Troubleshooting For Glass Art

PROBLEM - CAUSE - CORRECTION

What went wrong?

How did it happen?

Can it be fixed?

How to avoid repeating?

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Introduction

Troubleshooting is trying to understand failure.

Not everything works. When it doesn't work, we try to understand why. What went wrong? Why didn't I get the results I wanted? What might I have done to make it different? The more you do the more you will fail. Never be afraid to fail. The greatest of all failures is failure to try.

We learn most from our failures. When something works we don't ask why but when it fails we investigate and analyze what happened so the next time we try it won't fail. This guide is to help you troubleshoot your failures so your next efforts will be successes.

Pass it along

There is much to learn about how glass can be used to create art and it can take years to learn what you need. This guide was created to help you better understand what happens and to help you enjoy it more. Please pass it along to any others you think might benefit from it.

Help us keep this guide constantly updated and improved.

The Guide to Troubleshooting Glass Art was created as a cooperative effort with hundreds of comments and suggestions from hundreds of glass artisans ranging from beginner hobbyists to experienced professionals. It is designed to be routinely revised and improved.. Help us do that by sending us any comments or suggestions you might think should be included.

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Cutting Glass

Three factors determine to how accurately the break will follow the score.

1. Cutter held perfectly vertical – not tilted front to back or to either side.
2. Perfectly even pressure while scoring.
3. Perfectly even speed while scoring.

Glass failed to break after being scored

- Insufficient pressure scoring. You didn't press hard enough.
- Insufficient pressure breaking. You must be aggressive when you break. Score slow but break fast. It's not a request. It's a command.

Glass broke but failed to follow the score

- Changed pressure during the score.
- Changed speed during the score.
- Off level. Scored with cutter not vertical.
- Excess pressure. Pressed too hard causing the cutter to skip.
- Damaged cutter. Nicks in the cutter head. You can test to see if your cutter wheel has nicks but scoring on a piece of mirror. If is has nicks the reflection of the score will be a dotted line.
- Break started from part way on the score and not from one end.
- Cold glass. When glass is cold it will something refuse to follow the score.
- Insufficient oil. Although it is sometimes possible to get a good score without oil you will always get a better score with oil.

Glass broke on an angle and not a square edge

- Cutter wasn't held vertical.

SUGGESTION

The ideal pressure for scoring glass is 6 to 8 lbs. To check to see if you apply the right pressure when you score, practice scoring on a bathroom scale. Place a piece of glass on the scale and score it. You read the pressure you applied when you score.

- Did you press too hard?
- Did you not press hard enough?
- Did you change pressure somewhere in the score?

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SPECIAL ISSUES

Thick glass

Oil is important for cutting any glass but is essential for cutting thick glass. You will get the most reliable cuts on thick glass if you apply oil before you score so you score through the oil.

Thin strips

The narrowest strip that can reliably be cut off a piece of glass is the width of the glass thickness. If the glass is 3mm thick, the narrowest strip that can be reliably cut off is 3mm. If the glass is 6mm thick, you can cut off a 6mm wide strip but not a 3mm wide strip. It helps if instead of trying to break in a single action you instead do it in stages.

1. With breaking pliers at one end of the score start the break just enough to hear a crack.
2. Bend the pliers down just a little more the run the score part ways.
3. Bend the pliers down more to complete the score.

Iridescent & Dichroic glass

Will chip if you score non-metallic side. It's better to score on the metallic side. It's easy to identify the metallic side on colored glass but not so easy to identify on clear glass a trick that helps is to use a pencil or ball-point pen to examine the reflection. Place the tip of the pen or pencil on the glass. If the reflection touches the tip, that is the metallic side. If there is a space between the tip and the reflection, the other side is the metallic side.

Tapping

If can be difficult locating the back of the score to know when to start tapping to run a score. The easiest way to do that is to rely on your own muscle memory. Pull the glass just slightly off the table. Place your thumb on the score and bring your index finger up to touch your thumb to make the OK sign. Turn the glass over. Your finger is now exactly on the back of the score.

Tapping should not be done aggressively. The objective is not to break the glass but instead to create vibrations that will cause the glass to crack where it was scored. Just the way a jackhammer works to break up concrete. The steady vibrations will cause the material to break at its weakest point. With glass, the weakest point is where it had been scored. When you start tapping the back of the glass to run the score, create a steady rhythmic tapping like a little woodpecker on amphetamines. Start on one end of the score. As the glass cracks, move the tapping along the score to run it across the glass.

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Cracks

There can be so many different things that can cause glass to crack you often can't be certain of the cause but must settle for your best good guess.

If the edges of the broken glass are rounded off it means the glass cracked as it was heating up then rounded off when heated to a higher temperature. If the edges are a sharp clean break it usually means it cracked as it was cooling – but not necessarily. If the glass had cracked while being heated up but had not been heated above slump temperature the sharp edges would remain.

Thermal Shock Cracks

If the crack is relatively straight across the project, it's most likely caused by thermal shock from heating or cooling too fast. Projects that have variation in thickness are much more likely to experience thermal shock cracks than projects with a uniform thickness. The thinner parts will heat and cool faster than thicker parts.

Causes:

- Heated too fast. A slower temperature increase would avoid cracks.
- Cooled too fast. A slower temperature decrease would avoid cracks.
- Glass fired onto a kin shelf not elevated. A kiln shelf sitting on the kiln floor will retain heat causing the glass to cool faster than the shelf. The heat difference between the glass and kiln shelf can cause thermal shock cracks.
- Mold not elevated. If the mold is pressed against the kiln shelf, air can be trapped under the mold. That trapped air acts as an insulator to prevent even heat transfer between the glass and the mold.
- Draft from a kiln not fully closed. A lid that fails to firmly close can cause cool air.
- You peeked. It's safe to peek above 1000°F (540°C) but opening your kiln below that temperature can cause the glass to crack.

SUGGESTION

Thermal shock is the most common and most likely cause of cracks so should be the first thing to look for when your project cracked. Glass is immune to thermal shock crack above 1000°F (540°C) so it's safe to increase or decrease temperature as fast as you want above that but not so below that temperature. It can do no harm to ramp slower so it you aren't sure what is a safe speed to temperature up and down, it's a good practice to go slower.

Compatibility Cracks

If the cracks are along or around the edges of glass pieces that are fused together, it's likely caused by incompatible glass. Cracks resulting from fusing incompatible glass usually appear during or right after the firing but can happen days or even months later. If you are not sure all the glass you used in your project was compatible you should test it either with polarized lens or a freeze and thaw test.

Causes:

- Mistakenly included some glass that is incompatible. If you use glass in your studio that is not all compatible, it's important you keep it all carefully labeled to avoid such mistakes.

Inadequate Anneal Cracks

If the crack is an irregular wave across the project, it's most likely a result of inadequate anneal time. Treat this as a learning experience and pay more attention to annealing times for future projects.

Causes:

- Not long enough time to remove the stress in the glass. Like compatibility cracks, inadequate anneal cracks don't always appear right away but can be days or even months later.
- Wrong temperature – annealing at the wrong temperature can fail to remove the stress.

SUGGESTION

Annealing for too long can do no harm so, if you're not sure how long is safe, it's a good practice to anneal longer.

Repairs

The only thing you can do with a project with compatibility cracks is junk it. Projects with thermal shock or anneal cracks can sometimes be refired to fuse back together but it's rarely possible to repair a project without it looking like a repair. Most often the best choice is to recycle the glass into a project that uses scrap. Castings, mesh melts and vitrigraph pours are good options.

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Fusing Issues

Fused too much

- Fired at too high a temperature or held too long at top temperature.
- Your kiln controller is reading temperature wrong.
- Your kiln is retaining heat longer than you expected.

Fused too little

- Didn't fire to high enough temperature or didn't hold long enough at top temperature. This can be especially an issue when you set pieces of glass on top of a glass base and you want them to fully melt down into the base. It takes more time to allow that then is does to just fuse two layers of glass together.   Glass moves slow. Give it time to melt down.
- Your kiln controller is reading temperature wrong.

Spikes on glass edge

- Fired at too high a temperature for the thickness of the glass used.   If 3mm thick glass is fired above tack fuse temperature it draws in as it begins to thicken. Resistance to it sliding on the kiln shelf creates spikes along the bottom edges.

Cracked - Refer to Chapter on Cracks

Bubbles - Refer to Chapter on Bubbles

Inclusions - Refer to Chapter on Inclusions.

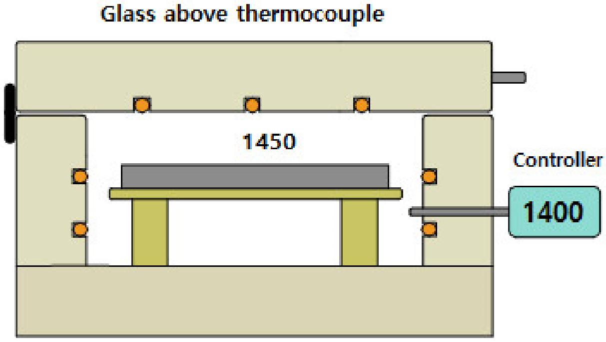
Stains - Refer to Chapter on Stains

Kiln Wash - Refer to Chapter on Kiln Wash.

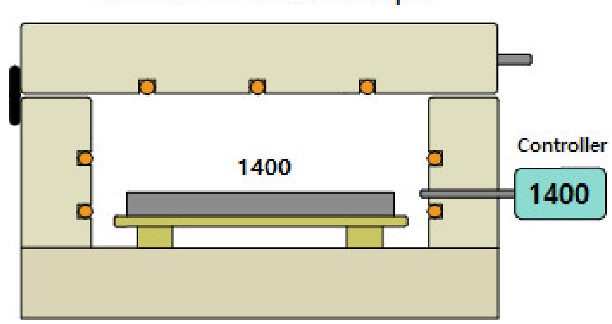
Temperature error

Your kiln only reads the temperature of the glass accurately when the glass is at the same level as the thermocouple.

Glass above thermocouple



Glass level with thermocouple



Slumping Issues

Slumping, also called sagging, is when you heat the glass to soften enough to drop or sag into a mold.

Glass cracked in the slump

- Did you raise or lower the temperature too fast for how thick the project is?
- Did your temperature change allow for any variance in thickness in the project?
- Was the mold elevated to allow air to flow beneath it?
- Was the mold of uneven thickness so some parts heated cooled faster than other parts?

Glass failed to drop fully into the mold

- Did you fire to a high enough temperature to soften the glass enough to drop?
- Did you hold at top temperature long enough to give the glass time to drop? How fast the glass drops depends on the span. The wider the span the faster it falls.
- Was air trapped under the glass preventing it from dropping?
- If the mold had an air release hole, was the hole open?
- Was the glass larger than the mold and gripped on the edges? The most a piece of glass can be safely set overhanging the edge of a mold when slumping is the thickness of the glass. If the glass is 3mm thick you can have your project extend 3mm off the edge of the mold and still trust it to drop into the mold. If your project is 6mm thick you can trust having the glass extend 6mm off the edge of the mold. You can NOT trust 3mm glass to extend 6mm off the edge of your mold.

Air trapped under the mold

- If the mold had an air release hole, was the hole open?
- Did you heat high enough or hold long enough to allow the glass to drop?

Glass dropped unevenly in the mold

- Is your kiln not level?
- Did one part of the project have more weight than another part. The heavier part will drop faster.

Glass stuck to mold

- Not enough kiln wash. If you failed to apply enough the glass will stick to the mold.
- Fired too high. Firing too high can cause the glass to stick to the mold.
- Metal mold. It is an almost universal practice to slump into ceramic molds and drape over steel molds. If you slump into a steel mold, both the glass and steel expand as they heat up but as they cool, the metal shrinks faster than the glass. This can cause the glass to stick to the mold.

Molds

Glass stuck to mold

- Not enough kiln wash.
- Kiln wash unevenly applied.
- Fired too many times. If you only fire to drape or fuse temperature kiln wash or boron nitride can be reused many times but if you fire to higher temperature the glass can stick to the mold if you didn't apply a fresh coat of separator.
- Slumped into a metal mold. Ceramic is used for slumping and metal for draping. Metal contracts faster than glass so as the mold cools it will press so hard against the glass it's impossible to remove the glass.
- Draped over a ceramic mold. Glass contracted faster than the mold and locked on.

Won't accept kiln wash

- Contamination on or in the mold material. Anything containing petroleum left on ceramic or steel molds can prevent kiln wash from sticking to the mold. Sometimes bits of the clay used to make molds gets contaminated. This causes them to refuse to accept kiln wash wherever the clay is contaminated. Sometimes this area can be sanded to remove the contamination but more often the contamination is right into the clay and the mold is useless.

Mold cracked

- Heated or cooled too fast. Just as glass can crack when heated or cooled too fast so can molds.
- Mold material is inconsistent. If the material in the mold is an inconsistent compound or if the mold is an inconsistent thickness, that inconsistency can cause thermal shock cracks the same as in glass. That's why most ceramic molds are made from slip cast clay to ensure a uniform texture and thickness.
- Mold set on kiln shelf. Ceramic molds set directly on a kiln shelf can fail to heat and cool as fast as the kiln shelf. This can cause the mold to crack. All molds should be elevated to allow air to flow beneath the mold.

SUGGESTIONS

- Kiln wash will stick better to metal molds if they are heated. A hair dry works well or put the mold on a cookie tray on the lid of your kiln when the kiln is firing.
- If you crack or chip a mold there are products available to repair the mold.

Draping Issues

Glass cracked in the drape firing

- Did you raise or lower the temperature too fast for how thick the project is?
- Did your temperature ramp speed allow for any variance in thickness in the project?
- Was the mold elevated to allow air to flow beneath it? This is a concern with all molds but a specially serious problem with metal molds. As the kiln heat rises, the metal mold seals against the kiln shelf and traps air inside the mold. That trapped air acts as an insulator preventing the glass from heating and cooling at the same rate as the mold.
- Was the mold of uneven thickness so some parts heated cooled faster than other parts?

Glass failed to drop fully drape

- Did you fire to a high enough temperature to soften the glass enough to drop?
- Did you hold at top temperature long enough to give the glass time to drop? How long glass takes to fall depends directly on how far it sticks out. The greater the span the faster it falls.

Glass fell too far and stretched

- You either fired to too high a temperature or held too long at the top temperature. Glass drapes at lower temperature than it slumps. Drape temperature should be lower than slump temperature. The farther the glass hangs out from the mold the faster it will fall.

Glass dropped unevenly on the mold

- Did you center the glass on the mold?
- Is your kiln not level?
- Did one part of the project have more weight than another part. The heavier part will drop faster.

Glass ruffled

- It’s normal. When glass slumps into a mold it will stretch but when it drapes over a mold it can’t shrink so it folds to create ruffles. How much is ruffles depends directly on the thickness of the glass. On single layer 3mm thick glass is will ruffle significantly. On double thickness 6mm glass it will ruffle only slightly. On glass 9mm or thick it will not ruffle at all but will pull down flat. This is because the combination of the weight of the glass and attempt to reduce thickness to only 6mm thick pulls it down against the mold.

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Drops

Heating glass to soften and drop through a hole allows you to produce shapes not possible slumping into a mold and allows you to have a project with air polish inside and out because it hasn't pressed against a mold. Drops have a few unique problems with the biggest issue the difficulty of calculating a fixed firing schedule. There are so many variables it is usually needed to program an extremely long hold at top temperature and peek during the firing to see when to stop the drop from continuing.

Uneven drop

- Uneven heat. If one part of your kiln is warmer than other parts, the glass will drop more where it is warmer.
- Kiln off level. If your kiln is not level the glass project will follow gravity and not the angle of the kiln.

Glass dropped through mold opening

- Temperature too high. Drops should be done at a temperature lower than slump and with longer hold times. At regular slump temperature when the glass softens and starts to drop it gains momentum that can encourage it to slide right through mold opening.
- Mold rim too narrow. As the glass drops through the mold opening it stretches down but also pulls in. If the mold rim is too narrow the glass can pull in enough to drop through the mold.

Glass stuck to mold

- Not enough kiln wash on mold.
- Unsuitable mold material.

Dropped too little

- Hold time too short. Hold at top temperature long enough for the glass to drop.

Dropped too much

- Hold time too long.
- Failed to allow for residual heat. Turning the kiln off does immediately does not stop the heat being applied to the glass. Heat retained in the kiln will encourage the glass to continue moving.

Edges curled over the mold

- Glass overhanging mold. If the glass bigger than the mold and extends past the edge of the mold, the overhanging part of the glass will soften and bend outside the mold. The extra restriction created by this can prevent the glass from dropping into the mold.
- That's supposed to happen. It's one of the effects that makes drops especially appealing. As that glass drops it stretches and any design stretches and elongates.

Casting Issues

Casting glass is a kiln is usually done by placing powder, frit or scraps of glass in an open mold and firing to full fuse temperature.

Spikes on edge

- Resistance to kiln wash in the mold. As the glass melts and slides down the edges of the mold any resistance to sliding will cause some of the glass to stick to the mold and leave ragged spikes behind where glass stuck to the mold. Using boron nitride instead of kiln wash will significantly reduce this. Filling the mold with the middle piled higher than the edges will also help.

Air bubbles

- Any air between pieces of glass can be trapped permanently in the casting. This is most likely to happen when you lay pieces of glass flat in the mold. The best way to avoid trapping air is to stand pieces vertically in the mold so as they melt down any air between the pieces is squeezed out.

Casting appears opaque

- Powder used in the mold. When used for casting, transparent glass powder loses much of its transparency and appears after as slightly opague because of the multitude of air bubbles trapped in the powder.. You can avoid this affect by using larger particles of glass.
- Devitrification. Some glass devitrifies at casting temperatures. This often happens when you used bottle glass, float glass or glass intended for stained glass.

Too thin

- Not enough glass included. You can either premeasure how much glass is needed to fully fill the mold or make your best good guess at how much to add. A good working guideline is to assume when the glass pieces melt down the glass level it will drop to about half the height of the pile of loose glass. The smaller the pieces of glass used in the mold the less it will drop.

Mold side not smooth

- The glass will adopt any texture in the mold and not have the same shiny polish as the side exposed to the air. You can correct this with coldworking or you can flip the casting over and return to the kiln for a fire polish to put a full shine on what was the mold side.

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Edge Texture

Edges failed to round

- Didn't' fire high enough. Glass doesn't start to round off until above tack fuse temperature.

Sharp on underside of edge

- Fired too high too fast. A smooth kiln wash or a separator like boron nitride that offers less resistance to glass sliding over it will reduce the likelihood this happens.

Sharp spikes along edge

- Fired too high. Glass started to move to become smaller and thicker. A smoother separator would have reduced but not necessarily completely prevent this happening.

Ragged edges

- Resistance to the glass dropping into the mold. Usually caused by glass fired in a mold lined with rough textured mold material like ceramic fiber paper but also in ceramic casting molds. If you use ceramic fiber paper you will always get some rough surface on any glass pressed against it but you can minimize the amount of texture by lining it with kiln paper or spraying it with BN before firing. If you use boron nitride in casting molds you will not get the same ragged edges you get from using kiln wash.

Frosted finish on edges

- Some brands of kiln paper will produce devitrification on the glass edge if the pieces of kiln paper are small enough to curl up against the glass edge during the firing. Inadequate cleaning to remove residual glass dust after grinding will produce a dull frosted finish.

Repairs

If you aren't satisfied with how smooth the edge is on your project you can refire it to full fuse to a fully smooth polish or coldwork it to smooth. If you coldwork it to a 200 grit finish you can fire to a fire polish to create a smooth polished edge at only 1300°F (705°C).

Glass on the left was fired to 1350°F (732°C)

Glass on the right was fired to 1400°F (760°C)

The higher temperature produced edge spikes.

Rough Bottom

When you fire glass into a mold or onto a kiln shelf the glass will adopt any texture that was on the mold or shelf. How much texture is adopted varies with different mold separators. In order of likelihood:

- No separator. Possible with some shapes in slump and drape firings.
- Boron nitride on float glass. Float glass is so much harder than art glass it can be used as a shelf or slumping mold.
- Kiln wash. Kiln wash can be sanded to provide a nearly perfect smooth finish.
- Kiln paper. Will leave a delicate but noticeable pattern in the glass. Different makes of kiln paper leave different patterns and different degrees of texture.
- Ceramic fiber paper. Will leave a relatively rough orange peel like texture in the glass. One side is slightly smoother than the other so you can choose you much texture you want in your glass project.
- Silica cloth. Will create a significant texture in the glass. Different textures of silica cloth will produce texture varying from a fine linen to coarse burlap.

Repair

If you aren't happy with the texture on the underside of your project you have three options to produce a smooth polished finish.

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Flip and fire
Turn it over and fire to produce a full smooth polish on what was previously the bottom.

Coldwork
Coldwork the rough surface to the desired smooth finish

Fire Polish
If you sand the glass to 200 grit you can fire it in the kiln to 1300°F (705°C) to put a full smooth polish on the glass.

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Size or Shape Change

6mm RULE

When art glass is fired to full fuse or higher, it moves to become a uniform 6 mm thick. If you start with thicker glass, it will press down and spread out the same way pancake batter spreads out when you pour it onto a griddle. If you start with thinner glass, it will draw in to contract as it moves to become thicker. The **6 mm Rule** is as persistent as gravity. If you toss something into the air, gravity will make it fall down. If you fire glass to above tack fuse temperature, it will move to become 6 mm thick. If you don't want something to fall down, don't throw it into the air. If you don't want your glass to thin or thicken, don't fire it above tack fuse temperature. Float glass responds exactly the same way. You must allow for this in your firing schedule

Glass drew in and got smaller

This is called "dogbone". It happens when you fuse a piece of glass that is thinner than 6 mm thick and it pulls in to thicken to become 6 mm thick. The corners remain close to the original size but the sides curve inward like the shape of a dog bone. The only way to prevent your glass project from dog boning is to either not fire above tack fuse temperature or take care to be sure the combined mass of glass is at least 6 mm thick. If your fused project has dogboned you can straighten the edges out by coldworking either with a grinder or wet belt sander.

Glass spread out and got bigger

This bulging happens when the total mass of glass is more than a uniform 6 mm thick and the project bulges out to become thinner. The edges push out more than the corners so the sides curve outward. The only way to prevent your glass project from bulging out is to either not fire above tack fuse or ensure the combined mass of glass is equivalent to 6 mm thick. If your project bulges, you can remove the bulge by either sawing it off or grinding it off. You can prevent bulging by firing your project in a mold.

Holes opening in the glass

On a small project less than 6mm thick the whole project will get smaller. On larger projects as it attempts to become thicker it doesn't just get smaller but opens holes in the glass to make it easier for some parts to become thicker.

If you place pieces on a 3mm base that has spaces between the pieces and fire to full fuse temperature the spaces with only 3mm glass will often open up to create holes. To prevent this requires using 6mm as a base.

Repair

- If the project has dogboned you can grind or sand the sides to a straight edge.
- If the project has bulged out you can grind or sand the sides to a straight edge.
- If the project has opened holes you can fill the holes with glass frit and fire again in the kiln.

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Bubbles

Bubbles between glass and kiln shelf

- Residual moisture in the kiln wash. At high temperature moisture expands as steam to create a pocket of air. The glass softens around the air pocket. It's a good practice to be sure kiln wash is dry before placing glass on it. Not everyone agrees moisture is an issue. You can decide for yourself how important it is to fully dry shelves and molds before firing.
- Hollow spot in the kiln shelf. It's more common than you might expect.
- Debris on the kiln shelf. It's a good practice to always sweep your shelf before loading.
- Edge weighted design. If the design is heavier along the edges than in the middle, the edges will press down before the middle and trap air. Be sure your design allows for air to escape.

Bubble between layers of glass

- Debris between the glass. Even the tiniest piece can trap air.
- Texture on one glass surface.
- Edge weighted design. If the design is heavier along the edges than in the middle, the edges will press down before the middle and trap air. Be sure your design allows for air to escape.
- Inclusion – air trapped around the inclusion. The thicker the inclusion the greater the chance it will trap air to create bubbles.

Bubble between glass & mold

- No vent hole. As the glass drops into the mold it can trap air.
- Vent hole plugged.

Bubble Prevention

- Be sure all kiln wash on the shelf or molds is thoroughly dry.
- Introduce a slow bubble squeeze in the firing schedule.
- Use inserts – pieces of glass along perimeter to hold the perimeter elevated causing the middle of the glass to drop first.

Bubble Repair

Usually the only way to repair a bubble is break it open or drill a hole it. Fill the space with frit and fire again in the kiln. Repairs almost always look like repairs. Prevention is always better than repair.

Color Change

It’s not a happy time when you carefully select colors for a glass project, fire it in your kiln and it comes out after with different colors.

Glass changed color

- Fired too high. Some glass changes color at high temperature firings. Red and orange are notorious for shifting towards brown and some blues will shift towards grey. This is a special concern with projects like pot melts, mesh melts, combing and vitrigraphs that are fired to temperature above that usually used for a full fuse.
- Reactive to other colors. Some glass reacts with other glass it touches and changes color. Glass makers produce some makes of glass specifically intended to produce a dramatic color reaction.
- A striker glass. Some glass colors are intended to strike to a different color with higher temperature producing a stronger color change. Such glass is usually labeled as “striker” glass.
- Multiple firings. Some glass will change color after multiple firings.

Glass lost its shine

- Art glass not suitable for fusing. Glass made for fusing is a different chemistry than the art glass made for stained glass. Art glass is more susceptible to devitrification which causes the glass to lose the shine adopt a dull frosted finish. This is most likely to exhibit on opalescent glass or any streaky glass with opalescent glass in it.
- Contamination on the glass. It could be dirt or even residue from something you used to clean the glass. Many glass cleaners are notorious for leaving a residue that can produce either a greasy smear or loss of shine on the glass.

Prevention

The best way to prevent color change is with education. Make a point of learning which colors will change in a kiln firing and how they will change.

Dichroic & Iridescent Glass

Edges chipped while cutting

- Scoring on the metallic side will produce a smoother break.

Edges chipped while grinding

- The finer the grit on the grinder head the less the metallic edge will chip. If instead of grinding you use a wet belt sander and hold the metallic edges up against the direction the belt moves you will get no chipping.

Surface puckered in a fuse firing

- Glass contracted. If the glass shrinks in the kiln firing the metallic surface will not shrink along with the glass. This causes the metallic surface to pucker.

Glass puckered in a slump firing

- Slumping with metallic surface up. As the glass bends the upper surface of the glass flows in. The metallic surface won't flow along with the glass so it puckers.

Surface cracked in a fuse firing

- As the glass flows out to expand the metallic surface doesn't flow with the glass so it cracks apart.

Surface cracked in a drape firing

- As the glass bends the metallic surface won't bend with the glass so it cracks apart.

Glass element didn't fuse into metallic surface

- The metallic surface remains as a solid film preventing any glass sitting on it from melting into it.

Iridescent side of glass failed to fuse to other iridescent glass

- The metallic side will fuse only to a non-metallic surface.

Dichroic side of glass failed to fuse to other dichroic glass

- The metallic side will fuse to a non-metallic side of other glass but will not fuse to a metallic side.

Iridescent surface burned off in the kiln firing

- Was it high fire iridescent glass made for fusing and not iridescent glass made for stained glass and not intended for fusing?
- Was it Wissmach Luminescent glass and you fired it with metallic face up? That glass must be either fired with metallic face down or if fired face up must have a piece of kiln paper on top.

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Freeze & Fuse

This is a technique using glass powder mixed with water in a mold, frozen, then fired in a kiln to create glass castings.

Shrunk in the firing

- It's natural. When the water steams out in the kiln the glass powder bits melts together but without the water will be 15 to 20% smaller.

Cracked in the firing

- Not enough water. The water binds the powder particles together. If you removed too much water before freezing the casting will fail to fully fuse.
- Incompatible glass. The same as with fusing projects. If you used any material that is incompatible it is likely to crack the casting.
- Grit too thick. Freeze & fuse castings work best with powder. You can use a small amount of fine grit material in a project but the more thicker grit material used the more likely the project will crack in the firing.
- Too slow loading. If the frozen casting was allowed to thaw it lost some of the moisture needed to hold it together.
- Too thick. The thicker the casting, the more likely it is to crack. You will have to experiment with how thick is safe. Anything thicker than 1 inch (2.5 cm) is risky.
- Ramped up or down too fast. You can increase and decrease temperature relatively fast for these projects but just as with all glass projects too fast can cause thermal shock cracks.
- Rough handling. You could have initiated a crack in the frozen casting while loading it into the kiln.
- Inadequate anneal. These projects must be annealed the same as fused projects. This would be unlikely on thin projects but is an issue on relatively thick castings.

Crumbled

- If you leave the casting too long to thaw it will start to crumble and when you handle it will be more likely to crack when fired in the kiln.

Colors failed to stay separate

- If you want to keep colors separated when applied in layers, it's important to control when you add water and not add too much. After the first layer of powder has been placed in the mold, cover it with the next layer. Only then add water and add it gently. An eyedropper works especially well for this. When the powder has been fully wetted tamp the powder with a stick or pencil to push the water down to the bottom of the mold. If you want multiple layers of color wet each layer as you go.

Pebbles

You can make round glass pebbles by full fusing stacks of square pieces of glass. The size of the pebbles you make will depend on the size of the squares and how many are stacked.

Pebbles didn't fully round

- The squares were either too large or too few to produce a fully round pebble.
- Not enough time at top temperature to allow the glass to draw into a full round.
- Resistance. Anything that restricts the glass from drawing in will prevent it from becoming a full round. If you use kiln paper instead of kiln wash you should allow extra time to allow the glass to draw in.
- Side heat. Everything is drawn towards heat. If your kiln has only side elements the glass is encouraged to move towards the kiln walls which discourages it from drawing in to form round pebbles. If your kiln has lid elements the glass is encouraged to move up which encourages it to draw in to form round pebbles. The best kilns for making pebbles are those with lid elements only.

Pebbles all different size

- Were the squares you used all a consistent size? If you want the pebbles to be all a predictable size you must use accurately sized squares.

Stuck to kiln shelf

- Kiln wash too rough. When the squares used to make pebbles draw in to become fully round they slide along the kiln wash. Any texture in the kiln wash will create resistance and encourage the glass to stick to the kiln wash. This happens much more with opal glass than with transparent. When you make pebbles you should sand the kiln wash as smooth as you can.
- Hold too long. The longer that glass is held at top temperature the more likely the glass will stick to the shelf. Firing to a higher temperature with shorter hold will encourage the glass to move faster into a round pebble.

Suggestion

You can make pebbles as small as 1/8 inch (3 mm) or as large as your kiln shelf. You can use the same technique for making pebbles to make hearts, ovals and teardrops by using different configurations in the stacks of squares.

Stringers

Refused to fuse

- This is very rare so it's most likely incompatible glass.
- Not fired high enough to fuse.

Changed color in firing

- Striker glass. The stringer may have been a striker glass that changes color in the firing. The degree of color change in striker colors is in proportion to the temperature fired to. The higher the temperature the more the color changes.
- Color reaction. The stringer may have reacted with the glass it was sitting on and changed color. Some glass is made specifically to be reactive.

Stringer bent in kiln firing

- Textured glass. If there is any texture in the glass the stringer was on (even a relatively small amount of texture) the stringer will bend to wrap along the texture. If you want perfectly straight stringers be sure you fuse onto perfectly flat smooth glass.
- Between uneven glass edges. If you place a stringer between two pieces of glass that are not perfectly straight, the stringer will bend to follow any wave in the glass.
- Stringer inconsistent thickness. If one part of the stringer is thicker than another part, the thinner part is more likely to bend as it melts.

Stringer moved in the kiln firing

- Rolled out of position. Stringers are round so roll easily. The heat from the kiln can cause them to roll. To prevent this happening you can glue them in place before firing. Easiest way to hold stringers in place is to place a drop of glue on top of the stringer so the glue drips over the stringer onto both sides to prevent it from moving.

Suggestions

The same issues that apply to glass stringers apply also to glass rods when used in a fusing project.

Enamels

Not all enamels respond the same when fired in a kiln. Some fire at relatively low temperature while others require much higher temperature. Some can be fused to almost any glass while others only to a relatively narrow range of COE. When fusing enamels to glass it's important you follow the manufacturer's instructions. Powdered enamels come in different grits. Most common is 80 grit but for painting is also available as fine as 325 grit.

Some enamels come premixed in liquid form to apply like paint while others come in dry powder form to be either applied dry or mixed with a liquid to apply like paint. Different makes perform in different ways and different liquids produce mixes.

Color faded

- Fired to wrong temperature. Did you fire too high or too low? Different makes of enamel require different temperature to produce full color.
- Applied too thin. You could have applied thicker or in multiple layers – but if you apply too thick you risk it cracking in the kiln firing. Sometimes to best way to produce a strong color is with multiple layers in multiple firings.
- Overly diluted if mixed as a liquid. When mixing powder enamels with a liquid to make paint, if you add too much liquid you risk diluting the color.
- Applied on tin side. If you apply enamels to the tin side of float glass they will often fail to fuse to full color.

Color changed

- Some enamels change color at high temperature.

Colors didn't blend into each other in the firing

- Not all makes of enamel will mix together to create a blended color

Colors ran together

- Some enamels remain separated and can be applied like oil paints. Others run together like watercolor paint.

Cracked in firing

- Did you allow to fully dry before firing?
- Applied too thick.

Powder keeps separating in the liquid

- Not all liquids hold the powder in suspension. Either regularly stir the mixture as you use it or use a liquid that will hold the compound in suspension. There are many different options but the lowest cost and most effective is CMC (carboxyl methyl cellulose) gel.

SUGGESTION

It's always a good idea to test different materials before committing to a brand. That applies especially with applying enamels to glass. Different makes produced different colors and different effects and are used in different ways. Be warned that diluting the compound usually dilutes the color.

Diluting

If you work with premixed liquid enamels, dilute them with what the manufacturer recommends. If you work with powders and mix with liquid to make a paint I recommend CMC gel. When first made it's a relatively thick gel than will make a relatively thick paint but it can be diluted. Don't dilute after mixing with powder but before. If you want a thinner more liquid paint, dilute the compound with water before adding the powder.

If you are not familiar with CMC gel there's a tutorial on the Glass Campus website explaining how to make it and all the ways to use it.

Inclusion

Some spectacularly attractive effects can be achieved by fusing enamels between layers of glass but do not assume all enamels can be fired that way. Check with the manufacturer before trying it.

Blending

Some enamels can be mixed together to create new colors (like mixing red with yellow to create orange) but do not assume all can be blended. Some makes will instead of creating orange from a red and orange mix produce a mix of red and yellow specks.

Compatibility

Because enamel grit is so fine it can usually be trusted to fuse to any glass but do not assume that will always be so. When in doubt, test first.

Mica

Mica will fuse to any glass regardless of COE so COE compatibility is never an issue.

Didn't fuse to the glass

- Applied too thick. Mica will fuse to any glass but will not fuse to other mica. If you pile mica onto other mica hoping to produce a stronger color, only the mica touching the glass will fuse. The rest will remain loose to wash off or brush off.
- Applied to metallic coating. Mica will fuse to glass but will not fuse to any metallic surface like dichroic or iridescent.

Color disappeared

- Wrong mica. Not all mica survives fusing temperatures. You should use only mica that has been previously tested as suitable for fusing.

Color faded

- Some colors do fade. Come mica colors will survive as high as 1800°F (980°C) but other colors fade when fired above 1350° (705°C). Bronze, copper, gold and silver colored mica are most likely to survive while blue, green, pink and purple are less likely.

Rough surface

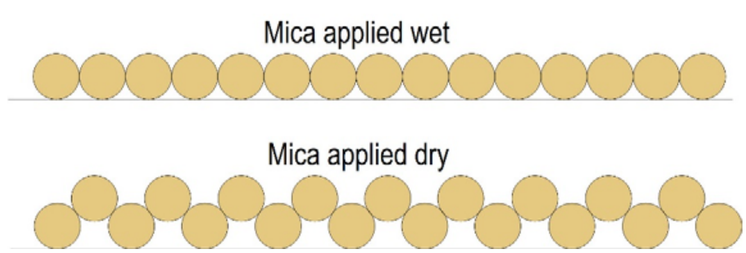
- Too low temperature or not enough time. If not fired to full fuse and given time to melt into the glass the mica will leave a rough sandpaper texture surface.

Bubbles when encased

- Applied too thick. If mica is applied as more than a thin layer particles of air will be trapped between the grains of mica. If you want to fire mica with glass cap it's better to fire it first to tack fuse, wipe off any mica that didn't fuse, then fire it with a glass cap over.

Stamped on mica images blurry

- Refer to Stamping chapter.



SUGGESTION

If you mix mica with a liquid and apply it like paint you will get a more even application than if you apply it dry.

Frit

Fused too much

- Fired either too long or too hot. The finer the frit the more it fuses. The lower the temperature you fire to, the more texture will be retained. For the most texture fire to slightly less than you use for a tack fuse.

Fused too little

- Temperature too low or not hold long enough. The fine the grit the more it responds to heat. A temperature increase will increase the amount of fuse faster on finer grit than coarser grit frit but a longer hold will provide more time to soften. A temperature change that produces the effect you want for fine grit will not produce the same amount of change for coarser grit.

Refused to fuse

- Incompatible glass. Many artisans believe if they use fine frit or powder they can get away with using different COE glass. This sometimes works but is not a safe assumption. Incompatible is incompatible regardless of size.
- Fired onto dichroic or iridescent glass. Frit fired onto any glass with a metallic surface will not fully fuse into the metallic coating. It will at best embed into the glass

Moved during the firing

- Not held firmly in place. As the air spaces between or beneath the particles of frit expand they can cause the frit pieces to move. You can prevent this happening by gluing the frit in place. Applying the frit to a coating of glue or applying hairspray over the frit will not perfectly prevent any frit movement but will significantly reduce how much moves.
- Uneven kiln. If your kiln is not level the frit can slide as it heats up.
- Glass sitting on frit. If you place a piece of glass on loose frit as the air spaces between the pieces of frit heat and expand the frit can act like rollers and cause the glass to move.

Transparent powder turned opaque

- When you fire glass powder to full fuse temperature pockets of air are trapped between the grains of powder causing the transparent glass to appear slightly opaque.

Stamping

Stamping is using rubber stamps to apply glue to glass then applying enamels,powder or mica to the stamped on design.

Part of image gone

- Not fully stamped. It's important to press the stamp straight down into the glue to ensure you get glue on all of the stamp face.

Image smeared

- Pressed the stamp too hard into the glue. If you push the stamp too hard into the glue you get some on the edges of the image. This produces a blurred image without crisp edges.
- Pressed the stamp on an angle into the glue. The stamp must be pressed straight down into the glue or you will get some glue on the edges of the stamp face.
- Pressed too hard onto the glass. If you press the stamp with glue attached too hard onto the glass you will apply some glue from the edges of the stamp pattern and not just the face of the design.
- Pressed the stamp on an angle on the glass. The stamp must be pressed straight down onto the glass or you will get some glue on the edges of the design.
- Wiped too hard. If you aren't gentle when wiping off excess mica you can smear the image.

Excess mica

- Not fully wiped. Any mica not wiped off will remain in the firing. If you have difficulty brushing it off you can remove any excess with a damp brush or Q-tip.

Suggestion

It takes some practice to become comfortable with applying glue to the stamp and wiping mica off after stamping. Spending an hour or so just practicing will prevent producing a lot of projects you're not happy with. You want to be aggressive enough to wipe off all the mica other than where attached to the glued image but gentle enough to not disturb any mica you want left. Either a soft cotton cloth or soft bristle brush works well.

Glass Campus

Troubleshooting Glass Art

Combing

Rake stuck while combing

- Glass not hot enough. The higher the temperature the softer the glass. It should be at least 1600°F (870°C) to allow a smooth comb. Even at that temperature glass is as sticky as peanut butter.
- Tried too many passes. In the time it takes to make a single pass the glass will cool and harden enough it's too stiff to be trusted to allow second smooth pass. You should make a single pass and close the kiln to reheat and resoften the glass for the next comb.

Glass too stiff to comb

- Not hot enough. Even when fully molten, the glass is stiff like molasses but the hotter the glass is the softer it is.

Glass slid on the shelf

- Not adequately braced. The pressure needed to comb through stiff sticky glass is easily enough to pull or push the project along the kiln shelf. You could easily move the glass to the edge of the shelf where the now molten glass will pour off the shelf onto your kiln floor. It's a good practice when combing glass to block the project in place so it can't slide.

Rake stuck in glass

- Rake still hot. After you comb the glass with a metal tool the metal stays warm. It if is still warm when you try the next comb it can stick to the glass. You should dip the tool in water immediately after each comb.

Suggestion

Because combing projects have been heated to much higher temperature than used for fusing and held at top temperature much longer than for fusing, it's a good practice to extend annealing time and reduce ramp speed.

Glass project blocked in place in the kiln ready to be combed.

Weaving Glass

Weave strips didn't fully slump

- Not high enough temperature or long enough hold. The smaller the span glass slumps into the more it resists slumping. The small spans used to make the serpentine weave strips require much higher temperature and much longer holds than is usually enough to slump glass projects. Where a slump is usually done at 1250°F (650°C) with a 20 minute hold, weave strips are usually done at 1350°F (732°C) with a 30 minute hold.

Cross pieces won't fit

- The weave strips failed to slump enough to allow the cross weave to fit in.
- Failed to allow for enough space in the slump. It's a good practice to not cut the cross weave pieces until after the serpentine weave strips have been finished.

Cross pieces too loose

- The pieces you're using are too small.
- Molds too deep. If the molds used to make the serpentine weave strips are thicker then 6mm there will be excess space in the opening.

Weave strips didn't fuse flat

- Molds too deep. If the molds you use to make the serpentine weave strips are deeper than twice the thickness of the glass being used for the cross weave pieces there will be extra space. That extra space will ruffle like glass does in a drape firing. If you work with 3mm thick glass your molds should be 6mm deep.

Cracked in tack fuse or slump

- Ramped too fast. Because there are irregular spaces between the glass pieces in a weave project heat doesn't travel uniformly through the glass. You must reduce the ramp rate to compensate for this.

Glass Campus

Troubleshooting Glass Art

Mesh Melts

Shelf Melts, Pot Melts, Mesh Melts

Stuck to ceramic mold

- Not enough kiln wash. Extra is needed to allow for the high temperatures used\.

Stuck to steel mold

- Not adequately lined. If you melt into a steel mold you cannot trust kiln wash, boron nitride or kiln paper. The metal expands when heated and contracts when cooled. The molten glass spreads into the expanded metal. When the metal contracts in cooling it presses so hard against the glass it refuses to release. You must line the mold with ceramic fiber paper to provide a cushion to allow the glass to release.

Gap opened in ceramic fiber paper

- Didn't allow for expansion. The fiber paper didn't expand along with the mold. That opening allowed the glass to stick to the mold. Either cut the fiber paper extra long and wedge it in to allow for that expansion or place a piece of kiln paper over the seam.

Kiln wash stuck on

- Not enough protection. The higher temperature and longer holds used for glass melts require extra protection. Kiln wash is often not enough. The best surface to fire onto is ceramic fiber paper. Placing a piece of clear glass on the shelf and melting onto it will significantly reduce the likelihood glass stick to shelf.

Cracked kiln shelf

- Thermal shock. As the glass and kiln shelf cools, the shelf will cool faster than the glass. The different cooling rate can cause the shelf to crack. The greater the difference in size between the glass project and the shelf the greater the chance the shelf will crack. If you're doing a small glass project in a large kiln you should use a shelf closer to the size of the melt.

Rough glass edge

- If you melt into a mold lined with ceramic fiber paper the molten glass presses into the fiber paper and adopts the texture of the fiber paper. Lining the fiber paper with kiln paper or spraying before firing with boron nitride spray will produce a much smoother finish on the glass.

Kiln paper embedded in the glass bottom

- Don't melt onto kiln paper. As the molten glass drips down it swirls and twists. That can tear kiln paper. If you want to melt onto kiln paper you should first cover it with a layer of clear glass.

Troubleshooting Glass Art

Glass slid off the screen

- Piled too loose   If you just pile glass on the screen without being sure it sits stable it can move during the firing. Expanding air under a piece of glass can cause it to move. As one piece of glass moves it will move other pieces.
- Piled too near the screen edge. As some glass moved it pushed some off the edge.

Mesh collapsed

- Not strong enough gauge.   When heated, metal softens the same way glass does.   The metal might be stiff and strong enough to hold the glass before it melts but when the metal softens the weight of the glass can collapse the metal screen.
- Metal too soft. Not all metal can be trusted. You should use only stainless steel.

Black specks in the glass

- Not stainless steel mesh. Metals other than stainless steel will produce significant spalling and leave black specks of metal in the glass.
- Improper firing schedule.   All metal spalls.   The trick to ensuring it isn't embedded in the molten glass is to use a firing schedule to include a hold at fusing temperature. The glass will still spall but it will not be at a temperature where it melts into the glass but instead at much lower temperature where it sits on the glass and can be swept off later.

More black than expected

- Black glass is lower viscosity than other colors and spreads out more.   A good practice is to use a lot less than you think. A guideline for melts is to use only 25% as much dark colors as you originally think would look right.

Red glass turned liver brown

- The glass made for fusing was not intended to fire to the temperatures used for melts. Red is especially a problem and always changes color.

Colors changed

- Some glass colors react and change color when in contact with other colors.   The higher temperature used for melts encourages this to happen.

Not as transparent as expected

- The swirling mix of colored glass in melts produces more opacity and darker colors than you might expect. It's a good practice to use a lot more clear than you originally think need.

Design didn't come out as expected

- It always happens.   It's near impossible to plan a design with melts. As the molten glass streams down one stream bumps another which bumps and other then yet another. All those streams are twisting and swirling around going wherever they please.

Vitrigraph

A vitrigraph pour involves taking a kiln with a hole drilled it its floor and setting a pot filled with bits of glass over the hole. The kiln is heated up enough to melt the glass in the pot and allow it to flow out from the bottom of the kiln. The size of the stream of glass is determined by the size of the hole in the pot. The speed the glass flows out is determined by the temperature the glass is heated to. Any size kiln can be used as a vitrigraph as long as it's possible to drill a hole in the floor and elevate it to allow the glass to pour out.

Pour too slow
Temperature too low. Either use a pot with a larger hole or increase temperature.

Pour too fast
Temperature too high. Either use a pot with a smaller hole or decrease temperature.

Glass stream too small
Pot hole too small. Either use a pot with a larger hole or increase temperature.

Glass stream too large
Pot hole too large. Either use a pot with a small hole or reduce temperature.

Pour started too large
It's usual. When the glass first melts, the first bulb coming out is huge. Consecutive bulbs are more relative to the size of the hole in the pot.

Pour size inconsistent
It's common. The pour often starts slow then accelerates as the glass becomes increasingly liquid. You can create a consistent size stream by manually manipulating the glass. If you want it to flow quicker, give the glass a little tug. If you want it flow slower, restrict it by holding it back. A faster will produce a thinner stream. Holding it back will produce a thicker stream. With practice you can ensure consistently uniform size pour.

Pour not straight
It will only be straight it you allow it to flow free. Anything you do to speed up or slow down the flow is likely create waves or kinks in the glass. You need to practice to be skilled at keeping the glass pour straight. Sometimes pulling the glass horizontally instead of letting if fall vertically produces more consistent size and perfectly straight glass.

Pour ended hollow
It's usual. When all the glass in the middle of the pot has drained out, all that remains is residual glass along the sides of the pot. As this glass drains out the hold it runs out only along the rim of the hold which creates hollow glass tubes.

Troubleshooting Glass Art

Pot cracked

Low quality clay. Earthenware pots from China and Mexico are notorious for cracking.
Wrong pot shape. Earthenware pots with a wide bottom usually crack in the first firing. The wide bottom retains a layer of glass that stays hot while the pot cools. Pots with narrow bottoms can usually be reused dozens of times.

Colors changed

A common result of high temperature firing. The glass made for fusing is not intended to be fired to the temperatures used with vitrigraph pour.

Pattern wasn't consistent

Changes during the pour. You can assemble a pattern of glass in the pot but it will pour out consistently in the pour. The glass from the middle of the pot pours out first leaving the glass near the edges of the pot to pour out later.

Pattern smaller than expected

It contracts. As the glass pours out, the pattern is reduced relative to the size of the hole in the pot.

SUGGESTIONS

Brace the pot. To reduce the chance molten glass will pour out onto your kiln floor from a cracked pot, brace the pot in the kiln. Kiln posts set flat on the kiln floor work well. If the pot cracks the braces will hold it together to prevent it from breaking open.

You can plug the hole with ceramic fiber blanket to prevent the glass from flowing out before you're ready or you can just turn the kiln on and let the glass to start to flow when it's ready. Either works. Try both before deciding which you prefer.

Experiment with different temperatures and make you own choice which temperature produces the flow speed you like best.

Experiment with different size and shape holes in the pot. A slot like a coin slot will produce a flat noodle. Two slots to create an X will produce a square pour. An elongated triangle hole will produce a teardrop shaped pour.

Stencils

A stencil is applied to glass as a template to apply powder. Once the powder is applied, the stencil is removed and the project fired in a kiln. You can use a variety of different materials as a stencil. If can be stiff like card stock or it can be pliable like painter's tape or vinyl. If the stencil you use is not pre-glued like tape or sandblast vinyl you need to use some kind of glue to hold it in place while applying the powder.

You can apply the powder mixed in a liquid and painted on or sift it on dry. You can apply it onto bare glass or you can pre-glue the glass before application. Spraying with hairspray or spray on glue is a popular way to pre-glue glass with stencils.

Stencil edges lifted

- Stencil material too soft.
- Stencil not adequately glued down.

Powder failed to stick to glass

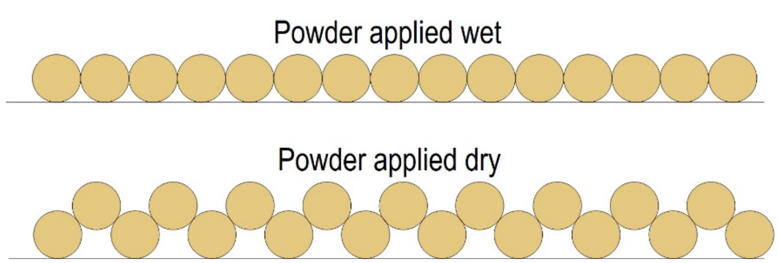
- Not enough glue
- Glue partly dry before powder applied.

Edges blurred

- Stencil not properly stuck down.
- Removed stencil too early.
- Removed stencil too aggressively.

Uneven color

- Uneven powder distribution. Happens more when powder is applied dry than wet. The chapter on Mica has a diagram showing how a wet application produces a more even distribution than dry.



Stains

Stains on a fused glass project are most often a result of contamination on the glass before firing.

Fingerprints

It's easy to apply a fingerprint onto glass while working with it. Prevention is usually better than correction. You can avoid spending a lot of time cleaning glass if you make the effort to keep it clean. Wash your hands carefully before handling the glass and avoid using any hand lotion.

Black smear

- Wood glue works to glue glass together but if used undiluted can leave a black stain in the glass. It should be used diluted 50/50 with water.

Oily smear

- Some glues will leave a stain, especially any containing any petroleum compounds. You should take care to use only glues you know have tested to be suitable or for fusing.
- A sticker (like a price sticker) left on and fired in the kiln with leave a stain in the glass.
- Any glue residue from a paper sticker your removed can leave a stain. Wiping with alcohol is an effective way to remove glue residue.
- Oil left on the glass from the cutter can leave a stain on the glass

Foggy haze

- Dirt or dust left on the glass.
- Window glass that has any coating on it will produce a foggy haze when fired in a kiln.
- Contaminated water. Using highly mineralized water to clean glass can leave residue on the glass.

Devitrification

- If you used float glass or art glass intended for stained glass but not intended for, or tested for, fusing it is highly susceptible to devitrification. If you are using glass susceptible to devitrification you can prevent it by painting on an anti-devitrification solution. Borax dissolved in water works well.
- Kiln paper sized too close to the edge of the glass pieces can curl up against the glass and cause devitrification.

Discoloration

- The fumes from some metal oxides firing in kiln a kiln can cause glass to discolor. Fumes from silver can turn clear glass the color of apple juice and can also discolor red glass.

Devitrification

Devitrification, commonly referred to as “devit”, is a growth of crystalline structure on or in the surface of the glass that exhibits as a white scum. Because glass is highly susceptible to devitrification when fired in a kiln, glass made for fusing is made using a formula that is much more resistant to it than regular art glass or window glass. Firing any glass not made for kiln use will significantly increases the likelihood you will create devit. Opalescent glass, or any glass containing opalescent glass, is more likely to develop devit than transparent glass.

What causes devit?

- Dirty glass. This is the most common cause.
- Temperature held too long at high temperature.
- Increasing or decreasing temperature too slow through devitrification range. Devit normally happens between 1200°F (650°C) and 1300°F (705°C) but some art glass can produce it at even higher temperature.
- Float glass firing wrong side up.
- Float glass second firing. Devit rarely happens on a first firing but almost always happens if you fire float glass a second time. Artisans that work with float glass try to engineer ways to produce a finished project in a single kiln firing.
- Kiln paper too close to glass size. Kiln paper can curl up against the glass and cause devit along the edge.
- Textured glass. Smoother glass is less likely to devit than textured glass.

How to avoid devit

- Thoroughly clean the glass before firing
- Increasing and decreasing temperature rapidly through the temperate range likely to cause devit.
- Coating with a solution to discourage devit. If your project will be handled with food take care when selecting a compound to avoid using one that contains lead.

REPAIRING

Sand off the devit and fire again with a cap of clear glass or coating of clear frit. A wet belt sand, lap grinder or sandblasting works well to sand off devit. You can also paint on etching cream, leave set overnight, thoroughly clean and refire to fire polish.

SUGGESTION

You can make your own devit solution but dissolving borax into warm water. Add borax to warm water and keep adding to maximum saturation then strain. A disposable coffee filter makes a great strainer.

GRINDING

Grinding glass edges does not cause devit but glass dust residue left on a glass edge and not adequately washed off will produce a frosted haze that looks like devit.

Troubleshooting Glass Art

Inclusions

Inclusions are materials fused sandwiched between layers of glass.

Cracks

- COE differences between the glass and anything included can cause thermal shock cracks. The greater the difference in COE between the glass and the inclusion the more likely it will cause the glass to crack.

Bubbles

- Particles of air trapped between anything sandwiched between layers of glass will expand and create air bubbles. The larger the inclusion the more likely bubbles will be created. When the top layer of glass drops over an inclusion it doesn't wrap firmly around it but leaves a pocket of air along the underside of the inclusion.

Stains

- Contaminant on the glass before firing.
- Reaction with the glass. The original stained glass paintings on glass were done by firing metal oxides to create fumes that would stain the glass. Different oxides produce different colors. A concern when firing silver in a kiln with clear glass is fumes from the silver can turn the glass the color of apple juice. The fumes from silver can embed in kiln bricks and contaminate future firings.

SUGGESTIONS

Expect failure.
The primary rule when first trying anything as an inclusion is to expect failure

Test first
Before trying something as an inclusion in an important project test first.

Size matters
The thicker the inclusion the more likely it will cause problems.

COE counts.
Everything has a COE. If you don't know what the COE of the material you want to use as an inclusion, assume the worst and expect failure.

Kiln Wash

Not all kiln wash is the same. Some produces a smoother finish, some tolerates higher temperature firings, some can be reused more times and some is easier to remove. You must choose which is most important to you. If you are having problems with your kiln wash, start by asking if your problems won't be solved by switching brands.

Leaves brush strokes

- Applied to thick. Mix ratio should be 1 part powder to 5 or more parts water. It's much better to apply more thin coats than fewer thick coasts.
- You can reduce the texture left on glass from brush strokes by applying it with a sponge instead of a bristle brush or by spraying it on.
- You can smooth out brush strokes by gently sanding with a dry sponge, soft cloth or your fingertips.

Stuck to glass

- Not suitable for glass. Not all kiln wash is appropriate for glass. Kiln wash intended for pottery can not be trusted to use with glass.
- Moisture. Moisture left in the kiln wash before firing can create steam when fired in the kiln and cause the kiln wash to stick.
- Applied over boron nitride. If you had previously applied boron nitride then applied kiln wash over it the kiln wash can't be trusted to the mold. The reverse applies if you applied boron nitride over a mold that had previously been coated with kiln wash.

Failed to stick to the mold or kiln shelf

- Contaminants in the mold or shelf can prevent the kiln wash from sticking. That can sometimes be in the clay when the mold or shelf was made or it could be something you applied to the mold or shelf while handling it.
- Often kiln wash won't stick to smooth metal. It helps if you heat the mold before applying the kiln wash or if you sand the metal to provide tooth to hold the kiln wash.

Cracked or chipped on kiln shelf

- Applied too thick. Too many coats added before being scrapped off and replaced. It's a good practice to apply a fresh coat after any firing higher than slump temperature.

Suggestions

You can significantly increase the number of coats on a kiln shelf without it cracking by wiping the shelf with a warm damp cloth or sponge after each firing. This has a double function. It removes any dust residue left from the firing and also smooths out and tiny cracks or fissures that will later expand.

It's a handy practice to have two kiln shelves. It takes time to recoat or replace kiln wash. If you have a second shelf you can always have one prepared and ready to go for the next firing.

Boron Nitride

Not all brands of boron nitride work the same in a kiln. Some can be trusted at drape or slump temperature but will fail at tack fuse or full fuse temperature. Some are fine at full fuse temperature but fail at the higher temperatures for combing or mesh melt projects. Some is available as a powder you mix with water to apply and some comes in an aerosol spray can.

Because boron nitride provides less friction on a mold than kiln wash it produces a smoother finish on the glass. In casting molds it eliminates the edge spikes created by glass resisting the drop into the mold. Sprayed onto ceramic fiber paper it reduces the amount of texture on the glass edge. It can even be sprayed onto float glass to use as a kiln shelf.

Failed to stick to mold

- Not enough applied. Did you cover all surfaces with at least 3 coats? Did you rotate the mold while spraying to avoid any parts not coated?
- Unevenly applied. It’s important to apply as evenly as you can.
- Was any kiln wash from a previously application fully removed? With steel molds it can be scrubbed off easily but not so with ceramic molds. When kiln wash gets into the mold pores it can’t be removed. If you have previously applied kiln wash to a ceramic mold you can not trust using boron nitride on it.
- Contamination on the mold. Any grease on a metal or ceramic mold will prevent the boron nitride from sticking to the mold.

Left residue on the glass

- Was the mold thoroughly clean?
- Was loose powder from a previous firing left on? After firing past drape or slump temperature, you should gently rush off any powder left on the mold.
- Was the glass thoroughly clean? Boron nitride can react with any contaminants on the glass.

Scratched off along rim of mold

- As it drops, the glass can scratch off the material sprayed onto the metal mold. A trick that helps prevent that happening is to cut a piece of kiln paper or ceramic fiber paper the shape of the flat upper part of the mold and set the glass on it. If you’re careful you can reuse it several times before it needs to be replaced. It also makes it easy to mark the center spot to make it easier to center the glass on the mold.

Suggestions

- Residue of boron nitride stuck on the glass after firing can be removed by soaking or scrubbing with vinegar or TSP.
- Some brands have flammable ingredients and cannot be shipped by mail or taken on an airplane.

Kiln Paper

Kiln paper is an excellent way to avoid the need for kiln wash but as with all things has both advantages and disadvantages.

Smelled foul while firing

- This is normal. When the organic compounds in the kiln paper are burning off it smells vile. The smell goes away when the organic materials finish burning off.

Turned black while firing

- The white paper turns black when the organic compounds in it burn off at about 500°F (260°C). No reason for concern. It returns to white further along in the firing cycle.

Turned to powder

- Some makes of kiln paper turn to powder and can only be used once. Other makes remain intact and can be reused multiple times.

Left a scum along the glass edges

- Kiln paper sized too close to the edge of the glass pieces can curl up against the glass and cause devitrification.

SUGGESTIONS

Firing high temperature projects into molds lined with ceramic fiber paper produces a rough orange peel texture on the glass. Lining the fiber paper with kiln will produce a much smoother edge.

The swirling glass in high temperature melts onto kiln paper can shred the paper but if you place a layer of clear glass on the paper it's safe.

Kiln paper can be a handy way to build elaborate projects outside the kiln to avoid having to spend time bending into the kiln.   By pulling it gently and slowly you can slide the paper with the project attached onto a kiln shelf to be transported to your kiln.

Ceramic Fiber Paper

Ceramic fiber paper is made by mixing ceramic fibers in an organic compound and rolling it into sheets of various thickness. It's most commonly available in 3 mm, 6 mm and 9 mm thick. It can be used as a separator the same as kiln paper and is often preferred because it is soft and allows for compression expansion during the kiln firing. It is also used to create sculptured bas relief texture in glass.

Smelled foul while firing

- This is normal. When the organic compounds in the kiln paper are burning off it smells like burning vegetation. The smell goes away when the organic materials finish burning off.

Turned black while firing

- It turns black when the organic compounds in it burn off at about 500°F (260°C). No reason for concern. It returns to white further along in the firing cycle.

Turned spongy after firing

- This is normal. The kiln firing burned out the organic compounds that held the ceramic fibers together.

Left a rough surface on the glass

- Once the organic compounds have burned off the molten glass adopts the texture of the loose ceramic fibers and leaves a texture like an orange peel. Spraying on boron nitride before firing will produce a much smoother finish.

Fibers embedded in the glass

- Long hold at high temperature will allow ceramic fibers to embed into molten glass. This is often a problem with high temperature firings like mesh melts and combing.

SUGGESTIONS

- Some users vent their kiln during the burning stage. Some don't. It's a personal choice and makes no difference to the results.
- Ceramic fiber paper turns soft and spongy after firing in the kiln. It can be reused as cushion between metal and glass in a mold but cannot be trusted for reuse in kiln carving projects.

Glue

The difference between different brands of glue is about the same as the difference between Chev and Ford. Just brand preference. The difference is in what different kinds of glue are to be used for and in how you use them.

Came unglued during kiln firing

- No glue survives the temperatures glass is fired to. Glue is intended only to hold pieces in place to transport to the kiln. If the glass pieces will not stay in place without glue there is no reason to expect they will stay in place with glue during the kiln firing.

Black smear on glass from glue

- This is relatively common when white wood glue is used to bond glass pieces together before firing. If you use this glue, dilute it first 50/50 with water.

Glued pieces came apart

- Used the wrong glue. Not all glue works for glass.
- Glue ingredients were mixed in wrong ratio. Glues like epoxy that rely on two parts mixed together must be mixed in accurate ratio. If the mix is wrong the glue will fail.
- Glue inadequately mixed. When using multi compound glues like epoxy it the glue compounds are not fully mixed the glue will fail.
- Surfaces not properly prepared. Different glues require different surfaces. UV cure glue requires a perfectly smooth surface and will often fail on textured surfaces. Epoxy glue is the opposite. It often fails on a smooth surface. It requires any smooth surfaces be roughened to provide “tooth” for the glue to bond.
- Took too long with epoxy. If you mix epoxy glue and wait too long before applying it can fail. When you use 5 minute epoxy it doesn’t mean it sets in 5 minutes. It means you have only 5 minutes before the mixture can no longer be trusted. It you can’t finish the job in 5 minutes you should be using 24 hour use epoxy that has 24 hours before it no longer works.
- Wrong UV light. Not all UV lights are the same. The kind of light used to identify tin side on float glass doesn’t work for UV cure glue. The kind used for tin side ID doesn’t work for glue. The kind used for broad spectrum UV light doesn’t work for anything other than making white shirts look purple.

SUGGESTIONS

Remember ….. smooth surface for UV and rough surface for epoxy.

UV light is referenced in 3 categories:

- UV A - Long Wave from 315 to 400 nm – used for UV cure glue
- UV B - Medium Wave from 280 to 315 nm
- UV C - Short Wave from 100 – 200 used for identifying tin side on float glass.

Coldworking

You can coldwork manually or with any of the many different machines made for coldworking glass. The important thing to remember when coldworking is water is your friend. If you aren't getting wet you aren't doing it right.

Glass cracked on WBS or lap

- Not enough water. Water prevents heat. Heat causes cracks. Use lots of water.
- Pressed too hard. Be patient. Let the machine to the work.
- Applied uneven pressure. Take your time and hold the glass as even as you can.
- Inadequate anneal. A lesson for next project.
- Too soon after taking from kiln. Still residual heat in the glass.

Scratches left after fire polish firing

- Not sanded enough before firing. The glass should be sanded to at least 200 grit smooth before firing. If you only sanded to 100 grit you will end up with polished glass with 100 grit scratches in it.

Some scratches left after fine grit sanding

- Some pieces of coarse grit mixed in the grit. Especially a concern if you're impatient and fail to fully remove all the previous grit or if you tried too great a change from one grit to another. After 100 should be 200 Jumping to 400 is likely to leave a lot of 100 grit scratches. You would have a 400 grit polish with some 100 grit scratches in it. Be patient. Polish in steady progressively finer grits and don't try to skip any stage.

Edge not square

- Failed to hold fully square while sanding or lapping. The best machine for sanding edges is a Wet Belt Sander but it can be done with any machine. Should make a jig to hold the glass square.

Waves on underside

- Uneven pressure while sanding. You must hold the glass down with even pressure and keep it moving to sand all areas uniformly. Automatic laps will do this automatically. Holding the glass manually is much harder and more likely to produce waves.

Dichroic or Iridescent glass edges chipped

- If you grind with a rotary grinder you will get visible chips on the edge unless you use a very fine grinder head. Better to use a sander to sand pushing only down against the metallic edge.

Drilling

Glass cracked

- Drilling too fast. – drilling too fast increases the possibility of creating friction. Friction creates heat. Heat cracks glass.
- Not enough water. The glass should be fully submerged. When that isn't possible a pond containing water built around the drill hole. Window putty or even chewing gum makes works well to build a containment ring to create a pond.
- Worn drill bit. Diamonds don't wear down but they do come off. Diamonds come off in time with use and come off faster on low quality bits. When diamonds have come off your drill bit you have bare metal rubbing against the glass.
- Too much pressure. If you're impatient and trying to drill too fast you generate friction which creates heat which cracks glass.
- Plugged drill hole. Drilling creates glass dust. Dust left in the drill hole creates friction which creates heat which cracks glass. Instead of drilling constantly it's a good practice to bob up and down as you drill. As you pull the drill bit out of the drill hole you rinse out the glass dust.
- Drilled on an angle. When you drill on an angle you generate friction along the sides of the drill hole. Drilling should be done straight down. Best with a drill press. If you drill with a dremel or hand drill, you can get a device to clamp it in to work as a drill press.

Bit skipped at start

- Drill not fully stable. When you first start the hole the rotary motion of the drill bit encourages it to skip along the glass. You must hold the drill firmly enough to prevent this happening. The best way to prevent skipping is by drilling with a drill press so you always drill straight down and never on an angle.

Cone or chip at bottom

- Glass not supported. If when you drill the glass you set it on another pieces of glass or something relatively firm, when the drill bit comes through the other side it will come out as a clean hole and not a cone shaped crater. Low quality or worn bits are more like to create a cone than better quality.

SUGGESTIONS

Low cost drill bits can only be trusted for a few holes. Better quality bits can be relied onto drill dozens of holes. Best quality bits are good for over 100 holes. The best quality bits are called "sintered". Sintered bits have diamonds embedded entirely through the end of the drill bit and not just attached.

Tools

Oil cutter leaks

- Some just do. Inexpensive oil cutters are notorious for leaking.
- Filler cap not screwed on tight.
- Damaged seal at cutter head. If a cutter has been dropped it can break the seal between the oil reservoir and the cutter head.

Oil cutter won't release oil

- Partial vacuum in oil chamber. As the oil wicks out it creates a partial vacuum in the oil chamber preventing the oil from releasing. You should routinely remove the filler cap to all the air inside to pressurize.
- Oil too thick. Did you use a type of oil too thick to travel through the cutter wick? The best oils for self-oiling cutters are kerosene or diesel oil. For those that dislike the smell of either of those oils, second best is the "cutter oil" sold specifically for glass cutters. Thicker oil often will plug up the wick. If you prefer to score by dipping your cutter in oil you can use almost any lubricant.

Cutter produces an uneven score

- Damaged cutter wheel. Check by scoring a piece of mirror and examine the reflection. If you see a dotted line and not a smooth consistent line you have nick in the cutter wheel.
- Cutter wheel jammed. Bits of glass shard or dust stuck in the wheel can prevent it from rolling smoothly. It's as good practice to start you score by "clearing the wheel". Roll the cutter in the direction opposite of that you usually use to score glass.
- Uneven wear on the cutter wheel. If you have failed to score with it kept vertical the cutter wheel can wear on one side.

Mosaic cutter wheels are loose

- They tend to come loose with use and must be routinely tightened.

SUGGESTIONS

A good practice to ensure good scores and maximize the life of your cutter is to routinely "clear the cutter". Before you start cutting, run the cutter backwards to clear the wheel of any debris. If you score by pulling towards you, start by pushing the cutter to roll it forward. If you score by pushing the cutter, start by rolling the cutter towards you. Make It a habit to start every cutting session by clearing your cutter.

Unless it's something rarely used, it's always a good practice to invest in good tools. Often the more expensive ones last so much longer they end up being the cheapest. A good practice in selecting tools is – but good – last long.

When you replace an old cutter, don't through it away. Save it for cutting thick glass.

Sandblasting

Resist lifted during blasting

- Not pressed firmly down enough. It's important to take the time to be sure the blasting resist is pressed fully down so it won't peel up during the blasting.
- Wrong resist. It's important to use a resist material strong enough to stand up to the blasting and with enough glue to hold it in place until blasting is completed.
- Tried to reuse resist. Resist can only be used once. It can't be trusted to be reused.
- Blasted too long for the kind of resist used.
- Dirty glass. Any contaminants on the glass can prevent the resist from sticking.
- Air pressure too high. Not all resist survives high pressure blast.

Uneven texture in etching

- Contamination in the grit. Any foreign material mixed in the blasting grit or any remnants of coarse grit will prevent the etched surface from being a uniform texture.

Scratches in the glass

- Contamination in the grit. Any foreign material mixed in the blasting grit or any remnants of coarse grit will prevent the etched surface from being a uniform texture.

Taking too long to blast

- Not enough air pressure. The higher the pressure the faster it etches.
- Grit too fine. The finer the grit the longer it takes to etch.
- Grit worn. Aluminum oxide wears down and stops working as an abrasive.
- Worn nozzle. As it wears the opening expands and slows down blasting.

Spurting while blasting

- Moisture in the grit. Moisture in the grit can cause it to form clumps which will prevent the grit from flowing smoothly.
- Hose plugged. Anything thing stuck in the hose can prevent the grit from flowing smoothly.

Fingerprints on etched surface

- The frosted surface created by blasting is notorious for holding fingerprints. There are commercial compounds available made specifically to protected against fingerprints or other stains. Fingerprints can be removed with isopropyl alcohol or lacquer thinner.

SUGGESTIONS

You can use masking tape as a resist if you're only doing a light surface etch. Sign vinyl works well for sandblasting resist but be warned. The resist made specifically for sandblasting is designed to go on easily, to stay on during the blasting, and also to PEEL OFF EASILY. Sign vinyl is designed to stay on and never be removed. If you use if for blasting it is extremely difficult to remove and usually must be scrapped off. That scrapping often scratches the glass.

Kilns

Kiln won't heat up

- Power failure. Whenever anything powered by electricity doesn't work the first thing to check is does it have electricity coming to it.
- Loose wire. A loose wire either in the line to the kiln or in the controller box will prevent it from working.
- Failed relay. This is the most common thing to fail in a kiln. If the relay fails in the off position it will refuse to turn on. Replacing a relay is an easy and inexpensive fix.
- Failed thermocouple. A broken thermocouple or disconnected wire to the thermocouple can prevent the kiln from turning on.
- Failed transformer. The transformer converts the AC power coming to the kiln to the DC power for the controller. If it fails there is no power to the controller.
- Broken element. If an element is broken the kiln will work fine but not produce heat. An easy way to check if an element isn't working is to wedge a small piece of paper between the element and kiln wall then fire the kiln to 500°F (260°C). If the element is heating the paper will be scorched.

Turns off and stays full on

- Failed relay. If the relay fails in the on position the kiln work run full on and ignore instructions from the controller.

Reading wrong temperature

- Thermocouple malfunctioning. Needs to be replaced or readjusted. It you know much the reading is wrong you can compensate for it in your firing schedules.
- Thermocouple damaged. Hitting it when moving a mold or kiln shelf can damage the thermocouple.
- Thermocouple pushed part way out. If it doesn't reach the correct distance into the kiln it will read the wrong temperature.

Firing too hot or too low

- Thermocouple reading wrong temperature. Needs to be adjusted or replaced.
- Your kiln is holding heat longer than you allowed for in your firing schedule. Adjust the time or temperature in your firing schedule to compensate.

Failing at high temperature

- If your electrical service is 3 phase power, it's 208 volt. If your kiln is wired for 240 volt, 208 volt might not provide enough power to reach top temperature. Firing a 240 volt kiln on a 208 volt power supply can take more time to reach temperature but will not affect the accuracy of the temperature.
- Power fluctuation. The voltage coming to you premise fluctuates relative to how many users drawing power from the system. There might not be enough power coming in to allow your kiln to reach the requested temperature.

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Troubleshooting Glass Art

Firing times are inconsistent

- Electrical voltage is not consistent. How long a firing schedule takes to complete depends on how much power is being delivered to the kiln. It's normal for a variance in electrical voltage during the day depending on how many users are drawing power from the grid. When there is a large power draw the voltage will drop. Lower voltage means it takes longer to provide the heat to your kiln.

Elements popping out

- Inevitable with time. The elements expand when heated and contract when cooled but in time don't' contract as much as they expand. They start to bulge and pop out from the groves in the kiln. J-shaped or U-shaped pins are available from high temperature wire to use to hold the elements back in. Be very careful to not break the when you push it back into the grove. If you heat it with a torch you can soften the element and squeeze the heat soften coils tighter together with pliers to make it easier to fit back into the element grove.

Cracked kiln lid

- Dropped when closing. Kiln lids are heavy and easy to lose your grip when lowered. Take care to ease the lid down slowly when closing it.
- Weight left on it. Your kiln is not a table. Storing something on it can cause lid damage.
- Hinges too tight. If the hinges are too tight it can create needless strain on the lid.

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Cracked kiln shelf

- Hot glass load in the middle. If a glass project like a combing or mesh melt fired to high temperature is significantly smaller than the mold it's fired on, the shelf will cool faster than the glass. The heat difference can cause the kiln shelf to crack. If you're doing a small hot glass project you should avoid doing it on a large kiln shelf but instead replace the large shelf with one closer to the size of the project.

Dust falling from kiln lid

- Inevitable. In time, the surface of the kiln brick begins to crumble and small pieces fall down. It's a good practice to routinely sweep and vacuum your kiln lid.

Glass bits in the kiln floor

- Molten glass will melt into kiln brick like acid into metal. Brick kiln floor should be thoroughly coated with kiln wash and the kiln wash routinely recoated. How often to recoat with fresh kiln wash is an individual choice. My practice is to apply another coat after every 20 or so firings. If you have bits on glass stuck in the kiln floor they MUST be removed or will continue to melt deeper into the brick. Remove them with something like a chisel and fill the holes with kiln mortar.

COMMENTS

Some glass artisans are concerned about firing their kiln when it is very hot or very cold. Unless the temperature extremes are outstandingly radical, there is no cause for concern. Artisans in parts of the US routinely fire their kiln when it's well above 100°F (40°C) and those in Canada when it's as cold as -20°F (-30°C). I expect the concern in summer would be having to power the air condition on turbo drive but in winter the feeling would likely be "Thank gawd the kiln is running". When it's unusually hot it takes extra time for the kiln to cool and when it's unusually cold you need to be more careful at what temperature you turn the kiln off

What is a serious concern is having your kiln somewhere with very high humidity. Long term exposure to moisture can do serious harm to the electronics in the controller.

SUGGESTIONS

Your kiln was a big expense and is an important part of everything you do. Take care of it. Don't wait for something bad to happen. Take preventive measure to protect it. Establish a routine for kiln care. If you take care of your kiln it will take care of your glass projects.

Kiln floor

- Keep it clear and free of debris and routinely apply more kiln wash as needed.

Elements

- When they start to bulge out, push them back in. Install element pins. If an element has stretched so much it won't stay back in the grove, take the time to heat it and squeeze it back to original shape.
- Keep the hinges adjusted and do not use it as a storage counter.
- Brush and vacuum to remove any dust.

Control box

- Keep it dust free. If dust starts to collect inside, blow it out.

Spare parts

- Relays are the most common thing to fail. Second most common is the thermocouple. It's a good practice to have replacement spares so if a relay or thermocouple fails you can replace it immediately and not need wait for a replacement to be shipped to you. You might also consider having a spare element.

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Electrical

Any issues with electricity can be dangerous and should be taken very seriously.

Breaker keeps kicking off

- Is the circuit breaker heavy enough amperage to carry the kiln power requirement?
- Is there something else on the same circuit as your kiln?
- Is there a short circuit in your kiln?
- Is there a short circuit in the kiln plug or receptacle?

Wire to the kiln gets warm

- Is the gauge of the wire to the kiln large enough to carry the needed amperage? It's dangerous if the wire to kiln get hot. This can cause an electrical fire.

Firing times vary

- That's normal. The amount of power being delivered to your kiln can vary at different times of the day depending on how much mower is being drawn from the system. When a lot is being used the voltage drops. When the voltage drops, your kiln has less electricity. It will still heat up the programmed temperature but will take longer to do it.

Lights dim when kiln turns on

- Kiln is on same circuit as lights. That means the power draw on that circuit is dangerously high. Your kiln should be on a circuit dedicated exclusively to the kiln with nothing else on the circuit. It that is happening without kicking the circuit breaker off, you may a breaker that is too high amperage for the size of wire.

Burn marks around plug

- Loose wire. Fix immediately
- Wire gauge too small. Fix immediately.

Sparks from plug outlet

- Loose wire. Fix immediately.

COMMENTS

Most residences are wired single phase 240 volt. Most business are wired 208 volt 3 phase. You can buy appliances like kilns wired for either 208 or 240 volt.

You can run a 240 volt kiln on a 208 volt circuit but it may not be able to fire to full temperature. Operating a 208 volt kiln on a 240 volt circuit risks damaging the kiln.

Keep Records

It's okay to make mistakes. We all do it, but it's not okay to repeat the same mistakes. The best way to avoid repeating mistakes is to keep records.

Some of us have good memory and some of us have a not so good memory but the book has a perfect memory. There are many things you can do to improve your memory but the best of all memory training techniques is to remember to write it down. Keep notes and keep records. If you keep a record of the results what happened with you tried something you can refer back to that record the next time you try it. Did it produce the results you want? Was there some change you think should have been made.

I practice and promote a 3 step process when I first open the kiln after a firing.

1. What is my first impression?
2. What might have been done differently?
3. What ideas does it give me for other projects?

Save your failed projects

It's also important to keep some of your failed projects. Bring them out sometimes to remind yourself of how far you've progressed. If you teach, those failures can be especially helpful to show students and encourage them to accept failure as part of the learning experience.

Keep a kiln log

If you keep a record of the results of your projects you can refer back to it to help remember what happened and what you thought should be change or corrected. It doesn't matter how you keep it. Write notes in a note pad, record it in your computer or paper your shop with stick notes. Just do it. It can be just a few notes and comments or it can be as detailed as an encyclopedia. Just do something to keep records. The minimum it should include would be:

- **Project description.** What was it? Fuse, slump, drape, cast?
- **Molds.** What molds did you use – ceramic, steel, plaster?
- **What glass used.** What make and what colors.
- **Firing schedule.** What firing schedule did you use?
- **Results.** Wonderful, pretty good, barely acceptable or seriously sucked?
- **Suggestions.** What do you think might have improved the results?
- **Ideas.** What ideas did the project generate for new projects?

If you make work for sale, it should also include:

- **Time.** How long did it take to make?
- **Materials.** What was materials cost?
- **Suggestions.** How could you reduce time and/or materials cost?

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Troubleshooting Glass Art

Create Good Habits

Troubleshooting is about examining what when wrong so you can stop doing it wrong. Maybe the best possible troubleshooting is to put more effort into preventing things from going wrong? Like caring for your body, prevention can prevent the need for cure. Like caring for your vehicle, maintenance can prevent the need for repairs. It's the same with your glass art. Avoiding mistakes removes the need to troubleshoot what caused them. You can do this by eliminating bad habits and creating good habits. It's easy to collect bad habits. Creating good habits takes effort. Some habits you might work at creating:

Glass Cutting Checklist

- **Clean the glass.** Start by removing any stickers or glue on the glass.
- **Release the vacuum.** As oil wicks out of the oil reservoir in your cutter is creates a vacuum which restricts oil flow. You should routinely remove the filler cap to repressurize the air.
- **Check the oil.** If you use oil, check the level.
- **Check for nicks.** Every week or so, check for nicks in the cutter wheel. Score on a piece of mirror. Look at the reflection of the score on an angle. If the cutter has no nicks, the reflection will be a smooth continuous line. If it has nicks, the reflection will appear as a dotted line.
- **Check for wear.** Check for wear on the side of the cutter head. After sliding alongside a straight edge a few thousand times, a grove will wear in the cutter head. You can either replace the head or turn it around. Some artisans regularly reverse the head to prevent it from wearing on one side.
- **Clear the wheel.** Start each score with a reverse score. On a piece of paper or wood, run your cutter the opposite direction you score glass. If you score by pulling towards you, roll the cutter away from you. If you score by pushing, clear the wheel by rolling it towards you. This will clear out any debris trapped inside that could restrict the smooth roll of the cutter wheel.

Kiln Programming Routine

A small mistake in a programmed schedule can create big problems. To prevent making a mistake programming in a firing schedule I religiously practice the 3 step routine with every firing.

1. Write out the firing schedule.
2. Program the schedule into the controller.
3. Start the kiln and review what was programmed.

It's surprising how often you can program in something wrong that you catch when you review what you programmed in. Always check.

Kiln Maintenance

You can reduce the likelihood of future problems with your kiln with a routine checklist .

- **Clean.** Carefully clean the floor, the lid and all element groves after each firing.
- **Elements.** Check to see if any elements are loose and need to be pushed back.
- **Thermocouple.** Check to see if it's the correct distance into the kiln and not bent. If it got bumped and bent it could malfunction. If it got pushed a little out of the kiln it will read the wrong temperature.
- **Kiln wash floor.** Check to see if any bare kiln brick is exposed and a new coating of kiln wash is needed. Just as you have a routine of replacing the oil in your vehicle after a given mileage you should have a routine of applying more kiln wash to your kiln floor after a given number of firings.
- **Kiln lid bands.** Check to see if they have loosened and should be tightened.
- **Electrical control box.** Blow out any dust that got in.

Improve Kiln Efficiency

- **Pipeline.** Have a number of projects set out in advance to fill any extra shelf space or just to keep your kiln firing constantly. It could be tests, experiments, pebbles or anything that can fill up the shelf to maximize the kiln load. Create an organizational pipeline and keep your kiln pipeline fully loaded to fire every day. Many of my kilns fire twice each day.
- **Spare kiln shelves.** To avoid time delay applying kiln wash or the expense of kiln paper, have 2 kiln shelves for each kiln. Have one always prepared ready to use so you can reload and fire your kiln immediately after reloading. My fixed routine is to take the shelf out of the kiln, wipe it with a warm damp cloth and apply a coat of kiln wash.
- **Molds.** Check each mold after each use and prepare it for the next use. If it needs another coat of kiln wash or boron nitride, do it now. Don't wait until you want to use it again. Prepare your molds in advance so they are always ready to use whenever you want.

Materials Inventory

It sucks when you're in the middle of a project and realize you've run out of something you need to finish. It's a good habit to be sure you have available everything you need to finish a project before you start it. I make it a routine practice to make a list of everything I'll need and set it out before starting the project.

It's also a good habit to maintain some stock of materials. The stuff we use to create glass art isn't like bread or milk where, if we run out, we can just dash down to nearest grocery store. Some things take days or even weeks to reorder. It's a good habit to keep a To Order list and whenever you run out of something. Also, routinely check your stock to see what you're running low on and will soon need to order more of.

The two most popular methods of keeping track of inventory are the Accounting Method and the Visual Method. The **Accounting Method** involves keeping a detailed record of what you have and deducting materials as you use them so your records accurately record what you have left.

Glass Campus

Troubleshooting Glass Art

The **Visual Method** involves setting everything out in a way you can look to see what things you are low on or out of.

Each of us chooses our own method. Walmart has a system where every item sold is recorded against inventory and adding to the list of items to be re-ordered each day. That works for Walmart but few of us can justify the time and expense of keeping such careful inventory count. I prefer the visual method. Whenever anything is used up or running low, it's added to the order list. Then, when I place an order with a supplier, I do "walkabout" and check everything to see what else should be added to the order.

Practice Organizational Efficiencies

- **5 Minute Rule.** Any task that can be done in 5 minutes or less should not be postponed but be done immediately. Too often a small job left undone can produce the biggest problems. When in doubt, do it now.
- **Keep a TO DO list.** Make lists to help you remember what needs to be done. When you think of something that needs to be done, write it down. Computers have made it easy to create and update a to do list. I keep one faithfully and update it daily. A print out hangs on a clipboard in the shop. We also have a white board to write notes on and a bulletin board to apply sticky notes. Whenever I think of something that should be checked or should be done, it's added to the list. When something is done, it's taken off the list. Each day the list is updated and a new version printed out.
- **Memory Tricks.** Create and use fun slogans or acronyms that will help you remember things. I tell torchworking students to always remember to take a POOP. That's the order in which the propane and oxygen is turned on and off. Turn on Propane than Oxygen. Turn off Oxygen then Propane. POOP. To remember which side of glass should be fired up, I remember to TUP it. Tit's up and tin up. To keep straight that short wave UV light is for tin test and long wave is for glue, I remember, "It takes a short time with the long light". To remember to always look the for the simplest and most efficient way to do something we KISS it. Keep It Simple Stupid. To avoid unnecessary steps, watch for SNUP stuff. Serves No Useful Purpose.
- **Best trick.** There are lots of tricks to help improve your memory but the best trick to improve your memory is to remember to write it down. Keep notes.

SUGGESTION

A good way to create the habit of keeping notes is to start with using the recorder on your cell phones. When you think of something you think of something worth remembering, dictate comments into your phone. When you get a chance, play back the records and make a permanent record of the things you want to keep. You might be surprised how easy it is to turn this into a routine habit.