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<https://doi.org/10.15760/etd.496>

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**ABSTRACT OF THESIS IN CERAMICS FOR PAPER REGARDING THE
DEVELOPMENT OF ENGObES FOR CONE SIX CLAY BODIES**

BY

Sister Rose Marie Strassel

(Sister M. Margaret Elizabeth Strassel)

Abstract approved by

Thesis Adviser

A STUDY OF ADJUSTABLE ENGONES FOR A CONE SIX CLAYBODY
TO DETERMINE THE POSSIBILITY OF A BASIC COMPOSITION
WHICH WOULD REQUIRE FEW VARIATIONS TO HAVE THE ENGONES
FIT WET CLAY, LEATHER-HARD CLAY, BONE DRY OR BISQUE
WARE AND THE APPLICATION OF THESE ENGONES TO THROWN
POTS AND HANDBUILDS

PROBLEM

The purpose of the experiment with adjustable engobes was to find a basic composition for cone six clay bodies which would require less adjustment for varying conditions and types of clay than some formulas suggested in textbooks.

PROCEDURE

Engobes are clays thinned with water to the consistency that best fits the method of application and the type of material to which they are to be applied. They may also be thin coats of clay applied to the surface of pottery to change the color or surface texture. The earliest examples of slip decorations were simply clays of contrasting colors painted on pottery; the secret of glazes came later. Primitive potters everywhere decorated pots with slip decorations of stylized natural forms or with geometric patterns.

The potter using any low fire clay may add colorants, but the colors will be darker than the original clay body. Because most clay bodies for cone six firing are high in iron content, they cannot be made into light-colored engobes. To attempt to lighten the color would change the original clay body too much.

It is obvious to those who have worked with clay, that a single formula for an adjustable engobe to fit clays that are wet, leather-hard, bone-dry or bisqued is impossible, but it was felt that a formula that could be adjusted easily to varying conditions

would be of great value. In the beginning my search started with the accepted idea that four variations would be needed. However, it was found that the basic formula worked well on wet and leather-hard clay and by adjusting the amounts of kaolin and ball clay within the range set by Stull's Limits for Good Engobes, it fitted to the bone-dry and bisque as well.

Ball clay is one of the basic clays for engobes; most ball clays fire light, they are fusible and they adhere well. They, therefore, seemed to be a good material to use in the experiment. However, too much ball clay in the mixture will cause trouble, as ball clay has a tendency to shrink excessively and then the engobe cranes and flakes off. The major problem of the experiment was to determine the proper amount of ball clay to use.

The next problem was to find a suitable variation of the formula for the basic engobe for dry or bisque ware. Clay in this state contains little moisture and because of the uneven shrinkage in drying presents some difficulties, which entailed an adjustment of the formula used for wet and leather-hard clays.

In working with various tables of engobe proportions, it was felt that the major source of trouble might be in the excessive amount of ball clay recommended in some texts, and in the small percentage of bentonite used as a suspension agent and as an adherent. Both materials have high shrinkage qualities that could cause crawling and flaking. It was decided to start with materials that would fit with greenware and leather-hard ware and then adjust them to fit bone dry and bisque. In this way it was discovered that actually only one adjustment to the original formula was necessary.

A SUMMARY OF RESULTS

In addition to finding a basic formula that with only one adjustment could be used successfully for engobes that would adjust to fit wet clay, leather-hard clay, bone dry or bisque ware, there were other observations that were helpful to remember. Chemicals affect colors. Chrome green, for example, will lose its hue when combined with zinc or tin. When the engobes fit the clay, glazes must be tested to fit the engobes and the clay body. One way to do this is to test engobes and glazes first on tiles and then on the pots. Another helpful discovery was that the addition of ten percent of the powdered clay mix used in the ware helped to insure an engobe that worked successfully on different stoneware bodies.

A SIMPLE ENGORE DEVELOPED FOR GENERAL STUDIO
USE FOR WET AND LEATHER HARD CLAY
WHICH MAY BE ADJUSTED WITH
ONLY MINOR CHANGES TO
FIT BONE DRY AND
BISQUE WARE

BY
SISTER ROSE MARIE STRASSEL

A
THESIS
SUBMITTED TO
PORTLAND STATE COLLEGE

IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE OF TEACHING
JUNE, 1968

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ACKNOWLEDGMENT

For many helpful suggestions and valuable criticisms in preparing this thesis, the writer wishes to express indebtedness to Raymond M. Grimm, M.S., of Portland State College, Portland, Oregon.

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PREFACE

There is in all of us a need for self-expression. The complex and highly mechanized society that has everything on the shelf ready for the taking, leaves a void in the lives of many people, particularly in urban areas. A deep-rooted need for individual expression has revived an interest in folk arts of all kinds; among these is pottery-making. Art classes almost everywhere give evidence of this interest.

To make something that is one's own is the longing of any creative person, even those without particular skills, as well as the serious craftsmen. Almost every facet of life has been touched by assembly line methods of the machine age. The old adage that "there's nothing new under the sun" does seem to drive some artists to a kind of frenzy to prove its fallacy, but for the most part, the potter works at his art and ignores the fads that come and go. He observes the world around him, toils at his craft, improves his skills, and one day inspired by a great idea and helped by his experience, he expresses it to his own satisfaction in a new way. From craftsmen before him he learned to use his tools and to perfect his techniques and then the spark of his creative spirit enkindles the inert matter. To be creative and original is but the beginning, the real artist has talent and has developed his skill.

Perhaps the term, "folk art" is not apt for present day ceramics, but the fresh charm and honesty of such work is still worth striving for. It takes years to develop as an individual, and to break away from the plentitude of visual expression imposed on modern society,

to express a new idea. Many do not reach the height of individual work, they come to terms with the demands of the public, who "know what they want". It takes courage to break out a new form; to shuck off the safe; to plunge into the unknown, and have sufficient confidence to express oneself in a different way. Surfeited, affluent twentieth century people often have nothing to express.

Today discerning individuals, who collect early American pottery, pay particular attention to the slip ware which brightened the often drab homes of the early settlers. Perhaps a mobile people constantly exposed to the "newest new", experience a nostalgia for the past.

The simplicity of the lives of the early settlers did not dull their sense for color, which was so often delightfully used in naive, highly-decorated slip ware. A paper on engobes must pay tribute to the skill and honest expression of these early American artists. In this paper I shall confine my remarks to Pennsylvania slip ware.

PENNSYLVANIA GERMAN SLIPWARE PLATE¹

¹ Life Editors, America's Arts and Skills, (New York, 1967), p. 59.

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CHAPTER I

EARLY AMERICAN (PENNSYLVANIA) AND MODERN AMERICAN TRENDS IN CERAMICS

Most of the early American pottery comes from Pennsylvania, Virginia and the adjoining North Carolina. New England has some, but the folk art with which we are most familiar was the work of the early settlers of Pennsylvania. In that state there is good quality kaolin which was used as a slip, as well as common red clay. Designs were trailed on the red clay body by means of a slip-cup into which was inserted a quill.² By placing a finger on the air hole in the stopper, the slip trail could be controlled. Nearly every nature form appears in these early pottery decorations. Birds, animals, flowers, and fish were commonly used; in addition, dots and scrolls were popular. Because the slip-flow is rapid, there was no time for the artist to dally with his design, which was often naive, but always free and alive.

Potters decorated the redware with slips in splotches, streaks and with variegated effects. Plain or solid colors were the exception. Iron, manganese, and copper were the common colorants. Blue was rarely used, as cobalt turned black on the red clay. Occasionally the whole pot was given a basic color coat of light engobe. On this type of pot, cobalt was used as well as other dark slips, as they would retain their coloring over the engobe.

In general the early ware consisted of utilitarian objects of everyday use, but which nonetheless reflect the simple tastes

2 A slip-cup was a cup-like device to hold liquid clay.

of the new settlers. Today collectors seek this old redware, even though the lead glaze has a tendency to chip, and the clay body is often too soft. These defects are attributed to the crude materials and to the wood-burning kilns that were hard to control and to bring to the proper heat for stoneware.

In time the arrival of more experienced potters to the settlement enabled the pioneers to improve both the composition of the clays and the kilns. Finer clay belts were located, and these combined with the red clays already in use, made a clay body that could withstand high temperature. Stoneware was popular among the German settlers, especially the slip decorated redware. Actually it is still produced, but in limited quantities.

Turning from early American settlers to the artists of the twentieth century we find that they can and do enjoy and recreate from the beauty of the past. In addition, the incredible speed of communication makes it possible to adopt new ideas almost immediately and blend them with the old to develop new forms.

Today we have in America, especially on the West Coast, in addition to European roots, early American practice and twentieth century taste, a fresh Japanese influence. This attraction to the art of the Far-east has grown since the war. Pottery reflects these changing times, but it also allows for great freedom of thought and expression. Daring individualists and far-out groups coexist with schools which teach basic forms and skills necessary for good craftsmanship in this ancient art.

The simple but very sophisticated taste of the Japanese has influenced pottery making. Simplicity and directness in decoration

are replacing the multicolored, detailed style that reflect European traditions. Even some architecture shows the effect of of the Orient. Rather austere rooms have areas set apart with dividers, units of adjustable shelving, or deep window ledges to provide a good setting for ceramic treasures. People with taste seem to have a growing appreciation for good design, rich and subdued color. The interest in ceramic and art shows, or sales, indicate a renewed esteem for the work of a craftsman rather than for the cheaper, shoddier factory-made copy.

Today some ceramists seem to use color with the same freedom that is common in other fields even outside of Art. There is room both for the subtle earth tones of the Japanese shibui stoneware, and for the bright colors. However, in pottery, sheer color seems to be gaining over subtlety of color, provided it is color with good design. Good design both of pot and its decoration are essential. The decoration should enhance and emphasize the structure. It is not an end in itself. It must not be added on like the icing on a cake. There must be in the use of engobes or slips something of the quality of Japanese folk art, if one can take the liberty of adding to the list of colors, the bright colors so much enjoyed today.

There is in this art a solidity and strength, a simplicity and directness which are very refreshing. The colors are usually rather somber -- black gray, dark browns, dark blues and dark greens being common -- and ornaments are simple and abstract. The whole effect is one of plain functional beauty which avoids ostentation, and in that way is quite different from much of the folk art of Europe, which tends to be gay and colorful and to show a far greater variety of design.

3 Hugo Munsterberg, The Folk Arts of Japan (Vermont, 1959), p.30.

The dash of Oriental spontaneity in the Japanese seemingly-casual application of quiet color to accent one area, has been popular in this country. The bright colors traditional to European pottery have long been an influence. American potters have the opportunity to integrate the best features of both east and west.

CHAPTER II

DEFINITIONS OF ENGOBES OR SLIPS

Engobes and slip are two terms used quite commonly by people interested in pottery. However, there seems to be a need for a precise definition of these terms. Consequently, before undertaking a description of the actual research entailed in developing the new formula, I shall attempt to define them in exact terms.

Engobes or slips are natural clays or mixtures of clays, fluxes, and non-plastics which are applied in a thin layer on a ceramic body to form a smooth coating; perhaps to cover defects in the clay body, or to change the color of the ware.⁴ Sometimes a distinction is made between engobes and slips; in which case, the engobe is considered a complete covering which is either poured over the pot, or into which it is dipped. The slip then is the decorative material, when it is applied with a brush, trailed with a syringe, or poured over only a part of the pot. When a glaze has been applied to an engobe, the engobe then may be called an underslip.

Each type of clay used in an engobe has its own good qualities; a combination of several may work successfully while one alone will not adapt to the particular ware. Only by patient and repeated testing and by keeping orderly notes will it be possible for the potter to work with ease and accuracy. Accurate records of experiments make it possible to duplicate a success and avoid a failure.

⁴ Cullen W. Parmelee, Ceramic Glazes (Chicago, 1948), p. 240.

CHAPTER III

BASIC ENGOBE COMPOSITION

An assignment to find an engobe to fit a cone six stoneware clay body made me realize the difficulties involved in fitting light-colored engobe clays to a dark or red clay body. The problem lies in finding the right proportions in mixing the light-burning clays so that they will shrink at the same rate as the dark clay body. I did my preliminary work on engobes the standard way by using the proportion table suggested in Parmelee's Ceramic Glazes.⁵

I did considerable work with the clays in actual use in the Portland area in an attempt to find a good light color that would adhere to the dark, cone-six body. Basically, lightness of color is desired so that colored oxides will show to advantage. Whiteness is obtained by combining clays, but they must be so adjusted that they shrink at the same rate as the dark clay body. In general, kaolins provide whiteness and reduce shrinkage, while ball clays add strength, but cause more shrinkage. Most engobes average between forty and seventy percent of these two clays. The proportion which I found most successful had no more than fifty percent of the two clays. Only ten percent of the fifty was ball clay. This fact prompted me to experiment further to ascertain whether a set formula could be established, and was the basic idea that encouraged me in the thought that it might be possible to eliminate some of the formulas in the standard tables.

⁵ R. T. Stull, quoted in Parmelee, p. 248.

Experience in engobe making taught me that too great an amount of ball clay caused excessive shrinkage, which in turn resulted in crawling and crazing. Because ball clay provides plasticity and has great adhering powers, it was too useful to omit. When the amount of ball clay was reduced to ten percent, there was no further crawling, and the engobes fitted well on the dark clay bodies.

The simplest of all engobes is one made by adding oxides to the clay body used in the ware. This is easily done by pulverizing an amount of that dry clay and sieving out the lumps left in the resulting clay powder. To the dry measure is added the percentage of colored oxide chosen, after which the two are blended thoroughly. Enough water is added to make a thick solution which is again sieved several times through a sixty-mesh or eighty-mesh screen. The drawback to this method is the fact that the only colors that may be used must be darker than the clay of the pot. It is impossible to alter a dark clay body to a light clay without greatly changing the formula.⁶ Because of this, a separate formula must be followed when applying white or light-colored engobe to red or dark clay. It must also be kept in mind that the engobe will have to be applied while the pot is still quite damp or the difference in shrinkage will be too great to work satisfactorily.

If engobes are needed for red clay bodies which are commonly used in the Portland area, they must be adjusted to shrink the same amount as the clay body. Light burning clays must be chosen, if colors are to show. Exact engobe formulas are not as necessary for

⁶ Daniel Rhodes, Clay and Glasses for the Potter, (Philadelphia, 1957), p.160.

successful slips as they are for glazes, but their composition must stay within certain limits. Because the characteristics of light burning clay are so different from dark clay, it is a matter of testing to find which combination will fit satisfactorily. This step is very important.

Basic Engobe Composition

The materials used in engobes are usually chosen from the following basics: (1) clays, (2) fluxes, (3) fillers, (4) hardeners, (5) opacifiers, and (6) colorants.⁷ The basic proportions for good engobes were chosen from Stull's Limits for Good Engobes found in *Parmelee*. Three formulas were listed, those used in this paper were chosen from the first list, but locally available materials were substituted for the brand names of materials in Stull's list shown in Table I.

My tables were adjusted from proportions I chose from Table 1, but under only two stages in the process. By experiment I discovered that I could accomplish the same results with this much simpler process. The fact that I could find no record of previous experiment in this regard made my experiments more meaningful.

Tests on tiles early in this project showed that the engobe formula for leather hard clay worked as well on wet clay. Although not stated in Table 1, but implied, I checked it for accuracy.

However, my own find was that the formulas for bone dry and

7 Rhodes, pp. 160-161.

bisque ware with slight adjustments, which will be indicated later, could be reduced to one formula.

TABLE I
STULL'S LIMITS FOR GOOD ENGOBES⁸

	On biscuit body	On leather- hard body	On bone- dry body
M.G.R. English china clay	15%-25%	25%-65%	15%-25%
English Cornwall stone	25 -55	5 -50	25 -55
Ohio Flint	15 -50	0 -45	20 -50
Pike's No. 20 English ball clay	10	10	10
Sodium Carbonate	1	1	1
North Carolina kaolin	15%-25%	55%-65%	15%-25%
English Cornwall Stone	15 -55	5 -25	25 -45
Ohio flint	15 -50	0 -30	25 -40
Pike's No. 20 English ball clay	10	10	10
Sodium Carbonate	1	1	1
North Carolina kaolin	15%-25%	55%-65%	
Brandywine felspar	15 -55	5 -30	
Ohio Flint	15 -50	0 -30	
Pike's No. 20 English Ball clay	10	10	
Sodium Carbonate	1	1	

These two sets of proportions remained constant for all the tests with one exception. For all tests carried out on cone six dark clay, ten percent of that clay was ground into powder and added to the engobe; for all tests run on Portland State Clay, ten percent of that clay was added to the formula. This addition was to help assure a good fit of the engobe to the clay body then being used, and was over and above the weight of the batch mixed. For better adhesion to the ware and for a toughening agent, I added one percent of sodium carbonate to the basic mix and blended all thoroughly. This particular formula will be found on Table 2; the proportions are my own, and will

⁸ Parmelee, p. 248.

not be found in any text exactly like this.

The dry kaolin or china clay and ball clay and other materials require careful weighing and thorough mixing, and if possible, sieving through a forty-mesh screen. This basic mix is then divided into as many parts as there are to be colored engobes. To simplify work, the amounts should be kept in round numbers (500 grams, 1000 grams). To each part of the basic mix is added the required percentage of colored oxide, this weight is over and above the engobe weight. The dry materials are then thoroughly blended; enough water is slowly added to make a rather thick creamy slip. Several sievings through a finer screen (fifty to sixty mesh or finer) will result in a well blended engobe ready for use.

Engobes should be stored in tightly covered containers in a creamy consistency. (Plastic cottage cheese containers with their tight fitting tops are just the right size). All engobes work better after some days, since the chemicals and clays can dissolve completely and they spread more easily as a consequence.

All engobe containers should be labeled carefully. Sample labels are given below:

Cone Six Blue Engobe
for Wet and Leather Hard Clay
10% Quarry Tile added

Cone Six Green Engobe
for Bone-dry and Bisque Clay
10% Quarry Tile added

Next in importance to the kaolin and ball clay is flint, which is sometimes called a filler. Flint is non-plastic and consequently reduces shrinkage. It has the added advantage of improving the whiteness of the engobe, thus helping the colors when added. Flint also has the property of hardness which helps with the glaze fit.

One percent of sodium carbonate aids adhesion and therefore also helps toughen the slip. The fluxes for engobes designed for firing at higher temperatures (cone one to cone ten) are ordinarily feldspars. Cone six is a stoneware temperature so the engobes were also adaptable to reduction firing in the gas kiln. (It may be well to mention here that these engobes will not mature in the low fire range, that is, in the cone 012 to 01 range.)

Some may wonder what the difference is between an engobe and a glaze. Essentially the difference is in the much greater amount of glass-forming material in the glaze. Engobes have the following characteristics which do parallel some of those of glazes, but the end result is not the same. Engobes must (1) cover the ware smoothly (2) this covering must cling to the ware during the shrinking stage which accompanies the drying and firing (3) the engobe must mature at about the same temperature as the ware (4) the engobe must maintain its color under the applied glaze without dissolving and without cracking or peeling.⁹

Glasses differ since they are transparent and glasslike, because of this they take much less oxide if they are colored. Engobes are clay for the most part, and require greater percentages of oxide for good color. Of themselves engobes do not have a glossy appearance, and are disappointing. However, the potter knows that spectacular results will follow when semi-mat or bright glaze transforms the pot during the glaze firing. The mat glaze will mute the colors; the bright glaze will show them in their full, rich intensity.

⁹ Rhodes, p. 160.

Only after the second firing, will the potter be rewarded. A thrill that never wears off will be his each time the kiln is opened on the transformed clay he placed inside.

QUARRY TILE CLAY PITCHER decorated with
black, white and blue (cone six) engobes.*

* This picture and all succeeding ones were taken by me of my work.

CHAPTER IV

BASIC ENGOBE PROPORTIONS AND THE COLORANTS USED IN THESE EXPERIMENTS

From early tests based on Stull's list, I found the most suitable proportions for engobes for my work to be those listed in Table 2. I narrowed the proportions from the wide range found in texts. I found that the short range was easier to control and keep in balance.

TABLE 2

BASIC ENGOBE PROPORTIONS USED IN THIS EXPERIMENT

MATERIALS USED	WET AND LEATHER HARD ENGOBE	BONE DRY AND BISQUE ENGOBE
Kaolin (China Clay)	40 grams	20 grams
Cornwall Stone Feldspar	35	30
Flint	25	30
Ball Clay	10	10
Sodium Carbonate (soda ash)	1	1
Quarry Tile or 50-50 Clay or Portland State Clay	10	10
Zirconium (for white only)	20-50	20-50

Even with the right proportions, it is important to choose materials for engobes carefully.¹⁰ Some of the necessary properties are:

1. Lightness of color to make the oxides show well.
2. Covering qualities to hide any body defects
3. A smooth colloidal consistency, thick enough to hold non-plastic materials in suspension, but thin enough to allow easy application to the ware
4. Adhesive quality, which will make the engobe stick to the ware when it is dry

¹⁰ Parmelee, p.243.

From Table 2, it can be seen, that the clay content for the wet and leather hard formula was about fifty percent of the total. For application to bone dry and bisque ware the clay content was decreased to thirty percent, while the flint was increased slightly. I found that lowering the china clay helped to reduce shrinkage thus aiding the fit to the much dryer body. If there were trouble with shrinkage flint could be increased, but I did not find it necessary to do this in my tests.

To check the engobe color, tests must be run on tiles, using the same clay body as in the pot to be decorated. Since many clays are dark, a good white engobe is essential, the basic formula will give an off-white effect, but an opacifier¹¹ must be added to strengthen the white, and to prevent it from disappearing when applied with a single stroke of the brush. Tin is the best opacifier, but is expensive and reacts to some oxides and affects the color of the engobe. Tin will cause chrome, that is usually green, to become a muddy brown. To avoid expense and possible adverse effect, zirconium oxide was substituted. It is not as strong as tin, and its color is somewhat harsher but I considered the advantages of using it outweighed its minor defects.¹²

Colorants are also affected by temperatures and by oxidation and reduction firing atmospheres in the kiln. A rich copper red may be obtained only at high reduction firing temperatures, but yellow

11 Opacifiers are chemicals that do not dissolve in the glaze firing, but remain suspended and so appear white.

12 Rhodes, p.124.

disappears in this temperature. Black, which is not a problem at lower temperatures, often turns brown or blue at stoneware temperatures depending on other glaze chemicals which may "pull out" the cobalt or manganese used in the black. In reduction firing, chromium oxide proved the best source of green, but the amount used has to be kept at a minimum since this colorant tends to become heavy and unpleasant. In combination with cobalt and iron a good blue green results, and for general use, I considered this the most pleasing green.

In oxidation firing, copper is probably the best source of green, especially since lead enhances the green colorant. Many low fire glazes contain tin or zinc; separately they change chrome green into a brownish grey, together, they sometimes give the chrome green a pinkish brown color. By using copper oxide instead of chrome the problem is avoided.

In the matter of color the main problem in dealing with dark clays, is to obtain sufficient whiteness in the engobes. It is not as simple a matter to solve this problem as might first appear. I found that thick coats of white engobe either poured on, or applied by dipping, would come through the firing well, but single brush stroke decorations disappeared in the glaze firing. To discover how much opacifier was necessary in order to get a good white, strong enough to be used effectively in single brush stroke decorations, I carried out a number of tests.

To avoid the expense of tin, and the adverse effects of both tin and zinc, I decided to try a method suggested by Carlton Ball,¹³

¹³ Carlton Ball, Decorating Pottery With Clay, Slip and Glaze (Columbus, 1967), p. 61.

which was to use zirconium oxide, as an opacifier, which is not common practice. To do this, I divided a dry batch of engobe into five parts and tried varying amounts of zirconium oxide with each. I used ten, twenty, thirty, forty and fifty percent of zirconium oxide. Each of the five tests was thoroughly blended, mixed with water and sieved in the usual way. All five tests were applied in vertical strips and carefully labeled. After bisque firing three good glazes were applied in horizontal strips over the white engobes. The results of the five tests were good; the zirconium had no ill effects on either engobe or glazes, even when used in large amounts. As many texts suggest, the addition of less than one percent of cobalt to the batch improves the white quality, much as bluing improves a rinse.¹⁴

In order to determine what percentage of oxides I should add to the dry weight of the base engobe to get the desired color, I ran a series of tests using Glenn Nelson's *Guide to Use of Colorants*.¹⁵ These percentages were adapted to fit my needs. Table 3 shows my adaptation.

The percentages of oxides given in Table 3 added to the dry weight of the base engobe should give the colors indicated. Some oxides in combining with others form a more subtle color variation. As has been stated previously, all engobes with colors added should be tested on tiles before being applied to pottery. Clay bodies differ so greatly that results will vary.

¹⁴ Parmelee, p.266.

¹⁵ Glenn C. Nelson, Ceramics, (New York, 1960), p.114.

TABLE 3

GENERAL GUIDE FOR USE OF ENGOBE COLORANTS

Oxides	Percent	Color
Cobalt Oxide	1-3	light to dark blue
Nickel Oxide	1-2	muted blue
Cobalt Oxide	2-3	
Cobalt Oxide	2	warm blue
Iron Oxide	2	
Iron Oxide	10-15	iron brown
Manganese Dioxide (more than 5% may bubble)	5	purple brown
Rutile	3-5	tan
Iron Oxide	2	tan
Iron (reduction firing)	2-3	green
Copper Oxide (oxidation) (above cone 8 copper volatilizes, and in reduction turns red)	5-8	green
Cobalt Oxide	2	black
Iron Oxide	8	
Manganese Dioxide	3	
Chrome (oxidation) (may turn pink if tin is present or gray if zinc is present)	1	green
Black cobalt	1	blue green
Red Iron Oxide	2	
Chrome Oxide	1	

Since Portland State College has a reduction kiln, as well as an oxidation kiln, in doing my testing, I found myself thinking in terms of both types of firing, even though I was actually using cone six firing, the lowest stoneware temperature. Most engobes work as well under either firing, but black engobes often show brown or

blue under these temperatures. While trying to find some further information about oxides in order to improve the usual proportions suggested in pottery books, I found some different proportions in Koenig's Abstracts.¹⁶ I decided to try them to see if they would be a help for general studio use, and to compare results.

KOENIG'S FORMULA FOR A BLACK COLORANT

Cobalt	11.0
Chrome Oxide	7.0
Iron Oxide	36.2
Manganese Oxide	12.0
Nickel Oxide	12.8

In order to blend the black colorants thoroughly and grind the particles finer, I ground the oxides for seventy-two hours in a ball-mill with just enough water to wet them well. Because this material was wet, it was kept in a closed container and measured in cubic centimeters. Since my engobes were for stoneware and general studio use at Portland State College, I tested them at cone six oxidation firing and at cone ten reduction firing. The basic formula is the same, but the colorants vary with the kind of glaze used and with the temperature and kiln atmosphere. Information concerning cone ten reduction firing of engobes is contained in the appendix of this paper.

The formula appears below.

FORMULA FOR CONE SIX ENGOBE (BLACK)

500 gm base engobe
 50 gm Quarry Tile or 50-50 Clay
 100 cc ground oxides

¹⁶ J. H. Koenig and W. H. Earhart, Literature Abstracts of Ceramic Glazes, (Philadelphia, 1961), p.247.

In preliminary testing I used many colorants, but I made a careful record of engobes using the following proportions. I set a thousand grams as the basis for each color and added the percentages of oxides shown in Table 4. The weight of the oxides is over and above the weight of the basic formula selected. To the dry weight of each batch I added ten percent of the clay used in the body of the ware, over and above the batch weight of the base formula.

TABLE 4
OXIDE PROPORTIONS USED IN THE EXPERIMENT

	BLUE GREEN	GREEN	BROWN	IRON GRAY	BLUE	WHITE	BLACK
RED IRON OXIDE	2			4	2		8
COBALT BLUE		1		2	2-3	$\frac{1}{2}$ (.005)	
MANGANESE DIOXIDE			5				3
CHROME OXIDE	1 $\frac{1}{2}$	5					
ZIRCONIUM (OPAX)						10-50	
BARNARD CLAY			25				
BLACK COBALT	1						2

To obtain a good black for reduction firing, the special formula already described was used, and the ball mill procedure was followed.

ENGOBED 50-50 CLAY BOWLS, fired to cone six; showing semi-mat and glossy glazes.

QUARRY TILE CLAY BOTTLE, decorated with black and white engobe and glossy glaze.

CHAPTER V

THE TESTING OF ENGOBES AND GLAZES

To obtain a good combination of engobes and glazes I made a preliminary experiment of a line blend on Portland State College Studio clay. Eight tiles about nine inches by nine and nearly half an inch thick were rolled out, five columns were lightly scored in order to keep the rows of engobes and glazes separated. As soon as one tile was stiff enough to accept engobes an inch and a half band of each color was painted from the top to one and half inches from the bottom. The space was left for labels.¹⁷ The process was repeated on a second tile, when it was leather hard, on a third when it was bone dry. When all four tiles were dry, they were bisqued; the fourth tile was then painted with engobes designed for bisque firing. All preliminary tests used Portland State Studio clay. The results of the tests were helpful. Not all the engobe colors were good and adjusting was necessary when dark clay was used, but in general they showed that the combinations of engobes, glazes and clay body were good. In addition, this test of colored slips showed that the coating of engobes should be fairly thick.

In later tests the process was simplified because of my discovery that two sets of formulas could be used instead of three. Originally, one formula worked well for wet and leather hard clay, a second was needed for bone dry ware, and a third for bisque ware. By further testing I found that I could adjust the proportions within

¹⁷ Ball, p.61.

the limits set by Stull, so that one engobe proportion worked for bone dry clay and for bisque ware. This adjustment expedited all the rest of my testing. A suggestion of Parmelee¹⁸ that ball clay be kept to no more than ten percent of the formula also proved particularly helpful.

Once the basic engobe mix has been made, the batch may be divided into smaller amounts for the addition of the oxide colorants. One thousand grams of dry engobe will make a generous amount with which to work. This amount will make over a quart of wet engobe and will fit neatly into two quart jars -- cottage cheese plastic containers are especially suitable. The colorants are thoroughly blended into the other dry materials for all engobes. It is important to label each container since the appearance of unfired colors is deceptive.

The proportions listed at the bottom of this page and at the top of the next page were among those tested successfully at cone six in oxidation firing with the addition of ten percent of the same clay as the body of the ware. In reduction firing ten percent of Portland State Studio clay was substituted with good results. There are endless combinations of colors that may be tried, but I am listing six different colors used in my tests, which are typical.

Typical Engobe Formulas

Blue Green Engobe

1000 grams base engobe
2% red iron oxide
1% black cobalt oxide
1½% chrome oxide
10% clay in ware

Green Engobe

1000 grams base engobe
5% chrome
1% cobalt (softens green)
10% clay in ware

¹⁸ Parmelee, p. 244.

Brown Engobe

1000 grams base engobe
 5% Manganese Dioxide
 25% Barnard Clay
 (a greater percent of Manganese
 may bubble)

Iron Gray Engobe

1000 grams base engobe
 2% cobalt oxide
 1% iron oxide

Blue Engobe

1000 grams base engobe
 2 to 3% cobalt
 2% iron to modify color
 (or use manganese instead
 of iron)

White Engobe

1000 grams base engobe
 10-50% zirconium silicate
 or opax
 1% cobalt to improve
 the white
 (this is $\frac{1}{2}$ of one percent)

In addition to testing the colors on Portland State Studio clay, it was necessary to run tests on other available clays. The most successful tests were on the Imacco clays distributed by the Art-Pak Products Company in Portland. These clays are air-floated in the huge Raymond Mills in California. This process enables the various clays to be the same in every shipment, which is no small factor in making possible a duplication of ware.

Quarry Tile Clay is dark red, pleasant to work with and fires from cone 04 to cone 8. Three sets of tiles for testing were made; one set with engobes in the wet and leather hard state, a second for bone dry. To show thick and thin application one half of each tile was covered with a heavy coat of engobe, the other half given a simple design with a thinner, one brush stroke of engobe. All the tiles were bisqued, then the third set was engobed. By experiment, I discovered that I had to dampen the bisque tiles first so that the engobe would spread evenly.

The second type of Imacco clays used is called the 50/50 Mix,

it is half Quarry Tile and half Off White Special Mix. It fires from cone 04 to cone 10. For general use it gives a better color, it fires to light red and responds to the engobes with more pleasing results.

The last clay tested was a blend of one half Quarry Tile and one half Portland State Studio Clay. This test was run to try to improve the color of Portland State Studio clay for oxidation firing. The results were not as pleasing in color as those achieved with 50-50 Clay.

The engobe tiles now had to be glaze tested. The first strip on each tile was left unglazed to show the engobe by itself. For cone six firing the glazes used were, Tizzie, La Matt¹⁹ and Rhodes #14 Transparent Colemanite.²⁰ The engobes of the half Quarry Tile and Portland State Studio blend were given a different treatment. The tiles were covered with one thick coat of engobe and tested with six glazes at cone six. I tried both mat glazes and glossy glazes. Because the colors on these tiles were less interesting than those made with the other clays, no further work was done with this blend.

Completed ceramic pieces of rich Quarry Tile Clay and of 50-50 Mix were quite pleasing. Personal taste would incline some people to choose the muted tones obtained with semi-mat glazes, others to prefer the richer effect resulting from the use of bright glazes. I prefer the glossy glaze which tends to bring out the rich red brown of the 50-50 Clay; while the Quarry Tile Clay becomes a deep brown.

19 F. Carlton Ball, Mimeographed Notes from College of Arts and Crafts, (no date) California.

20 Rhodes, p. 210.

CHAPTER VI

THE APPLICATION OF ENGOBES AND GLAZES TO THREE TYPES OF WARE

The tests in the previous chapter were to establish that the clay of the engobe would match the clay of the body and to find suitable colors and glazes for particular cone six clays. The actual application of the engobe to the body of a pot is much different from the application to the flat tile surface. The test tiles show the possibility that engobes can be applied to certain bodies, but the tiles do not require the technique it takes to make the engobes adhere to a pot without crawling or crazing. This chapter will report some findings about applying engobes to wet and leather hard, bone dry and bisque ware and point out some techniques acquired through practice.

Pots that are newly thrown and which require a minimum of trimming may be set aside for an hour or two, and then decorated with engobe, providing that they are dry enough not to collapse from the extra moisture. Because of the danger of damaging the decoration, it is safer to decorate them after they are trimmed. I found that:

- (1) Quite a heavy coat of engobe may be safely applied to a wet or leather hard pot. One may pour engobe on, dip the pot, or syringe engobe over areas;
- (2) After ware is really bone dry, only engobe designed for that state should be used. Bone dry ware must have a thinner engobe decoration compared with that which may be placed on leather hard ware or the engobe will curl off;
- (3) To apply bisque engobe to a bisqued pot, it is better to dip the pot in water first.

On damp bisque, the engobe will spread better and a much smoother effect may be obtained. A completely dry pot sucks the water from the slip instantly, and causes the engobe to chip off the surface. On bisqued ware, brushing is one of the best ways to apply decoration. Thinned engobe may be poured quickly over an area, but thick application with a syringe is not satisfactory.

There are numerous ways of decorating pottery with engobe; much can be learned from the many excellent texts now available. Some of the best of these, as well as some of the periodicals to which the leading potters of the country contribute articles, are listed in the bibliography.

Tile testing of engobes and glazes, too, is really much simpler than the actual application to a piece of pottery. Apart from all other considerations, color on a test tile seldom looks the same as a mass of color on a piece of pottery.

I am including in the following pages of this chapter, the formulas for glazes that I used satisfactorily for cone 6 in oxidation firing.

TWO BRIGHT GLAZES FOR CONE 6 OXIDATION FIRING

TIZZIE GLAZE c/08 to c/9 Oxidation²¹

Flint	463
White Lead	1500
Kingman Feldspar	300
China Clay	420
Frit 312½	570

Tizzie Glaze is fluid, shiny and enhances the red clays used in

21 F. Carlton Ball, Notes.

these tests. Since there is no tin or zinc in the formula, there was no color problem.

Rhodes #14 Transparent Colemanite c/6 Oxidation²²

Kingman Feldspar	1320
Colemanite	522
Barium Carbonate	555
Whiting	216
China Clay	72
Flint	315

This glaze is similar to Tixie, but does not require the frit that is necessary for that glaze. Again there is neither tin nor zinc. Rhodes suggests cone four but it works well at cone six.

TWO SUCCESSFUL SEMI-MAT GLAZES FOR CONE SIX OXIDATION FIRING

Newcomb Mat c/04 to c/9 Oxidation²³

Lead Carbonate	1310
Feldspar	840
Kaolin	1000
Flint	180
Zinc Oxide	100
Whiting	200

This is a dependable mat glaze which allow dark engobes to show if the coat of glaze is thin. Because zinc is one of the materials it does not work well over chrome oxide.

L.A. Mat c/3 to c/6 Oxidation Firing²⁴

Kingman Feldspar	1548
Flint	168
Whiting	564
Zinc	258
China Clay	462

22 Rhodes, p.210.

23 E. Carlton Ball, Notes.

24 Ibid.

A good semi-transparent mat that allows colors to show in a muted way. Neither of these two semi-mats enhance red clay. However, they could be used in conjunction with wax resist and one of the bright glazes.

CHAPTER VII

ENGObE MAKING A VALUABLE EXPERIENCE

Engobe making is exacting, challenging, and rewarding. It provides excellent training, and increases insight into, and appreciation for the complex skills of the good potter. The study of engobes focuses the attention of the craftsman on form and structure. It helps him develop a stronger sense of form. Good decoration enhances, and becomes, in a sense, part of the whole. It should never be an encrustation.

While the artist must not allow the decorating to overwhelm the actual structure; while he must not allow a feeling for detail to spoil the design of the pot, yet the very making of engobes requires much detail and patience. It is exacting to exercise constant care to keep in good order the particular engobes which will match particular clays. From the appearance of engobes in their containers, there is no means of telling their final color, so proper labeling after each test is necessary.

In addition, the experimenting potter gradually acquires a more practical knowledge of clays and glazes, and the surprising chemical reactions that occur in firing. Engobe making is good training, and provides excellent experience for any potter, even if his later work does not require the making of them.

I found engobe work particularly rewarding, perhaps because I developed a simpler method of devising proportions than those suggested in pottery texts, and because I acquired some practical

knowledge that I feel would help other student-potters. On paper in words my deductions sound rather insignificant, but in the studio they save hours of time and effort. To restate them: instead of working with three different sets of engobes -- one for wet and leather hard clay, a second for bone dry clay, and a third for bisque ware, by adapting basic proportions in Stull's List to a narrowed range, I found that for engobes for bone dry clay, and bisque ware, I could use the same formula, and thus, eliminate one whole set of tests.

Through experience, I learned that on dark clay the bright glazes enhance both the clay and the engobes. For muted colors, the semi-mat glazes will produce a softer effect, but the clay body will not offer as much contrast as in the case of the dark clay. The oxide percentages can be increased slightly for these glazes, if greater depth of color is desired.

Teachers will find the material detailed in this paper especially helpful since most schools use electric kilns for which these engobes were designed. For potters who have gas kilns, the engobes will adjust readily to that higher temperature and the colors will be still richer because of the reduction atmosphere.

Students who wish to decorate their pottery, but who have not yet a great deal of experience will still need to test thoroughly, but they will find the suggested clays and engobes harmonious, and as a consequence, good results should not be too hard to obtain.

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APPENDIX

BOWL OF PORTLAND STATE CLAY, black and
white engobe. Transparent Grey Mat
Glaze, fired to cone ten. (reduction)

CONE TEN ENGObES AND GLAZES FOR REDUCTION FIRING

The basic materials used in engobes for cone ten reduction firing are the same as those used for cone six oxidation firing; both temperatures are stoneware temperatures. However, the oxides are not always the same. Neither do they act in the same way in this different atmosphere. The glazes must also be changed to fit cone ten reduction firing, and the selection of chemicals must be watched so that none have an adverse effect on the oxides used in the engobes.

The difficulty in obtaining a good black has been explained. While this color presents a problem at cone six it is an even greater one at cone ten. The usual formulas turn blue or brown, so the special mix explained on page 16 was used in the following formula for cone ten reduction engobes. This black worked beautifully on a number of pots that I fired in reduction, and it seemed to me well worth the extra effort involved.

Cone Ten Black Engobe

500 gm base engobe
50 gm Portland State Clay

100-125 cc black oxides (special formula)

On the following pages are given two bright glazes and two semi-mat glazes for cone ten reduction firing. These were tested and then used on a number of engobed pots with very satisfactory results.

TWO BRIGHT GLAZES FOR CONE 10 REDUCTION FIRING

"K" 2 Glaze²⁵

Kingman Feldspar	2016.0
Whiting	270.0
Dolomite	331.2
Barium Carbonate	178.3
Kaolin	185.4
Opax	297.9

"K" 2 Glaze is the best general glaze for clear effect over engobes in reduction firing. The glaze allows the colors of the engobes to come through beautifully and at the same time enhances the clay body not covered with engobe.

Gee Mat Glaze Cone 10 Reduction²⁶

Kingman Feldspar	1120
Nepheline Syenite	820
Whiting	300
Dolomite	180
Barium Carbonate	390
China Clay (Kaolin)	260
Flint	120

Gee Mat Glaze is only slightly mat, and because of this, it seems better to think of it as transparent, or semi-transparent rather than as a mat glaze. However, it does mute the colors more than really clear glaze.

TWO SEMI-MAT GLAZES FOR CONE 10, REDUCTION FIRING

RHODES MAGNESIA, CONE 10 REDUCTION²⁷

Kingman Feldspar	1800
Colemanite	520
Dolomite	280
Talc	600
China Clay	200
Flint	800

25 Frank A. Colson, "Oxide and Wax Resist Decoration," Ceramics Monthly, 15 (February, 1967), 20-23.

26 IBID., pp. 20-23.

27 Daniel Rhodes, Notes, Dittoed Sheet, Portland State College.

This glaze has a slightly milky appearance with a tint of blue.
It allows colors to show well, and is a generally good glaze.

BALL'S TRANS GRAY MAT CONE 9-10 REDUCTION FIRING ²⁸

Dolomite	558
Nepheline Syenite	1350
Whiting	300
Kaolin	822
Flint	460
Opax	110
Zinc Oxide	80

This soft, smooth glaze is really excellent over engobes
and over the clay body as well.

28 Ball, p. 62.