

Reader V3 – Translation English

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Ian Currie was a friend who stayed with me when he gave workshops in Europe. I visited him in Australia. We shared information and experiences, which is why he left his notes and materials with me. He knew I would ensure his ideas were passed on. His books are still available through his son. Participants in a workshop I lead receive this reader for their own use.

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Developing one's own style is something every ceramicist aspires to. Recognition of your work brings a sense of satisfaction, especially when the design and appearance of your work are the result of significant effort and investment of energy and time.

Being able to make your own glazes is often an important part of this. However, calculations, computer programs, reading formulas, and the like can often be a barrier. The grid method, however, is easy—no complicated formulas, no computer program, no studying with difficult books—but simply a slightly more involved way of mixing and making test tiles. And you can easily assess the results visually yourself.

1. Choose a set of fluxes

– This becomes Glaze C.

2. Gradually add kaolin

– This is the gradual increase in the stabilizer from Glaze C to Glaze A.

3. Gradually add the glass former

– This is the gradual increase from Glaze C to Glaze D.

Glaze B combines the smallest amounts of A, C, and D.

This is a simplified explanation of the method, but with the following explanation, anyone can follow and understand it.

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A What is a glaze?

- It is a glass,
- it is a thin layer of glass that has adhered to a clay surface
- it has decorative qualities such as: color, texture, transparency, opacity, etc.
- it has functional qualities such as: water-resistant, hygienic surface, etc.

What is the difference between window glass and bottle glass?

Glass consists mainly of silicon, silica (quartz), and oxygen. We are familiar with quartz in its raw form as quartz sand or silver sand. When magma cools very slowly, substances can take on crystalline forms. We therefore usually know quartz as crystals or in crystalline form, such as rock crystal.

Glass as we know it, such as window glass and bottle glass, is quartz that has cooled rapidly. Chemically speaking, it is a liquid, i.e., a liquid in the solid phase or a state of aggregation.

Glaze is therefore also a glass. Under a microscope, we see glaze as a matrix, i.e., a lattice of silicon atoms and oxygen atoms.

When we talk about the glass-forming component in a glaze, we are referring to the molecules consisting of one silicon atom (Si) and two oxygen atoms (O), represented as SiO₂.

Ordinary glass is thin and fluid in its molten state. It is unsuitable as an enamel because it will run off the objects in the kiln. An enamel must be tougher, more viscous, and have a high viscosity. And preferably, it should have a longer melting range.

But our problem is that SiO₂ (silicon dioxide) has a melting point above 1700° Celsius.

When discussing glaze, we talk about a flux, and some even refer to melting agents. Can we simply add such an agent until we reach the desired melting temperature? Most people think so, but **no, it works differently.**

The various forms of calcium we use as fluxes—such as chalk (calcium carbonate), lime (calcium oxide), and bone ash (calcium phosphate)—themselves have melting temperatures ranging from over 1300 °C to even above 2500 °C, yet they still aid in the process.

What is a eutectic?

Most raw materials we use have a crystalline structure and change from a solid to a liquid at a certain temperature. In physics, we know of a process that helps us lower a melting point.

We have a substance that melts at a certain temperature (T_a) and another substance that melts at a different temperature (T_b). If we mix these two substances, the mixture suddenly melts at a lower temperature—even at a **temperature lower than either of the two substances individually**. We call this phenomenon a eutectic, and glazes are based on eutectics.

Many people have soldered something at some point and have seen numbers on the roll of solder, usually 40/60. That means 40% lead and 60% tin; this is a eutectic with a melting point of 180 °C.

That is considerably lower than that of the individual metals, ± 600° and 500°.
See the principle in the following diagram.

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This diagram illustrates this phenomenon. Raw material A has a melting temperature T_a (e.g., 1700°C) and raw material B has a melting temperature T_b (say 1450°C). The mixture has a melting temperature of T_e (e.g., 1250). However, this diagram also shows that there is an optimal ratio where the melting temperature is lowest, namely A40% and B60%.

We make use of this when creating glazes. The diagram also indicates that there is some leeway, and you can deviate from the ideal ratio and still achieve a reduction in the melting temperature.

In the following diagram, we see a number of known melting temperatures for a stoneware glaze.

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The scientific diagram has all sorts of wavy lines, but these are the most characteristic points for us. Stoneware temperatures that can thus be achieved with just three raw materials.

For clarity, the first diagram is a simple illustration of the principle. In practice, the temperature reduction can occur quickly or slowly, smoothly or in stages.

For me, the diagram explaining how it works was an “eye-opener” when I saw it in Ian’s book.

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The representation of glazes: how they are noted.

A) The Recipe

For example, the following Low-temperature stoneware Cone 5 (Medium Range) 1200°C - 1220°C
Semi-transparent ash glaze

Feldspar 12

Wood ash 42

Calcium borate frit 32

Ball Clay 14

The glaze recipe, the list of raw materials, is what you need to actually make a glaze.

But comparing and evaluating glazes based solely on this is virtually impossible. It may also contain raw materials that you don’t have or that are only available in certain parts of the world. And it says absolutely nothing about the fired glaze, its character, etc., or the way it was fired.

(image from: The Potter’s Book of Glaze Recipes—Emmanuel Cooper)

B) The % Analysis

For example

Alkaline borosilicate glaze

NaO K₂O CaO Al₂O₃ B₂O₃ SiO₂

5.85 0.55 7.98 20.09 15.11 49.18

This represents the actual weight of the various oxides in the glaze expressed as percentages. This is the method primarily used to describe raw materials and clay. Comparing glazes has now become possible with this method.

(image from: Ceramic Glazes—Wolf E. Matthes)

C) The Seger Formula

The Seger formula represents the ratio of all oxides based on the number of molecules present. By convention, the group of all fluxing agents is collectively recalculated to a total of 1.

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As an example, here is the same glaze as in the % analysis

NaO 0.38 Al₂O₃ 0.71 SiO₂ 2.94

K₂O 0.07 B₂O₃ 0.85

CaO 0.55

This latter representation, the Seger formula, has significant advantages.

The representation of the function of the different groups is clearer.

Comparing glazes with one another is now possible.

A recipe should always be converted to a Seger formula and then converted back into a recipe using raw materials that we can choose ourselves.

The ideal solution? No, not that, but it does offer the possibility to compare glazes, observe certain ratios, and even make predictions based on them.

The quartz-to-aluminum ratio, for example, says something about the quality and stability of the glaze, and the levels of these oxides can indicate the expected melting temperature.

(image from: Regout and Matthey catalog)

Conclusion

The Seger formula and the grid method are complementary; both are based on the three distinct groups that form the basic elements of every glaze.

The Seger formula provides an indication of whether the glaze will be matte or glossy based on the aluminum-to-quartz ratio. For example, an optimal (food-safe) glaze has an Al-Si ratio of around 1:9 (1:8 – 1:10).

The amount of Al-Si indicates the melting temperature.

And based on the Seger formula, you can create your own recipe using your own raw materials.

Afraid of math? There are very affordable glaze programs available today that do all the calculations for you. For example, Matrix

Is it necessary? No, the grid method works entirely based on a single table and a list of raw materials, and evaluating the results can be done purely visually. Is chemistry complicated? No, not when it comes to making glazes. We only look at the elements present after firing. And that's exactly how we list them. And we don't need to know more than 12 elements.

We can read and understand almost any glaze formula with a dozen oxides. And you'll learn such a small number naturally just by working with them. So it's not that bad.

See Appendix 1

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Food for thought: How do you explain that when increasing the amount of flux in a test, the melting temperature does not decrease but actually increases?

Tip: Consider the principle of eutectics.

An exception??

In the examples, you may notice that borax (B_2O_3) is included in the Seger formula in different groups. In some books, it is listed with the glass formers, and sometimes in the middle as a stabilizer. Borax is a glass former, but it has a very low melting point and a different quality. Because of its low melting point, it is always used as a flux, often in the form of Gerstly borate or as a frit, such as Ferro 3134. In the Currie grids, we therefore place it with the fluxes in group C.

Frits

Some raw materials are water-soluble, toxic, or difficult to obtain in a pure form. And therefore unusable for us. The solution is to melt these substances together with a glass-forming agent and then grind them into a powder. For us, these are the frits that have become easily usable in this form. They often have a low melting point. They are therefore always classified under fluxes, so for us in Group C.

An appointment.

When we talk about firing temperature, we indicate it using the Seger Cone or Orton Cone.

A glaze is, in fact, the result of two variables: temperature and time. For example, one person might achieve the result of a Cone 6 by following a relatively short firing curve up to 1220°C and then holding, while another is accustomed to using a longer trajectory of gradual ramp-up to 1240°C.

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B What is a Currie Grid?

A Currie grid, also known as an "assessment tile" or aluminum-quartz matrix, is a method for testing and designing glazes developed by Ian Currie. Originally a method used in Australia to test glazes and share research results by mail, since the vast distances made it impossible for people to gather as a group.

Why do we use Currie grids?

The quality of a glaze is determined by many factors and variables. The testing methods we know are useful but also have their limitations. A "line blend" works well when we want to find a specific color, but a series of mixes where the amount of quartz changes also means that the quartz-to-aluminum ratio is constantly shifting. This can alter the entire character of the glaze, for example, from matte to glossy. And from our understanding of eutectics and phase diagrams, we know that changing the amount of a flux can also have an adverse effect.

With the grid method, we proceed more systematically and investigate more than one variable, specifically the interrelationships between them, across a wider range.

The Grid Method

A grid is a rectangular tile on which we display 35 glazes. The layout consists of 7 rows and 5 columns.

By convention, the corners, as well as the numbering, have a fixed position and order.

Four glazes are placed at the four corners, and all other fields or squares contain glazes created by mixing the four base glazes at the corners.

C, the lower left corner, is always the starting point of the investigation. This glaze contains only fluxes. In the Seger formula, this is therefore the RO / R₂O group.

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Notes on the standard recipes on the tile. Page 10

- Glaze 31 consists of 100% fluxes. This is corner C.
- Glaze 1 consists of fluxes and up to 40% kaolin. This is corner A.
- The left vertical column A–C contains no quartz.
- Glaze 35 consists of fluxes and up to 50% quartz. This is corner D.
- The bottom horizontal row contains no kaolin.
- Glaze 5 is the aluminum/quartz combination, up to 25% / 40%. This is corner B.
- These are all recipes for “base glaze” in quadrant C.
- The addition of coloring and opacifying agents to the matrix will be explained later.
- This arrangement of glaze numbers and ingredient percentages applies to all tiles in the Grid method. That is also what makes this method so powerful.
- This makes the following possible:
- If you have a recipe from angle C (glaze 31) (or one of the other 35 glazes), you can derive and work out the recipes for the entire set. Each glaze set is defined by angle C. If you want to compare the recipes of two different sets, you can easily do so by comparing the angle C glazes.
- If you look at the rows and columns, except for the bottom row and the left column, you will notice that the percentages of kaolin and quartz are not constant. The actual layout can be seen in the following diagram.

Graph of the 35 glazes according to the percentages of kaolin and quartz.

The reason for this unusual shape is to cover the range where glazes typically melt as efficiently as possible through the process of mixing volumes. This is the range of earthenware and stoneware glazes.

Understanding the Grid Method

The Principle

To understand the relationship between the 35 glazes, imagine the following:

To start, design the composition of Glaze 31, the starting point consisting of 100% fluxes. We create the remaining glazes by adding kaolin and/or quartz to glaze 31. As a result, the fluxes do not change even as the amount of kaolin and quartz increases. In practice, however, we do not mix the entire set of 35 glazes in this way.

The Method

To create the entire set, we only need to make the 4 corner glazes—numbers 1, 5, 31, and 35—and then mix them to create the remaining glazes. We refer to these 4 corner glazes as A, B, C, and D.

A complete set tells the story: namely, the character of the group of fluxes as the amounts of aluminum and quartz increase.

Glaze C (31) is the only glaze we record, note down, and pass on. If there is a deviation from the standard—for example, by using ball clay instead of kaolin—this must be explicitly noted in the set (test) (“non-standard grid”).

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How do we obtain the 35 recipes?

They can be calculated from the recorded percentages, but there’s a much simpler way.

Ian Currie’s website features a “Calculation page.” Enter Glaze C, and the rest is calculated automatically and ready to print.

Go to: <http://ian.currie.to>

go to “Online resources” and select “Calculations page”

At the bottom, it states that the amount per glaze is 300 grams. You need that amount to mix the entire set of 35 glazes and fill a series of tiles. Incidentally, this can be adjusted.

The “Matrix” glaze program also allows you to create a set and print out the recipes.

Colors and opacity

To maintain the maximum benefit of the grid method, we must limit the number of variables to two: kaolin and quartz. If we use coloring components and opacifiers, these are added as fixed percentages and therefore remain the same in all 35 glazes of the set. On the “Calculation Page,” you can specify raw materials that add color and make the glaze opaque. In the printout, you will see that the percentages remain the same for all glazes.

If you want to go further and expand the research on color, the sequence is as follows: first, create a complete set. Then choose a glaze from the set and continue with coloring oxides and stains by creating a linear or triangular mixture.

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Research options, angle C

Glaze C has so far consisted solely of 100% fluxes, but what and how do you choose these?

It stands to reason that you should take any raw material for which you have no data or analysis, but which you know contains fluxes, as a basis—that is, as Glaze C.

Think of wood ash—in fact, any ash containing organic material. Also consider basalt, granite, lava flour, and other weathered rock products. Consider clay you've mined yourself. Secondary clay—sedimentary clay, i.e., clay deposited by rivers—certainly contains fluxes.

If you're unsure, you can also use, for example, 40% feldspar and 60% unknown clay.

But this method is particularly useful for unknown recipes and recipes that lack data on atmosphere, firing cycle, and temperature.

In doing so, remove all raw materials from the recipe except those clearly intended to introduce fluxes. This is now your Glaze C.

Or take a recipe you use that works well. Identify which raw material clearly plays a role among the fluxes and replace it with another. For example, replace chalk with dolomite or wood ash.

Use a table as a rule of thumb (Appendices 2 and 3)

Appendix 2 indicates the maximum percentage for a flux within the total flux group (corner C).

Appendix 3 provides guidelines for the quantity and type of fluxes, based on the firing temperature (stoneware, "mid-range," earthenware).

Literature

Revealing glazes, using the grid method

Ian Currie

Bootstrap Press 2000

ISBN 0-9589275-3-7 out of stock

Stoneware glazes, a systematic approach

Ian Currie

Bootstrap Press 1985

ISBN 0-9589275-2-9 out of stock