

SELECTION 88/84 1,000–1,300°C

SELECTION 88 : Lead- and cadmium-free underglaze colors

SELECTION 84 : Lead-free cadmium containing inclusion underglaze colors

1. General Information and Color chart

Features!

- Fine particle size.
- Wide range of intermixable colors.
- Suitable for wide range of substrates and firing conditions by all applications.
- Can be used as glaze stains and mixing with SELECTION 78/64 inglaze colors.



SELECTION 88/84 1,000–1,300 °C Lead- and cadmium-free, intermixable, underglaze colors for hard porcelain, porcelain, bone china, earthenware, fine china, vitreous china and tile. SELECTION 84 colors are Lead-free cadmium containing inclusion underglaze colors.

Table 1

Product No.	Color tone	Intermixable	Lead free(below 90ppm)	Cadmium free (below 40ppm) *1	88101 mixing flux	Maximum firing temperature (°C)	Oxidation firing condition	Reduction firing condition	Zinc glaze	P.S.D. D50 (μ)	P.S.D. D100 (μ)	Chemical composition	CAS No.
88101	flux	✓	✓	✓	✓	1300	G	G	G	3.5	40	Si-B-Al	65997-18-4
88200	mixing white	✓	✓	✓	✓	1300	P	G	P	1	5	ZrSiO ₄	10101-52-7
88321	yellow	✓	✓	✓	✓	1250	G	F	P	7	35	(Zr,Pr)SiO ₄	68187-15-5
88307	orange yellow	✓	✓	✓	✓	1300	P	G	P	6.5	25	(Zr,V)O ₂	68187-01-9
88404	chrome green	✓	✓	✓	✓	1300	G	C	C	1	5.5	Cr ₂ O ₃	1308-38-9
88405	yellow green	✓	✓	✓	✓	1300	G	P	C	2	20	(Co,Zn)(Al,Cr) ₂ O ₄	68187-49-5
88406	blue green	✓	✓	✓	✓	1300	G	P	C	2	15	(Co,Zn)(Al,Cr) ₂ O ₄	68187-49-5
88521	yellow brown	✓	✓	✓	✓	1250	G	C	C	4.5	25	(Ti,Cr,Sb) ₂ O ₂	68186-90-3
88527	ochre	✓	✓	✓	✓	1250	G	C	P	3	10	(Fe,Zn)(Fe,Cr,Al) ₂ O ₄	68186-88-9
88509	rose wood	✓	✓	✓	✓	1250	G	F	P	4.5	15	(Zr,Fe)SiO ₄	68412-79-3
88528	chestnut	✓	✓	✓	✓	1250	G	C	P	4.5	15	(Fe,Zn)(Fe,Cr,Al) ₂ O ₄	68186-88-9
88720	light gray	✓	✓	✓	✓	1250	G	P	F	4.5	20	Al ₂ O ₃ .MoO ₃ .ZnO	1344-28-1 1313-27-5 1314-13-2
88721	gray	✓	✓	✓	✓	1250	G	F	G	2.5	15	(Sn,Sb) ₂ O ₂	68187-54-2
88722	yellow gray	✓	✓	✓	✓	1250	G	P	P	4	25	(Co,Ni)O.ZrSiO ₄	68186-89-0
88707	light black	✓	✓	✓	✓	1250	G	C	C	3	15	(Fe,Cr) ₂ O ₃	12737-27-8
88706	black	✓	✓	✓	✓	1250	G	C	C	3.5	15	(Co,Fe)(Fe,Cr) ₂ O ₄	68186-97-0
88827	turquoise	✓	✓	✓	✓	1300	G	P	P	9	35	(Zr,V)SiO ₄	68186-95-8
88804	cyan	✓	✓	✓	✓	1300	G	P	C	6	25	(Co,Zn)(Al,Cr) ₂ O ₄	68187-49-5
88808	dark cyan	✓	✓	✓	✓	1300	G	P	C	1	5.5	(Co,Zn)(Al,Cr) ₂ O ₄	68187-49-5
88810	light blue	✓	✓	✓	✓	1300	G	P	C	2	35	(Co,Zn)(Al,Cr) ₂ O ₄	68187-49-5
88805	sky blue	✓	✓	✓	✓	1300	G	P	P	6.5	30	(Co,Zn)Al ₂ O ₄	68186-87-8
88829	light cobalt blue	✓	✓	✓	✓	1300	G	P	P	4	20	CoAl ₂ O ₄	68187-40-6
88806	cobalt blue	✓	✓	✓	✓	1300	G	P	G	3.5	45	Co ₂ SiO ₄	68187-40-6
88910	violet	✓	✓	✓	✓	1250	G	F	F	6	45	(Sn,Cr) ₂ O ₂	68187-53-1
88923	pink	✓	✓	✓	✓	1250	G	F	F	6.5	45	CaO.SnO ₂ .SiO ₂ .Cr ₂ O ₃	68187-12-2
88924	maroon	✓	✓	✓	✓	1250	G	F	F	5.5	25	CaO.SnO ₂ .SiO ₂ .Cr ₂ O ₃	68187-12-2
88925	light red pink	✓	✓	✓	✓	1300	G	P	F	8	45	(Al,Mn) ₂ O ₃	68186-99-2
SELECTION 84: Lead-free cadmium containing inclusion underglaze colors													
84313	lemon yellow	✓	✓	*1	✓	1300	G	P	P	4	35	CdS in ZrSiO ₄	102184-95-2
84318	cadmium orange	✓	✓	*1	✓	1300	G	P	P	5.5	50	Cd(S,Se) in ZrSiO ₄	102184-95-2
84412	cadmium green	✓	✓	*1	✓	1300	G	P	P	5	40	CdS in ZrSiO ₄ (Co,Zn)(Al,Cr) ₂ O ₄	102184-95-2 68187-49-5
84623	cadmium orange red	✓	✓	*1	✓	1300	G	P	P	6.5	50	Cd(S,Se) in ZrSiO ₄	102184-95-2
84628	cadmium red	✓	✓	*1	✓	1300	G	P	P	6.5	50	Cd(S,Se) in ZrSiO ₄	102184-95-2
84634	cadmium dark red	✓	✓	*1	✓	1300	G	P	P	6.5	50	Cd(S,Se) in ZrSiO ₄	102184-95-2

*1: lead- free cadmium containing colors

G : Good

P: Positive results

F : Color fading

C : Color changing

2. Firing Conditions

Type of ware	Firing range
Hard porcelain	1,300–1,350°C
Porcelain	1,230–1,300°C
Bone china	1,000–1,150°C
Earthenware	1,000–1,050°C
Fine china	1,000–1,200°C
Vitreous china	1,000–1,200°C
Tile	950–1,050°C

SELECTION 88/84 colors are suitable for normal firing of 6–12 hours, cold-to-cold conditions. They can be fired at reduction firing conditions up to 1350°C. For more details refer to Table 1. Their color tone will be varied under different firing conditions and type of glazes; therefore, we recommend to test under several firing conditions to check their color variation range.

3. Application

SELECTION 88/84 colors are suitable for direct and indirect screen-transfer printing, spraying, pad printing and hand painting.

SELECTION 88/84 colors can be used as glaze stains by just mixing with base glazes without additional grinding because of their fine particle size.

4. Particle size of Distribution (P.S.D.)

Product	D ₅₀ average	D ₁₀₀ biggest
88101 transparent mixing flux	3.5 μ m ($\pm$ 1.0)	35 μ m ($\pm$ 5.0)
SELECTION 88 colors	1–8 μ m ($\pm$ 1.0)	5–45 μ m ($\pm$ 5.0)
SELECTION 84 colors	4–6.5 μ m ($\pm$ 1.0)	35–50 μ m ($\pm$ 5.0)

For more details refer to Table 1.

5. Printing

【5.1 Mesh size】

We recommend polyester screen with 60–305 mesh/inch (24–120 thread/cm) for all screen applications. Their color tones depend on the thickness of color deposit.

【5.2 Medium ratio】

Product	Color : medium	Recommended mesh
88101 flux : Medium PM2	10 : 5-10	60-305 mesh/inch (24-120 thread/cm)
SELECTION 88 colors : Medium PM2	10 : 5-8	60-123 mesh/inch (24-48 thread/cm)
SELECTION 84 colors : Medium PM2	10 : 5-8	60-123 mesh/inch (24-48 thread/cm)

We recommend C12 cover coat by printing 70 mesh/inch (27 thread/cm).

We recommend using DM1 pasting lacquer to apply organic decals on biscuit ware.

Lead free underglaze colors absorb any moisture easily. Therefore, keep powder colors in a dry place. We recommend drying the color powder before using.

6. Mixability

SELECTION 88/84 colors can be mixed with each other in any proportions. They are also intermixable with **SELECTION 78/64** inglaze colors to increase color intensity. However, we recommend testing the stability of mixing colors and overprinted flux and colors under end-user's firing conditions before mass production. Please note following points and refer to Table 1.

88101 flux: Adding 5-20% of **88101** flux is suitable for all of **SELECTION 88/84** colors as mixing flux to improves adhesion strength to the substrate.

Mixing white: To obtain pastel-color tone, it is suitable to mix **88201** mixing white.

Tin-Chrome colors: Tin-Chrome stain colors, **88910** violet **88923** pink and **88924** maroon cannot be used on the glaze which contains high zinc. These colors are very sensitive to long and high firing temperature but thicker printing show better and much more stable results.

High-Aluminum oxide containing colors: **88720** gray and **88925** pink contain high amount of aluminum oxide therefore they show stable color tone at high firing temperature but they may show negative defect such as pinholes. In this case adding **78172** flux is effective.

SELECTION 84 colors are lead-free cadmium containing inclusion colors. They show very intensive color tone and are stable at low- and high-firing temperatures. Even though, they do not show cadmium release after proper firing, we separated them from the **SELECTION 88** series because they contain cadmium. **SELECTION 84** colors are intermixable and can be used with **SELECTION 88** colors under the same firing conditions. Adding **88201** white shows better results for pinholes and rough surface (orange skin problem).

7. Chemical durability

Chemical durability of **SELECTION 88/84** colors depends on type of ware, glaze, kiln, color deposit and firing conditions. The following are the results of tests on porcelain, fired at 1,300°C, with 10 minutes of soaking time, 12 hours of cold-to-cold firing conditions by gas kiln in production run.

【7.1 Residual lead and cadmium content】

SELECTION 88 colors contain less than 90 ppm residual lead and less than 40 ppm residual cadmium and are, therefore in compliance with Californian Proposition 65, FDA, CPSIA, EU, and Japanese requirements. **SELECTION 84** colors contain less than 90 ppm residual lead and contain more than 50,000 ppm cadmium as inclusion pigments.

【7.2 Lead and cadmium release】

According to the DI EN 1388-1-2 test, **SELECTION 88/84** colors show lead and cadmium releases are below AAS limits.

【7.3 Acid resistance】

According to the DI EN 1388-1-2 test, all of the **SELECTION 88/84** colors do not show any visible attack after immersion in a 4% acetic acid solution for 24 hours at a room temperature of $22 \pm 2^{\circ}\text{C}$.

【7.4 Alkali resistance】

According to ASTM C556-88 test, **SELECTION 88/84** colors do not show any visible attack for over 6 hours.

8. Safety Data Sheet (SDS)

Safety data sheet (SDS) of **SELECTION 88/84** colors are available on request.

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