

Common Glaze Faults

No matter how careful and consistent we are in buying and storing materials, in mixing and applying glazes, and in loading, firing, and cooling kilns, periodic glaze problems are inevitable. Glaze materials change from one batch to the next, and we are all capable of human failure. It is important that we learn to recognize glaze faults, and to deal with them in an appropriate manner to correct the problem.

Pitting and **pinholing** usually result from air escaping from the porous clay during application of the glaze – water is entering, thus air is escaping. These flaws can also result from outgassing of volatiles during the glaze firing if the bisque firing was conducted too quickly or to an inadequate temperature. If pits and pinholes are visible in the unfired glaze surface, gently rubbing with a fingertip will fill them with powdered glaze. Serious pinholing in multiple glazes can often be cured by bisque-firing to a slightly higher temperature and assuring adequate air circulation in the bisque by leaving top and bottom spyholes open. If plagued by pinholing, a good approach is to mix your glazes a bit thicker and dip the wares in water ten minutes before glazing. Of course test this method before attempting with a whole kiln-load of wares.

When reduction firing, a fifteen minute oxidation soak at maturation temperature before shutting off the kiln will encourage pits and pinholes to heal. Certain glazes that seem to preserve flaws in the surface might need a slight increase in flux content or substitution of more powerful flux.

Crawling is one of the more destructive and troublesome glaze flaws, and is characterized by the liquid glaze peeling or receding, leaving areas of dry clay surface. Crawling may be caused by a number of factors. If localized, especially if the glaze is quite thick, the cause is most likely a residue of grease or dust on the bisque surface before glazing, which can interrupt the glaze-clay interface. The solution is to keep unwanted grease, oil, or wax off the bisque wares, and wash, brush, or blow off any dust or powdery residue before glazing. When applying wax resist, be especially careful to avoid getting wax fingerprints on the wares. Avoid greasy moisturizing creams or skin protectants or wear rubber gloves.

Some coloring oxides including red iron oxide, cobalt carbonate, chrome oxide, and rutile, are powdery and refractory, and if used underglaze will likely result in crawling. The one exception is when oxide washes are brushed onto relief pattern or texture and sponged off the high spots before glazing.

Glazes applied excessively thick frequently crawl in the firing, especially if there are visible cracks in the dry unfired glaze surface. This is especially common in improper double- and triple-dipping of glazes (see the sections on glaze application and thickness early in this chapter).

Any glaze which is excessively powdery will develop a weak bond with the clay surface and may crawl in the melt. This is especially common in glazes that are low in clay content. Common solutions include adding up to 3% bentonite, substituting ball clay for kaolin in the recipe, or reformulating the recipe to increase clay content.

Lowfire glazes containing high quantities of Gerstley borate are especially prone to surface cracking and crawling problems if they sit around for a year or more due to the partial solubility of this material. Unless you use such glazes quickly, they should be reformulated with a Gerstley borate substitute or 3134 frit.

Glazes with components showing very high L.O.I. (loss on ignition) may crawl. This phenomenon is used to advantage in *controlled crawl glazes* made with a high content of magnesium carbonate, which has extremely high L.O.I.

Peeling is similar to crawling but far more severe, characterized by large areas of glaze peeling away from the surface before or during the firing, often ending up as large drips of glaze running off the wares or even pools of glaze on the kiln shelf. The most common cause is a poor bond between a very powdery glaze coating and the claybody beneath, especially if any glaze or oxide wash is brushed or layered over the troublesome glaze before firing. A less common but far more destructive case of glaze peeling can occur if a firing proceeds to a point just above red heat and is then interrupted and cooled, perhaps because the cone-packs have failed. In this case both clay and glaze have begun to sinter but no appreciable clay-glaze bond has formed. When the wares cool and in subsequent refiring, inevitably differential contraction and expansion between clay and glaze can cause separation of large areas of glaze, resulting in large areas of the glaze peeling away in massive flakes, leaving large areas of clay unglazed. When a glaze-firing proceeds in a normal way, the pyroplastic flexibility of the clay and glaze allows them to remain in place while progressive sintering and glassy-phase formation reinforce the clay-glaze interface. Except in a genuine emergency, once a glaze firing has reached early red-heat, never interrupt it and allow it to cool unless the kiln has at least reached normal bisque-firing temperatures. Even in the event of exploded or fallen cone packs discovered only after early red heat, always continue the firing at least to bisque temperatures, or else complete the firing and estimate maturity by visible color.

Fine bubbles in the glaze surface can be very desirable in some glazes such as traditional Chinese celadons and chuns. There is a lot of air in dry unfired glaze coatings, and as the glaze passes from sintering to vitrification and glass flows into the spaces between the refractory particles, the air ends up as bubbles. Given adequate firing time, the bubbles will coagulate and eventually escape to the surface, and that is what we generally attempt to achieve. In a more viscous glaze they may be preserved in suspension. If undesirable they can usually be eliminated by a thinner glaze application, a slow climb near maturing temperature, a brief soak at maturing temperature, glaze-firing at a slightly higher temperature, or slightly reducing viscosity by increasing flux or substituting a stronger flux.

Unwanted Opacity or Surface Mattness - Unwanted opacity is usually due either to underfiring or excessively fast firing, or to excessive glaze thickness. In the first case, underfiring or excessively fast firing does not allow for thorough melting and dispersion, and air bubbles remain trapped in the glaze. In the second case, many transparent glazes will go milky when applied too thick.

Unwanted surface mattness can result from any of four circumstances.

- 1.** An ***underfired glaze*** will of course be matt, and as mentioned earlier, if the glaze has been fired to the desired maturation temperature but appears dry and underfired, it must be reformulated to increase the proportion of fluxes to alumina and silica and thus lower the maturation temperature.
- 2.** Stable, durable matt glazes are achieved by including sufficient amounts of alkaline earth fluxes that encourage crystal growth during the cooling cycle. If unwanted matting appears and the glaze has been fired to the proper maturation temperature, it is likely that the glaze contains ***excessive alkaline earth fluxes***, and the glaze should be analyzed with Insight and reformulated to replace some of the alkaline earth fluxes with alkaline soda or potash fluxes.
- 3.** Most gloss glazes contain some alkaline earth fluxes (usually calcium and/or magnesium), because they help give durable, low-expansion glazes. However, if the glaze is ***cooled too slowly through the zone of crystallization***, those alkaline earth fluxes can cause surface mattness. If the objective is shiny, smooth glazes, then the kiln may be cooled fairly quickly through the normal zone of crystallization to discourage the crystals that cause mattness.
- 4.** ***Excessive silica*** can give a sugary, crystalline glaze surface that is very unstable. Analysis with insight will tell if the balance of alumina and silica is off. Remember that the silica to alumina ratio should be very close to or within the ideal six to ten parts silica to one part alumina.

A wavy or pebbly glaze surface usually results from underfiring, from allowing inadequate time for the glaze to smooth out completely, or from excessive viscosity in the glaze at the intended maturation temperature.

Cratering is the result of bubbles remaining or only partially healing in the glaze surface upon cooling. Sometimes these remain as distinct bubbles in the surface of the glaze, but more often the upper portion of the bubble pops and leaves a distinct crater in the surface. If the dome of the bubble is very thin but survives until cool, it will subsequently break and leave a crater with razor-sharp edges. Different materials volatilize and outgas throughout the firing. If the firing is ended and cooling commences while this is occurring, bubbles and craters will be preserved in the surface. A soaking period in an electric kiln or an oxidation soak in a reduction firing before shutting off the kiln will usually allow the glaze to heal. A full kiln will naturally fire and cool slower with less tendency towards cratering. The problem most often occurs in over-fired glazes, or in a sparsely filled kiln that fires quickly and begins cooling abruptly at shutoff. If you must fire a sparsely-filled kiln, place several hard brick around the wares on each layer of shelves. This thermal mass stores enough heat to retard cooling, allowing glazes to smooth out more fully.

In some cases, partially healed craters provide desirable surface effects, particularly in shinos and oil-spot temmokus.

Bloating is sometimes assumed to be a glaze flaw but is in fact a claybody problem that can occur if any claybody is overfired, or if volatiles are trapped within the clay due to excessively-fast bisque-firing or excessive early reduction in a glaze firing. In any of those cases, as the firing proceeds to maturity the volatiles expand, causing laminar separation within the clay and the characteristic lumps on the surface beneath the glaze. To prevent this, always bisque-fire slowly with plenty of air circulation to fully outgas all volatiles, and maintain a neutral or slightly oxidizing atmosphere in a fuel-kiln glaze-firing until at least cone 012.

Running is usually caused by excessive glaze thickness, inadequate glaze viscosity in the melt, and/or over-firing. If a firing reaches the desired temperature and glazes still run, you can generally identify the problem fairly easily. If a large amount of glaze runs but still leaves a reasonable coat of glaze in place, then the glaze was applied too thickly. If the glaze runs and leaves a very thin coating showing the texture of the claybody, the glaze viscosity should be increased by adding a little clay (increasing alumina and silica) or by decreasing flux content or substituting a less powerful flux. In highfire, substitute an alkaline earth or potash feldspar for some of the soda feldspar or nepheline syenite. In low fire, substitute a little nepheline syenite for some of the Gerstley borate or calcium borate frit.

Leaching is the process where metallic components are released into food substances, especially acidic foods like vinegar or tomato-based foods. In a properly vitrified glaze, the component materials are locked in in a durable, stable glass and there should be no leaching of soluble materials. Only a certified ceramics testing lab can do an accurate test for leaching, and any glazes containing barium, chrome, manganese, lithium, copper, lead, or other potentially problematic materials must be properly tested if used on food-contact surfaces. To perform a general experiment that gives some indication of leaching, make small vessels lined with any glazes in question. Fill them half-way with vinegar and let sit overnight. After you pour out the vinegar the next day and dry the surface, any color shift at the dividing line indicates that something is leaching out of the glaze. This is not a valid test for food-safe glazes, but might provide some indication or demonstration.

Excessively dull surfaces are usually caused by an overload of matting agents, opacifiers, or refractories, by under-firing, or by excessively long firing or over-firing, where the glaze is partially absorbed by the claybody. You may have to do some experimenting to find the particular cause in each case.

Glaze Problems Associated With Glaze-Fit

Crazing is the fine network of surface cracks in a glaze that occurs when the glaze shrinks slightly more than the body. The ideal situation is when the glaze is under slight compression, but this is possible only in midrange and highfiring. Visually, crazing is not always seen as a flaw, but technically it should be considered a minor flaw because it weakens the body. It is not an issue of health and hygiene – there is absolutely no evidence that craze cracks harbor food residue or bacteria. In a lowfire transparent gloss glaze crazing is almost inevitable. Midrange and highfire glazes high in sodium tend to craze, and thus most gloss glazes in salt and soda firing always craze. In designing utilitarian glazes for midrange or highfire, glaze-calculation software will help you adjust crazing by a decrease in flux and/or increase in silica. A very slight change will often reduce or eliminate crazing, often just a partial substitution of a lithium feldspar like spodumene for some of the potash or soda spar, or the substitution of kaolin for ball clay (slightly increasing silica content).

Some people feel that very slow cooling at the end of the glaze firing decreases crazing, but this is an unethical practice if you plan to sell the wares, because you have simply delayed the crazing. If your glazes craze and you are unwilling or unable to eliminate the crazing, far better that the crazing occurs before someone purchases your wares.

It is often difficult to see crazing on a freshly glaze-fired piece. If you want to see if a test piece

is crazed, gently warm the surface with a torch or heat-gun, wipe India ink across the surface and rub off the excess right away. This treatment will stain any crazing, making it easy to see. This also works great if you want to accentuate craze lines.

Shivering, dunting, and shattering are appropriately named, for they are perhaps the most dreaded of clay/glaze flaws. *Shivering* is exactly the opposite of crazing, and is one of the most unnerving, disappointing, and dangerous flaws in ceramics. Shivering is when excessive glaze compression builds up enough tension to cause glaze to pop off outer rims, corners, and edges in small razor-sharp slivers. This can continue to happen for some time after the firing, so when any shivering occurs on a functional vessel, it must be destroyed. That should be taken seriously, because if you decide to keep the vessel or give it to a friend you have no control over who will eventually use it, and such razor-sharp slivers in someone's food could cause very serious problems.

The cure is just the opposite of that for crazing, with a slight increase in flux and/or decrease in silica in the glaze, often just by replacing a small amount of potash feldspar with soda feldspar, or by replacing kaolin with ball clay.

Dunting and shattering are variations of the same thing and refer to serious cracking occurring as the kiln cools or afterwards. There are a number of things that can cause these defects. The most common cause is severe glaze compression, especially if the walls of the form are very thin in comparison to the glaze coating. Over-vitrification is another factor causing dunting or shattering, and can be a simple case of overfiring, or in some cases can be a combination of circumstances. With the increase in popularity of cone-6 and cone-10 electric firing, clay suppliers have come up with iron-bearing bodies that give red-brown, brown, or even black in oxidation. If one of those claybodies ends up in a reduction firing, the iron turns to black iron oxide, seriously over-fluxing the claybody and causing over-vitrification and dunting or shattering.

If the clay is over-supplied with silica, cristobalite will form at high temperatures, drastically reducing thermal shock resistance. This is especially common in slow firing in hardbrick salt, soda, or wood kiln, where there is more time for cristobalite formation. The problem can also occur with an excessively refractory and thus underfired claybody that develops inadequate strength in comparison to the glaze coating and is unable to stand up to differential thermal expansion.