Application and Firing

Glass powders are applied to the substrates and parts in a variety of techniques, e.g. Screen Printing, Doctor Blading, Electrophoresis, Spin-Coating, Pre-forming etc. This typically involves the mixing of the glass powder in a liquid vehicle to form a slurry.

The vehicle you use to apply the glass is typically composed of a binder, which promotes substrate adhesion and film green strength, and a solvent. The higher the resin content of the vehicle, the greater the green strength and the higher the viscosity of the vehicle; and subsequently, the viscosity of the glass slurry. Resins should be selected to allow decomposition, or "burn-out", below the glass T_g.

Each of the techniques indicated above have optimum slurry viscosities dictated by the equipment you are using and the glass application characteristics you are attempting to achieve. Glass slurry viscosity is controlled by the ratio of the glass powder to the vehicle ratio and by the particle size distribution of the glass. The finer the glass powder, the higher the slurry viscosity for the same ratio; and also the more difficult to remove.

After applying the slurry, the solvent is removed during a drying stage by heating in air at 125-150°C for 10-20 minutes. The binder is then removed in either a separate binder burn-out stage, which is recommended, or in conjunction with the final firing stage.

The binder decomposition is most efficiently done in air, at a temperature below the T_g of the glass. Insufficient binder burn-out can lead to excessive porosity and possible reduction of any reducible heavy metal components, such as PbO, present in the glass. The time and temperature required is dependent upon the binder selected, thickness of the glass layer and the particle size distribution of the glass. A Binder Burn-out Profile, sometimes called a Glazing Profile, can be found in the appendix.

The firing temperatures listed in this brochure should be used as initial guidelines and are for the specific application listed. The appropriate firing temperature and time should be optimized for your specific firing equipment and application to ensure sufficient flow and wetting of the substrate. Most devitrifying glasses require extended firing times to achieve the appropriate level of crystallization. Variations in time and temperature for these types of glasses can significantly change properties, particularly CTE, and performance.

Final firing should typically be done in air or other oxidizing atmospheres. If it is necessary to prevent oxidation of metal parts, a neutral atmosphere, such as nitrogen, is recommended. Reducing atmospheres can cause reduction of heavy metal glass components.

Heating rates are generally determined by part size, configuration and thermal conductivity, and should assure that the substrate/parts and the glass are in equilibrium. Devitrifying glasses are particularly sensitive to heating rates.

Cooling rates are similar to heating rates, except within the "annealing range" of the glass. The fired unit should be cooled as slow as possible from the Annealing Point (T_a) to the Strain Point (T_{st}), or T_g ±25°C. Rates should be less than 5°C/min or less than 3°C/min for large parts or where CTE mismatch between glass and substrate are present. Typical firing profiles can be found in the appendix.