

SELECTION 35 760-900°C

Lead- and cadmium-free onglaze colors

1. General Information and Color chart

SELECTION 35 series is a range of lead- and cadmium-free, intermixable, onglaze colors for porcelain, bone china, earthenware, vitreous china and enamel ware.

Options for this series: Please refer to their individual technical information.

SELECTION 34: Lead- free cadmium containing colors.

SELECTION 35 Relief: Relief flux and white.

SELECTION 35M: Metallic and interference metallic colors.



SELECTION 35 760–900°C Lead- and cadmium-free, intermixable, onglaze colors for porcelain, bone china, earthenware, vitreous china and enamel ware.

Table 1

Product No.	Color tone	Pantone No.	Intermixable	Precious metal containing	Lead free (<300ppm)	Cadmium free (<100ppm)	Acid resistant, DIN 1388-1-2 *1	Alkali resistant, ASTM C556-88 *2	35 101 mixing and overprinting flux	35 104 mixing and overprinting flux	Enamel ware	Bone, vitreous china, earthenware	Porcelain	Hard porcelain	Remarks
35 101	flux		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	mixing and overprinting except pcelain and hard porcelain
35 104	flux		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	mixing and overprinting except hard pcelain
35 200	mixing white		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	mixing white
35 213	opaque white		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	very opaque white, underlay white on color glaze
35 301	lemon yellow	101C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	four-color yellow
35 302	yellow	102C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 305	orange yellow	123C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	four-color orange yellow
35 401	grass green	359C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 402	chrome green	364C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 403	yellow green	3425C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 404	blue green	328C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 521	yellow brown	130C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 505	ochre	1385C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 524	chestnut	1615C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 601	iron dark red	181C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	iron red, mixture limited
35 602	iron red	164C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	iron red, intermixable
35 721	gray	650C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 702	dark gray	warm gray 8C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 703	black	process blackC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	four-color black
35 801	turquoise	2905C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 802	cyan	307C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	four-color cyan
35 808	dark cyan	641C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	four-color cyan
35 811	sky blue	2727C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	need overprinting flux for gloss, for soft glaze recommended
35 804	azure	293C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 901	lilac	2748C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 902	purple	525C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 923	violet	529C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 904	light blue pink	203C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 925	light red pink	1905C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 926	red pink	205C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 908	magenta	220C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	four-color magenta standard
35 911	dark blue maroon	221C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
35 934	dark red maroon	215C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Relief flux & white															
35 180	relief flux		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	relief flux, can mix with all 35 colors
35 286	relief white		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	relief white, can mix with all 35 colors

*1: DIN EN 1388-1-2 : The test pieces are immersed in a 4% acetic acid solution for 24 hours at 22±2°C.

*2: ASTM C556-88 : The test pieces are immersed in a 0.5 % sodium carbonate solution in water at 95°C for 2, 4 and 6 hours.

2. Firing Conditions

Type of ware	Firing range
Porcelain	820–900°C
Vitreous china	800–900°C
Bone china	780–900°C
Earthenware	760–840°C
Enamel ware	800–830°C

SELECTION 35 colors are suitable for both normal firing of 3–10 hours and fast-firing of 60–120 minutes, cold-to-cold conditions. They should also be only used with lead-free colors and glazes. They must be fired only under lead-free conditions to avoid heavy lead release..

3. Application

SELECTION 35 colors are suitable for screen-transfer printing, direct printing, spraying, pad printing and hand painting.

4. Coefficient of Thermal Expansion (C.O.E.)

Product	Thermal Expansion (C.O.E.)
SELECTION 35 colors (average)	Varies between $6.8-7.3 \times 10^{-6}/^{\circ}\text{C}$
35101 flux, low-firing temperature, mixing, overprinting for all except porcelain	$8.0 \times 10^{-6}/^{\circ}\text{C}$
35104 flux, high-firing temperature, mixing, overprinting for all wares	$6.3 \times 10^{-6}/^{\circ}\text{C}$
35180 relief flux	$5.5 \times 10^{-6}/^{\circ}\text{C}$
35286 relief white	$6.2 \times 10^{-6}/^{\circ}\text{C}$

SELECTION 35 colors are carefully developed and tested under optimum conditions to minimize cracking or chipping problems. The maximum thickness of the color layer should be bellow $20 \mu\text{m}$ (approx. by 200 mesh/80T, double printing) for porcelain glaze (C.O.E. $4.0-5.0 \times 10^{-6}/^{\circ}\text{C}$). Thicker printing of more than $25 \mu\text{m}$ could be allowed for bone china, earthen ware and vitreous china (C.O.E. $5.5-7.5 \times 10^{-6}/^{\circ}\text{C}$) However, it is necessary to test the cracking or chipping before mass production. The results will depend on the end-user's conditions.

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

Product	D ₅₀ average	D ₁₀₀ biggest
SELECTION 35 colors (average)	3–3.5 μ m	30 μ m
35101, 35104 flux	2–2.5 μ m	15 μ m
35180 relief flux	10–15 μ m	80–100 μ m
35286 relief white	2–3 μ m	15–20 μ m

6. Printing

【6.1 Mesh size】

We recommend mesh sizes that are 180–355 mesh (71–140T) for all screen applications.

Gold and high silver containing colors: We recommend that 35925 pink, 35926 pink, 35934 magenta are printed using 250–355 mesh (100–140T). If the color deposit is too thick, the high silver-containing colors become brownish.

Relief flux and white: We recommend that 35180 relief flux is printed using 100–150 mesh (40–60T) and 35286 relief white is printed using 100–120 mesh (40–48T). Printing 1–3 times is recommended. Printing by finer mesh shows smoother surface and less pinhole than rough mesh.

【6.2 Medium ratio】

SELECTION 35 color : Medium PM2/PMT8	10 : 7–9/8–10
35101, 35104 overprinting flux : Medium PM2	10 : 9–11
35180 relief flux : Medium PM2/PMT9	10 : 6–7/7–8
35286 relief white : Medium PM2/PMT9	10 : 6–7/7–8

SELECTION 35 colors: We recommend PM2 flowing medium, PMT8 thixotropic medium for dot and four-color printing. We recommend C12 cover coat by printing 70 mesh (27T).

Relief flux and white: We recommend PM2 flowing medium for smooth relief and PMT9 weak thixotropic medium for high and sharp relief. We recommend C33 cover coat by printing 70 mesh (27T). Adding just sufficient medium will improve the surface of relief, if it has pinhole problems.

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

7. Color and Mixability

SELECTION 35 colors can be mixed with each other in any proportions. However, we recommend testing the stability of mixing colors and overprinted flux colors under end-user's firing conditions before mass production. Please note following points and refer to Table 1.

Mixing white: To obtain pastel-color tone, it is suitable to mix 35200 mixing white or 35213 opaque white.

Mixing flux: 35101 flux (except for porcelain) and 35104 flux are suitable for mixing all colors. After mixing with flux, the color is lighter and glossier.

Underlay white: 35213 is opaque white and suitable for using as underlay white on color glaze.

Iron oxide red: When 35601 iron red is mixed with other colors, it is necessary to mix more than 50 % of 35601 to maintain the stability of iron oxide.

35811 sky blue: 35811 sky blue is specially developed for soft-glaze, bone china, vitreous china and earthenware. On porcelain, it becomes very mat appearance. This blue is high firing temperature and we recommended overprinting 35104 flux to make it glossy.

Overprinting flux: 35101 flux is suitable as overprinting flux for all colors, but if blues and iron red become very weak, and reddish gold-containing pinks and maroons become brownish, we recommend 35104 flux instead. For porcelain we recommend using 35104. Overprinting flux improves color gloss and chemical durability, such as heavy metal release, alkali durability and dishwasher resistance.

Relief flux and white: 35180 relief flux and 35286 relief white are suitable for mixing all colors. After mixing with **SELECTION 35** colors, color relief can be developed.

35101 flux porcelain: Basically, mixing and overprinting 35101 flux with **SELECTION 35** colors on porcelain are not recommended. Because of high thermal expansions, it will be a cause of cracking or chipping problems but it depend on type of porcelain glaze and firing conditions.

8. Four-color printing

【8.1 Choice of colors】

Yellow	35301 lemon yellow, 35305 orange yellow
Magenta	35908 magenta, 35934 reddish magenta
Cyan	35802 cyan, 35808 dark cyan
Black	35703 black
Flux	35101, 35104, mixing and overprinting flux

To adjust each color tone, 35301 lemon yellow can be mixed with 35305 orange yellow. 35908 magenta can be mixed with 35934 reddish magenta. 35802 cyan can be mixed with 35808 dark cyan. 35101 and 35104 flux are suitable as overprinting flux for all colors.

【8.2 Printing order】

yellow → magenta → cyan → black → overprinting flux.

【8.3 Mesh size】

We recommend mesh sizes that are polyester 300–330 mesh (120–130T).

【8.4 Medium ratio】

35301 lemon yellow, 35305 orange yellow : PMT8	10 : 8–9
35908 magenta, 35934 reddish magenta : PMT8	10 : 8.5–9.5
35802 cyan, 35808 dark cyan : PMT8	10 : 8–9
35703 black : PMT8	10 : 8–9
35101, 35104, overprinting flux : PM2	10 : 9–11

We recommend PMT8 thixotropic medium for printing **SELECTION 35** four colors.

We recommend PM2 flowing medium for overprinting 35101 and 35104 flux.

We recommend C12 or C33 cover coat by printing 70 mesh (27T).

9. Chemical durability (refer to the Table 1)

Chemical durability of **SELECTION 35** colors depends on type of ware, glaze, kiln, color deposit and firing conditions. The following are the results of tests on vitreous china, fired at 850°C, with 10 minutes of soaking time and 120 minutes of cold-to-cold firing conditions of gas kiln in production.

【9.1 Residual lead and cadmium content】

SELECTION 35 colors contain less than 300 ppm residual lead and less than 100 ppm residual cadmium and are therefore in compliance with Californian Proposition 65, FDA, EU and Japanese requirements.

【9.2 Lead and cadmium release】

According to the DI EN 1388-1-2 test, **SELECTION 35** colors show lead and cadmium releases are below AAS limits.

【9.3 Acid resistance】

According to the DI EN 1388-1-2 test, **SELECTION 35** colors do not show any visible attack after immersion in a 4% acetic acid solution for 24 hours at a room temperature $22 \pm 2^\circ\text{C}$, except 35804 azure and 35901 lilac.

【9.4 Alkali resistance】

According to the ASTM C556-88 test, **SELECTION 35** colors do not show visible attack for up to 6 hours. If 35101 or 35104 flux are overprinted, they can stand more than 6 hours.

10. Material Safety Data Sheet (MSDS)

Material safety data sheet (MSDS) of **SELECTION 35** colors are available on request.

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