USAGE AND DESIGN GUIDE

Ceramic Resin

Ceramic Resin is a unique material in the Formlabs library, a composite resin engineered for the Form 2. Ceramic is intended to be fired in a kiln or furnace, where the polymer matrix burns away and the model transforms into a silica ceramic part. By 3D printing with Ceramic Resin, you can create complex ceramic objects that would be impossible to cast. **After firing, Ceramic is:**

Heat resistant over 1000 °C.

Resistant to deformation over time.

Dinnerware safe when glazed.

As a Form X experimental product, Ceramic Resin has a lower print success rate than standard Formlabs materials, and therefore benefits from a higher level of skill and attention than other Formlabs products. Ceramic Resin has special requirements for part design and print planning. Some models require modification to fire well. Follow these guidelines to successfully print and fire parts.

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Required Equipment

Formlabs Form 2 3D printer
Cone 8 (1271 °C) or hotter kiln/furnace with external ventilation and digital time/temperature control

Recommended Supplies

Extra Form 2 build platform	220 and 180 grit sandpaper
Kiln wash	High fire glaze
Clear adhesive-backed plastic film	Setter sheets (optional)

Notice: *Ceramic will degrade the appearance of the cover of the Form 2 if liquid resin touches the cover. Apply clear adhesive-backed plastic film to protect the inside of the cover. Clean with soap and water only.*

Ceramic Pre-Print Checklist

***Notice**: Skipping one or more of these steps will likely cause your print to fail.*

- [ ] Import a single part into PreForm measuring less than 100 mL
- [ ] Scale the part to offset firing shrinkage
- [ ] Generate supports using default settings
- [ ] Mix resin in the tank with the wiper or scraper
- [ ] Vigorously shake the resin cartridge for 1 minute
- [ ] Firmly scratch the build platform with 180 grit sandpaper

Printing Overview

Ceramic Resin is a Form X material that requires special handling. Read and follow these guidelines to achieve success when printing and firing Ceramic Resin.

PART SIZE

Follow the **Design Guidelines** on page 8 for part design specifics.

Form X Ceramic Resin is best suited for printing small and thin parts. Wall thickness for fired parts should be between 2 and 10 mm. Thicker sections are more likely to crack during the burnout stage of firing and more likely to tear off of supports during printing.

> **TIP:** Parts should measure less than 100 ml and thin-walled to maximize print success.

SUPPORTS

Due to its high filler content, Ceramic is fragile in the green (unfired) state, and requires more support than other Formlabs resins.

Default support settings will typically work for small objects. Larger objects may require larger support touchpoints and higher support density, especially for parts with thick cross-sections. Very small objects may be printable with smaller or fewer support touchpoints.

After printing and removing the supports, smooth the part surface with 120 grit sandpaper to smoothly remove support marks. Sanded support touchpoints disappear during the bisque fire.

MIXING

Ceramic Resin will separate and settle over time when stored in the cartridge or tank. Mix the resin in the resin tank and cartridge before each print.

Vigorously shake the resin cartridge for one minute. If the cartridge has been sitting unused for several days, settled filler may obstruct the bite valve. Ensure the vent cap is closed, then gently push a toothpick through the pre-existing slit in the valve to clear the opening. Insufficient mixing of resin in the cartridge will result in inconsistent ceramic content within the resin, which will cause inconsistent shrinkage between the first and last prints from the cartridge.

Ceramic Resin settles in the tank and must be fully mixed to print successfully. Before each print, remove the tank from the printer and use the wiper or scraper tool to fully mix resin in the tank.

> **TIP:** In order to prevent clogging, store Ceramic Resin cartridges horizontally, with the label facing down.

BUILD PLATFORM ADHERENCE

Ceramic Resin requires a rough surface to properly adhere to the build platform. Firmly scratch the build platform with 180 grit sandpaper before printing.

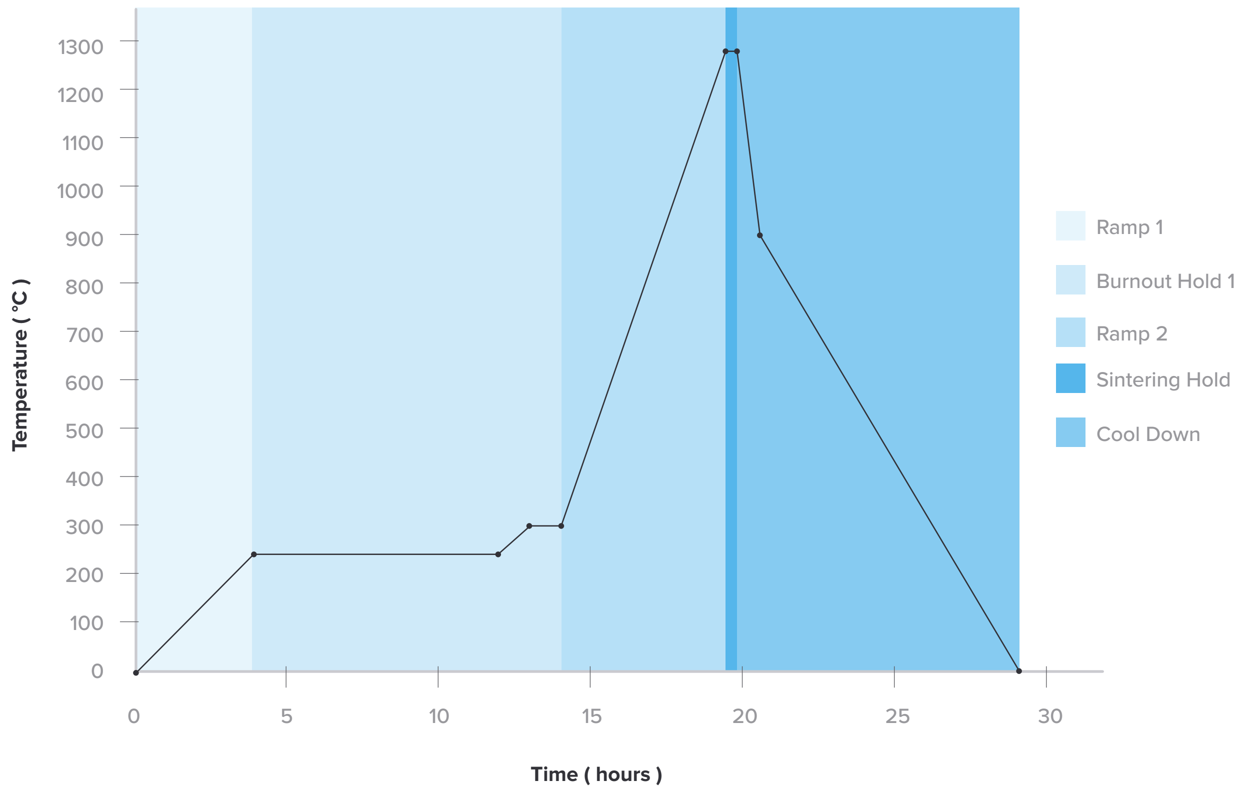
WASH AND DRY

Wash the printed part for 5 minutes in isopropyl alcohol. Use a separate wash bucket to prevent loose ceramic particles from adhering to non-Ceramic parts. Ceramic Resin does not require post-curing, however parts must be fully dry before firing. Allow parts to fully dry before firing.

> **TIP:** Consider printing splash guards (STL) for your resin tank to add an extra layer of protection against spills.

Firing Overview

CERAMIC RESIN FIRING SCHEDULE



Total Time (min)	Time to Temp (min)	Temp (°C)	Phase
0	0	0	Ramp 1
240	240	240	
720	480	240	Burnout Hold
780	60	300	
840	60	300	
1173	333	1271	Ramp 2
1178	5	1271	Sintering Hold
1238	60	900	Cool Down
1688	450	0	

1. Ramp 1

During Ramp 1, the part is heated to 240 °C for Burnout.

2. Burnout

Ceramic Resin prints with a polymer matrix, which is removed during the burnout phase. At burnout temperatures (240 °C), the ceramic particles have not yet fused, and are loosely held together as a powder body.

The Burnout phase should be long enough to completely remove the polymer matrix. Partial burnout will cause vapor pressure to increase during the Ramp phase, resulting in cracks and distortion as vapor escapes. Thinner walls (less than 6 mm) require less time to burn out, and tend to have the best surface quality and accuracy. Very thick sections (thicker than 10 mm) require very long burnout times.

Set the burnout hold (time at 240 °C) based on the the maximum cross-sectional thickness of any part being fired. Parts can be held at the burnout hold temperature for extra time without issue.

A short secondary hold at 300 °C ensures that all polymer is burned out before Ramp 2.

> **GUIDELINE**: Hours at 240 °C should be equal to the maximum wall thickness of your part in millimeters.
>
> For example, a part with a maximum wall thickness of 15mm should be held at 240 °C for 15 hours, then at 300 °C for 1 hour. A part with a maximum wall thickness of 4 mm should be held at 240 °C for 4 hours, then at 300 °C for 1 hour.

3. Ramp 2

The Ramp 2 phase is the increase in temperature preceding sintering. Formlabs recommends a ramp rate of 3 °C per minute in order to heat parts uniformly.

Parts with large variations in wall thickness benefit from slower ramp rates. Parts designed to have uniform, thin walls throughout can be ramped more quickly.

4. Sintering

During sintering, the silica particles in Ceramic Resin fuse to form a solid part. The particles become semi-liquid, allowing them to shrink together and become denser. Ceramic shrinks by 15% during sintering, reaching up to 90% density.

When Ceramic Resin is properly sintered, the material becomes slightly translucent and watertight. Parts printed with Ceramic Resin are fired at temperatures between 1250 °C and 1300 °C. Formlabs recommends holding at 1271 °C for 5 minutes. Decreasing the maximum temperature or hold time will result in a more porous, less glassy part.

If you require specific dimensions, compensate for shrinkage by scaling the model. Learn more about how to properly scale and support models in the Design Guidelines.

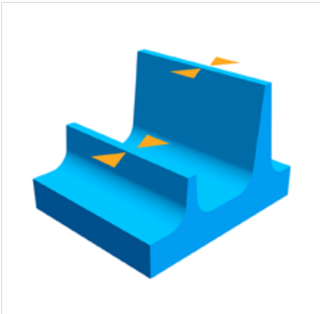
5. Cool Down

Between maximum temperature and 900 °C, cool at the freefall rate of your kiln or furnace. This fast Cool Down phase limits additional slumping. Cool at a controlled rate of 1 °C per minute between 900 °C and room temperature to avoid structural cracking.

> **TIP:** Many kilns do not have a linear natural cooldown. Program the final step to ensure a constant cooldown rate.

Design Guide for Fired Parts

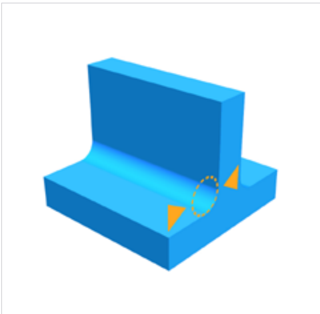
Ceramic Resin is a Form X material that requires unique design preparation. Read and follow these guidelines to achieve success when designing parts to print with Ceramic Resin.



FIRED WALL THICKNESS

Min: 2 mm, **I**deal: 3 - 6 mm, Maximum: 10 mm

Small walls and features may work under 2 mm



FILLETING

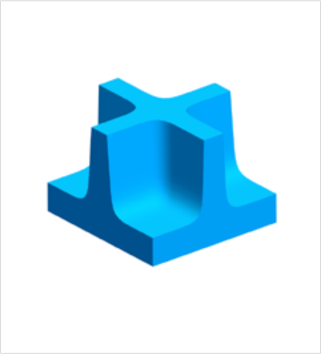
Fillet internal edges to avoid stress concentrations and decrease cracking: **Min**: 1 mm fillet radius, **I**deal: 2 mm+

GENERAL SHRINKAGE

Shrinkage is caused by sintering, and gives Ceramic its strength by increasing the density of the part. General shrinkage occurs mostly uniformly across the part, and parts shrink by approximately 15% during sintering. Scale the part by 1.15 in PreForm to account for this effect.

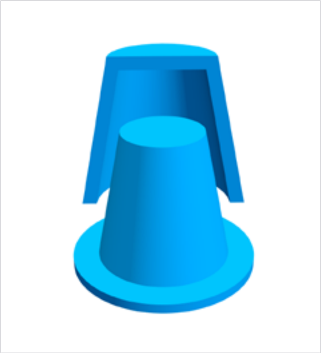
Z-SHRINKAGE

Parts shrink more along the printed Z axis than the XY axis due to the lower concentration of ceramic particles between layers. If a model is printed at an angle, this causes a skewing effect when fired. Pre-scale the model in the printed Z axis to correct this effect. The printed "green" part will be skewed, but the part shape will correct during firing. Compensate for Z-shrinkage in the Ceramic material selection screen in PreForm.



SELF-SUPPORTING STRUCTURES

Ceramic particles can move during sintering, which means that the shape of the model is affected by gravity. Self-supporting structures maintain their shape, but unsupported overhangs tend to slump or collapse. Design structures that are self-supporting to minimize the volume of support structures and prevent slumping during firing.



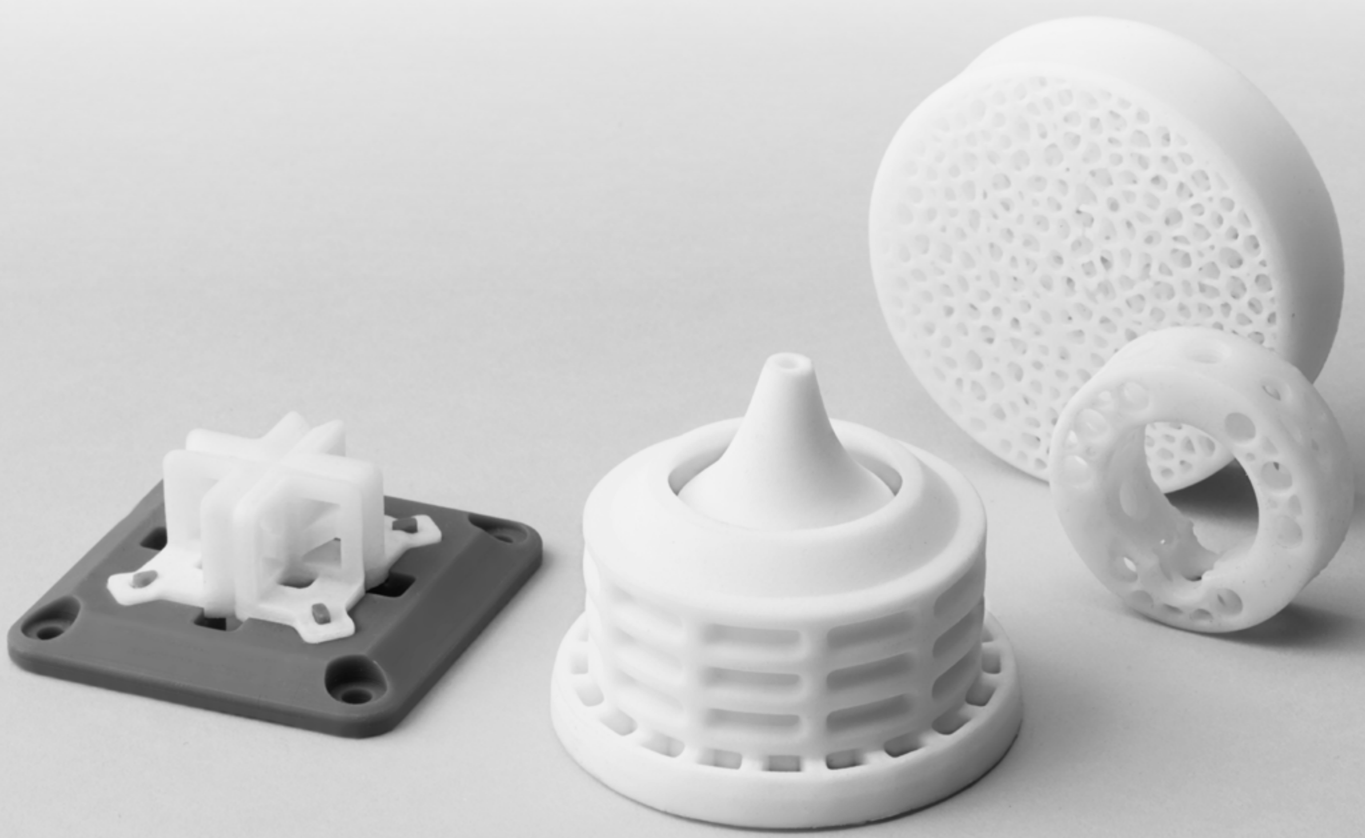
UNSUPPORTED STRUCTURES

Unsupported structures, such as overhangs and bridges, are often unavoidable. There are two major ways to control the potential slumping effect:

Print custom setter(s) (must be printed in the same orientation as part).

Fire on supports.

TIP: Parts often require several scaling iterations to reach the desired fired dimensions.



Glazing Instructions

Glaze parts printed in Ceramic Resin to make them smooth to the touch. If using a dinnerware safe glaze, finished parts can be used in contact with food. Although Ceramic fired to Cone 8 is typically watertight, it is not considered dinnerware safe unless glazed.

Formlabs Ceramic Resin can be used with high-fire glaze. Brush glaze onto the fired ceramic bisque in two thin coats, allowing the glaze to fully dry between coats.

Start Experimenting

Ready to start working with Ceramic Resin?

Order Ceramic Resin Now

Troubleshooting

PROBLEM	CAUSE	SOLUTION
Printing		
Print did not start or resin was not properly dispensed	• Resin too viscous to flow into tank • Cartridge has settled or valve is clogged	• Shake the cartridge and clear the valve before printing
Part broke off of supports during print	• Insufficient support (**or**) • Excessive cross sectional area	• Increase support touchpoint size • Increase support density.
Base fell off build platform during print	• Build platform too smooth	• Re-sand build platform with 180 grit sandpaper
Firing		
Fired or green part has cracks at interior corners	• Interior corners too sharp	• Part requires larger fillet at corner
Unfired part has a prominent line which cracks upon firing	• Resin settled during long pause mid-print	• Clear cartridge valve and shake well before print • Avoid printing interruptions
Part slumped or fell apart during firing	• Walls too thin (**or**) • Geometry not self-supporting	• Increase wall thickness (**and / or**) • Fire on supports
Fired part has large cracks in the direction of layers	• Walls too thick	• Increase burnout hold time at 240 °C
Fired part has surface bubbles	• Insufficient burnout time	• Increase burnout hold time at 240 °C
Fired part has large cracks in random directions	• Dunting (too fast cooldown)	• Slow furnace cooldown rate
Fired part has sagged more than expected	• Geometry not self supporting	• Decrease Sintering Hold time (**or**) • Fire on supports (**or**) • Print custom setter
Warp between top and bottom of part	• Setter drag	• Apply kiln wash to shelf (**or**) • Apply setter sheets to shelf
Fired part has skewed to an angle	• Ceramic Resin has extra Z-shrinkage when fired	• Increase Z-scaling before print
Fired part too fragile or porous	• Kiln not hot enough	• Increase sintering hold time • Replace kiln thermocouple
Glazing		
Glaze soaks into part when fired	• Bisque fired part is not fully sintered and is too porous	• Increase sintering hold time • Replace kiln thermocouple • Check peak kiln temperature
Part falls apart after glaze firing	• Glaze compression of part	• Reduce glaze thickness • Increase cooldown time • Glaze may be incompatible