DRY GLAZE MIXING INSTRUCTIONS

SAFETY

The first thing to remember about any glaze in the dry powder form is that it is hazardous as a dust, so you must **take care not to breathe it**. This is true regardless of whether the liquid form of the glaze is rated lead free and non-toxic or otherwise. Therefore when mixing dry glaze always work in a properly ventilated work area and wear a respirator and safety goggles.

PREPARATION

When preparing to mix either a 10 lb. or 50 lb. bag of dry glaze be aware that even though the powder is thoroughly mixed when it leaves the factory the components will tend to segregate as they are shaken about in shipping. The heavier components of the glaze will settle to the bottom of the bag. Therefore, when you are mixing dry glaze either use the entire bag or, if you only want to mix up part of the bag, make sure the entire bag of dry glaze is thoroughly mixed first. One way to mix up the dry glaze is to put it in a clean, dry 5 gallon plastic pail with a sealing lid. Rolling the pail on the floor for a few minutes should sufficiently mix the powder. Do not open the pail lid immediately after mixing; wait a few minutes for the dust to settle. Make sure you are wearing a mask.

MIXING

When mixing a glaze always use a clean vessel whose volume is at least 25% greater than the amount of glaze you expect to finish with. Put 90% of the required amount of water in the mixing vessel. Then immerse the mixer in the water and turn it on. Slowly feed the powder into the agitated water. The remaining 10% of water can be added if the glaze becomes too thick to mix properly. If the additional water is not needed hold it back to the end and add it gradually to adjust the viscosity and density. Mixing should be done with a powered mixer, which can be as simple as a drill with a paddle on the end of the shaft. Manual mixing is not recommended. After the glaze is thoroughly mixed it should be screened through an 80 mesh screen to remove any coarse particles. **Note**: Some dry glazes will come with a small pouch of ingredients labeled "add after sieving". These are materials that produce the speckled effects in the glaze and will not pass through your 80 mesh screen – add them to the wet glaze last and give the glaze a stir.

HOW MUCH WATER DO YOU NEED?

The following recommendations are just guidelines to establish a starting point and the actual quantities required may vary. The following are some typical examples of the amount of water that is required to mix dipping glazes and the approximate amount of glaze that will be made.

Prod. No.	Description	Ratio of water to Dry Glaze by Weight	Qty of water per 10 lbs. of dry glaze	Approx. Qty of Glaze made
700-D	Clear Gloss Glaze(06/04)	0.78	7.8 lbs. = 6 ¼ pints	+ 1 ½ Gallons
705-D	Opaque Gloss Glaze (06/04)	0.63	6.3 lbs. = 5 pints	+ 1 ¼ Gallons
850's	Raku Glazes	0.65	6.5 lbs. = 5 pints	+ 1.25 Gallons (4.75 ltr.)
900's	Low Stone Glazes (06/04)	0.65	6.5 lbs. = 5 pints	+ 1.25 Gallons (4.75 ltr.)
1100-D	Clear Gloss Glaze (5/6)	0.65	6.5 lbs. = 5.25 pints	- 1.5 Gallons (5.67 ltr.)
1140-D	Reactive Hi-Fire Glaze (5/6)	0.63	6.3 lbs. = 5 pints	+ 1.25 Gallons (4.75 ltr.)
1420'S	Ash Glazes (5/6)	0.57	5.7 lbs. = 4.5 pints	+ 1 Gallon (4 ltr.)

Prod. No.	Description	Ratio of water to Dry Glaze by Weight	Qty of water per 7.5 lbs. of dry glaze	Approx. Qty of Glaze made
1500's (4 ltr.)	Nova Stoneware Glazes (5/6)	0.76	5.7 lbs. = 4.5 pints	+ 1 Gallon

GUIDE TO ADJUSTING GLAZE VISCOSITY AND DENSITY

Unfortunately there is no perfect set up for dipping glazes that will work in all applications. The goal is to find the right set up, in terms of viscosity and density (specific gravity) that will provide the finish you want to achieve. Ideally for a clear dipping glaze you are trying to deposit the least amount of glaze that will provide a clear glossy finish over the entire piece. An opaque glaze will require a thicker coating of glaze to provide a consistent color and finish. There are several factors that affect the thickness of glaze deposited on a piece. The first is the bisque temperature. The hotter a piece is bisque fired, the tighter the body becomes and the less glaze is picked up by the piece. The formulation of the clay body being used can also affect the tightness or porosity of the piece and therefore the amount of glaze deposited. The other significant factor is the dryness or wetness of the piece. The drier a piece is when it is dipped the more glaze it will be able to pick up. This is particularly important for pieces with a lot of underglaze decoration on them. If the underglaze has not been allowed to thoroughly dry before dipping the decorated areas will not pick up as much clear glaze as the areas of bare bisque and may look rough or partially unglazed after firing. Re-bisquing pieces that have been decorated will help minimize this potential problem.

Due to the great variety of conditions under which dipping glazes can be used, our recommendations for dipping glaze set up should be used only as guidelines. They are generally appropriate. However, to obtain the best results for your particular conditions the first time you use a new dipping glaze you should dip a series of test pieces in order to determine the range of density and viscosity readings that provide the best results. The simplest way to do this is to start with a set up slightly thicker than recommended and add water in small increments, such as 2 oz. per gallon of glaze being adjusted. Dip a test piece and record density and viscosity after each addition of water. Be careful not to add too much water as glazes that are too thin can settle to the bottom of the container. The results of the fired test pieces should show you the range of density and viscosity readings that produce good results.

Specific gravity is a measure of the density of a liquid measured in grams per cubic centimeter. Water has SG=1.0, which means that 1 cc of water weighs 1 gram. To calculate the SG of a glaze divide the weight of the glaze by the weight of an equal volume of water (i.e. weigh 100 cc of glaze and divide by 100 to obtain the SG of the glaze). This can be done easily using a digital scale and a plastic measuring cylinder cut off at the 100 cc mark. Fill the cylinder to the top, weigh it (remember to subtract off the weight of the cylinder) and divide by 100 to obtain the SG.

For a dipping glaze a combination of viscosity and SG is required that will result in the correct thickness of glaze being deposited on the piece in one dip application. The usual range of SG for a dipping glaze is 1.50 to 1.70, the lower end of the range being for clear glazes and the higher end for opaque glazes. Various other factors will affect the determination of the appropriate SG of the glaze. These factors include whether the piece to be dipped is greenware or bisque, the bisque temperature, whether the piece is made from pug clay or casting slip, the moisture content of the piece, and anything else that affects the ability of the piece to absorb glaze. By comparison brushing glazes usually have SG in the range of 1.45 to 1.60.

Glaze viscosity (thickness) can be measured in terms of the number of seconds that a given volume of glaze takes to flow through a hole of a certain diameter. The easiest way to measure viscosity is by obtaining a viscosity cup, also called a Zahn cup, from a hardware or paint store plus a stopwatch. The viscosity cup is a small container with an open top and a bowl shaped bottom with a small hole to allow the liquid, such as glaze, to flow out. The cup has a handle so that it can be dipped in the glaze. Fill the cup to the brim while holding a finger over the hole. Start your stopwatch when you remove your finger from the hole. Record the time it takes until the stream of glaze breaks at the bottom of the cup and only drips remain. The number of seconds is a reliable measure of the viscosity of the glaze.

Dipping glazes generally have viscosities in the 20 to 30 second range, although many of the factors mentioned previously with respect to SG may also call for viscosities outside of this range.

By maintaining the specific gravity and viscosity of a glaze within a predetermined range it is possible to control the thickness of glaze that is deposited on the piece. This is especially important with respect to dipping glazes versus brushing glazes since you do not want to vary the number of coats being applied. Also dipping glazes tend to thicken up as they are used because water is sucked out of the glaze into the bisque as pieces are dipped. Therefore it is necessary to monitor viscosity and SG on an ongoing basis, not only in the initial set up of the glaze.

The control of glaze thickness is essential for the production of consistent, high quality results. Glazes that are applied too heavily or too lightly are the cause of any number of glaze defects including pitting, crawling, color variation and rough spots. The most reliable way to check glaze thickness is with a thickness gauge which can be purchased through an instrument supply catalog. Hold the gauge on the surface of the unfired glaze. When the button is pressed a needle penetrates the glaze to the bisque surface and displays a reading of coating thickness in either millimeters or thousandths of an inch. However for many potters and ceramists the simple scratch test is sufficient. After dipping a test piece and letting it dry, scratch through the glaze down to the bisque with the tip of a knife. The correct thickness of glaze is usually about the thickness of a thumbnail.

Testing pieces to determine the range of glaze thickness that will produce the desired results can save many hours of unnecessary troubleshooting. Once the appropriate thickness range has been determined it can be correlated to a range of viscosity and SG values that produce the correct thickness. Maintaining viscosity and SG within the desired range can usually be achieved by the addition of small quantities of water. There are other materials, such as Spectrum's Glaze Suspender(1071) for thickening and Glaze Thinner(1072), that can be used rather than water. Achieving the proper glaze thickness on a consistent basis through the control of viscosity and specific gravity is one of the keys to avoiding many common glaze defects.

GLAZE TROUBLESHOOTING

SETTLING OUT When a glaze "settles out" some or all of the heavier components of the glaze sink to the bottom of the container. If you try to use this glaze without thoroughly re-mixing it you will be applying a partial glaze with key ingredients missing. A glaze stays in suspension due to the presence of various types of suspenders, such as ball clay, bentonite and CMC gum. One of the common causes of settling out is the addition of too much water to the glaze, which dilutes the effect of the suspension agents causing some of the heavier glaze ingredients to drop out of suspension. Another possibility is the growth of bacteria which will consume any organic materials, such as gum. This is of particular concern in the case of brushing glazes because gum is usually a large part of their suspension system. To prevent bacteria growth do not return used glaze, which has been poured out of the original container, back into that container. Also do not introduce potentially contaminated objects, such as brushes, into the original glaze container. Storing glaze in a hot or sunny environment may also encourage bacteria growth. Freezing can also destroy the action of gum, although in most cases frozen glazes can be gradually thawed and show no ill effects. If a glaze has settled out, but has not gone rock hard on the bottom of the container, it can be re-suspended by the careful addition of Spectrum's 1071 Suspender. After a glaze has settled out and been re-suspended it is generally a good idea to filter it through an 80-mesh screen to remove any coarse particles.

CRAZING Glazes that have crazed show a fine pattern of cracks in the surface of the glaze, just the same as a crackle glaze although the latter is intended and the former is not. Sometimes the cracks are easier to detect by breathing on the piece and fogging the glaze surface. Crazing is the result of a mismatch between the coefficients of expansion of the glaze and the clay body. When the glaze has too high a coefficient of expansion relative to the clay body crazing will occur. The solution is to reduce this difference in expansions. This can be achieved by lowering the expansion of the glaze by adding a relatively low expansion material, such as silica, or by using a higher expansion clay body. You should be aware that delayed crazing can occur hours or even days after the piece has come out of the kiln if the expansion mismatch is close to the limits where crazing will occur. Delayed crazing can also occur over time as porous, exposed clay takes on moisture from the atmosphere – causing the pot to expand slightly, and cracking the glaze surface. Because of the porous nature of earthenware clay, it is not recommended to make earthenware vessels with a "dry foot" ring, but rather to glaze them entirely and fire on stilts. This is not generally a problem with stoneware or porcelain as they are vitreous when fired to maturity.

SHIVERING When a glaze shivers it cracks and pieces of the glaze peel right off the piece, often at the edges of the piece. This is the opposite condition to crazing where the expansion coefficient of the glaze is too low relative to the expansion coefficient of the clay body. One solution is to increase the expansion of the glaze by adding a high expansion material, such as a crackle glaze. If producing both castware and ware from pugged clay, be careful to test your glaze on both. Casting slip often has a different coefficient of expansion than pugged clay and as such it is possible to have a glaze that fits handbuilt or thrown pieces, but shivers off of slip cast pieces.

CRAWLING OR CREEPING When a glaze crawls or creeps it will tend to mound up and expose an area of bare bisque. This often happens in corners where glaze has built up too heavily or has not flowed all the way into the corners. Glaze can crawl because the coat is too thick or because it has not adhered properly to the bisque surface. Improper adhesion can be from bridging, such as in corners, or from the presence of dust, grease, finger oils, or other dirt on the piece. Be careful to clean the piece thoroughly before glazing. Sometimes crawling is a defect of the glaze itself caused by the use of materials that have been too finely ground. Materials that have too fine particle size create an excess of surface tension, which tends to pull the glaze apart. Crawling may also be result of a heavy application of glaze, which is allowed to dry too fast, producing cracks in the unfired surface of the glaze. This will then lead to crawling when the glaze is fired. Putting on thinner coats of glaze and allowing the glaze to dry thoroughly between each coat can resolve this problem. Another possibility is too heavy a layer of underglaze or stain under the glaze. Glaze requires a porous surface to adhere to, so anything that completely fills the pores in bisqued clay, and leaves nowhere for the glaze to seep into can result in crawling.

PINHOLES One of the most common glaze defects is pinholes, tiny holes in the glaze surface that penetrate all the way through the glaze to the body. Pinholes are caused by gases that escape from the clay body during the firing cycle. The gas originates from tiny pieces of organic matter, such as charcoal, which is present in the clay and for some reason has not managed to completely burn off during the bisque firing. The material then attempts to off-gas while the glaze is melting, and gets trapped in the glaze as the surface turns from liquid to solid. For earthenware, the best remedy is to ensure that the piece is bisque fired 2 cones hotter than it is glaze fired (i.e. when glaze firing to cone 05, bisque fire to cone 03). Other possible remedies include: a slower bisque firing cycle to give the carbon more time to burn out; a 15 minute soak at the peak temperature to keep the glaze in a liquid state a little longer; lowering the glaze firing temperature by 1 cone (for earthenware only); or using a glaze with more flux. **

BLISTERS Glaze blisters look like little craters in the glaze surface and may have sharp edges. Possible causes of blistering include: insufficient drying of the piece between glazing and firing; too dense a clay body that traps air in the piece; gas forming impurities in the glaze or body; over-firing the glaze; and a firing cycle that is too fast. The most common type of blisters comes from overfiring. More often than not, people fire without witness cones now. This means that they are unaware of differences in temperature from top to bottom in their kiln (even with the advent of kiln controllers, most kilns are not the exact same temperature from top to bottom). If firing a glaze with a range of firing temperatures (cone 4-6 for instance), then firing to the middle temperature (cone 5 in this example) will ensure that hotter spots in your kiln will not exceed the rating of the glaze. **

** Always be sure to analyze a glaze defect carefully. Pinholes result in tiny craters with soft edges, whereas blisters result in slightly larger craters with sharp edges. The remedies for each are very different, and mixing up the two will likely worsen the problem.