Pottery
A Beginner's Handbook

by
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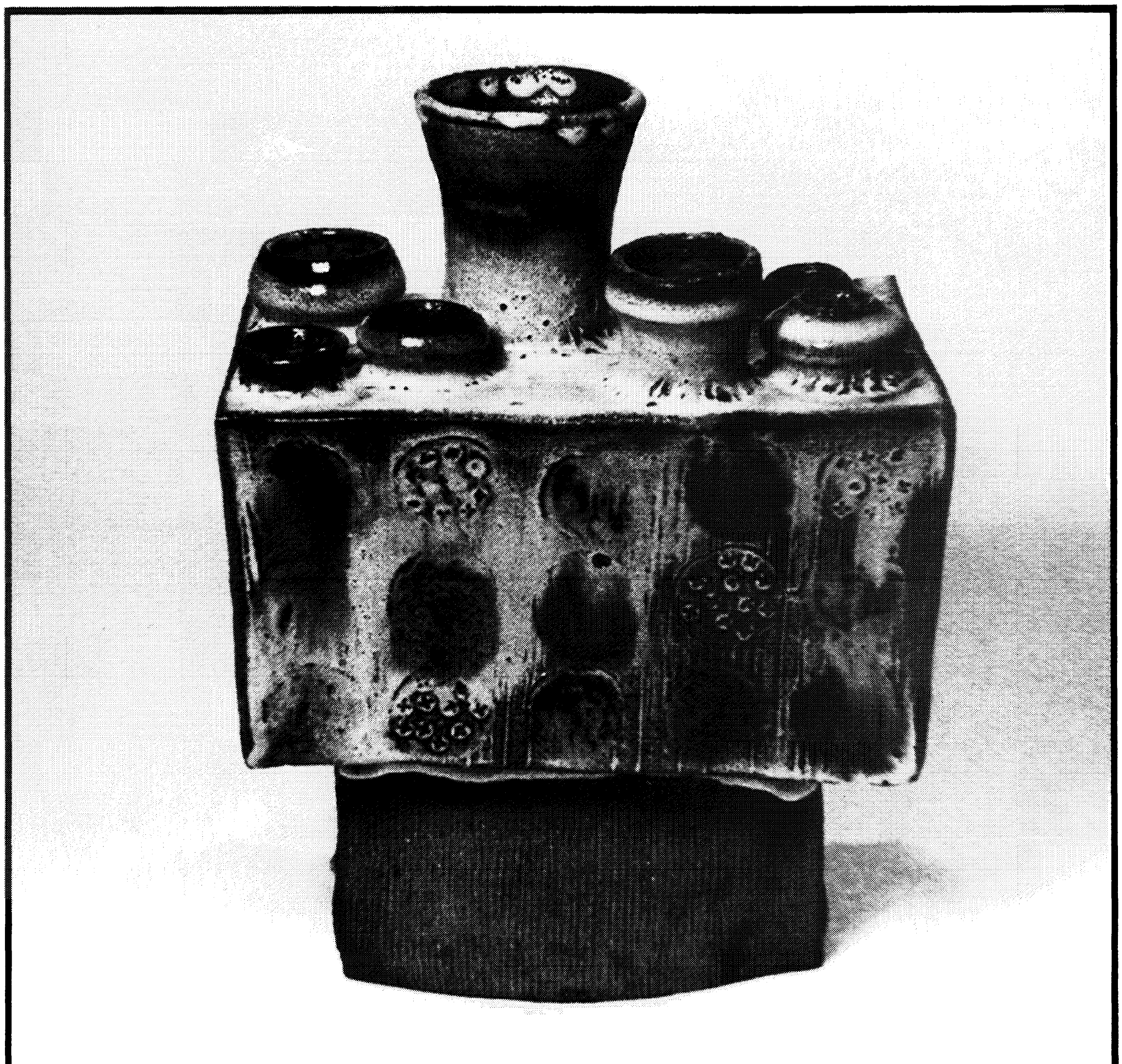

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Introduction

Making pottery involves learning a number of somewhat demanding skills that can only be mastered through much practice. In addition to learning these skills, the novice potter must become familiar with the material; it's a material that dries too fast (when it shouldn't), cracks at the worst possible moment, sags in the wrong place, and then explodes for some "unknown" reason. Becoming aware of the reasons for these and other disasters takes a great deal of trial and investigation on the part of the beginner and is probably the most frustrating part of becoming a potter.

It is the purpose of this handbook to give you an idea of what making pottery is all about. Most texts, in an effort not to miss anything, try to cover enormous amounts of information that the beginner is often at a loss to digest. This book, on the other hand, was written to break down the information and whet your appetite for more as you become more fully involved with pottery.

The first part of the book is intended to provide a basic grounding in the fundamentals of ceramics. You'll learn about clay and why it's such a "magic" material. You'll discover what happens to it when it's fired in a kiln. And you'll become familiar with the many glazes and tools that potters use. The reading assignments and tests should help you to absorb what you have learned.

The second part takes you right into the potter's studio and shows you, one step at a time, the basic construction methods for making pottery. Once you get started on projects of your own, you'll find that the pictures and information in this section will serve as a handy guide for carrying out your work successfully.

Included at the back of the book are suggestions for further reading, a glossary of ceramic terms, and an index. Answers for the reading exercises and tests are also provided.

Firing

CLAY AND THE FIRE

One of the most exciting experiences you as a potter can have is that of firing your ware in your own kiln, especially if it's a gas or wood fire. As the temperature approaches its maximum, the kiln seems to come alive. It roars, spews flame, at times belches smoke, and emits a tremendous pulsing heat. You, the novice, wonder if your fragile pots are still in one piece or if this monster has devoured them. You keep peering through the spyholes in an effort to see, but the most you can see are those little pyramid-shaped cones that are supposed to bend.

As the orange-yellow incandescence increases and the cones remain upright, you start to wonder if you put the cones in correctly or even if you put in the right ones. Finally a cone goes down, slowly—oh, so slowly—and a sigh of relief ushers in the uncomfortable feeling that you are not exactly sure when to turn the thing off. Now that you are there, a potter and your kiln, both burning with incredible excitement, isn't there something about letting the clay and glazes "soak" up the heat? For how long? If the "soaking" isn't long enough, won't the glazes blister and bubble on the ware? If it goes too far, too high, too long, will the clay slump and warp, and will the glazes run off the ware?

You make a decision and make it blind, except for those little cones that are starting to become a flat mass. You turn off the monster, tame it, and close the damper, keeping all that heat inside. Now you stand around and listen to the tinkle as it cools. Better yet, you go away. You go back to work, go to a party, or go to bed; there is nothing to do now but wait. You wait for eight to ten or twelve excruciating hours to find out what really happened.

At last comes that famous "Moment of Truth." You open your kiln. Your emotions run the gamut from awe to disappointment to quick moments of anger as your fingers are burned. Great joy—the red pot in the middle came out perfectly. So what if the blue fruit bowl cracked? It will still make a great planter. In the flush of fascination at trying to see everything at once, you the neophyte forget to *make note* of where the cracked blue pot was situated in the kiln. You overlook the position of those goblets that bent and those that didn't. These and a hundred other important observations are lost. The first fire is over, and at least the kiln works. Next time you'll know when to turn it off, and next time you'll make notes, hopefully! Maybe you will even play with the damper a little; there must be some reason why that coffee mug with the "red" glaze came out half green.

There are reasons, explanations, judgments, generalizations, and a lot of other things that the new guy with the kiln is going to find out about. Things occurred in that and all firings that can't be seen. The more you know about the unknown, the more successful you will become. So let's consider the effect of fire and atmosphere on clay.

It probably sounds a little far out to say that successful firing begins as the ware is being constructed or thrown. But it's true. Let's analyze the situation.

WHEN CAN WE FIRE?

Before a clay pot or sculpture can be fired, it should be dry. How dry? Two days, a week, or maybe a month? There is no set rule on time. It's possible to make pottery one day during a Southern California summer and load it in a kiln to be fired the next day. On the other hand, some pieces of sculpture or thick ware may take several weeks to dry completely.

The rule on dryness isn't how long the ware has been on the shelf, it's whether all the moisture (water of plasticity) has evaporated or not. When the potter thinks this has happened, the ware is ready for the fire. One method or test for dryness is to hold the "**bone dry**" ware against your cheek. If the pot feels cold, there is still moisture in the body; if it is warm or you can't feel any warmth or coldness, the pot is ready to fire.

Check Your Reading

Supply the missing words to complete the statements below.

1. Kilns are heated (fired) with various fuels. Two of the most exciting to use are ______________ and ______________.
2. Spy or "peep" holes in the kiln door allow the potter to observe the progress of the firing. True or False? ______________.
3. Pyramid-shaped cones are supposed to ______________.
4. Glazes are supposed to ______________ up heat.
5. If the kiln is fired too far or too high or too long, the clay will slump and ______________, and the ______________ will run off the pot.
6. When the kiln is turned off, the potter has to wait eight to ten or ______________ hours before the kiln is ______________ enough to open the door.
7. In the excitement of trying to see everything at once, the neophyte forgets to ______________ where things were in the kiln. Hundreds of important ______________ are lost.
8. Sometimes "red" glazes will fire to a ______________ color.
9. Things happen when the kiln is firing that cannot be ______________.

10. Successful firing often begins as the ware is being ________________ or ________________.

11. Before clay can be fired it should be ________________.

12. The rule for dryness is not how long the ware has been on the ________________. Dryness occurs when all the ________________ (water of plasticity) has evaporated. A test for dryness is to hold the ________________ ware against your ________________.

13. If the pot (or sculpture) is ________________ against your cheek, it is ready to fire.

14. It's possible to make pottery one day and fire it the next. True or False? ________________.

15. When the kiln is finally turned off, the best thing the potter can do is ________________.

Test Yourself

Write T if the statement is true. Write F if it is false.

1. ______ A wide variety of fuels is used to heat (fire) kilns.
2. ______ Wood and gas are two of the more exciting fuels used for firing.
3. ______ The most exciting fuel to use is electricity.
4. ______ Spy or "peep" holes in the kiln door allow the potter to watch the progress of the firing.
5. ______ If you see smoke or flames, your kiln is too hot.
6. ______ The damper should be left open after you turn the kiln off.
7. ______ If a kiln is fired at a temperature that is too high for the clay, the clay will slump and warp, and the glaze will run off the pot.
8. ______ Kilns are often heated through the "peep" holes.
9. ______ When the kiln is turned off, potters wait a few minutes and then open the door to see if the firing has gone well.
10. ______ Glazes are supposed to soak up heat.
11. ______ Sometimes "red" glazes will fire to a green color.
12. ______ Before ware can be fired it should be dry—bone dry.
13. ______ Successful firing begins when the pots are being stacked in the kiln.
14. ______ It's possible to make pottery one day and fire it the next.
15. ______ If the pot (or sculpture) is damp or cold when held against your cheek, it is ready to fire.
16. ______ Pyramid-shaped cones are supposed to bend.
17. ______ The best time to turn a kiln off is just before the cones start to bend over.

18. ______ Things happen in a kiln being fired that cannot be seen.

19. ______ If the glaze doesn't soak up enough heat, it will blister and bubble.

20. ______ Success in firing a pot often begins when the ware is being thrown or constructed.

DRYING

How a pot will dry and ultimately fire is directly affected by the type of clay and how it is used. Granulated bodies, used by industry in press molds, have very little water of plasticity and are not plastic; a studio potter couldn't use them, but they dry rather fast. Plastic clays as used by studio potters contain from 30 to 35 percent water, and this takes time to evaporate. Student potters usually use too much water when learning to throw. Part of this is absorbed by the clay, causing the mechanical water content to rise beyond the 30 to 35 percent level. The beginner's pot may be as much as 40 percent water.

Shrinkage

You may have noticed that the "giant" pot you threw yesterday is smaller today. In fact, it's a lot smaller. Two things have happened. The first is real and measurable. Drying *is* accompanied by shrinkage. As the moisture evaporates, the clay particles draw closer together. By the time the pot is what we call leather hard, it may have shrunk 5 to 10 percent. If the pot was ten inches tall when you took it off the wheel, it may be only nine inches when dry. The second thing that happens is mental. As you walk around thinking about this last marvelous accomplishment, the image gets bigger and bigger in your mind. Reality is somewhat of a shock. (It always is.)

Warping and Cracking

As your pot dries and shrinks, thick and thin sections will shrink in different amounts. Then what happens? The pot may crack or warp, or both. If it does neither in the drying stage, it may set up stresses that do cause warping or cracking when the ware is fired. The obvious solution to this problem is learning to throw consistent thicknesses in the walls and bottom of your ware.

Drying and shrinkage happen at a rate dictated by the atmosphere surrounding the ware. If the humidity is high, drying is slow. Conversely, if the humidity is low or near zero, drying is rapid. Of the two, slow drying is best. Slow drying allows the moisture to escape more evenly from all parts of the pot at the same time. This reduces warping and cracking in both well-made and poorly thrown or constructed ware. The addition of grog to a clay body facilitates drying in large thrown or hand-constructed ware and sculpture.

Putting a pot in direct sunlight or near a firing kiln or in an area where one side will dry faster than the rest will probably cause warping. A sudden draft of warm air on one side of the pot will sometimes be enough to cause warping. Therefore, drying racks or shelves should be away from doors and windows.

Although it is not always practical, the best way to dry a pot is in a damp closet or box or under a plastic bag until the ware is ***leather hard.*** At this stage, the pot is partly dried but still damp; it is firm and no longer plastic. When a warped or cracked pot is removed from a glaze fire, the warp or crack often was already "set" into the ware before it was ever placed in the kiln. The "set" was caused by improper drying, the crack by improper handling.

One more thing about cracking: Often cracks will develop in the bottom of thrown ware. These cracks are caused by the thrower. Throwing too wet, not compressing the bottom, and not sponging all the water out are several common errors that result in cracking.

Check Your Reading

Supply the missing words to complete the statements below.

1. How the pot will dry and ultimately fire is directly affected by the type of ________________ and how it is used.

2. Granulated clay bodies have little water and are not ________________.

3. Plastic clays, like those used by studio potters, contain __________ to __________ percent water of plasticity.

4. Student potters usually use too much ________________ when throwing. Part of this is ________________ into the clay.

5. A beginner's pot may contain as much as __________ percent water.

6. Drying is always accompanied by ________________.

7. Thick and thin sections will shrink in ________________ amounts.

8. If shrinkage is uneven or varied, the pot may ________________ or ________________.

9. Even if a pot does dry without warping or cracking, ________________ may cause it to warp or crack when it is being fired. The obvious solution to this is to learn to throw consistent ________________ in the walls and bottom of your ________________.

10. Drying and shrinkage are dictated by the ________________ surrounding the ware. If the humidity is high, drying is ________________. If the humidity is low, drying is ________________.

11. Slow drying is ________________ because it allows the moisture to escape more ________________ from all parts of the ware at the same time.

12. The addition of grog to a clay body helps ________________.

13. The best way to dry a pot is in a ________________ closet or box or under a ________________ until the ware is ________________.

14. Throwing too ________________, not compressing the bottom, and not sponging all the ________________ out of the bottom of the pot are several common reasons for cracks in the bottom of thrown ware.

15. A sudden draft of warm ________________ is sometimes enough to cause ware to warp.

Test Yourself

*Write **T** if the statement is true. Write **F** if it is false.*

1. ______ Kilns are often heated through the "peep" holes.
2. ______ Sometimes "red" glazes will turn out green.
3. ______ Successful firing often begins when the ware is being made.
4. ______ Thick and thin sections will shrink the same amount.
5. ______ A sudden draft of warm air is enough to cause ware to warp.
6. ______ A leather-hard pot is completely dry.
7. ______ The type of clay used affects the way a pot dries and fires.
8. ______ Plastic clay bodies shrink less than granulated clay bodies.
9. ______ If pottery is fired too high, it may melt into a clay pancake.
10. ______ It's possible to make pottery one day and fire it the next.
11. ______ Studio potters often use granulated clay bodies.
12. ______ Spyholes are used to observe the progress of the firing.
13. ______ Drying is seldom accompanied by shrinkage.
14. ______ Granulated clay bodies have little water but are very plastic.
15. ______ Throwing too wet is a common reason for cracks and warpage.
16. ______ The best way to dry a pot is to place it near a warm kiln.
17. ______ If the humidity is high, a clay pot will usually dry very fast.
18. ______ The addition of grog to a clay body increases plasticity.
19. ______ Glazes are supposed to soak up heat.
20. ______ Before clay is fired, it should be "bone dry."
21. ______ Grog is powdered clay that has been fired.
22. ______ Kilns are usually opened as soon as they are turned off.
23. ______ Shrinkage is both real and mental.
24. ______ Pyramid-shaped cones are supposed to bend.
25. ______ The addition of grog to a clay body facilitates drying.
26. ______ Slow drying of ware is usually a wastee of time.
27. ______ Things happen in a kiln being fired that cannot be seen.
28. ______ The most exciting fuel to use is electricity.
29. ______ A wide variety of fuels are used to heat (fire) kilns.

THE FIRING CYCLE

When the ware is "bone dry," it is stacked into a kiln for firing. "***Bone dry***" means the ware *feels* completely dry. It has the look and feel of dried bones. The clay isn't really dry. It can't be, because our atmosphere is never zero humidity. Thus drying is completed in the kiln. the ***firing cycle*** is what we call the whole process of firing ware in the kiln.

Water Smoking

When the temperature in the kiln reaches 212°F, all remaining water of plasticity is burned off. This is the first in a series of critical points. Water boils and turns to steam at 212°F. It doesn't matter whether you are boiling eggs or firing clay; it's the same kind of water, and it does the same thing. If the steam leaves the clay too fast, the pot explodes; if you boil eggs too fast, they crack. Fire the kiln slow and easy with the door open a crack to allow the steam a chance to escape. In large kilns, enough steam is often generated to be seen. For this reason the early part of the firing cycle is called ***water smoking***.

Dehydration

As the temperature increases to 660°F, the chemical water starts to burn off. By 950°F the clay is completely ***dehydrated***—all the chemical water has been burned off. The clay is now a chemically different material than it was when put into the kiln. It is now an aluminum silicate known as **mullite.** ($Al_2O_3 \bullet 2SiO_2$). This change is not reversible.

The Quartz Inversion

The next critical change begins at about 1000°F. The ***quartz*** crystals in the clay undergo a change called the ***quartz inversion***. The crystals grow and change in shape. Just as with the water smoking period and the burning off of the chemical water, the quartz inversion has to be done slowly.

Oxidation

Oxidation (the burning off of organic materials) occurs at 1600°F to 1700°F. This has no chemical effect on the clay, but it does leave the clay more porous. This is an advantage when glazing bisque ware (see "The Bisque Fire," p. 33).

Vitrification

Partial ***vitrification*** begins as the temperature rises. This will be determined by the type of clay body. Clay with a high alumina content (stoneware and porcelain) will vitrify more slowly and at a higher temperature than clay high in fluxes such as iron or talc (earthenware). Vitrification, you will remember, is a melting of the clay platelets. Complete vitrification results in a glasslike material; therefore, clay ware is never completely vitrified.

Check Your Reading

Supply the missing words to complete the statements below.

1. When the pottery is ____________________, it is ready to be ____________________ into the kiln for firing.

2. Bone dry means the ware ____________________ completely dry.

3. Clay isn't completely dry until it has been fired to a temperature of over ____________________.

4. If a pot is fired too fast, it will probably ____________________.

5. At 660°F the ______________ water starts to burn off. By ______________ °F the clay is completely ______________.

6. When all the chemical water has burned off, the clay becomes a chemically different material known as ______________. This change is not reversible.

7. At about 1000°F, the quartz crystals change. This is called the ______________. The crystals ______________ and change shape.

8. The burning off of organic materials is called ______________. It occurs at 1600°F to ______________ °F.

9. Vitrification is the last stage in firing. This is determined by the type of ______________.

10. Such clays as ______________ and ______________, with a high amount of alumina, vitrify slowly and at a high temperature.

11. Vitrification is the melting of clay platelets. It means the process of becoming ______________.

12. Earthenware is a low-temperature clay. True or False? ______________.

13. Earthenware is high in fluxes like ______________ or ______________.

14. Fired clay is known as mullite. Its formula is ______________.

15. A clay goes through ______________ stages before it is mature. They occur in this order:

    1) ______________

    2) ______________

    3) ______________

    4) ______________

    5) ______________

Test Yourself

*Write **T** if the statement is true. Write **F** if it is false.*

1. ______ Bone dry means the ware is completely dry.
2. ______ If a pot is fired too fast, it will probably crack or explode.
3. ______ Clay is completely dry when it has reached a temperature of 185°F.
4. ______ At 660°F the mechanical water starts to burn off.
5. ______ Mechanical water and chemical water are the same thing.
6. ______ By 950°F the clay is completely dehydrated.

7. ______ Clay that has been completely dehydrated is known as mullite.

8. ______ If the ware (pottery) looks completely dry, it is bone dry.

9. ______ The quartz inversion starts at about 1000°F.

10. ______ During the quartz inversion the quartz crystals move around.

11. ______ Oxidation occurs when the organic materials burn off.

12. ______ Earthenware is a high-temperature clay that is usually vitrified.

13. ______ Vitrification is the last change the clay undergoes in the fire.

14. ______ Earthenware is a high-temperature clay that is usually vitrified.

15. ______ Vitrification means the process of becoming glasslike.

16. ______ A clay goes through seven stages of firing before it is mature.

17. ______ Water smoking is the first stage of firing.

18. ______ Clays like stoneware and porcelain are seldom vitrified.

19. ______ Mullite has the chemical formula of $Al_2O_3 \bullet 2SiO_2 \bullet 2H_2O$.

20. ______ Vitrification is the melting of the clay platelets.

21. ______ The kiln door should be firmly shut at all stages of firing.

22. ______ The boiling temperature of water is 212°F.

23. ______ Quartz crystals grow in size during the quartz inversion.

24. ______ Often, pottery can be fired when it is leather hard.

25. ______ Dehydration takes place when the chemical water burns off.

THE BISQUE FIRE

It's the practice of many studio potters and most schools to turn off the kiln at about 1800°F and let it cool. At about 1800°F most stoneware and porcelain clay has vitrified enough to be handled safely but is porous enough to hold a coating of raw glaze. This partially vitrifying fire is called a ***bisque fire***. Pottery, or ware, that has been bisque fired is called ***bisque ware***.

The unglazed clay is about as porous as a red building brick. This makes it easier to apply glazes without chipping or cracking the pot, and if for some reason the glaze doesn't go on the way you wish, it can be washed off and reapplied. It gives students a second chance. Applying a glaze to ***greenware*** (unfired pottery) is tricky. Special gums and adhesives must be added to help the glaze adhere to the ware. If you allow too much of the water from the glaze to penetrate the greenware, your pot may crack.

Another potential problem is solved by the bisque fire. If by chance a pot blows up in the bisque fire, it leaves only unglazed ***shards*** (pieces of fired clay) to be swept out of the kiln. If ware is glazed green and then blows in a glaze fire, the glaze melts. Pieces of the blown pottery stick to the inside bottom of other pieces, and the rest of the blown ware has to be chiseled out of the kiln. It's not just the blown piece that is ruined.

THE GLAZE FIRE

After the bisque ware has cooled, it is glazed, and the glaze is cleaned off the ***foot*** (bottom) of the ware. Then the pottery is again loaded in the kiln and fired to its vitrifying point. This is called the ***glaze fire***. Water smoking and oxidation do not reoccur; the quartz inversion does.

It is best to warm up the ware slowly to around 300°F before turning up the gas and going for it. Why? The glaze had water in it, and the pot absorbed some. The glaze frequently contains some clay, and quartz is almost surely part of the glaze as well as the pot. Give the glaze and the pot a chance to meld together before taking off. Two popular vitrification points are 2250°F to 2350°F (cones 9 and 10—see below), because clays and glazes are easy to compound for this temperature and easy to fit together. This doesn't mean that good things can't be done at other temperatures. It just means that this temperature range is the easiest.

During a glaze fire the final shrinkage happens. The platelets begin to melt into each other, and that's about as close as they can get before turning into a liquid. Hopefully, the glaze has melted into a honeylike liquid and smoothed out. Most glazes are compounded to melt but not run excessively over a certain range of temperatures called a three-cone span. This means that a cone 10 glaze (cones are explained in the next section) will often fire much the same at cones 9, 10, and 11. Although this is preferred, it is not always the case. Shiny, glossy glazes are more apt to run than mat or waxy glazes. Of course, if you fire too high or put the glaze on too thick, the glaze will run. Sometimes if the runny glaze is on the inside of a dish or bowl, it's kind of neat. Unfortunately, the glaze on the outside gets just as hot and also runs, off the ware, which isn't so neat.

PYROMETRIC CONES

Long before we had thermometers, potters had to know what was going on in their kilns. One of the tricks they used was to make rings of clay and glaze them. These were called **draw rings.** When the color inside the kiln looked "right," the potter reached into the kiln with an iron rod, pulled out a ring, and dropped it in water to cool fast. This process was continued at intervals until a ring that looked finished was removed. Then the potter turned off the kiln.

As people progressed, they invented the ***pyrometer***, a thermometer to measure heat in the kiln. Technology reared its head, and rings were no longer necessary—right? Wrong! The rings didn't measure temperature; they measured the effect of heat over a period of time or, more succinctly, the work the heat did. But rings weren't the best solution.

Pyrometric cones, clay that is compounded to react (bend) the way the clay and glazes react, were developed. The cones were easier to watch, and the potter didn't have to worry about pulling out the last draw ring too soon. A cone will not always bend at the same temperature. It bends when the clay (cone) has absorbed enough heat to mature. Each cone has a stated temperature at which it is supposed to bend. However, it might actually bend after a longer time at a slightly lower temperature or a shorter time at a higher temperature.

That is why cones don't bend and are not compounded to bend at regular intervals. Cones were and are made to fit the clay and glazes, not the pyrometer. Potters speak in terms of cone this and cone that. "I'll fire this at cone 10." "I think cone 5 is best for this." Potters know the approximate temperatures involved, but that is not important. The cone is important, because the cone tells exactly what is happening.

In industry, where control is of utmost importance and the "happy accident" is never desired, pyrometers are used, but only as indicators. Cones tell the final story. They are as important to large manufacturing firms as they are to the studio potter. Studio potters sometimes use pyrometers too, but only as a gauge as to how fast the temperature is rising or falling or to help maintain a constant temperature for the "soaking" period after the last cone has bent.

TEMPERATURE EQUIVALENTS for ORTON STANDARD PYROMETRIC CONES[x]

CONE NUMBER	LARGE CONES 150°C*	270°F*	SMALL CONES 300°C*	540°F*
020	635	1175	666	1231
019	683	1261	723	1333
018	717	1323	752	1386
017	747	1377	784	1443
016	792	1458	825	1517
015	804	1479	843	1549
014	838	1540	870	1596
013	852	1566	880	1615
012	884	1623	900	1650
011	894	1641	915	1680
010	894	1641	919	1686
09	923	1693	955	1751
08	955	1751	983	1801
07	984	1803	1008	1846
06	999	1830	1023	1873
05	1046	1915	1062	1944
04	1060	1940	1098	2008
03	1101	2014	1131	2068
02	1120	2048	1148	2098
01	1137	2079	1178	2152
1	1154	2109	1179	2154
2	1162	2124	1179	2154
3	1168	2134	1196	2185
4	1186	2167	1209	2208
5	1196	2185	1221	2230
6	1222	2232	1255	2291
7	1240	2264	1264	2307
8	1263	2305	1300	2372
9	1280	2336	1317	2403
10	1305	2381	1330	2426
11	1315	2399	1336	2437
12	1326	2419	1355	2471
13	1346	2455		
14	1366	2491		
15	1431	2608		

× *The Edward Orton, Jr., Ceramic Foundation, Westerville, Ohio*

* *Temperature increase per hour.*

Check Your Reading

Supply the missing words to complete the statements below.

1. Many studio potters and schools partially vitrify their stoneware and porcelain at about 1800°F. This type of fire is called a ______________.

2. ______________ is pottery that has been bisque fired.

3. Bisque firing leaves the ware hard enough to be ______________ safely and ______________ enough to hold a coating of raw glaze. This makes it easier to apply a ______________ without danger of chipping or cracking the pot.

4. If a glazed greenware piece blows up, it will often ruin several other ______________. Bisque firing prevents this.

5. Water smoking, dehydration, and oxidation do not reoccur in a ______________ fire (except on the thin coat of glaze). The ______________ does reoccur.

6. In a glaze fire, it is always best to warm up the ware slowly to about ______________°F.

7. Cones 9 and 10 are two popular vitrification points because clays and ______________ are easy to ______________ for this temperature range.

8. During a glaze fire, the final ______________ happens because the platelets begin to ______________ into each other.

9. Most glazes are compounded to melt over a ______________-cone temperature span. This means that a cone 10 glaze will often work at cones ______________ and ______________.

10. Before thermometers, potters used clay rings called ______________ to find out what was going on in the kiln.

11. Draw rings didn't measure temperature. They measured the ______________ of the ______________ over a period of time. ______________ do the same thing.

12. Pyrometric cones are clay that is ______________ to bend (or react) the same way clay bodies and glazes do.

13. Cones do not always bend at the same ______________. They bend when they have ______________ enough heat to mature.

14. Cones are more important than pyrometers because they tell exactly what is happening in the ______________.

15. Pyrometers only gauge how ____________________ the temperature is rising or ____________________, or if the temperature is remaining constant.

Test Yourself

Write T if the statement is true. Write F if it is false.

1. _______ Refractory means to become glasslike.
2. _______ During the quartz inversion, the quartz crystals move around.
3. _______ Mullite has the chemical formula of $Al_2O_3 \bullet 2SiO_2$.
4. _______ Oxidation occurs in the first fifteen minutes of the firing.
5. _______ The melting of the platelets is the vitrification stage of firing.
6. _______ A bisque fire is not as high as a glaze fire.
7. _______ If glazed greenware blows up, it won't hurt anything.
8. _______ Schools and all studio potters always bisque fire.
9. _______ Bisque firing makes it easier to apply glazes safely.
10. _______ Porcelain and stoneware clays are bisqued at about 1300°F.
11. _______ Bisque firing leaves the ware hard enough to handle but porous.
12. _______ The quartz inversion reoccurs when the pot is glaze fired.
13. _______ Cones 8 and 12 are two popular vitrification points.
14. _______ Most glazes are compounded to be useful over a temperature range of three cones.
15. _______ It isn't necessary to warm up the kiln slowly for a glaze fire.
16. _______ Cones are a true measure of the temperature inside the kiln.
17. _______ A cone 10 glaze will often work at cones 9 and 11.
18. _______ Draw rings were used before cones were invented, to find out when the firing was finished.
19. _______ Pyrometric cones are made of special types of clay.
20. _______ Cones are seldom more important than pyrometers.
21. _______ Bone dry means the ware looks and feels completely dry.
22. _______ The water of plasticity burns off at about 212°F.
23. _______ During a glaze fire, the final shrinkage occurs.
24. _______ Fired clay is an aluminum silicate known as mullite.
25. _______ Greenware is pottery that has not been fired.