Understanding Ramp Speed

Asking "How fast can I ramp?" is like asking "How fast can I drive?" The correct answer is always, "It depends". How fast to increase and decrease temperature in the kiln is one of the most important decisions in kilnforming glass and is also one of the most misunderstood. The common assumption is that as long as you ramp slowly everything will be fine. Not so. Sometimes ramping slow causes a problem and ramping fast eliminates it.

Three factors determine how fast you should ramp:

1. Glass thickness.
2. Uniformity of thickness.
3. Susceptibility to distortion.

Glass Thickness

This is the easiest to understand. The thicker the glass, the slower the ramp speed. The temperature must increase or decrease slow enough that the surface of the glass is not so much different from the temperature inside the glass that it causes the glass to crack from thermal shock. How slow? Just slow enough to not crack. Slower is not needed. Compare it to driving on the highway. If it's safe to drive at 60 mph there's no reason to drive at 30 mph. Whether driving a car or ramping a kiln firing, instead of traveling needlessly slow, learn what speed is safe and stay at that speed. A safe guideline that has always proven effective for me is:

- 1/8" (3mm) thick ramp 500°F/hr
- 1/4" (6mm) thick ramp 400°F/hr
- 3/8" (9mm) thick ramp 300°F/hr
- 1/2" (12mm) thick ramp 200°F/hr
- 3/4" (18mm) thick ramp 100°F/hr
- 1" (24mm) thick ramp 50°F per hour

Uniformity of Thickness

You might think it's safe to apply a ramp speed that allows for where the glass is thickest but it's not. The greater the difference in thickness in different parts of the glass, the greater the likelihood one part will absorb or shed heat a lot quicker than a part of different thickness. For example, a ¼ inch thick nugget or stack of glass set on top of a ¼ inch base is ½ inch at the thickest point – but it's only ¼ inch thick elsewhere. The thinner part will fully absorb heat while the inside of the thicker parts are still much cooler. This temperature difference can, and frequently will, cause thermal shock. My guideline for calculating ramp speed for projects with thickness differences is to add the measure of the thin part to the measure of the thick part and use the combined total measure to calculate ramp speed. Thus, a project with ¼ inch thick nuggets on a ¼ inch thick base would be measured as ¾ inch thick (¼ inch thinnest + ½ inch thickest) and ramp at no more than 100°F per hour – safer closer to 50°F per hour

The tack fuse firing of this project with pre-fused ¼" thick nuggets made from pieces of a broken up screen melt on a ¼" thick base was at 150°F per hour. Even at that low ramp speed, the kiln heat failed to transfer evenly through the glass and it cracked on the ramp up

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Both the fuse and the slump and drape firings of this tray made with pre-made full fused ¼" thick nuggets and strips of glass rod on a ¼" base were ramped at 75°F to allow even heat transfer through the glass. This was ½ inch thick at thickest point and ¼" at thinnest. If it had been a uniform ½ inch it could safely have ramped at 200°F. Uneven thickness required a much slower ramp speed.

Susceptibility to Distortion

We all understand that glass wants to be ¼ inch thick and when heated to full melt temperature will migrate to become that thick. Thicker glass will spread out and thinner glass will either draw in or create craters. This effect can be significantly minimized by increasing ramp speed above 1000°F. The glass will still migrate, but not nearly as much as it would if heated at a slower ramp speed.

Thermal Shock Safety Zone

Slow ramping to avoid thermal shock cracks is only needed below 1000°F (515°C). Thermal shock cracks will not happen above that. If you ramp slow enough to be safe and hold the temperature to soak the heat into the glass at 1000°F, you can ramp at much higher speed right up to top performance temperature. Some undesirable effects can be eliminated and some desirable effects created by ramping fast above 1000°F.

Bubble Squeeze

Bubble formation between the glass and the kiln shelf or between layers of glass is a serious problem. The likelihood of bubbles forming can be reduced by introducing a very slow ramp above 1000°F to slowly squeeze out any air that might cause bubbles to form. This is usually done by introducing a slow ramp of about 200°F per hour from 1000°F up to 1200°F slump temperature.

Fire Polish

There are times when you want to fire the glass just enough to polish the surface but not enough to change anything else. The problem is glass won't fire polish until 1300°F and that's hot enough to cause it to sag or distort. This is where the "always ramp slow" is the wrong advice. You want to do the exact opposite. After holding the glass at 1000°F to ensure it is the same temperature throughout, ramp at 1200°F up to 1300°F and hold for only 3 or 4 minutes before ramping as fast as possible down to anneal temperature. That ramp speed is too fast, and the hold is too short for the glass to have a chance to sag or distort. I call this the "Commando Raid" ramp system. Run in fast. Do the job. Run out fast.

This turbo speed ramp system is perfect when you want to fire polish a cast piece without causing it to sag or when you want to fire a combined slump and fire polish in the same firing. A typical high speed firing to fire polish a casting or finish an edge might be:

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Segment 1, 400°F/hr to 1000 hold 20 minutes
Segment 2, 1200 °F/hr to 1300°F hold 4 minutes
Segment 3, 9999 °F/hr to 960°F hold 1 hour
Segment 4, 400°F/hr to 300°F hold 0

A typical firing combining slumping and fire polish might be:

Segment 1, 400°F/hr to 1000°F hold 20 minutes
Segment 2, 900°F/hr to 1200°F hold 20 minutes
Segment 3, 1200 °F/hr to 1300°F hold 4 minutes
Segment 4, 9999 °F/hr to 960°F hold 1 hour
Segment 5, 400°F/hr to 300°F hold 0

Although different temperatures are needed to produce similar finished results on different COE, the same ramp speeds apply for all COE glass. I have always used identical ramp speeds for COE 86 float, COE 90, and COE 96 glass.

Thick glass slump or drape

Glass is never a perfectly uniform consistency and can't be relied on to soften uniformly. If you slump or drape glass thicker than ¼ inch, you risk having it not sag uniformly. The thicker the glass, the greater the risk. Using the same high speed ramp as for a fire polish will increase the likelihood your project will drop without distorting

Fusing and slumping glass is like cooking food. There is no universal guide for how fast or how long to cook. It will always depend on what you're cooking and how well you want it cooked.