Fusing and Slumping with COE 96 Kiln Glass

Fusing and slumping are the foundations of kilnformed glass. Creating fused and slumped glass plates, bowls, and trays is always a fun and exciting project. Learning how to fire glass in your kiln is essential to the success of your projects, but there is no one-size-fits-all firing schedule. This brochure will discuss our recommended firing schedules for glass fusing and slumping a 6mm plate using Wissmach Glass. It will also explain the segments of the firing schedule and why each is so important to the success of your project. These firing schedules are a guideline based on firing in a Paragon GL24 kiln and may need adjusting for other kiln styles. Let's get started.

Here is our recommended full fuse firing schedule to create a 6mm project using two 3mm layers of Wissmach Glass. The firing schedule lists temperatures in Fahrenheit and Celsius.

Segments	Rate	Temperature	Hold
(1-2) Initial Heat to Pre-Rapid Heat Soak (Bubble Soak)	400 ˚F	1225 ˚F	:30
(3-4) Rapid Heat to Process Soak	600 ˚F	1460 ˚F	:10
(5-6) Rapid Cool to Anneal	As Fast As Possible	960 ˚F	1:00
(7) Anneal Cool	100 ˚F	700 ˚F	:01
(8) Cool to Room Temperature	As Fast As Possible	70 ˚F	:00

Let's dissect this firing schedule into steps to understand better what is happening and why.

Segment 1) Initial Heat

The initial heat brings the glass from room temperature to the first hold in your firing schedule. The initial ramp to heat individual 3 mm layers of sheet glass can be aggressive, but you do not want to be overly aggressive and thermal shock your glass. We recommend an initial heat of 400 per hour to 1225 degrees. If heating glass thicker than 3mm, your initial heat should slow down. For example, we recommend an initial heat ramp of 300 degrees per hour for a 6mm thick piece of glass.

Segment 2) Pre-Rapid Heat Soak, or Bubble Soak

The initial heat ramp brings us to our first soak segment in our firing schedule. The first soak is the pre-rapid heat soak (or bubble soak) held for 30 minutes. This soak does two things to help our glass fusing project be successful. First, it allows all of the glass in the project to reach a safe temperature above the thermal shock zone. Thermal shock can happen anywhere up to 1000 degrees.

Second, the glass at this stage begins to lose its brittleness and behaves more like a stiff liquid. When this happens, the layers of glass begin to make better contact with each other. This contact pushes the air out from between both layers and helps to reduce the number and size of bubbles in your finished piece. The reduction of air is why we refer to this hold segment as a bubble soak. The object size can affect the bubble soak hold time. Add more hold time for larger objects.

Segment 3) Rapid Heat

Now that the glass is heated evenly, safely out of the thermal shock zone, and free of air between the layers, it is time for the rapid heat segment. Since we are clear of the thermal shock zone, we can heat our glass more aggressively than during the initial heat. We do this to help prevent the formation of devitrification on the surface of the glass. Devitrification can occur anywhere from approximately 1300 degrees up. When the glass fires hotter and faster during the rapid heat segment, it speeds it through the devitrification zone. We recommend firing your glass at 600 degrees per hour in this segment to reduce the chance of devitrification. The rapid heat segment takes the project to the process soak segment.

Segment 4) The Process Soak

Simply put, the process soak is the peak of the firing schedule pyramid. It is the hottest temperature the glass will experience. It is also the reason for the firing. In the case of a full fuse firing, we recommend a process soak temperature of 1460 degrees Fahrenheit. Since our process soak temperature is well within the devitrification zone, we must limit the time we spend at this temperature to only what is essential in completing our full fuse. We recommend a 10-15 minute hold at 1460 to full fuse a project.

Segment 5) Rapid Cool

Once the process soak is complete, the glass must pass back through the devitrification zone as quickly as possible as it begins cooling down. The rapid-cool segment cools as fast as the kiln allows. Our schedule above reads as fast as possible. This fast rate will help ensure the glass does not get devitrification cooling down to its anneal soak.

Segment 6) Anneal Soak

The anneal soak allows the glass to reach an even temperature before it begins its final cool down. It is just as essential for a glass object to cool down evenly as it is to heat evenly. Before the final cool-down can begin, the glass must be at, or close to, the same temperature. There cannot be more than a 10 degrees difference in temperature between the top middle of the glass, the edges, or the interior center. If a difference of more than 10 degrees occurs, the glass can experience annealing strain and crack. We recommend an annealing soak hold time of 1 hour at 960 degrees Fahrenheit for a finished object that is 6mm in thickness. Hold time must increase if annealing thicker objects or objects not of uniform thickness.

Segment 7) Anneal Cool

Once the anneal soak is complete, the glass can begin the anneal cool segment. The anneal cool segment takes the glass object from 960 degrees through the anneal strain zone. The glass must cool extremely slowly during this segment to reduce the chance of cracking. We recommend a cool-down ramp of 100 degrees per hour to 700 degrees. Thicker projects, or projects not uniform in thickness, must be cooled down even slower.

Segment 8) Cool To Room Temperature

After the glass safely cools through the annealing strain zone, it can be left in the kiln to cool to room temperature. The most important part about this segment is not to give in to temptation and peek before the glass has cooled down. If the glass object is too hot to touch with your hands, it is still in danger of cracking if removed from the kiln. We recommend allowing the glass object to cool to room temperature before opening the kiln and removing the piece.

Now you have a beautiful finished fused glass object created using Wissmach Glass! Next, let us dive into a standard slumping schedule.

There is no one-size-fits-all slumping schedule usable for every mold. Molds with a flat bottom generally require more heat and hold time than a gently curved sushi plate mold. Typically slumping temperatures range from 1180 -1250 degrees Fahrenheit. Be aware it is possible to over-slump your glass using too hot a temperature. Signs that you have done so can be seen on the bottom of your glass object. If you notice that the glass has seeped into the air holes of the ceramic mold, you have slumped your glass at too hot a temperature. Clogged air holes can also cause air bubbles between the mold and the glass, which may result in the formation of a dome in the center of the object. Below is a firing schedule for a standard slump using a square sushi plate mold.

Segments	Rate	Temperature	Hold
(1-2) Initial Heat to Process Soak	300 ˚F	1200 ˚F	:10
(3-4) Rapid Cool to Anneal	As Fast As Possible	960 ˚F	1:00
(5) Anneal Cool	100 ˚F	700 ˚F	:01
(6) Cool to Room Temperature	As Fast As Possible	70 ˚F	:00

As you can see, there are differences between this slumping schedule and the previous full fuse schedule. There are also some similarities.

Segment 1) Initial Heat

The first difference is in the initial heating segment. Notice that the initial ramp temperature drops from 400˚ to 300˚. This slumping schedule is for a 6mm thick fused glass object created using the full fuse firing schedule above. Since the object is 6mm thick, the initial heat must be slowed from 400˚ per hour to 300˚ per hour to reduce the risk of thermal shock.

Segment 2) Process Soak

The next difference between the slumping and full fuse schedule is the lack of a bubble soak. Since our glass is already fused together, no air will trap between layers. Instead of a bubble soak, the initial heat segment takes the glass directly to the process soak segment. A simple shape such as a sushi plate does not require a lot of heat or hold time to slump. For this project, a 10-minute hold time at 1200˚ is plenty.

We hope this information is useful and inspires you to get creative with fused and slumped projects using Wissmach Glass.

Happy Kilnforming!

These recommendations were tested and written by Wissmach's Kiln Consultant, Drew Kail.

For more tips and project ideas, visit https://wissmachglass.com/news-blog/