Spectrum Glass presents:

System 96®

Getting Started with Kiln-Fired Glass

Guide to Materials and Procedures

Updated

Beautiful fused glass projects are easy and fun!

Glass Meets Kiln

> *Any kiln with a programmable controller can be used to fuse glass.*

There are only a few basic requirements to set you on your path to becoming a Fused Glass Artist: a kiln, a creative urge, some "compatible" glass, and a few tools. This booklet introduces you to the tools, components, techniques, and resources common to successful Glass Fusing.

After you become familiar with the basics, we hope you will experiment, stretch, play, and continue to learn — glass is endlessly fascinating and rewarding!

What is Glass Fusing?

Glass Fusing is simply the process of stacking two or more layers of compatible glass together to make a design, then placing the stacked glass into your kiln, where it melts (fuses) together.

Assembly

A project generally begins with a **base layer** (often one or two pre-cut glass Bases) with a **design layer** on top, including glass accents, focal elements, and often a border treatment.

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Flat Firing

After assembly, the project is placed in the kiln and slowly taken from room temperature up to 1300-1500 degrees Fahrenheit. Different effects can be created by combining the variables of time and temperature. These are outlined in the "Firing Programs" section.

The resulting flat project could be a tile, suncatcher, coaster, or decorative art. Stop here, or fire again — "slump" — for a three-dimensional shape.

Slumping

Once your design is fused into a single flat unit, the project can be returned to the kiln and heated just to its softening point (about 1225° F), causing it to sag *over* or *into* a mold. This transforms the flat project into a functional or artistic 3-D piece, such as a bowl, tray, platter, or vase. The actual goal temperature and hold time for a slump depends on what type of project you're making.

Special Notes

Compatibility

Glass expands when it is heated and contracts when it cools. Glass from different manufacturers has a distinct rate at which it expands and contracts, called the Coefficient of Expansion (C.O.E.). When you assemble your projects using only **System 96**® glass, you are drawing from a family of products that have been "tested compatible." You can trust all products that bear the System 96 logo to work well together.

> Do not add other kinds of glass (non-System 96) to your projects and expect success. **Project breakage will result!**

Degrees, not "Cone"

If you have a ceramic kiln, set it to display temperature in degrees, not "cone."

Fire Glass Separately

If you also fire ceramics, do not fire glass and ceramics in the same kiln at the same time — glass fires at lower temperatures.

Glasscrafting Tools & Supplies — Getting Started

This list includes the most commonly used tools and supplies for creating glass projects.

Nippers

Like "scissors" for glass, the nippers chew up glass with ease, creating a characteristic curvy break that's artistic and versatile. Aim flying nips into a basket or tray, and always wear safety glasses.

Glass Cutter

The cutter's wheel creates a "score" as it's guided across the glass surface. When pressure is applied to both sides of this score, the glass will break. You can create beautiful projects **without ever picking up the glass cutter** — but with a bit of glass-cutting skill, a world of design possibility opens up.

Running Pliers

These specially designed pliers put presssure on both sides of the glass cutter's score, encouraging a "run" (crack) along the line of the score. Often the glass will break all the way along the score with just gentle pressure from this tool.

Breaking Pliers

These sturdy pliers act like metal fingers, to grab, pull, and break the glass along the glass cutter's score line. Especially useful for small pieces, or to nibble off pointy spots.

Klyr-fire

Use this viscous, slow-drying adhesive for holding Frit in place, or sticking on tiny pieces too small to glue individually. Apply with a cotton swab, brush, or dab from a squirt bottle. It burns away during firing.

Elmer's Glue

Use just a pinpoint of glue, applied with a toothpick, to hold pieces in place as you transfer your project to a kiln shelf.

Cutter Oil

Lightweight oil lubricates the cutter's score line and prolongs the life of the cutting wheel. Keep a little in a small jar with a piece of sponge at the bottom, and just dip your cutter in it every few strokes.

PAPYROS® Kiln Shelf Paper

Provides a layer of protection between the glass and kiln shelf. Prevents sticking and helps avoid formation of large air bubbles beneath the glass. (Visit System96.com/PAPYROS for usage & clean up information.)

Slumping Molds

Generally speaking, slump **INTO** molds to create bowls, dishes and other shallow forms. For prep, see "Preparing Molds for Slumping" section.

Draping Molds

Slump **OVER** to create vases, candleholders and other interesting shapes. For prep, see "Preparing Molds for Slumping" section.

Shelf Primer and Application Brush

Keeps glass from sticking to molds.

Dedicated Glass-Firing Kiln Shelves

A few smooth shelves reserved for glasscraft will keep the undersides of your projects smooth and even.

Shop Vac with Small-Particle or HEPA Filter

Highly recommended for all glass cleanup chores. Captures tiny glass splinters and harmful dust residue after firings.

Brushes

Small brushes are great for brushing Frit into place or out of spaces it doesn't belong.
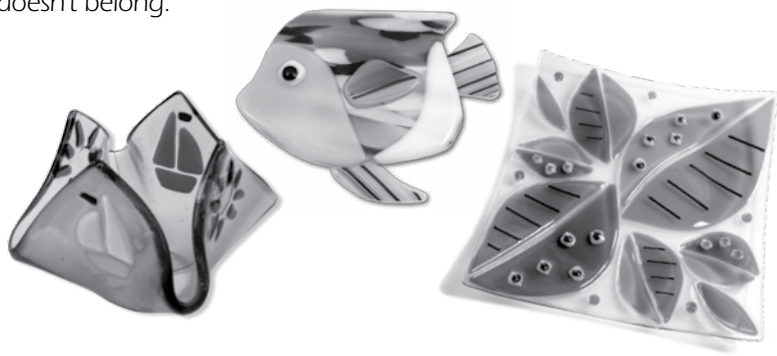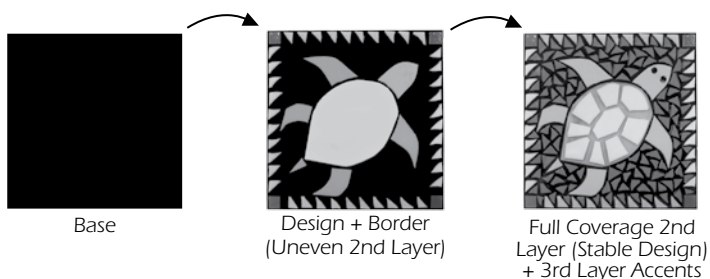
Glass Fusing Components — How to Use Them

The System 96 Glass Craft Program uses a set of pre-defined components to make project creation easy and foolproof. You may find them pre-cut and ready to purchase on the shelves of a System 96 Glass Fusing Center, or you may choose to cut them yourself from sheet glass.

Pre-Cut Bases   Bottom layer for projects. *If slumping, choose a Base that coordinates with an available mold. (See pg.12)*

Sheet Glass   Assorted transparent, opalescent, and specialty glass. *Cut or nip to create shapes or Project Bases.*

Nippits™   Assorted colors of glass pieces, about 2" x 6". *Use with glass nippers to create random-sized pieces, or with glass cutter for specific small shapes.*

Chips   1/2" squares of various colors. *Ready-made design elements with many uses.*

Strips   1/2" x 12" lengths of various colors. *Nip or cut.*

Rods   Various colors of cylindrical, pencil-thick glass. *Nip off 1/4" or smaller bits to create "dots" or bumps. Nip longer lengths for borders or bold design elements.*

Noodles   Assorted colors of fettuccine-like strands. *Nip to length.*

Stringer   Assorted colors of thin strands like angel-hair pasta. *Break with fingers or nippers.*

Frit   Ground glass, in various particle sizes and many colors. *Sprinkle, pour, or place with tweezers; use with Klyr-fire.*

Pebbles™   Small, pre-formed droplets of glass in assorted colors. *Versatile design or border elements.*

CutUps™   A variety of pre-cut glass shapes in assorted colors. *Use as design elements or inspiration.*

Dichro Shapes   Metallicized color-shifting sparklers in pre-cut shapes. *No cutting necessary; use as design elements.*

Dichroic Glass   Small pieces of metallicized color-shifting sparklers. *Nip or cut to desired shape.*

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Making a Project

Projects are assembled by stacking glass pieces in layers. The bottom layer is often a single glass circle or square, called a "Base." We place other glass pieces on top of this to create a design that covers the entire Base fairly evenly. **(In fusing, a 2-layer design ensures a state of equilibrium during the firing process that results in a more stable finished piece** — see page 8 for more information.) Some detail or accents can be added in a third layer.

IMPORTANT: Each layer adds thickness to the finished project. The most successful projects are built with a **fairly uniform thickness of at least 2 layers.** The firing guidelines in this booklet will successfully fire projects **up to about 3/8-inch (3 glass layers) thick.**

Base

Design + Border
(Uneven 2nd Layer)

Full Coverage 2nd
Layer (Stable Design)
+ 3rd Layer Accents

Step 1: Planning Your Design

Here are some approaches:

▪ Follow a Project Guide

Choose from the many 'tested and true' Project Guides available on the System 96 website to create specific projects. You'll be learning techniques, discovering your firing preferences, and improving your skills — while creating projects that have been proven successful. (See Resources pg.15)

▪ FreeStyle Design

Start with a glass Base, then begin to decorate it with various shapes and sizes of smaller glass pieces. **If your design will not create a fairly even second layer, it's best to begin with a 2-layer Base** — especially important if you're making a 'full-fused' dish that will be functional. Have fun and learn from every project you make.

Volume and Shape Control

Distortion of a project's shape (perimeter) during firing can lead to some surprises, or it can contribute to a well-executed design.

It's important to understand that glass, as it gets to a full fuse temperature range, will naturally seek to become a circular "puddle" about 1/4-inch (6mm) thick. If it's thicker than that to begin with (more than 2-layers of glass), it will spread out. If it's thinner, it will draw in, ever seeking that 1/4-inch thickness equilibrium. Understanding this inclination is important to creating a thoughtful design and predicting fired results.
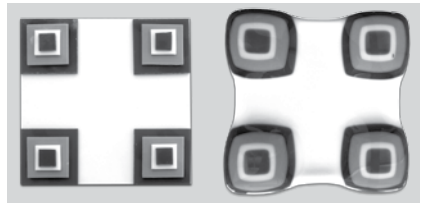
Left: Strictly for the sake of demonstration, we created a single-thick square of glass with smaller square stacks in each corner. Right: After Full Fusing, the thin areas draw in; the thicker areas push out as the uneven layers seek equilibrium.

For more instruction on fine-tuning your glass fusing, look to the System 96 website or take a class offered by fusing instructors in your community.

Step 2: Assembling Your Project

Glue Sparingly

Glue pieces onto your project only as necessary to prevent shifting as you transfer it into the kiln. We use two types of adhesive:

Elmer's Glue: Apply **PINPOINTS** with a toothpick. (Too much will char.)
Klyr-fire: Allows lots of working time and always burns off. Apply with a cotton swab, brush, or squeeze bottle.

Support Your Project and Prevent Sticking

You may need to move your project several times before it is fired. We recommend using a Project Base to provide support. Otherwise, assemble the project either on your kiln shelf or on a flat, unglazed ceramic tile that will go directly into the kiln.

In either case, **use PAPYROS® Kiln Shelf Paper under every project** as a buffer between the glass and the ceramic surface. It prevents sticking and helps avoid bubbles under your project. Size the paper to extend at least a 1/2-inch beyond the edges of your project, to allow for the possible expansion of the glass.

Step 3: Loading the Kiln

Whether you have a kiln that accommodates one project or several dozen, your goal is to **heat the glass as evenly as possible**. Here are some guidelines to achieve even heat distribution.

- Position projects at least 2" from kiln elements.

- If using a single shelf, position it centrally in the kiln.

- If stacking shelves, position them so that at least one side-element freely radiates between each shelf. Post the lowest shelf off the kiln floor, and the highest shelf well below the lid.

- Do not stack shelves in kilns equipped with lid elements only.

- If your kiln controller is equipped with "Zone Control," use it.

> On the kiln shelf, always leave at least 1/2" between projects and 1/4" between the project and the edge of the shelf, to allow for expansion of the glass.

Step 4: Programming Your Kiln

"Ramp and Hold"

Heating glass to fusing temperature and cooling it, without introducing internal stress, is accomplished in your kiln with a time-temperature cycle called a Ramp & Hold firing program.

Entering a Ramp & Hold program into your controller is easy. Consult your kiln manual if needed, but don't be intimidated! Once entered, you need only recall it from (your kiln's) memory for future use.
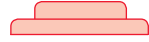
A Ramp & Hold program is made up of several segments. Once started, your kiln will execute each segment, in sequence, until the firing program is complete. Our recommended firing schedules have six segments, each with three parts: The Ramp, the Goal Temperature, and the Hold Time. The diagram that follows explains this.

Ramp	Goal Temp	Hold Time
The rate, in degrees per hour, that kiln temp will rise or fall during each segment.	The temperature the kiln will seek to reach during each segment.	The number of minutes the kiln will stay at the Goal Temp, once it is reached.

BASIC Firing Programs

THE PROGRAMS THAT FOLLOW ARE DESIGNED FOR PROJECTS UP TO ABOUT 3/8" THICK. THEY ARE INTENDED AS A BASIC PLACE TO START. FOR MORE FIRING OPTIONS, VISIT SYSTEM96.COM

TACK FUSE *Glass pieces are fused together with little change beyond softening or rounding of edge.*

Segment	Ramp (ºF per Hour)	Goal Temp (ºF)	Hold Time (Minutes)
1	250	1050	30
2	250	1250	20
3	300	**1350-1370****	**10**
4	9999*	950	60
5	200	800	10
6	300	100	0

as fast as possible   **see Forming Stage Ranges on pg. 11

CONTOUR FUSE *Glass pieces are fused together, edges are soft and rounded, project surface retains a degree of dimension.*

Segment	Ramp (ºF per Hour)	Goal Temp (ºF)	Hold Time (Minutes)
1	250	1050	30
2	250	1250	20
3	300	**1400-1450****	**5**
4	9999*	950	60
5	200	800	10
6	300	100	0

as fast as possible   **see Forming Stage Ranges on pg. 11

FULL FUSE *Glass pieces are completely conjoined into a single uniform layer, top surface is smooth and void of dimension or relief.*

Segment	Ramp (ºF per Hour)	Goal Temp (ºF)	Hold Time (Minutes)
1	250	1050	30
2	250	1250	20
3	300	**1460-1470****	**10**
4	9999*	950	60
5	200	800	10
6	300	100	0

as fast as possible   **see Forming Stage Ranges on pg. 11

Tack, Contour, or Full Fuse

The shaded areas in the preceeding charts are what determine the fusing level; Tack, Contour, or Full fuse. The more total heat (both temperature and time) at this "forming stage," the greater change in the shape and appearance of the glass during firing. The differences in the three levels are described below.

- **Tack Fuse:** Projects are joined together with little change beyond the softening or rounding of glass edges. Use this schedule when trying to preserve the maximum amount of detail in a project. (For decorative use — not recommended for functional dishes.)

- **Contour Fuse:** The glass edges are soft and rounded, yet the project surface retains a degree of dimension. Use a Contour Fuse when layers need to be more fully combined, but detail is still desired.

- **Full Fuse:** Works best on two-layer projects containing an even amount of glass on each layer. These will melt together completely and have a smooth surface, while still retaining the perimeter shape of the piece.

Forming Stage Ranges (Illustrations represent a cross-section view of 2 layers of glass.)

Tack Fuse	Contour Fuse	Full Fuse
1350-1370° F	1400-1450° F	1460°-1470° F

We recommend starting with the basic firing programs outlined here. As you become familiar with the results at these three fusing levels, you will likely want to explore adjusting the process times and temperatures. Please see the System 96 website for more complete firing programs: www.system96.com.

When in Doubt, Tack or Contour Fuse

Projects can easily be returned to the kiln and re-fired for a more "melted" result. Obviously, the opposite is not true!

Full Fuse is Not Recommended for Single-Layer Projects!

Left: A demonstration tile of a single-thick square of glass with smaller square stacks placed unevenly, then Full Fused. The perimeter of the piece becomes distorted because of the uneven distribution of glass. The piece will be very fragile.

Don't Peek!

Glass is sensitive to temperature changes, and cooling from the goal temperature is carefully regulated by the firing programs. While the glass is cooling, it is going through an annealing phase, in which the glass adjusts to its new form. **Opening the kiln before the firing schedule is complete can result in project breakage!**

After the firing cycle is complete, **leave the kiln lid closed.** Use the peephole if you must, briefly. Otherwise, demonstrate patience, and don't open until the internal temperature is below 100°F.... **Then Admire Your Fused Glass Art!**

Slumping (Optional Step 5)

Most glass projects can be fired a second time to form a functional or artistic three-dimensional shape. In this firing, you will re-heat the previously fused flat project to the point of softening, and it will "slump" **into** and take the shape of the mold you've selected. Or, you may choose to place the project on top of a mold (usually stainless steel) and let it slump **over**.

Planning Your Design to Fit

To create a piece that you plan to slump **INTO** a mold, make sure your assembled project is no larger than about 1/8" outside the perimeter of the mold.

To create a piece intended for slumping **OVER** a mold, make sure the project is not so large that it will sag completely down and flatten onto the kiln shelf. Keep in mind that the piece may stretch a bit as it softens, so leave some extra space.

Preparing Molds for Slumping

Ceramic (Bisque) Molds:

1. If not already done, drill a few small air holes where the glass will sag down into the mold. This will let air escape from beneath the glass as it slumps.

2. Brush several smooth, thin coats of Shelf Primer — reapply when it shows wear or imperfections.

Stainless Steel Molds:

Pre-fire steel molds so they'll more readily accept the Shelf Primer.

> Ceramic and stainless steel molds are re-usable.
> Just re-apply Shelf Primer as needed.

Centering

Place the flat fused piece on or into your mold, aligning the project's center point with the center of your mold.

BASIC SLUMP FIRING *Previously fused project softens and slumps to take the shape of selected form or mold. This is a place to start: you will need to adjust depending on the severity/complexity of the mold, finished effect, etc.*

Segment	Ramp (°F per Hour)	Goal Temp (°F)	Hold Time (Minutes)
1	250	250	15
2	250	1050	30
3	150	**1225**	**10**
4	400	950	60
5	200	800	10
6	300	100	0

Important Safety Notes

Just like getting a ding on your shiny new car, it won't take long before you are "initiated" by cutting yourself with glass. Use common sense, keep a supply of Band-Aids, and take minor cuts in stride.

> For your protection, **<u>always wear safety glasses</u>** and gloves when working with glass.

Here are a few other things to keep in mind:

Hot Glass

Be cautious about touching glass in the kiln, even when the controller reads room temp. The glass itself may be much hotter.

PAPYROS Clean Up

PAPYROS remains fairly intact after firing, making clean up easy. We found the "spatula method" to work well in disposing of the paper. Please see the PAPYROS website for a demonstration of this technique as well as other important product usage and safety information: system96.com/PAPYROS.

Glass Clean Up — Be Smart

- Never brush glass off your work area with your hands. Keep a bench brush handy, or use your vac.

- If you save remnants of unused glass, it's safest to "square up" the pointy pieces.

- Don't put glass remnants into your regular trash without covering with a heavy protective wrap, so the unsuspecting trash bagger will not get cut.

Fusing Tech Support

You may email us with technical questions specific to System 96 products at this address: **hotglass@system96.com**

Helpful Resources

System96.com has supply information, tutorials, and other resources to further your Glass Fusing experience. Be sure to look into class opportunities in your community to further develop your skills and learn new techniques.

System 96 Project Guides

Project Guides make fusing as easy as it gets. Each Guide provides step-by-step instructions on project creation, including specific techniques to expand your general fusing knowledge.

Get started today ... visit system96.com under the "New to Glass Fusing?" tab to download and print your favorite Project Guides.

System 96 Glass Suppliers

Find authorized suppliers of System 96 products and other fusing materials on System96.com.

Spectrum Glass PAPYROS® KILN SHELF PAPER

- **Extra Sturdy**
- **Fast & Easy Clean-up**
- **Available in Convenient Sheets & Three Roll Sizes**

PAPYROS® Kiln Shelf Paper is a ceramic-based paper specially formulated for glass fusing. When placed between the kiln shelf and the underside of a glass project, PAPYROS prevents the glass from sticking to the shelf during firing.
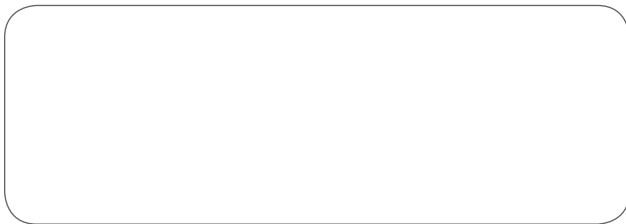
Visit *system96.com/PAPYROS* for tips on maximizing use of PAPYROS, easy clean-up instructions, and safety information.

PAPYROS is available from your Spectrum Glass/System 96 supplier.

System 96® is a family of glass products designed and produced to work together, then tested to ensure their harmony (compatiblity). The products are materials for the Hot Glass Arts — user-friendly and forgiving for the beginner, versatile and predictable for the professional.

Spectrum Glass Company and Uroboros Glass Studios bring a combined 60+ years of art glass manufacturing expertise to the hot glass community. Coatings by Sandberg is a highly specialized maker of the 21st century phenomenon called Dichroic Glass. In cooperation with other carefully chosen companies and individuals around the world, we manufacture the System 96 tested-compatible family of art glass products. Learn more at System96.com.