



Glass Fusing Explained

What is fusing?

When you heat glass it begins to soften. You can heat it enough to be soft enough to bend into or over a mold or heat it more to bond pieces of glass together. Fused glass is not glued. It has bonded permanently at the molecular level.

Glass is a liquid

It has the same molecular structure as water. You see glass as a solid because it is solid at room temperature. The 3 stages of a material are gas, liquid and solid. All materials will change stages with temperature change. At room temperature oxygen is a gas but when cooled will become a liquid and when cooled more will become a solid. Water is a liquid but when heated will turn to steam as a gas and when cooled will become ice as a solid. You can turn glass into liquid by heating it to over 1400°C (2600°F). You can turn it into a gas by boiling it at 2950°C (5340°F) to make it a gas.

Just enough to soften

Glass will change from solid to liquid but not quickly. It changes slowly to different degrees of softness at different temperatures. By controlling the temperature you heat glass to, you can make it slightly soft, moderately soft or completely soft.

Key Temperatures

Some important temperatures used to make glass art.

1200°F (650°C)	Drape – glass softens enough to bend over a mold.
1250°F (675°C)	Slump – glass softens enough to bend into a mold.
1300°F (705°C)	Fire Polish – glass melts enough to produce a surface polish.
1350°F (732°C)	Tack Fuse – pieces of glass will permanently fuse together.
1450°F (788°C)	Full Fuse – pieces of glass will fuse and melt to a single level.

Heatwork

Heatwork is the term used to describe the combination of time and temperature that makes glass soften. Higher temperature causes it to soften more and the longer it's held at a high temperature the more it softens.

6 mm Rule

The viscosity of glass is such that when heated to full fuse temperature it will move to become 6 mm thick. If layers are stacked higher than 6 mm, it will melt down and spread out. It's like what happens when you pour out pancake batter onto a griddle. If you pour out more batter, it will not get thicker but will spread out to get bigger. That's what happens to glass when it's heated. If it is less than 6 mm thick it will draw in to become thicker. The only way to prevent glass from moving to become 6 mm thick is to not heat it above tack fuse temperature.



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Compatibility

Glass will not fuse to other glass unless it is compatible to that other glass. Glass artists refer to COE (coefficient of expansion) to describe how different glass expands when it's heated. Compatibility is determined by both COE and viscosity. Viscosity is how liquid the glass becomes when heated. Unless two different pieces of glass are similar COE and have similar viscosity, they will not fuse together. Glass used by glass artists has been specially factory made to be compatible.

Shaping.

Glass can be shaped by heating it enough to soften and copy the shape of a mold it drops into or over. When heated to 1200F (650C) glass is as soft as cooked pasta. When glass is heated to drop into a mold, it's called slumping. When it's heated to bend over a mold, it's called draping.

Multiple kiln firings.

Most glass art projects are done with multiple firings with each firing at a different temperature. A glass tray or bowl would be produced by first fusing in a kiln at fusing temperature then returned to the kiln to be slumped into a mold at lower temperature.