



## How To Freeze 'N' Fuse™

Pâte-de-Verre Technique  
Paul Kimball, Pyros Glass Studio

### Welcome to Freeze 'N' Fuse!

Freeze 'N' Fuse is an exciting new way to produce three-dimensional figures in glass, without the use of high-temperature molds. Freeze 'N' Fuse is a type of pâte-de-verre (pronounced to rhyme with "hot to wear"), which means "paste of glass".

Freeze 'N' Fuse art is made in flexible molds. You simply mix powdered glass with water, fill the mold, and freeze it. Then you pop out your piece and fuse it in a kiln. Although Freeze 'N' Fuse pieces are made of real glass, they fuse at relatively low temperatures (about 1300 degrees F). Glass powder shrinks when it melts together, so your piece will end up about 15% smaller than your mold in each dimension, and will preserve the finest details of your mold.

Please read these instructions carefully before starting, and pay special attention to our important tips. They'll help you do your best work!

### Safety First!

You'll have lots of fun making Freeze 'N' Fuse projects, but I want you to be safe while doing it.

**Please wear safety glasses and gloves when working with kilns.** Also, it is very likely that you will be peeking at your work while it is fusing, so **wear glasses that protect your eyes from Infrared (IR) radiation**, to avoid the risk of eye damage due to prolonged exposure. Glasses with IR protection usually have a metallic gold coating.

**Always wear a respirator when measuring or mixing dry glass powder.** Glass powder can't cut you, but it is very bad for you to breathe the fine dust (google "Silicosis"). Extra-strong dust masks (respirators) are available in most hardware and building supply stores. Always pour and mix dry powders away from your face, and work in a well-ventilated room. If you will be working a lot with glass powders, an exhaust fan and HEPA vacuum are good investments for your studio. Once the glass powder is mixed with water, it is quite safe.

## Getting Started

You will need:

1. Flexible molds
2. Clear and colored glass powder
3. Disposable mixing cups
4. Paper towels or tissues
5. Palette knife
6. Toothpicks for popping bubbles
7. Wet/dry sandpaper for finishing your piece
8. Distilled water
9. A kiln that can go to 1300 degrees F (your oven won't work!)
10. A kiln shelf and shelf primer (kiln wash)

Optional, but handy, are the following tools and supplies:

1. Pyros Wetting Solution Concentrate
2. Pyros Ultrabind
3. A scale with a capacity of at least 200 grams and accurate to a tenth of a gram

## Step-by-Step Instructions

Please refer to the diagram while reading these instructions.

### Step 1 - Pick your mold

Molds for Freeze 'n' Fuse projects must remain flexible when frozen, so that you can remove your project. I've had excellent results making molds with two-part silicone rubber. Though expensive, they are extremely durable and flexible, and preserve fine detail. Many varieties of silicone are available, including brush-on and putty products. I've even made very good molds out of ordinary Silicone I caulk mixed with an accelerant to help it set up properly.

For fine detail at a lower cost I like latex rubber, which is easy to use and extremely flexible, allowing for deep undercuts. Latex molds are thin and can be turned completely inside-out when removing complicated shapes like the shells. A thin mold like this is called a "glove" mold. Commercial polymer clay push molds also work well; be sure to use the flexible rubber ones.

For extreme economy and fun, nothing beats plastic candy and soap molds, which can be found in any craft store. These come in a zillion shapes and sizes, and are very cheap. Since they are vacuformed, their disadvantage is that they have neither undercuts nor very good detail. However, these clear plastic molds do let you see your work as you fill the mold. This is particularly handy if you're using several colors to make dots or stripes. Pick a mold that looks like fun!

### Step 2 - Measure and Mix your colors

There's a lot to be said about mixing colors, and I say it in Pyros Tech Note #6 - "Blending Colored Glass Powders for Pâte-de-Verre Work". The most important rule: when mixing colors, go light!

Colored glass looks a lot darker after it fires than it does when powdered. It only takes a little bit of colored glass to make a very dark shade. Start with a mixture of about 10 parts clear to one part color.

### **Step 3 - Add glass powder to water**

Put some water in a shallow mixing cup. I recommend that you use distilled water, and add a few drops of Pyros Wetting Solution Concentrate. This will cause the water to wet the surface of plastic and rubber molds, and will really help you avoid bubbles in fine details of your work.

Add your glass TO the water, not the other way around. This way, bubbles are released as the dry powder hits the surface of the water. The water should completely cover the glass. Don't worry about having too much water - use plenty! Any extra will be poured off later. You want to get your glass thoroughly wet. Slowly stir the glass and water to release any bubbles and mix your colors.

### **Step 4 - Drain and repeat**

Let the glass settle, then pour off the excess water into another cup. It may be a bit cloudy. This is the extra fine glass particles being carried away. For best results, repeat this process so that your glass is rinsed at least twice. The last time, just pour off the extra water and you have the perfect paste.

#### **Watch out!**

DON'T pour the discarded water or glass powder down the sink. It will clog your drain and cause an expensive visit from a Plumber, who will make more money from you in one hour than you can make standing at a craft show for a whole rainy day.

Also, DON'T reuse the waste water to mix more glass powder for another project. Although it seems wasteful, my experiments have shown that the rinse water often has dissolved gunk and extra fine particles that can hurt the surface finish of subsequent projects.

### **Step 5 - Fill your mold**

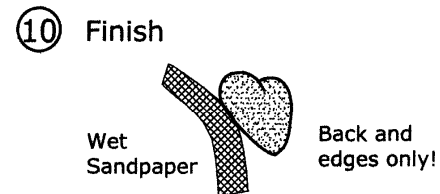
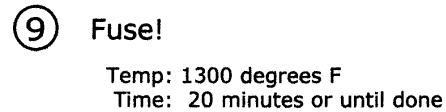
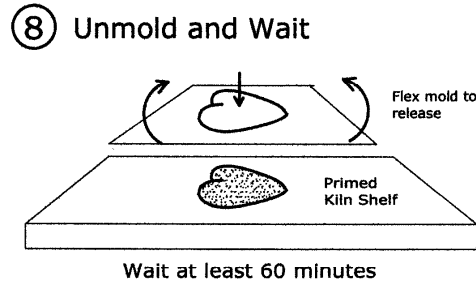
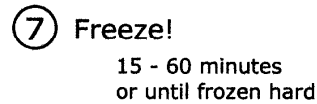
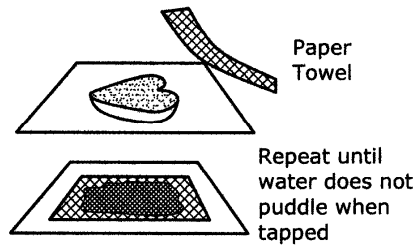
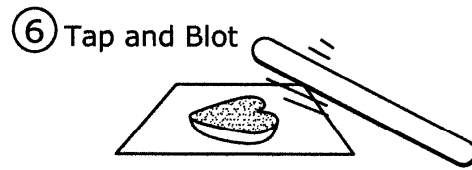
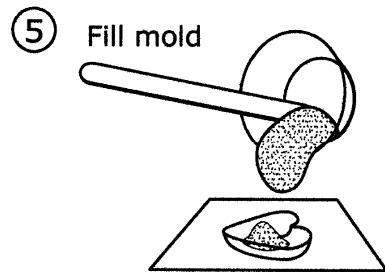
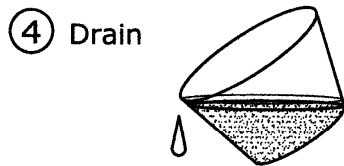
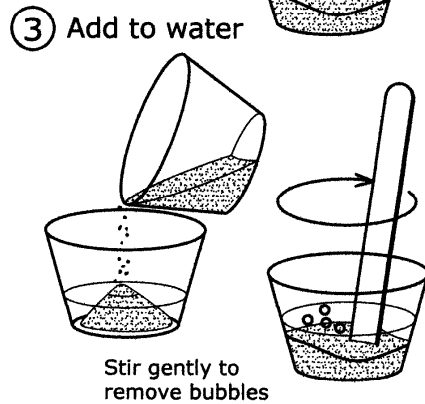
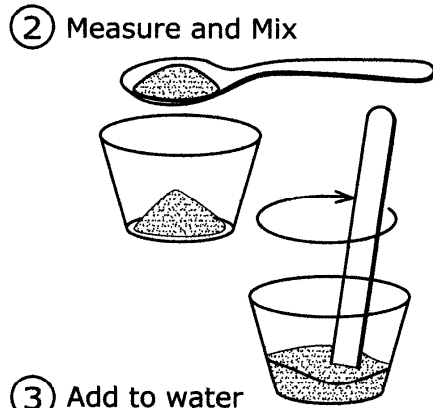
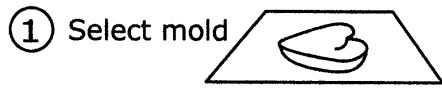
Mold your project. Your glass powder is now a puddle of glass paste! Use your palette knife to move it from the cup into your mold. You can "pour" it by firmly patting the mud until it moves, or use the palette knife to pick up blobs of glass mud and place them in your mold. DON'T drop the gobs of wet paste into the mold. This will trap bubbles. Instead, lay the glass paste against the surface of the mold and gently tap the palette knife to cause it to flow.

If you are filling your mold with several different colors, use your palette knife to place blobs of glass paste in different sections. Tap the mold gently to let the paste settle. Where two colors meet, use a small piece of paper towel to blot one color dry before adding the other color next to it. This will make it easier to make clean boundaries. Some prefer to freeze the mold between colors. Another method is to use a syringe or a paintbrush with a thick binder (such as Pyros Ultrabind) to draw designs on the inside of the mold. Let the binder dry, then pack the mold with wet glass as usual.

#### **Important Tip**

If you do get a bubble trapped in your piece, it is easy to get rid of it. Just put a few drops of water on the glass over the bubble. Holding a toothpick between your thumb and forefinger, twirl it to drill

down through the glass and free the bubble. This makes a hole in your piece, but just tap your mold a few times and the hole will seal itself up.



### Step 6 - Tap and Blot

Now you must compact the glass together in the mold and get rid of extra water. You want just enough water left in your piece to hold it together when you freeze it.

Hold your mold in one hand and vigorously tap it with the edge of a palette knife. Don't slap it. You want to vibrate it. You can also vibrate it with an electric tooth flosser such as the Oral-B Hummingbird. This vibrates the glass/water mix, and lets the glass settle closer together. When you do this, you will see a puddle of water start to form on the surface of the glass. Fold up a square of paper towel and place this flat on the glass surface to blot away the excess water. You don't have to dab at it; just let it sit there for a few seconds and then lift it away. Repeat this procedure.

### **Important Tips**

Keep tapping and blotting until you can't blot off any more water. If you leave too much water in the mold, it will expand when it freezes and give your piece a funny shape. It will also pool on the surface of the piece as it melts, and affect the surface finish.

With deep molds, it is hard to get all the water out just by tapping and blotting. Just do your best. The tapping is still very important to pack the glass tightly together. After you have removed all the water you can, you'll usually find that you can get some more out by inverting the mold and letting it sit for a half-hour on a few tissues or paper towels.

Remember that when you pop your piece out of the mold, the side that you are blotting will become the bottom. Your piece will fuse better with less chance of breaking if the bottom is nice and flat. One way to get a flat bottom is to overfill your mold a little bit, then draw your palette knife across it to make a flat surface. Another way is to slightly *underfill* the mold and rely on the vibration of the mold to level the surface. I find this not quite as reliable in terms of flatness, but it can produce a nicer edge to the piece.

### **Step 7 - Freeze**

Pop your mold in the freezer and wait until your project is *completely solid*. This will take between 15 minutes and an hour, depending on the size of your piece and how powerful your freezer is. Beware of those tiny office refrigerators that come with a miniature ice tray, but have no real freezing power! I know people who tried them and their piece *never* froze. In classes and at trade shows I rarely have a fridge, so I use a picnic cooler with about ten pound of dry ice in it.

While you're waiting, get your kiln shelf ready. A warm, dry, porous shelf is best. I like using inexpensive bisque tiles because they are more absorbent than mullite kiln shelves. Apply a light, smooth coating of shelf primer (also called kiln wash) to your kiln shelf. This keeps fused glass from sticking to it, and allows your piece to shrink uniformly as it fuses. Let the shelf dry.

### **Step 8 - Unmold and WAIT**

Take your mold from the freezer. Invert the mold over your shelf and gently twist or flex the mold to release your project. Don't bend the piece itself or it might break. If the piece will not release cleanly, make sure that it is completely frozen. It should be hard as a rock!

### **Important tips**

If you do crack your project at this point, don't despair! Just put it back in the mold and let it thaw a bit. Add some water and remold (tap, blot, etc.). DON'T try to fix it by pushing the pieces together on the kiln shelf. This never works.

Now comes the hard part! You must wait for your piece to dry. This helps the glass pull tightly together and will give you a clearer surface finish. For thin pieces wait at *least* an hour. Large pieces may need to dry overnight. "How dry?" is a question that is currently being debated. My tests show that if you want a clear, smooth finish you should let the piece dry *completely*. If you like a more "antiqued" finish, you can fuse right away without drying.

Ideally, the water in the piece will melt down into the kiln shelf; don't be surprised to see spreading wet spots around your pieces. Once they are dry, pieces are *very* fragile and must not be touched, though you can carefully carry them on the kiln shelf to put them in the kiln. It is probably better to let them dry in the kiln with the lid open so that you will not need to move them after they are dry.

## Step 9 - Fuse

Place your shelf in the kiln at room temperature. If you are using a small kiln with an "infinite" switch, set it at about "4" to start. You may have to turn it up later. When the temperature nears 1300 degrees F your pieces will start to fuse. You will know that this is happening because the pieces will shrink and start to become shiny.

Especially on small tabletop kilns, remember that your pyrometer may read as much as 100 degrees higher than the *actual* temperature in your kiln. This is because the temperature sensor is often right next to the heating elements and gets more than its share of heat. For a more accurate reading, turn the kiln off for a minute and then read the temperature. The kiln will lose hardly any heat in this time, but the temperature inside will equalize, causing the sensor to read correctly.

The *best* way to gauge when your pieces are done is to look at them periodically with a flashlight. They are done when they are shiny. This usually takes about 20 minutes at 1300 degrees F. When your pieces are done, they are solid glass and must be annealed as appropriate to their size.

If you are using a programmable kiln, the following program works well for small jewelry-sized projects on larger kiln shelves:

1. 600 degrees/hour to 1000, hold 30 minutes
2. 600 degrees/hour to 1300, hold 20 minutes
3. FULL to 965, hold one hour
4. OFF

For larger pieces, or in pieces where a binder is used, this schedule must be adjusted. If you are using any binder in your piece, you should soak at 1050 F on the way up, until the binder is completely burned out. For larger pieces, a lower, slower schedule is necessary to avoid too much slumping:

1. 300 degrees/hour to 1000, hold 30 minutes
2. 200 degrees/hour to 1200, hold 30 minutes
3. 50 degrees/hour to 1270, hold 30 minutes and WATCH to see when it is done.
4. FULL to 965, hold 3 hours
5. 25 degrees/hour to 865
6. OFF

These schedules are only examples! The important thing is to adjust according to the size and shape of your piece.

## Step 10 - Finish

If your piece has any sharp edges, use wet sandpaper or a diamond file to smooth them.

## Troubleshooting

This section discusses some of the most common problems encountered with freezing and fusing, and possible solutions.

### **My piece won't come out of the mold. It sticks to the mold and breaks up.**

Your piece is not completely frozen. *It should be hard as a rock.* Use a bigger freezer or dry ice.

### **My piece cracked when I put it on the kiln shelf**

Probably you got a little rough with it taking it out of the mold, or you cracked it when it wasn't really completely frozen. Unfortunately, I don't know a reliable way to fix this on the shelf, so put it back in the mold, thaw it, and then add a few drops of water. Tap and blot and refreeze.

### **My piece cracked while heating up**

This usually happens because the bottom of the piece is not completely flat. Use a straightedge to level the bottom surface before freezing. On wide thin pieces even a little bulge can cause the piece to break when it dries out. To avoid this, fire on a 1/4" bed of plaster or sand, which will support the piece evenly across the bottom. You have to kind of press the piece into the bed while it is frozen.

### **My piece didn't fuse**

Mainly a problem on little kilns. *Don't believe your pyrometer.* If the glass itself is 1300 degrees it *will* fuse, believe me! On my Evenheat Hot Box, the pyrometer routinely reads about 1400 when it is really 1300 in there. This is because the temperature sensor is right next to the heating element, and the heat shines on it. If you want to know what the temperature *really* is in your small kiln, turn the kiln off and read the pyromometer a minute later, after the temperature inside equalizes. That being said, the *best* way to know when your piece is done is to watch it.

### **My piece has a "sugary" texture**

This is something you can control. Fuse a few minutes longer or a just a little bit hotter. Some people *like* a sugary texture on more "natural" looking surfaces like shells.

### **My piece melted into a puddle**

You got it too hot or left it too long. I find the best way to judge when a piece is done is to watch it. To remind yourself to look periodically, buy one of those handy little kitchen timers that comes on a lanyard. Set and wear it whenever you have something in the kiln. I confess that I often get puddles when I forget to use a timer.

### **My piece came out with dark smudges**

Make sure that your mold is clean before you pack it. There are some colors that are not happy being mixed, and leaving even a little bit of dust in the mold can affect the next piece. Bullseye Pink with Turquoise Blue is an example; even a little bit of one in the other will cause dark metallic smudges. If you have eliminated cleanliness as a cause, read on:

The root cause for most other discoloration is not getting the piece dry thoroughly before freezing or before firing. You'll probably notice that the worst discoloration is occurring in raised areas or corners of your design. Here's what I believe is happening and what you can do about it:

### **I have white hazy or lacy patches on the surface**

Sometimes these have a frosted or gauzy look. If you look at these under a microscope you'll see that they are made of gazillions of really tiny bubbles.

These are caused when the piece has extra water left in it after tapping and blotting and the water cannot escape down into the piece after it is unmolded, because it is still frozen inside. The extra water melts on the surface of the piece and allows extra fine bits of powder to move around, breaking up the perfect surface that it had when frozen. These then dry to form a tiny crust which melts first when the piece fuses and traps bubbles in the microscopic channels below. Some artists use this as a way of achieving some interesting surface effects.

It tends to happen more on deeper pieces because it's hard to blot the water out of these completely. If you like this effect, you can achieve it by leaving a little extra water in your piece, and not letting it dry completely before firing. In class, this tends to happen automatically to the eager students that fire their pieces first. They get the "antiqued" finish. The ones who have to wait for a kiln get plain, non-frosted pieces.

If you don't like it, you can avoid it in several ways: First, pour off some of the the extra fine particles after mixing your powder with water. Vibrate and blot thoroughly. ( BTW, Phil Teefy found the most marvelous tool for vibrating little molds. It's called the Oral-B Hummingbird, and it is sold as a little flossing tool. It vibrates like crazy! Look in any drug store. If you can't find one there, we'll be selling them on our web site starting next week.) Finally, let your piece dry on a warm and porous shelf until it is completely dry. This pulls the water into the kiln shelf and drags the ultrafine particles back into the surface.

Another way that suggests itself would be to "freeze dry" the piece by taking it out of the mold, putting it on the kiln shelf, and returning it to the freezer until it dries out there. That way the water won't be able to move around as it dries. I haven't tried this yet, though. Let me know if it works!

As a last resort, you can lightly mist your pieces with distilled water after they are dry, which also causes the fine particles to settle down. Don't get carried away with the mister, or you'll wash your piece away like a melting sandcastle. Of course, this too could be an interesting effect.

### **I have brown or black "burnt looking" discoloration**

This takes the form of dark patches on the surface, usually in corners or raised areas, and often together with type one bubbles. They look like burned marks, and you can see them forming way before the piece begins to fuse, even below a thousand degrees.

This is caused by dissolved impurities in the water or the glass. Once again, this is aggravated by the piece not drying properly. Ideally, all the water in the piece should soak down into the kiln shelf, carrying any impurities with it. But sometimes the kiln shelf is not very absorbent, or you don't wait for the piece to dry.

In that case, the water has nowhere to go but up and out. It carries the dissolved impurities with it to the surface of the piece, where they get deposited in the raised and pointy parts. Impurities may include dissolved metal salts and oxides, sodium silicate, carbonates, sulfides and any other crud in the water.

(Side note: Ironically, it was just this effect that the Egyptians relied on when making faience pieces. When the piece dried in the hot, arid Egyptian air, the dissolved soda was concentrated on the surface of the piece, where it fluxed the surface and turned it to glass. But this is frozen frit, not faience, so we don't want it!)

Well, ideally, you don't have impurities in the first place, so the key to taming this sort of discoloration is to clean your frit!. First, use the most powerful magnet you can find to remove any iron particles. Second, use only distilled water. Third, rinse your glass powder at least twice with distilled water before using it. Pour off any ultrafine particles, and don't reuse the water that you pour off from your glass powder. Finally, let your pieces dry completely on a warm, porous shelf.

As a last resort, your glass powder may be contaminated with iron particles that are too tiny to remove with a magnet. You can dissolve these with a mixture of distilled water and citric acid (available in the supermarket). But that's WAY too much effort, so don't bother doing this unless it is clear that this is your problem.

### **Dark spots formed on the kiln shelf around the edges of my piece.**

These occur when the kiln shelf does its job properly and dissolved impurities and very VERY tiny bits of glass get carried down into the kiln wash. Together, these actually flux the kiln wash and turn it into a very crude and ugly glass. These spots are hard to remove, and your best defense is to use a pretty thick layer of kiln wash and clean your frit thoroughly.

## **Going Farther**

Freeze 'N' Fuse projects are pure glass and can be made into jewelry, magnets, pins or whatever you like. They can be fused to compatible 90 COE glasses or cemented to other materials with clear epoxy or other glass adhesives.

I hope you enjoy Freezing and Fusing! When you finish with it, you may want to make your own molds or get additional colors. See the Pyros website or catalog for more exciting Freeze 'N' Fuse kits and supplies.

### **Contact Us!**

We'd like to hear from you. If you have questions or problems, or want to share your projects with us, please drop us a line, or email us at [info@pyrosglass.com](mailto:info@pyrosglass.com).



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