

# Factory Startup Manual: For The Production of Ceramic Water Filters



*From [www.elfiltron.com](http://www.elfiltron.com)*

**Brand Name: *Silver Filter***  
**(“Al Hib Al Fedi”)**

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## Objective

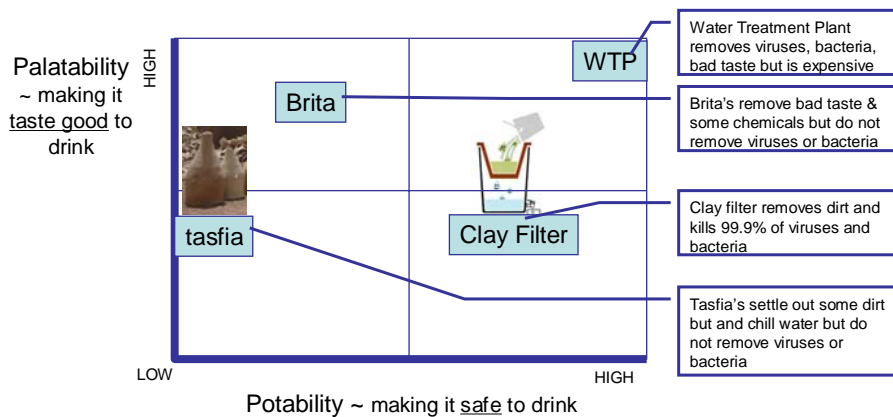
The objective of this manual is to become a comprehensive resource for the establishment of a factory to fabricate water filters made of clay. These water filters are used in each household and provide disinfection of water for drinking.

The factory can range from a rural setting with little improved infrastructure and modest production output to an urban setting with full build out, equipment and high production output. The flexibility of these options demand this Manual provides a number of scenarios for most of the processes. The decision shall be left to the factory owner to determine the best approach for his/her needs.

For a background on the filters, please see The Proposal in Appendix 1 **Error! Reference source not found.** The figure below shows the competing water filter products in the market to product safe drinking water. Along the horizontal axis we have the potability or the ability to make the water SAFE to drink. Along the vertical axis we have the palatability or the ability of the product to make the water TASTE GOOD to drink. Clearly we would like to be in the top right quadrant where the water is both safe and tastes good. Here the best option is a water treatment plant, however these can cost tens of millions of dollars to produce and require considerable expertise and money to maintain.

The best alternative is the clay filter which purifies the water (kills 99.9% of bacterial and viruses) and removes solids and some taste. At the lower end of quality (to the left) we have the Britas – which do not purify but do remove some taste, and the tasfias which do not purify but do settle out the solids and cool the water.

## Competitive Landscape



## Factory Site Selection

The ideal location for the factory will have good access to transportation outlets, workers, and a good supply of raw materials. Security is also an important factor that must be considered of utmost importance. Any of these can be accommodated for if something is missing and the owner decides a site is worth considering. The ideal site will also have electric and fuel access for the kiln (natural gas is recommended).

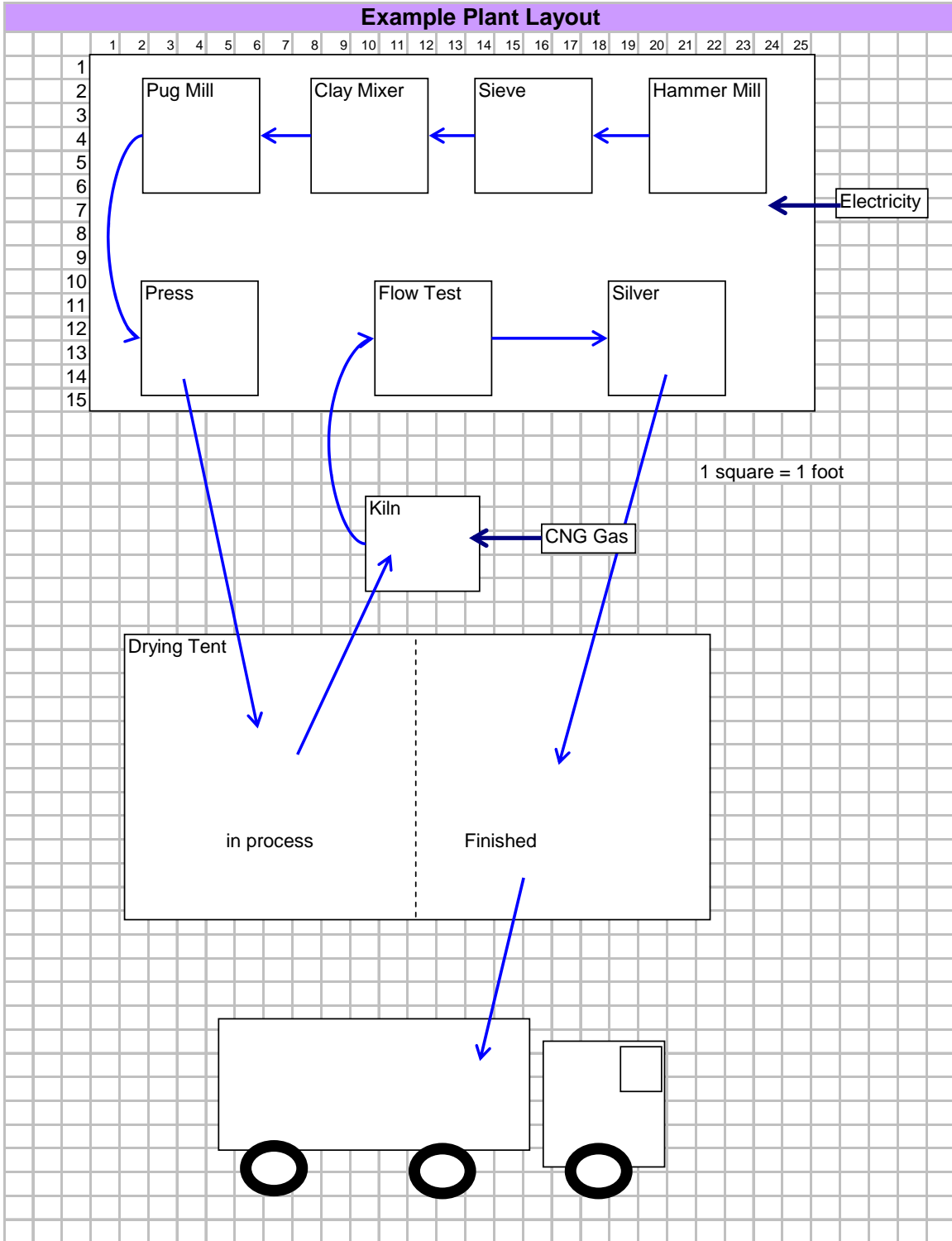
The ideal site setup should have the following:

1. An area for receiving raw materials. Preferably with decent road access and storage for the clay, friable<sup>1</sup> material (sawdust, rice husks...), water, and plastic containers/lids.
2. An area for processing raw materials and mixing clay. The Clay and Friable Material will need to be sifted, the materials will need to be mixed, the clay will need to be “wedged” (covered in Process section). Should be a clean area indoors so the wind will not blow the dry mix.
3. A small area for pressing the mixed lump into the mold. Does not need to be a huge area and could be in the same room with the materials processing/mixing.
4. A dry area, possibly outdoors, for drying the “green<sup>2</sup>” pot. This can be outside or in a tent. Avoiding direct sunlight (depending on the season) can keep the pot from drying too quickly - if the pot dries too quickly it will crack.
5. An area for the kiln that has access to fuel (natural gas, propane, oil...). The kiln does not need to be huge. Actually it is better if it is smaller so the temperature can be more evenly heated. More on this in the Kiln section and Appendix 2. Kiln Construction.
6. An area for the final pots to cool.
7. An area for the assembly of the container, spigots, lids, label, and filter.
8. An area for retail if the owner decides to sell product at the factory.

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<sup>1</sup> Friable means that it burns. This can be either sawdust (used most often) or rice husks. The friable material is mixed with the clay and water to form the “green” pot. When it is fired in the Kiln the friable material is burned off leaving voids in the pot for the water to trickle through.

<sup>2</sup> Green means that the pot has the final shape but has not been fired in the kiln. Firing in the Kiln causes a chemical change in the material that changes it from being a Green pot to be a Ceramic one.



## Notes on working with Clay

Before we start talking about process descriptions, It is important to mention a few things about working with clay – the main raw material of the ceramic filter. Most of these notes have been taken from “Clay and Glazes for the Potter” by Daniel Rhodes.

### ***Not all clay is the same***

There are many types of clay with many different kinds of properties. These properties determine the ability to work with the clay and it’s usefulness for certain purposes. Overall, we are looking for a *clay body*, or a mixture of clay, to have the right plasticity so we can work with it that will melt at the proper temperature, and hold the proper shape. The types of materials which go into a clay body can be thought of as Plastics, Fillers, or Fluxes. These are defined below:

*Plastics* ~ This is the clay part of the clay body. Plasticity is very important aspect to working with clay. Different processes require different plasticity. If the clay body is going to be thrown on a wheel it must be very plastic. If it is going to be stamped in a press it can be less so.

Very plastic clays (such as ‘ball clays’) can be rolled into a rope and wrapped around a thumb without breaking. Non-plastic clays will break when this is attempted and do not hold their shape well when extruded.

Factors that affect the plasticity of a clay body are composition, wetness, aging, and bacteria. The plasticity of the clay body can be increased by adding more plastic clays to the composition or adding more water (to a point). Aging the clay body increases the plasticity by allowing the clay particles the time to be thoroughly wetted. *Some potters allow their clay to age for 2-3 weeks before use.* Bacteria, when given time, increase in number in the clay body and increase the acidity of the mix which increases the workability and plasticity. *Some potters will mix in some old clay full of bacteria with the new clay body to promote bacterial development.*

*Note: For the filter, which will be pressed, the clay should be moist but on the dry end, and should hold it’s shape when squeezed through the circle formed by the thumb and ring finger. If the clay is too wet it will not hold it’s shape when pulled out of the mold and will ‘slump’ over.*

*Fillers* ~ Fillers are added to the clay to add stiffness and decrease warping during drying and decrease shrinkage. Fillers are non-clay materials such as silica, grog, or recycled, fired clay.

*Note: Sawdust is added to the clay body of the filter as a filler. The sawdust also is burned u pin the kiln leaving holes that water will filter through.*

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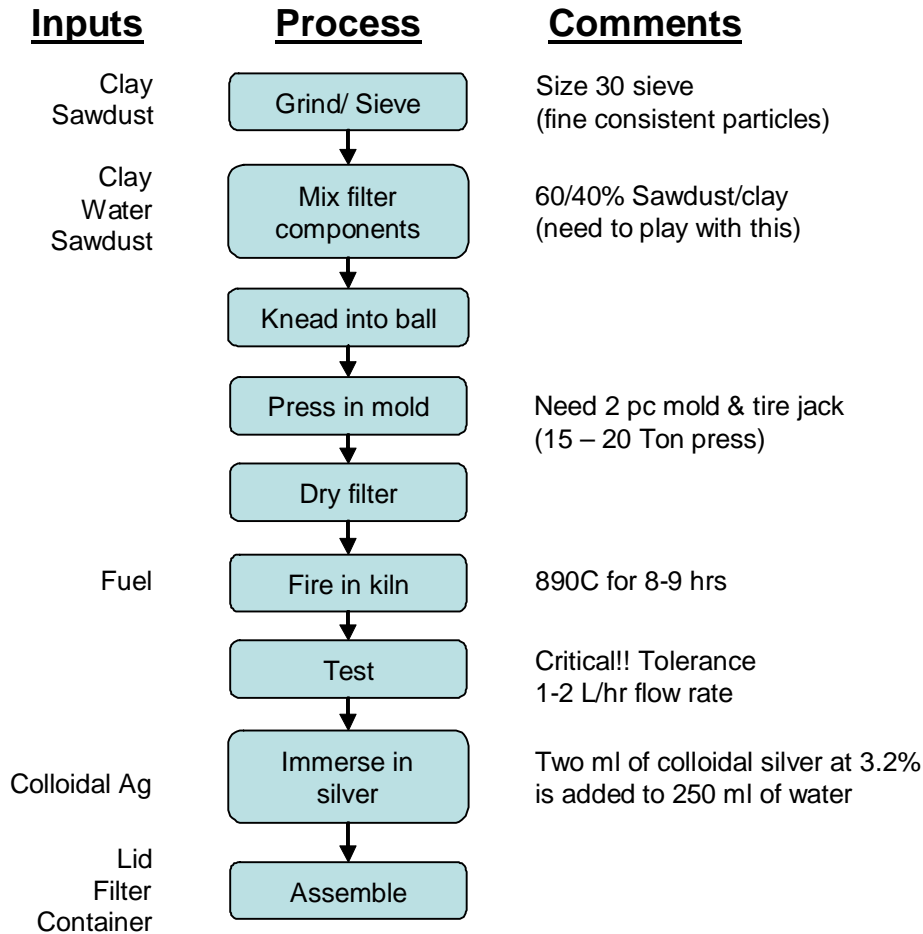
*Fluxes* ~ Fluxes are added to the clay body to control the fusion or hardening point. A flux, such as feldspar can be added to the clay body to lower the fusion point temperature (the temperature the shaped clay is fired).

*Note: Fluxes are not typically used in the filter production.*

### Formation of the clay body

With the understanding of the types of materials added to a clay comes the ability to make a clay body that, when worked and fired, will have the desired properties: Dry shrinkage, plasticity, total shrinkage, absorption at cone 9 (a pyrometric cone temperature), and warpage.

## Process Descriptions



### **Step 1. Obtaining Raw Materials (see Appendix 3 for a listing of Raw material Suppliers)**

1. Clay. The clay can be bought from any pottery or brick factory and is a major component of the soil in parts of Iraq. It is preferred to have the clay sifted at the harvest site before shipping to remove unusable rocks or clay clumps. This will also decrease the workload at the factory.
2. Friable material. This can be sawdust, rice husks, or any material that burns and has a small particle size. Sawdust is difficult to find in Iraq due to the poor supply of lumber but can be found in major furniture production centers like Baghdad. Rice husks can be found wherever rice is grown but may need to be pulverized to fit through the sieve.
3. Water can be found anywhere.
4. Fuel for kiln. The kiln can be fired with anything that can heat it to 1650 degrees F (890°C). Natural gas would be easiest, diesel can work, as can oil. If propane tanks are going to be used care must be taken to ensure the manifold does not freeze up since we will be pulling off a lot of propane to fire the kiln. 'Residual' from the oil refining process can also be used, however it does not flow well below 70°F (21°C) and has a high concentration of heavy metals. It is not recommended that the exhaust- if residual is used- does not come in contact with the filters during firing for this reason.
5. Colloidal Silver. The silver is the most difficult raw material to acquire, however there is a liquid silver source in Mexico and a powdered silver source in . Fortunately a small amount of silver treats a large number of pots (about \$500 dollars worth of silver will treat about 20,000 pots).
6. Plastic. There are a number of plastic suppliers in Iraq for containers, lids, and spigots. The type of these is not crucial and need only have the right size for storing the water that is filtered.

### **Step 2. Sifting the clay and friable material**

Sifting the clay and friable material is important to ensure that the voids (holes) in the final product are the correct size. Holes that are too big will cause the flow rate to be too fast and will not filter enough dirt out of the water. Holes that are too small will cause the flow rate to be too slow and will not produce enough drinking water for the day.

A sieve can be made with a wooden frame (1 meter square) and window screening or mosquito netting. The clay is dumped onto the sieve and then it is shaken onto a clean floor. The sifted material is then swept up with broom and dustpan and placed into a container for mixing.



The same process is used for the friable material to ensure particle size consistency in the mix.

### **Step 3. Preparing the Dry Mix of Clay and the Friable Material**

Once the dry materials have been sifted, we are ready to prepare the dry mix. The proportions of the clay to the friable material are crucial to determining the right ‘plasticity’ and final flow rate of the filter. A 50:50 mix BY VOLUME of clay to friable material is a good place to start. If this turns out to cause cracking in the press or feels like it is not very plastic, add more clay to the mixture (e.g. a 60:40 mix of clay to friable material).



The mix proportions can be done using any scoop and varying the number of scoops for each of the ingredients. For example, a 60:40 mix can be obtained by using 3 scoops of clay to 2 scoops of friable material.

The dry mix should be mixed thoroughly in a container, cement mixer (for larger batches), or a plastic sheet on the floor rolled back and forth. Remember that every time we increase the amount of clay to the mix we decrease the final flow rate of the filter. It is crucial to experiment with the percentage to obtain the optimal proportions by volume.

### **Step 4. Preparing the Wet Mix**

Once the dry ingredients have been thoroughly mixed, it is time to add the water. The amount of water typically added to the mix is measured by weight (in Step 3, the dry mix was added by volume). However, this can also be done by “feel” by adding the water using experience.



A 30% mix BY WEIGHT of water to the dry mix is a good place to start. The wet mix should have the approximation of moistness without obvious “drippiness.” What we are looking for is proper coating of the particle surfaces without it being so sloppy it will not hold its shape once formed. It should feel a little drier than a typical cement mix. Just when the clay begins to hold its shape when squeezed out through the hands it is ready. If it is too wet it will slump in the press or fall over when drying.

### **Step 5. Wedging the Clay**

When the Wet Mix is prepared we will have a moist lump of clay. In this step we wedge or knead the clay to get further work in the moisture and get all of the air out of the mixture. Wedging consists of folding the clay over upon itself repeatedly and applying pressure. This is similar to kneading dough for bread.

## **Step 6. Pressing the Clay into the 'Pot' shape**

After Wedging, we have a consistent, air-free, lump of moist clay. It is now time to press the clay into its final shape. Begin by ensuring that the ejector plate is in the bottom (female) mold. Then line the female mold with a garbage bag to prevent sticking when the filter is taken out. Place the tin plate (also known as a bat) in the liner with another piece of plastic on top of that. Finally, place the lump of kneaded clay in the female part of the mold. *It is important to have plastic separating the clay and any metal so that the clay does not stick to the metal after pressing.*



The mold is then closed by pumping the jack handle or operating the motor (depending on the type of press) until the male and female molds meet.

*Note: In the current aluminum mold design, the proper stopping position is when the two mold halves are about 1/4 inch (6mm) apart so that the lip of the pot is about 14mm thick. We are working to improve the mold so that this lip thickness is correct when the mold halves meet.*

*The new mold design will also have rounded corners at the bottom of the pot to make it easier for the clay to 'Flow' around the bottom of the mold.*

Once the mold is 'closed' hold the pot up while removing the jack (make sure to remove the jack plate between the jack and female mold) and the jack platform. Next place the ejection rod in the hole at the bottom of the press and align it with the hole in the bottom of the female mold. Lowering the top mold onto the ejection pin exposes the newly pressed filter. Be careful not to jerk the mold up and down as this will shock the filter causing it to slump.

While the mold is in this 'green' (unfired) shape, it can be cleaned up to remove any fringe clay, stamped with the date, factory symbol, and lot number. A design, if desired, can be added also at this time for a personal touch.

## **Step 7. Air Drying the 'Green' Pot**

At this time, we have a pot shape with our factory markings and are ready to air dry it. The purpose of drying it is to remove as much moisture as possible before we stick it into the Kiln. If the pot has excessive moisture, the water will evaporate inside the clay when we fire it in the Kiln and will cause the pot to explode.



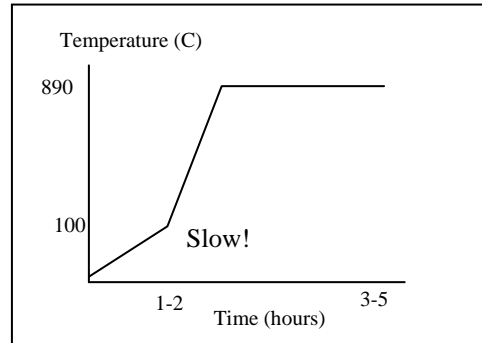
Place the pot in a dry area for a day or so. Avoid drying it too quickly or the pot will crack. Direct sunlight, especially in the hot summer months, should be avoided.

### **Step 8. Firing the Pot in the Kiln**

The dried out, green pot can now be placed in the kiln to be vitrified (chemical process which hardens and glassifies the clay). This is a crucial step in the fabrication of the filter and should be experimented with to make the pots properly and efficiently.

The kiln should be fabricated properly (see Appendix 2) so that the temperature is both controllable and even throughout the kiln. A rule of thumb for firing the kiln is: to do it as quickly as possible without exploding or cracking the pot. It will not hurt the pot if it is cooked too long.

The kiln should be fired very slowly up to the boiling point of water (212 deg °F, 100°C) so the water moisture inside the pot has a chance to escape before it boils at 212°F. After 212°F the temperature can be raise quickly to 1650°F (890°C) and held there for several hours to cook the pot. After the pot is cooked, the kiln can be allowed to cool slowly over 2 hours until the pot can be handled by hand. Careful not to damage the pot while it is hot.



*Note: Measuring the temperature in the Kiln can be done with Pyrometric Cones which melt when they have been 'at temperature' for a certain amount of time. Such as those in our 55-gallon drum kiln. The cone is placed at sight level through the peep hole. When the temperature has been reached for the proper amount of time they will melt over (like the white cone on the left).*

Temperature can also be measured ‘real time’ using a pyrometer temperature sensing device which have a probe that is placed inside the kiln near the pots. These devices allow you to see the progress of the temperature in the kiln.



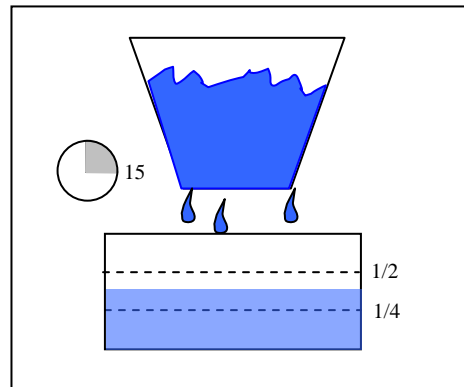
*Note: a good size for the kiln would be to fire three days worth of pots. The Kiln should have good cross flow and draft so that the hot air circulates throughout the Kiln. Kiln construction materials can be built out of whatever is at hand. Insulated ‘fire bricks’ and fiberflax clot is recommended.*

### **Step 9. Flow tests of the Filters**

Now that we have fired the pots they are now ceramic. Allow them to cool to room temperature for the flow test.

The flow test is critical to for the quality of a good water filter. If the filter’s flow rate is too fast, it will not filter out all of the dirt and disease from the water. If the filter’s flow rate is too slow, it will not produce enough drinking water for the day to be useful. The flow rate we need is between 1 – 2 liters per hour. The filter should be soaked thoroughly for the test.

The flow test can be done in a number of ways depending on the factory owner. All techniques require the pots to be soaked in water thoroughly before the start of the test. One technique would be to place a known quantity of water in the filter and time how long it takes to flow out. Another would be to place water in the filter and to measure how much goes through in 15 minutes then multiple it by four to get the liters per hour. Use whichever method works for the owner.



*Note: It is crucial to have filters that have the correct flow rate. Selling pots that are incorrect will cause people not to use the pots and they will stop buying them. SMASH THE POTS THAT DO NOT PASS THE TEST!!!!!!!*

### **Step 10. Coating the filter with Colloidal Silver**

For the pots that pass the flow test, it is now time to coat them with the silver which will kill bacterial and stop diarrhea in the drinking water. The filters must be completely dry before coating with silver so that all of the silver will be absorbed into the filter. The filters can be coated by either ‘painting’ the silver on with a brush or by dipping the filter into a bath of silver dissolved in water. If painting is used, coat the inside of the pot with

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2/3 of the paint (200ml) and then use the remainder of the paint to coat the outside (100ml). The recommend process is to dip it into the silver solution bath however it may waste more silver in the process.

Each filter requires about 300ml of the solution with a concentration of 220 mg/L of silver. The silver can be acquired in either a solid powder or in a liquid. Preparing the solution can occur using either of two methods:

1. For solid, powdered silver: add 66mg of Silver to 300 ml of water and mix well. However this requires a fine measuring device like a Mettler Balance. An easier, two-step process requires making a concentrated solution of 33,000 mg/L silver by adding 33 grams of silver to a liter of water and then adding 2 ml of this solution to 300 ml of water.
2. For liquid silver: Add two mL of 3.2 percent (32,000 ppm) solution of colloidal silver to 300 mL of bottled water before application.

The 300 ml solution can be brushed on with a regular painting brush until all of the solution is consumed. Or a 220 mg/L Silver solution can be prepared in a large volume to be used as a bath for dipping the silver.

### ***Step 11. Final Drying***

Now that the filter has been coated with Silver it is ready for final drying. Place the filter in a dry location until it is no longer wet. Be sure to separate these filters from the 'green' filters that are drying before they go into the Kiln.

### ***Step 12. Labeling of the filter***

If desired, now is the time to label the filter to uniquely identify it as coming from your factory. Labeling can be stamped into the green pot before firing or can be painted on at this step (recommended). Painting occurs by painting a rectangular area with a red stain and then using a sharp point such as a nail to etch out the label. Some ideas for labeling:

1. The Brand name of the filter ("Silver Filter")
2. The name of the filter factory
3. The date the pot was fired (this could be used as the "Lot Number")
4. The number of the pot in the lot (this could be used as the "serial number").

### **Step 13. Prepare Container and Assemble with Filter**

Plastic containers are prepared by punching a hole in the side near the bottom and screwing on a plastic spigot. Clay containers must have the hole prepared before firing and then the spigot is screwed on. Either type works as long as the throat of the container holds the filter. If desired, the pots can be left unassembled and then packaged and stacked for transport to market.



## Appendix 1 Proposal for Point of Use, Ceramic Water Filters

### Background

Iraq's drinking water ranges from questionable quality in the urban areas to reportedly disease-causing in the remote villages. Municipal water- while it does benefit from treatment at the city water treatment plant- may still be degraded in the distribution system from contaminate entry caused by back-siphonage from pressure loss or contaminate propagation caused by un-maintained water mains. Both of these systems would benefit from additional water treatment at the point of consumption.

Iraq's poor drinking water quality is shared by many third world countries such as those in Central America. One approach, lead by NGO "Potters for Peace"<sup>3</sup> in Nicaragua, uses a clay water filter impregnated with a disinfectant to treat the water at the point of consumption. The technology (Trademarked as Filtron is covered in Figure 1) has been used for several years and claims significant removal (99%) of disease causing particles and microbes. Proof of concept studies has been conducted at The Massachusetts Institute of Technology and University of Chicago with favorable results.

I have been in contact with Ron Rivera, PfP international Director and Richard Wukich a contributor for the first Iraq effort. Both have shown interest in working with us for a second attempt.

### Objective

Development of a nationwide Point of Use Water Filter (POUWF<sup>4</sup>) would meet the following Objectives:

- Create goodwill by increasing the water quality for Iraqi people. This 'goodwill' can not only be spread to the larger cities, but to the smaller villages as well.
- Create employment through development of filter factories. These can be done using a centralized approach with one factory per nation/province or can be decentralized with a factory for each tribal area. Experience in Central America shows that 3-7 people per factory is typical. In addition to the factory, employment is created through ancillary services (transportation, raw material production...).
- Create economic stimulus by promoting small business and wage earning at lower socio-economic levels. Promoting potters and factory workers discourages inequality, promotes free enterprise, and generates follow on businesses. Decreasing wage inequality promotes 'velocity of money' developing a positive loop of entrepreneurship.

### Technology

The Filtron™ clay pot filter assembly is comprised of three main pieces: a container which holds the water and the pot and had a tap for water removal, a silver impregnated,

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<sup>3</sup> PfP has an Anti- Iraq War declaration on their Web site. When I first asked them to work with us, I mentioned they would be working with Coalition Forces. This did not raise any alarm with them and they appear interested in bringing their technology to the Iraqi people.

<sup>4</sup> We need to think of a sexier acronym.

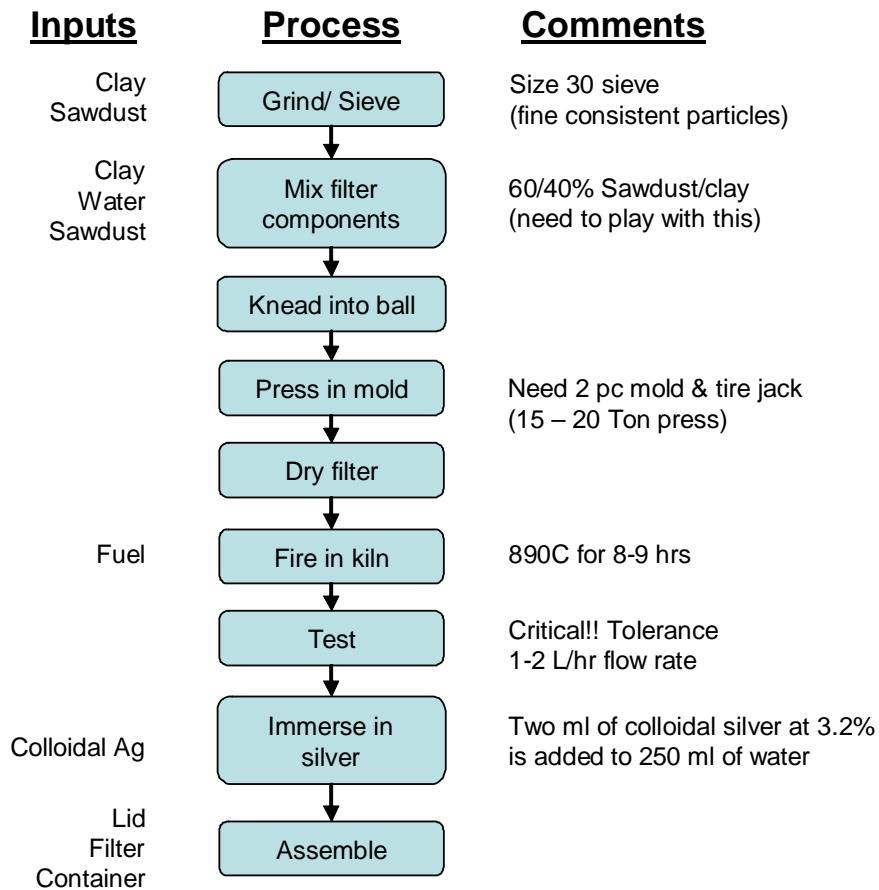
clay pot filter which nests inside the container and filter the water, and a lid to cover the assembly.

The process is shown in Figure 1 to be multi-stepped. The filter design begins with a grinding the clay and sawdust to create a fine powder. Consistency in the powder is obtained by sieving using a size 30 sieve (mosquito net). The two powders are then mixed with water and kneaded into a ball for pressing in the mold (see Figure 2) to obtain the 'green' final shape of the filter. After pressing it is fired in the kiln to burn out the sawdust and de-water.

Testing is a crucial next-step in the process. The filter must yield a flow rate of 1 – 2 liters per hour. Faster than this may not provide enough filtration and slower than this may not yield enough drinking water in a reasonable timeframe. During the startup period, this step may cause a considerable amount of wasted filters as the mix is adjusted to meet a tolerable flow rate.

Filters that pass the flow rate test are then immersed in colloidal silver (the disinfectant) and allowed to dry. The filter, now complete, is assembled with the lid and container and placed in storage for use at the customer site.

**Figure 1. Filter Production Process**



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The process is not overly complex however, it does require a considerable amount of dedication to the process to get the proper flow rate through the filter and to maintain quality control.

Mr. Rivera has mentioned successful potters are those that exhibit some familiarity with quality control, marketing, costing, meeting deadlines, and use of large equipment. All of these are capabilities of a successful business owner and the focus of a small business development center.

**Figure 2 Filter Press (from [www.potpaz.com](http://www.potpaz.com))**



## Economics

### MARKET ESTIMATION.

The focus for this project would be to bring the filters where the water quality is poorest; namely the population centers under 10,000 inhabitants where there is little treatment for drinking water with most people drinking directly from river or ground water sources.

It is difficult to determine how many of Iraq's 26 million people live in population centers of our target size. We would need to work with our S-2 to determine the actual numbers however it is reasonable to estimate that this need is significant. A quick (and conservative) back of the envelop calculation follows:

- Assume
  - o All agricultural (Ag) employees are villagers (we will include those involved with Agriculture transportation and warehousing)
  - o For every 2 Ag workers (father & son) there are 5 family members
  - o Conservative estimate of 30% of employable workforce of 7.8M is involved in agriculture = 2.34M
  - o One filter for each family of 7.
- Total family members who would need the filter =  $2.34M * 5/2 = 5.85M$
- Total filter market =  $5.85/7 \approx 800,000$  filter systems country-wide

PfP in Nicaragua has found their startup costs to be between \$5000 – 8000 depending on the sophistication of the factory and have employed 5-7 folks. The cost of goods for the

complete filter assembly is about \$10 with \$4 of that attributed to the clay filter itself. The filter lasts about one year whereupon it would need to be replaced.

- Total market size = \$10 \* 800,000 = \$8M
- Total filter replacement market size = \$4 \* 800,000 = \$3.2M (at peak)

#### COSTING.

The costs for the project are broken out for training and training material for the NGO who will come out to train us at no profit to himself, the capital outlay for the building, equipment, and Fit out of the building, Market costs, and a four month supply of materials to get the factory running appropriately. For a detailed look at the costing see Appendix 6 and Appendix 7.

#### **COST DAT FROM NICARAUGA SHOWS PRICE PER SYSTEM (POT AND PLASTIC) TO BE BETWEEN 3-7 US DOLLARS.**

#### TOTAL FUNDING REQUEST.

The funding for the factory would cover the initial capital investment for the Property, Plant, and Equipment of [COST DATA REMOVED] with an additional for marketing as well as the initial startup cost of materials for four months of operations of [COST DATA REMOVED]. This is a total funding request for the first plant of [COST DATA REMOVED]. This price will fall appreciably as we bring successive plants online due to learning and Iraqi sourcing of their own materials (thusly eliminating the coalition pricing gouge).

Salaries and operating costs outside of the four-month startup phase would have to fall under Iraqi control, operating profit, or NGO's.

#### **Roll out**

There are two approaches being considered for rolling out this project. The first is a centralized approach with one factory that is well developed, has experienced potters who are used to deadlines, quality control, and have equipment necessary for large-scale production. The second approach involves having multiple, smaller factories that are not quite as sophisticated but are collocated with the markets they serve.

#### **Alternative #1. Centralized National Factory**

Pros	Cons
<ul style="list-style-type: none"><li>- Capability of potters is fully developed</li><li>- Gain economies of scale at factory</li><li>- Changes in design are consistent across country</li><li>- Most efficient use of resources</li><li>- Only one building, set of equipment required</li></ul>	<ul style="list-style-type: none"><li>- Least number of people hired</li><li>- Cross Tribal boundary shipment required</li><li>- Most susceptible to terrorism</li><li>- Increases chances of 'graft'</li></ul>

**Alternative #2. Decentralized Tribal Factories**

Pros	Cons
<ul style="list-style-type: none"><li>- Promotes high tribal morale and ownership</li><li>- Easier to get local 'buy-in'</li><li>- Easy access to market from collocated factory</li><li>- Hires more people</li></ul>	<ul style="list-style-type: none"><li>- more difficult to implement changes</li><li>- less efficient</li><li>- more redundant equipment required</li><li>- Less leverage when buying supplies</li><li>- Learning not conveyed on national level</li></ul>

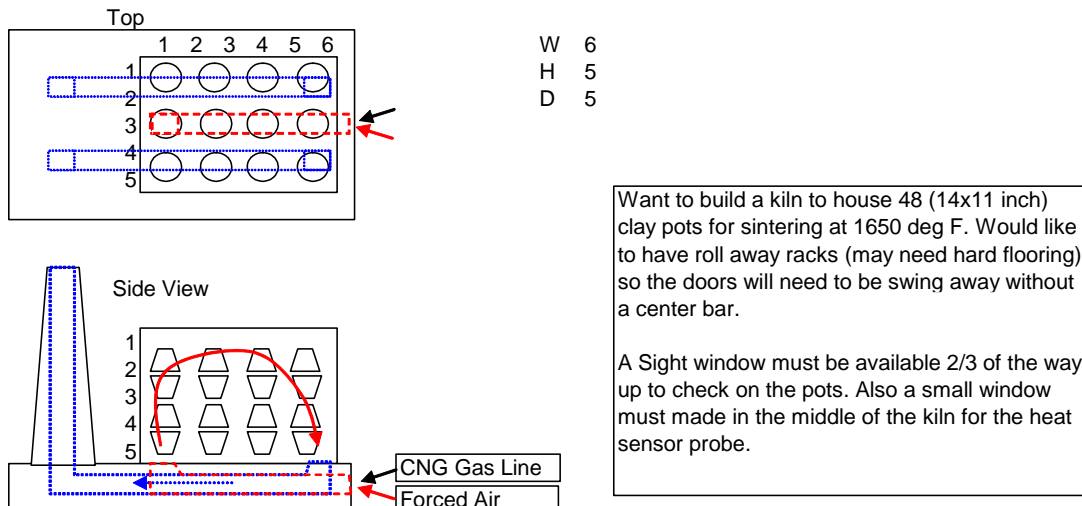
## Appendix 2. Kiln Construction

**Objective:** The purpose of the kiln is to heat about 3 days worth of pots (50 – 100 depending on desired volume which supports a 3 day firing cycle [day 1 unload and reload, day 2 fire, day 3 cool) to a temperature of approximately 1650 degrees F (890 C). Pottery Kilns must have good temperature control (+/- 25 degrees C) and have good temperature consistency throughout the kiln (we don't want one side to be a lot hotter than the other).

**Fuels:** Just about any fuel can be used to heat the kiln. Gases such as clean natural gas (preferred) or propane are the easiest to control. It is best to have them plumbed into the local utilities instead of using tanks since the tanks will freeze up do to gas expansion. Oils and diesels can be used as well and can be controlled with a spigot arrangement. All of these fuels will require a great deal of air to be forced into the system so that the kiln will get very hot with complete and clean combustion of the fuels.

**Construction:** The shape of the brick should allow good draft flow around the inside so that the temperature is consistent. The size should be big enough to allow 3 days worth of pots to be fired at once (50 – 100 pots). Firebrick (heat retardant brick) is a good solution for the walls. FiberFax or other heat insulative material will be needed to make the roof. The door can be open and then bricked in for each firing or an insulative wall can be made. Peep holes should be made in the kiln to check on the pots and to insert a temperature sensing probe.

An example for the construction follows:



### BOM

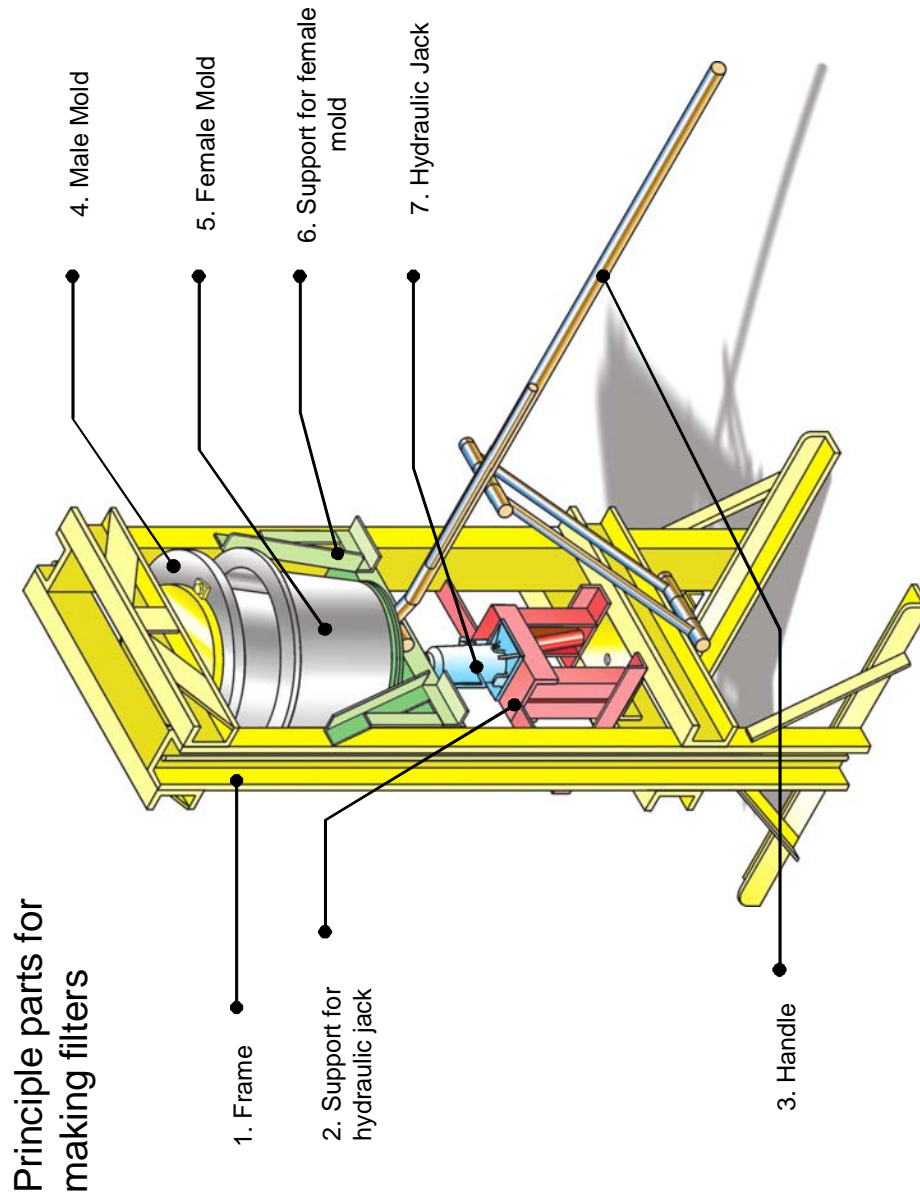
- 1 100 feet of angle iron or 2"x2" steel bar, to make the frame
- 2 130 SF heat resistant siding material
- 3 50 SF heat resistant roofing material (can be same as siding)
- 4 180 SF of insulating brick, fiberboard,... to hold 1000 deg F heat
- 5 25 ft CNG piping
- 6 CNG pipe fittings and valves
- 7 enough brick and mortar to make the sides.

**Appendix 3. Raw Material Suppliers**

Material	Source	Comments
Colloidal Silver (3.2%)	Currently the only known sources are powdered in Spain and liquid in Mexico.	<p><b><u>Powdered colloidal silver</u></b>            LABORATORIOS ARGENOL S.L.            Autovía de Logroño km 7 4            Polígono Europa 2            naves 1-11            50.011 Zaragoza (Spain)            Tel: + 34 976 336266            Fax: + 34 976 533659            www.argenol.com</p> <p><b><u>Liquid colloidal silver</u></b>            Luis Arizcorreta            Owner and general Manager            Microdyn            Roland De México            Asturias No. 58            Col. Alamos            03400 Mexico DF            tel. 55382068            Fax 5385963            maxkenlon@yahoo.com</p>
Clay	local	
Sawdust (or rice husks)	local	
Fuel for Kiln (CNG)	Local hopefully hooked up to city utilities.	Can also use residual from the oil refining process. This would be free.
Containers (5-20 Gallon with 14 inch diameter)	These can be bought at a market	
Lids for container	These can be bought at a market	
Taps	Sold in Baghdad also a source in US called Tomlinson Industries	

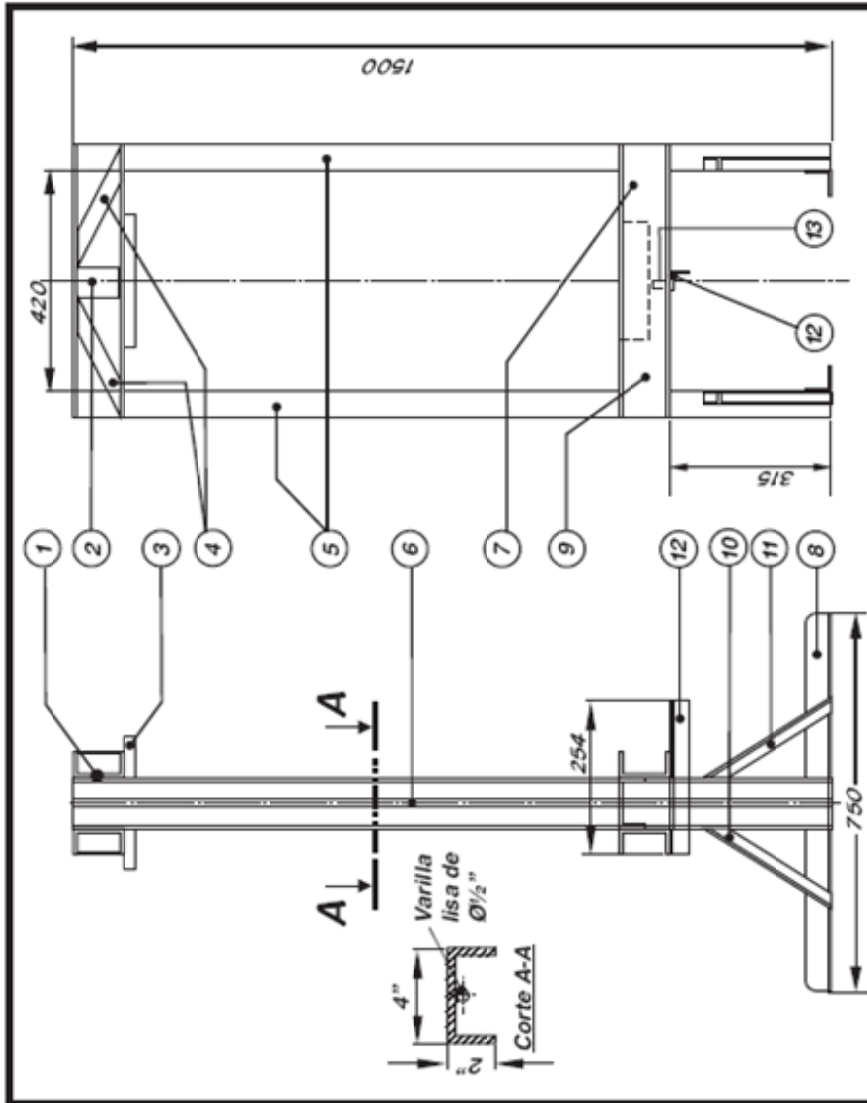
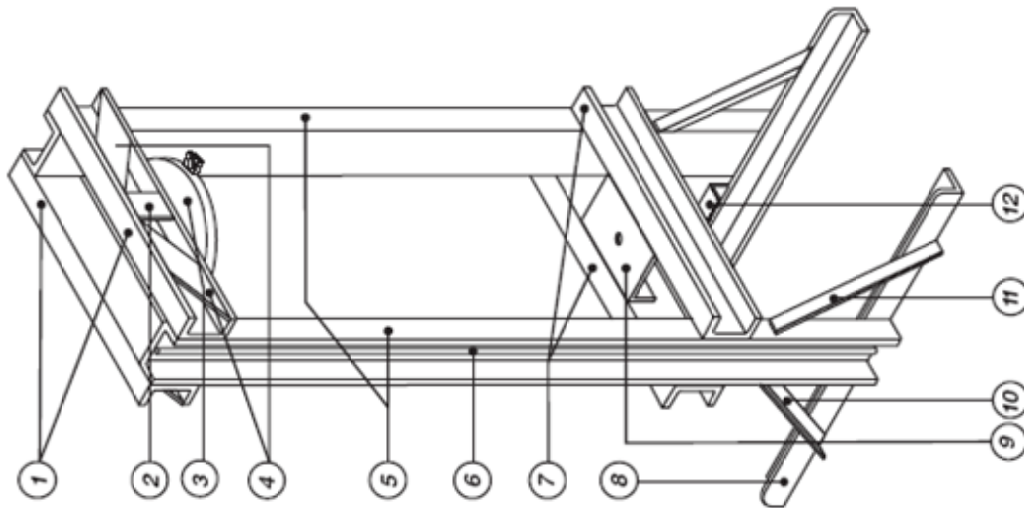
### Appendix 4. Filter Press Schematics

#### INSTRUCTION MANUAL FOR FABRICATION THE PRESS TO MAKE FILTERS



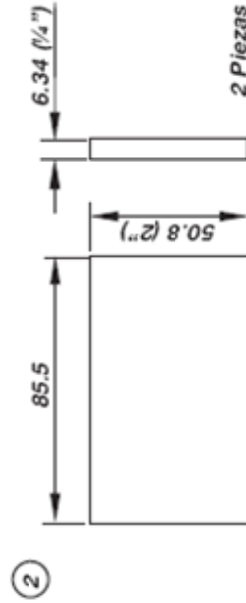
Dutch Press Schematics

**I. FRAME**

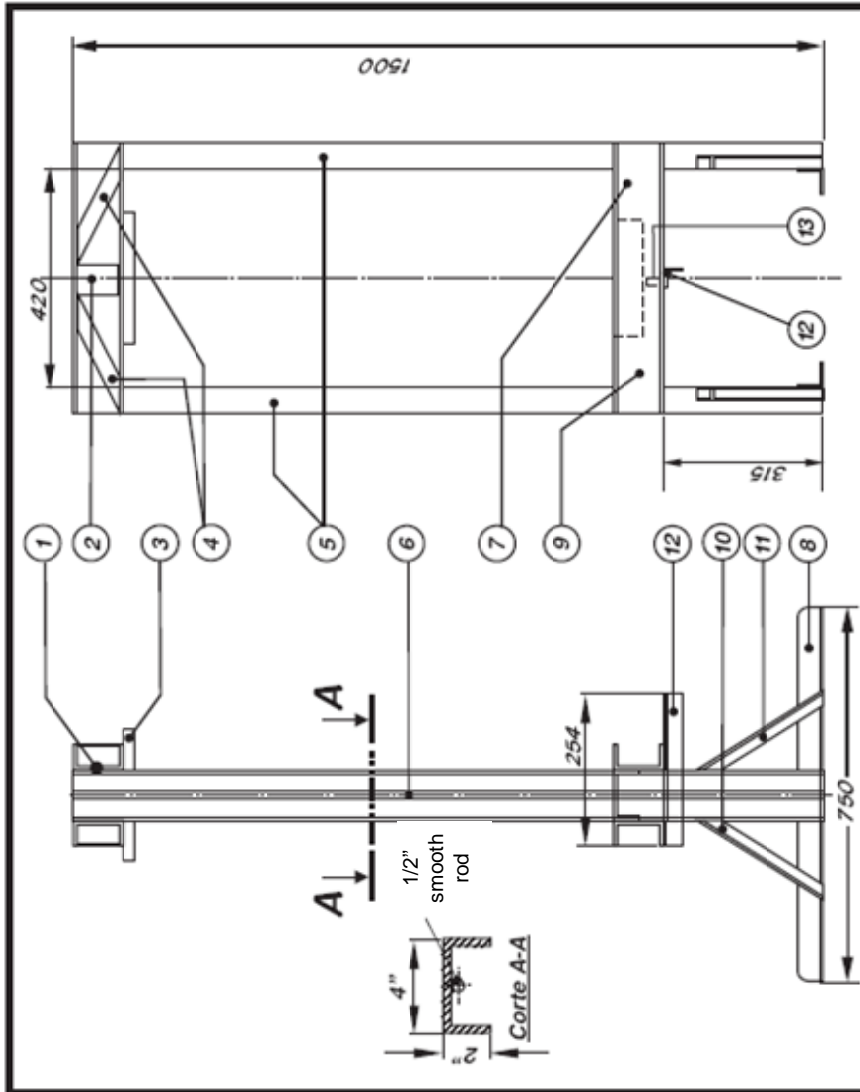
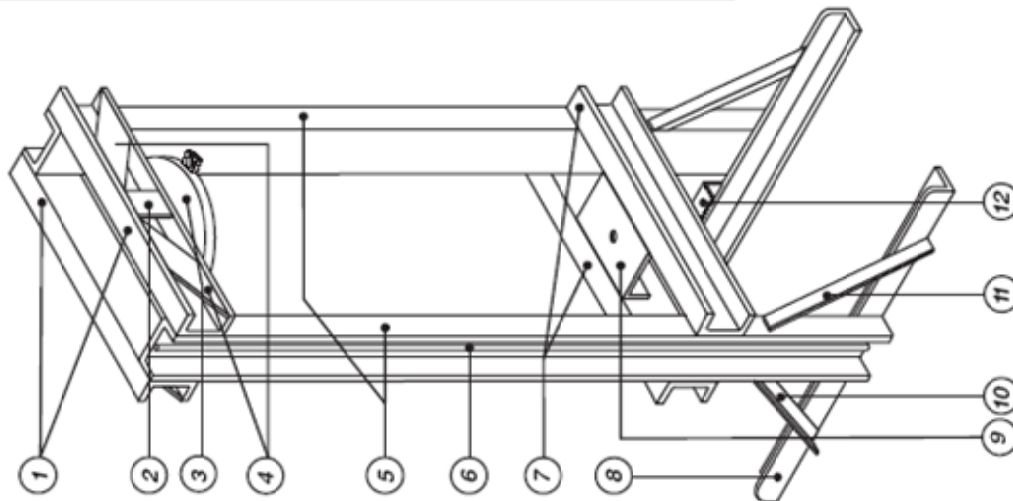


① Profile in "C" (4"x2"). Length = 508mm (2 Pieces)

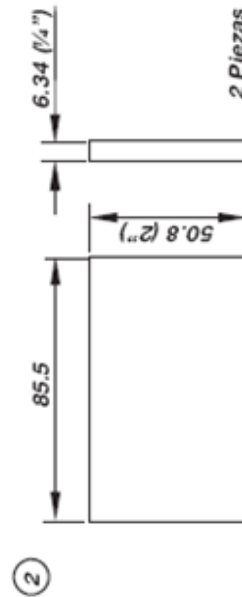
FRAME PIECES



I. Frame



1 Profile in "C" (4"x2"). Length - 508 mm. 2 Pieces



Pieces of the Frame

# 1. Frame continued (pieces of the frame)

**3** 1 piece

Pieces of the frame

**4** 1/4 inch plate. 2 pieces

**5** Profile in "C" (4"x2"). thickness = 8mm. Length = 1500mm (2 Pieces)

**6** 1/2 inch smooth rod  
 Length = 1500mm. (2 pieces)

**7** Profile in "C" (4"x2"). Thickness = 8mm  
 Length = 508mm. (2 pieces)

**8** Angle 2"x2"  
 Thickness = 4mm  
 Length = 750mm  
 Round off edges (2 pieces)

**9** Profile in "C" (4"x2").  
 Length = 180mm. (1 Piece)  
 Drill 1/2" hole in center of Face plate

**10** Angle 1"x1". Thickness 3mm.  
 Cut 2 right pieces and 2 Left pieces

**11** Angle 1 1/2" x 1 1/2". Length = 254  
 Thickness = 5mm (1 piece)

**12**

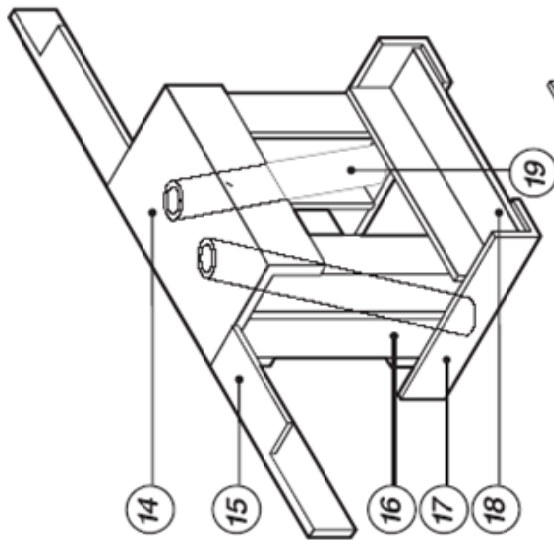
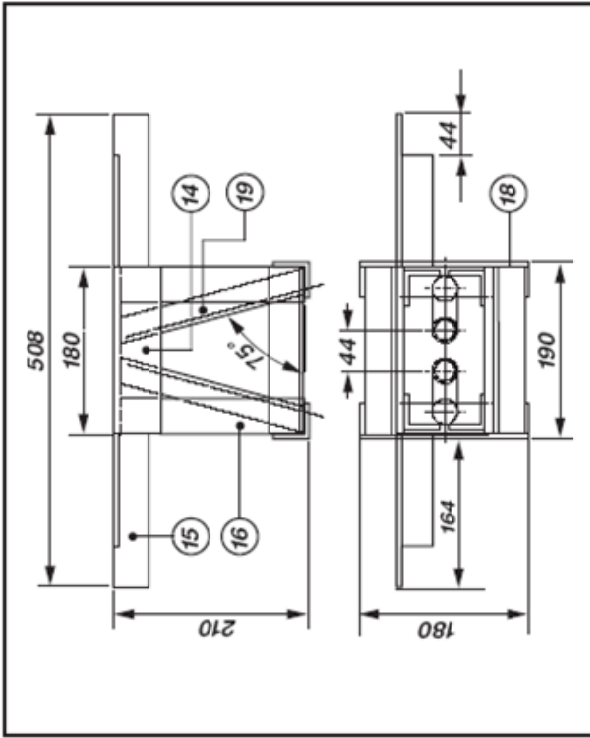
**13** 1/2" Galvanized Tube  
 Length = 30mm. Align With hole from #9

**14** Male mold centered on piece #3  
 And welded to frame (top view)

Line up holes and weld Plates with the male mold as A guide

LUCAS P. PRESS SCIENTIFICS

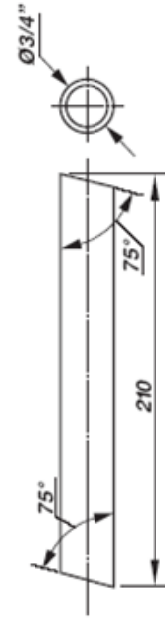
## 2. Support for the Hydraulic Jack



Mounting Diagram

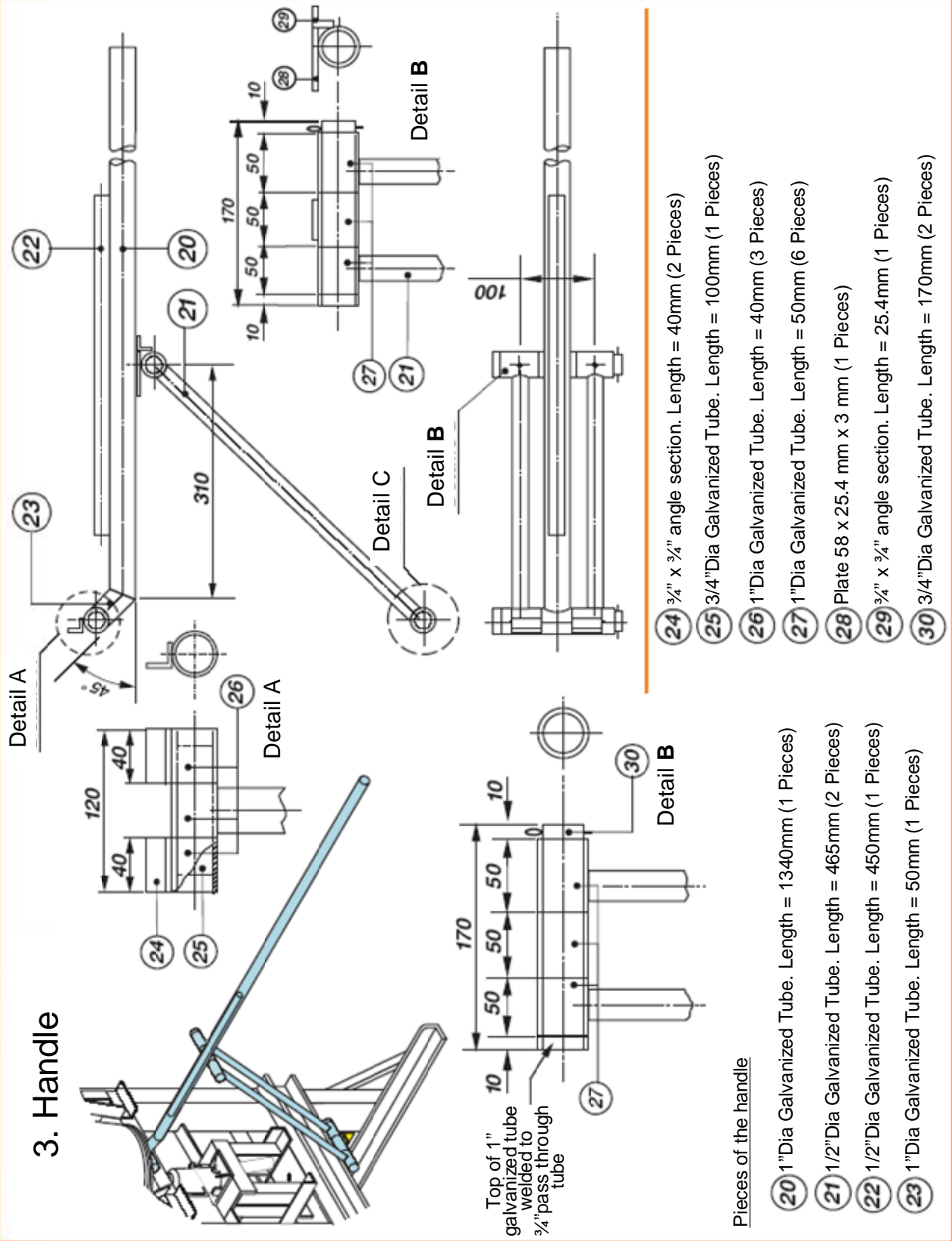
### Pieces for the hydraulic jack

- ⑭ Profile "C" (4" x 2"). Length = 180. (1 Piece)
- ⑮ Angle 1 1/2" x 1 1/2". Length = 164mm. Thickness = 5mm (2 pieces)  
 \*Cut one straight piece and one left angle
- ⑯ Angle 1 1/2" x 1 1/2". Length = 197mm. Thickness = 5mm (4 pieces)
- ⑰ Angle 1 1/2" x 1 1/2". Length = 180mm. Thickness = 5mm (2 pieces)
- ⑱ Angle 1 1/2" x 1 1/2". Length = 180mm. Thickness = 5mm (4 pieces)
- ⑲ 3/4" dia. Galvanized Tube. Length = 210mm (2 pieces)



Dutch Press Schematics

### 3. Handle



Dutch Press Schematics

### Appendix 5. Test Kiln Construction

If desired, a small kiln can be made to be used for training. This can be made small enough to hold 2 pots and use minimal resources, yet show the process for firing pots.

Two common shapes for the mini-kiln are the 55-Gallon Drum kiln and the brick kiln (about the size of a pit BBQ).

The drum, mini-kiln is show below:



55 – Gallon Drum with diesel. Has a spigot in “bung” hole to control flow to the copper tubing (which is inserted into hole in 2” pipe

55 – Gallon Drum coated with 3” of concrete mix (1/3 clay, 1/3/concrete, 1/3/ sawdust)

Brick base with U-channel to accept flame. A target block was placed in front of channel near flame to disrupt flow.

Leaf blower connected to 2” pipe (which has the fuel line inserted into it) to force air into drum



(Above left: brick kiln with diesel drum & air blower. Peep hole and temperature probe hole visible in kiln. Manifold had inlet for fuel and air and burns directly into kiln. Above right: setup inside kiln with fire box on bottom, pyrometric cone, and circular pedestal for the pot. Kiln was lined with fiberfax heat insulative blanket.

**Appendix 6. Equipment and Equipment Costs**

NOT ALL OF THIS WILL BE REQUIRED FOR ALL SITES. EQUIPMENT DEPENDS ON CLAY, SITE LOCATION, AND PRODUCTION VOLUME.

**Capital Equipment per Factory (All costs in US Dollars). Costs estimates as of Sep 2005**

ID	Major End Item	Components	Comp Cost	Item Cost	Comment
1.0	Hammer mill (to make dry clay into powder)	NA		10000	This is a big ticket item that depends on the clay. If it is hard and rocky than this will be essential. If the clay is fine and 'powdery' than we may be able to get by with only sifting
2.0	Sieve for sifting	Sreening and wood		50	Used to ensure the clay and friable material is the same size
3.0	Clay mixer (to add sieved and measured ingredients to develop a clay body)	NA		5000	Bailey C-119-200 Professional mixer <a href="http://www.baileypottery.com/pugmills-mixers/soldnerclaymixers.htm">http://www.baileypottery.com/pugmills-mixers/soldnerclaymixers.htm</a>
4.0	Pug mill (to homogenize the mix with water and develop a standard)	NA		3200	Bailey Model A-400 / A-800 Single Auger Deairing Pugmills <a href="http://www.baileypottery.com/pugmills-mixers/baileypugmills.htm">http://www.baileypottery.com/pugmills-mixers/baileypugmills.htm</a>
5.0	Press (either electric or screw, hydraulic or manual, the bigger the better) for tiles or other items	Below			
	5.1 Press		3000		Used to press the shape of the filter. Hydraulic ones are being made in Holland, Electric 'drive screw' ones are made in cambodia
	5.2 Screw motor		500		
	5.3 Intallation		200		Electrical, floor bolting, cement pedestal
				3700	
6.0	Kiln (5x5x6)	Below			Big enough for 50 pots, CNG fired, with shelving footer, draft 'dtiches'
	6.1	Cement foundation		150	This is the reimbursable cost to the Consultant for the burners. These are critical to maintaining temperature.
	6.2	Burners (fabricated in US)		500	Used to control air/fuel ratio, increase temperature in kiln
	6.3	Air Blower (Pricing for 2)		150	Frame for roof and door, burner supports
	6.4	Angle Iron (100 feet)		1000	Hinges, temperature sensor, handles, fasterners
	6.5	Fasteners/ hardware		200	Sides
	6.6	Fire Brick (1200 bricks)		650	used for flue and structure
	6.7	Regular Brick (500 bricks)		125	Fiberglass blanket and insulation necessary to achieve 1650 Def F
	6.8	FiberRax insulation Material (180SF)		900	
	6.9	Tubing, valves, connectors		50	
	7	Pyrometer for measuring Kiln Temperature		150	Used to measure temperture up to 2200 deg F
	Kiln Total			3875	
7.0	Mold (Aluminum)	NA		500	This will need to be cast and then spun. Currently, the only source is Nicaraugaua
8.0	Building	Below			
		Large covered work area (15 x 25 Feet). Plumbed for electric, water, waste.		30000	Might be able to use an existing structure
	7.1				
	7.2	Drying Tent		2000	Could use a GP Medium
	Building Total			32000	
8.0	Fit Out	Below			
	8.1	Wood shelving		1500	
	8.2	cabinets		1500	
	8.3	tables		1000	
	8.4	Gas lines		500	
	8.5	Safety equipment		500	Fire hydrant, shielding, gloves, placarding
	8.6	Chairs/desks		1000	
	8.7	Misc		1000	
	Fit out Total			7000	

**Total Capital Cost**

**65325**

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### Appendix 7. Consumable Costs

**Operating costs. Assume production of 500 completed filters per month. Will Cover first 4 months (till FGSP)**

ID	Description	Comp Cost	Item Cost	Comment
<b>1.0 COGS (Costs of Good Sold)</b>				
1.1	Colloidal Silver (3.2%)	600		For 20,000 filters
1.2	Clay	500		for 2,000 filters
1.3	Sawdust (or rice husks)	500		for 2,000 filters
1.4	Fuel for Kiln (CNG)	800		for 2,000 filters
1.5	Containers (30 Gallon with 14 inch diamter)	5000		for 2,000 filters
1.6	Lids for container	3000		for 2,000 filters
1.7	Taps	2000		for 2,000 filters
<b>COGS Total</b>			<b>12400</b>	