Firing Guide

A basic guide to kiln-firing System 96® products

These pages contain guidelines for Fusing and Slumping 12-inch (30cm) projects of various thicknesses, using the System 96 family of Tested-Compatible products. These are guidelines, not strict rules. Times and temperatures will vary with equipment and project size. We've also included an instructive Forming Stages chart, basic technical data and other information to assist you in understanding how System 96 products behave during the kilnforming process. Check **system96.com** for more detailed information on firing larger projects.

Fusing (Fahrenheit) Project size: 12-inches

Segment	Thickness (inches)	Rate (° F per Hour)	Temp ° F	Hold (minutes)	Step Time (minutes)	Elapsed Time (hours)
1. Heating I:	1/8	600	1000	0	75	1.2
	1/4	400			120	1.9
	3/8	300			180	3.0
2. Heating II:	1/8	2000	1465	Desired Effect	25	1.6
	1/4					2.3
	3/8					3.4
3. Cool to Anneal:	1/8	As fast as possible	1000	5	15	1.9
	1/4			8	20	2.7
	3/8			10	25	3.8
4. Anneal I:	1/8	600	955	10	20	2.3
	1/4	300		20	35	3.3
	3/8	200		40	55	4.8
5. Anneal II:	1/8	400	800	0	20	2.6
	1/4	200			50	4.1
	3/8	150			60	5.8
6. Cool Down:	1/8	800	120	0	60	3.6
	1/4	400			120	6.1
	3/8	300			170	8.7

Bubble Squeeze — Guidelines for Controlling Bubbles

If you're seeking to reduce or eliminate bubbles, try slowing the rate of heating in Segment #2 (Heating II). Inserting a half-hour soak at around 1220° F(660C) may also help, allowing added time for air to escape from between glass pieces before the edges seal and trap it in the form of bubbles. For large projects, experiment with a "ramp squeeze," a very slow ramp up from softening to tack temperatures, say 60° per hour from 1100-1300°F (590-704C). If your project has a clear base, consider using our "Double Thick" clear instead of two layers of regular clear. You can't trap air where there isn't a space.

Technical Data	Strain Point*	Anneal Point*	Softening Point
Fahrenheit:	890 (+/-10)	955(+/-10)	1255(+/-10)
Celcius:	476 (+/-12)	513(+/-12)	680(+/-12)

*At the Strain Point of a glass, internal stresses are substantially relieved in a matter of hours. At the Anneal Point, internal stresses are largely relieved in a matter of minutes.

Slumping (Fahrenheit) Project size: 12-inches

Segment	Thickness (inches)	Rate (° F per Hour)	Temp ° F	Hold (minutes)	Step Time (minutes)	Elapsed Time (hours)
1. Heating I:	1/8	600	1000	0	75	1.2
	1/4	400			120	1.9
	3/8	300			180	3.0
2. Heating II:	1/8	1200	1225	Desired Effect	15	1.5
	1/4					2.2
	3/8					3.3
3. Cool to Anneal:	1/8	As fast as possible	1000	5	15	1.8
	1/4			8	20	2.5
	3/8			10	25	3.7
4. Anneal I:	1/8	600	955	10	20	2.1
	1/4	300		20	35	3.1
	3/8	200		40	55	4.6
5. Anneal II:	1/8	400	800	0	20	2.5
	1/4	200			50	4.0
	3/8	150			60	5.6
6. Cool Down:	1/8	800	120	0	60	3.5
	1/4	400			120	6.0
	3/8	300			170	8.5

New to System 96? — What to Expect if You're Used to "90 COE"

Lower Temperatures: Take a few minutes to compare the System 96 Firing Guides with what you're used to. Then study the Forming Stages chart on the back. The differences aren't huge, but they're important. *It takes less time & temperature for System 96 glasses to reach a given viscosity than "90" glasses.* Slumping begins sooner and reaches "optimum" earlier. "Tack" happens faster. Edges start to round at lower temperatures. Awareness of this will help you anticipate differences and form more accurately, with less "trial and error."

Forming Control: With System 96, you will immediately notice a wider range of temperatures between "not-yet-fused" and "beyond-full-fused." This is a characteristic of the family's longer "working range." "90" glasses progress *very fast* from "edges starting to round" to "over-fired." In contrast, System 96 glasses move slowly and predictably through clearly discernible stages of forming. This takes a little getting used to, because it's not what you've learned to expect. You have more precise control over surface dimension and a much wider (and welcome) margin of error.

Design Lines & Detail: Lines formed by adjacent colors will stay sharper and more defined than you are accustomed to. "90" glasses are looser (less viscous) at higher temperatures, so adjacent colors are more prone to bleed into each other. This causes the phenomenon that "90" users call "the jigglies," in which lines soften and distinction blurs. System 96 glasses retain crisp lines throughout the firing process, and you'll want to plan for this difference in your designs.

Technical Support — Answers, Advice & Assistance

System 96 is the most "fuser friendly" glass ever made. It's easy to cut, exceptionally stable and predictable through the firing cycle, and remarkably consistent from run to run. Still, kilncraft is a many faceted endeavor and there are always questions, concerns and curiousities. The System 96 web site is your first stop (**System96.com**). We maintain a "Common Questions" page as well as a System 96 *Knowledge Base* where issues and concerns are posted, along with our ideas, advice and suggestions. We also recommend the bulletin board at *www.warmglass.com.* There you'll find a wealth of information as well as a ready group of experienced hot glass artists who are eager to share their knowledge. Still stuck? If the problem is specific to System 96, send us an email at hotglass@system96.com. We'll do everything we can to help.

Annealing

Simple Advice for Thorough Annealing

Different colors have different "ideal" annealing temperatures. Generally, opals tend to anneal best several degrees lower than transparents, and hot colors (reds & oranges) are best annealed lower than opals. Most all of System 96 glasses have ideal annealing temperatures between 965°F (518C) and 940°F (504C).

Annealing will still occur if you hold 20-30° above or below the ideal temperature; it just takes more time. The further away you are from the "ideal" temperature, the longer it takes to get a good anneal. If you hold at a temperature which is *too far* away from the ideal anneal temperature (say, 40° or more) you may never sufficiently relieve the internal stresses. It is also important to ramp slowly down from the anneal point to the strain point. If the temperature throughout the project is not very similar, it is possible to create permanent stress.

To assure a good anneal, we recommend holding at 955°F (540C), then slowly ramp down (around 150° per hour) to 800°F (513C) Holding time and ramp speed depend on how big and thick your project is. Refer to Firing Schedules for guidelines.

Fusing (Celcius) Project size: 30 cm

Segment	Thickness (mm)	Rate (° C per Hour)	Temp ° C	Hold (minutes)	Step Time (minutes)	Elapsed Time (hours)
1. Heating I:	3	315	540	0	75	1.2
	6	200			120	1.9
	9	150			180	3.0
2. Heating II:	3	1100	800	Desired Effect	25	1.6
	6					2.3
	9					3.4
3. Cool to Anneal:	3	As fast as possible	540	5	15	1.9
	6			8	20	2.7
	9			10	25	3.8
4. Anneal I:	3	315	513	10	20	2.3
	6	150		20	35	3.3
	9	90		40	55	4.8
5. Anneal II:	3	200	430	0	20	2.6
	6	90			50	4.1
	9	65			60	5.8
6. Cool Down:	3	425	45	0	60	3.6
	6	200			120	6.1
	9	150			170	8.7

Slumping (Celcius) Project size: 30 cm

Segment	Thickness (mm)	Rate (° C per Hour)	Temp ° C	Hold (minutes)	Step Time (minutes)	Elapsed Time (hours)
1. Heating I:	3	315	540	0	75	1.2
	6	200			120	1.9
	9	150			180	3.0
2. Heating II:	3	650	665	Desired Effect	15	1.5
	6					2.2
	9					3.3
3. Cool to Anneal:	3	As fast as possible	540	5	15	1.8
	6			8	20	2.5
	9			10	25	3.7
4. Anneal I:	3	315	513	10	20	2.1
	6	150		20	35	3.1
	9	90		40	55	4.6
5. Anneal II:	3	200	430	0	20	2.5
	6	90			50	4.0
	9	65			60	5.6
6. Cool Down:	3	425	45	0	60	3.5
	6	200			120	6.0
	9	150			170	8.5

Forming Stage Diagrams (2 layers of glass in cross section)			
			
Tack Fuse	**Relief Fuse**	**Contour Fuse**	**Full Fuse**

Forming Stages information is intended to help users understand how System 96 products behave under given conditions. These are not firing instructions; they are test results. The descriptions of each stage are explained in the "Definitions" chart. Tests were performed using a kiln with top (infinite control set to High) and side (infinite control set to Medium) elements. Your results will vary based on the characteristics of your equipment.

Forming Stages ° F (° C)	**Opals**	**Cathedrals**				**Uroboros**	
Behavior	**200SF** white	**100SFS** clear	**142SF** purple	**523-8SF** teal	**151SF** red	**60-00-96FIR** clear irid	**60-56-96FIR** black irid
Starts Moving	1020 (549)	1055 (569)	1050 (566)	1050 (566)	1020 (549)	1080 (582)	1020 (549)
Just Before Tack	1180 (638)	1180 (638)	1180 (638)	1180 (638)	1180 (638)	1180 (638)	1180 (638)
Tack Fuse	1220 (660)	1220 (660)	1220 (660)	1220 (660)	1220 (660)	1220 (660)	1220 (660)
Slump 12-inch span	1275 (691)	1285 (696)	1275 (691)	1275 (691)	1265 (685)	1275 (691)	1260 (682)
Relief Fuse	1400 (760)	1400 (760)	1400 (760)	1400 (760)	1400 (760)	1400 (760)	1400 (760)
Contour Fuse	1440 (782)	1440 (782)	1440 (782)	1440 (782)	1440 (782)	1440 (782)	1440 (782)
Fire Polish	1470 (799)	1470 (799)	1460 (793)	1460 (793)	1460 (793)	N/A	N/A
Full Fuse	1470 (799)	1470 (799)	1470 (799)	1470 (799)	1470 (799)	1470 (799)	1470 (799)
Combing	1660 (904)	1660 (904)	1660 (904)	1660 (904)	1660 (904)	1660 (904)	1660 (904)

Forming Stages	**Definitions**
Starts Moving	Temperature at which a 1-inch strip spanning 12-inches begins to slump.
Just Before Tack	Maximum temperature at which a 1-inch piece can still be moved on top of 100SFS
Tack Fuse	Temperature at which a 1-inch square bonds to a 100SFS base. (Edges are still sharp.)
Slump 12-inch Span	Temperature at which a 1-inch strip spanning 12-inches slumps 3 inches in the middle.
Relief Fuse	Temperature at which a 1-inch square bonds to a 100SFS base. (Top edges are rounded.)
Contour Fuse	Temperature at which a 1-inch square bonds to a 100SFS base. (Edges are rounded to the base glass.)
Fire Polish	Temperature at which a sandblasted 2-inch square fully recovers a fire polished, liquid-smooth surface.
Full Fuse	Temperature at which four 1-inch squares on a 2-inch 100SFS base fuse to a liquid-smooth top surface.
Combing	Recommended temperature for a 3/8-inch thick combing.

The Partnership

System 96 is a family of products made by different companies and tested to an identical standard. Spectrum Glass Company and Uroboros Glass Studios are the primary partners. Coatings by Sandberg (CBS) is the licensed manufacturer of System 96 Dichroic glass products. System 96 products undergo 3 rigorous test firings before receiving their "Tested" label. Each firing result is measured for color-shift, opacification, devitrification and C.O.E. change. The red System 96 triangle logo is your assurance that a glass has been "Tested Compatible" within the System 96 family.