Expertise

A TECHNICAL GUIDE TO CERAMICS

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A Technical Guide to Ceramics

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The information in *Expertise* is designed to supplement the information in the main text, *Hands in Clay*. It includes a series of clay and glaze tests that you can follow in progression using the accompanying charts. If you work through the clay and glaze tests in Chapter 1A, you will develop a basic understanding of both the composition and the qualities of different clay bodies and glazes. Chapter 2 provides useful information for programming your kiln and firing your tests and ware. If you want to go deeper into testing and glaze calculation, Chapter 3 provides an example of changing the flux in a glaze and follows a potter calculating, testing, and modifying a high-fire glaze. It also includes charts of chemical information you will need. Chapter 4 lists various types of plaster formulas and their applications, as well as solutions to typical problems one experiences when making plaster molds and slipcasting. It also covers the considerations one makes when installing ceramic pieces on walls or outdoors. Chapter 5 lists sources of health and safety information and suppliers of equipment and materials.

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1A

Clays and Glazes Formulated for Testing

The following recipes were formulated for *Hands in Clay* to provide a learning experience for mixing and testing clay bodies and glazes. The clay recipes will produce clay bodies with various qualities and firing temperatures, while the glaze recipes will give you practice in changing the color of a base glaze. Testing is only a means to extend your creativity in clay. What makes a successful ceramic technician and artist? He or she must maintain a bright spirit, solid determination, and hope for a dash of luck!

CLAY BODIES FOR TESTING

Although the clay body tests were fired at cone 05, cone 5, and cone 10, allowing for a wide range of firing temperatures, the actual range of the cones and temperatures for these tests is less rigid than the charts imply. For example, the low-fire white clay can be fired as low as cone 010 and as high as cone 1, whereas the cone 5 porcelain develops a richer sheen when fired at cone 7 or even as high as cone 10. Changes in firing temperatures will affect the shrinkage and color of the clay, and changes in components will affect the workability of the body. While you are developing your own clay bodies through tests, it is wise to be flexible about material substitutes, temperatures, and kiln atmospheres. Each of these factors will subtly affect the outcome of your tests, adding to the excitement as you proceed. Do not be discouraged from mixing clays or glazes if the names of the materials listed in the following recipes are not the same as those in your area. For example, the names of fire clays, ball clays, and feldspars will vary depending on where you live. You will just have to test the substitutes thoroughly.

***Hands in Clay* Cone 05, 5, and 10 White Clay Bodies (CL1, CL2, CL3, CL4)**

Components	*Percentage*		
	Cone 05 (CL1)	*Cone 5* (CL2)	*Cone 10* (CL3, CL4)
Kentucky ball clay (OM4)	50.0	21.0	20.0
Kaolin (Georgia)		27.0	28.0
Fire clay (Lincoln)			
Feldspar (Custer)			25.0
Feldspar (nepheline syenite)		25.0	
Silica 200 mesh (flint)		25.0	25.0
Talc	50.0		
Macaloid		2.0	2.0

Notes:
White base clay bodies in oxidation (CL1 to CL3):
Cone 05—smooth, warm-white body (CL1)
Cone 5—smooth, slightly off-white (CL2)
Cone 10—smooth, slightly off-white (CL3)
White base clay bodies in reduction:
Cone 10—smooth, light gray (CL4)

Components of Blended Clay Bodies

BALL CLAY Ball clay has highly plastic qualities, and for that reason it is used in both low-fire and high-fire clay bodies that require plasticity—for example, those to be thrown on the wheel. It is also used in low-fire slip for casting bodies.

FIRE CLAY Maturing at a high temperature and readily available and inexpensive, fire clay is used in stoneware bodies to provide silica and alumina, refractory materials, and to increase the heat-resistant quality of the clay. Fire clays are relatively plastic.

TALC Talc is a magnesium-bearing rock that sometimes contains impurities of iron and alumina as well as alkalies and lime. Because of its magnesium content, it is used as a flux for low-fire clays and casting slips.

FELDSPARS Feldspathic rocks are among the most common rocks in the earth's crust, and the feldspars used in ceramics come from those rocks as they are broken down by geologic forces. Feldspars contain alumina, silica, and, depending on the composition of the particular feldspar, varying amounts of sodium, potassium, or calcium. Feldspars are heat resistant and are used as a principal flux in stoneware clays, because stoneware is heated to temperatures high enough to melt the feldspar (above 2192°F/1200°C). Since feldspars mined in different places vary in composition, it is important to know the chemical formula of the feldspar you use.

Clay Bodies Formulated for Use in Color and Glaze Tests

The following clay bodies were mixed in 300-g batches. The clays were first blended dry; then they were mixed with water into a slip. For the smooth clay bodies, the water content was about 20% of the batch, while the bodies with 20% grog required roughly 13–15% water content per batch. The slip was poured onto a plaster bat and left 5 to 10 minutes or until enough moisture had been absorbed to bring the clay to the right consistency for wedging. The base recipes for these clay bodies were formulated to total 100%. Coloring oxides and stains were added to the base clay in varying percentages. The letters and numbers in parentheses refer to the test tiles in *Hands in Clay*, Figure 10-11. Be sure to follow the precautions given in Chapter 10 for handling dry clay when you mix these clay bodies.

Substitutions for the materials and chemicals listed in the recipes will cause changes in the color, texture, and firing range of the clays. If you substitute, you will need to carry out additional tests. Some possible substitutes include:

- *Kaolin:* EPK or Grolleg or other kaolin may be substituted for Georgia.
- *Feldspar:* Locally available feldspars such as Unispar 50, G-200, or Kona F-4 may be substituted for Custer, a potash feldspar.
- *Fire clay:* Fire clays such as IMCO#400 or #800, Cedar Heights, Goldart, Pine Lake, Hawthorne Bond, or Missouri may be substituted for Lincoln.

- *Ball clay:* Bandy, CP-7, Copper Light, Taylor, Champion and Challenger, Black Charm, Jackson.
- *Macaloid:* Assists in giving plasticity to some clays; it may be eliminated for test purposes, or vee gum or bentonite can be substituted.
- *Any red earthenware,* such as C-Red, Newman, Laterite, Redart, Kreth Red, or Cedar Heights Redart terra-cotta, can be substituted for the Red Horse clay.
- *Stains:* Other pink or yellow (praseodymium) glaze or body stains may be substituted, as can other color stains. Be aware of the maximum cone or temperature range of whatever stain you substitute, because some colors fade at high temperatures (D320 pink and #6440 tin-vanadium yellow are both high-temperature stains).

Coloring Clay Bodies with Natural Clays (CL5 to CL8)

To make subtle changes in the color of a clay body, you may simply wedge two colors of clay together to create a lighter or darker shade. However, the following clays for testing were mixed dry, and then water was added to make a slip that was poured onto a plaster bat to absorb the water and stiffen the clay. (See the general instructions for mixing clay bodies in *Hands in Clay,* ~~Chapter~~ 10.)

Components	*Percentage*		
	Cone 05 (CL5)	*Cone 5* (CL6)	*Cone 10* (CL7)
Kentucky ball clay (OM4)	30.0		35.0
Earthenware (Red Horse)*	50.0	50.0	
Fire clay (Lincoln)		50.0	65.0
Talc	20.0		

*For test purposes, Red Horse clay can be substituted with C-Red, Kreth Red, Redart, or any red earthenware clay.

Notes:
Coloring white clay bodies with natural clays:
Cone 05—warm light red, smooth (would burnish well) (CL5)
Cone 5—rust-red, slightly grainy (CL6)
Cone 10 oxidation—gray-buff, smooth (CL7)
Cone 10 reduction—warm brown, smooth (CL8)

Texturing Clay Bodies with Grog/Fillers/Tempers (CL9 to CL12)

To give differing textures to clay bodies, you can introduce various types of grog or filler in place of the buff grog (30–70 mesh) or the **molochite.** You can also blend the texturing materials in combinations, adding even greater tooth and openness to the clay body. For example, for a sculpture body use half sand, half grog, or a variety of mesh sizes of sand, grog and pearlite in combination.

Components	*Percentage*			
	Cone 05 **(CL9)**	***Cone 5*** **(CL10)**	***Cone 10(A)*** **(CL11)**	***Cone 10(B)*** **(CL12)**
Kentucky ball clay (OM4)	40.0	50.0	28.0	28.0
Kaolin (Georgia)				
Fire clay (Lincoln)		30.0	52.0	52.0
Feldspar (Custer)				
Silica 200 mesh (flint)				
Talc	40.0			
Macaloid*				
Grog (buff 30–70 mesh)*	20.0	20.0	20.0	20.0
Molochite (porcelain grog)				

*Can be substituted with the following materials:

Silica sand	(30–90 mesh)	5–10% (Sand in some clay bodies fired to around cone 10 may form a gritty surface.)
Ione grain	(30–150 mesh)	5–20% (Ione grain is no longer available. For test purposes substitute with local grogs from your region.)
Red grog	(9–30 mesh)	5–20%
Pearlite	(fine or coarse)	1–5%

Notes:
Texturing clay bodies with grog/tempers:
Cone 05—white, slightly rough surface (CL9)
Cone 5—off-white, rough surface (CL10)
Cone 10(A) oxidation—gray-buff, slightly rough surface (CL11)
Cone 10(B) reduction—warm brown, lighter speckles, rough surface (CL12)

Cone 10 White Stoneware Clay Body* (WS1 Oxidation, WS2 Reduction)

Components	*Percentage*
Kentucky ball clay (OM4)	25.0
Silica 200 mesh (flint)	20.0
Kaolin (Georgia)	20.0
Feldspar (Custer)	20.0
Macaloid	2.0
Molochite	13.0

*A textured stoneware body for general use.

Shrinkage Test

Since clay bodies have different rates of shrinkage, when you formulate a clay body it is important to test it for shrinkage on drying and after firing. For example, the white 05 clay used in these tests shrank about 5% from wet to dry and about 6% from dry to fired state. One way to measure the amount of shrinkage of a clay is to cast a block of plaster, carve lines into it 1 in. (25.4 mm) apart, and number the lines from 1 to 10. To make a clay test tile, simply press a slab of clay onto the block to imprint the pattern of lines and numbers in the clay, then dry and fire the slab. You can then measure how much the clay shrinks after drying and firing by comparing its measurement before and after with this plaster ruler. Or you can use a commercial **shrink ruler.**

Casting Slip

Hands in Clay Cone 05 Low-Fire White Casting Slip (SL1)
Batch Formula for 128 Fluid oz. (1 gal. [3.875 l])

Components	*Amount*	*Percentage*
Kentucky ball clay (OM4)	2,027.25 g	50.0
Talc	2,027.25 g	50.0
		100% total
Additives:		
Soda ash	4.46 g	.11
Sodium silicate (N)	18.65 g (fluid wt.)	.46
Water	1,900.60 g (67 fluid oz.)	46.69 g (1.65 fluid oz.) water per 100-g batch

Notes:
Weigh the deflocculants sodium silicate and soda ash on a gram scale and mix with water. Add talc and ball clay and mix for 30 minutes, then screen the slip through a 40- to 60-mesh sieve. Accurate sequence, measurement, and mixing time are crucial to suspension and fluidity, and screening is essential for smoothness. Be sure to follow the given sequence in mixing the components, the water, and the sodium silicate. Immediately before casting, slip should be mixed again for 1 to 2 minutes. See Chapter 13 in *Hands in Clay* for pouring directions.

Hands in Clay Cones 5–7 White Porcelain Casting Slip (Electric Kiln) (SL2)
Batch Formula for 128 Fluid oz. (1 gal. [3.875 l])

Components	*Amount*	*Percentage*
Kaolin (Georgia)	1,380.0 g	25.0
Feldspar (Custer)	552.0 g	10.0
Feldspar (Nepheline syenite)	1,656.0 g	30.0
Silica 325 mesh (flint)	552.0 g	10.0
Kentucky ball clay (OM4)	1,380.0 g	25.0
		100% total
Additives:		
Soda ash	5.52 g	.10
Sodium silicate (N)	22.08 g (fluid wt.)	.40
Darvan #7	13.80 g (fluid wt.)	.25
Water	1,564.92 g (55.20 fluid oz.)	55.60 g (2.0 fluid oz.) water per 100-g batch

Notes:
Follow the same measuring and mixing directions as for the cone 05 slip. For casting an object with fine detail, it is a good idea to put the slip through a ball mill. You may also want to use up to an 80-mesh sieve to screen the slip. In that case, you probably will have to push the slip through with a flexible spatula. One way to check the amount of water needed in the casting slips is to measure out 1 pint (.48 l) of slip and weigh it. If it weighs less than 26–28.5 oz. (735.8–806.6 g) for low-fire slip, or less than 28.5–32 oz. (806.6–905.6 g) for high-fire slip, your mixture has too much water. This could cause settling.

Hands in Clay Cones 10–11 White Porcelain Casting Slip (for Gas or Electric Kiln) (SL3) Batch formula for 128 Fluid oz. (1 gal. [3.875 l])

Components	*Amount*	*Percentage*
Kaolin (Grolleg)	1,951.20 g	40.0
Feldspar (Custer)	1,219.50 g	25.0
Silica 325 mesh (flint)	975.60 g	20.0
Kentucky ball clay (OM4)	731.70 g	15.0
		100% total

Additives	*Amount*	*Percentage*
Soda ash	6.09 g	.125
Sodium silicate (N)	19.51 g (fluid wt.)	.40
Darvan #7	19.51 g (fluid wt.)	.40
Water	1,936.0 g (68.29 fluid oz.)	39.62 g (1.40 fluid oz.) water per 100-g batch

Notes:
Fired in oxidation, this is a white slip; in reduction it will be gray. Follow the same measuring and mixing directions as for the cone 05 slip. For casting an object with fine detail, it is a good idea to put the slip through a ball mill. You may also want to use up to an 80-mesh sieve to screen the slip. In that case, you probably will have to push the slip through with a flexible spatula.

Egyptian Paste

Cone 015 White Egyptian Paste* (EP1-4)

Components	*Percentage*
Nepheline syenite	25.0
Frit 3134	15.0
Silica 200 mesh (flint)	20.0
Silica sand 70 mesh	8.0
Kentucky ball clay (OM4)	24.0
Soda ash	3.0
Borax (powder)	3.0
Macaloid	2.0
	100% total

*The components of this clay body form an integral glaze on its surface as it is fired. (See Chapter 2 in *Hands in Clay* for historical information on Egyptian paste.)

Notes:
Mix the dry components, then add enough water to form a stiff paste. Shape it into whatever small object you wish, then dry it slowly until soluble salts form on the surface. Fire it at cone 015. Once you mix the base white body, you can experiment with a variety of stains and oxides for coloring. The following percentages will give you a starting point for your testing.

Colorants:

Turquoise: Copper carbonate	2.50%	(EP2)
Blue: Cobalt carbonate	.75%	(EP3)
Soft lavender: D320 pink stain	3.00%	(EP4)
Cobalt carbonate	.15%	

Speckling:
Granular ilmenite: forms tiny black specks
Silicon carbide (36 grit): forms prominent black specks

COLORING CLAY BODIES WITH OXIDES AND STAINS (CS1 TO CS6)

Dry stains can be mixed directly into the dry clay. In the following tests of cone 05, cone 5, and cone 10 clay in oxidation firing, the same percentages of stain were used, so only one chart is given below with notes on the colors achieved in each clay.

Stains and Oxides Added to *Hands in Clay* Cones 05, 5, and 10 White Clay Bodies

Colorants	***Percentage***					
	Blue **(CS1)**	***Medium Brown*** **(CS2)**	***Green*** **(CS3)**	***Pink*** **(CS4)**	***Yellow*** **(CS5)**	***Dark Brown*** **(CS6)**
Cobalt oxide	3.0					1.0
Iron oxide (red)		5.0				4.0
Chromium oxide			3.0			2.0
Manganese oxide						3.0
D320 Pink stain				5.0		
#6440 Tin-vanadium yellow					5.0	

Notes:
Coloring code 05 white clay body with stains and oxides (oxidation) (CS1 to CS6):
Blue—a light, rather watery blue (CS1)
Red-brown—a light reddish brown, the color of flower pots (S2)
Green—pale leaf green, no blue tones (CS3)
Pink—very pale pink, almost off-white (CS4)
Yellow—pale, beige-yellow (CS5)
Brown—more gray than brown (CS6). On this clay, the low-fire clear glaze (G1 formula on page 9) has a milky appearance.

If you like a matt finish, fire the test without a glaze; if you want to deepen and intensify the color and add a glossy finish, apply a clear glaze.
Coloring cone 5 white clay body with stains and oxides (oxidation) (CS1 to CS6):
Blue—rich deep blue with very slight purple tinge (CS1)
Medium brown—warm brown (CS2)
Green—dark leaf green (CS3)
Pink—light pink, flesh color (CS4)
Yellow—earthtone yellow; not clear lemon yellow (CS5)
Dark brown—rich chocolate brown (CS6)

Applying the clear glaze over these clays does not intensify the color but adds a glossy surface.
Coloring cone 10 white clay body with stains and oxides (oxidation) (CS1 to CS6):
Blue—very dark blue, slightly purplish tone (CS1)
Medium brown—cold gray/brown (CS2)
Green—yellow green (CS3)
Pink—paler than cone 5 pink (CS4)
Yellow—slightly yellower than cone 5 yellow (CS5)
Dark brown—rich chocolate brown (CS6)

GUM SOLUTION FOR TRANSPARENT UNDERGLAZE STAIN OR OXIDES USED ON WHITE CLAY BODY

If you would like to make your own transparent water-based underglazes, you can mix oxides and ceramic stains using a solution of CMC gum in water in the following formula:

Basic Stain Solution

Water	*CMC Gum*
1 gal. (3.875 l)	130.66 g
or	
1 pint (.48 l)	16.33 g

SURFACE COLORS/ UNDERGLAZES, STAINS

Colorants (Stains and Oxides) for Use on White Clay Body

Colorant	*Solution*	*Color: Cone 05*	*Color: Cone 5*	*Color: Cone 10*
5 g Cobalt	3 oz. (91 ml)	Matt gray blue (S1)	Dark blue, slight gloss (S5)	Dark blue, slight gloss (S9)
5 g Yellow stain	3 oz. (91 ml)	Bright yellow (S3)	Pale yellow (S7)	Pale yellow (S11)
8 g Iron	3 oz. (91 ml)	Matt red-brown (S4)	Dark matt brown (S8)	Dark matt brown (S12)
5 g Chromium	3 oz. (91 ml)	Matt leaf green (S2)	Dark leaf green (S6)	Dark leaf green (S10)

You may brush, spray, or paint on the underglaze. Apply it thinly in one coat; otherwise, any glaze you use over the underglaze may crawl. The test underglazes applied with this solution were fired from cone 05 up to cone 10 in oxidation. The oxides and stains tested held their colors at these cones. You will need to make more tests to see which proportion of coloring agents will work best for you, depending on your clay and the temperature at which you fire the tests. With a coat of transparent glaze over the underglaze, the colors are generally brighter (ST1 to ST12). If you plan to keep the solution for later use, you may add a few drops of formaldehyde, but because formaldehyde can produce allergic reactions, we recommend that you mix only enough solution for immediate use.

Water Ratio

You must control the amount of water you add to the glaze materials because the proportion of water affects glaze-material suspension as well as application properties. The percentages in the following chart indicate the water-to-glaze ratio for the glaze test formulas in this appendix. Use the chart only as a guide when formulating your own test glazes. In our testing, the glazes were applied with two to three brushed-on applications. For dipping or pouring, more water would be needed. The varying porosity of bisque ware affects the water ratio. For example, Larry Murphy's cone 10 glaze (see p. 9) needs 3.4 oz. (102.91 ml) of water per 100 g of glaze for dipping. For brushing, two coats will usually suffice; for dipping, it takes one to two dips.

Once you have established the water content for a glaze through testing, if settling occurs, try reducing the amount of water and refer to the glaze-suspension chart in Chapter 1B. Start by adding .5–2% of bentonite or macaloid. Purified bentonite was used for the tests in this chapter. The addition of gums, which will thicken a glaze, may necessitate increased amounts of water.

Water Proportions for *Hands in Clay* Glazes

Glaze	*Per 100 g of Glaze Material*	*Per 100 g of Glaze and Colorant*
Hands in Clay Cone 05	2.5 oz. (75.67 ml)	2.5 oz. (75.67 ml)
Hands in Clay Cone 5	2.5 oz. (75.67 ml)	3.0 oz. (90.81 ml)
Larry Murphy's Cone 10	3.4 oz. (102.91 ml)	4.0 oz. (121.08 ml)

GLAZES FORMULATED FOR TESTING

The following glazes were tested on the white base clay body. Since a glaze consists of a combination of chemicals that fuse and adhere to a clay body under proper application and firing, both the clay body and the firing are equally important in developing successful glazes, and the two must work in a symbiotic relationship. The glazes in this section were formulated to be used on the clays that you have already tested. The cone 05 glaze fits the cone 05 clay, the cone 5 glaze fits the cone 5 clay, and the cone 10 glaze fits the white cone 10 clay.

How you apply the glaze and the type of kiln and atmosphere in which you fire it will also affect the final result. Make notes as you test so that you can make changes based on what happened in your tests. Devise a system of displaying or storing your test tiles so that they are easily available for reference. Our notes following the clay and glaze recipes describe the appearance of the test tiles after firing in a test kiln. Your tests may differ from these descriptions, and the colors or textures as they appear on these small test tiles may also look quite different on a piece of sculpture or a pot.

Glaze Recipes to Mix and Test

Hands in Clay Cone 05 Glaze Recipe (for Testing Only)

Components	*Clear Base* (G1)	*White* (G2)	*Blue* (G3)	*Brown* (G4)	*Green* (G5)	*Black* (G6)	*Pink* (G7)	*Yellow* (G8)
Frit 3195 (3811) (F434)	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0
Kaolin (Georgia)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Bentonite	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Added Colorants	*Clear Base* (G1)	*White* (G2)	*Blue* (G3)	*Brown* (G4)	*Green* (G5)	*Black* (G6)	*Pink* (G7)	*Yellow* (G8)
Tin oxide		12.0						
Cobalt oxide			2.0			2.0		
Iron oxide (red)				6.0		4.0		
Chromium oxide					6.0	2.5		
D320 Pink stain							7.0	
#6440 Tin-vanadium yellow								7.0

Notes:
Cone 05 tests fired in a small test kiln in oxidation:
Clear—good clear glaze, no crackle; pencil shows (G1)
White—glossy, almost opaque; black underglaze pencil shows through slightly (G2)
Blue—deep blue with attractive mottling; covers pencil (G3)
Brown—rich, opaque dark brown with golden brown areas; covers pencil (G4)
Green—opaque shiny green; completely covers clay surface and underglaze pencil (G5)
Black—brownish-black, slight pinholing; covers pencil (G6)
Pink—pale pink; underglaze pencil runs but shows clearly (G7)
Yellow—glossy yellow, more opaque than the pink; underglaze pencil shows somewhat (G8)

***Hands in Clay* Cone 5 Glaze Recipe (for Testing Only)**

Components				***Percentage***					
	***Clear Base* (G9)**	***White* (G10)**	***Blue* (G11)**	***Brown* (G12)**	***Green* (G13)**	***Black* (G14)**	***Pink #1* (G15A)**	***Pink #2* (G15B)**	***Yellow* (G16)**
Calcium carbonate (whiting)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Kaolin (Georgia)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Gerstley borate*	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Nepheline syenite	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
PV (plastic vitrox) clay	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Bentonite (purified)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Added Colorants				***Percentage***					
	***Clear Base* (G9)**	***White* (G10)**	***Blue* (G11)**	***Brown* (G12)**	***Green* (G13)**	***Black* (G14)**	***Pink #1* (G15A)**	***Pink #2* (G15B)**	***Yellow* (G16)**
Tin oxide		12.0							
Cobalt oxide			2.0			2.0			
Iron oxide (red)				6.0		4.0			
Chromium oxide					6.0	2.5			
D320 Pink stain #1 test†							7.0		
F444 Pink stain #2 test†								7.0	
#6440 Tin-vanadium yellow									7.0

**Substitutes:* Leslie Ceramics Akiko Borate, Laguna Clay Co. Borate. Check with your local supplier for other substitutes.

†This test was run first with the Pink stain D320 in the same proportion as in the cone 05 glaze. Since no pink color showed, a new test was run with Pink stain F444 substituted, which produced a true pink at cone 5. This shows that a stain that gives true color at one cone may not hold color in another cone range. For this reason, it is important to run tests at a number of temperature ranges, using other colors of stains to see which colors hold true.

Notes:

Cone 5 glaze tests fired in a small test kiln in oxidation:

- *Clear*—smooth, clear, with some crackling; pencil shows (G9)
- *White*—semiopaque white; pencil shows slightly (G10)
- *Blue*—rich, smooth, and glossy dark blue; pencil covered (G11)
- *Light brown*—translucent golden brown; some crackle; underglaze pencil shows (G12)
- *Green*—shiny green, slightly darker than in cone 05 firing; covers body and pencil completely (G13)
- *Black*—shiny, almost a true black with only slight brown tone; covers pencil (G14)
- *Pink #1*—no pink color using stain D320; milky white matt; pencil shows through, blurry (G15A)
- *Pink #2*—stain F444 gave a true pink at this cone (G15B)
- *Yellow*—runny and slightly more transparent than in cone 05; pencil blurred, but shows more (G16)

Larry Murphy's (*Hands in Clay*) Cone 10 Matt Glaze Recipe*

Components	*Matt Base* (G17)	*White* (G18)	*Blue* (G19)	*Brown* (G20)	*Green* (G21)	*Black* (G22)	*Pink* (G23)	*Yellow* (G24)
Kaolin (Georgia)	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Silica 325 mesh (flint)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Feldspar (Custer)	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Calcium carbonate (whiting)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0

Added Colorants	*Matt Base* (G17)	*White* (G18)	*Blue* (G19)	*Brown* (G20)	*Green* (G21)	*Black* (G22)	*Pink* (G23)	*Yellow* (G24)
Tin oxide		12.0†						
Cobalt oxide			2.0			2.0		
Iron oxide				6.0		4.0		
Chrome oxide					6.0	2.5		
D320 Pink							7.0	
#6440 Tin-vanadium yellow								7.0

*Very slightly changed from the proportions given for this glaze in Chapter 3A.) (G17 to G32)

†Varying quantities of tin oxide may affect glaze smoothness and will affect opacity.

Notes:

Cone 10 glaze tests fired in small test kiln in oxidation:

Murphy formulated this to be a cone 10 matt. The surface is smooth and pleasantly matt, the colors more subtle as a result. The glaze was applied on the *Hands in Clay* cone 10 white test clay (CL3, CL4 on page 2) rather than on Murphy's stoneware clay because the white clay provided a better background for testing color.

Matt—semiopaque (G17)
White—completely opaque (G18)
Blue—handsome, matt blue, softer color than when shiny (G19)
Brown—still golden brown tinge, but darker than at cone 5; slightly rough surface (G20)
Green—deep green (G21)
Black—truer black than either of the other glazes (G22)
Pink—the brightest pink of all! Semiopaque with the underglaze pencil fuzzy but quite clear (G23)
Yellow—soft, almost golden yellow; pencil shows (G24)

Cone 10 glaze tests fired in gas kiln in reduction:

Matt base—semimatt white; underglaze pencil shows (G25)
White—yellowish pale beige (G26)
Blue—deep blue, matt, slightly mottled (G27)
Brown—yellowish brown (G28)
Green—semimatt green (G29)
Black—semimatt black (G30)
Pink—pale pink; underglaze pencil shows (G31)
Yellow—turned gray with some white speckles, which came from the clay (G32)

Line Blend Testing

After testing any combination of *Hands in Clay* glazes from G1 to G24, you can continue developing glazes by line blend testing. If you take 90% (by volume) of the *Hands in Clay* cone 05 clear base glaze (G1) and blend it with 10% of (G3) blue, you will achieve a light-blue transparent glaze. If you continue the process and blend 80% of the clear with 20% of the blue, you will have a slightly darker blue transparent glaze and so on. By continuing in this manner and changing percentages of the glazes, you will end up with nine different shades of blue.

You can take this process a step further by blending one of these glazes with another glaze to develop yet another color. For example, to make a blue-green transparent glaze, blend one of your light-blue transparent glazes with a green glaze such as G5.

Although used primarily for achieving color variations in glazes, line blend testing can also be used to test changes in ingredients in order to affect any glaze's maturing point. For example, to lower the maturing of a high-fire glaze such as *Hands in Clay* cone 10 matt glaze, G17, you could perform a line blend test by blending 90% of G17 with 10% of *Hands in Clay* cone 5 clear base, G9. Then continue this process by blending 80% of the high-fire glaze G17 with 20% of the cone 5 clear, G9. As you continue increasing the proportion of the cone 5 glaze to the high-fire glaze, you will gradually lower its maturing point. The surface color and texture of the glazes will also be affected: One glaze will be matt and the other a gloss glaze.

Using this method of testing, you will also be able to explore the wide ranges of glazes between cone 05 (1915°F/1046°C) and cone 10 (2377°F/1303°C). You can best understand this process by following through a line blend test. The test shown in the following table uses two *Hands in Clay* glazes, G1 Clear and G3 Blue.

Sample Line Blend Test

Base Glaze Clear G1	***100%***	***Base Glaze Blue G3***	***100%***
Test 1	90%	Test 1	10%
Test 2	80%	Test 2	20%
Test 3	70%	Test 3	30%
Test 4	60%	Test 4	40%
Test 5	50%	Test 5	50%
Test 6	40%	Test 6	60%
Test 7	30%	Test 7	70%
Test 8	20%	Test 8	80%
Test 9	10%	Test 9	90%

Note:
If necessary, the percentages shown in the chart can be changed to grams, pounds, ounces, spoonfuls, tablespoons, cups, liters, quarts, gallons, or any other measure you wish to use. For example, 90% can equal 9 grams, 9 ounces, 9 spoonfuls, or 9 cups, and so on.

EXPLANATION OF LINE BLEND TESTING First, the two dry base glazes (G1 and G3) were mixed in 200-g batches and were scooped into 1-pint (.48-l) plastic containers ~~with 5 oz.~~ (151.35 ml) of water, and shaken up until all the chemicals were blended. Then the glaze G1 Clear was painted on a test tile and identified as Test G1, and G3 Blue was painted on another test tile and identified as Test G3. When fired, these test tiles showed what the base glazes looked like.

Now the line blend testing began: Nine jars, each 1 oz. (30.27 ml), were marked (Test 1, Test 2, Test 3, Test 4, Test 5, Test 6, Test 7, Test 8, Test 9). Test jar 1 was placed on a gram scale, and using a slip trailer to transfer the glaze from container G1 to the test jar, 9 g (90%) of glaze was dripped into the jar. Then 1 g (10%) of G3 was dripped into the same jar. The two glazes were mixed and painted on a test tile. This process continued with Test 2—by taking 8 g (80%) of G1 and blending it with 2 g (20%) of G3—on through Test 9, incrementally changing the proportions as shown in the chart. These test tiles were then fired to cone 05.

If you see lumps of chemicals floating on top of your liquid glaze, that means it is not thoroughly mixed. For faster and more thorough mixing of the base glazes, you can use an electric kitchen blender. Hot water will also help to dissolve sticky clays and chemicals such as bentonite, macaloid, or gums that do not disperse easily when mixed. You can also screen the glazes through a 50- to 80-mesh sieve. Oxides or stains that are not thoroughly ground can show up on test tiles as spots. To avoid this, use a mortar and pestle to grind the glaze components.

Fluidity Test

Mark your glaze tiles with a line lightly scored into the clay or with a black underglaze pencil, halfway or a third of the way down the test tile. (Use the lower section for marking the cone number, glaze components, glaze number, or firing atmosphere; e.g., *OX* for oxidation, *RE* for reduction.) If the glaze travels past the line during the firing, you can see how much it flowed. It is a good idea to fire your tiles set on end at about a 10-degree angle.

Opacity Test

To test the opacity of your glazes, mark each tile with a dark-colored underglaze pencil prior to glazing and firing. In this way you can observe the opacity of the glaze when fired by noting how clearly the pencil mark shows through the glaze.