CONTAINER GLASS ENAMEL DECORATION SYSTEMS

Ferro Systems

Ferro's container glass products are formulated to meet the needs of our customers from all market segments

▪ Lead-Free Systems

	Market Segment	Ferro System	Firing Temp. (°C)
Page 9	Multi-trip bottles	VNR Plus	640-650
Page 10	Single-trip bottles	VNG 100	580-610
Page 11	Cosmetic & perfume bottles	VN	580-600
Page 12	Tumblers & tableware	NPR	630-650
Page 13	Borosilicate glass	VPS	630-640

▪ Lead-Containing Systems

	Market Segment	Ferro System	Firing Temp. (°C)
Page 14	Multi-trip bottles	VR	600-630
Page 15	Semi-resistant cosmetic bottles	VS	580-600
Page 17	Low firing cosmetic bottles	30	540-580
Page 18	Borosilicate glass	PR	620-640

Heavy Metal and Lithium Guarantees

Our heavy metal-free systems are provided with the following guarantees, in compliance with Packaging Directive EU/94/62/EC:

	Pb	Pb+Cd*	Li
VNR Plus multi-trip bottles**	< 100 ppm	< 100 ppm	< 30 ppm
VNG 100 single-trip bottles	< 100 ppm	< 100 ppm	< 30 ppm
VN cosmetic and perfume bottles	< 100 ppm	< 100 ppm	
NPR tumbler & tableware	< 100 ppm	< 100 ppm	
VPS borosilicate glass	< 300 ppm	< 300 ppm	

* for those containing cadmium-free pigments

** Exceptions are the cobalt blue products (VNR 2403, VN 2301 and enamels containing even partially these two cobalt blues), which have a guaranteed Pb + Cd content of maximum 300 ppm.

Chrome VI and Mercury are not used in the manufacture of our heavy metal-free glass enamels

Heavy Metal Content in Packaging

Latest legislation requires decorators to declare the content of heavy metals in their decorated articles.

To support you, based on the weight of the glass and the enamel deposited on the article, we can calculate the quantity of heavy metals and relate that to the total weight of the packaging, according to EU Packaging Directive 94/62/CE.

SYSTEM TEST SPECIFICATIONS

1. Thermal Expansion Coefficient

Values quoted are measured between 50 – 300 ^{o}C (ramped at 4 ^{o}C.min^{-1}), on the basic fluxes used in the systems concerned and they are indicative values.

2. Firing Temperature

The optimal range shown is based on laboratory control tests, established during conception of each system.
Under industrial conditions, the actual firing cycle can be influenced by factors such as the type of kiln, the ware loading, the thickness and weight of the decorated articles.
We recommend setting the fire cycle with our systems on site, and our technicians will provide a full support to help achieve the optimal conditions.

3. Chemical Durability

There are many tests available to judge the chemical resistance of glass enamels. The test results will depend, not only on the chemical formulation of the enamel, but also on the nature of the article, the layer thickness of the enamel and the firing cycle used.
Also for dishwasher resistance testing, the final results are influenced by the article, machine set-up, and the detergent type.
To try to overcome these testing variations, Ferro has created its own control tests to evaluate chemical resistance, with a visual testing scale to compare one system with another.

- **Acid resistance** test method QKB-9047 – 10 % citric acid, 15 min at room temperature.
- **Alkali resistance** test method QKB-9045 – 10 % NaOH, 4 h at 88 ^{o}C.

The visual testing scale is as follows:
(1) No attack
(2) Iridescence or visible stain on the exposed surface when viewed at a 45° angle but not apparent at angles < 30°.
(3) Definite staining which does not blur reflected images and is visible at angles < 30°.
(4) Definite stain with gross color change or strongly irridescent surface visible at angles < 30° and which may blur reflected images
(5) Surface dull or matt with chalking possible
(6) Significant removal of enamel with pinholing evident
(7) Complete removal of enamel in the exposed area

Additionally, we control our products according to the following market-specific International test methods:
- **EN 1388-2** – designed specifically for the glass tableware market
  Measurement of Cd & Pb released by exposure to 4 % acetic acid at 22 ^{o}C for 24 h, to simulate the effect of exposure to food contact.
- **ASTM C777-84** – for the glass packaging market
  Measurement of attack of the glass enamel by H_2S, to simulate the effects of exposure to sulphur attack, either from the atmosphere or certain types of corrugated packaging.

METHODS OF USE & RECOMMENDATIONS

Glass enamels are ground mixtures of fluxes - formulated according to the fusibility and expansion of the glass substrate to be decorated - and inorganic pigments, which produce a wide range of shades after firing.
They can be blended with several types of medium system, depending on the final method of application (direct screening, decal, spraying).

Our colors from all systems are usually provided in the following forms:

- Powder form
- Water-friendly pastes for conventional and electrostatic spraying
- Oil-based liquid pastes for cold screen-printing
- Thermoplastic pastes for multi-color hot screen-printing
- Wet spray

Mediums suitable for all applications can also be provided separately (see separate medium section).

1. Storage and Shelf Life

Powders, medium and color paste systems should be stored in dry conditions and at temperatures not below 5°C (40°F) nor above 35 °C (95 °F).
Partly used tins must be tightly sealed after use. Pastes must be stirred thoroughly before printing.
If stored as recommended, the products are guaranteed with a minimum shelf life from production date of :

- 6 month for the liquid paste.
- 2 years for the thermoplastic pastes
- unlimited for the powders.

2. Recommendations for converting powders to pastes

2.1. Cold Screen printing

The ratio powder/medium can be provided from our technical support technicians. The mixing should be performed using a mixer, then by processing the paste through a triple-roll mill.

2.2. Spraying

Use the same process as in 2.1., then add 40 to 60 parts water to adjust the viscosity for final application. We recommend a spray viscosity of 25-30 s at 23°C, as measured with a No.4 (4mm) Ford flow Cup.
Typically, spray guns with a 1mm nozzle are used, with spray pressures set at 2.5 to 5 bars (35 - 75 psi).
We recommend stirring the spray paste in the tank to avoid sedimentation or settling.

2.3. Banding/Lining

Use the same process as in 2.1., except that the final viscosity should be adjusted with 25-30 % of our recommended medium, after roll milling. Test with a 6 mm flow cup to reach a viscosity of 25-30 s at 23°C.

2.4. Brushing

Typically, the powder is mixed with an oil-based medium and thinned with turpentine.

3. Recommendations for Screen Printing

3.1. Cold Screen-printing

Our pastes can be supplied ready-to-use, although more typically our customers prefer to thin to a suitable printing viscosity on site. Printing viscosities in the range 18-23 Pa.s (180-230 P) at 23°C are recommended.
Nylon or polyester screens – 120 to 300 meshes per inch (opening of 48-120 µm), may be used.
Squeegees should be made of hard rubber and sanded enough to avoid printing streaks.
Screens can be cleaned with a suitable solvent, generally ethanol, following the usual safety precautions.

3.2. Hot screen-printing (TP)

Thermoplastic glass enamels, which are solid at room temperature, need heat applied to become printable. The molten enamel is screen-printed through a heated metal screen, which can be heated either electrically or with IR-lamps.
Their main advantage is that each print-layer 'freezes' as it hits the colder glass, and therefore no drying is required between each successive print. This makes thermoplastics ideal for automatic multi-color printing machines.

Pre-melting
TP inks perform best when pre-melted in temperature-controlled melting pots. We recommend melting at 65-75°C (150-165 °F). Avoid overheating, signified by smoke emission, as this may change the properties and printing behavior of the ink.

Screens
We recommend stainless steel screens, with mesh size 150-300 meshes per inch (screen opening of 60-120 µm), dependant on the type of print.
For lead-free thermoplastic glass enamels, coarser mesh sizes are recommended, compared to those typically used with lead-containing enamels. This ensures good deposit weight and optimum brightness of the fired glasses.
Heated screens should be maintained at 70 - 90°C (160-195 °F) and overheating (emission of smoke) should be avoided.

Coverage
Around 1g of thermoplastic glass enamel will print a surface area of 100 cm^2.

4. Drying Recommendations

For oil-based pastes or wet spraying applications, the decoration must be dried prior to firing, if the ware is to be handled or is to be over-printed, or if the temperature at the kiln entrance exceeds 100° C (212 °F).
Decorated ware can be dried either at room temperature or in a drier. Alternatively, a hot-air draft over the decorated ware will speed up the drying process.
Tunnel-type driers can be used and are usually powered by gas or electricity. An adequate flow of air in the tunnel must be maintained to assist evacuation of the fumes via the chimney.
The heat input and drier length should be designed such that the decorated ware is at approx.40° C (100 °F) at the exit.

5. Thermal decomposition of the medium

During the firing of our glass colours:
- at around 70°C, there is an endothermic reaction, signifying the melting of the medium
- at 180-320°C, we observe an exothermic reaction, which signals the combustion of the major components of the medium, mainly waxes and fatty alcohols.
- at 320-520°C, a small exothermic reaction takes place, corresponding to the burnout of resins.

It is absolutely necessary that all medium components are burned off before the vitrification of the glass enamel powder components. If not, there is a potential to create defects, such as craters, bubbles and pinholes.
Whilst our systems are formulated to minimise such defects, we always recommend to adjust the firing cycle up-to 500°C, but especially between 250-320°C, so that the medium has sufficient time to burn out completely.

6. Firing Recommendations

During the firing cycle, the organic components of the medium are burnt off and the enamel fuses to the glass surface to become a vitrified coating. Because of the presence of hydro-carbon organics in the kiln atmosphere, good ventilation must be maintained to minimise the possibilities of decoration defects.
Typical firing cycle profile:

- room temperature to peak temperature: 20-40 min.
- soak time at peak: 10-20 min.
- cooling zone cycle will be adapted to the type of decorated glass.

This typical cycle can be modified dependant on the glass thickness, to achieve optimal results.
With tempering glass cycles, the duration of the firing is reduced to a few minutes, dependant on the thickness of the glass.

7. Trouble-Shooting Guide

The most commonly noticed defects are:

- bad aspect of Cd-containing reds and yellows

Cadmium pigments are very sensitive to kiln atmosphere. Oxidising atmospheres are necessary for the good color development of cadmium-containing reds and yellows.
In addition, we recommend to manage a good extraction of the combustion gases from the kiln and to leave enough space between the decorated items in the kiln, for an improved air circulation.

- « back-lapping »

This is an irregular deposit on one of the sides of the ACL label, which can occur if the glass enamel is too fluid during printing.
Solution is to decrease the temperature of the heated screen.

- blistering

This is created by the formation of bubbles in the body of, or craters at the surface of the glass enamel. The defect is caused by a bad evacuation of the gases formed from the combustion of the medium (see 5).
There are several solutions:

- improve the extraction in the kiln
- decrease the speed of the kiln belt i.e. throughput
- increase temperature and/or speed of the pre-heat phase of the firing cycle

- crawl

This is where the glass enamel recedes from the glass surface, and is generally caused by oily deposits on the glass before decoration.
Solution is to clean the glass before decoration.

- drip-through

In this defect, the glass enamel drips through the screen
Solution is to decrease the screen temperature, in order to increase slightly the TP ink viscosity.

- tears

This is where the glass enamel runs down the glass to form tears, and is often due to condensation of some of the waxes, onto cold items in the first zones of the kiln. Solutions are:

- improve the kiln extraction, especially in the first zones of the lehr
- increase the temperature in the pre-heat zone more rapidly
- increase the space between the decorated articles to improve the air circulation

MEDIUM SYSTEMS

We offer 3 types of medium:

- Water-friendly mediums – these systems can be diluted with water; equipment can also be cleaned with water
- Oil-based mediums – these products must be let-down with solvent, not water
- Thermoplastic mediums – used for hot screen printing

Recommended Ferro Medium Systems

APPLICATION METHOD	PRODUCT REFERENCE.	MEDIUM TYPE	PROPERTIES
Direct screening	MX 54	Oil-based	Medium drying rate
	80 392	Oil-based	Fast drying rate
	80 674	Oil-based	Thinner
	MX 44.62	Thermoplastic	Mainly for Pb-products
	MX 57	Thermoplastic	Mainly for Pb-frees
	MX 100	Thermoplastic	For VNG 100 series
Indirect screening (decals)	80 820	Oil-based	Low thixotropy
	83 450	Covercoat	EGA-free
Spraying	80 1022	Water-friendly	Medium drying rate
	80 1026	Water-friendly	Long drying rate

Generally the medium used is also used as the thinner.