part extraction, powder, storage, and mixing in a single free-standing device. A negative air pressure system prevents powder from pluming into your workshop or studio while also enabling open access under the hood and easy cleanup with the integrated vacuum hose. No other SLS system on the market today provides this level of functionality from one device.



Build Chamber

SLS 3D printing uses a fiber laser and a moving print platform to fuse powder into near-isotropic parts. The build chamber, a key component of the process, is the container into which the print bed lowers the cake of sintered parts and unsintered powder while printing. After completing a print, you can remove the build chamber from the Fuse 1 and load it into the Fuse Sift for cooling, part extraction and material reclamation.

Keeping an extra build chamber in your toolkit allows you to run a new print as soon as a previous job is completed, similar to working with multiple build platforms on our stereolithography printers like the Form 3. Each Fuse 1 includes one build chamber, and additional units are available for purchase.



Powder Cartridge

The Fuse 1 uses a powder cartridge to load material dispensed from the Fuse Sift into its hopper. The powder cartridge is also used as a mixing vessel when combining fresh and used powder.



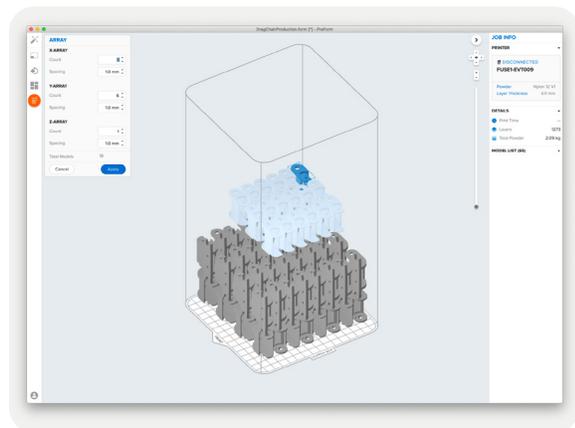
Powder Containers

Formlabs SLS printing powder ships in a box containing two 3 kg containers, and an RFID card preloaded with virtual print credit. Fresh powder is added to the Fuse Sift, while powder credit is added to the Fuse 1 for tracking material usage and available unsintered powder.



PreForm

The Fuse 1 uses intuitive PreForm print preparation software to automate print setup as much as possible and allow for powerful manual refinement as needed. PreForm for SLS offers advanced setup and monitoring tools, including a live video feed of the print bed. Those familiar with Formlabs stereolithography printers will be able to use the same software across their fleet, and FORM files are cross-compatible across machines.



Service Plans

Formlabs is proud to offer industry-leading customer support for all our products. Customers can choose between Standard and Premium Service Plans that cover both the Fuse 1 and Fuse Sift for one, two, or three years.

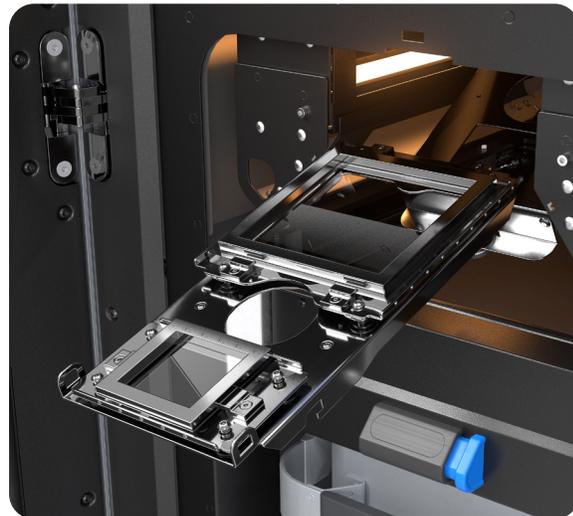
SERVICE	STANDARD	PREMIUM
Training	Remote	Customized Onsite
Extended Warranty	✓	✓
Remote Support (Phone & Email)	✓	✓
Onsite visit (1/yr)	✓	✓
Additional onsite	Pay per visit	Unlimited

Our exemplary phone, email, and chat support, on-site and remote training sessions, local support from a Formlabs Certified partner and Ready to Plug installation options will ensure a seamless SLS experience from day one. Site visits are included in both service options to take care of annual system maintenance, ensuring a worry-free ownership.

Optical Cassette

The environment inside an SLS printer is filled with off-gases that result from sintering thermoplastic. These gases collect onto optical surfaces as stains that degrade the accuracy of the laser. All SLS printers require operators to clean the optics before every print, which often involves disassembling complex systems.

The Fuse 1 protects its optics with an optical cassette designed for tool-free removal and installation. To remove the optical cassette, simply turn the thumb screw that holds it in place. Each Fuse 1 includes two optical cassettes, so you can seamlessly swap a dirty cassette out for a clean one to quickly start another print.



Vacuum

A clean workspace is important both for efficiency and safety. SLS post-processing can get messy, so the Fuse Sift incorporates an external vacuum. The integrated hose and controls allow you to easily tidy up your workspace, clean off a build chamber, or remove debris from the sifter mesh.

Due to potential hazards associated with powders, a static dissipative vacuum that is NFPA 652 compliant is required. For customers with environments that have more stringent safety requirements, an optional purchase of a Class II Division 2 vacuum is available from Formlabs. Please contact your Formlabs representative for more information.



A DAY IN THE LIFE OF **THE FUSE 1**

The Fuse 1 is not just a printer; it's an entire ecosystem for turning CAD files into fully-functional end-use parts with industrial thermoplastics. Let's take a look at the workflow for setting up, printing, extracting parts, and reclaiming material from prints.

File Setup

The Fuse 1 uses PreForm print preparation software to import STL or OBJ part files, orient and arrange models, estimate print times, monitor your printers, and upload job files. The PreForm workflow has been tried and tested over millions of stereolithography prints, and we're excited to bring the same level of intuitivity to SLS.

A FEW NEW FEATURES SPECIFIC TO SLS PRINTS ARE:

- Pack and Array allows you to seamlessly duplicate and organize multiple parts within a 3D grid to use as much of the build space as possible for a single print.
- Z-Manipulator can be used to position parts along the Z-axis of the build space.
- Camera Feed provides a livestream of the print bed to watch each new layer take shape without ever walking away from your computer.

Interested in trying it out? [Download the latest version of PreForm](#) to use a virtual printer and explore setting up parts for the Fuse 1.

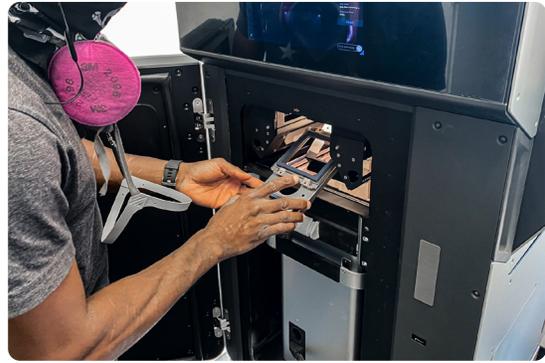
Printing

Most SLS systems require extensive training, tools, and physical effort to prepare and maintain. The Fuse 1 changes the SLS landscape, bringing the ease of use central to Formlabs products to SLS. Let's take a look at printing with the Fuse 1.

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- 1. Add powder:** Load powder to the Fuse 1 using the powder cartridge. Credit included with fresh powder is stored on the Fuse 1 so it knows which material is currently loaded and how much is available for printing.



2. Insert an optical cassette: Removal, maintenance, and reinstallation of the optical cassette do not require any tools or disassembly. A second cassette enables you to run another print without cleaning one used for a previous print.



3. Insert a build chamber: Carry the build chamber between the Fuse 1 and Fuse Sift using its integrated handles, no casters or support frames necessary. Having multiple build chambers in your workflow enables you to run another print while a previous one is still cooling.



4. Preprint checks: A checklist on the touchscreen with written and visual instructions explains each procedure step by step. The Fuse 1 monitors itself over time, and automatically notifies you when a maintenance procedure is required.



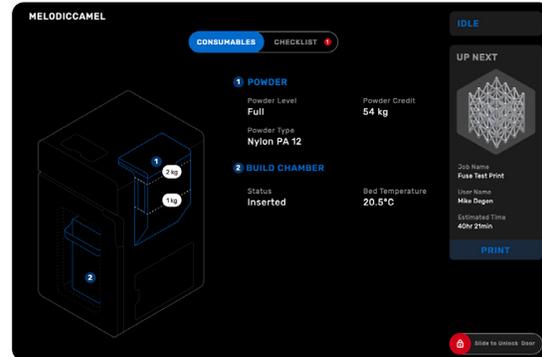
5. Start the print: Once all preprint checks have been completed, the Fuse 1 is ready to print. The home screen transitions to display a live stream of the print bed so you can watch each new layer take shape. This camera view is also available in PreForm.



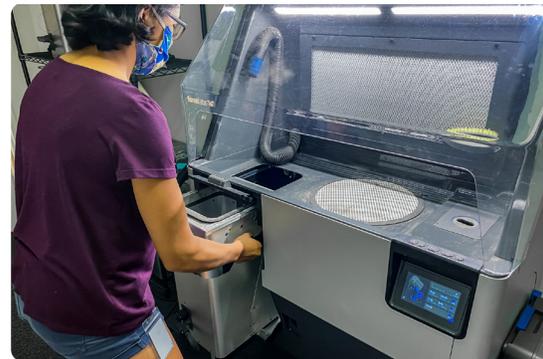
Cooling a Print

After a print completes, the build chamber needs to cool down in the print enclosure before post-processing. This allows parts to steadily dissipate heat, preventing them from warping or developing suboptimal mechanical properties.

- 1. Cool in print enclosure:** Immediately after a print completes, allow it to cool down in the print enclosure for 30-50% of the total print time. If a print takes 10 hours to complete, leave it in the print enclosure for up to 5 hours.



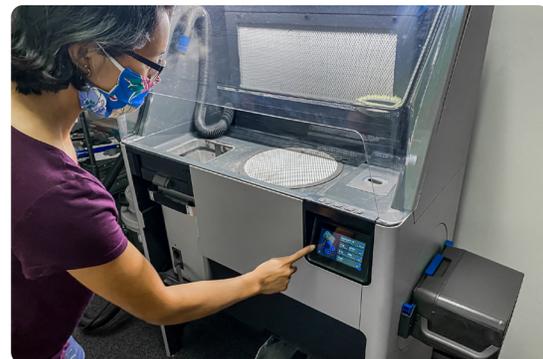
- 2. Finish cooling in Fuse Sift:** After completing the initial cooldown in the Fuse 1, transfer the build chamber to the Fuse Sift. Plug the build chamber into the Fuse Sift to monitor the temperature, and receive a notification when the print is ready for extraction.



Extracting Parts

The Fuse Sift is the multi-tool of the Fuse product line. It not only stores and dispenses powder, it is also the workstation for extracting parts and reclaiming unsintered powder from a print. Let's take a look at extracting parts from a print with the Fuse Sift.

- 1. Start the vent:** Before using the Fuse Sift, turn on the vent to create a negative draft that prevents powder from blowing out of the workspace. A HEPA filter picks up any mobilized powder for later disposal.



2. Start the sifter: As parts are extracted from the cake, unsintered powder is dislodged and funneled into the sifter below the workspace. A sieve filters out any small chunks or debris to keep the powder clean. The reclaimed powder is then stored in a dedicated hopper until mixing with fresh powder for the next print.



3. Ejecting the cake: Use the physical and virtual touch controls to raise and lower the print bed, allowing you to stagger the cake as it ejects from the build chamber into the Fuse Sift workspace. This is helpful for prints that contain a densely packed assortment of small or various parts.



4. Extracting parts: This step is sure to bring back childhood memories of the sandbox! An included set of brushes and picks of varying sizes helps scrub and scrape powder out of even the tiniest of features. Chunks of powder can be easily broken up by hand or scrubbed off with the included large brush. A wire basket is provided to neatly collect your parts while you continue processing a print.



5. Cleanup: After extracting parts, begin cleanup. Powder that accumulates within the workspace can be wiped into the sifter and recaptured for later use. Smaller deposits around the workspace, within the build chamber enclosure, and on the hood can be picked up with the integrated vacuum hose for later disposal. The vacuum is controlled by a physical button conveniently located on the control panel.





Reclaiming Powder

A dirty secret of SLS printing is that most systems cannot actually achieve their advertised refresh rates, typically marketed at 50%. As a result, entire reclaimed powder supplies totalling several kilos are thrown away because some of it is too degraded from just a handful of prints, and would result in parts with diminished mechanical properties.

The Fuse 1 consistently produces parts that achieve the advertised mechanical properties of our Nylon 12 Powder using a minimum refresh rate of 30%.

For context, the refresh rate is the percentage of fresh (virgin) powder that is mixed with reclaimed powder for a print. A refresh rate of 30% means you can print with up to 70% reclaimed powder. Our approach to SLS enables reclaimed powder to be used with a 30% refresh rate indefinitely. This translates to reduced material costs, less wasted powder, and ultimately more printing.

The Fuse Sift also sets itself apart from the large, expensive material processing equipment often used with other SLS systems. A common theme in the industry is to offer one device for reclaiming powder, one for storing it, and another for mixing streams. In addition to being prohibitively costly, we find this approach profoundly inefficient.

In the Fuse 1 workflow, extraction of parts and unsintered powder, as well as storing, dosing, and mixing of streams, are all handled by one device: the Fuse Sift. The only additional device necessary to make the most of the Fuse 1 workflow is an external Class II Division 2 vacuum—which is attached directly to and controlled by the Fuse Sift.

Media Blasting

The final stage of any 3D printing workflow is post-processing. Media blasting SLS parts is the go-to final step because it achieves the most refinement with the least amount of work. A few seconds under a blasting gun is all it takes to make a coarse surface smooth. This can be a crucial step if your parts are intended for end-use applications, especially those requiring minimal or dust-free environments.

Formlabs recommends using Silicon Dioxide (SiO₂) or Alumina (Al₂O₃) blasting media with a nominal diameter range of 125 - 250 microns (µm). A few of our beta users have also experienced positive results with Silicon Carbide (SiC). Its hardness of 9.5, however, makes it extremely aggressive on plastics so its working speed is substantially faster than Silicon Dioxide or Alumina.

If you are interested in purchasing a blasting cabinet but are concerned about upfront costs, there are several cabinets for under \$1,000 USD.

- [Fastenal](#)
- [Grainger](#)
- [McMaster-Carr](#)

FUSE 1 PARTS

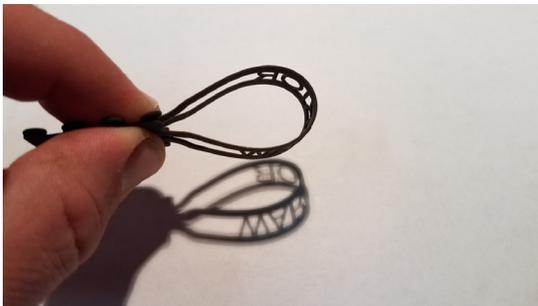
Now that we've introduced you to the Fuse ecosystem, let's take a look at what it can actually print!

Hypertherm

Hypertherm is notorious for developing and manufacturing CNC cutting hardware and software. Their vast areas of expertise made them a great candidate to beta test the Fuse 1. While they initially used the Fuse 1 to develop prototypes and manufacturing tools, they quickly changed gears once the coronavirus took center stage.

After partnering with Dartmouth Hitchcock Medical Center and a handful of other New Hampshire companies, Hypertherm turned their prototype Fuse 1 into a PPE micro-factory. Equipment like custom-fitted respirator housings and face shield frames that were combined with plastic sheets manufactured by a neighbor were printed for Hypertherm and Dartmouth Hitchcock's staff, all on the Fuse 1.

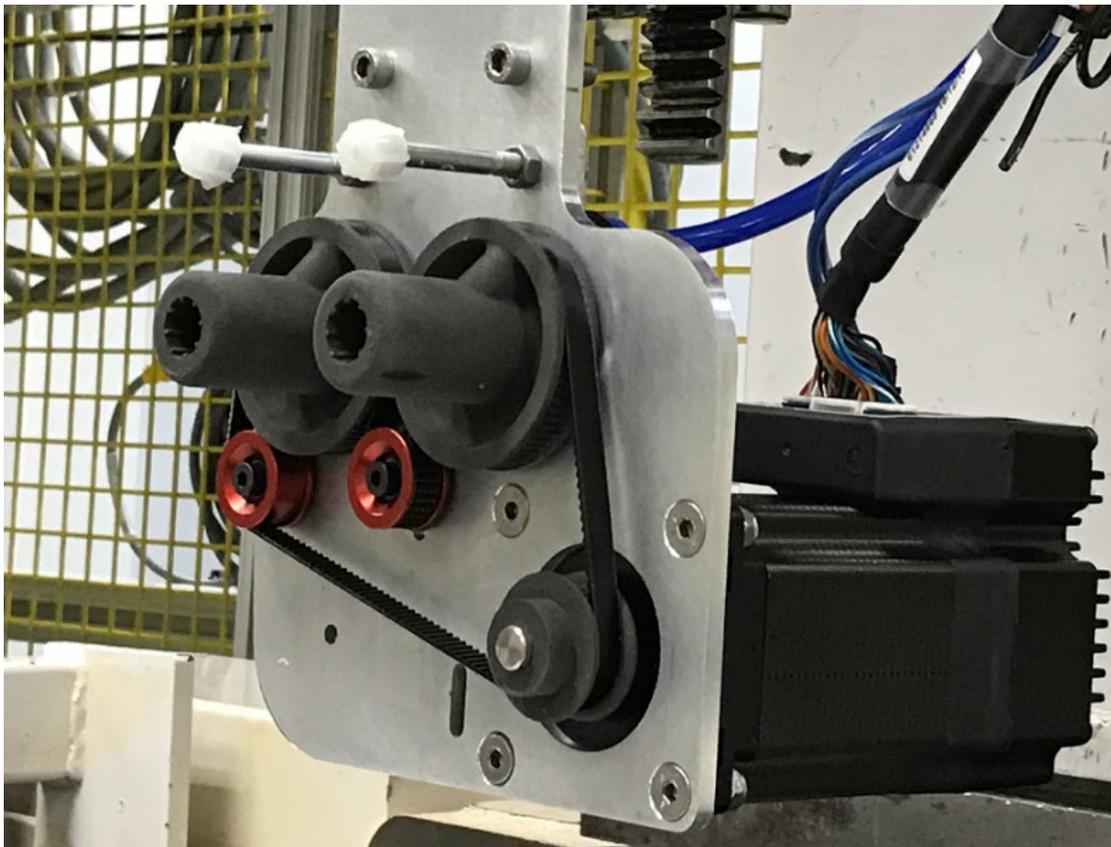
Hypertherm also cranked out multiple batches of a device dubbed The Ear Saver for wearing masks without using ears to anchor the straps, and distributed to local residents and businesses.



Tessy Plastics

Tessy Plastics operates manufacturing facilities in New York, Virginia, and China, making it a powerhouse for high-quality injection molding manufacturing. While experts in all things plastic, their experience with SLS printing was limited to service bureaus—until we asked them to join the Fuse 1 beta.

The Fuse 1 found itself at home in no time, as Brian Anderson at Tessy developed and successfully fitted a set of replacement pulleys for one of their injection molding systems. In conjunction with a motor and timing belt, this setup allowed Tessy to avoid re-toiling mold sets for a threaded feature, saving them time and money on a specialty part.



Brian Anderson: “The photo above is the arm of the robot that picks the parts from the mold, we added a motor and timing belt setup to it to allow us to unscrew the part from the stationary core. The strength of the Nylon let the print hold up much longer than we anticipated and it has successfully run tens of thousands of cycles – in the process saving a significant amount of money by not having to redesign and rebuild the tool to facilitate the unscrewing action.”

They even printed over a dozen replacement fan shrouds for their FDM prints, completely eliminating the need to purchase replacements.