

Appendix 2

CLAY AND CERAMIC LECTURE NOTES
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Today we want to increase your understanding of clay, what it is and what happens to it between taking it out of the ground and becoming a finished stove liners

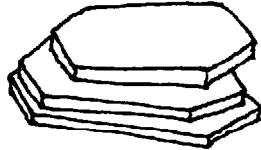
What is clay?

The term clay refers to a certain particle size of a soil mineral.

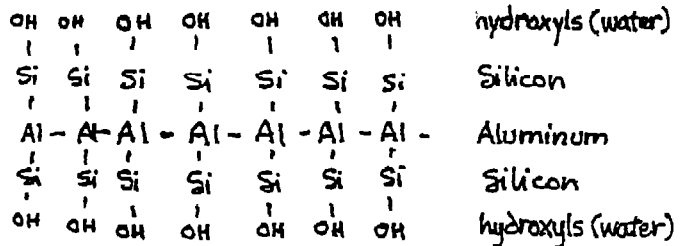
Clay comes from weathered rocks. When rocks are exposed to sunshine, to heat and cold, to rain and ice, they decompose, or break down into small particles. This is usually a very slow process, and some rocks take much longer to decompose than others. Some rocks break up rather easily, and get carried downhill by glaciers or streams. The finest particles get carried the farthest. they are often dropped only when the river spreads out over a flood plain and slows down. Many layers of these tiny particles become clay deposits. (Some clays are formed differently: the rock decomposes in place. These clays are usually very white.)

Clay is defined as a particle size which measures 10 microns or less in size. That means that 100 of the largest clay particles, side by side, would measure only one millimeter across. Silt is the next largest particle size: 40 of the largest silt particles measure one millimeter across. Sand is the next largest particle size: fine sand measures up to one third of a millimeter across.

Why does clay stick together?



shape of clay particles

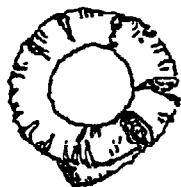


chemical structure of clay (simplified)

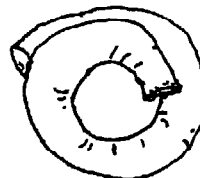
Clay particles are hydrated, that is, they are chemically bound to water. Even after clay has dried in the sun, there is still water between the the clay particles. This bonded water sticks to other water, and so the particles of wet clay are both attached and lubricated by the water between them. The clay particles slide apart or closer together as the clay is pressed and formed.

Smaller particles of clay have more surface area, and can hold more water in between them relative to larger clay particles. Clay that is very sticky has small particles of clay.

The ability to stick together, and to be formed without cracking, is called PLASTICITY. If clay can be easily shaped, we say it is highly plastic. If it breaks when coiling around your finger, it is not very plastic. Plastic clay is flexible due to having a good mix of particle sizes. Plastic clay has some very fine (small) clay particles. But very fine clay, all by itself, is too sticky to work with.



non-plastic clay



plastic clay

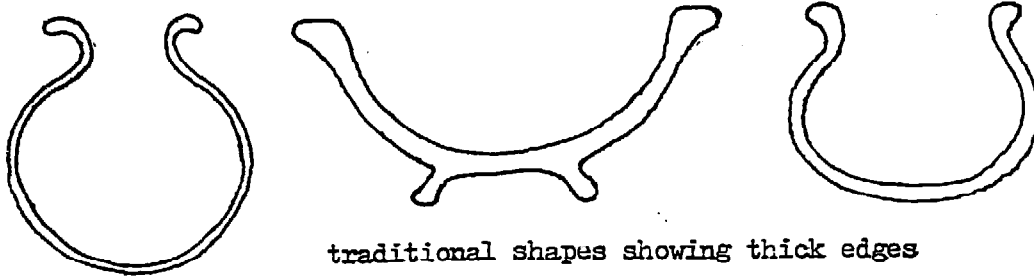
One of the reasons we blend different clays together to make pots and stove liners is to get good plasticity. This enables the clay to be formed without cracking, and also dry without cracking. (The clay grips and holds onto itself.)

Plasticity also increases with ageing the clay. In many parts of the world, potters mix clay weeks or months before they use it. In China, potters work with porcelain, a non-plastic clay. They mix clay for their grandchildren and use clay made by their grandparents.

What happens during drying?

After a clay piece has been formed, it is left to dry. While drying, most of the water between the particles of clay evaporates into the air. Just like drying clothes, this happens faster when the air is warm and dry and the piece is in the sun. However, with clay pieces, it is very important that they dry evenly - from side to side, top to bottom, and inside and out. Careful drying is important because as the water between the clay particles evaporates, the clay particles move closer together. This results in the piece shrinking in size. If one part of the pot or stove liner dries faster than another part, then it shrinks more and cracks away from the rest.

Thinner parts dry faster than thicker parts, so it is important that the clay walls be of all the same thickness. The edges of any pieces should be slightly thicker because they dry faster.



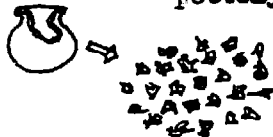
traditional shapes showing thick edges

Traditional folk potters usually add materials with large particle sizes to the clay mix to help the pieces dry evenly. The relatively large grains of sand, mica, or "grog" (crushed fired clay) do not shrink. They also allow a path for water between particle inside the clay wall to pass toward the outside of the clay wall and evaporate. The tiny holes in such clays make them porous, we say they have high porosity. (A sponge is another example of porosity.) Very plastic clays, all by themselves, tend to warp and crack (unless they are very slowly and very carefully dried).

sand



grog (crushed pottery)



mica (a soft rock that has thin layered crystals)



The clay is actually strongest during the leatherhard drying stage. This is when the clay is stiff and feels like leather - not quite wet and not quite dry. It is difficult to deform or pull apart. When clay is very dry (much lighter in color), it easily chips when bumped because there is not enough water to hold the particles together.

What happens when the clay is fired?

During the firing process, the clay changes to ceramic. After proper firing, the piece cannot be dissolved into clay again. There are several stages of firing which are important to look at in respect to firing pottery stove liners.

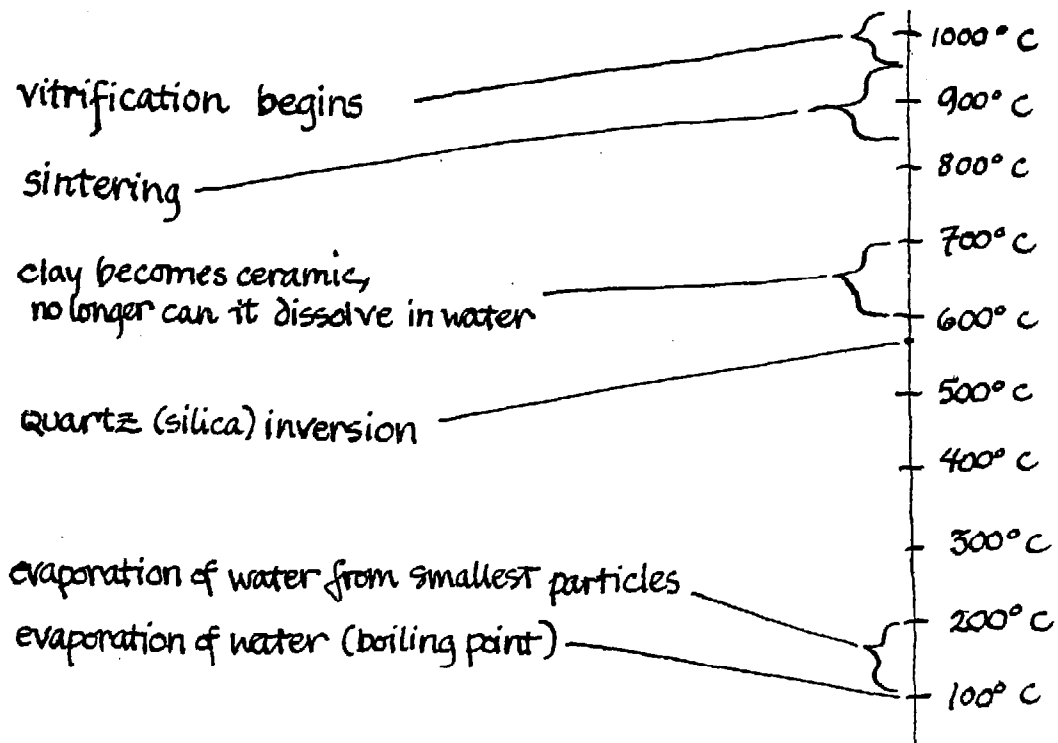
At 100° C, water is boiled out of the clay. Between 100° and 200° C, water finally escapes from between the tiniest clay particles. When water turns to steam, it expands greatly. Therefore the early stages of firing must be very slow so that the steam does not form inside the clay walls. Steam can cause little explosions or cracks in the clay pieces.

At 573° C quartz inversion occurs. This is marked by a structural expansion of the free silica in the clay body. At temperatures below 573° C, the silica crystals are in a cramped state. At 573° C, it suddenly stretches out into a symmetrical shape that is 1% larger in size. It stays in this state until it cools below 573° C, when it suddenly inverts back to the cramped state and shrinks 1% in size. In the same way that thin parts of a piece might dry too fast, there can be problems with thin parts during this stage of the firing. The kiln should heat slowly during quartz inversion so that all parts of the ceramic pieces reach 573° C at the same time. Otherwise the thinner parts may crack off.

Upon reaching the temperature range between 600° and 700° C, the clay will no longer dissolve in water. In fact, it is no longer clay. It is now ceramic, but has yet to develop a good ceramic bond. It is weaker now than when it was dry clay.

Between 850° and 950° C, the solid particles begin to sinter. Sintering is what gives ceramic pieces fired strength. The particles stay solid but the surfaces begin to "weld" together, much like iron pieces weld together without melting. Other minerals in the clay, such as potassium or iron, will help encourage sintering. After sintering, the particles are no longer separate, but have joined into one very porous piece.

At temperatures above 950° C, the ceramic begins to vitrify. It becomes more and more like glass. And, like glass it is unsuitable for stoves. The particles melt together and fill the pores between them. (The ceramic shrinks significantly as it vitrifies.) While stoves are used for cooking, parts of it receive enough heat to expand significantly. Low-fired (900° C) porous stoves can absorb the shock of thermal expansion because of the spaces between the "particles." High-fired ceramic has no room for uneven thermal expansion, and the firebox is likely to crack.



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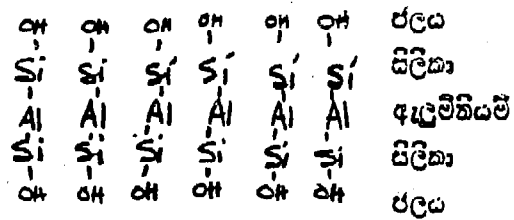
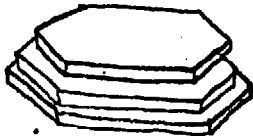
අද අපිට මැටි පිලිඹුණු සමඟේ දැනුම වර්ධනය කිරීමට අවශ්‍ය වේ. මැටි යනු කුමක්ද? වස්ම වය පොලවෙන් ගැනීමටත් ලිපක් සෑදා අවසන් කිරීමත් අතර, වෙනස කුමක්ද දැනගත යුතුය.

මැටි යනු කුමක්ද?

මැටි බහිෂ්ඨ ද්‍රව්‍යවල නිශ්චිත වස්තූන් පරිගණක කුඩා අංශු වශයෙන් සකස්කළ හැක. මැටි ලැබෙන්නේ පඵත වලට කාලගුණය බලපෑමකි. පඵත හිරු වලිට, උෂ්ණත්වයට, සිතුවම්, වැස්සට අස්ථිභව ඔලපෑම නිසා එහි ක්‍රියාකාරීත්වය කරනකොටගෙන ඉතා කුඩා කැලී වලට කැඩී යයි. මෙය ඉතා හෙවිභිට සිදුවන්නකි. වස්ම සමහර පඵත වෙතත් පඵත වලට වඩා මෙසේ සු සිදුවීමට කාලයක් ගතවේ. සමහර පඵත ඉතා පහසුවෙන් මෙසේ කැඩේ. ඉන් පසුව ඒවා වැඩිව නිසා නිමිත වලට ගලායයි. ඒවායේ හොඳ කොටස් අනව ගලායයි. ඒවා ගොඩනැග ගලන කාලයට ගණනි දෙපස මිදෙන්නට පටන් ගනී. මෙසේ කප්පාදක් මිදෙන විට එම තට්ටු මැටි බවට පත්වේ. සමහර මැටි වර්ග වෙතත් වෙතත් ක්‍රම වලට හැඩගැසේ. පඵත වෙතත් ක්‍රම වලට දියායයි. ඒවා සාමාන්‍යයෙන් සුදුසාටය.

මැටි සාමාන්‍යයෙන් මිටිකුණු 10 ට හෝ ඊටත් වඩා කුඩා ප්‍රමාණයේ අංශු වලට ගතහැකිය. මෙහි අදහස වනුයේවය පැත්තෙන් පැත්තට සියවාරයක් වියාල මැටි අංශු මිලි මීටර් 1 ක් පමණ මැනිය හැකිය. ඊලඟට වියාල අංශුව තම මිදෙන මැටිය. 40 වාරයක් වියාල මෙම අංශුවක් හරහව මිලි මීටරයක්වේ. ඊලඟ පමණ තම වැටිය. ඉතා හොඳ වැටිකැටයක් මිලි මීටරයකින් 1/3 කි.

ඇයි මැටි එකට ඇලෙන ගතිකත්වය යුක්ත වන්නේ? :-



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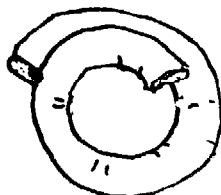
මැටිවල රසායනික සංයුතිය

මැටිවල රසායනික ව්‍යුහය සාමාන්‍යයෙන් මැටි අංශුවක ජලය ඇත. එහි අදහස ඒවා රසායනික වශයෙන් ජලයෙන් බැඳී ඇත. මැටි අවිවෙන් වැස් ඇතත් ඒවාහුල ජලය ඇත. ඒ නිසා ජලය අතින් කොටස් වලට එකතු වේ. එනිසා මෙම අංශු තෙත මැටි එකට ඇලෙන ගතිකයන් හා ලිස්සන ගතිකයන් යුක්ත වේ. මෙහිසා මැටි එකට හැඩගන්වන විට හෝ තඳ කරන විට ඇලේ.

ඉතා කුඩා මැටි අංශුවල

පුද්‍රව්‍ය බොහෝ ඇත. ඒවායේ වියාල කැලී වලට වඩා ජලය උරාගන්නා සිදුවූ ඇත. ඉතා හොඳට ඇලෙන මැටිවල ඉතා කුඩා මැටි අංශු ඇත.

ඇදෙන සුළු ගතිය යනු මැටිවල ඇලෙන ගතිය හා එය තොකැඩී තවදුරටත් - ට හැකිවීම. මැටි පහසුවෙන් හැඩ ගත්වා ගැනීමට තම අපි එය හොඳට ඇදෙන ගතියකින් යුතු මැටි බව නිශ්චය කළ යුතුය. එය සමඟේ ඇතිවී වටා සහන විට කැපේතම එය හොඳට ඇලෙන ගතියක් ඇත. ඇලෙන සුළු මැටිවල ඇදෙන ගතියක් ඇත්තේ එය හොඳ මිශ්‍රකයක් හා ඉතා කුඩා අංශු නිශ්චිත නිසාය. ඇදෙන සුළු මැටිවල ඉතා කුඩා මැටි අංශු ඇත. නමුත් ඉතා හොඳ මැටිවල බොහෝ පුරව ඇලෙන ගතියකින් ඔහු වැඩට පහසුය.



අපි වෙනස් වෙනස් මැටිගෙත වැඩ කරන වලං සාදන ලීර් සඳහා එක හේතුවක් නම් මැටිවල ඇදෙන සුළු ගබඩායි. එය පිටිරීමක් නැතිව හැඩගන්වා ගැනීමට පහසුය. ඒවා වේලෙන විටද නොපිටිරේ. මැටි එකට ගොදුරු තද වේ.

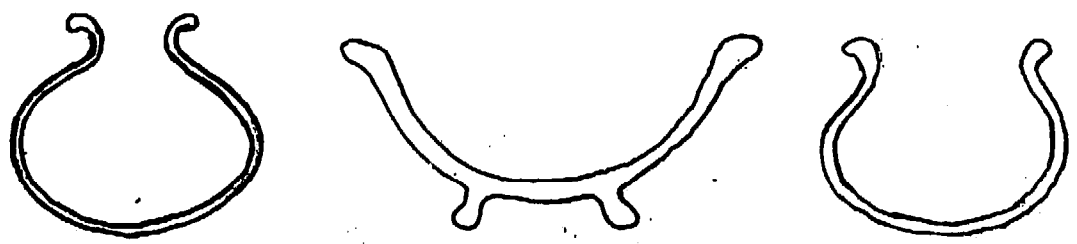
ඇදෙන සුළු ගබඩා මැටිවල කල්පැවැත්මටද බලපායි. ලෝකයේ බොහෝ රටවල වලං සාදන්නන් මැටි වැඩ කිරීමට ප්‍රථමයින් කිරිපාට හෝ මාස කිරිපාට පෙර මැටි අතරබියි. ඊතයේ වලං කාර්මිකයින් පෝෂිලේන් නමැති මැටි වලින් වැඩ කරයි. ඒවා ඇලෙන සුළු ගබඩා නැත. එම නිසා යථුන් යථුන්ගේ දැරූ ප්‍රායුරුත් විසින් පාඨා මැටි පුදානම්කර තබයි.

වියලෙන විට මැටි වලට සිදුවන්නේ කුමක්ද?

මැටි කැබලි හැඩගැන්වීමෙන් පසුව එය වේලීමට ඉඩ හරිනු ලැබේ. ඒවා වේලෙන විට අඹුපල නිමෙන බොහෝ පලය වාතයට හුමාල වේ. මෙය සිදුවන්නේ ඔදි වේලෙන ආකාරයටය. මෙය වාතය යනුයේ අවස්ථාවල හා අවිච සැර අවස්ථාවල ඉක්මනින් සිදුවේ. කෙසේ හෝ මැටි කැබලි ඒවායේ පැත්තෙන් පැත්තට වියලීමට අවශ්‍ය ඉහල සිට පහලටත් පිටත සහ ඇතුළත පලය හුමාලය වන නිසා වියලෙන විට හැකිලීමක් විය යුතුය. මැටි අඹු පුසා ක්‍රීටිවුව නිමෙන නිසා මෙය සිදුවේ.

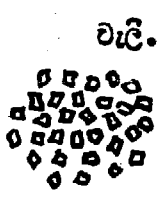
වලඳේ හෝ ලිෂේ

එක කොටසක් අනෙක් කොටසට වඩා ඉක්මනට වියලෙන විට එහි අත් කොටස් පිටිරීමට පටන් ගනී. ගතකළ නැති කොටස් හා ගත කොටස් වලට වඩා ඉක්මනින් වියලේ. එම නිසා සෑම කොටසක්ම එකම ගතකළකින් හිමිම වැදගත්ය. ඒවායේ අධික තරමක් ගතකළට හිමිය යුත්තේ එය ඉක්මනින් වියලෙන නිසාය.



පාරම්පරික හෘත්වවල ගුණකම අධිකයින් පෙන්නුම් කරයි.

පාරම්පරික වලක් සාදන්නන් ඒවා වියලීමට පහසු වීමට සාමාන්‍යයෙන් වෙනත් ද්‍රව්‍යයන් එම මැටි වලට එක් කරයි. සාමාන්‍යයෙන් විශාල වැලි තැටි මයිකා හෝ වියළුණු මැටි (පිලිස්සුණු කැබලි අසිරා) විසි කල විට ඒවා හැකිලෙන්නේ නැත. ඒවා අඹු අතර ජලය රඳා පවතින ජලය පිට වීමට උදව් වේ. එසේම හුමාලය වී ඉවත් වීමටද උපකාරී වේ. මෙම ඉසා කුඩා සිදුරු පොරෝසිටි ඔහුවෙන් හැදින්වේ. ස්පන්ඩි එකක් මෙයට හොඳ නිදසුනකි. ඉසා හොඳ ඇලෙන සුළු මැටි වුවද ඒවා හොදට ප්‍රවේසම් සහිතව වේලුවේ නැත්නම් පිටිරීමට ඉඩ ඇත.



වැලි. (sand)
පිලිස්සු මැටි කුඩු කර සාදා ගත් මැටි.

මයිකා. මාදුකැටි තුනි පතුරු, තුනි කැබලි.



ඇත්ත වශයෙන්ම මැටි වියලෙන අවස්ථාවේදී එය ඉතා හොඳට ශක්තිමත් වේ. හොඳට වියලීමෙන් හෝ ඉතාමත් තෙහට තිබීමෙන් ඒවා නැවත හැඩගැන්වීමට අමාරුය. මැටි හොඳට වේදුනාට පසුව ඒවා පහසුවෙන් කැබලි වලට කැඩෙන්නේ ඒවායේ ඇති තරම් වතුර ඒවා සවි වීමට නැති නිසාය.

මැටි පිලිස්සීමට පසුව සිදු වන්නේ කුමක්ද?

මැටි පිලිස්සීම තරම් වට එය පිලිස්සුණු මැටි බවට පත් වේ. හරියාකාර පිලිස්සීමෙන් පසුව ඒවා නැවත මැටි බවට පත් කිරීමට බැරිය. මෙම මැටි පිලිස්සීමේදී ඉතාමත් අවධානය යොමු කළ යුතු පියවරවල් කිහිපයක් ඇත.

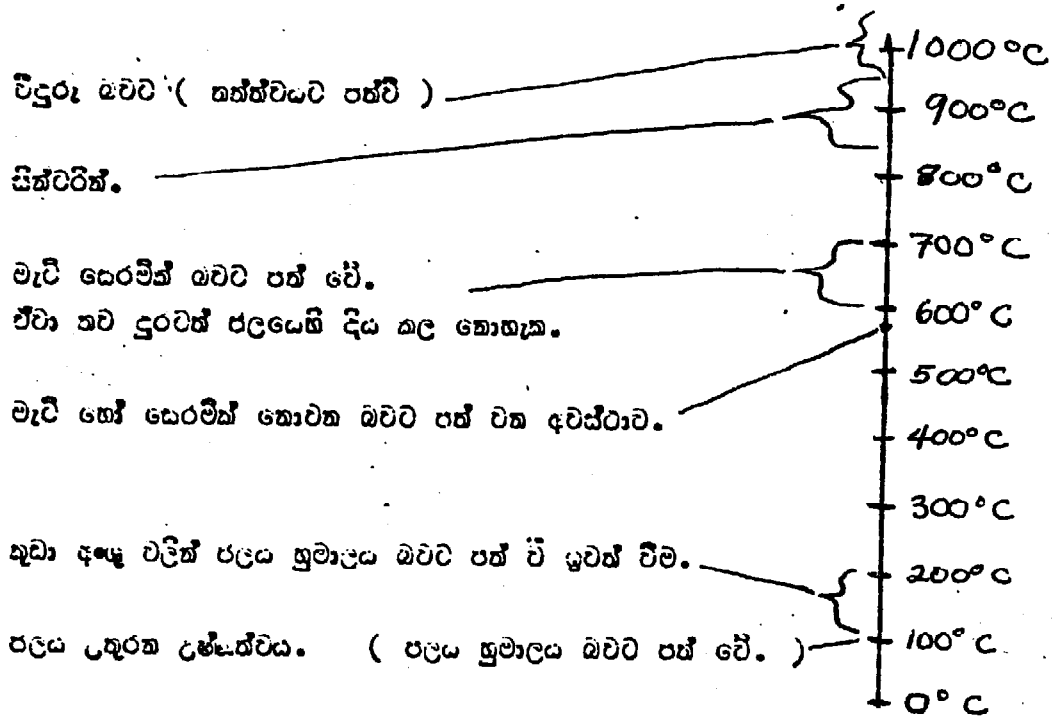
සෙ. ශ්‍රේණි 100' මැටි වල ජලය උතුරයි. සෙ. ශ්‍රේ. 100'-200' ජලය ඉතා කුඩා අංශු වලින් ඉවත් වේ. ජලය ක්‍රමාලය බවට පත් වන විට එය වියාල වේ. එම නිසා පුද්ගලික පලමු පියවර වලදී ඉතා සියුම්ව කළ යුතු වන්නේ එහි ඇතුළට නැවත ජලය නොයන පරිදි පිලිස්සීමය. මෙම ක්‍රමාලය කුඩා පිපිටිම් වලට හේතු වීමට ඉඩ ඇත.

සෙ. ශ්‍රේ. 573' ද එය මැටි හෝ සෙරමික් තොටිත තත්ත්වයට පත් වේ. සිලියාමල ඇති කිදහස් ක්‍රියාව නිසා මෙය පලල් වීමට ඉඩ තිබේ. සෙ. ශ්‍රේ. 573' පහල මෙම සිලියා කිරීවැදෙන තත්ත්වයට පත් වේ. සෙ. ශ්‍රේ. 573' දී ඒවා හදිසියේම 1% නිත් වියාල වේ. එය සෙ. ශ්‍රේ. 573' පහලට සිතල වනතෙක් පවතී. මෙහිදී හදිසියෙන් හිරි වැටුණු තත්ත්වයට පත් වුණු විට 1% නිත් හැඩගැනේ. එම ආකාරයෙන්ම තුනී කොටස් ඉක්මනට වේලේ. එම නිසා පිලිස්සීමේදී මෙහිදී ගැටළු ඇති වීමට පිලිවන. මෙම මැටි පිලිස්සුණු තත්ත්වයට පත් වන විට පෝරුන් තත්ත්වය ප්‍රමාණවත් විය යුතුය. මන්ද නිත් භාණ්ඩයේ හැම කොටසක්ම එකම වේලාවේදී සෙ. ශ්‍රේ. 573' ද උෂ්ණත්වයට පත් විය යුතුය. එසේ නොමැති නම් එහි තුනී කොටස් ඉක්මනට පිපිරේ.

උෂ්ණත්වය සෙ. ශ්‍රේ. 600 - 700 ක් අතර වන විට මැටි තව දුරටත් පලයෙහි දිය කල නොහැක. ඇත්තවශයෙන්ම ඒවා තව දුරටත් මැටි භෞවේ. ඒවා දැන් පිලිස්සී ඇත. එසේම හොඳ තත්ත්වයට පත්වීමට තව පියවරවල් කිහිපයක් ඇත. එය දැන් වියවුණු ඒවාට පඩා ශක්තියෙන් අඩුය.

සෙ. ශ්‍රේ. 850' - 950' අතර සීරීර අංශු සිත්ටර් බවට පත් වේ. මෙම කොටස් සෙරමික් ශක්තිමත් වීමට උපකාරී වේ. මෙම අංශු සීරීරව නිශේත අතර එහි මතුපිට උණුවීම සිදු වේ. යකඩ කැබලි උණු නොකොට එකට සවි කරන්නාක් මෙන් මැටි වල වෙනත් යනිප පොරොසියම් හෝ යකඩද ඒවා සිත්ටර් වීමට උපකාරී වේ. මෙයට පසුව මෙම කොටස් වෙන් කල නොහැක. තදින් එකක් බවට පත් වී ඇත.

සෙ. ශ්‍රේ. 950' දී එම සෙරමික් උණු වීමට පටන් ගනී. ඒවා විදුරු තත්ත්වයට පත් වේ. විදුරු මෙන් ඒවා ලිපි වලට නුසුදුසුය. අංශු උණු වී සිදුරු සියල්ලම වැසේ. (ඉතා හදට සෙරමික් හැඩ ලී ඒවා උණුවේ.) ලිපි කැම පිපිටිම ප්‍රයෝජනවත් භක්තා විට උණුසුම් රඳා පවතින කොටස් ඉක්මනට පලල් වේ. සෙ. ශ්‍රේ. 900' පහල තත්ත්වයට පිලිස්සූ ලිපි වල සිදුරු පලය උරා ගැනීමට හැකි තත්ත්වයට පත් වන්නේ ඒවා අතර නිශේතනා වූ ඉතා කුඩා අංශු අතර ඉඩ තිසයි. ඉතාමත් හදට පිලිස්සුණු සෙරමික් වල පලල් වීමක් ඇති නෙවෙත නිසා එහි පිපිටිම් ඇති වීමට ඉඩ තිබේ.



WORKING WITH POTTERS ON STOVES

Selecting Your Potter



Selecting potters is a very important step - maybe the most important. Look for these qualifications:

1. High quality work. Pots that are
 - a) symmetrical;
 - b) having even thickness;
 - c) without cracks;
 - d) well fired, with even color and a good ringing sound.
2. Good location for clay and distribution. This is essential for avoiding delays and having access to markets.
3. Efficient production. You want a potter who
 - a) works hard;
 - b) works full time;
 - c) has enough work and storage space for drying large numbers of stoves;
 - d) uses a pottery wheel.
4. Willingness to learn and try new things.
5. If a potter is also willing to teach, s/he will be of great value in training other potters.

Training

In training a potter, you must be respectful, patient, and persistent. To achieve good quality pottery stove liners, the potter must be careful in clay preparation, forming, and handling the liners while they are moist - much more careful than in making traditional pots.

Each potter has his/her own way of working. There are usually good reasons for the habits they have. Thus you should only try to change their habits when there is a particular problem caused by the habit.

Method:

In the beginning, bring a top quality liner with you. The potter will learn most of his/her lessons from this example. Leave the liner with the potter, and order one (1) liner exactly like it. Let the potter make the stove without any instructions or templates.

When it has been fired, measure the dimensions and assess the quality. Discuss with the potter the differences between his or her stove and the sample you brought.

Then order five (5) more stoves. This time, work closely with the potter, giving instructions in the use of templates and careful handling. (Give the potter a set of templates.) Come back in two days and give instructions in assembling the pieces. Follow closely and avoid letting the potter make any mistakes - these soon become bad habits, difficult to change. Let the stoves be fired. Discuss their quality with the potter.

Then order ten (10) stoves. Work with the potter and encourage use of the templates and proper handling. Discuss any flaws with the potter before and after firing. If these stoves are

of good quality, order twenty (20) more. (If they are not all of acceptable quality, order only ten (10) more stove liners.) Let the potter make these without your assistance. But always select out unacceptable stoves before firing.

Increase the number of stoves you order from the potter according to the quality he is producing. For at least six (6) months, check the stoves before they are fired. Do not let the potter fire stoves that are distorted or have incorrect dimensions. This is crucial to developing the potter's discipline, and avoiding misunderstandings with him/her.

Emphasize
these
points
while
training:

Pottery liners must be made to the proper dimensions. Most potters will resist using templates - they've never needed them before, and may consider them an insult, rather than an aid, to their abilities. Many potters will only need to use the templates to measure the first fifty (50) stoves. After that they will only need to check a few stoves each day. If the stoves continue to be correct, then they can check them less often. If there are problems regarding size, the potter should use the templates more.

Cracking of pottery liners must be avoided. The main causes of cracking are weak joints when assembling and rapid, uneven drying. Many cracks may not appear until after firing or even during use - but the weakness was created in the pre-firing stages. Train potters to make strong joints where the tunnel and the door join the firebox. If cracking problems continue, insist that he score the surfaces to be joined. If cracking problems still continue, insist that s/he score and slip (put watery clay) onto the surfaces to be joined.

Distorting or misshaping the circular potholes must be avoided. The major cause of the circle becoming an oval shape is moving the firebox or the second burner onto an uneven surface to dry. The main causes of bumps on the rim are lumps in the coils or lifting the firebox from the top while it is still wet. Help the potter avoid distorting the liners by providing (or selling) the potter sturdy wooden planks that measure 14 by 14 inches. The extra size allows the door to be added without moving the firebox.

Remember
these
differences:

While you must respect the skills and traditions of the potter,, you must also understand the invisible science behind the traditions, to be able to introduce something as new and as different as the ceramic stove liner. There are some aspects of the pottery liners that the potter has no tradition for.

1. The firebox and second burner have no bottom.
 - a) The walls are much more likely to change shape if they are picked up before they are stiff enough to hold their shape (leatherhard).
 - b) Having an uneven floor surface actually helps support the traditional round bottom shapes. But uneven floors greatly distort the bottomless stove liner shapes.
2. Clay pieces are joined at right angles. All the traditional pots, especially the large ones, are single curved walls. The pots are made at one time, not assembled later.

3. The stove liner must be made to exact dimensions in order to work properly. The two parts must fit together, and the potholes must properly accommodate the cooking pots. The firebox and tunnel must promote good combustion and transfer of heat.
4. The stove liner will be subjected to much more heat stress in use than the cookpots or water jars. The liner requires more porosity and better fired strength. (The Sri Lankan clay appears to be well suited to stove liners.)

Checkpoints:

When wet, are each of the parts the correct size and shape?

- 8" top diameter on the firebox (inside)
- 10" bottom diameter on the firebox (inside)
- 7" height of the firebox
- 2½" deep door
- 7" height of tunnel
- 3½" x 5" inside the tunnel
- 8" inside diameter of second pothole
- ½" potrest thickness

Are the tunnel, firebox, and door for each stove made at the same time? (If not, they are more likely to crack.)

Is the firebox left to stiffen in good condition, with the top perfectly round?

Are the tunnel and door joined to the firebox with a good, strong joint - so strong that if you pulled them apart, the walls would break instead of the joint?

Before firing, are the potholes perfectly round, and no cracks anywhere?

After firing, are there no cracks? Are the potholes a perfect circle? Are the dimensions the correct size? Does the liner make a ringing sound when you tap on it?

YOU SHOULD ANSWER "YES!" TO ALL OF THE QUESTIONS ABOVE!

Quality Control

Problem Solving

Part of the extension worker's job is **QUALITY CONTROL**. Any problems with the stoves should be caught early, and a systematic approach used to illustrate the cause or causes of the problem to the potter. Only then can you guarantee the full participation of the potter in permanently correcting the production process. This involves a six (6) step process, outlined below with an example following.

1. Define the problem.
 2. Observe carefully the entire production process, covering all possible causes of the problem.
 3. Make a good guess at what actions or inactions might be causing the problem.
 4. Talk with the potter about the possible causes. Ask the potter what s/he thinks the cause is.
 5. Devise a test to scientifically determine and illustrate the causes of the problem. Try to prove and disprove both the potter's and your theories.
- Alter the production methods to avoid this problem.

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1. Say, for example, that smoke and flames come up around the first pothole. You look closely and define the problem as being that the top of the firebox on many of the stoves is not perfectly round like the cockpots are.
2. You stay with the potter while he makes some stoves. You observe that the final shaping of the top of the firebox is done correctly, and they form a good round circle. You observe that the fireboxes are lifted from the planks the same day they are made and set on the clay floor. The clay floor is not perfectly level, and some of the fireboxes are no longer perfectly round after being moved to the floor.
3. You guess that the unevenness of the floor pushes up parts of the wall of the firebox, and picking up the liners while they are wet stretches the top out of shape. You guess that moving the firebox off the planks they are made on, while wet, changes the round top to an uneven oval shape.
4. You talk with the potter about the problem and the possible causes. The potter says that the deformation happens in the firing. He says that the liners fired in the bottom layer of the kiln bend due to the weight of the liners above them.
5. Now the biggest step: you test these ideas by making marks on the liners to identify them, and treating them differently during production. Keep careful records on paper.
 - a) Treat the first 10 liners in the usual way, lifting them from their boards the first day and setting them on the uneven floor. On each stove mark a number, 1,2,3,4, etc., up to 10. Make another 10 liners that are not lifted from their boards until they are leatherhard - the door is added and the tunnel assembled without removing the firebox from the board, and the liner left to stiffen until it is firm. Mark a number on each stove: 11,12,13, 14, etc., up to 20.

- b) Be present during the days the liners stiffen and dry. Make sure the stoves numbered 11 through 20 dry to the leatherhard state on their boards. On a sheet of paper, with numbers 1 through 20 on it, write how each stove was treated and any observations regarding how round or how deformed the top of the firebox is at each stage. Record the dates of your observations as well as the dates of construction and assembly.
- c) Be present when the potter is ready to load his kiln. Be sure to mark on your paper any stoves which are already deformed. Are stoves 1 - 10 more deformed than stoves 11 - 20? Discuss your observations with the potter. If the stoves 1 - 10 are significantly deformed, and stoves 11 - 20 are not, and the potter agrees that picking them up off their boards while wet deforms them, then it is not necessary to fire the deformed ones. Have the potter place half of the 1 - 10 stoves to be fired on the bottom layer of the kiln, and half on the top layers. Have the potter place half of the 11 - 20 stoves on the bottom layer, and the other half on the top. Be sure to mark on your paper next to each number whether that stove was rejected, placed on the bottom layer in the kiln, or placed on the top, or middle layers of the kiln.
- d) Be present when the potter unloads the kiln. Discuss with the potter the condition of the stoves. Did any of the 11 - 20 stoves fired on the bottom layer of the kiln get deformed into an oval shape? Mark the paper. Is there any difference between the 1 - 10 bottom layer stoves and the 11 - 20 bottom layer stoves? Small deformations may increase under the weight in the kiln, but a careful study would have to be done to prove this. Of the 11 - 20 stoves, are the ones placed on the bottom consistently more deformed than the ones placed in the top layers of the kiln? If so, then placement in the kiln is a cause of the problem. If not, then the potter should understand that that kiln placement is not a cause of the problem. Are the 1 - 10 stoves consistently more deformed than the 11 - 20 stoves? If so, then keeping the wet clay firebox on its board until it is leatherhard is important in eliminating the problem of deformation. Analyze the test results with the potter.
6. Alter production to eliminate the problem. If the movement of wet fireboxes proved to cause deformation, then you must alter methods to enforce that the fireboxes stay on their boards from coiling to assembly to leatherhard state. If the kiln placement is (also) a problem, then production costs will rise considerably. Either the potter only fires them on the top layer in the kiln (reducing the number of stoves he can produce) or, he fires only one or two layers of stoves at a time, increasing the time and fuelwood spent on each liner.

Other Issues

Altering the clay mix: Changing the potter's clay is possibly a solution to the problem of cracking. But it should only be tried after all other options have failed to solve the problem. Try first a) improving the joints between pieces and coils; b) careful firing and cooling; c) very careful handling of wet and dry liners.

It is very difficult to select clay mixes. If you continue to have cracking problems, you may require some heat-resistant material with large particle sizes to be added to the clay: either sand, mica, or grog (crushed pottery). Make sure that what you add is clean and free of salt, (ocean sand must be washed), and free of dust-sized particles, as these will reduce plasticity without helping your cracking problem. A 20% (twenty percent) proportion of sand, mica, or grog is usual for clay used in stoves..

Kilns and firing methods: The firing techniques in Sri Lanka are quite good. Changing firing techniques is extremely difficult. If many stoves are poorly fired, the potter may be taking shortcuts to save fuelwood or time. Before buying any stove liner, tap on it with your finger. Listen for a good ringing sound - on all parts of the stove. This indicates it was evenly fired to a high enough temperature. If you instead hear a dull "thud" sound, then do not buy the liner. Insist that it be refired. This is an essential part of quality control. If proper firing of liners is not important to you, it will cease to be important to the potter.

Money: You must make money arrangements with the potter before you begin to work. During the training period, the potter will be spending a lot of time learning how to make proper liners. Settle with him/her in advance how you will pay for this time: how many rupees for a perfect stove, how many for an imperfect stove, how many rupees, if any, for a rejected stove. Once out of the early training period, however, you should only buy the high-quality liners. Settle on a price that is fair: that encourages the potter to make liners, but not much more than s/he makes with other pottery. Keep agreements clear, quality control strict and consistent, and communication constant. Remember that making perfect liners requires boards for each firebox for about 4 days (depending on weather conditions) and more storage space than traditional pottery requires. A cost analysis (for twenty (20) stove liners) follows:

- clay	landowner	30
	digging labour	10
	transport	20 *
	mixing labour	25
	water	2.50
- forming	labour: making coils	
	making pieces	
	assembly	100
	skill training time	
	space for work, storage, and boards	3
-firing	firewood	50
	time and skill, firing	75
	kiln building, maintainance	40
		<u>355.50</u>

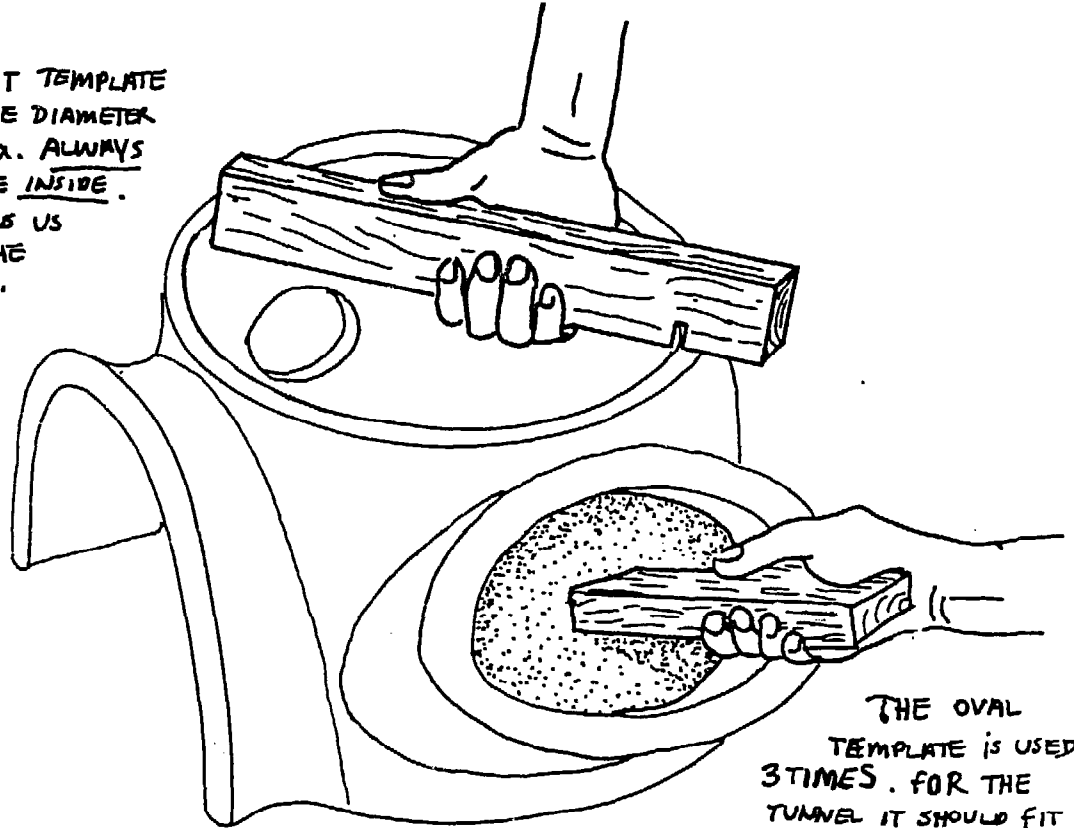
Rs. 355.50 ÷ 20 stoves = Rs. 17.7 each, or about 18.

*(It should be noted that transportation cost of clay will vary from potter to potter, and the marketing system used will affect the final price of the stove liner.

GETTING THE MEASUREMENTS RIGHT

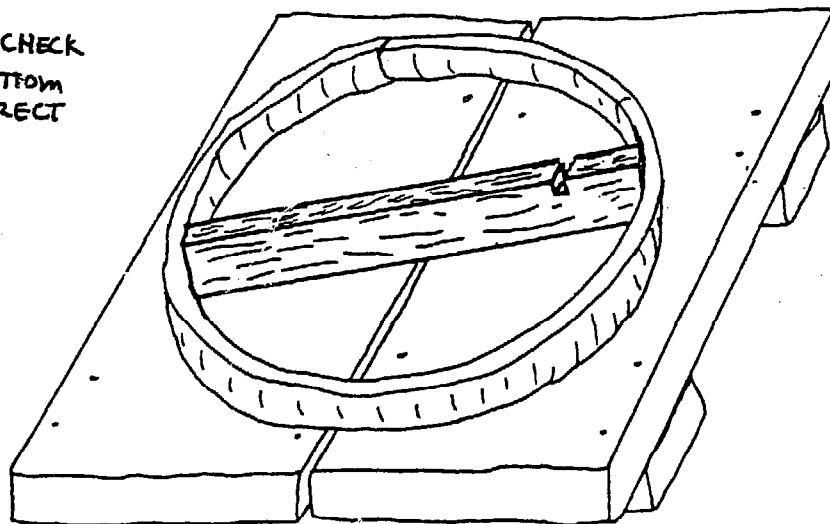
THE TEMPLATES: USE ON WET STOVES ONLY (AS THE STOVE IS BUILT)

THE STRAIGHT TEMPLATE MEASURES THE DIAMETER OF THE FIREBOX. ALWAYS USE IT ON THE INSIDE. THE CUT SHOWS US HOW WIDE THE TOP SHOULD BE.

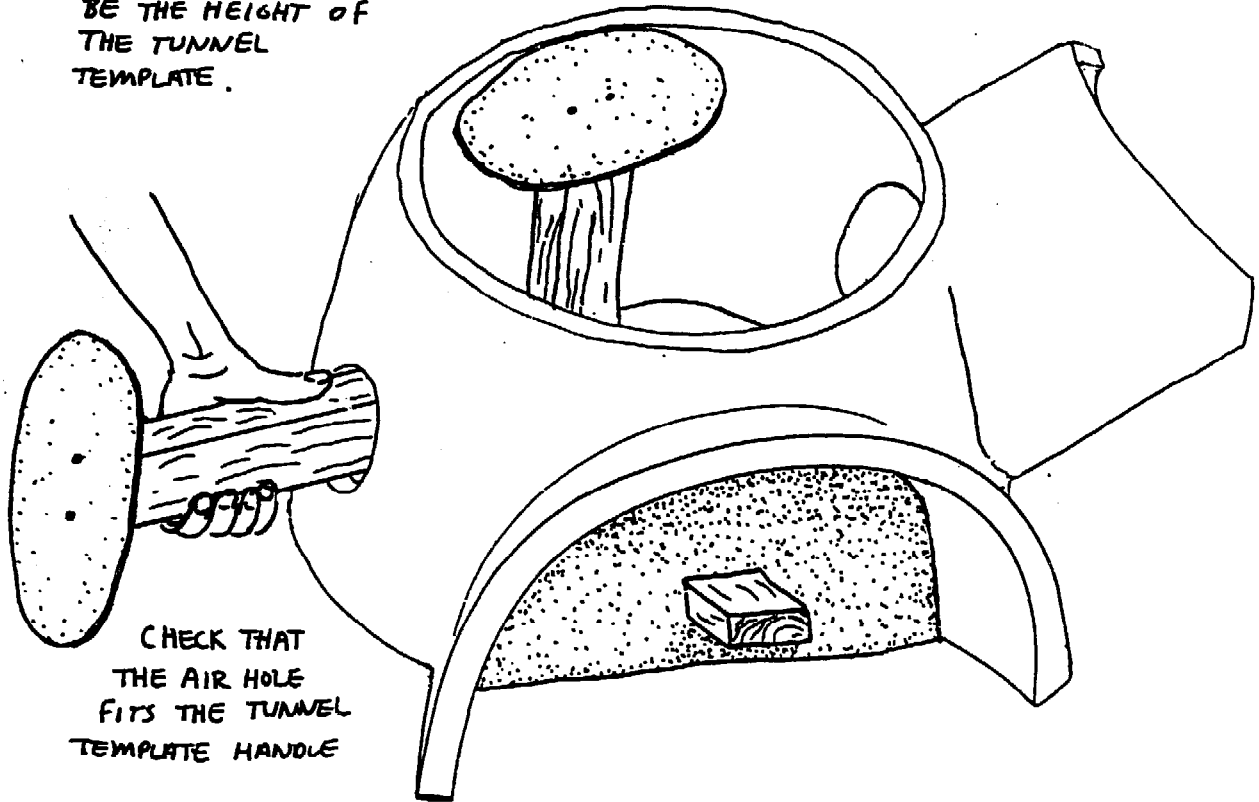


THE OVAL TEMPLATE IS USED 3 TIMES. FOR THE TUNNEL IT SHOULD FIT ALL THE WAY IN.

FIRST YOU CHECK THAT THE BOTTOM IS THE CORRECT SIZE.

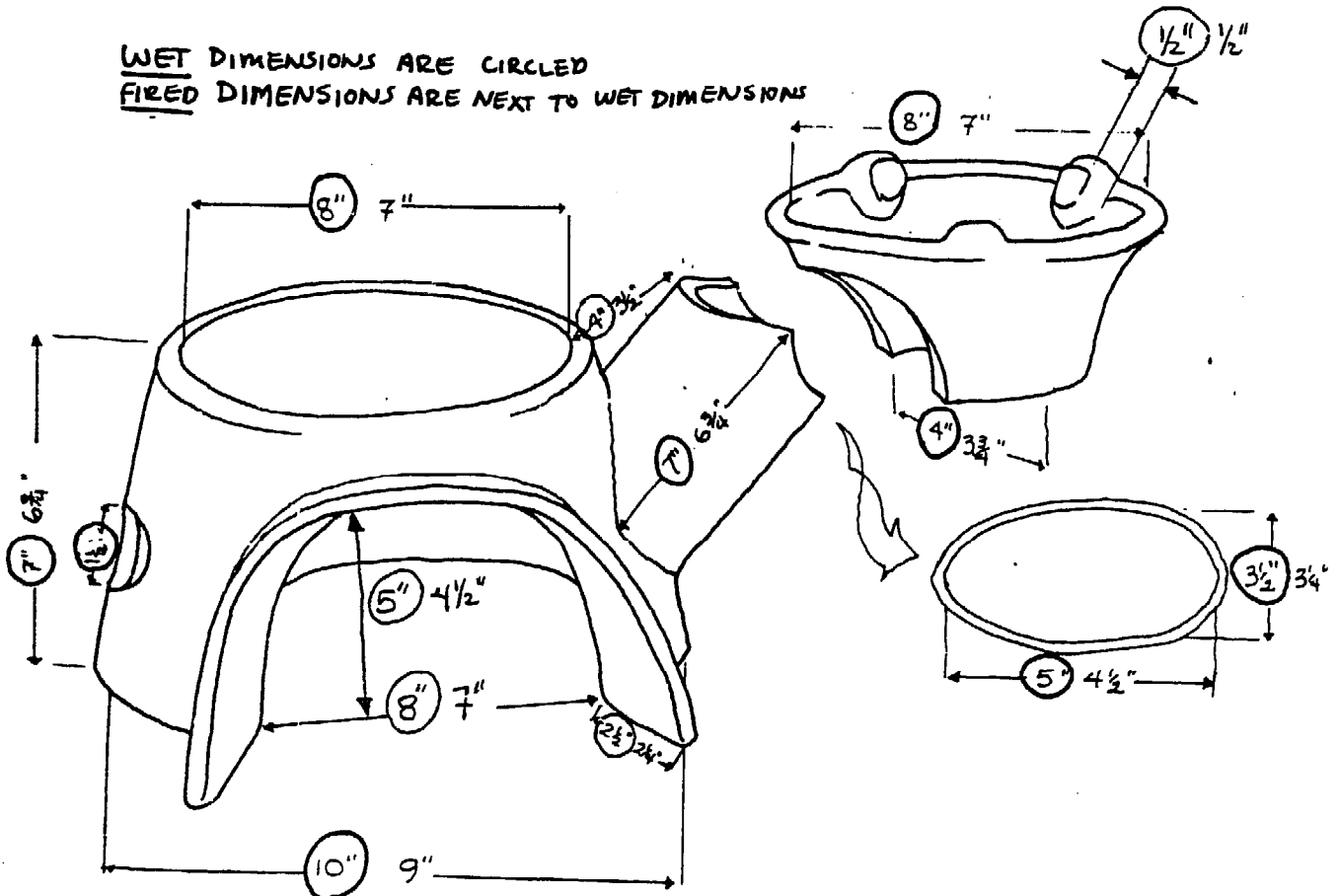


THE FIRE BOX MUST
BE THE HEIGHT OF
THE TUNNEL
TEMPLATE.

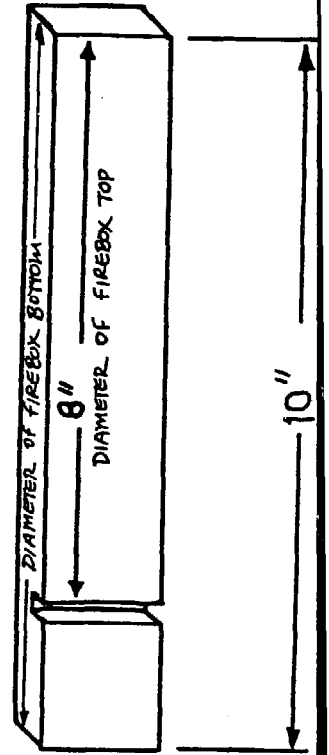
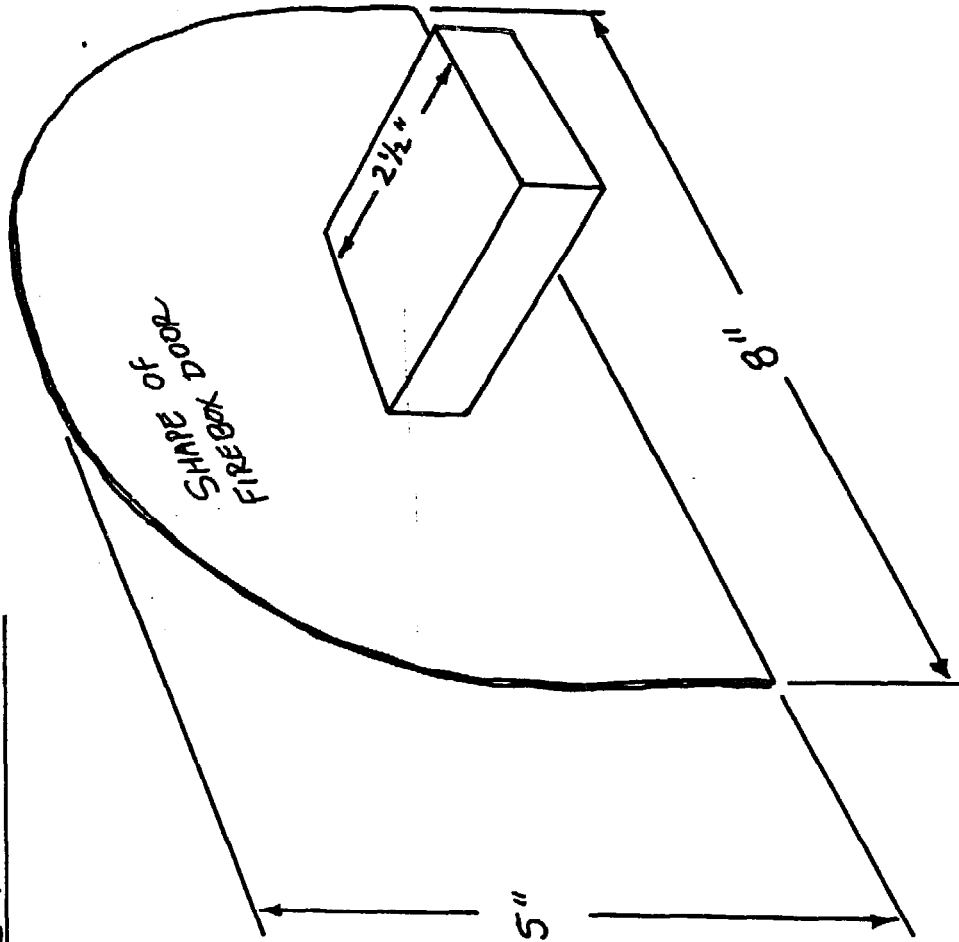
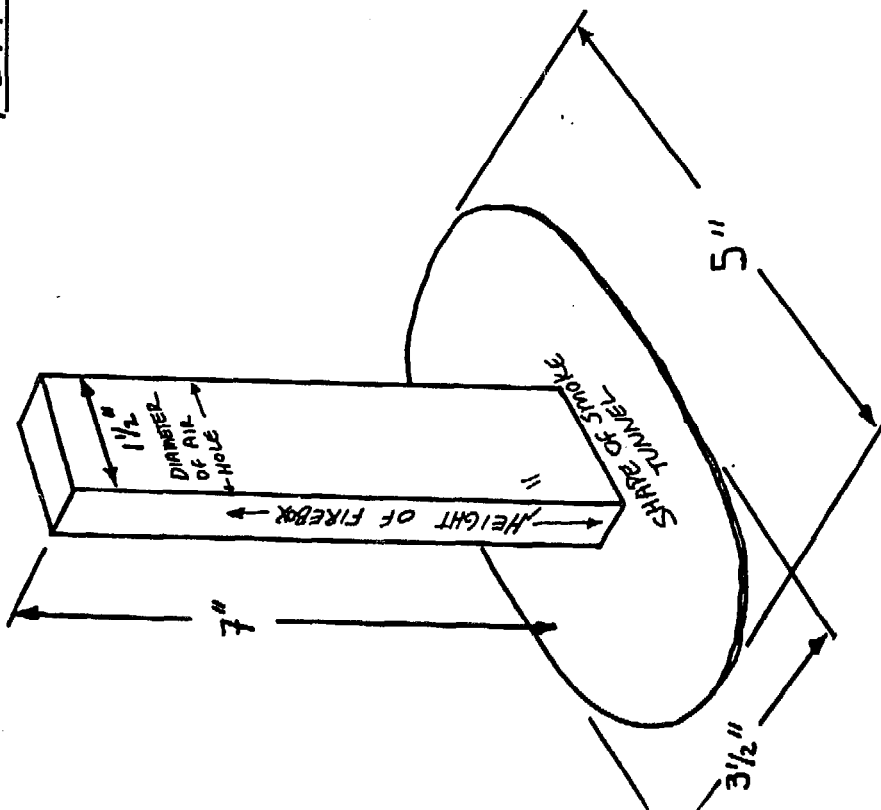


CHECK THAT
THE AIR HOLE
FITS THE TUNNEL
TEMPLATE HANDLE

WET DIMENSIONS ARE CIRCLED
FIRED DIMENSIONS ARE NEXT TO WET DIMENSIONS



TEMPLATES FOR POTTERS



THESE TEMPLATES ARE TO BE USED AS THE POTTER. MAKES THE STOVE. SINCE STOVES SHRINK AS THEY DRY, THEY CANNOT BE USED WITH DRY OR FIRED STOVES.

APPENDIX 5

OBSERVATION SHEET

	Inches	Too big or too small?	Effect
Height of fire box			
Diameter of Fire box			
Height of door			
Width of door			
Depth of door			
Size of air hole			
Distance of air hole from ground			
Distance between pot holes			
Diameter of Second Pot			
Height of Pot supports			

Are the pot holes round? What is the effect?

First _____

Second _____

Is the tunnel attached to the second pot hole well? What is the problem _____

Is the soil mix on the stove smooth and hard? YES NO

What happens if it is too soft? _____

Are there any major problems with this stove? _____

