

ENAMELING 101 FOR METAL CLAY ARTISTS

Vitreous enamel is a beautiful, durable, and versatile medium for adding color to metal clay. If you have not enameled before you may find your first enameling results mysterious. Here is a primer to help you understand how enamel works.

- 1) **COMPATIBILITY:** Vitreous enamels are made to “fit”¹certain metals. Jewelry enamels are made to “fit” copper, gold and silver although other substrates are sometimes possible. Therefore Fine Silver and 24K Gold metal clays are workable substrates². Copper clay is also possible but takes extra care and is not covered in this article. Please see Pam East’s article “Firing and Enameling Art Clay Copper” on her website www.pameast.net/library.
- 2) **CHEMICAL REACTIONS:** When a metal is heated e.g. fired in a kiln, it will out gas and in some cases these gasses react with the enamel. This can result in a color change – sometimes into something quite undesirable e.g. red transparent can turn brown (on copper) or yellowish (on silver). How do you know when this will occur? You don’t for sure. But here are a few generalizations to serve as guidelines.
 - a) When enamel is fired onto 24K gold there are no chemical color changes. But because the metal is yellow it will visually influence transparent colors e.g. a blue transparent will appear greener over a gold background.
 - b) On fine silver there are many possible chemical reactions. Be suspicious of “warm colored” transparent³: reds, oranges, yellows, pinks and sometimes purples. Ask the manufacturer of the enamel what the reaction will be. It is possible to coat the silver with a non-reactive enamel first⁴. But even then problems can arise after several firings, especially with hotter firings. Another possibility is to burnish pieces of gold foil onto the spaces of silver clay where you wish to put warm colored enamels or fire a layer of gold clay over the silver. Fortunately, there are some warm colored enamels that will keep their true color, even when fired directly onto fine silver (see the chart). Cool colors e.g. green, blue, turquoise etc. rarely, if ever, have this chemical reaction with silver.
- 3) **CRACKING:** Glass and metal are very different materials. When they are fired the glass bonds to the metal. And then when they cool, certain stresses are set up which can cause enamels to crack. This is more likely to happen with metal sheet than with metal clay. However, if it does occur, try enameling both the front and the back of the piece in order to

equalize the stress. Or if that is not possible, try using a thick piece of metal clay with a thin coat of enamel. It also helps to dome a 2-D piece; to use a shape like a circle or a square (rather than an elongated shape); and to make your piece from a piece of metal clay of uniform thickness.

4) TESTING: Enameling results are not easy to predict because there are so many variables at play. It is wise to make test samples on the same metal clay material that you plan to use for your piece. Keep records and be open to experimentation. The chart⁵ will get you started with a minimum of frustration. ALL of the colors on the chart, warm and cool colors alike, work well directly on silver PMC+⁶ or with a silver flux undercoat. The tests below were done with Precious Metal Clay but other metal clays should react in a similar fashion.

The lead bearing enamels for these tests were supplied by Enamelwork Supply Co., Ninomiya Color Shippo and Nihon Shippo. The PMC was supplied by the Mitsubishi Company. The time and talent were supplied by PMC artists Barbara Simon and Jean Vormelker.

Color Number	Color Name
N-1	Flux for Silver
N-3	Double sifted Flux for silver
N-20	Light Orange
N-21	Medium Orange
N-23	Dark Orange
N-24	Light Yellow
N-26	Medium Yellow
N-27	Dark Yellow
N-36	Light Chartreuse
N-37	Chartreuse
N-38	Yellow Green
N-39	Dark Yellow Green
N-40	Very Pale Green
N-41	Pale Green
N-42	Medium Green
N-43	Dark Green
N-44	Very Dark Green
L-44	Lt. Moss Green
L-45	Med. Moss Green

N-45	Very Lt. Mint Green
N-46	Light Mint Green
N-47	Medium Green
N-48	Dark Green
L-46	Med. Yellow Green
L-47	Dark Yellow Green
L-48	Dark Green
N-49	Very Pale Aqua
N-50	Pale Aqua
N-51	Med. Blue Green
N-52	Dark Blue Green
L-50	Medium Green
L-54	Light Blue Green
L-55	Med. Blue Green
L-56	Dark Blue Green
N-55	Pale Water Blue
N-57	Med. Water Blue
N-58	Dark Water Blue
L-59	Medium Teal
L-60	Dark Teal
L-61A	Light Water Blue
L-61	Light Water Blue
L-62	Med. Water Blue
L-63	Dark Water Blue
L-64A	Medium Ultramarine
L-64	Dark Ultramarine
L-65	V. Dark Ultramarine
N-69	Eggplant
N-71	Very Pale Violet
N-72	Pale Violet
N-73	Medium Violet
N-74	Dark Violet
L-69	Very Light Blue
L-70	Light Blue
L-71	Medium Blue
L-72	Medium Blue

L-74	Dark Cobalt Blue
L-77	Very Dark Blue
N-75	V. Pale Red Purple
N-76	Pale Red Purple
N-77	Medium Red Purple
L-80	Light Blue Purple
L-81	Medium Blue Purple
L-82	Dark Blue Purple
L-83	Very Dark Bl. Purp.
N-84	Very Pale Tea
N-85	Pale Tea Brown
N-86	Medium Tea Brown
N-87	Dark Tea Brown
L-86	Dark Purple
N-88	Very Pale Black
N-89	Pale Black
N-90	Medium Black
N-91	Medium Black
N-92	Dark Black
N-93	Darkest Black
L-90	Medium Red Purple
L-91	Dark Red Purple
G-110	Flux for Silver
G-701C	Light Pink for Silver
G-703A	Bright Pink for Silver
G-703C	Bright Pink for Silver
G-704	Red for Silver
G-709	Coral Red for Silver
NG-302	Opal White
K-305	Opal White

In addition to understanding the “science” of enamel, there are other factors you will want to consider. Let the following information guide your decisions.

POWDER VS LUMPS: Enamel is made in big pancakes of glass that are then broken up into chunks (often called lumps or frit) and then ground into powder in a ball mill. The powder form is the form you will likely use. You can buy the powder or grind it yourself from lump or frit. Why would you

want to grind it yourself? Purists grind their enamel because this makes a clearer transparent. Enamels start to deteriorate when they are subjected to moisture. Powder grains have a lot more surface area to be attacked than the larger chunks do. Therefore the latter are much less likely to suffer from deterioration. In practice, not many people grind their enamels. But care must be taken to keep your enamels dry. Only wash (see below) the amount of enamel that you will be using at the time and store the dry enamel in airtight containers.

CLEANING ENAMEL: Enamel is not really dirty but enamelists use this term to mean separating out the fine grains of enamel. Again, why would you do this? Enamel grains come in all different sizes. Even though they are usually advertised as 80 mesh, it just means that most would pass through an 80-mesh screen. The smallest grains in this mixture can cause a transparent to be cloudy and an opaque to have a mottled appearance. Not everyone removes these “fines”. If you like the way it looks just as it comes, use it that way. But if you do want to remove the fines they can be removed either by “washing” or by “screening”. To **wash** an enamel put it in a jar, add distilled water, and stir it. Or put a lid on the jar and shake it. Wait a few seconds and you will see the bigger grains settle to the bottom. Pour off the cloudy water (into a coffee filter so that it does not go down the drain). Repeat the washing until the water is clear. To **screen** enamel, pour it into a 200 mesh sieve and sift the fines out. Sandwich the sieve between two caps – one to catch the fines and the other to act as a lid. This will keep the amount of enamel dust that you might inhale to a minimum. If possible use a ventilation system also. When no more fines will separate out (you will have to open it up to see), let it sit for a few minutes for the dust to settle and then use the grains THAT ARE LEFT ON THE SCREEN. Sometimes the fines (the grains that sifted through to the bottom container) can be used for counter enamel. Test a sample to see if you like the way it looks.⁷

FIRING TIMES AND TEMPERATURES: To bring an enamel to maturity you must juggle two factors, the temperature of the kiln and the amount of time you leave your piece in there. In general the hotter the kiln, the shorter the firing time and vice versa. I bet you would like to know exactly how long and at what temperature you should fire your enamels. Sorry, no one can tell you that. But these are the things to consider: how big (in all dimensions) the piece is, how much “kiln furniture” is involved, how long the kiln has been on, how quickly the kiln recovers after the door is opened, the temperature of the room, and of course the characteristics of the enamel(s) that you are using and the metal substrate. A good starting point for your tests on silver and gold metal clay would be 3 minutes at 1400° F. Keep notes – after a few firings YOU are the expert on that piece.

PREPARING THE METAL: Because metal clay is porous it is a good idea to burnish it in order to close up the “pores” as much as possible. If the pores are left open there will be a greater chemical reaction between the metal and the enamels. Tumbling with steel shot after sintering does a great job of getting into all the nooks and crannies of your metal clay piece. But if you do not have a tumbler, hand burnishing or brushing with a brass brush will help smooth over the surface. After burnishing, oxides, grease and oil, and tumbling solution must all be removed. If soap is used, remove it with water in an ultrasound or boil it out before enameling. Be sure it is dry before you start applying the enamel.

¹ Fit has to do with the coefficient of expansion – the amount a material moves (expands and contracts) when it is heated and cooled.

² There is a difference in porosity however. It is important to burnish your metal clay before enameling.

³ These same precautions pertain to opaque and translucent enamels. In addition to the warm colors, white and gray opaques and white translucent enamels can sometimes be a problem.

⁴ Usually the undercoat is a clear, colorless enamel called “flux” (not to be confused with soldering flux).

⁵ This chart lists lead bearing Japanese enamels but other enamels are possible – TEST THEM FIRST.

⁶ PMC3 can also be used but the testers found PMC+ caused fewer problems.

⁷ See Karen Cohen’s book [The Fine Art of Enameling](#) for other suggestions for using the “fines”.