Glass Fusing 101

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- There are many forms of glass art. Fused glass is one of them.
- The basic idea behind fused glass is that art objects can be created by melting glass in a kiln. That simple idea is behind hundreds of techniques.
- Fused glass (sometimes called kilnformed, warm or, kiln-glass) is an accessible and rewarding art form for many people around the world - and it is growing quickly in popularity.
- Unlike stained glass, fused glass has no "lead lines". Dimensional (non-flat) pieces can be created without having cut and assemble hundreds of smaller pieces.
- Unlike blown glass, the learning curve is relatively short, there are far fewer physical demands on the artist, and anyone's garage can be converted into a well equipped fused glass studio.
- Below are descriptions of several of the fundamental kilnformed glass techniques.

Casting: Creating an object by filling a mold with liquid and then allowing or causing that liquid to harden. In the case of kilnformed glass, the liquid is molten glass.

There are various approaches to casing glass. Most kiln cast processes use a mold made from plaster and silica flour.

Coefficient of expansion: (COE) is the rate at which a material expands when heated.

For kilnformed glass artists, the COE is shorthand for describing glasses that are compatible with each other. For example, Spectrum's System 96 glass (as well as compatible glass that is manufactured by Uroburos) is often described as simply "96 glass". Simillarly, Bullseye's compatible glass is frequently referred to as "90 glass".

While useful as a shorthand way to describe families of compatible glass, it is important to understand that expansion rate, though critical, is not the only thing that determines compatibility between glasses.

- **Basic Techniques**
- **Fused:** Two or more pieces of glass are placed in the kiln and heated until they fuse together into a single piece.
- **Slumped (or draped):** Glass is placed over a mold and heated until it slumps into (or drapes over) the shape. Frequently the glass being slumped has design elements already fused to it.
- **Cast:** The glass is melted so that it flows into a mold. There are many variations of glass casting, including lost wax and pate de verre. Cast glass objects are typically thick and dimensional.

Terminology

Things to consider:

As with Final Cooling, this is simply a transition phase – a step to get us from one temperature (process) to another (annealing). Other than cooling, there is nothing to accomplish and there is little that can go wrong. For almost any firing schedule, the segment for this phase is the same: full speed down to our Annealing phase.

Anneal

As with most materials, glass expands when heated and contracts when cooled. This contraction occurs in glass simultaneously with the change from a liquid to solid state. If the contraction and stiffening do not happen evenly throughout then the glass is left with residual stress.

The controlled cooling of glass in order to reduce undesired stress is known as annealing.

Annealing cannot, though, reduce or eliminate stress that results from fusing incompatible glasses.

- **Initial Heating**
- **What it does:**
- Heats the glass from room temperature to about 900° F (482° C).
- **Things to consider:**
- For most glass firings, the only thing to worry about in the initial heating is thermal shock. Thermal shock can happen when glass heats unevenly and part of the glass expands a lot more than another part. Since solid glass doesn't stretch, it breaks.
- Here are some situations that can cause thermal shock:
- Firing thicker glass too quickly can result in the outside of the glass expanding much faster than the inside of the glass.
- Glass that is close to heating elements will heat faster than glass that is further away. Examples include large projects whose edges are close to side elements and slumping projects that sit high on molds close to the top elements.
- Metal inclusions, dichroic, and iridized surfaces all change the way heat is reflected and absorbed into your project, causing uneven heating.
- Large areas of different glass – for example a circle that is half transparent and half opaque – will often absorb heat differently.
- When considering the risk for thermal shock, remember that all your risk factors work together. A thick piece of glass that is close to the side elements and has a large piece of copper foil embedded between layers is going to require much more caution during the Initial Heating.
- **Reducing Risk:**
- The best defense against thermal shock is to slow down the Initial Heating temperature ramp. Fortunately, you can always slow down this step without any negative consequences.
- You can also reduce the risk of thermal shock by ensuring that you load your kiln with the largest projects toward the center of the shelf, where the heat will be most even.
- When the edge of your large project must be close to the side elements (when that's the only way it will fit in the kiln), consider building a short wall of kiln furniture between the elements and the glass. This will act as a heat baffle and protect the glass for direct shots of heat.

My firing time:
On Medium: 0 – 700 degrees – 25 mins
Flip to Hi: 700 – 1700 degrees – 25 mins
Lift lid to view level of fusion
Turn off and cock lid to vent and allow to soak and anneal to about 500 degrees. Can at this time be moved to cooling blanket (on tray)

Dichroic: means literally "two colors". Dichroic glass changes color as it is moved in the light.

Dichroic glass is manufactured by fusing thin metallic films to the surface of the glass. These films allow the glass to transmit different colors than they reflect.

Dichroic glass is especially popular with glass kiln forming artists making jewelry.

firing schedule

The series of specific heating and cooling steps used to fuse, slump or otherwise kiln form glass.

Firing schedules can be executed manually (watch the temperature, turn the dial) or automatically by a kiln controller.

FusedGlass.Org has a number of useful firing schedules available for download.

fiber paper: A refractory material that may resemble paper, felt or fiber mat.

Fiber paper has countless uses when fusing glass including kiln-carving and as a separator between glass and shelves and/or damns.

Fiber paper usually has an organic binder that allows it to be handled and cut easily. The binder burns away when fired, leaving a softer, cotton-like material.

Fiber paper comes in several thicknesses and is most readily available 1/16 and 1/8 inch thick

Iridized (flash): A lustrous, metallic surface.

Iridized glass is manufactured by spraying metallic salts such (often stanous flouride) onto the glass at high temperatures.

Compare to mica and dichroic.

Shelf Primer: A solution of clay materials mixed with water. Also called kiln wash.

Used as a separator so that the melted glass does not stick the kiln shelf or molds.

Compare with shelf paper.

Stress: Internal force or tension within a piece of solid glass.

Stress can be caused by glass incompatibility or improper annealing.

All glass has some internal stress. The acceptable amount of stress is determined by the object's purpose. Any amount of stress below that which will break the glass under normal conditions is considered acceptable for art glass.