

THE ART OF SLIPMAKING

Making good slip is the first and most vital step in a successful slip casting operation. Although there are those who will say they have been using the same Dixie Cup for the last ten years to measure Sodium Silicate, and a nail on a wooden barrel for a water marker, this approach leaves far too much room for error.

Accurate measurements of weight and specific gravity are important. It doesn't take a ceramic engineer to make a good quality casting slip, but slip mixing is a chemical process which is affected by even the slightest changes in temperature, humidity and the chlorine and chemicals which are added to water supplies. Changes in conditions such as weather and water can sometimes affect the mixing formula but if you adhere to the following procedures, you will consistently make good slip.

It should be noted that our suggestions are based upon average climatic and water conditions in our laboratory in the City of Industry, CA. Adjustments may be necessary to fit your climate, water and general studio or plant conditions. Also, for best results, make your slip 24 hours before using it for casting.

EQUIPMENT NECESSARY FOR SLIPMAKING

An efficient casting room should be equipped with the following items:

1. **A Slip Mixer** (With a motor and blades which are capable of properly mixing your batch of slip.)
2. **A Gram Scale** (A postage scale is not accurate enough)
3. **A Viscometer** (Developed to aid in controlling the quality of slip. It is used to weigh the slip, which will show the ratio of clay to water in the slip, and to measure the viscosity of slip, which indicates the amount of slip that flows per second.)
4. **A Liquid Ounce Measuring Cup** (Sodium Silicate for instance, must be measured by the liquid ounce, not by weighing it on a scale. 4 ounces of Sodium Silicate, measured by volume, weighs approximately 5 ounces on a scale.)
5. **A Hydrometer** (The Hydrometer, an inexpensive and exceptionally easy to read instrument which displays the viscosity of the slip as it relates to specific gravity.)
6. **Respirator Mask** (OSHA Approved)
7. **A Minimum of 60 Mesh Sieve (Talisman Sieve) or a Shaker Screen** (A Talisman Sieve is an invaluable aid in screening your slip. You simply turn the handle and the slip is forced through the screen.)

CHEMICALS NECESSARY FOR SLIPMAKING

SODIUM SILICATE (N Brand) (Also known as Electrolyte, is used for deflocculating. Always dilute the amount of Sodium Silicate suggested with a like amount of water to yield a fifty-fifty solution.)

SODA ASH (It works with Sodium Silicate for deflocculating.)

BARIUM CARBONATE (Toxic in raw form) (To neutralize sulphates present in the clay and water. German Barium recommended)

DISPERSAL (Darvan) (May be necessary for additional deflocculating.)

ALWAYS MEASURE DRY INGREDIENTS BY WEIGHT, AND MEASURE SODIUM SILICATE AND DARVAN IN LIQUID OUNCES.

SODIUM SILICATE (N BRAND) is a chemical used to deflocculate casting slip. *NEVER ADD UNDILUTED SODIUM SILICATE TO THE SLIP BATCH.* Too much Sodium Silicate causes over-deflocculating. (See the section on Over-Deflocculating.) With the batch formulas we have given the ranges from the least to the greatest amounts of Sodium Silicate needed to deflocculate each batch. If you have had no experience with making slip at your location, measure the least amount of Sodium Silicate needed with your first one or two batches and "add as needed". It is easier to do this than try to adjust a batch to which too much Sodium Silicate has been added. Keep records of the amounts you mix and mark that figure on the "Sodium Silicate Range" which we list with the Formulas. This is important for future reference.

NEVER ADD PREMEASURED SODIUM SILICATE TO THE BATCH ALL AT ONE TIME. ADD ONLY IN SMALL AMOUNTS.

Sodium Silicate may be stored for extended periods in tightly closed plastic containers. (Aluminum, galvanized iron or zinc containers SHOULD NOT be used.)

SODA ASH works to dissolve lignite in clay. It works in combination with Sodium Silicate to aid in deflocculating. The correct combination of the two will give proper casting qualities, but if only Soda Ash is used, your clay will become sticky. If Soda Ash is not stored in tightly closed containers, a chemical change occurs and it becomes Sodium Bicarbonate (Baking Soda). If this occurs it will then act as a flocculant (it will thicken) instead of deflocculating.

BARIUM CARBONATE (Toxic in raw form) It is usually necessary to use Barium Carbonate in your slip batches to neutralize sulphates that may be present in the clay or in the water and sulphates leached from molds used in casting. Because of natural changes which occur in the mining of the raw clays, one should add Barium Carbonate.

DISPERSAL (Darvan) is an organic deflocculant which can be used with less fear of over-deflocculating. It is especially effective in hard water areas.

MIXING FORMULAS

The hardness or softness of the water in your community will affect the results of your casting slip. Therefore, we will avoid recommending precise amounts of the ingredients in our formulas. Instead, a range of quantities will be given. We recommend that you begin with the minimum amounts of each ingredient and, if adjustments are needed, slowly and carefully add additional quantities.

Formula using 100 lbs. Clay Blend (Yield: 10 Gallons) (Start with MINIMUM AMOUNTS shown in formula)

Clay Blend 100 lbs.

Barium Carbonate 1/2 ounce (14.75 gr.)

Soda Ash 1 ounce (28.35 grams)

Water 5 to 5 1/2 gallons (19.50 to 21.45 liters)

Sodium Silicate (N Brand) 2 1/2 to 3 1/2 fluid ounces (You must dilute this amount with a like amount of water. This will yield 5 to 7 ounces diluted Sodium Silicate.)

***SODIUM SILICATE SHOULD ALWAYS BE DILUTED 50/50 WITH WATER BEFORE BEING ADDED TO THE BATCH.**

MIXING PROCEDURES

1. Before you begin mixing, put on a good quality respirator mask to protect you from inhaling dust.
2. Measure water carefully and pour water indicated for your size batch into the slip tank.
3. Accurately measure the minimum amount of Sodium Silicate indicated for your batch and add a like amount of water (i.e. 3 oz. Sodium Silicate +3 oz. water) in a measuring cup. SET ASIDE. NEVER ADD SODIUM SILICATE FULL STRENGTH TO A BATCH OF SLIP.
4. Accurately measure the amounts of Soda Ash and Barium Carbonate indicated for your size batch. SET ASIDE.
5. Add Barium Carbonate and Soda Ash (which you have previously measured in Step 4) into one quart of warm water. (Warm water aids in mixing the chemicals.)
6. Turn mixer on. Add diluted Soda Ash and Barium Carbonate (which you prepared in Step 5) to the water which is in the tank. Mix for 5 minutes.

7. While the tank is still mixing, slowly add 1/3 of the clay indicated for your size batch to the water.
8. Add 1/3 of the Silicate solution (as mixed in Step 3) to the batch.
9. After mixing a short time, allowing the Sodium Silicate to thin the batch, add 1/3 more of the clay. Allow clay to mix into the batch.
10. Add 1/3 more of the Sodium Silicate solution. This will again thin the batch.
11. After mixing a short time (approximately 10 minutes), add the final 1/3 of your clay to the mixer.
12. The last 1/3 of the Sodium Silicate should be added at this time.
13. The mixing time should be approximately as follows:

100 lbs. = 2 Hours	1000 lbs. = 4 Hours
300 lbs. = 3 Hours	2000 lbs. = 5 Hours

Mixing will cause the Sodium Silicate to blend into the clay and water. Therefore, the batch will thin as it is mixing. For this reason, the slip maker should not judge the consistency of the slip until it is completely mixed or the batch could become over-deflocculated and too thin. After the batch is completely mixed, test it as recommended in the Testing Section. EYE-BALLING slip is an extremely inadequate method of confirming quality.

TEST PROCEDURES

Proceed with testing. However, we do not recommend that any adjustments be made to the formula until 24 hours after batch is made and tests are repeated.

TEST I HYDROMETER

The Hydrometer is an inexpensive and exceptionally easy to read instrument used for measuring the viscosity of a deflocculated slip whose Specific Gravity has been predetermined by a weight test prior to using the Hydrometer. After turning off the mixer, simply place the Hydrometer in the batch of slip. It will sink and stop at the reading indicator. It will then float like a buoy. A normal reading is between 1.76-1.82. The thicker the slip, the greater the reading and the less the instrument will sink into the batch. The thinner the slip, the deeper the Hydrometer will settle. For example, water has a Specific Gravity of 1.00, and a Hydrometer will nearly submerge. The opposite occurs in slip. Remember, liquid slip is not really a liquid. It is a mixture of clay, suspended, not dissolved, in water. For this reason, the Specific Gravity of slip, as determined by the weight test, is important. Clay becomes slip only when mixed with water in the proper proportions. Specific Gravity is the density of the slip. Remember that the reading on the Hydrometer will reflect the thickness and thinness of the slip which is effected by the amount of deflocculant used during the mixing. The reading on the Hydrometer should reflect the weighed Specific Gravity. For instance, if a pint of slip weighs 29 ounces it will have a Specific Gravity of 1.75. If a pint of slip weighs 30 ounces, it will have a

Specific Gravity of 1.80. The Hydrometer should have a similar reading. If the Hydrometer reading is above 1.80 it indicates that your slip is not properly deflocculated. In reality, the Specific Gravity, as determined by the weight test, may be correct and should not be altered with further additions of water or clay.

HOW TO USE THE HYDROMETER

Be sure the Hydrometer is completely clean and dry. There should be no trace of water on its outside surface. Hold the Hydrometer gently between your index finger and thumb. Keep the Hydrometer pointed straight down and not tilted. Slowly lower it into the slip. As the bulb is lowered into the tank and submerges into the slip, release the Hydrometer. (Take care not to push the Hydrometer to an angle as you let go). Let the instrument settle to its natural level and read the indicator. Rinse the Hydrometer clean after each usage. Allow it to dry before re-using.

TEST II WEIGHING TEST

If you have followed the procedure we recommend for mixing, the consistency of your slip should be either correct or slightly under deflocculated. To find out, fill a pint jar with slip and weigh it on the scale. (Be sure that you first weigh the jar itself, so you can subtract its weight from your measurement.) The correct weight for a pint of slip is between 28.9 oz. (820 grams) and 29.2 oz. (828 grams). This simple measurement, along with the hydrometer reading, quickly indicates whether the batch has enough clay and water and whether it has been correctly deflocculated. A pint of slip that weighs 29 oz. will have a Specific Gravity of 1.75. A pint of slip that weighs 30 oz. will have a Specific Gravity of 1.80. The Hydrometer reading should correspond to these readings.

TEST III VISCOMETER

If you are using the Viscometer, you may eliminate the above weighing test and proceed with the following instructions. The Viscometer was developed to prevent problems related to slip casting. The Viscometer test will determine the ratio, by weight, of clay to water, and the Viscosity (the rate slip flows per second).

USING THE VISCOMETER FOR THE WEIGHING TEST

STEP I Fill the flask with slip to the 500 ml. mark.

STEP II Weigh the slip and the flask.

STEP III Subtract the weight of the flask from the total weight (glass flask weighs approximately 195 grams; plastic flask weighs 89 grams). The result will be the net weight of 500 ml. of slip. Normal slip weight will be 860 to 900 grams. Experience will teach you which weight is most appropriate for your casting conditions. If weight is under 860, more clay blend is needed. If it is over 900, more water is needed. Divide the gram weight of the slip by 500 to establish the weighed Specific Gravity. For example: If your slip weighs 875 gram \div 500 the Specific Gravity will be 1.75. When your slip is properly deflocculated the Hydrometer will read approximately the same.

USING THE VISCOMETER FOR THE VISCOSITY TEST

STEP I Replace the stopper into the already filled flask.

STEP II Hold your finger over one hole in the stopper and turn the Viscometer upside down.

STEP III Release your finger from the hole and time the flow of slip until all the slip has drained from the flask to the fifth drop. Normally the slip will flow through in 100 to 130 seconds per 500 ml. A fast flow time (thin slip) will probably lead to a slower setting time, whereas a slow flow time (thick slip) will set up faster in your molds.

A. If the slip weight is normal, it is highly unusual for the flow rate to be less than 100 seconds per 500 ml.

B. If the slip weight is normal and the flow time is more than 130 seconds, you may need a little more Sodium Silicate or Dispersal.

C. After testing, always wash your Viscometer with cold water and store at room temperature.

It is recommended that slip be screened through a 60 mesh sieve before using

REPEAT TESTING AFTER 24 HOURS. MIX BATCH FOR 30 MINUTES THEN BEGIN RETESTING.

OVER-DEFLOCCULATION

Sodium Silicate, while it is the most commonly used deflocculant, has a very narrow range of deflocculating. Therefore, one can easily over-deflocculate slip.

The addition of Sodium Silicate to a slip batch thins (deflocculates) it. When a certain point is reached, the addition of more Sodium Silicate will begin to re-thicken (flocculate) the slip.

If your slip has not reached the over-deflocculated state, the addition of a few drops of a Sodium Silicate water solution will thin the batch. But if you have gone beyond the allowable limits of Sodium Silicate water solution and your slip has become thick because of it, the addition of more Sodium Silicate will actually thicken the batch more.

If your slip is badly over-deflocculated, it is most prudent to discard it, as it is very difficult to correct over-deflocculating.

DISPERSAL (DARVAN)

Dispersing agents such as "Darvan", commonly used for deflocculating, can be added after you have added the maximum amounts of Sodium Silicate. You may add as much as 1 ounce of dispersal per 100 lbs. of dry clay without fear of over-deflocculating.

DO NOT ALLOW DISPERSAL TO FREEZE

ADJUSTING THE BATCH

If your batch needs adjustment, use the following procedures:

If extra clay is added, mix the batch for the full recommended time (i.e., 3 hours for a 300 lb. batch). On the other hand, your slip need only be mixed for fifteen minutes if only extra water or Sodium Silicate is added. If your weight and viscosity readings are slightly higher or lower than the ranges given in our Testing Procedures, casting under your conditions will be the ultimate test.

If your weights and Specific Gravity are not within recommended limits, but your slip casts well, you should not make any adjustments.

CAUTION: Too much water added to your batch, while it may make your slip easy to drain, can cause cracking in your molds and can produce brittle castings. Lignite may also surface.