

Glass Fusing

The art of glass fusing has been around for many years. It regained popularity during the 1960's and has maintained a strong place in artist communities since. Fusing glass in a kiln is a fascinating technique that enables artists to create unique and gorgeous projects but getting started can be intimidating for artists new to hot glass techniques. The information and tips provided below will provide some basic information and make it easy to get started!

Glass compatibility (COE)

The Coefficient of Expansion (COE) refers to the rate at which glass expands and contracts when heated and cooled. All glass has a COE but we don't always know what it is. It's important that all of the glass you are fusing together expands and contracts at the same rate or stress and cracking can occur. Glass manufactured specifically for fusing is tested for compatibility. Always fuse glass with the same COE or tested compatible glass.

Properties of Hot Glass

When heating glass to a full fuse (1450° F) it wants to become ¼" thick and round. A standard sheet of glass is approximately 1/8" thick.

- When firing a single layer of standard glass the edges will contract to become ¼" thick.
- If fusing three layers of standard glass your glass will expand to become ¼" thick.
- Unless you are damming the glass, two layers are ideal to maintain your projects original size and general shape.

In the picture below, notice how the following stacks of glass appear before and after firing.



In the next picture, notice how each cabochon is approximately the same thickness



Viewing the cabochons from the top you can see how the stacks spread when they were fired.



Keeping the ¼" rule in mind will help you achieve the desired effect without growing or shrinking your project.

Heating and Cooling Glass

Glass cannot be heated or cooled too slowly. Heating and cooling too fast can result in cracked glass or thermal shock. Ideally you want your glass to stay approximately the same temperature as the kiln. Because the glass heats more slowly than the kiln, you should consider your project size and how long it will take the piece to "catch up" to the kiln temperature.

- The larger your project the slower you should go – 200° - 300° F an hour is safe a speed.
- Smaller projects, like jewelry, can be heated more quickly – 500° F per hour is a safe speed.
- Be sure to keep track of the schedules you try so you'll know what works best.

Slow, controlled cooling, commonly referred to as annealing, is the process in which you allow the glass to gradually cool down in order to remove internal stresses that may have occurred during the firing process.

Annealing allows the glass to stabilize and adds strength to your finished project.

- Ideal annealing temperatures are 900° F for 90 COE and 950° F for 96 COE glass.
- 30 minutes is usually sufficient for small projects but you may choose longer annealing times for larger pieces.
- When in doubt, anneal longer; you cannot over anneal.
- Allow your kiln to cool completely before opening the lid – a rush of cool air into a hot kiln will cause thermal shock and often crack your project. Breaks from thermal shock generally go straight across the piece and have a little hook near the edge.

Never Refuse to Re-Fuse

If your glass breaks in the kiln, your project didn't turn out quite as expected, or you feel the need to add further embellishments to your project, you can re-fire your project until you get the results you desire. For cracked glass some artists add additional pieces of glass to the top of the glass to reinforce and cover the "seam" where the crack occurred. Do not try to re-fire projects with incompatible COE's. Even if the project survives the heating and cooling process the stress remains and the piece can crack or break later.

Key Temperatures in the Firing Process

The firing process you select will determine the final appearance of your fired project. Many projects will require multiple firings using different processes before they are complete.

Temperatures Ranges	Fusing Stage	Glass Stages
800° F – 1100° F	Brittle Zone	Do not open the kiln in this range
1250° F – 1300° F	Slump	The glass is placed on a mold and bent into the desired shape.
1300° F – 1350° F	Tack Fuse	Edges are soft, glass is stuck together, embellishments are well defined.
1350° F – 1400° F	Medium Fuse /Fire Polish	Edges are softer, surface is shiny and embellishments are slightly less prominent.
1400° F – 1500° F	Full Fuse	Glasses combine, thickness is uniform throughout

The photographs below show glass projects with similar embellishments, fused at various temperatures.



1250° F – 1300° F



1300° F – 1350° F



1350° F - 1400° F



1400° F – 1450° F



1450° F - 1500° F

Common Firing Schedules

The schedule that works for you will depend largely on the size, scope and desired look of your finished piece. The firing schedules below will provide a great place to start.

Full Fuse	Rate (Ramp)	Temperature	Hold (Soak)
Segment 1	300° F /hour	1000° F	5 minutes
Segment 2	300° F/hour	1250° F	30 minutes
Segment 3	300° F/hour	1450° F	10 minutes
Segment 4	Full (9999)	900° F (90 COE) 950° (96 COE)	
Slump	Rate (Ramp)	Temperature	Hold (Soak)
Segment 1	300° F /hour	1000° F	10 minutes
Segment 2	300° F/hour	1290° F	10 minutes
Segment 3	Full (9999)	900° F (90 COE) 950° (96 COE)	20 minutes
Tack Fuse	Rate (Ramp)	Temperature	Hold (Soak)
Segment 1	300° F /hour	1000° F	10 minutes



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Segment 2	300° F/hour	1340° F	5 minutes
Segment 3	Full (9999)	900° F (90 COE) 950° (96 COE)	20 minutes
Fire Polish	Rate (Ramp)	Temperature	Hold (Soak)
Segment 1	300° F /hour	1000° F	10 minutes
Segment 2	300° F/hour	1350° F	5 minutes
Segment 3	Full (9999)	900° F (90 COE) 950° (96 COE)	20 minutes

All Kilns are Not Alike

- Your kiln size, controller type, and individual project may require some alteration to the schedules above for best results. Firing times and temperatures may vary, each kiln is unique.
- Use firing schedules as a guide, but remember to check your piece frequently during fusing, and record changes in schedules as needed.
- Prepare your kiln by applying kiln wash with a kiln brush. Apply one thin coat in each direction. Don't forget to apply kiln wash to molds, too.

Project Firing Logs

Using a project and firing log to keep track of information about your projects and firing schedules can be an extremely useful tool for every artist. Once you've achieved a good result you can reference the logs to re-create the project or simply re-use a firing schedule for a similar project. Click on the buttons at the top of the page for a copy of this document and a project firing log to get you started.