Practical Glaze Course

Raw Material Testing

Aim:

- To explore how the various chemicals and minerals used in glazes melt.
- To examine the materials various raw characteristics.
- To learn the names of each material.
- To learn the health risks associated with raw minerals and chemicals.
- Basic labelling rules.
- To understand how pyrometric cones work.

Method:

1. Make test tiles that are small dishes, large enough to hold a teaspoon of material, these need to be bisque fired.
2. Each tile needs to be labelled with the material it will contain. If there is insufficient room on the tile then use an abbreviation. The mixture we use for labelling is a teaspoon of iron oxide, 1/2 teaspoon of manganese dioxide, a pinch each of clay, talc and flux all mixed together with enough water to make it to a consistency you can easily paint on.
3. Take one level teaspoon of each raw material and place in the appropriate test tile.
4. Fire the test tiles in your kiln to the same temperature as your normal glaze firing. Use the cone chart below to select the appropriate cone for your firing.

Analysis:

The following characteristics should be noted for each tile:

1. Type of clay used
2. Temperature fired to (use cones where possible)
3. Name of material
4. Characteristics of the raw material (feel, colour and weight)
5. Degree of melt (is it still powder or semi fused or fully melted)
6. Colour of fired sample
7. Opacity of fired sample
8. Reaction of surrounding bare clay (has the material coloured the surrounding clay)

Summary:

The purpose of this testing was to further your understanding of the various materials used, examining both their raw and fired properties. Cones are composed of the same raw ingredients as just tested. These glaze ingredients are formulated to melt after a certain amount of heat work. This means that it is not just how hot the kiln is, but also how long the firing took. The longer the firing the lower the temperature the cone will bend at (up to a point), see the table below. Cones are regraded as a more accurate indication of the temperature of the kiln than a pyrometre.

Orton Cones

Cone	60^0 p/h	150^0 p/h	Cone	60^0 p/h	150^0 p/h	Cone	60^0 p/h	150^0 p/h
010	880	890	03	1086	1101	5	1177	1196
09	915	923	02	1101	1120	6	1201	1222
08	945	955	01	1117	1137	7	1215	1240
07	973	984	1	1136	1154	8	1236	1263
06	991	999	2	1142	1162	9	1260	1280
05	1031	1046	3	1152	1168	10	1285	1305
04	1050	1060	4	1168	1186	11	1294	1315

Glaze Mixing

Aim:
To understand the process of making up a glaze
Make up the following test glaze:

Potash Feldspar	40g
China Clay	10g
Whiting	20g
Silica	30g
Fire to Cone 8	

Method:
1. Ensure that you have the listed ingredients and equipment on hand.
2. You need 2 clean containers of between 1 and 2 cups capacity, fine scales, 80 mesh sieve (fine), wide brush and test tiles.
3. Using the most accurate pair of scales you have, measure the ingredients one by one into one of the containers.
4. Mix the dry ingredients together.
5. Slowly add clean water as you continue stirring until the mixture resembles a cream consistency.
6. Pour the mixture through the sieve into the other container. Use a clean brush to work all the material through the mesh.
7. Add a little more water to make the glaze the consistency of milk.
8. Dip a test tile into the mixture and hold under for 3 seconds.
9. Once the glaze has dried then dip one corner of the tile in the glaze for 10 seconds.
10. Label the test tile.
11. Fire the glaze test to the specified cone.

Analysis:
- Examine the test tile for the characteristics listed in the 'Test Glaze Sheet'. Fill out one of these sheets each time a test glaze is fired and it will improve your analysis of the test. Some characteristics of the glaze may not be desirable now, but later on may be just what you are after.

Summary:
The purpose of this testing was to familiarise yourself with the equipment and the method used to make a test glaze up. It also introduced you to the method of record keeping needed to analyse a glaze.

Colour Line Blends

Aim:

- To introduce you to the testing method known as Line Blending.
- To use line blends as a tool for discovering glaze colour.
- To examine the following glaze's colour response to Iron Oxide, Copper Carbonate, Manganese Dioxide, Titanium Dioxide, Nickle Oxide, Chrome Oxide and Cobalt Carbonate.

Glaze A	
Potash Feldspar	80g
China Clay	20g
Whiting	40g
Silica	60g

Glaze B	
Soda Feldspar	100g
China Clay	20g
Whiting	40g
Silica	40g

Glaze C	
Potash Feldspar	60g
Soda Feldspar	60g
China Clay	10g
Dolomite	30g
Silica	40g

Fire to Cone 8

Method:

1. Make up the above glazes as outlined in 'Glaze Mixing', note that the quantities have doubled to 200g.
2. Use the schedule below to add an amount of colouring oxide as listed above:

Test Number	1	2	3	4	5	6
Colour Percentage	0%	1%	2%	3%	4%	5%
Amount to Add	0	2g	2g	2g	2g	2g

3. Each time you add a colouring oxide the glaze needs to be re-sieved from one container to the other.
4. Dip a test tile into the glaze in the same manner as we did in 'Glaze Mixing'.
5. Label the test tile with the letters CLB, then the glaze A, B or C, and finally the number of the test.

Analysis:

Use the 'Test Glaze Sheet' to summarise each test series. In particular note the following:

- The way the colour varies across the series.
- Any difference in the melt characteristics across the series.
- The amounts of colouring oxides that were either too much or too little as this gives you the range of possibilities.
- The way the different base glazes affects the colour.

Summary:

Line blends are a powerful method of finding out the correct proportion of colouring oxide that is needed to colour a glaze. However, they do suffer from an accumulating error problem and so keeping the series of tests short improves their accuracy.

Material Line Blends

Aim:

- To use the line blend method to vary 2 glaze materials in a base glaze.
- Understand the maths for ascertaining the proportions in various mixes.
- To discover the limits of materials in a glaze using the glazes on the attached sheet.

Method:

1. Make up both glazes using the same amount of water so that their volumes are identical. Start with the glaze that has the most clay in it and once that glaze is mixed to the usual cream consistency then make the other glaze equal in volume.
2. The glazes need constant stirring throughout testing as they can settle very quickly.
3. Using either a syringe or a measuring spoon remove some of glaze A as per the schedule below and empty it to an empty cup. Add the balance of glaze B as per the schedule and mix the two together. Sieving is not necessary.

Test Number	1	2	3	4	5	6
Ratio A:B	100:0	80:20	60:40	40:60	20:80	0:100
Amount of A		80ml	60ml	40ml	20ml	
Amount of B		20ml	40ml	60ml	80ml	

4. Dip the test tile into this mixture and label according to the schedule. Then move onto the next test. For tests No 1 and 6 just dip the test tile into the large batch of glaze A and B respectively.
5. Label all the tests with MLB, then the glaze combinations (eg. A.B), then the number of the test.

Analysis:

Use the 'Test Glaze Sheet' to summarise each test series. In particular note the following:

- The way the texture of the surface changes across the series, note which end feels rough, which end feels smooth.
- Note the way crazing can vary across the series.

Summary:

This version of the line blend is a very useful tool for varying one or two ingredients in a glaze to discover the function of those ingredients, or to fine tune a glaze. The number of steps may be as large as you like, but practically speaking 5 steps would be the minimum and around 15 would be as fine as ever needed. The maths needed to derive a glaze in the series appears daunting at first but with practice is very logical.

Glaze A	%	Batch = 300g
Soda Feldspar	37	111
China Clay	27	81
Whiting	9	27
Silica	27	81

Glaze B	%	Batch = 300g
Soda Feldspar	37	111
China Clay	9	27
Whiting	27	81
Silica	27	81

Tile	A ml	B ml	Soda Feldspar	China Clay	Whiting	Silica
1	100	0	37	27	9	27
2	80	20	37	23.4	12.6	27
3	60	40	37	19.8	16.2	27
4	40	60	37	16.2	19.8	27
5	20	80	37	12.6	23.4	27
6	0	100	37	9	27	27
MIX	50	50	37	18	18	27

Glaze C	%	Batch = 300g
Soda Feldspar	30	90
China Clay	5	15
Whiting	30	90
Zinc	5	15
Silica	30	90

Glaze D	%	Batch = 300g
Soda Feldspar	60	180
China Clay	5	15
Whiting	5	15
Zinc	5	15
Silica	25	75

Tile	C ml	D ml	Soda Feldspar	China Clay	Whiting	Zinc	Silica
1	100	0	30	5	30	5	30
2	80	20	36	5	25	5	29
3	60	40	42	5	20	5	28
4	40	60	48	5	15	5	27
5	20	80	54	5	10	5	26
6	0	100	60	5	5	5	25
MIX	50	50	45	5	17.5	5	27.5

Glaze E	%	Batch = 300g	Glaze F	%	Batch = 300g		
Potash Feldspar	40	120	Potash Feldspar	48	144		
China Clay	10	30	China Clay	10	30		
Whiting	25	75	Whiting	10	30		
Talc	5	15	Talc	20	60		
Silica	20	60	Silica	12	36		
Tile	E ml	F ml	Potash Feldspar	China Clay	Whiting	Talc	Silica
1	100	0	40	10	25	5	20
2	80	20	41.6	10	22	8	18.4
3	60	40	43.2	10	19	11	16.8
4	40	60	44.8	10	16	14	15.2
5	20	80	46.4	10	13	17	13.6
6	0	100	48	10	10	20	12
MIX	50	50	44	10	17.5	12.5	16

To determine what a particular glaze recipe is from anywhere in the series follow this procedure:
1. Note the ratio of whichever test you are interested in.
e.g. test no. 2 is C=80, D=20
2. Multiple all the ingredients in glaze C by its' ratio number.

e.g. glaze C for test no. 2 is:		
	Soda Feldspar	30 X 80 = 2400
	China Clay	5 X 80 = 400
	Whiting	30 X 80 = 2400
	Zinc Oxide	5 X 80 = 400
	Silica	30 X 80 = 2400

3. Multiple all the ingredients in glaze D by its' ratio number.

e.g. glaze D for test no. 2 is:		
	Soda Feldspar	60 X 20 = 1200
	China Clay	5 X 20 = 100
	Whiting	5 X 20 = 100
	Zinc Oxide	5 X 20 = 100
	Silica	25 X 20 = 500

4. Now add together the 2 glazes, matching up the same ingredients where possible.
e.g. glaze C + glaze D for test no. 2 is:

	Soda Feldspar	2400 + 1200 = 3600
	China Clay	400 + 100 = 500
	Whiting	2400 + 100 = 2500
	Zinc Oxide	400 +100 = 500
	Silica	2400 + 500 = 2900
		Total = 10000

5. Now we simplify the numbers so that the Total will equal 100. We do this by dividing each number by 100.

e.g.. normalising test no. 2		
	Soda Feldspar	3600 ÷ 100 = 36
	China Clay	500 ÷ 100 = 5
	Whiting	2500 ÷ 100 = 25
	Zinc Oxide	500 ÷ 100 = 5
	Silica	2900 ÷ 100 = 29
		Total = 100

Whenever possible it is good practice to make all your glaze recipes total to 100 as this makes comparison between glazes that much easier.

Material Triaxial Testing

Aim:

- To explore the use of a three way mix for discovering new glazes.
- Understand the maths of three way ratios.
- To better understand the ratios of the major glaze constituents: fluxes, stabilisers, glass formers.

Method:

1. The 2 attached sheets detail how the triaxial graph is laid out and how to mix the various glazes together.
2. Make up the 3 glazes as per the schedule using the batch amounts. The percentage recipe is needed to understand the various ratios of materials. They must all be made up to identical volumes of glaze.
3. You will need to have 18 separate pots that the main 3 glazes will be divided into.
4. Lay out your glazes and mixing pots according to the graph, label each pot with MTT, then the glazes used, then its number and also label each of the test tiles with the same reference number.
5. Using either a syringe or measuring spoons divide up glaze A into all the cups using the schedule to determine amounts. It is important to always stir the glaze before removing any to insure an even consistency.
6. Now divide up glaze B and C in the same manner. Each mixing pot should have the same volume of glaze in it.
7. Stir each cup just before you dip a test tile into the mixture.

Analysis:

- Lay out the test tiles into the same triangle pattern as the graph. The same sheet that you used to make up the tests also has a breakdown of what the recipe is for each tile. Use this in conjunction with the 'Test Glaze Sheet' to note the following:
- The trends across the group, for instance, changes in opacity and colour response.
- Note the qualities each corner exhibits and the way it is modifies as it progressively mixes with the other glazes.
- The maths used to derive the glazes for each number of the graph are very similar to the maths used in Material Line Blends but this time you need to use the proportions of all three glazes added together.

Summary:

Triaxial testing can quickly pinpoint areas of interest and to see the effects of each material, both in isolation and in various combinations. Triaxial testing can be used to trial various flux combinations with great accuracy, or test a substitute material.

Glaze G	%	Batch = 600g	Glaze H	%	Batch = 600g	Glaze I	%	Batch = 600g
Potash Feld	40	240	Potash Feld	40	240	Potash Feld	40	240
China Clay	5	30	China Clay	25	150	China Clay	3	18
Whiting	40	240	Whiting	13	78	Whiting	17	102
Silica	15	90	Silica	22	132	Silica	40	240

Tile	G ml	H ml	I ml	Potash Feld	China Clay	Whiting	Silica	
1	100			40	5	40	15	
2	80	20		40	9	34.6	16.4	
3	80		20	40	4.6	35.4	20	
4	60	40		40	13	29.2	17.8	
5	60	20	20	40	8.6	30	21.4	
6	60		40	40	4.2	30.8	25	
7	40	60		40	17	23.8	19.2	
8	40	40	20	40	12.6	24.6	22.8	
9	40	20	40	40	8.2	25.4	26.4	
10	40		60	40	3.8	26.2	30	
11	20	80		40	21	18.4	20.6	
12	20	60	20	40	16.6	19.2	24.2	
13	20	40	40	40	12.2	20	27.8	
14	20	20	60	40	7.8	20.8	31.4	
15	20		80	40	3.4	21.6	35	
16		100		40	25	13	22	
17		80	20	40	20.6	13.8	25.6	
18		60	40	40	16.2	14.6	29.2	
19		40	60	40	11.8	15.4	32.8	
20		20	80	40	7.4	16.2	36.4	
21			100	40	3	17	40	
MIX	0.33	0.33	0.33	39.96	10.99	23.31	25.64	

Glaze J	%	Batch = 600g
Potash Feld	45	270
China Clay	10	60
Dolomite	10	60
Whiting	10	60
Silica	25	150
Iron oxide	1	6

Glaze K	%	Batch = 600g
Potash Feld	45	270
China Clay	12	72
Talc	18	108
Whiting	7	42
Silica	18	108
Iron oxide	1	6

Glaze L	%	Batch = 600g
Potash Feld	40	240
China Clay	10	60
Barium Carb	20	120
Whiting	10	60
Silica	25	150
Iron oxide	1	6

Tile	J ml	K ml	L ml	Potash Feld	China Clay	Whiting	Dolomite	Talc	Barium	Silica
1	100			45	10	10	10	0	0	25
2	80	20		45	10.4	9.4	8	3.6	0	23.6
3	80		20	44	10	10	8	0	4	25
4	60	40		45	10.8	8.8	6	7.2	0	22.2
5	60	20	20	44	10.4	9.4	6	3.6	4	23.6
6	60		40	43	10	10	6	0	8	25
7	40	60		45	11.2	8.2	4	10.8	0	20.8
8	40	40	20	44	10.8	8.8	4	7.2	4	22.2
9	40	20	40	43	10.4	9.4	4	3.6	8	23.6
10	40		60	42	10	10	4	0	12	25
11	20	80		45	11.6	7.6	2	14.4	0	19.4
12	20	60	20	44	11.2	8.2	2	10.8	4	20.8
13	20	40	40	43	10.8	8.8	2	7.2	8	22.2
14	20	20	60	42	10.4	9.4	2	3.6	12	23.6
15	20		80	41	10	10	2	0	16	25
16		100		45	12	7	0	18	0	18
17		80	20	44	11.6	7.6	0	14.4	4	19.4
18		60	40	43	11.2	8.2	0	10.8	8	20.8
19		40	60	42	10.8	8.8	0	7.2	12	22.2
20		20	80	41	10.4	9.4	0	3.6	16	23.6
21			100	40	10	10	0	0	20	25
MIX	0.33	0.33	0.33	43.29	10.66	8.99	3.33	5.99	6.66	22.64

Glaze M	%	Batch = 600g	Glaze N	%	Batch = 600g	Glaze O	%	Batch = 600g	
Soda Feldspa	60	360	Soda Feldspa	30	180	Soda Feldspa	35	210	
China Clay	10	60	China Clay	15	90	China Clay	12	72	
			Talc	15	90	Zinc Oxide	13	78	
Whiting	10	60	Whiting	15	90	Whiting	15	90	
Silica	20	120	Silica	25	150	Silica	25	150	
Copper Carb	2	12	Copper Carb	2	12	Copper Carb	2	12	

Tile	M ml	N ml	O ml	Soda Feldspar	China Clay	Whiting	Zinc Oxide	Talc	Silica
1	100			60	10	10	0	0	20
2	80	20		54	11	11	0	3	21
3	80		20	55	10.4	11	2.6	0	21
4	60	40		48	12	12	0	6	22
5	60	20	20	49	11.4	12	2.6	3	22
6	60		40	50	10.8	12	5.2	0	22
7	40	60		42	13	13	0	9	23
8	40	40	20	43	12.4	13	2.6	6	23
9	40	20	40	44	11.8	13	5.2	3	23
10	40		60	45	11.2	13	7.8	0	23
11	20	80		36	14	14	0	12	24
12	20	60	20	37	13.4	14	2.6	9	24
13	20	40	40	38	12.8	14	5.2	6	24
14	20	20	60	39	12.2	14	7.8	3	24
15	20		80	40	11.6	14	10.4	0	24
16		100		30	15	15	0	15	25
17		80	20	31	14.4	15	2.6	12	25
18		60	40	32	13.8	15	5.2	9	25
19		40	60	33	13.2	15	7.8	6	25
20		20	80	34	12.6	15	10.4	3	25
21			100	35	12	15	13	0	25
MIX	0.33	0.33	0.33	41.63	12.32	13.32	4.33	5.00	23.31

Colour Triaxial Testing

Aim:

- To use triaxial testing to examine the effects of various colouring oxides in combinations.

Method:

1. Use the 2 sheets provided, one is the triaxial graph and the other details the glazes that need to be made up and the various percentages of each to mix together. Use the same method as for Material Triaxial Testing to mix the glazes and dip the test tiles.

Analysis:

- Layout the test tiles in the same order as the triaxial graph and note the variation of colours across the tiles. Also note if any of the colouring combinations made the glaze more or less fluid.

Summary:

Triaxial blends are a fast and effective way to explore a multitude of colour effects and to quickly refine a colour pallet that works.

Glaze P	%	Batch = 600g
Soda Feldspar	45	270
China Clay	10	60
Whiting	15	90
Calcium Borate	10	60
Silica	20	120

Glaze Q	%	Batch = 600g
Soda Feldspar	45	270
China Clay	10	60
Whiting	15	90
Calcium Borate	10	60
Silica	20	120
Copper Carb	5	30

Glaze R	%	Batch = 600g
Soda Feldspar	45	270
China Clay	10	60
Whiting	15	90
Calcium Borate	10	60
Silica	20	120
Iron Oxide	5	30

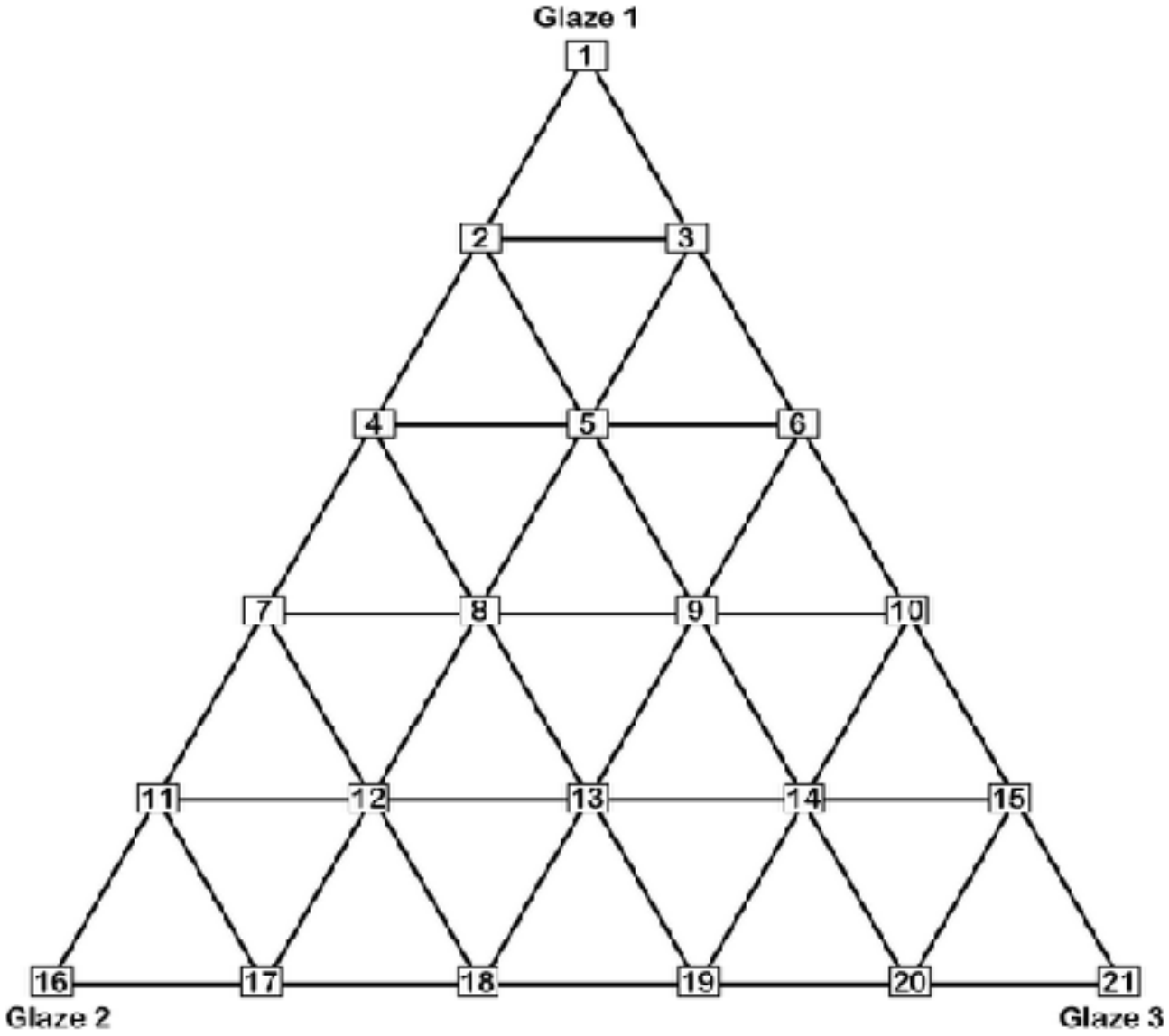
Tile	P ml	Q ml	R ml	Copper Carb	Iron Oxide
1	100			0	0
2	80	20		1	0
3	80		20	0	1
4	60	40		2	0
5	60	20	20	1	1
6	60		40	0	2
7	40	60		3	0
8	40	40	20	2	1
9	40	20	40	1	2
10	40		60	0	3
11	20	80		4	0
12	20	60	20	3	1
13	20	40	40	2	2
14	20	20	60	1	3
15	20		80	0	4
16		100		5	0
17		80	20	4	1
18		60	40	3	2
19		40	60	2	3
20		20	80	1	4
21			100	0	5
MIX	0.33	0.33	0.33	1.67	1.67

Glaze S	%	Batch = 600g	Glaze T	%	Batch = 600g	Glaze U	%	Batch = 600g
Soda Feldspar	45	270	Soda Feldspar	45	270	Soda Feldspar	45	270
China Clay	10	60	China Clay	10	60	China Clay	10	60
Whiting	15	90	Whiting	15	90	Whiting	15	90
Calcium Borate	10	60	Calcium Borate	10	60	Calcium Borate	10	60
Silica	20	120	Silica	20	120	Silica	20	120
			Manganese Diox	5	30	Titanium Diox	5	30

Tile	S ml	T ml	U ml	Manganese Diox	Titanium Diox
1	100			0	0
2	80	20		1	0
3	80		20	0	1
4	60	40		2	0
5	60	20	20	1	1
6	60		40	0	2
7	40	60		3	0
8	40	40	20	2	1
9	40	20	40	1	2
10	40		60	0	3
11	20	80		4	0
12	20	60	20	3	1
13	20	40	40	2	2
14	20	20	60	1	3
15	20		80	0	4
16		100		5	0
17		80	20	4	1
18		60	40	3	2
19		40	60	2	3
20		20	80	1	4
21			100	0	5
MIX	0.33	0.33	0.33	1.67	1.67

Glaze V	%	Batch = 600g	Glaze W	%	Batch = 600g	Glaze X	%	Batch = 600g
Soda Feldspar	45	270	Soda Feldspar	45	270	Soda Feldspar	45	270
China Clay	10	60	China Clay	10	60	China Clay	10	60
Whiting	15	90	Whiting	15	90	Whiting	15	90
Calcium Borate	10	60	Calcium Borate	10	60	Calcium Borate	10	60
Silica	20	120	Silica	20	120	Silica	20	120
			Cobalt Carb	1	6	Chrome Ox	1	6

Tile	V ml	W ml	X ml	Cobalt Carb	Chrome Ox
1	100			0	0
2	80	20		0.2	0
3	80		20	0	0.2
4	60	40		0.4	0
5	60	20	20	0.2	0.2
6	60		40	0	0.4
7	40	60		0.6	0
8	40	40	20	0.4	0.2
9	40	20	40	0.2	0.4
10	40		60	0	0.6
11	20	80		0.8	0
12	20	60	20	0.6	0.2
13	20	40	40	0.4	0.4
14	20	20	60	0.2	0.6
15	20		80	0	0.8
16		100		1	0
17		80	20	0.8	0.2
18		60	40	0.6	0.4
19		40	60	0.4	0.6
20		20	80	0.2	0.8
21			100	0	1
MIX	0.33	0.33	0.33	0.33	0.33



Test Glaze Sheet

Name of glaze: Recipe:
Date:
Source of recipe:
Temperature fired to:
Cone number:
Test tile number:

Shine:
(how shiny or matt is the surface of the glaze?)

Tactile quality:
(how smooth does the surface of the glaze feel?)

Opacity:
(how transparent is the glaze?)

Thickness:
(how does the glaze vary with thickness?)

Melt:
(how melted does the glaze look?, is it running off the test tile?)

Colour:
(how well does the glaze show off the various colouring oxides?)

Crazing:
(does the glaze show any cracking?, how much?)

Shivering:
(is the glaze flaking off the tile?, check the rims and edges.)

Crawling:
(has the glaze pulled back on itself and formed droplets of glaze?)

Pin holing:
(does the glaze display small holes that reach to the clay underneath?)

Summary:

Any further testing needed?

Very Good Good Average Poor Very Poor