FERRO

CONTAINER GLASS ENAMEL DECORATION SYSTEMS

Table of Contents

Version 09/10

Version 09/10

CONTAINER GLASS ENAMEL DECORATION 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 meatl-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.

FERRO

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^{o}C (150-165 ^{o}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^{o}C (160-195 ^{o}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^{o} C (212 ^{o}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^{o} C (100 ^{o}F) at the exit.

5. Thermal decomposition of the medium

During the firing of our glass colours:

- at around 70^{o}C, there is an endothermic reaction, signifying the melting of the medium
- at 180-320^{o}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^{o}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^{o}C, but especially between 250-320^{o}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
	MX100	Thermoplastic	For VNG 100 System
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	Slow drying rate

Generally the medium used is also used as the thinner.

FERRO

LEAD-FREE SYSTEMS TECHNICAL DATA

VNR Plus System

Main Market Use

These lead-free enamels are recommended for decoration of soda-lime glass packaging, more particularly **multi-trip bottles**. They are the most durable of the lead-free systems for packaging glass on the market.

Chemical Composition

Colors in this System do not contain voluntary additions of heavy metals – Pb, Cd, Hg and Cr^{6+}.
Exceptions are the cadmium-containing green, yellow, reds and oranges (marked * below) which need to use cadmium pigments, to provide the color tones required by the market.

COLOR	REFERENCE	Pantone	Coca-Cola/Pepsi Cola	REFERENCE	Pantone
GREEN	VNR 1431 *	349	White	VNR 9407	
BLUE	VNR 2414	2985	Coke Red 2000	VNR 7418 *	186
BLUE	VNR 2419	640	Sprite Blue	VNR 2416	293
YELLOW	VNR 3414 *	102	Sprite Yellow	VNR 3417	107
RED	VNR 7424 *	485	Fanta Blue	VNR 2439	661
ORANGE	VNR 7408 *	021c	Fanta Green	VNR 1412	360
BROWN	VNR 6407	490	Pepsi Red	VNR 7452	174
WHITE	VNR 9407		Pepsi Blue	VNR 2417	293
BLACK	VNR 4403		Mountain Dew Red	VNR 7452	174
FLUX	VNR 401		Mountain Dew Green	VNR 1427	380
AcE IMITATION ETCH	VNR 9426		Teem Yellow	VNR 3434	107
			Coke Zero Black	VNR 4403	
			Mirinda Green	VNR 1415	347

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors (marked *) with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)

This system is suitable for most chemical compositions used in the production of soda-lime glass bottles.

Recommended Firing Conditions

From 630°C to 650°C (1165-1200°F) in a cycle of 1 h -1.5 h or more with a soaking period of approx. 10 min, dependant on both the type of furnace and the volume of ware fired. We recommend an oxidising atmosphere to give optimal fired appearance and brightness. It is essential to maintain good ventilation, and an efficient extraction of the combustion gases and the products resulting from decomposition of the medium.

Chemical Resistance

Acid resistance: 4
Alkali resistance: 5

See page 4 for details.

VNG 100 System

Main Market Use

These lead-free enamels are recommended for decoration of soda-lime packaging **single-trip non-returnable bottles**, where chemical durability is not an issue.

Chemical Composition

Colors in this System do not contain voluntary additions of heavy metals – Pb, Cd, Hg and Cr^{6+}.

COLOR	REFERENCE	Pantone
GREEN	VNG 1943	355
BLUE	VNG 2900	293
WHITE	VNG 9920	-
BLACK	VNG 4900	-
FLUX	VNG 900	-
AcE IMITATION ETCH	VNG 903	-
RED	VNG 7953	7622
Yellow	VNG 3951	128
Orange	VNG 7935	159

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)

This system is suitable for most chemical compositions used in the production of soda-lime glass bottles.

Recommended Firing Conditions

From 580°C to 610°C (1075-1130°F) in a cycle of 1 h-1.5 h with a soaking period of approx. 10 min, dependant on both the type of furnace and the volume of ware fired.
We recommend an oxidising atmosphere to give optimal fired appearance and brightness. It is essential to maintain good ventilation, and an efficient extraction of the combustion gases and the products resulting from decomposition of the medium.

Chemical Resistance

Acid resistance: 7
Alkali resistance: 7

See page 4 for details.

VN System

Main Market Use
These lead-free enamels are recommended for decoration of cosmetic and perfume containers.

Chemical Composition
Colors in this System do not contain voluntary additions of heavy metals – Pb, Cd, Hg and Cr^{6+}.
Exceptions are the cadmium-containing green, yellow, reds and oranges (marked * below) which need to use cadmium pigments, to provide the color tones required by the market.

COLOR	REFERENCE	Pantone
TURQUOISE	VN 1301	329
APPLE GREEN	VN 1306	347
GREEN	VN 1313 *	376
COBALT BLUE	VN 2301	2746
BLUE	VN 2305	286
BLUE	VN 2329	2925
YELLOW	VN 3301 *	3955
YELLOW	VN 3326	101
DARK RED	VN 7301 *	187
RED	VN 7300 *	1795
ORANGE	VN 7315 *	152
BROWN	VN 6301	4695
WHITE	VN 9320	
BLACK	VN 4300	
FLUX	VN 821	
AcE IMITATION ETCH	VN 9326	

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors (marked *) with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)
This system is suitable for most chemical compositions used in the production of soda-lime glass bottles.

Recommended Firing Conditions
From 580°C to 600°C (1075-1110°F) in a cycle of 1 h-1.5 h with a soaking period of approx.10 min, dependant on both the type of furnace and the volume of ware fired.
Enamels from this System are sensitive to overfiring.
We recommend an oxidising atmosphere to give optimal faired appearance, gloss and brightness. It is essential to maintain good ventilation, and an efficient extraction of the combustion gases and the products resulting from decomposition of the medium.

Chemical Resistance
Acid resistance: 7
Alkali resistance: 7
See page 4 for details.

NPR System

Main Market Use

These lead-free enamels are intended mainly for the decoration of glass tumblers and tableware.

Chemical Composition

Colors in this System do not contain voluntary additions of heavy metals – Pb, Cd, Hg and Cr^{6+}.
Exceptions are the cadmium-containing green, yellow and reds (marked * below) which need to use cadmium pigments, to provide the color tones required by the market.
NPR System contains lithium and we do not recommend these enamels for the decoration of pressurised containers.

COLOR	REFERENCE	pantone
GREEN	NPR 1820	7714C
GREEN	NPR 1821 *	3425C
BLUE	NPR 2822	301C
BLUE	NPR 2824	293C
BLUE	NPR 2826	7687C
YELLOW	NPR 3820 *	108C
YELLOW	NPR 3822	130C
YELLOW	NPR 3823	114C
RED	NPR 7820 *	485C
RED	NPR 7822 *	202C
WHITE	NPR 9820	
BLACK	NPR 4820	
FLUX	NPR 820	
AcE IMITATION ETCH	NPR 9822	

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors (marked *) with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)

This system is suitable for most chemical compositions used in the production of soda-lime glass tableware.

Recommended Firing Conditions

From 630°C to 650°C (1165-1200°F) in a cycle of 1 h to 1.5 h, with a soaking period of approx. 10 min, dependant on both the type of furnace and volume of ware fired.
We recommend an oxidising atmosphere to give optimal fired appearance, gloss and brightness. It is essential to maintain good ventilation, and an efficient extraction of the combustion gases and the products resulting from decomposition of the medium.

NPR glass enamels are also suitable for tempering cycles; tests are recommended.

Chemical Resistance

Acid resistance: 4
Alkali resistance: 5
See page 4 for details.

VPS System

Main Market Use

These low expansion lead-free enamels are specially designed for decoration of low expansion borosilicate glasses, such as alkali boro-silicate glass.

Chemical Composition

Colors in this System do not contain voluntary additions of heavy metals – Pb, Cd, Hg and Cr^{6+}.
Exceptions are the cadmium-containing yellow, reds and oranges (marked * below) which need to use cadmium pigments, to provide the color tones required by the market.
VPS System contains lithium and we do not recommend these enamels for the decoration of pressurised containers.

COLOR	REFERENCE	Pantone
GREEN	VPS 1100	349
EMERALD GREEN	VPS 1101	322
ROYAL BLUE	VPS 2102	2945
ULTRAMARINE BLUE	VPS 2101	302
YELLOW	VPS 3100 *	102
YELLOW	VPS 3130	128
ORANGE	VPS 7101 *	Orange c
RED	VPS 7100 *	485
DARK RED	VPS 7103 *	201
BROWN	VPS 6100	4705
WHITE	VPS 9102	
BLACK	VPS 4100	
FLUX	VPS 857	

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors (marked *) with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)

Avge C.o.E. measured on the basic frit System is 60 ($\pm$ 4).$10^{-7}K^{-1}$.
The enamels are specially formulated for application onto borosilicate glass and they should be tested for suitability to the expansion of the glass to be decorated. The 'fit' of these enamels is also dependent on application weight and to avoid microcracking or fracture problems, they should not be applied too thickly.

Recommended Firing Conditions

From 630°C to 640°C (1165-1185°F) in a long cycle; from 630°C to 700°C (1165-1290°F) in a short cycle. Enamels from this System are sensitive to overfiring. We recommend an oxidising atmosphere to give optimal fired appearance, gloss and brightness. It is essential to maintain good ventilation, and an efficient extraction of the combustion gases and the products resulting from decomposition of the medium.

Chemical resistance

Acid resistance: 7
Alkali resistance: 7
See page 4 for details.

FERRO

LEAD-CONTAINING SYSTEMS TECHNICAL DATA

VR System

Main Market Use

These enamels are recommended for decoration of soda-lime glass packaging, more particularly single-trip and
multi-trip bottles.
This System can also be used for special applications, such as color-break enamels for pharmaceutical
boro-silicate glass ampoules.

Chemical Composition

Colors in this System contain lead and cadmium. We guarantee a lithium content of maximum 30 ppm.

COLOR	REFERENCE	Pantone
DARK GREEN	VR 99.59	342
GREEN	VR 231	370
BLUE	VR 209	2935
COBALT BLUE	VR 208	2735
YELLOW	VR 241	109
YELLOW	VR 242	116
RED	VR 270	1795
DARK RED	VR 272	186
ORANGE	VR 261	1505
BROWN	VR 280	175
WHITE	VR 290	
BLACK	VR 285	
AcE IMITATION ETCH	VR 296	

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors (marked *) with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)

This system is suitable for most chemical compositions used in the production of soda-lime glass bottles.

Recommended Firing Conditions

600°C to 630°C (1110-1165°F) in a cycle of 1 h-1.5 h, with a soaking period of approx.10 min, dependant on both the type of furnace and the volume of ware fired.
It is also possible to fire the VR System at a temperature of 600°C-700°C (1165-1290°F) in short cycles, such as used for pharmaceutical glass bottles. Tests are recommended.

Chemical Resistance

Norm EN 1388-2 (tests on the basic flux system in laboratory conditions)
- Lead release is < 10 mg/dm^2 of the decorated surface.
- Cadmium release is < 1.5 mg/dm^2 of the decorated surface.

Acid resistance : 4
Alkali resistance : 4
See page 4 for details.

VS System

Main Market Use

These enamels are intended mainly for the decoration of tumblers, but are also used for cosmetic and perfume bottles.

Chemical Composition

Colors in this System contain lead and cadmium.

COLOR	REFERENCE	Pantone
DARK GREEN	VS 327	
GREEN	VS 321	362
ROYAL BLUE	VS 300	2727
COBALT BLUE	VS 302	2747
BLUE	VS 3318	299
YELLOW	VS 68.59	109
LIGHT RED	VS 370	1795
DARK RED	VS 372	187
ORANGE	VS 361	151
BROWN	VS 73.59	483
BLACK	VS 384	
WHITE	VS 390	
AcE IMITATION ETCH	VS 392	

The Pantone references are provided as an indication of the shade only.

.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors **(marked *)** with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)

This system is suitable for most chemical compositions used in the production of soda-lime glass bottles.

Recommended Firing Conditions

From 580°C to 600°C (1075-1110°F) in a cycle of 1 h-1.5 h with a soaking period of approx.10 min, dependant on both the type of furnace and the volume of ware fired.

Chemical Resistance

Norm EN 1388-2 (tests on the basic flux system in laboratory conditions)

- lead release is < 25mg/dm^2 of the decorated surface.
  Exception is VS 302 cobalt blue, with a lead release of c. 60 mg/dm^2 of the decorated surface.
- Cadmium release is < 3 mg/dm^2 of the decorated surface.

Acid resistance : 4
Alkali resistance : 5

See page 4 for details.

System 30

Main Market Use
These low-melting enamels are mainly used for the decoration of thin glassware which would deform at higher temperatures - such as lamps, fancy and small hollow glassware.

Chemical Composition
Colors in this System contain lead.

COLOR	REFERENCE	Pantone
GREEN	11 641	349
DARK GREEN	11 667	3435
LIGHT BLUE	12 530	293
DARK BLUE	12 602	Reflex Blue
YELLOW	13 440	116
ORANGE	13 464	166
RED	17 395	186
BLACK	14 171	
WHITE	19 130	
FLUX	10 042	
AcE IMITATION ETCH	19 961	

The Pantone references are provided as an indication of the shade only.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors **(marked *)** with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)
These enamels have a high C.o.E., and therefore it is advisable to take special care when applying these colors. Enamels with a higher C.o.E. than the glass substrate to be decorated, can weaken the glass. We recommend decorators make preliminary trials to check that the end results are in accordance with their requirements.

Recommended Firing Conditions
From 540° C to 580° C (1005-1075°F) with the higher temperature recommended for optimal transparency.

Chemical Resistance
Acid resistance : 7
Alkali resistance : 7

See page 4 for details.

PR System

Main Market Use
These low expansion enamels are specially designed for decoration of low expansion borosilicate glasses, such as alkali boro-silicate glass.

Chemical Composition
Colors in this System contain lead, cadmium and lithium

COLOR	REFERENCE	Pantone
GREEN	PR 106	349
BLUE GREEN	PR 109	323
ULTRAMARINE BLUE	PR 113	2945
ROYAL BLUE	PR 108	Reflex Blue
BLUE	PR 102	2727
YELLOW	PR 107	012c
ORANGE	PR 101	021c
MEDIUM RED	PR 100	186
DARK RED	PR 118	200
BROWN	PR 105	470
BLACK	PR 112	
WHITE	PR 104	

The Pantone references are provided as an indication of the shade only.

.

These colors are intermixable. We recommend performing preliminary tests before launching production with color mixtures from this System, especially for combinations of red or yellow cadmium-containing colors **(marked *)** with any other colors.
Additional colours are available on demand.
Our technical service teams also offer a full custom-color matching service.

Expansion Coefficient (C.o.E.)
Avge C.o.E. measured on the basic frit System is 57 ($\pm$ 4).$10^{-7}K^{-1}$.

The enamels are specially formulated for application onto borosilicate glass and they should be tested for suitability to the expansion of the glass to be decorated. The 'fit' of these enamels is also dependent on application weight and to avoid microcracking or fracture problems, they should not be applied too thickly.

Recommended Firing Conditions
From 620°C to 640°C (1150-1185°F) in a long cycle; from 630°C to 700°C (1165-1290°F) in a short cycle. Tests are recommended.

Chemical Resistance
Norm EN 1388-2 (tests on the basic flux system in laboratory conditions)
- Lead release is < 10 mg/dm^2 of the decorated surface.
- Cadmium release is < 1 mg/dm^2 of the decorated surface.

Acid resistance : 4
Alkali resistance : 4
See page 4 for details.

THE COMPLETE FERRO PACKAGE FOR THE GLASS WORLD

Ferro is unique amongst suppliers to the glass industry in offering a complete package of products for the container glass market worldwide.
In addition to the Container Glass Decoration enamels detailed here, we supply a complimentary range of other materials and services, which add value to our customer's glass and the final end use product.
Our technical service experts would be pleased to advise on any aspect of your requirements. Also please check out our detailed literature for:

AcE Imitation Acid Etch

Our line of durable, abrasion resistant glass enamel coatings and inks, indistinguishable from the real thing.

SpecTruLite Organic Coatings & Inks

If you are looking for a heavy metal free product with the full color range in brilliant shades – including Cd-free bright reds - we recommend our organic systems.
These systems contain organic inks for screen print applications, as well as water borne organic coatings for spraying by conventional and electrostatic disc/aerobell, with a full range of opaque and transparent colors, plus special effects.
Apart from being environmental friendly, these organic products can be cured at low temperatures, around 200°C (390 ^{o}F).

Forehearth Color Technology

Ferro pioneered the development of forehearth coloration as a cost effective, flexible alternative to glass tank coloration.
Not only does this provide the glass manufacturer with the option of producing 'standard' tank colors in relatively short runs, but also allows for the production of specialist colors that would otherwise be extremely costly, or in some cases impossible to achieve in the tank.

Cermark Laser Decoration

A recent innovation, Ferro is at the forefront in the development of laser decoration and I.D. marking of glass.
For containers, we have developed a line of specialist colors for application on cosmetic and beverage bottles, and tableware.
The innovation is providing exciting new opportunities for the decoration of glass.
This 'non-contact' technique creates complex designs, combined with instant firing, to produce a permanent durable decoration. The need for a secondary firing process is completely eliminated.
It is low maintenance, efficient, cost effective and extremely flexible, with the added capability to link to computer design and to print on complex geometrical surfaces.

A Ferro Glass World Built on Perfomance and Style