

## Appalachian Center for Crafts - Clay Studio

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Vince Pitelka, 2016 - The following is adapted from *Industrial Ceramics*, by Felix and Sonja Singer, Chemical Publishing Company, Inc., New York, 1965

### Salt Glazing

Salt glazing differs fundamentally from regular glazing. Instead of coating the raw or bisque-fired ware with a water-suspended glaze and then fusing this to form a glassy coating in the glaze fire, the salt glaze is formed in the kiln by the action of vapors, produced from salt, water and other substances on the hot, fired body. Successful salt glazing is influenced by three interdependent factors:

1. Composition of the body.
2. Firing schedule.
3. Composition of the salting mixture.

#### ***Composition of the Body***

The sodium ions in the glazing vapors react primarily with silica in the body surface, and it is found that the ratio  $\text{SiO}_2:\text{Al}_2\text{O}_3$  may not be too small, although opinions about the best value differ. Barringer gives it as 4.6 to 12.5, whereas Mackler says that a good salt glaze can be obtained with as low a value as 3.3 to 1. In practice a ratio of about 5 to 1 is normal. Clays that will not take a salt glaze because of silica deficiency may have finely ground sand or sandstone added. (V.P. note: The Insight software is intended primarily for glazes, but if you enter a claybody formula in Insight it will tell you the silica-to-alumina ratio.)

Although white-burning, iron-free clays may be salt glazed as seen in the old Staffordshire ware, the presence of iron in the clay helps in the formation of the salt glaze. Clays with 0 to 2% iron oxide tend to form white to tan glazes, those with 3.5 to 4.75% form medium browns and those with 4.75 to 8.2% develop a dark mahogany. The actual color is always influenced by the presence of other constituents and very largely by the firing schedule. The iron compounds in the body assist in the salt glaze formation in two ways: (a) by acting as a flux to vitrify the body which can then better take the glaze; and (b) by reacting with the salt vapors during the glaze formation. It is the ferrous compounds that assist in body vitrification, although the iron in the raw body is usually in the ferric state. Ferric compounds are decomposed to ferrous ones at about 2190 Fahrenheit so that in bodies fired above this temperature the iron is already in the beneficial condition. In bodies fired to lower temperatures the fluxing action is obtained by using a reducing kiln atmosphere. It is, in fact, traditional in many works to maintain a reducing atmosphere towards the end of the firing, before salt glazing, whether or not it is necessary to assist in the reduction of the iron.

Calcium makes a salt glaze dull at low temperatures and at high ones it turns an iron rich glaze yellow if cooled slowly or greenish-black if cooled fast. 1.5% magnesium assists in salt glazing, but above 3% makes the glaze dull. 1 to 5% titanium in otherwise suitable clays tends to make the glaze more brilliant.

### ***Firing Schedule***

The vaporization of salt and its interaction with steam, etc. is considered not to take place satisfactorily below cone 2 (2120 F.). Normal salt glazing cannot, therefore, be undertaken below that temperature. Certain bodies that mature earlier and have a high alkali and iron oxide content can, however, be salt glazed as low as cone 05 (1050 C., 1922 F.).

Salt glazing is generally done in a down-draft open-fired kiln. When setting the ware in the kiln attention must be paid to the necessity of good circulation of the vapors. Charging of the salt occurs towards or at the end of the firing. With red-burning clays this is about cone 01 to 5 (2084 F. to 2192 F.); with fireclays and stoneware clays the usual temperatures are cone 8 to 11 (2282 to 2408 F.). The ware is usually fire-flashed before salting, i.e. kept in a reducing atmosphere so that the iron is reduced to the ferrous state.

When the maturing temperature has been held for sufficiently long time to make the ware dense, the salting mixture is charged into the firebox and the damper closed for a short time, and then reopened. When the vapors have cleared and the temperature has been regained the next salting is undertaken. From four to eight saltings may be made.

The burners must be turned up a bit to prevent drop of temperature due to the extra heat required to volatilize the salt and for the reactions at the body surface. The salts vaporize and interact with water and the claybody producing a grey (ferrous) glaze. The kiln is then cooled slowly with an oxidizing atmosphere when the ferrous iron is reoxidized to the ferric state and the glaze becomes brown. The practice of slow oxidizing cooling in order to make the glaze brown is brought about by the general belief among consumers that a good salt glaze should be brown, and so only the brown ware is more saleable. Rapid cooling produces a greenish-black glaze which is not technically inferior to a brown one. Furthermore a calcium-containing body gives a yellow glaze if the iron reoxidizes during slow cooling, but a greenish one if the cooling is rapid and it remains in the ferrous state. Also the higher the firing temperature, the more of the iron in the body reacts and the darker the color.

### ***The Salting Mixture***

The actual mechanism of the chemical reaction during salt glazing is not completely clear, but essentially the sodium chloride is vaporized, and then meets hot steam which reacts with it, either directly or indirectly, in the presence of silica, to give hydrogen chloride gas and sodium oxide. All gas-fired kilns contain a certain amount of steam, but salt glazing is assisted by adding some water with the salt. The sodium oxide immediately reacts with the silica in the body to give sodium silicate and then further with other body constituents to give a glaze of about the following composition:

Flux	Refractory	Glass-former
Na <sub>2</sub> O - 0.777	Al <sub>2</sub> O <sub>3</sub> - 0.586	SiO <sub>2</sub> - 2.588
K <sub>2</sub> O - 0.002		
MgO - 0.002		
CaO - 0.174		
FeO - 0.045		

This has a SiO<sub>2</sub>:Al<sub>2</sub>O<sub>3</sub> ratio of 4.418.