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DAY 1 – DISCUSSION & TEST TILE MAKING

DEFINITION: WHAT IS A GLAZE?

A glaze is a vitreous (glass) coating on a ceramic material whose primary purposes are decoration or protection (sealing). Glazes are a specialized form of glass (amorphous solids). Glazing is the process of coating the clay piece with a thin layer of the mixed raw materials which, on firing, will form a hard, glass-like coating.

CHEMISTRY: Melting Range & Coefficient of Expansion –

It is important to match your glaze formula to the clay body used. Glazes are formulated from a variety of ingredients which are chemically balanced to melt (vitrify) at a given temperature range, and “fit” the underlying clay body. When fired to a controlled temperature, the surface glaze materials turn to glass while the clay body is short of vitrification. At that final temperature range, the clay body particles start fusing together, losing interstitial spaces, solidifying, but not melting. As the glaze melts there is a zone of interaction between the clay body and the glaze surface, and when their “coefficients of expansion” (they expand and shrink similarly) are dissimilar it results in undesirable glaze defects like spalling, cracking.
Chemical/formulaic balance: The elements used in a glaze, are formulated to melt at a given temperature and have a coefficient of expansion matching a clay body. The stochiometric chemistry involved in this formation requires all the various elements to be used (balanced), so the end product is complete and controlled. This stochiometric glaze chemistry is complicated and is NOT covered in this class. We are lucky in this day and age that this kind of calculation is done using computer applications, which have resulted in a myriad of existing glaze formulas. Shino glazes are purposefully “unbalanced”.

BASIC GLAZE MATERIALS:

Glazes must have three elements:
1) Silica (the vitrifying element converts the raw pottery into a glasslike form—found in ground and calcined flint and quartz,
2) Flux, which fuses the glaze to the clay; lowers the melting temperature of the glaze
3) Refractory material, which hardens and stabilizes the glaze.
Color is derived by adding metallic oxides.
Most high fire glazes are made up from just 10 basic materials:

Feldspar (50%) Most Feldspar contains 10 – 15% potassium, sodium and lime combined. The remainder is alumina and silica in roughly equal parts.
Flint: (20%) Flint furnishes silica, basic substance of all glass & glazes. It lends hardness, stability and durability. Also improves the fit to the clay and reduces the chance of crazing.
Clay: (0 – 15%) Added to give better adhesion to the pot and help keep the ingredients of the glaze suspended. Furnishes alumina to the glaze, which increases the viscosity of the melted glaze and helps adhere to the walls of the pot without excessive running.
Whiting: (0 – 15%) contributes calcium to the glaze., and functions as a flux.

Barium Carbonate: (0 – 10%) A flux, but used in limited amounts. Larger amounts tend to make the glaze "dry", and interferes with its melting.
Magnesium Carbonate: (0 – 10%) Furnishes magnesia, which is a flux, functions similar to barium.
Dolomite: (0 – 15%) Composed of Calcium Oxide and Magnesium Oxide, similar to adding Calcium and Magnesium separately
Talc (0 – 15%) Magnesium silicate, provides a source of magnesia and furnishes some silica to the glaze
Colemanite: (0 – 15%) Contains both calcium and boric oxide, used as a very active flux. Adds a characteristic textural effect
Zinc Oxide: (0 – 5%) Flux, and also used for crystalline effects.
Basic Glaze information document

TYPES OF GLAZES:

SURFACES: Glossy – Semi-gloss – Matt (Transparent to Opaque)
In addition to the functional aspect of glazes, aesthetic concerns include a variety of surface finishes, including degrees of gloss and matt, variegation and finished color. Glazes may also enhance an underlying design or texture which may be either the "natural" texture of the clay or an inscribed, carved or painted design. Glazes that "break", i.e., Tenmoku

TEMPERATURES:
High Fire Glazes (Cone 10): harder (scratchproof), more lasting, durable, not susceptible to acid decay. More than practicality, beauty arises from 3 distinct factors: the close relationship existing between glaze and the clay body, quality of the glaze surface and the quality of the color. Today, there are more than a few Cone 6 formulated clay bodies, and when fitted nicely to a glaze, they exhibit many of the same qualities as Cone 10 bodies/glazes.

High Fire Glazes (Cone 8 – 11)
Some Porcelains (Cone 12 – 14)
Mid Fire Stoneware Glazes (Cone 4 – 7)
Low Fire Earthenware Glazes (Cone 08 – 3)
Lowest – Luster Glazes (Below Cone 08)

We will concentrate on Mid-Fire glazes (Cone 5 – 6) with some discussion of Soda firing at Cone 10, Raku at Cone 06.

Pyrometric Cone Chart (Orton Standard)

When heated at 150 degrees C/hour

Cone No.	Centigrade	Fahrenheit	Cone No.	Centigrade	Fahrenheit
022	600	1112	04	1060	1940
021	614	1137	03 1/2	1080	1976
020	635	1175	03	1101	2014
019	683	1261	02	1120	2048
018	717	1322	01	1137	2079
017	747	1376	1	1154	2109
016	792	1457	2	1162	2124
015	804	1479	3	1168	2134
014	838	1540	4	1186	2167
013	852	1565	5	1196	2185
012	884	1623	6	1222	2232
011	894	1641	7	1240	2264
010	900	1652	8	1263	2305
09	923	1693	9	1280	2336
08	955	1751	10	1305	2381
07	984	1803	11	1315	2399
06	999	1830	12	1326	2419
05	1046	1914	13	1346	2455

Low-Fire	Mid-Fire	High-Fire	Some Porcelain
Earthenware	Stoneware	Kaolin (China Clay)	

FIRING ATMOSPHERES: Controlling the kiln's atmosphere while firing provides a multitude of variations to the final glaze –

- Oxidation – Electric Kiln – plenty of oxygen available
- Reduction – Gas – reducing oxygen available by diminishing air flow into the kiln – results in Metallic Oxides reduced to a Metal, i.e., Copper Oxide (green colors) reduced to Copper (red colors)
- Soda – Baking soda (Sodium Bicarbonate) in a warm water solution, is sprayed into a kiln (between cone 6 – 9) creating a sodium rich atmosphere. The sodium will interact with the surface of the clay vessels and form a glaze on the surface, and can interact with various oxides on that surface, even more so in a reduction environment. Ware that is to be used functionally, needing a protected glaze surface (inside pitchers, cups, bake ware) glaze these inner surfaces with a good liner glaze.
- Salt – Very similar to Soda atmospheric firings, although done using Sodium Chloride (table salt). However, this produces a toxic chlorine glass during the firing, and the kiln must be very well ventilated and have no vegetation near the kiln (the fumes kill the bushes/trees)
- Raku – fired to about 900° F. Ware is removed from the kiln while the glaze is molten on the surface. It is placed into a can filled with combustible materials. The pot is hot and it starts the combustibles on fire. At this point, the lid is put on the can. The fire needs oxygen to burn, so it consumes all the oxygen available in the can, then "grabs" the oxygen from the molten glaze surface, causing a reduction. The thermal shock of removing the ware from the hot kiln creates cracking in the glaze surface, and the burning/smoky atmosphere in the can, fills the

cracks with black soot. Sometimes a metallic oxide (stannous chloride solution) is sprayed onto the hot surface producing opalescence. Also, horsehair has been dropped onto the pot’s surface, creating black patterns.

- Pit Fire (organics) – the ware is packed into a pit that is filled with combustibles: wood, wood chips, leaves, sawdust, kelp, whatever burns. An accelerant is used to get the fire going, and a covering placed over the pit. Copper carbonate can be introduced into the atmosphere by packing a long copper tube end with the carbonate, placing the packed end into the pit, and blowing out the carbonate – this provides color, and when the fire needs more oxygen, adds to the reduced environment producing reds and metallic coppers.

<u>GENERAL SAFETY CONSIDERATIONS</u>

Face Mask - Eye Protection - Gloves
Raw Glaze Materials (dry): Always wear a breathing mask and eye protection. Silica, one of the most common ingredients both clay and glazes, can produce long-term damage to your lungs, as well as be a major eye irritant.
Many glazes also contain heavier metallic oxides which can cause skin irritation, liver & kidney damage. Always use protective gloves when glazing.
Hi-temp gloves are needed for protection when firing/unloading any kiln.
Tie long hair back and avoid loose fitting/hanging clothing while firing.

<u>Test Tiles</u>

There are many ways to make test tiles:

- Thrown rings with a flange, cut into sections
- Extruded tiles (a die is used to extrude a tile or self-standing shape),
- Slab tiles
- Rolled coil/flattened

Various Clay body tiles: The same glaze will look/interact differently on various clay bodies. Choose one-two clay bodies (same cone). You can make test tiles from each clay body OR you can make a slip out of one clay body, apply it to half of the test tile. Using slip on the test tiles gives you more information than using your clay body alone.

Make test tiles NOW for future use!

- It's a good idea to <u>always</u> have a stock of bisqued tiles on hand for glaze testing.
- It is helpful to make a hole for mounting/hanging test tiles. Remember, the holes shrink during drying and firing, and if you want to mount these on a nail later, you have to make them bigger than the desired result to allow for shrinkage.
- Make an incised /stamped texture to test for glazes that break or pool (A fork is handy for this. Don't use a pin tool: lines are too small.).
- Use iron oxide and water with a small brush or a glaze pencil to label the tile.

Fire the tiles upright
You will need to know if the glaze pools, striates, mottles, or is runny. Firing the glaze flat will only give you partial information (i.e. what the glaze looks like on flat tiles, not on vertical surfaces).

DAY 2: DISCUSSION & PROJECTS

TEST PROJECTS:

1) Formulating Your Own Glaze**:**

Select a base glaze. These recipes below are chemically balanced for a specific cone temperature and surface. You weight out the ingredients for the glaze (I recommend making up 1000 grams), which gives you 100 grams for 10 variant tests. Glaze Info Document

Cone 6 BASE GLAZES

TRANSPARENT BASE (^6 OX) Silica 25% EPK 25% Wollastonite 10% Frit 3134 25% F-4 Feldspar 15%	GLOSSY BASE 1 G-200 Feldspar 20.0% Frit 3134 20.0% Wollastonite 10.0% EPK 20.0% Talc 11.5% Silica 18.5%	SEMIMATTE/GLOSSY BASE Nepheline Syenite 36.0% Wollastonite 13.0% Zinc Oxide 10.0% EPK 10.0% Silica 31.0%	MATTE BASE (^6 OX) Silica 5% EPK 35% Wollastonite 27% Frit 3124 36%
CLEAR BASE (^4 - 10 OX) Gertsley Borate 20% Wollastonite 10% Nepheline Syenite 30% EPK 10% Flint 30%	GLOSSY BASE 2 Frit 3134 26.0% Custer Feldspar 22.0% Talc 5.0% Whiting 4.0% EPK 17.0% Silica 26.0%	SEMIMATTE BASE (^6 OX) Gristley Borate 54.9% Talc 14.6% Silica 30.5%	MATTE BASE (^6 - 8 OX/RED) Gerstley Borate 10.2% Strontium Carbonate 15.2% Wollastonite 15.2% Nephylene Syenite 38.7% EPK Kaolin 10.2% Silica 10.5%
CLEAR BASE (^6 OX/RED) Gerstley Borate 10.31% Whiting 10.31% Nephylene Syenite 40.24% EPK Kaolin 7.22% Silica 31.92%	GLOSSY CLEAR LINER GLAZE G-200 Feldspar 20.0% Frit 3134 20.0% Wollastonite 15.0% EPK 20.0% Talc 6.0% Silica 19.0%		

Color: Oxides for color in glazes:

Cobalt carbonate ½% = medium blue
Cobalt carbonate ¼% = light blue
Cobalt carbonate ½% + Chrome Oxide 1% = Turquoise
Cobalt Carbonate ½% + Rutile 3% = warm textured blue
Cobalt Carbonate 1/3% + Nickel oxide 1% = grey-blue
Nickel oxide 1% = gray or gray-brown
Magnesium carbonate 4% = brown
Magnesium carbonate 4% + Rutile 4% = textured brown
Ilmenite 3% = spotty brown
Ilmenite 2% + Rutile 2% = textured yellow-brown
Iron Oxide 1% = Celadon
Iron Oxide 2% = dark olive celadon
Iron Oxide 4% = mottled green or brown
Iron Oxide 10% saturated iron red
Copper Carbonate ½ % copper red (reduction)
Copper Carbonate 1% = deep copper red (reduction)
Copper Carbonate 3% = red to black (reduction)
Cobalt carbonate 1% + Iron Oxide 8% + Manganese 3%

TESTING

Making accurate glaze tests is a good investment of time. You learn how the materials work, and have a visual record for future use.

I cannot stress strongly enough the need to document EVERYTHING you do.
Record your information in your log book. Label your test tiles with an iron oxide stain.
I cannot help you if you get spectacular results, but can't remember what you did.

2) Test Matrix Using Existing Glazes:

You have 10 mixed glazes. You will need 100 test tiles. A column of ten tiles will have the first dip (down length of tile) in Glaze A. You will have ten columns, Glaze A thru J, with each column having a first dip of the specific glaze. Across the rows, the 1st row (is a second dip, half-way down) of that column's glaze. The second row will have a second dip using Glaze B, etc. This will result in seeing the results of all glazes double-dipped, and dipped over and under. The results can vary quite dramatically, i.e., Ohata on White vs White on Ohata – they do NOT produce the same final effect. This testing requires good documentation, attention to detail, organized labeling of the tiles, and it helps to have a partner. You can do a glaze matrix for the various clay bodies, and for different atmospheric firings, typically oxidation VS reduction.

3) Line Blends

As opposed to overlapping glazes, a line blend is where two glazes are mixed together in various proportions resulting in a series of glazes of intermediate composition. You can also use a blend to study the effects of varying the composition of material in your glaze recipe. This technique can be used to explore existing glazes you have, or to develop color blends, to see the effect of increasing a particular ingredient on a glaze. [Glaze document with great instructions]

Quick and Dirty Tests:
To quickly add to your existing glaze palette when you already have a stable of glazes mixed:
Select 2 glazes to use. Use 2 fairly dissimilar glazes, i.e., one translucent and one opaque; one shiny, one matt; one yellow, one blue.

Mix the glazes volumetrically. A very simple 1st test would use 5 test tiles:

TT1 100% Glaze A	TT2 75% Glaze A 25% Glaze B	TT3 50% Glaze A 50% Glaze B	TT4 25% Glaze A 75% Glaze B	TT5 100% Glaze B

Here's an example of a 7 tile line blend:

TT1 100% Glaze A 0% Glaze B	TT2 83.3%A 16.7%B	TT3 66.7%A 33.3%B	TT4 50%A 50%B	TT5 66.7%A 33.3%B	TT6 16.7%A 83.3%B	TT7 0%A 100%B
60 ml glaze A	50 ml A + 10 ml B	40 ml A + 20 ml B	30 ml A + 30 ml B	20 ml A + 40 ml B	10 ml A + 50 ml B	60 ml glaze B

Mix the glazes thoroughly, then dip the test tile into each sample. Make sure your test tiles are labeled and you have a good record of what you are doing. **Biaxial blends** [Examples]

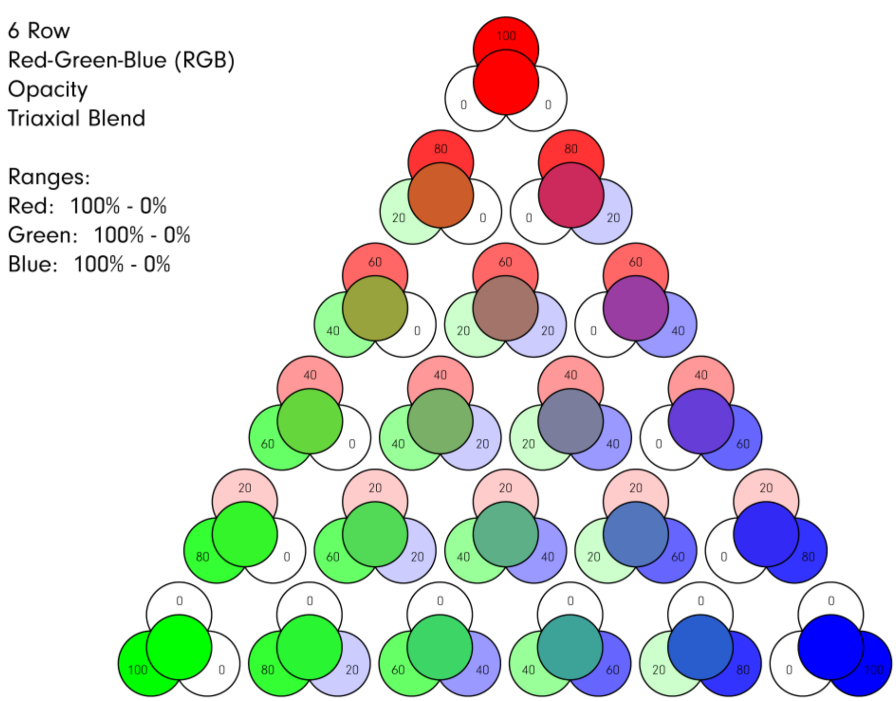
Biaxial or Quadraxial blends are used when you may want to explore:

- Changes involving two materials in a recipe e.g. if you wanted to explore the effects resulting from changes to both EPK Kaolin and Silica.
- Changes involving four materials in a recipe. This is the most complex of scenarios and perhaps the least used except in the case where the materials are colorants.
- The results of simply blending four different recipes

These blends are slightly more complicated, involving the blending of 4 glazes at the corners of a square or rectangular grid. The reasons you would do a biaxial blend would be to get a much more detailed view of a certain glaze with only two variables (i.e. a glaze where alumina and silica levels are varied), or to get a broad range of colors from a couple of additions to a specific base glaze.

Triaxial blends   Examples

The idea behind this testing is that you get 21 different variations on 3 base glazes which opens up quite a new world of color development to the ceramic artist. A Triaxial Blend is a group of glazed and fired ceramic tiles that are arranged in a triangle. The tiles show the effect of combining different percentages of three different glazes.



DAY 3 GLAZES AND GLAZING

USING A TRIPLE BEAM SCALE AND/OR A DIGITAL SCALE

Hands on demo

METHODS OF GLAZING

Dry: Soda, Salt, oxides…usually introduced when kiln is close to cone 6 – 10.

Dipping: Our glazes are mixed to a specific gravity (density based on water content). When a piece is dipped into a bucket of glaze, counting to 3 seconds provides a sufficient penetration even layer onto the surface of the pot. Glazes may be dipped to produce an overlap, and many of these interactions are unique to which glaze is applied first.

Pouring: The glazes are similar to the consistency of thick milk, which may be easily poured onto or into your pots. Again, overlap of two or three different glazes produces varying effects of color and texture.

Spraying: Spraying typically produces a much thinner application of a glaze, and the application thickness can be controlled by layering while spraying. A good rule of thumb is to spray a surface until it is glossy-looking. Let it dry, then spray another coat on it until "glossy". Dry. For a thicker application, apply one more coat. Stencils can be easily incorporated into this application, producing a wide range of interesting effects.

Underglaze: Decoration applied under the glaze on pottery is generally referred to as underglaze. Underglazes are applied to the surface of the pottery, which can be either raw, "greenware", or "bisque". A wet glaze—usually transparent—is applied over the decoration. The pigment fuses with the glaze, and appears to be underneath a layer of clear glaze. An example of underglaze decoration is the well-known "blue and white" porcelain famously produced in England, The Netherlands, China and Japan. The striking blue color is achieved by using the powerful colorant cobalt in the form of either cobalt oxide or cobalt carbonate. You can use stripes of underglaze on your test tiles to see their possible effects. User Guide

Overglaze:
Decoration applied on top of a layer of glaze is referred to as overglaze. Overglaze methods include applying one or more layers or coats of glaze on a piece of pottery or by applying a non-glaze substance such as lusters, enamels, glass, or metals (i.e., gold leaf) over the glaze.

NOTES:

Clean/dust bisque-ware prior to glazing: bisque firing and/or standing on a shelf adds particulate dust to the surface and insides of your ware. Use a damp sponge to wipe the surfaces clean before glazing. DON'T submerge ware in water – if you penetrate the bisque surface with water, the glaze will NOT adhere well.
Clean your bottoms! Ware is fired directly onto a kiln shelf. If your glaze is applied too close to the bottom, it will run off and stick your pot to the shelf, damaging BOTH pot and shelf. WAX the bottom of your piece, removing any droplets of glaze on the waxed surface with a damp

sponge. Soda & Salt fired ware uses “wadding” balls to keep the ware from sticking to the shelf. For bowls/mugs/vases, you can dip the foot into water for a few seconds; the glaze will not adhere well, and can be easily wiped off with a sponge, eliminating the use of wax.

Glaze Information: All the glaze buckets are labeled with the NAME of the glaze. There is also information about the glaze on a document adhered to the outside of the bucket. If you are unfamiliar with a glaze, please read this information. You will find a general description of opacity, color, texture, and “run” factor, and safety information.

Mixing the Glaze: The heavier components of a glaze settle to the bottom of the bucket. In some cases, this settling can happen within 5 minutes. Use the electric drill, equipped with a heavy duty paint mixing blade, to thoroughly mix a bucket of glaze that has been sitting for more than a few hours. While glazing, a hand “whip” should be used to remix the glaze on a periodic basis. Using a “settled” glaze can produce “unsettling” results.

PREFERRED FINAL WET DENSITY

When the dry ingredients are mixed up (wear your mask & eye protection), water is added. A glaze is normally mixed at a preferred density of 1.45 Gm/cc This means you have 1.45 grams of dry mix, to 1 cc of water. To calculate how much water you need for your varying final weights of your dry mixtures,

Wgt of Final Mix / X (CCs of water) = 1.45 Gm / 1 CC

$$\frac{wgt\ of\ mix\ in\ grams}{X\ in\ CC\ Water} = \frac{1.45\ Grams}{1\ CC\ water}$$

To solve for “X”, you cross multiply and divide: i.e.

$$\frac{100\ gms}{X} = \frac{1.45\ Grams}{1\ CC\ water} \quad 100 \times 1 \div 1.45 = X$$

X = 68.9 CC (69 CC) water added to your 100 grams of dry glaze.

ADDITIONAL HELPFUL LINKS:

Listing of Ceramic Info Documents: Glazes, kilns, Basics
Ceramics Art Network Blog
Ceramics Monthly
Linda Levy – Email (831) 426-4906

DAY 4 – TEST RESULTS

Photo-documentation – Examples

Notebooks

Discussion of what worked, what didn’t, what you like most