ROCKET STOVE DESIGN GUIDE

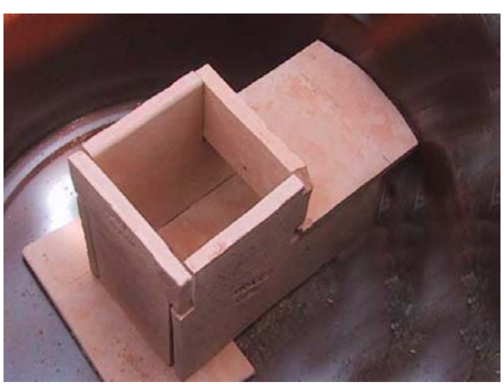
The first step is to decide which kind of combustion chamber you want to put in your rocket stove. The type of combustion chamber will change the dimensions of the rocket body and the size of the shelf. Be sure to follow the directions for the appropriate size of combustion chamber. During the workshop we constructed combustion chambers, or Rocket Elbows, from 3mm mild steel and 1.4mm stainless steel. There are, however, other choices. Listed below are some of the other combustion chamber possibilities.

Option 1: Ceramic tiles

Kiln-fired **ceramic tiles** form a Rocket elbow combustion chamber that is inexpensive and extremely durable. In Central America, Aprovecho has been using these for 3 years and have had very few problems.

They last for years with out cracking and cost the equivalent of R10 for an entire combustion chamber. They are made with common clay, and once fired, take only seconds to assemble and install.

The ceramic tiles have a higher mass than the 3CR12 but their low conductivity aid in maintaining high combustion chamber temperatures. If you are interested in pursuing this option I recommend contacting a traditional artisan who makes brick or ceramic wares and ask them to make you 5 bricks that are 25 by 250 by 250mm each. Ask them to use a mixture that can withstand high temperatures after firing. If they make ceramic pots for cooking, ask them to use a similar mixture for your tiles. It will take some trial and error to get the right mix but it is well worth the effort.



Option 2: Stainless Steel or 3CR12

(3CR12 - “the poor man’s stainless steel’’- costs about half the price of traditional stainless and has very similar properties - low mass and low conductivity.

Use the thinnest piece that you can weld comfortably. This will vary depending on your welding ability. A MIG welder is preferable to an arc welder. 3CR12 is low mass and more resistant to oxidization then mild steel. Its low mass means that it will light and fire quickly. It will last longer if it is used for many brief firings per day as opposed to one long continuous firing. In other words, if it is used for three times per day for 2 hours each firing, it will last for a long time. If it is fired for 6 consecutive hours each day, its life span will be greatly reduced.

Option 3: 3mm mild steel

3 mm mild steel is the least durable, prone to oxidization (rusting) and degrades at around 475 degrees C. It does, however, have some excellent advantages. It is cheap, easy to acquire and simple to construct. I would recommend buying 100 mm square tubing or 125 mm round tubing (if people insist on a larger diameter feed chamber) and construct as shown in the following pages.

Option 4: Cast Iron

Cast iron will last indefinitely and is not terribly expensive if large quantities are ordered. The drawback of cast iron is that it is less efficient than mild steel, stainless or ceramic. This is due to its relatively high mass and high conductivity that robs heat from the fire.

Combustion needs heat. Massive objects absorb heat, cool the combustion chamber, and quench the fire. Remember:

Low mass and insulation: good.
High mass: bad.

The most expensive part of cast iron is the set up of the mould, after that, the price decreases significantly. If you can find a foundry that casts metal you can give them the dimensions to cast a single piece combustion chamber. Before doing that however, I recommend building a few prototypes first and ask your customers to experiment before settling on final dimensions. For the experiments use 3mm mild steel pipe or 3CR12 or weld together a scrap piece of cast iron piping. Once you have the correct size ask the foundry to form a mould for the casting. Make it as thin as possible (<3mm). Remember:

Small diameter opening; good
Large diameter opening: bad

A larger diameter opening = more cool air which = less fire. A smaller fuel magazine also prohibits the user from over filling the combustion chamber.

A note on combustion chamber dimensions

When constructing any of the above combustion chambers I would recommend either a 100mm square or a 125mm round combustion chamber. In class we created a square combustion chamber that was 115mm in width. This size is a compromise between theory and practice. In theory it is more efficient to have a smaller opening - say 100mm diameter square opening - but some users like a larger fuel magazine. (The fuel magazine, or feed chamber, is where the wood is inserted into the stove).

I recommend experimenting with the size of the opening and see if cooks in your area will accept a smaller fuel magazine. The smaller magazine needs to be tended more carefully , which means that it is less forgiving if the cooks are busy doing other tasks and don't have the time to tend the fire. Cooks, as we know, are often happy to sacrifice some efficiency points if the stove is easier to use.

As I mentioned in class, the ideal relationship between the fuel magazine (or feed chamber) and the rocket chimney is 1:1.5. Which means that if the feed magazine were 100 mm in diameter then the Rocket chimney would be 150mm 35 (note: the rocket chimney is the vertical part of the combustion chamber). If it was 115 then the Rocket chimney would be 172. Again these are ideals that might not be practical in the real world. In class we used 1.15:135.

When deciding on the height of the combustion chamber, remember:

Taller elbows produce less smoke but are slightly less efficient - due to the greater distance between the pot and the radiant heat of the coals *and* the higher losses into the stove body.

shorter elbows produce more smoke but have greater heat transfer due to the closer proximity of the pot to the radiant coals.

It is a trade off but the dimensions that I have given you are a happy compromise.

The stove body

The external body of the rocket stove, as with the ecostove, can be made with clay, brick, cement, stainless steel, cast iron or sheet metal . The materials used for the external body have little impact on the efficiency or userability of the stove. What is important, is the combustion chamber and the insulation.

The stove body, as it is not exposed to excessively high temperatures, will not degrade for many years (4+). This means that the Rocket elbow can be replaced as necessary, but the pot stand, skirt, and body can be used for many years. The diameter of the stove body needs only to be 25mm larger then the largest pot. The combustion chamber needs to be surrounded by at least 75 mm of vermiculite.

The cheapest option for the stove body is to make it with un-galvanized mild steel (like used oil drums) and painted with rust protector paint. High temp paint for the stove body is not necessary, but can be used if desired.

The body can also be made with 1 mm galvanized steel. Un-painted galvanized is attractive and will last a long time, assuming it is not cracked, over heated or had salty liquid repeatedly spilled on it

Stove insulation

The ideal insulation for the stove is vermiculite; medium or light grade or a mixture of the two. Wood ash (not charcoal) can be put on top of the vermiculite to cover it up. Exposed vermiculite might be to tempting for people to play with. See the next heading for ideas about covering your insulation.

The next option is to use **light pumice rock**. A mixture of large and small particulates is also recommendable.

If neither of those is available, you can use **dry wood ash**. If the wood ash has ever been exposed to rain or moisture it will **not** be effective insulation. Remember:

insulation is small pockets of air separated from other pockets of air.

The insulation itself is not what traps heat. The insulation only traps air, which prohibits the passage of heat. The individual air pockets should be as small as possible. Larger air pockets (>4mm) will form convective currents that increase heat loss.

If using vermiculite, have it be placed in the stove *after* it is delivered **or** cover the stove before transporting it. Wood ash should be placed in the stove after it is delivered as it is heavy and difficult to transport and can damage the stove body.

Whether working with wood ash or vermiculite always use an appropriate particulate mask and always breathe through your nose. Vermiculite, although not poisonous to eat, can sit in your lungs and do serious damage after prolonged exposure. The vermiculite is only dangerous if airborne i.e. when it is being poured out of the bag; once it is in the stove it is not a respiratory hazard.

Covering the stove top

It is not necessary to cover the stove. Ideally the stove should be filled with insulation to the very top of the stove (i.e. flush with the stove body and combustion chamber). However there is concern that the vermiculite could be removed by people or blown away in transport or by the wind.

This can be addressed by making a galvanized metal top - cut to the same dimensions as the stove box bottom - and placing it on the stove.

There are 2 options for the placement of the metal top

The first option is to sink the top so that it is 50 mm below the top edge of the stove body. It is imperative that the metal top sits just below the pot legs. Do **NOT** raise the pot stand up to accommodate the 3-legged pots. Always maintain the 25 mm gap between the pot and the combustion chamber. See plans for more info. The problem with this arrangement is that the insulation will not be flush to the top of the stove, which will reduce the heat transfer to the pot. Remember:

Hot flue gases are not stupid; they will take the path of least resistance and will not enter the pot unless forced to by the creation of an ideal gap between the pot and the stove.

Ideally, insulation should be placed all around the combustion chamber and under the bottom of the pot so as to maintain the 25 mm gap.

The second option is to cut off 80% off of the pot legs. Leave just enough of the legs so that the pot will continue to stand upright when placed on the ground. If this is done then the metal stove lid would *not* need to be sunken into the stove body. In other words, the metal top would instead be *flush* with the top of the Rocket elbow.

This is the most **attractive** option, but it might be one that the women would be reluctant to perform on their own pots.

Local experimentation is necessary to see which is the most suitable solution in your community.

The pot skirt

The best material option for the skirt is thin 3CR12 (.5 – 1.2mm). Your customers will thank you if you spend the few extra dollars on a quality skirt. This type of skirt should last 5+ years.

The next option is uncoated mild steel painted with or without a high temperature paint. Galvanized steel is not recommended, as it will begin to degrade once its zinc coating is burned off. If you have no other option, galvanized steel can be used.

The skirt around the pot should be as high as possible to maximize heat transfer. In the case of the 3 legged pots this means up to the handle rings , in the case of the Zimbabwe flat bottom pots, up to the pot handle.

You might try attaching the skirt to the stove body in the correct position so as to encourage its use. This might however discourage some users from using the stove at all. Something to experiment with…

An insulated skirt is even better than an un-insulated skirt. Place a second skirt, 40 mm larger in diameter, around the initial skirt. This can then be filled with insulation. If desired, you can seal the bottom gap between the two skirts or leave it open. Obviously if it is left open, the insulation will run out if is removed from the. The outer skirt, because it is exposed to lower temperatures can be made from .5-1mm galvanized steel.

The gap between the pot and the combustion chamber

We need to maintain the cross-sectional area of the combustion chamber so that the air and the heat will continue to flow through the stove and around the pot . This is commonsense, obviously if the pot was placed right on top of the combustion chamber, so as to touch it, no heat whatsoever would pass around the pot. The ideal gap between the combustion chamber and a flat bottomed pot is 25mm. The correct gap between a round bottom pot and the combustion chamber is 20 mm from its lowest point. The pot stand, detailed in the following pages, maintains this gap.

The gap between the pot and the skirt

Maintaining the gap between the skirt and the *pot* is just as important as maintaining the gap between the pot and the *combustion chamber.* If the gap is too small, then the heat will not flow through the system . If it is too big than the heat will not be forced to rub against the pot. A good rule of thumb for the gap between the pot and the skirt is 1cm for big pots size 3 and larger; 1.5cm for medium pots (size 2); and 2cm for smaller pots.

If you want to find out the exact gap for each pot and combustion chamber combination you can use this simple equation (in cm)

$$\frac{2.5 * \text{diameter of combustion chamber}}{\text{diameter of pot.}} = \text{gap between pot and skirt}$$

Remember this is the ideal gap and might need to be widened to make the skirt more user-friendly.

The shelf

The best material for the shelf is .9 –1.2 mm 3CR12.

The next best option is 3mm mild steel.

If you are using a tubular combustion chamber the shelf doesn't need 'feet', as it does with a square tube, to support itself. The sides of the circle will support it. Place the shelf so it sits between ¼ and ½ from the bottom of the combustion chamber.

The gap between the shelf and the bottom of the combustion chamber should be no less than 25mm. For ideal performance, the shelf should in theory be placed in the middle of the combustion chamber. Again experimentation is needed to see what your local users will accept

Material costs

The cost of the rocket stove varies depending on the materials used. It can range from 10 to 300 Rand. I would recommend a 100 Rand Double Burner Rocket as it attractive and will last for many years (4+). If used-drums are cheap and available in your region. I would recommend using them. Prices are quoted for Pietersburg and might be different in your area.

Normal price		(Cheaper alternative)	
Stove Body			
(Used 200 litre oil drums*)	5R		
Combustion chamber X 2			
3cr12	30 R		
		(3*125mm mild steel tubing)	20R
		(ceramic tiles*)	10R
Skirt X 2			
3cr12	22 R	new 1 mm mild sheet steel	10R
		used steel drum (with high temp paint!)	2R
Shelf			
3CR12	4R		
		(3mm mild steel)	2R
Pot stands			
12 mm round bar	2R		
25 by 3 by71 mm flat bar	2.5R		
Vermiculite	25R	wood ash	free

Depending on which alternate materials are used the price of the Rocket can vary between 100 and 200 Rand.

Things to remember for the best use and design of the Rocket Stove

- Use a small amount of wood cut into small diameter pieces
- Use dry wood.
- A larger pot filled to the top will give a higher efficiency as more of the heat will travel past a greater surface area
- Always use a skirt
- The feet of the shelf should never be less than 25 mm

- The rocket elbow is generally oversized, that means that even if you build a rocket for use with a larger pot (size 4-7) you can usually use the same diameter of Rocket elbow
- Its not true that where there is smoke there is fire; in truth, **where there is smoke there is poor fire!**

Trouble shooting the Rocket Stove

Smoke coming out of the top of the stove?

Too much wood in the stove. Pull some of the sticks out of the combustion chamber.

The combustion chamber is over filled with coals. This results from pushing wood too quickly into the stove. Encourage users to push wood into the stove on a slower and more consistent basis

There is insufficient draft. This is caused by the gap between the pot and the skirt *or* the pot and the combustion chamber being too small. This will result in increased smoke production, and a 'lazy' looking fire

The combustion chamber might be to short. Increase the height of the combustion chamber if you have altered it.

You are using wet wood. Encourage people to use dry wood

Fire coming out of the front of the stove/feed chamber?

Insufficient draft check pot /skirt gap and pot/combustion chamber gap

The combustion chamber is overfilled with coals instruct users to clean after each firing.

Peace
Peter Scott
Please contact us for more info
apro@efn.org