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Kiln Glass

Firing Suggestions

Enjoy this firing e-book provided by Petra Kaiser and good luck with writing your own firing schedules from now on. If you have any questions please contact Petra@kaiserlee.com or text me at 239.540.1137.

One Size Fits All - Firing Schedule!

Wouldn't That Be Nice!

That's only going to happen when all your glass pieces have the same size, shape and color. Never have firing schedules been so slow and hold times so long and when I ask people why, the typical answer is, somebody gave it to me and it works. After several incidents where people reported white glass cracking after firing I decided to talk to you about firing schedules and their consequences. First I tested the glass in question to see if there is any stress between the white and the clear. And each test so far has shown absolutely no stress. Then I tried to copy the piece and see if it would crack. But so far so good - I could not get the glass to crack.

I suspected the difference in firing would be the issue and so I went back to books on glass fusing including my own, wondering if I could find a scientific explanation for all my theories when studying those schedules. After several days of research I think I found the scientific explanations I was looking for. The results from my research are explained on the following pages.

Sample of a Full fuse schedule that resulted in a stress related crack after firing. "in °F and (°C)"	**Suggestions which will be explained further on the following pages.**
300 (148) per hour to 450 (232) and hold :20,	Omit
300 (148) per hour to 1000 (537) and hold :20,	Here you can go faster in a first fuse firing
500 (260) per hour to 1150 (621) and hold :30,	Omit
500 (260) per hour to 1450 (787) and hold :15,	COE 96 glass full fuses around 1420 °F (148)
afap to 980 (526) and hold :120,	Wrong - reason for crack
100 (37) per hour to 950 (510) and hold :120,	Too slow and Too long - reason for crack
50 (10) per hour to 750 (398) and hold :1,	100 (37) per hour to 700 (371)

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Glass Firing Suggestions

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	Segment or Step	Rate (DPH)* (Speed)	Process Temperature (Destination)	Soak or Hold in Minutes	Reasoning Do not ask **HOW,** ask **WHY** and bypass generic firing Schedules!
1	**Initial Heat Cycle**	600°F 222°C	1000°F 538°C	:10	Be efficient and heat uniformly to avoid thermal shock
2	**Pre Rapid Heat**	AFAP***	1210°F 651°C	:15	You can skip this segment if you do not have any **Bubble or Mold** concerns
3	**Rapid Heat to Process Temp.**	AFAP***	1410°F ** 765°C **	:12	Going up fast will avoid devitrification and increases efficiency. Choose the right Process Temperature and soak time and avoid over firing
4	**Rapid Cool to Anneal Soak**	AFAP***	900°F 482°C	:45	Equalize the temperature in the mass of glass and mold. Adjust hold time for size and thickness of glass.
5	**Anneal Cool**	100°F 38°C	700°F 371°C	:1	The actual annealing is happening by cooling slowly through this annealing range.
6	**Final Cool Down**		90°F 32°C		Leave the kiln closed to avoid thermal shock.

*** DPH** = degrees per hour **** Process temperature** - please adjust to your kiln and to your desired effect.

*****AFAP** = as fast as possible - See if your digital controller has a “full” setting right after 0000

When you fire glass you bring it from a rigid stage to a somewhat liquid stage. The temperatures can vary in glass types and colors and when we also take into consideration that the thermometer reads the kiln temperature and not the glass temperature it is common practice to work within a range of those points. The glass temperature going up is usually 50°F (10°C) lower and coming down 50°F (10°C) higher than the reading of your controller.

During these stages several things happen …

Softening Point: 1000° F to 1150°F (537° C to 621°C). No more thermal shock

Process Temperatures: These are only starting points. Please adjust the process temperatures to your liking and keep firing notes. **Tack Fuse:** 1300°F (704°C) **Fuse:** 1410°F (765°C) **Drape Over:** 1180°F (637°C) **Slump:** 1280°F (693°C) **Cast:** 1440°F (782°C) **Combing:** 1600°F (871°C)

There is a relation between hold time and temperature. You can full fuse glass by holding it for several hours at 1250°F (676°C). So holding it at any stage for an extended amount of time can change the desired results and are unnecessary and inefficient.

Annealing Point: Is anywhere between the softening point and Strain Point. Ted Sawyer concluded after an array of testing that it is much more efficient to move the annealing point closer to the Strain Point. It could actually be counter productive to hold glass for an extended time at higher temperatures. This is why we follow his suggestion and will change the annealing temperature to 900°F (482°C).

Strain Point: Corning assumes that for most glass types the range of strain points is around 840°F (450°C). Once you are passed the strain point the glass will not anneal any more. But you still have to be cautious about thermal shock. So leave the kiln closed to room temperature.

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1	**Initial Heat Cycle**	600°F 222°C	1000°F 538°C	:10	Be efficient and heat uniformly to avoid thermal shock

In an initial **first fuse firing**, where all the glass starts out with layers of 3 mm glass, you can go up between 900°F (482°C) and 600°F (222°C) per hour. The speed depends also on the size of glass. Anything under 12” (30 cm) can be easily heated at the rate of 900°F (482°C) and bigger than 12” (30 cm) you can slow it down to 600°F (222°C) per hour.

Let’s assume you have already fused a blank and now want to **fuse it again**, or **kiln form** it on a mold, you should slow down the initial heat cycle - and depending on size of the piece you can go up 450°F (232°C) and 300°F (148°C) per hour. Re-firing a cast glass piece of 3/4” (2 cm) thickness I do not go slower than 200°F (93°C).

Holding it for 10 minutes at 1000°F (538°C) is sufficient to avoid thermal shock before you advance to the Pre Rapid Heat.

2	**Pre Rapid Heat Soak**	AFAP***	1210°F 651°C	:15	Optional. No more worries about thermo shock, just equalize temperatures and minimize bubbles.
3	**Rapid Heat to Process Temp.**	AFAP***	1410°F ** 765°C **	:12	Going up fast will avoid devitrification and increases efficiency. Choose the right Process Temperature and Avoid overfiring

In this part of the firing you decide about your final result and adjust the Time and Temperature for the process like: tack fuse, full fuse, slump drape, casting, combing …. Lower temperatures and longer hold times usually will give you better results. Avoid over firing and undesired results, like kiln wash sticking to glass and shifts in color and transparency, bursting bubbles and even shifts in compatibility.

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4	**Rapid Cool to Anneal Soak**	AFAP***	900°F 482°C	:45	Rapidly go through the devitrification zone. Equalize internal glass temperature before going through the annealing zone.

During the anneal soak we have to equalize the glass to the point where top middle and bottom have no more than 10°F (5°C) difference in temperature. This is the minimum requirement, before the glass keeps cooling through the Strain Point.

5	**Anneal Cool**	100°F 38°C	700°F 371°C	:1	Once you are passed the strain point the glass will not anneal any more.

The actual range for the strain point in glass is between 800°F and 880°F. Taking the glass slowly through 700°F is playing it safe.

6	**Final Cool Down**	Natural Rate	90°F 32°C		Leave the kiln closed to avoid thermal shock.

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Date: ______________________________

Project: ______________________________

Material: ______________________________

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Cost: ____________ Work Time: _________

Notes: ____________________________________

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Drawing/Picture

Process: ___________________________________

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Date: ____________________________

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Drawing/Picture

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