APPLICATION GUIDE

Introduction to Casting for 3D Printed Jewelry Patterns

The way jewelers work is changing, and castable photopolymer resins are leading the way. From independent designers concepting and prototyping in their studios, to casting houses increasing capacity and diversifying their offerings, digital fabrication techniques are increasingly key to growing a successful jewelry business. In this guide, learn how to cast fine jewelry pieces 3D printed on Formlabs printers.

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Essentials

Made by Formlabs

- Form 3 (SLA) 3D Printer
- Castable Wax 40 Resin
- Castable Wax Resin
- PreForm software (free)
- Finish Kit or Form Wash

Made by Third Parties

- Certus Prestige Optima investment
- Furnace (732 °C or 1400 °F), vacuum investment machine, and casting system such as Neutec J2R
- For indoor burnout, active ventilation such as Vent-A-Kiln

What Is Direct Investment Casting?

Direct investment casting, or lost wax casting, is a popular moldmaking technique that can be used to fabricate small and large parts in a wide variety of metals. Originating over 5,000 years ago, casting enables creators to work with a wide variety of materials and is one of the easiest ways to make metal parts.

In investment casting, a hollow mold is created from a hand-sculpted or 3D printed master pattern. The master is immersed in a refractory casting material (or “investment”), which dries and hardens. The wax or 3D printed pattern is burned out, leaving a negative mold of the design. Metal is poured into this hollow cavity to create the final part.

Wax patterns for intricate jewelry are complicated to produce by hand, and in a world driven by high demand and fast fashion, it can be difficult for hand-crafted pieces to keep pace. Advanced materials and affordable in-house 3D printers such as those from Formlabs are changing the way jewelry manufacturers and designers work, bringing industrial quality to the desktop and making it easier to produce and fit complicated geometries that once required hours of meticulous labor.

1. Design for Casting

Use CAD software such as RhinoGold, JewelCAD, or 3Design to take your parts from concept to 3D printed pattern using these best practices.

Products referenced:

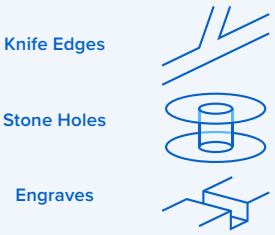
Castable Wax 40 Resin: A high wax-content direct casting resin with superior castability, accommodates a wide range of design features such as stone holes and engraves.

Castable Wax Resin: A lower wax-content, high green strength resin appropriate for ultra-fine structures such as wire filigree.

AVOIDING INVESTMENT BREAKAGE

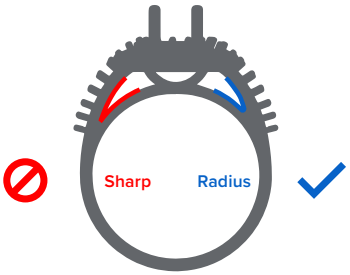
Design of traditional wax patterns and 3D printed resin patterns share many principles, such as the importance of smooth surface flow. Where possible, avoid creating sharp corners and edges. Sharp edges not only increase metal turbulence, but they also concentrate expansion stresses in the mold.

Concentrated expansion stress causes **investment breakage**, which is one of the most common quality issues in direct-resin casting. Signs of investment breakage are filled-in negative features such as engraves and stone holes in the cast part. Investment breakage is usually accompanied by rough cast surfaces or pitting, resulting from investment debris.



In addition to sharp edges, be mindful of the depth of negative features. A good rule of thumb is to keep engraved channels and holes wider than they are deep. This guideline is more important if the negative feature is small, and the investment that fills around the feature is fragile.

In the Formlabs ecosystem, Castable Wax 40 Resin is designed to minimize expansion and investment breakage, allowing for more reliability where negative features are required.



SPRUES

Delicate sprue channels can be 3D printed to save labor and improve mold fill to areas of fine detail. Design feed sprues that are either straight, or taper down towards the piece.

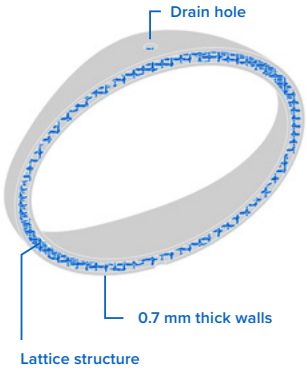
Supports added in PreForm should not be used as sprues. If you intend to 3D print sprues, we recommend incorporating them into your CAD design.

3D printed feed sprues should only be used where placing wax sprues would be difficult, eg. where a sprue connects one inaccessible area of the resin pattern to another. Real wax sprues promote better cast part quality, by giving the pattern early access to oxygen when they melt out.

SPRUE ATTACHMENT POINTS

Resin patterns do not melt, which means that heavy parts can sometimes be tricky to attach (and keep attached) to wax sprues. By adding a sprue attachment point to your CAD model, you can avoid the frustration of finding a 3D printed pattern floating in the flask you just poured. This can be as simple as a hole in the bottom of a ring band, or a small hollow post that you can fill or surround with wax when attaching it to a sprue rod.

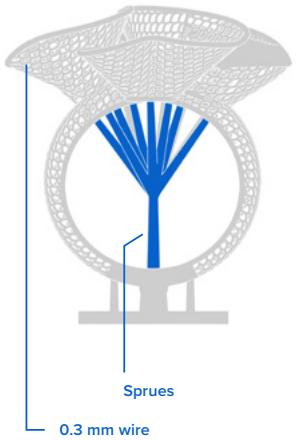
THICK AND LARGE PARTS



Castable Wax 40 Resin is suitable for printing and casting thick jewelry parts, such as heavy class rings. This material can accommodate cross sections up to 4mm in most places in the model. Thick regions of a model will tend to perform better in casting the closer they are to the feed sprue.

Thicker walls up to 10mm may be possible with sufficient wax sprues to provide oxygen to the site. Due to its low green strength, Castable Wax 40 Resin is not recommended for large, thin shells, or designs with long, thin, unsupported spans.

Castable Wax Resin is an alternative material for designs that are both large and monolithic, such as statues. Due to Castable Wax Resin's higher green strength, this material supports hollowing designs to a thin-walled shell. This strategy minimizes expansion forces on the investment during burnout. **Parts thicker than 3 mm should be shelled, and drain holes must be added** to allow resin to flush out of the hollow interior.



Formlabs recommends 0.7 mm thick walls for hollow shells printed in Castable Wax Resin. A lattice structure can also be added to the interior to improve the handling strength of large shelled parts.

- When creating a hollow thin-shelled pattern in Castable Wax Resin, check for areas of the model that are close to (or less than) double the minimum 0.7 mm wall thickness for the shell.
- These areas may be untouched by a shell CAD operation, resulting in regions of the pattern that are too thick for casting. Excessively thick parts are likely to cause expansion cracks during burnout.

FILIGREE

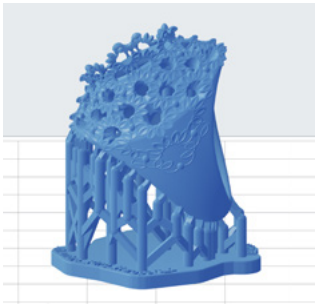
The exceptional detail of Castable Wax Resin allows you to create pieces with intricate filigree. These fine meshes of wires are challenging but possible to cast with careful sprue design.

Fine meshes can be printed with a wire diameter as thin as 0.3 mm. Printed filigree is fragile and easily damaged by support removal. Design filigree parts to be as self- supporting as possible.

In filigree designs, 3D printed sprues may serve a dual purpose as "supports" that are removed after casting. To avoid metal freezing in these thin channels, add sprues that feed metal to many points on the rim of a filigree mesh.

Note: Castable Wax 40 Resin is not recommended for printing wire filigree, due to the lower green strength of this resin.

2. Print and Prepare Parts for Casting



Orient top-heavy parts at an angle for best results

PRINTING

Jewelry patterns can be printed individually or in batches on the Form 3 desktop 3D printer. For the best quality prints in Castable Wax 40 Resin, we recommend printing top-heavy parts such as signet rings oriented and supported at an angle, rather than vertically. Lighter weight jewelry designs, and parts printed in Castable Wax Resin, may be printed vertically.

WASHING

Thoroughly washing parts in 90%+ isopropyl alcohol (IPA) is critical to a clean casting. Excess uncured resin can interfere with investment curing and will cause casting defects.

Allow the parts to fully dry after removing them from the IPA bath. Use compressed air to ensure all IPA is fully evaporated prior to post-curing and casting. If parts are still sticky after washing and drying, you may need to replace your IPA.

CASTABLE WAX 40 RESIN	
Form Wash	5 min + clean IPA final rinse
Cleaning Kit	5 min + 5 min (second wash in clean IPA)

CASTABLE WAX RESIN (V1)	
Form Wash	5 min + clean IPA final rinse
Cleaning Kit	10 min + 5 min (second wash in clean IPA)

CURING

Castable Wax 40 parts may be optionally post cured for extra handling strength, if you experience parts breaking while spruing. If your parts are fragile, we recommend post-curing after support removal. Green parts are more flexible and less likely to shatter as you snip supports.

Post-cure will not improve casting results, unless parts are insufficiently washed.

CASTABLE WAX 40 RESIN	
Form Cure	Not required (30 min no-heat cure optional)
Nail Salon	

CASTABLE WAX RESIN (V1)	
Form Cure	Not Required
Nail Salon	

Tip: Post-curing parts may cause a small (<1%) degree of shrinkage.

Warning: Do not post-cure Castable Wax 40 parts above room temperature. Elevated temperatures can melt the solid wax content in the resin, causing sticky parts.

A wax heat pen makes it easier to join resin patterns to the wax sprue tree.

3. Build the Sprue Tree

Attach the post-processed prints to a main wax sprue with sticky sprue wax. Melt the wax to create smooth junctions between each printed pattern and its feed sprue.

A wax heat pen makes it easier to join resin patterns to the wax sprue tree.

Arrange thicker parts at the bottom and thinner parts at the top of the tree. 3D printed parts may require slightly more space between parts than a traditional wax tree. If you are casting large “thin-shelled” parts, make sure to fill any drain holes with wax to prevent any investment material from entering the print.

CASTING BARRIERS

Formlabs does not recommend dipping Castable Wax 40 patterns into a “casting barrier” film. Casting barrier films may interfere with the ability of the resin to lose liquid wax during heating.

Tip: Printed resin patterns do not melt. If you have difficulty joining a print to a wax sprue, try using a small amount of super glue or fast setting epoxy. Adding a sprue attachment point to the model can also be helpful.

4. Prepare the Mold

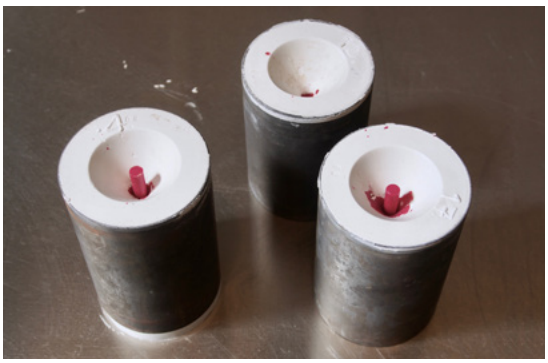
The following steps are a standard procedure for preparing any investment flask mold. A vacuum investing machine helps to evenly mix, degas, and pour the investment easily and cleanly. However, it is also possible to use a separate mixer and vacuum chamber.

1. Attach a casting flask to the sprue base. If the flask is perforated, wrap it with clear packing tape to contain the investment.

2. Mix investment powder and cold distilled water according to manufacturer's instructions.

Tip: Dissolve boric acid (1% of water weight) into investment water before mixing to increase mold strength.

3. Slowly pour the investment down the side of the flask, avoiding the pattern tree. A smooth pour is less likely to trap bubbles. Use a vacuum chamber to extract any bubbles from the flask. Allow the investment to harden and dry.



4. Carefully remove rubber sprue base from the flask and allow it to set in a vibration-free environment for 2-6 hours. Follow the investment manufacturer's safety recommendations. We recommend wearing a dust mask or respirator.

INVESTMENT MATERIAL OPTIONS

Formlabs recommends Certus Prestige Optima jewelry investment for both Castable Wax 40 Resin and Castable Wax Resin. Castable Wax 40 Resin will give you more freedom in investment materials. If you are casting especially difficult designs, consider upgrading to a stronger phosphate bonded investment material, such as Nobilium Microfire. When using alternative investments, incorporate the manufacturer's burnout recommendations.

5. Burnout and Casting

Place the casting flask in the burnout oven and heat using the recommended Burnout Schedule. Make adjustments depending on the investment instructions, flask size, and amount of printed material.

Formlabs recommends using a well-ventilated furnace (with an inlet and an outlet), to provide sufficient air flow throughout the chamber and to safely exhaust all vaporized resin material.

SHORT BURNOUT

Significantly shorter burnouts (4-8 hrs) are limited to lightweight geometries and strong phosphate-bonded investment materials. Phosphate bonded investment will allow for a faster burnout with all Formlabs casting resins.

Tips:

- Venting is essential, but it can cause the temperature in the oven to drop. Monitor the oven and flask temperature and adjust your process as you develop a burnout schedule suited to your own equipment.
- If using active ventilation, increase suction as much as possible to improve airflow throughout the oven.
- If the oven is full, burnout will be less effective per flask. Attach an oxygen generator or low flow air line to the oven to increase the airflow.

CASTING

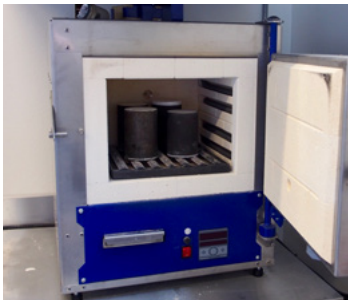
Remove the mold from the furnace and cast metal. Centrifugal or vacuum casting machines such as the Neutec J2R (USA) and the Indutherm MC-series (EU) are simple to use and highly controllable.

After casting, carefully quench the mold in water and wash away the investment.

PRECIOUS METAL COMPATIBILITY

Formlabs has tested gold, silver, and bronze castings from Castable Wax 40 and Castable Wax patterns. Metal compatibility is foremost a property of the investment. Different metals require varying degrees of temperature resistance from the investment.

Formlabs direct-casting resins require temperatures of at least 732 °C to complete burnout. Ask the manufacturer if you are unsure about resin compatibility with a specific investment.



Place flasks in a well ventilated burnout oven.

Vacuum or centrifugal casting improves fill to thin details.

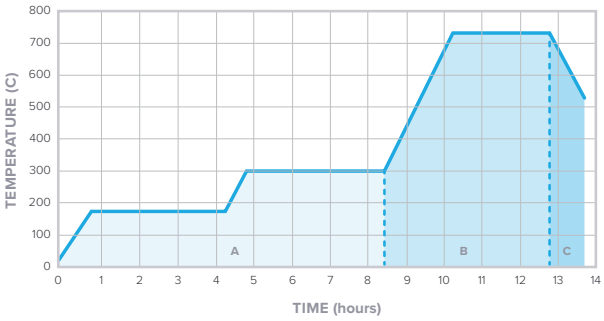
Quench and de-vest the flask by submerging it in water.

6. Burnout Schedule

Formlabs offers Castable Wax 40 Resin and Castable Wax Resin for jewelry investment casting. Castable Wax 40 Resin is designed to offer improved flexibility in its burnout schedule, and is more forgiving if you are new to casting resin. Castable Wax Resin requires stricter adherence to burnout guidelines and geometry limitations to achieve high quality casting results.

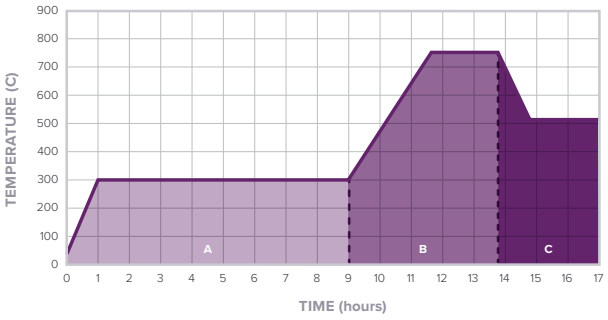
Recommended schedules for each material are shown below, for use with Certus Prestige Optima or equivalent investment.

Castable Wax 40 Resin



	PHASE	TIME	SCHEDULE °C	SCHEDULE °F
	Heated Flask Drying	180 min	55 °C	131 °F
A	Ramp	48 min	2 °C / min	3.6 °F / min
	Hold	180 min	150 °C	302 °F
	Ramp	75 min	2.0 °C / min	3.6 °F / min
	Hold	180 min	300 °C	572 °F
B	Ramp	108 min	4.0 °C / min	7.2 °F / min
	Hold	180 min	732 °C	1350 °F
C	Ramp	44 min	- 5 °C / min	-9 °F / min
	Casting Window	Up to 2 hours	Desired casting temp	Desired casting temp

Castable Wax Resin



	PHASE	TIME	SCHEDULE °C	SCHEDULE °F
A	Insert Flasks	0 min	21 °C	70 °F
	Ramp	60 min	4.7 °C / min	8.4 °F / min
	Hold	480 min	300 °C	572 °F
B	Ramp	100 min	4.5 °C / min	8.1 °F / min
	Hold	180 min	750 °C	1382 °F
C	Ramp	60 min	- 4.0 °C / min	- 7.1 °F / min
	Casting Window	Up to 2 hours	Desired casting temp	Desired casting temp

Troubleshooting Casting

PROBLEM	CAUSE	SOLUTION
Holes or engraves filled ***and*** **Pitted surfaces nearby**	Localized investment breakage due to stress from resin thermal expansion.	Slow burnout ramp rate.
		Add fillets to sharp corners of model in CAD.
		Reduce depth of engraved feature in CAD.
		Upgrade to Castable Wax 40 Resin (if using Castable Wax Resin).
		Add boric acid to strengthen investment.
Metal flashing	Investment too weak, cracked due to bulk thermal expansion of resin.	Slow burnout ramp rate.
		Increase spacing between resin patterns.
		Decrease ratio of water added to investment.
		Increase bench set time after investing.
		Consider switching investment material.
Rough surfaces ***(without visible investment breakage)***	Resin boiling from excessive heating prior to liquid wax elimination.	Slow burnout ramp rate, increase low temperature hold time.
	Insufficient oxygen for combustion.	Increase airflow in burnout oven.
		Add wax sprue from problem area to main feed sprue.
		Evacuate flask with light vacuum pressure prior to casting.
	Resin cross section too thick for resin system, part constrained against mold wall during combustion.	**Castable Wax 40:** • See above. **Castable Wax v1:** • If wall thickness is <2mm, try steps above. • If wall thickness is >10mm, hollow part to thin shell. • If wall thickness is between 2-10mm, consider switching to Castable Wax 40
Small bubbles on casting	Investment is too viscous.	Increase ratio of water added to investment.
	Investment working time too short to fully degas flask.	Use cold water in the investment mixture.

Papilio Ring,
LACE by Jenny Wu

Learn More About Digital Jewelry Fabrication

Casting is an involved process, so for best results, we suggest working with a casting specialist.

Special thanks to Lars Sögaard Nielsen and the KEA (Copenhagen School of Design and Technology) for letting Formlabs document their casting process.

RELATED RESOURCES

Designing for 3D Printed Jewelry

An introduction to desktop stereolithography 3D printing for jewelry, covering tips and tricks for success in printing and casting with many detailed examples.

Vulcanized Rubber Molding for 3D Printed Masters

Learn how to use the Form 2 to produce multiple wax pieces by 3D printing a mold master for use in room temperature and medium temperature vulcanization processes.

Selling Custom Jewelry with 3D Printing

The Form 2 is easy to use and is suitable for operation in a showroom or retail environment. Learn strategies for using 3D printed maquettes to provide a better client experience for custom work.