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Introduction To  
Kilnformed

# Glass Cutting Basics



**Cutting Glass** is an essential skill. The best hand cutting tools today have oil reserves in the handle which helps lubricate the cutting wheel, and penetrates into the the fine fractures caused by the wheel helping it to break evenly.

There are cutters for thin (1/16 - 3/16), medium (3/16 - 5/16) and thick glass. Using the correct cutter as well as the sharpness of the cutter is important to obtain consistent cuts.

- ✦ Never pass over a cut a second time.
- ✦ Use a light oil or mixture of mineral spirits and oil to dip you cutter into before cutting, or, use a cutter with an oil reserve.
- ✦ Keep even pressure when scoring.
- ✦ When cutting complex shapes start running your break from the interior of the glass and not at the edges.

**Cleaning Glass** is absolutely essential. Every fingerprint or film of dirt will appear as a dull patch on your fired project. Many glass cleaners have additives which will also cloud your glass after firing. Test any cleaner before using it on a project.






I have had luck with Hope's Perfect Glass Cleaner sold at Linen And Things. Bullseye recommends Spartan Glass Cleaner. Use a clean lint free cloth or paper towel. Insure the cloth was not clean in a washer with

a fabric softener or dried with some additives to your dryer. These also leave a residue on your project.

After cleaning only handle your project by its edges.

For more information see [Bullseye's Education page](#).

## Glass Cutting Tool List

	<p>Pistol Grip style cutting with oil well. \$30. Toyo is a good brand.</p>
	<p>Cutter Mate can cut any pattern including circles. \$250</p>
	<p>Right angle straight edge is essential. \$5 for 12 inch.</p>
	<p>Circle Cutter. \$30</p>
	<p>Grozer Pliers. \$6</p>

	Mosaic Pliers for nipping edges and cutting rods. \$25
	Running Pliers used to cause a straight score to break. \$9
	Grinder. \$100 - \$300
	Safety Glasses

as having the same Coefficient Of Expansion.

Without getting into a lot of technical jargon when a manufacturer certifies their glass as having a 90 or 96 or other COE, then you can be reasonably assured that all of their glass with the same COE will work together. The same is also true of glasses with like COEs from different manufactures.

That said, the conventional advice is that you should always test the glass yourself before making a large project with glasses from different manufacturers even if the COE is the same. This is mainly because in reality COE is not the be-all and end-all in the discussion of compatibility but is a sufficient guideline for the beginning kilnworker.

From my experience the 90 COE glass from Bullseye and Uroboros is very compatible. The palate of colors from both companies is extensive and I personally find no need to look elsewhere.

## Glass Compatibility

### Glass Sources

For the beginner the easiest rule to go by is just don't mix glass from different sources. For example you can't take left over glass from a stained glass project, and fuse it with glass left over from a broken window.

Even if you know the manufacturers of the glass it is very likely not to work. Glasses for kilnworking must be manufactured to be compatible. Unless the manufacturer states that two types of their glasses are fusible, then it is dangerous to fuse with the glass. A project made with untested glass will likely break hours, days and maybe even years later.

COE

The second rule is to use glass that has been tested

### Other Glasses

However, these glasses are fairly expensive to manufacture in comparison to other sources, and consequently a few years back a other glass manufactures, desiring to capture some of the growing kilnforming market opted to create a new fusing standards.

One of these was System 96 with a COE of 96 instead of Bullseye's 90 COE. Again, avoiding all the jargon and details. System 96 simply represented a cheaper alternative, but as with anything else you get what you pay for and there are limitations to this system which you must be aware of should you want to explore that alternative.

Use this link to find out more about the [System 96 Controversy](#) as well as the legal battles that occurred.

Any glass can be used for kilnforming (except tempered

glass) if the proper precautions are taken, including but not limited to issues of compatibility and the proper firing schedule for the glass being used.

At times there are very good reasons to use the cheapest glass possible such as when doing test firings where new elements such as mica, gold or copper leaf or other additives and inclusions are being researched and the base glass does not matter.

Certain commercial projects where successful sales are based on competitive pricing will require a source of cheap glass. Float glass (AKA window glass) is a very cheap source. Recognizing this fact a limited range of glass colorings (frit) has been developed for float glass.

The rule of thumb that I go by on the choice of glass is to evaluate what the requirements of the project are, and choose the best glass for that project. If cost is a significant factor over variety of color, or, if there is a desire to recycle as a marketing ploy, then other choices besides the gold standard of Bullseye glass may be the correct choice.

Experimenting with non conventional glass for kilnworking could set you on a journey that in the end sets you apart from other glass workers. Personally for example, I have found in my experimentation that certain effects that I enjoy are only possible with float glass.

## Kiln Safety

Fire only in a well-ventilated, covered and protected area. This is especially true if mold making material, fiber paper, or other project supporting 'furniture' will have a burn-off period, releasing unpleasant fumes.

Do not open the lid until kiln has cooled to room temperature and all switches are off.

Dangerous voltage: do not touch the heating elements with anything.

Disconnect kiln before servicing.

Do not leave kiln unattended while firing. Do not leave a kiln turned on at your studio while you are at home sleeping. While it is impractical to stay up all night with a kiln, controllers along with the condition of your elements and thermocouple are known to occasionally misfire.

Wear firing safety glasses capable of filtering infrared light when looking into a hot kiln. Be careful with prescription glasses with various reflective coatings. These coatings can 'craze' under the intense heat if you are manipulating glass manually when the kiln is at a high temperature. Something that you shouldn't be doing anyway.

Keep the kiln lid or door closed when the kiln is not in use. This keeps dust out of the kiln. Also, should someone turn on the kiln while you are away, the closed lid will keep the heat safely inside the firing chamber.

Never place anything on the kiln lid, even when the kiln is idle. If people become accustomed to placing papers and other objects on the kiln, they may forget and do that while the kiln is firing.

Remove all tripping hazards from around the kiln. Keep the kiln's supply cord out of traffic areas.

Do not let the cord touch the side of the kiln, which may damage the cord.

Avoid extension cords. If an extension cord is necessary insure that it is rated for the type of kiln you own. An underrated cord is a fire hazard, and could damage your kiln.

Do not remove the glass from the kiln until the kiln has cooled to room temperature. It is possible for thermal shock to break hot pieces where its internal temperature is not near room temperature. This is important for thick pieces (greater than 1/2 inch) where a high internal temperature and cold exterior could cause the glass to crack.

Fire only approved materials purchased from a knowledgeable supplier. Do not fire pieces of concrete, rocks, and other objects. Rapid heating to high temperature can cause violent reactions in many materials.

Avoid firing toxic materials inside the kiln or other experimental materials and chemicals. There is a danger of creating toxic fumes.

Never fire tempered glass inside a kiln. It could explode.

Greenware, which is unfired clay sometimes used as mold material or supports must be bone dry before firing. Moist greenware can explode inside the kiln, damaging the ware and the kiln.

Place a piece of greenware against the inside of your wrist. If it feels cool, it is too wet to fire.

Do not fire on cracked shelves. They can break during firing, damaging the glass inside the kiln, or worse damaging your kiln or causing a fire.

Store kiln shelves in a dry area. Moist shelves can explode inside a kiln.

If you smell burning plastic, turn the kiln off. Examine the wall outlet and supply cord for signs of burning.

Never place extra insulation around the kiln in an attempt to conserve energy. The extra insulation can cause the wiring and the steel case to over-heat.

Do not wear loose-fitting clothing around a hot kiln.

Pure cotton clothing is best since it will not melt if you reach into the kiln.

Unplug the kiln, or turn off the electrical shut-off box or circuit breaker when the kiln is not in use, especially if you are concerned that someone could turn it on while you are away.

Remove flammable materials from the kiln room. If you fire a kiln in the garage, park your car outside. Remove the lawn mower, gasoline, and other flammable materials. Keep packing materials such as shredded newspapers out of the kiln room.

Keep unsupervised children away.

Read and follow the safety instructions that come with your kiln.

# Kilns & Kiln Setup

## Basic Kilnworking Supplies

- Gloves: terry, welding leather, or kevlar
- Over glaze spray (Spray A)
- Kiln shelves
- Various molds
- Various brushes: haik, fan, others
- Shelf primer or shelf paper
- Pyrometer
- Stressometer
- Kiln furniture
- 3M particulate mask
- Fire extinguisher

## Miscellaneous Supplies

- Mixing bowls or buckets
- Shifters to apply powders
- Hammer and Newspaper to crush glass
- 

[Knowing Your Kiln](#)

[Preparing Your Kiln Shelf](#)

[Kiln Maintenance](#)

## Stand & Vent Assembly

Kiln stands are usually shipped disassembled. Follow the assembly instructions and check to see that the frame is level once in position. You kiln stand should be placed on top of a fire proof or fire resistant board. There should be nothing flammable on the walls near the kiln or stored under the kiln. It is advisable to use a stand so that the kiln can be vented.

Vents are not required, but are highly desirable. Especially as you become more advanced and begin to use various types of molds, shelf primers, and other advanced kilnforming materials which often need a burn out phase to prepare the material before using with glass. During the burn out process chemicals are released into the air which in many cases are unpleasant and in some cases are dangerous.

Vents are attached to the bottom of the kiln. Mounting instructions are provided by the manufacturer.

[Orton Glass Kiln Vent](#)

## Placement of the Kiln

Center the kiln on the stand so that it's stable and allows for the minimum of 18" to the closest wall or object. The kiln may have a metal bottom which is secured with screws. Position the kiln on the stand so that these bottom screws are not resting on the stand.

Check that the kiln is level and shim with metal if necessary. Once positioned, check again that it's stable. Do so with the lid closed and again with the lid opened.



If your kiln is equipped with swing away peephole covers, loosen the screw ¼ turn to allow the cover to swing easily. The peephole covers are fastened securely for shipping.

Before firing for the first time in a new kiln coat the whole interior with shelf wash. This will protect the kiln from glass. Glass is corrosive to the soft kiln brick. Over time if a fair sized piece of glass can eat through the bottom of a kiln especially if you habitually fire and hold at high temperatures.

## Daily Maintenance

### Cleaning

The kiln should be vacuumed occasionally and brushed with a small dusting brush to remove any brick or brick dust loosened by the last firing. Be sure to vacuum the lid element groove. Dust in these grooves will cause imperfections in the finished piece if they fall onto the glass during firing. Be careful as brick is fragile.

If you assemble projects in the kiln itself insure that no glass frit has found its way onto the elements. These must be vacuumed away before the firing otherwise

the glass will melt onto the element, causing a hot, and resulting in the element to burn out prematurely.

### Kiln Wash

Kiln wash, a.k.a. shelf primer, is a protective coating used to prevent glass from sticking to the firing surface. All items used for firing from shelves to molds must be coated with this kiln wash. Kiln wash is normally supplied in a dry form and must be mixed with water before application.

Mix the kiln wash to desired consistency. Water to powder ratios are usually given on the package. Use a soft brush to apply the wash to the surface of the shelf or mold. Keep in mind that your glass will take on the texture of the shelf or mold. A very smooth coating is generally the goal.

Many coatings will be needed to fully coat the shelf with reasonable drying times between coats. It is possible to hasten the drying process by loading the shelf or mold



into the kiln and taking the temperature up to 400 to 500°F.

Be sure that the shelf or mold (when using kiln wash on a glass mold) is completely dry before using. While it's possible that the kiln wash will remain on the shelf or mold after many firings it's always a good idea to inspect for wear and re-coat if necessary.

Depending on the particular kiln wash you are using and the firing schedules you normally run the wash will need to be occasionally replaced. Failing to replace the wash in time will result in your glass project becoming embedded with a white chalk-like substance on the back (self side) of your project. The glass may even stick to the shelf itself, resulting in a permanent divot on your self when you pull the glass off of the shelf, removing part of the shelf with it.

Recoating the self with every firing is the safest practice. You can either put a fresh coat right on top of the old, or, completely remove all of the old wash, replacing it with new. The old wash is easily removed with a 'green pad' such as 3M's Scotch Brite or similar scrubbing pad. Use a dust mask when removing the old wash.

## Other Shelf Coverings

Personally, I found liquid shelf primers in general requiring too much attention. My preference is to use a product like Bulleye's Thin Fire fiber paper as a shelf covering. Thin Fire is bought in a sheet or roll, and a new sheet is cut and placed on the shelf for each firing. The product acts as the separator of the glass from the shelf. This product however is a bit messy, is expensive, and the shelf must be cleaned and a new replacement applied after every firing. The improvement over kiln wash is that it is a little less maintenance and the back side of the glass is smoother with less effort than achieved with shelf primers.

One frustration for beginners is that a project might

randomly develop bubbles during firing, where by the glass in a small area of the project rises off of the self while the rest of the project remains flat on the shelf. Sometimes these bubbles are as large as one to two inches in diameter. I've seen these occur when using kiln wash, but have never seen them when using Thin Fire.

There is a debugging process to understand how to eliminate this problem, however my personal choice is to avoid using shelf primers altogether.

Shelf primers and Thin Fire do not eliminate the primary hallmark of kilnworked projects, that being a shiny side (top) and dull side (bottom shelf side). The shelf side inevitably becomes dull because of the contact with the shelf and picks up any textures and a general matt appearance no matter how smooth you try to make the shelf.

Some kilnworkers go through the laborious process of polishing the dull side of their finished project. This is not only laborious but also expensive due to the cost of time and the special equipment needed to polish glass.

It is easier and more natural to embrace what is inherent in a process rather than try to fight against it. Consequently, in my personal work I find methods that accentuate the nature of the self contact in kilnworking. There are any number of creative ways work with rather than against this fact of fusing.

Early in my explorations I purchased a roll of heavy (1/8 inch) ceramic fiber paper which I use as a self separator. This type of fiber paper gives the glass a nice irregular texture which I find pleasing, bubbles are never a problem, and it can be reused any number of times. It can also be turned over and the second side used. When finally exhausted the scraps can be bagged and used in future projects such as kiln carving, linings of furnaces, or for other advanced and specialized purposes.

There are any number of products on the market that can be used as shelf separators enabling reliable kilnwork.



I encourage you to obtain a catalog from one of the many kilnformed glass supplies such as Ed Hoy, Fusion Headquarters, C&R Loo, and many others to see what types of products are being offered as it pertains to the type of work you do.

The firing schedule section does not have a column for how long in minutes each segment is. I recommend adding a column called 'Elapsed Time' so that you know how long your schedule will be from start to end. By looking at the elapsed time you will know when it will be time for you to return to the kiln to monitor a critical stage.

You calculate elapsed time divide the rate into the target temp. For example 625/hour divided into a hold temperature of 1250 equals 2 hours for that segment to reach 1250 degrees. Then add to that the hold time for the total of that segment. Do that for each segment then total the elapsed time to find the total runtime of the whole schedule.

I would add to the Bullseye project notes another page to include:

- Any mixing ratios (powder, glue, water)
- Any set up times (drying, hardening)
- Detailed list of all materials used (additives, metal type and thickness, composite pieces)
- A photograph of each important stage.
- What you were trying to achieve, how successful you were, and what to try next time.

## Record Keeping

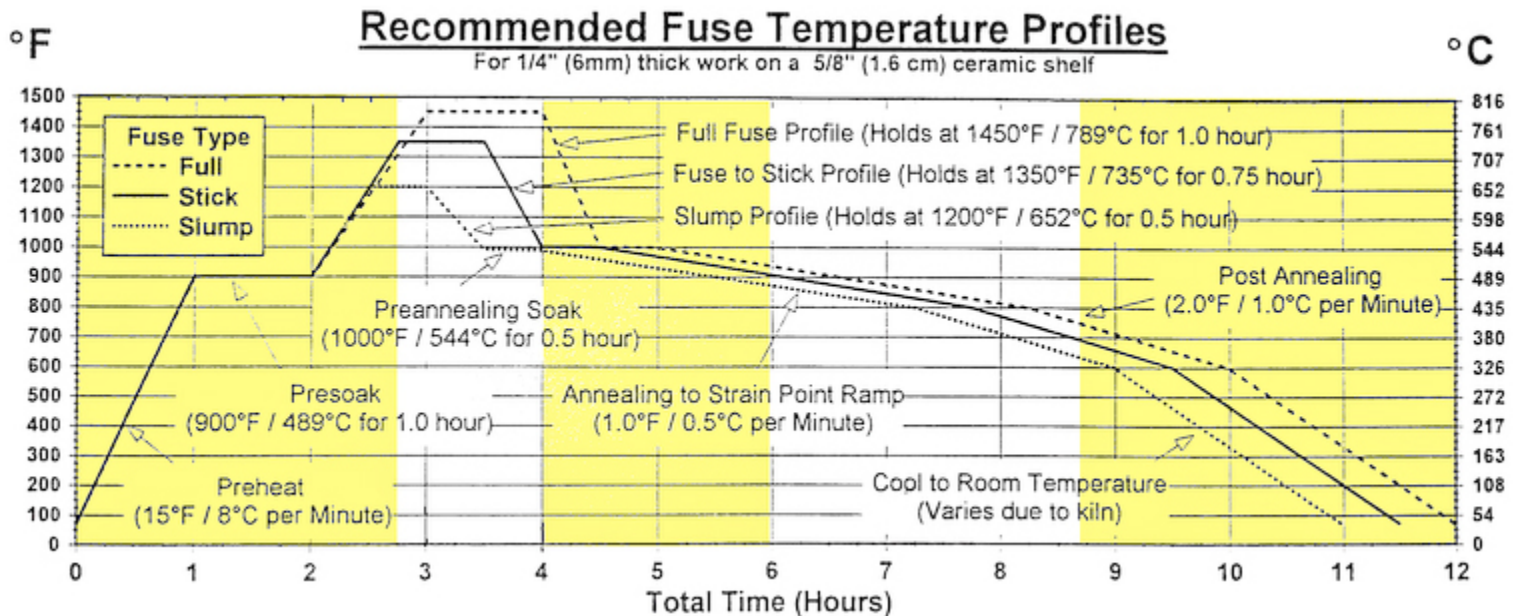
Detailed record keeping is essential to repeat earned, and waste time and money. Especially so when you are learning or experimenting with a new technique. You will often not repeat a project for some period of time. Keeping detailed records enables you to reproduce you project without having to rediscover what you already knew.

Do not rely on your memory. Trust me. You will forget the details faster than you realize.

The following link is to Bullseye's Project Notes project data sheet and it is a good starting point for keeping track of you own projects.

[Bullseye Project Notes](#)

# The Firing Process & Schedules



The Slumping, Fuse-to-Stick, and Full Fuse guidelines below are conservative and apply to pieces 1/4" (6mm) to 3/8" (9mm) thick up to 12" (30cm) in diameter, even when solid as in second or subsequent firings. Thinner pieces will not fire well above the Fuse-to-Stick range. The final guideline is for Kiln Casting a 15" x 15" x 3/4" (38cm x 38cm x 2cm) slab, in a plaster/silica mold, from either casting billets or sheet pieces. Each table includes annealing information. Faster ramp up rates are possible (particularly for Frit firings), or slower ramps may be necessary depending upon a variety of conditions, including, but not limited to:

- kiln type and shape
- heating element location and how close the glass is to it
- thickness and thermal mass of shelf or molds
- density of pack within the kiln, and available air circulation
- size of the component pieces of glass being heated for fusing
- thickness and diameter of the work
- thickness variations within the work

In general, Uroboros will fire similarly to Bullseye or Spectrum fusing glasses, though experienced users will detect variations between the brands, between COE points, or even between colors within one brand.

Process	Definition	Degrees
Full Fusing	Joining two or more pieces of glass by heating until they flow together	1450 to 1550
Tack Fusing	Fusing until the glass just sticks together, with each piece retaining its individual character.	1350 to 1450
Slumping	Shaping glass by bending it over or into a mold	1200 to 1300
Combing	Manipulating glass by raking a tool across the surface of molten glass	1650 to 1750
Fire Polishing	Heating glass just enough to round the edges and give it a shiny appearance	1300 to 1400
Kiln Casting	Fusing small pieces of glass (called "frit") inside a mold	1500 to 1600
Pate de Verre	Fusing a paste made with small pieces of glass inside a mold	1300 to 1500
Glass Casting	Melting liquid glass into a mold	1500 to 1700

Table taken from Brad Walker's book [Contemporary Warm Glass](#).



## General Firing Procedure

It's not possible to layout an exact firing schedule for all glass. Much depends on the type of hot glass work that is being done, the type of glass that's being used and the effects desired. The following procedure is a very basic fusing schedule. It's designed primarily to teach you about the various control functions and what is done throughout a firing.

Generally speaking, glass can be taken to 1000°F in the first hour of firing. This rate allows the temperature of the glass to increase relatively quickly without breakage. After the 1000°F temperature has been reached the glass can be fired as fast as possible to the fusing temperatures or until desired results are achieved. Fusing temperatures range from 1300 to 1500°F. Once desired results are achieved the kiln is vented quickly to stop further changes to the glass. After this venting period the kiln is closed and allowed to cool slowly which anneals the glass.

# Appendix

## Sample schedules for CBS dichroic glass 90 COE.

Tack Fuse (layers of glass minimally melt into each other, giving a glued look)

Step #1 3 hours to 1000 degrees F  
Step #2 hold for 15 min. @ 1000 (soak)  
Step #3 1 min. to 1320 degrees F  
Step #4 10 min. @ 1320 (soak)  
Step #5 1 min. to 1100 degrees F (crash)  
Step #6 2 hours to 960 degrees F  
Step #7 2 hours @ 960 degrees F (soak)  
Step #8 2 hours to 600 degrees F  
OFF

Partial Fuse (layers of glass melt into each other, partially leaving a soft texture)

Step #1 2 hours to 1000 degrees F  
Step #2 15 min. @ 1000 (soak)  
Step #3 1 min. to 1425 degrees F  
Step #4 10 min. @ 1425 (soak)  
Step #5 1 min. to 960 degrees F  
Step #6 2 hours @ 960 (soak)  
OFF

Full Fuse (layers of glass melt flush with one another)

Step #1 2 hours to 1000 degrees F  
Step #2 15 min. @ 1000 (soak)  
Step #3 1 min. to 1425 degrees F  
Step #4 12 min. @ 1425 (soak)  
Step #5 1 min. to 960 degrees F  
Step #6 2 hours @ 960  
OFF

Slump Program (slumping glass into or over molds)

Step #1 3 hours to 1000 degrees F  
Step #2 1 min. to 1350 degrees F  
Step #3 15 min. @ 1350 (soak)  
Step #4 1 min. to 960 degrees F  
Step #5 2 hours @ 960 degrees (soak)  
OFF