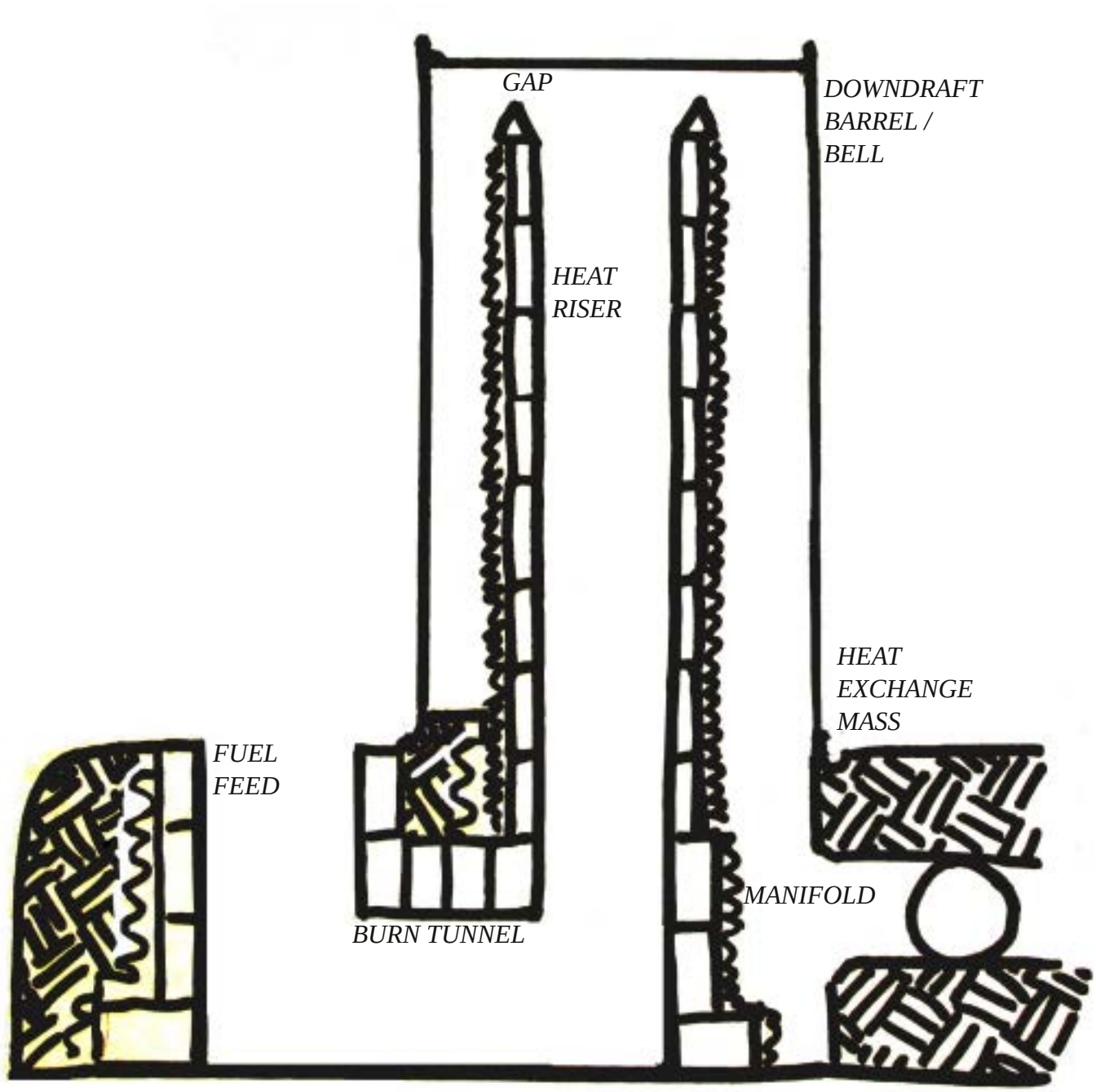
Chapter 4: Operation and Maintenance

This chapter is formatted as a stand-alone manual for owners of rocket mass heaters.

The procedures outlined in this chapter apply to heaters built according to the preceding chapters of the *Rocket Mass Heater Builder's Guide* (Wisner, 2014), or proven to work in a similar way through extensive prototyping. Heaters with improvised alterations or "improvements," including unconventional chimneys, may present quirky behaviors not covered here.

For general troubleshooting tips for non-standard heaters, we recommend the FAQ section of the general text *Rocket Mass Heaters* by Evans and Jackson. There are also numerous popular discussions of improvised heaters and stoves and their quirks online, such as the energy forums at www.permies.com.



Rocket Mass Heater
Operation and Maintenance Manual

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Contributors:_____
_____

Note to Readers:

This Manual describes the operation and maintenance of residential rocket mass heaters as described in the *Rocket Mass Heater Builders' Guide*. Each mass heater is built with a site-specific layout and features. This manual may contain information about features or methods that are not relevant to your particular heater.

Builders and owners may need to include additional information to complete an accurate, unique manual for each particular heater. Throughout the manual, blank sections are provided to prompt additional information. These may be filled in by the owner or builder.

This Manual documents the Rocket Mass Heater located at:
_____*(site name/address)*
_____
_____
_____

Name of owner/builder(s) and helpers:

_____

_____

_____
_____
_____
_____
_____

4. Operation and Maintenance:

Table of Contents:

Optional additional content: Attach extra pages for additional features, such as:

- Bypass damper: recommended settings, chimney design details
- Fuel feed lid, screen, or air controls
- Outside air, room air circulation, or other additional channels
- Cushions and fabric: heat-tolerance (high iron or tumble-dry), conditions for use
- Cooking/potpourri on barrel: placement, temperatures, techniques
- Warming oven, drying racks, or other features: clearances, passive/active ventilation
- Wood trim: locations/clearances, monitoring for temperatures, finishes

Repairs and remodels:

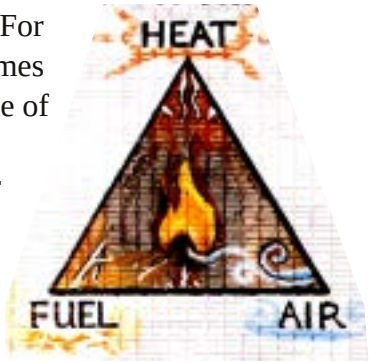
- Finishes, appropriate options for re-painting or re-surfacing

WARNINGS: Heating involves well-known hazards, which are the operator's responsibility to manage. Please be aware:

- **Fire is dangerous.** By lighting a fire *anywhere*, you become responsible for tending it. Check and remove nearby combustibles before lighting any fire. Watch it, feed it only appropriate fuels, and make sure it's finally out. **Never leave fire unattended.**
- **Smoke is nasty.** Smoke carries heat, toxic and flammable vapors, carcinogens, heavy metals, depleted oxygen, invisible CO and CO_2. The operator must ensure proper ventilation and eliminate all preventable smoke—not just indoors, but residual smoke that can coat channels with creosote or pollute shared outdoor air.
- **Metal and masonry get hot.** Keep unsuitable items away from hot surfaces. Observe the actual operating temperatures of your particular heater, during and after firing. Monitor for changes if fuel, weather, or operating patterns change.
- **Wood burns.** Natural fuels are less predictable than refined fuels; the operator is responsible for fuel choice, dry storage, and fire tending. Store fuel and other flammable materials away from heat and sparks.
- **Dust Chokes.** Avoid breathing anything other than air: smoke, masonry dust, ash, insulation fibers, or funky upholstery. Use water to control dust during masonry work, and use respiratory protection and good vacuum filters during maintenance.
- **Water erodes.** Watch for signs of water damage, leaks, or corrosion—especially in areas where your stovepipe goes through the walls or roof, exposed joints, cleanouts, and any areas where spills or rising damp condensation could collect and pool.
- **People play.** Enjoy your heater. Play with it. Anticipate the natural curiosity of visitors (especially children) who may play with the firebox, move cleanouts or dampers, or drop toys in odd places. Check the heater carefully after guests visit.

The laws of nature are not subject to lawsuit or appeal.

These are radiant heaters, not an automated furnace or boiler—they rely on **manual operation** for safe and effective performance.



Rocket mass heaters are designed by and for observant, responsible operators. For many people, the operating principles are counter-intuitive at first. Operation becomes easier with knowledge and training, but more importantly, with practice. An attitude of cheerful problem-solving goes a long way.

Most owners, builders, and designers will be happy to offer advice if you encounter any difficulties. Please share the benefits of your own experience the same way. We're all in it together; these risks and benefits affect everyone.

Do your best, ask questions, compare notes, and then decide for yourself whether this is the right heater for your situation. Be safe. Have fun.

THIS MANUAL is intended to assist, not replace, your own observation, skills, and experience. Every site-built heater is unique. The authors take no responsibility for the accuracy, safety, or applicability of this information to a particular situation. No persons associated with this publication can be held liable for injury, damages, or deaths resulting from this information or related activities.

Please write your own notes, or adapt this manual as needed to suit your needs. Non-commercial sharing and adaptation is permitted and encouraged.

ABOUT ROCKETRY, STOVES, and MASS HEATERS:

Rocket mass heaters operate fully in accordance with the laws of physics - they are not a magical solution, but a nuanced response to a common problem. In order to operate one successfully, it helps to understand the original design parameters of this type of heater.

A 'heater' is an object designed primarily to heat the space around it. Some heaters are stoves, others are larger like a fireplace or oven. In general, a 'stove' is a light-weight object, often somewhat portable, that can produce heat quickly for cooking or parlor heating. An 'oven' is for baking (creating dry heat in an enclosed space).

A "furnace" or "'central heating system" is located in a separate room or basement, heating nearby spaces by blowing warm air through dedicated ductwork. A "boiler" is designed to operate in a separate space or even an entirely separate building, producing hot fluids such as water or steam for distribution into other rooms or buildings.

A rocket mass heater is a heavy (massive), radiant heater. It produces heat primarily for the space in which it is located. It is not a furnace or boiler; it should not be located in a hidden space or left to burn unattended.

The 'rocket' in the name comes from a line of clean-burning cook stoves developed in the 1970's to facilitate safer, more frugal use of scarce natural fuels. The common denominator is an insulated 'heat riser' and at least one 90-degree turn. Some say 'rocket' refers to space-age insights, others to the 'whooshing' sound the stoves make during a full burn. The principle of the insulated, confined cooking chimney has been known and used for millenia all over the world; it is one of many insights forgotten and re-discovered in modern times.

Rocket mass heaters are designed to operate entirely in harmony with the laws of physics, with attention to common human comfort needs. The design makes a few assumptions:

1) Steady heat, not hot and cold spikes. Mass heaters are at their best in cold climates with a long, relatively predictable heating season. In summer, the thermal mass can also serve as a heat-sink to reduce unwanted heat during the peak temperatures of each day.

In variable climates or under certain usage patterns that call for brief heating only, occupants may prefer a more responsive low-mass heater, or a bypass that allows heating only part of the heater's mass in certain conditions.

2) Heat people, not space. Especially, heat people when and where they most want it. The most useful time and place for warmth, the times when occupants are most likely to feel chilled, are predictable: chilly evenings and nights, while resting after meals, and during prolonged sedentary work or relaxation. Therefore, a heated seating bench or daybed located conveniently to sedentary activities is the most efficient way to deliver heat. It is also most convenient to operate, as it can be run with little interruption of normal routines.

Heat stored in masonry is of very little value if the occupants are not present. Heaters located in a basement, crawl space, or separate addition may squander as much as 3/4 of their heat before any useful remainder reaches the occupants. Likewise, a space that is only used a few hours at a time (such as a chapel or ski cabin) may need a more responsive, radiant heater instead of thermal mass storage.

Our modern lifestyle includes a great volume of space per person, but heating this seldom-used space comes at a cost. Traditional homes in cold climates were often smaller, more densely occupied, and/or had a dedicated fireplace for each occasional-use room (and doors to shut them when not in use, so they served as a buffer for the warm core of the home). A regionally-appropriate home design makes heating and cooling immensely easier.

3) Heat operated by people, not automatons. The heater's design assumes that a responsible person will be monitoring the heater during the entire burn cycle, putting up dry firewood a year ahead, and performing annual maintenance. Responsible operators are lifetime learners, always improving their skills and preparedness, committed to a certain amount of time and effort as the price of independence. Energy savings results from clever use of natural forces, skill, and labor (as contrasted with purchased power).

Operators accustomed to heating with wood will find that the heaters offer far more in return for far less effort (not just warm mornings, not just a huge amount of time and space freed up from woodshed chores, but even the occasional winter holiday without frozen pipes. Monitor your heater's storage profile several times before planning a lengthy vacation, however.)

Owners accustomed to electronically-controlled thermostats and remote furnaces or boilers may find themselves annoyed to tend the fire, forgetting the cost those automated controls exacted in energy transfer losses, energy to run and monitor the system, not to mention the automated heat wasted on heating unoccupied space (both around ducts or pipes, and during unoccupied times). Owners who need the reliability of an automated furnace may still experience substantial cost savings from a rocket mass heater, used as supplemental heat to offset part of the central heating load.

In general, if you are happy with your existing heater, woodstove, or furnace, we suggest keeping it while you become accustomed to the rocket mass heater.

4) Harmony with nature - human nature, plant nature, and the nature of heat. The heater extracts the most heat possible, from the most abundant waste fuels (scrap wood, such as orchard trimmings, fallen branches, ladder fuels, etc). Using the natural convective flows produced by that heat, the heater extracts and provides the most convenient and comfortable warmth for the human occupants. It does not waste energy pushing hot air down, or adjusting temperatures day and night for phantom occupants.

The heater also provides a way to store energy with even less effort: capturing solar energy in the mass. Passive-solar design includes orienting buildings to trap energy in season when it's wanted, but screen out unwanted heat during hotter months. Because the sun's angles change first, with a lag time before the weather's heat builds up or drops away, passive solar design also may include adjustable drapes, awnings, or deciduous shade plants. Sensible choices like insulation (especially on ceilings and shady sides), sunny windows, and adjustable cross-breeze or stairwell openings will also give effortless comfort and convenient control.

While we've enjoyed several centuries of artificial luxury, spending endless calories of cheap energy to produce ice and heat out of season, we figure working with natural laws is likely to give better return on effort in the long run.

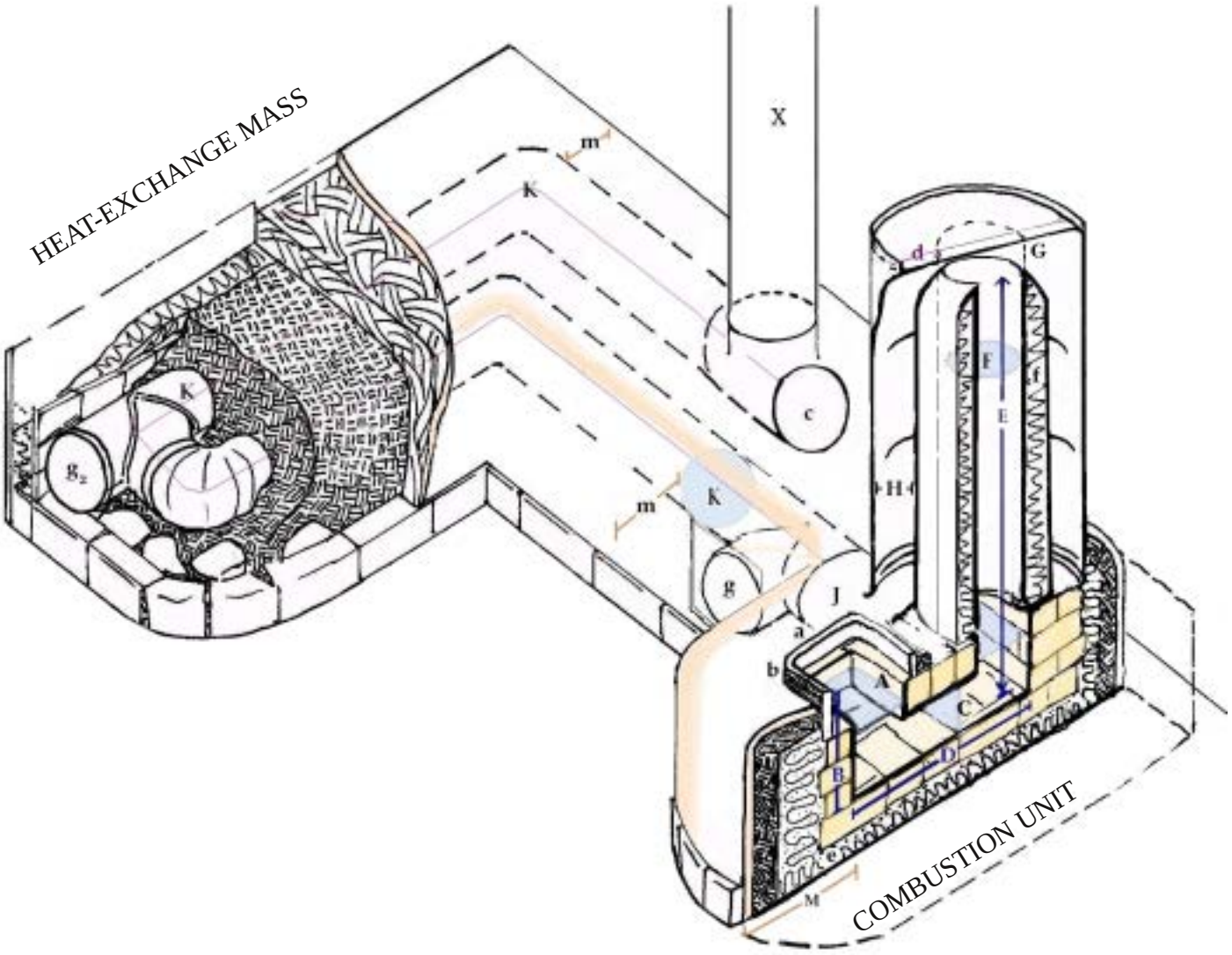
The heater designers make some assumptions about the needs, wants, and abilities of the occupants that may not apply to your situation. If a different system will bring you more comfort, we encourage you to adapt the design and patterns of use to suit your nature.

Rocket Mass Heater Operation and Maintenance:

Rocket Mass Heaters are highly efficient solid-fueled heaters. They are designed to warm people, plants, and buildings with constant, steady heat, while requiring minimal operator effort, fuel, and pollution.

Rocket mass heaters have:
– a **combustion unit** for clean burning of fuel;
– a **heat-exchange mass** to capture and store that heat for gradual release;
– and **site-specific** layout, features, and proportions.

The image below represents a sample rocket mass heater.



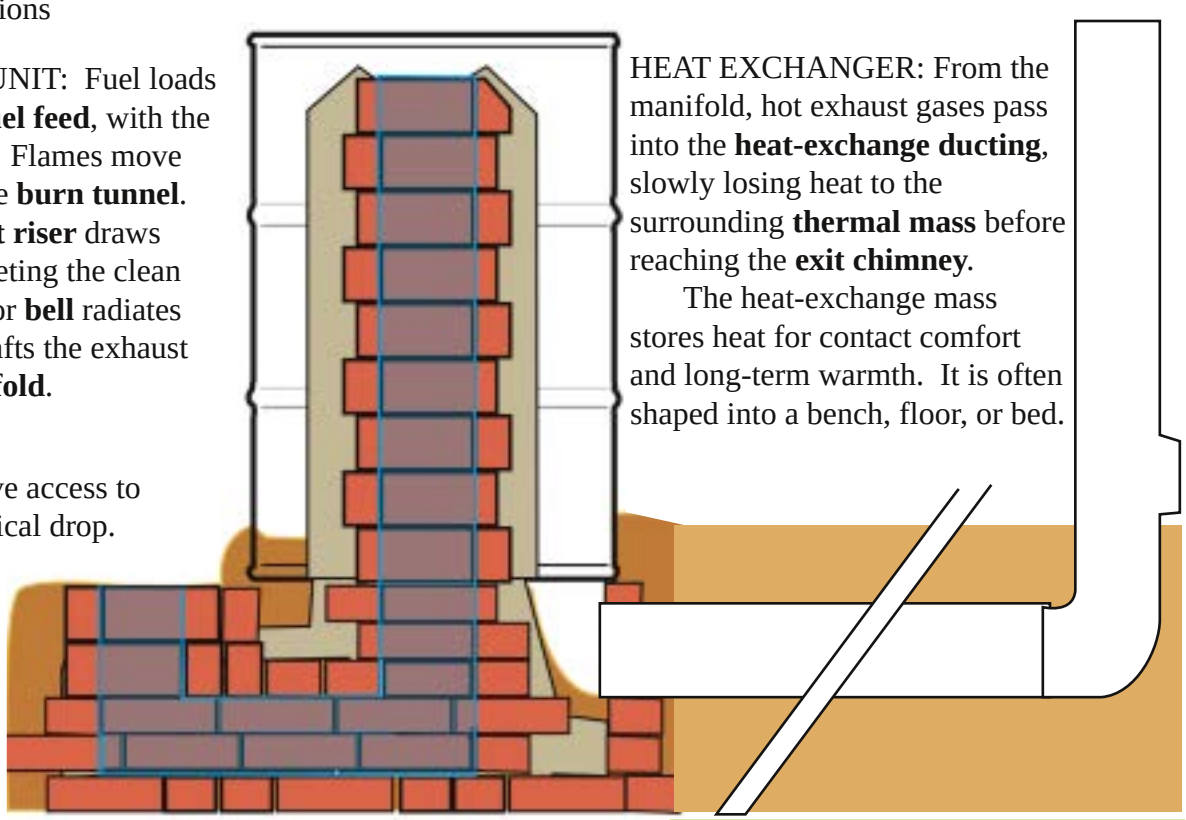
ROCKET MASS HEATER LAYOUT:
Terms and Definitions

COMBUSTION UNIT: Fuel loads vertically in the **fuel feed**, with the fire at the bottom. Flames move sideways along the **burn tunnel**. The insulated **heat riser** draws flames up, completing the clean burn. The **barrel** or **bell** radiates heat and down-drafts the exhaust gases to the **manifold**.

HEAT EXCHANGER: From the manifold, hot exhaust gases pass into the **heat-exchange ducting**, slowly losing heat to the surrounding **thermal mass** before reaching the **exit chimney**.

The heat-exchange mass stores heat for contact comfort and long-term warmth. It is often shaped into a bench, floor, or bed.

Cleanouts give access to each turn and vertical drop. Some heaters may have an **ash trap**, a **bypass damper**, or **outside air intakes**.



System size:
A 6" system or 8" system refers to the interior diameter of pipe used to make the exhaust channels and exit chimney. The cross-sectional area (CSA) of this pipe represents the desired flow area for all channels in the system, including the combustion channels.

6" system: CSA about 30 square inches
7" system: CSA about 40 square inches
8" system: CSA about 50 square inches.

Systems as small as 5" and as large as 12" have been built, but present unique problems outside the scope of this manual.

Heat-Exchange Ducting: *Most rocket mass heaters have 20-40 feet of lined channel snaking through the heat-exchange mass. The length, material, turns, and cross-sectional area of this channel all affect the heat storage and draft performance. Note any special features like bypass damper, branching channels, or large cavities.*

Thermal Storage Mass: *Most heaters have 30-100 cubic feet of masonry mass, with at least 4" around the heat-exchange ducts. Since material density and conductivity affect performance, document materials and methods during construction.*

Combustion Area Proportions: *Correct proportions are critical to performance. Document heights, lengths, and gaps in the heater summary (next page).*

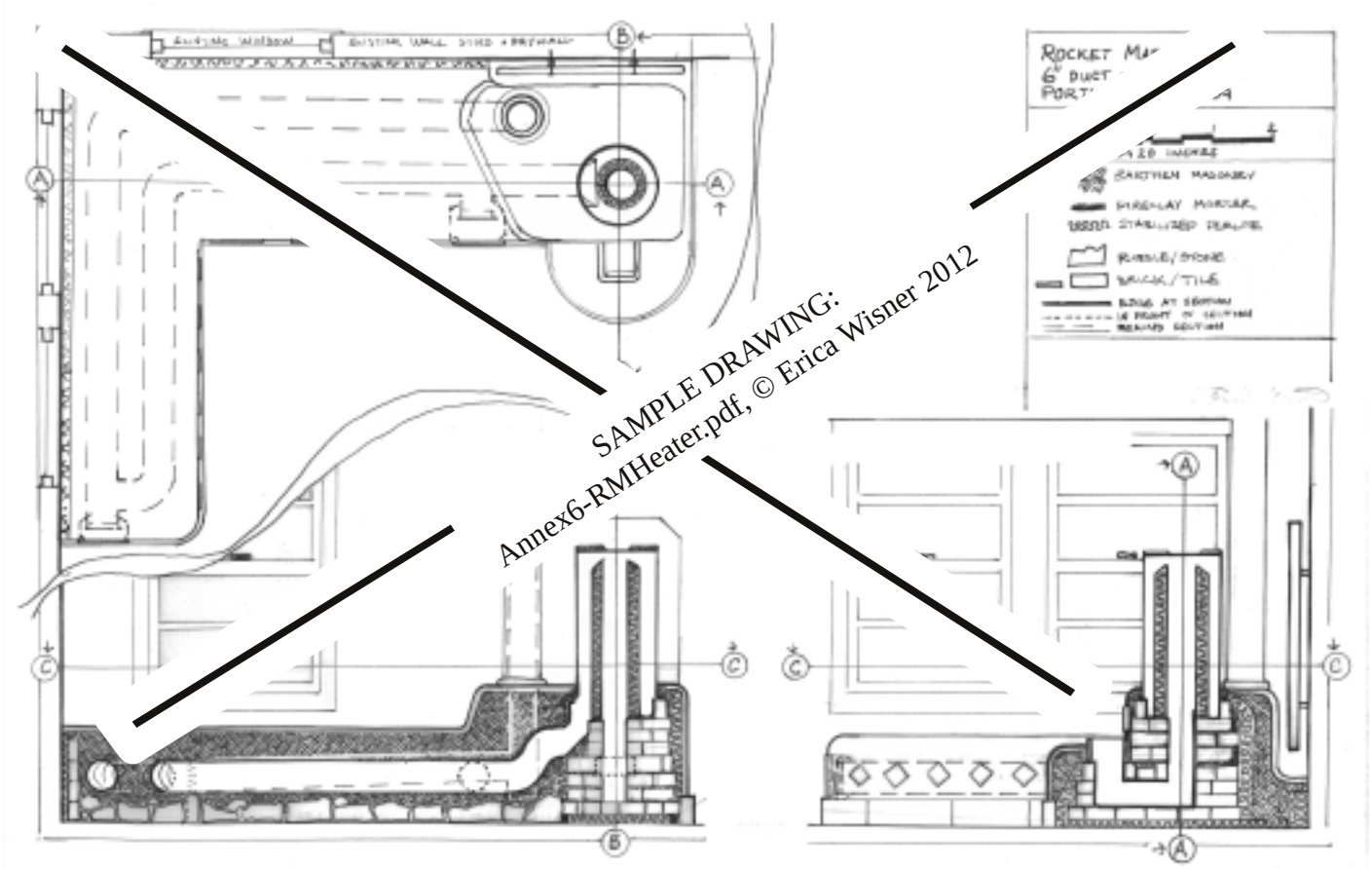
As-built drawings show what actually got built, not just what was planned.

Don't worry about artistry, just make practical notes. You can write the measurements on a pencil sketch, or take photos at each stage of the project. Show scale with a ruler in the photo.

Show these details:
– Top view (plan)
– Side view (section)
– Materials and construction details
– Dimensions of the heater, thermal mass, and surroundings
– Combustion unit dimensions
– Cleanout locations
– Foundations
– Exit chimney or vent
– Any special features such as:
  bypass damper
  heat shielding
  outside air, room air, fans
  hidden access panels
– Any buried hazards (utilities, asbestos, glass or sharp infill)

My Rocket Mass Heater: AS-BUILT DRAWINGS

Attach the documents that show your particular heater: plans, scale drawings, project photos, etc.



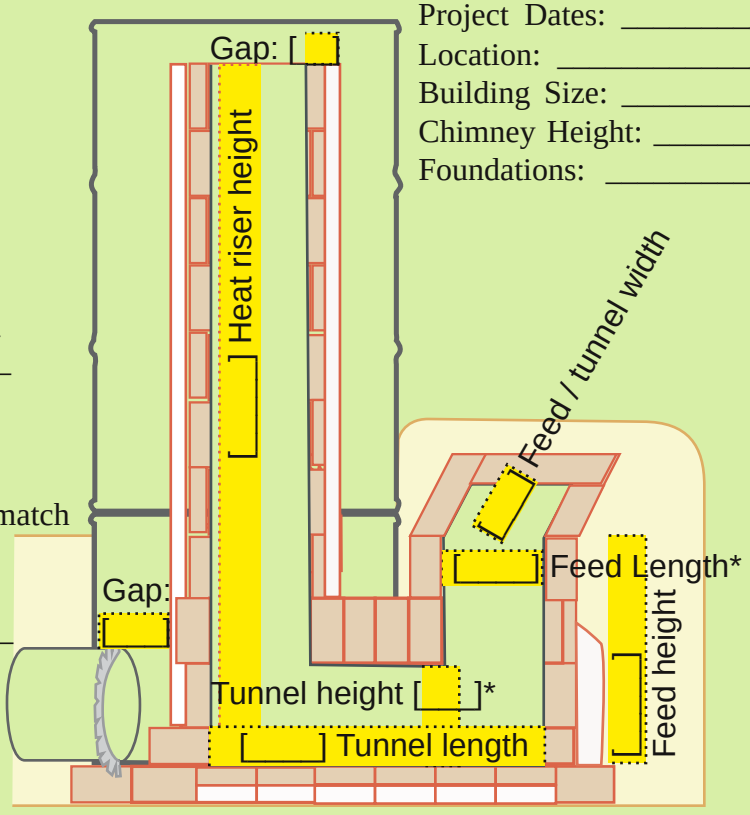
HEATER SUMMARY

Heat-exchange mass:
Duct size:_____
Duct length: _____
Thermal storage material, size, weight:
_____

Combustion unit:
Heat riser height:_____
Fuel feed height:_____
Burn tunnel length:_____
Firebox opening size:
width: ____ length/height*:_____
*feed length and tunnel height typically match

Gap above heat riser:_____
Gap in manifold (minimum clearance): __

Attach as-built drawings or photos.



SITE DETAILS

Project Dates: _____
Location: _____
Building Size: _____
Chimney Height: _____
Foundations: _____

OUR HEATER HISTORY Attach additional pages as needed.

INITIAL DOCUMENTATION

Team: List name & contact info for people involved with the heater's installation and repairs:
Designer: _____
Book, plans, or other design references: _____
Builder(s): _____ _____
Helpers: _____ _____ _____
Were there any contracts, guarantees, or warranties? Technical support?
_____
Where do we keep records of the design and building process? (Attached, if possible)
_____
Was the heater officially permitted, approved, or exempted? _____
Were there any design changes in order to meet local codes? Y/N _____
Did these changes affect performance? _____

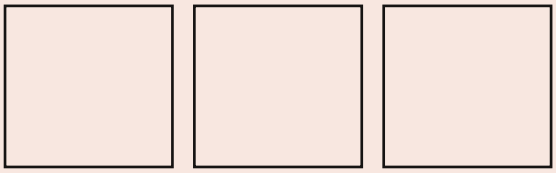
CONSTRUCTION NOTES

Any building issues, hidden features, hazards, or warnings? _____
(e.g. electrical wiring, hidden dampers or cleanouts, buried glass or other hazards)

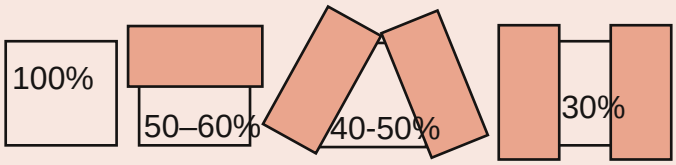
OPERATOR NOTES

Tinder: How many sheets of newspaper/paper bags does it take to start this heater? _____
Kindling: Does it like a lot of kindling, or a few scraps? (at first _____; once warm, _____)

Fuel loading: Does this heater perform best (as most do) with a full fuel load? Y/N _____%
Draw optimal fuel load:
kindling: warming up: at full heat: *Fuel Types: Any favorite fuel blends, types, or sizes?*
Twigs/sticks/poles/log(s)? _____



Hardwood/softwood/mixed? _____
Bark-on/split/scrap lumber/paper? _____



Air controls: Performs well full-open? Y / N
What air setting makes no smoke, indoors or out?:

Weather: Does weather affect this heater's performance?
Wind force/direction _____ _____ _____ *Outdoor temperature* _____ *Rain or snow* _____

Change in fuel, air, or other control settings may indicate cleaning time or other maintenance needed.

Cleaning: What part(s) need to be cleaned out most often? ___Firebox, ___manifold, ___ cleanouts?
What depth of ash do we leave the firebox? _____

Troubleshooting: Does the heater have any special tricks for handling draft, smokeback, or cold starts?
Observations:

PRELIMINARY INSPECTION:

Look over the entire heater, with attention to the following:

All surfaces:

___ no cracks or damage
___ no evidence of leaks (soot or smoke streaks outside, cleared streaks in soot inside)
___ no heat-sensitive items (cloth, wax, paper) in wrong places

Cleanouts: *Mark locations on heater drawings (C1, C2, ...).*

___ Use cleanout openings to confirm that system is clean and free of debris.

♦ Soot and fly ash normally accumulate between annual cleanings. Streak or spray patterns in soot indicate air leaks, which must be sealed.

♦ Sticky creosote should never occur; may indicate problems with heater or use of damp/green fuels.

♦ Outdoor debris (leaves, nests) may indicate a missing exhaust screen.

___ Close cleanout caps securely before lighting the heater.

HOT SPOTS:
– Barrel (200–800°F/50–400°C)
– Feed opening (radiant heat from coals that are up to 1800°F/900°C)
– Combustion area masonry, cleanouts (150–200°F/65–100°C)
– Hidden voids or insulated areas, such as under upholstery

Fuel feed and combustion area:

___ Fuel feed lid or bricks to cover opening, adjust incoming air.
___ Fireplace tools present and in good condition:
___ long-handled tongs, ___ metal ash bucket
(optional: __ hatchet, __ hearth brush, __ ash scoop or shovel)
___ Tinder and Fuel: Fuel must be dry, sized to fit in the fuel feed, and stored a safe distance from the heater.
___ Clear any combustible items from fuel feed/hearth area (4" air gap around masonry, 18" hearth around fuel feed).

Radiant metal barrel/bell:

___ Clear any heat-sensitive items from top and sides.
– 18" clearance to combustibles around upper third of barrel.
Do not dry fuel on, or in contact with, radiant metal surfaces.

Optional Features (not all heaters have these):

___ Wood trim: Good condition, no discoloration or warping near heat. – All wood should stay cooler than 150°F (65°C) throughout heating cycle.
___ Upholstery: Good condition, heat-tolerant fabrics (dry or iron on 'high' setting) such as canvas, wool, linen. Avoid delicate, synthetic, or treated fabrics.
– Any upholstery is properly placed on the zero-clearance bench area (not against the barrel or fuel feed hearth).
___ Fresh air channels including outside air, room air, heat shield air gaps:
– All air gaps clear of lost items and flammable debris (lint, dust bunnies).
– Heat shields: minimum 1" air gap behind, below, and above for convection.
___ Bypass damper: Use nearby cleanout(s) to inspect damper condition, if possible.
– Set to correct position (open for cold start, close to store heat).

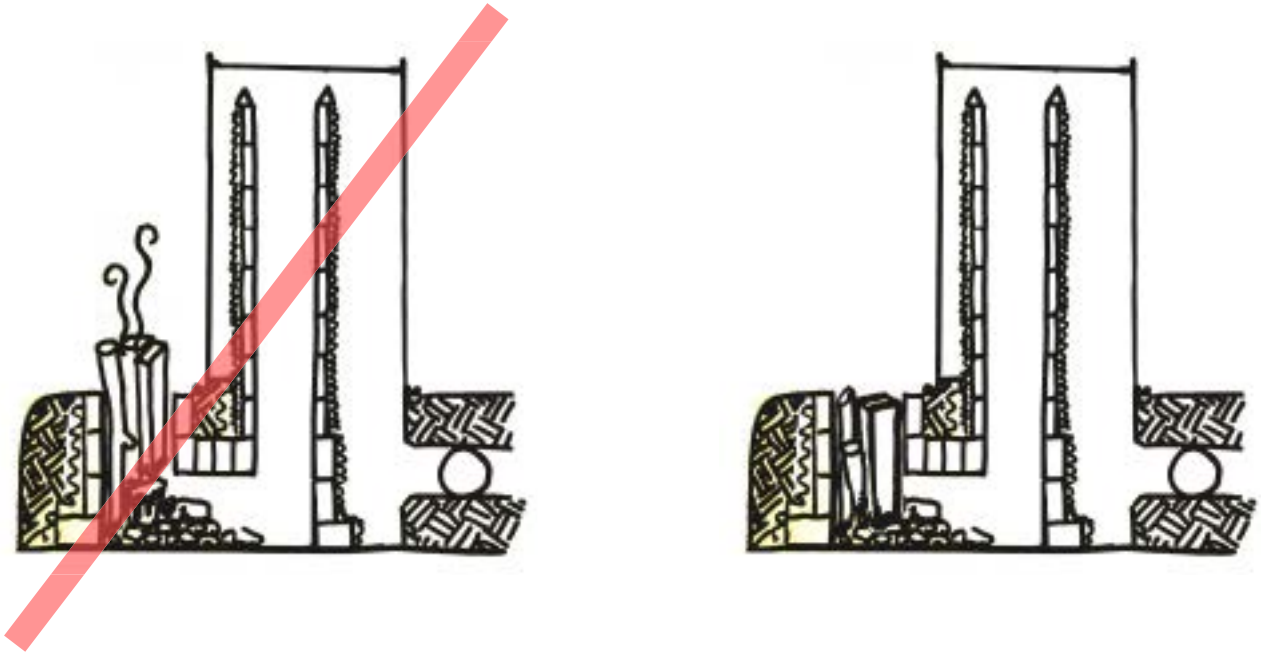
TROUBLE SPOTS:
– Random items left on top of the barrel, or leaning against it
– Toys, flammable tools, or fuel scraps around feed area
– Fuel, upholstery, clothing, or other flammable items too close to hot spots
– Cleanout covers missing or loose

OPERATION:
Most owners run their heater while relaxing at home in the evening, or at any convenient time of day during indoor office work, reading, or entertainment.

Rocket mass heaters generally:
– Should not be left burning unattended
– Are fired intermittently: full heat for a few hours, then close down between firings
– Stay warm for many hours (or days) after each firing
– Do not need to be fired overnight
– Take time to "recharge" with heat if they have been allowed to cool completely

For best results:
– Inspect the heater before lighting (see inspection list)
– Check the draft with a candle or newspaper before lighting
– Operate with about 1/4" of ash in firebox (a little ash insulates the fire and bricks, but anything more than 1" can choke the fire)

Fuel:
– Use only dry, natural firewood that fits in the firebox. Too-tall fuels can cause indoor smoke and may drop outside the firebox as they burn away. Wet fuels sap energy from the fire and cause creosote problems. Synthetic fuels burn hot and toxic, and can damage the heater and/or cause nasty smoke problems.
– Place wood vertically, with thick ends down (this allows it to drop instead of wedging)
– Once kindling has burned down, use larger wood



♦ Use the inspection checklist to make sure all the parts of the heater are in working order. Check for warmth: most heaters start easiest when already slightly warm. If any parts of the heater are unusually hot, the heater may have already been run today, and a second fire could create an uncomfortable amount of heat.

♦ Light a candle or twist of newspaper, and tuck it down through the feed opening into the burn tunnel. Is the draft working?

If the heater is cooler than the outside air, it may require extra priming to overcome this 'cold start'. Several methods are described later on.

♦ When the flame flickers away from you down the burn tunnel, the draft is working properly.

♦ Prepare your tinder and light the fire, using the instructions on the following pages. As the first kindling starts to burn, add more kindling behind the first bundle until you have a thick cluster. Add a piece or two of larger wood in the back, to fill the feed tube.

♦ Remain near the fire for the first phase of the burn, to ensure that all kindling catches and feeds properly. The kindling should fall downward as it burns, maintaining a merry fire for about 20 minutes before you add more wood. If any thick ends get wedged in the opening, rattle the kindling to settle it.

♦ Always add fresh wood behind the existing fire, so the new wood doesn't interrupt the flame. If needed, move the burning logs forward with tongs so you can load the next piece behind them. Once the fire is well established, use mainly larger pieces of wood (2” to 5” across) for the easiest-tending fire.

♦ Eliminate any vertical “chimneys” between pieces of wood. Wood that is too tall for the firebox or unusually pitchy may draw flames upward. Use this wood sparingly, or cut it down to a shorter length before burning.

♦ Most rocket mass heaters burn best with a full fuel load and full-open air. If necessary, use a brick or tile to partially cover the opening. Always leave it at least 1/3 open throughout the burn.

♦ Once the house is comfortable and enough heat is stored, stop feeding the fire. Reduce the air as the fuel dwindles, to maintain a clean, balanced burn.

♦ When the fire is completely out, shut the feed lid to stop the air flow.

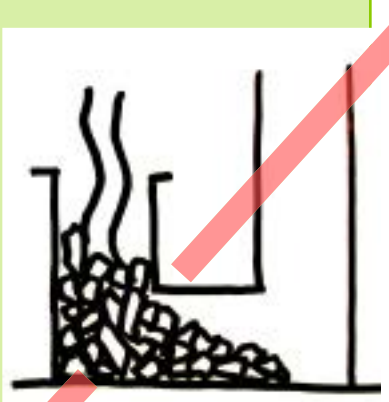
Emergency shut-downs are not recommended. Water can damage the heater masonry and create a cloud of noxious steam and smoke. Smothering the fire by sealing off its air supply can cause smoke damage and creosote buildup. If you suddenly have to leave before the fire is finished, you can close the opening down to a screened air slot (1" or so) and let the fire burn itself out. If the heater itself is involved in the emergency, it may be safest to remove burning fuels to outdoors with tongs and metal bucket, and extinguish the coals outside.

CHOKING ON EMBERS:

After the firebox is hot, it turns kindling into coals very quickly.

Large amounts of kindling, wood chip, junk mail, or other small fuels can create a blockage of ash and embers.

Use a poker to clear an airway, and allow the fire to burn down before adding any more fuel.



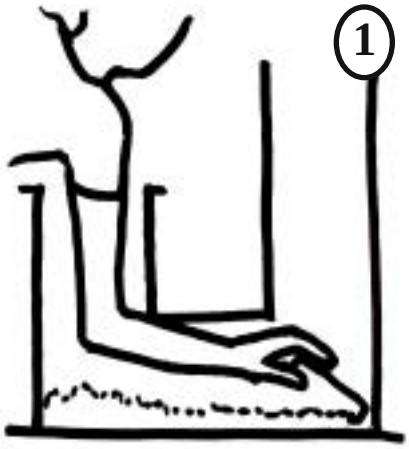
To avoid this problem, load larger logs instead of small fuels once the firebox is hot.

To reduce ash buildup in all parts of the system, use the cleanest tinder you can get. Avoid color-printed material (contains clay and weird minerals).

Plain newsprint, brown paper bags, or shredded natural fiber make excellent tinder with little ash. Small quantities of butter wrappers, grease paper, or sawdust/wax firelighters are helpful too.

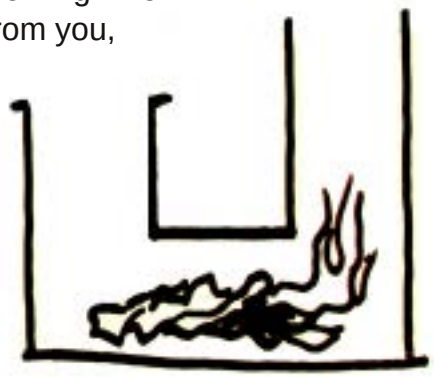
Rocket Mass Heater - Lighting the Fire:

1 Inspect the heater and clean the firebox (leave 1/4" of ash).



2 Use a candle or tinder to establish draft.

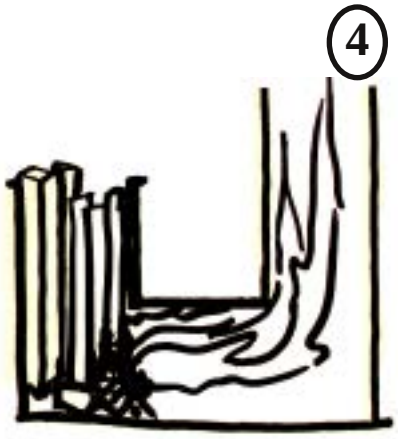
Tuck lighted tinder partway into the burn tunnel. Draft is working when the flames pull away from you, toward the heat riser.



3 Drop kindling onto the burning tinder.

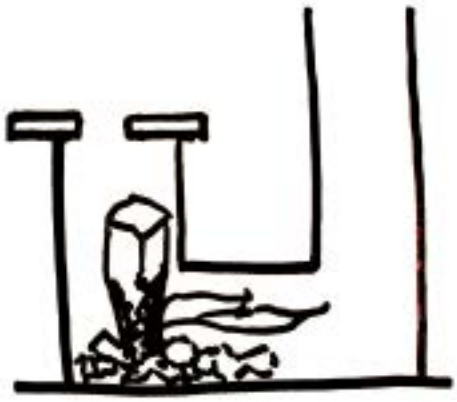
Set the sticks vertically against the tunnel opening.

4 Once kindling is burning, add larger fuel behind the fire.



5 Load fresh logs behind the burning fuel. Re–load as needed, using the largest practical logs.

6 Adjust air flow if needed—at least 1/3 open throughout the main burn.



A full fuel load and full–open air allows the fire to self–regulate.

7 As the fire burns down, reduce air flow.

8 When the fire is done, close the feed opening.

COLD STARTS

A "cold start" is when the mass of the heater is colder than outside air. Cold starts affect fireplaces and woodstoves too. A cold chimney will draw cool air downwards, instead of warm air upwards. It can be difficult to reverse that flow when you need to start the proper draft for your fire.

Cold starts most commonly happen under specific circumstances:

– during the first fire of the season
– when the mass is damp (as in a new heater being built, or a greenhouse bench under watered plants)
– in occasional-use heaters such as vacation cabins
– when the heater is fired during warmer weather, for whatever reason (mild climates, sporadic heating needs, or show-and-tell)

Unlike most fireplaces and woodstoves, the rocket mass heater has an 'airlock' profile (like the U-trap in a kitchen sink). It drafts beautifully when hot, but slowly when cold. This helps the fire self-regulate its air intake, and prevents the heater from removing warm air from your home if you forget to close the feed lid after a fire. But the airlock feature does make cold starts more challenging.

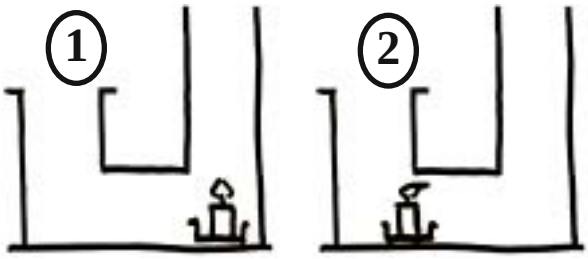
Cold air can act as a dense 'plug,' pooling and swirling like fog in a valley. Trying to force warm air through a cold plug can make some very weird effects, like smoke 'bouncing' out of the fuel feed after the fire had just started to draw.

The secret to cold starts is to prime the vertical chimney(s) slowly, pre-heating the heat riser and exit chimney to draw cold air out of the system before lighting a larger fire.

COLD START METHODS

PAPER PUSHER: classic fireplace method
Light a twist of newspaper under the heat riser as you would in an ordinary fireplace throat, to confirm good draft before starting the fire. When the flames draw properly (away from you, toward the heat riser), then add kindling and light the fire.

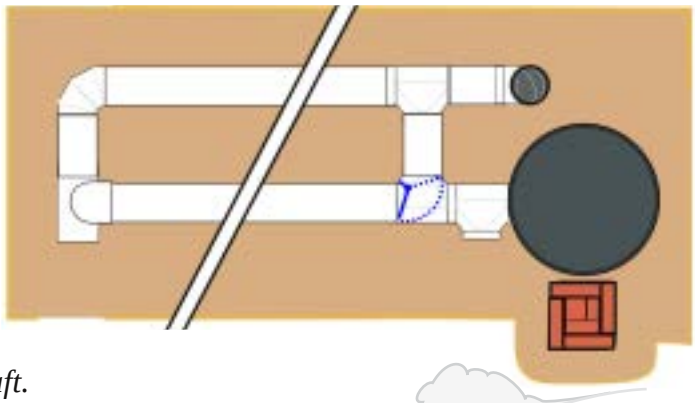
CANDLE METHOD: simple and sweet
1) Light a candle under the heat riser. Wait about 10 minutes, then pull it out and check.
2) When the flame points toward the heat riser instead of back at you, the system is primed and ready. This may take up to 40 minutes, but we've never needed a second candle.



CHIMNEY–PRIMING METHOD: rough-and-ready

Remove the cleanout cap at the bottom of the exit chimney, and light a small fire right inside the chimney. Burn a wad of newspaper, Sterno stove, or some other small, clean fire right in the exit chimney. If possible, replace the cap while this little fire is still burning, to forcibly draw the cold air out of the thermal mass and replace it with warmer room air.

Chimney–priming fires work well in combination with the candle method. But don't bother putting the cap back on to 'suck out the smoke' after a failed full-size fire; the spent exhaust will put out the priming fire.

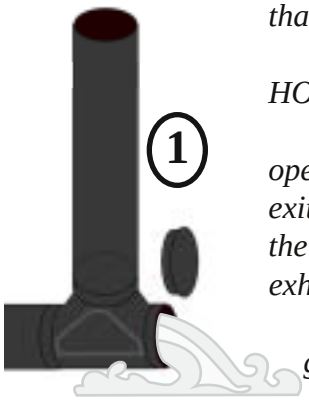


BYPASS: planning ahead

Some heaters are built with a bypass: a shortcut that allows the exhaust directly into the chimney, bypassing the longer heat-exchange channels.

With the bypass damper open (as shown), the system can get going very quickly. Once the combustion unit and chimney are warm, gradually close the damper to force warm exhaust into the heat-exchange channels. It may take some time to fully circulate the cold, stale air out and establish normal draft.

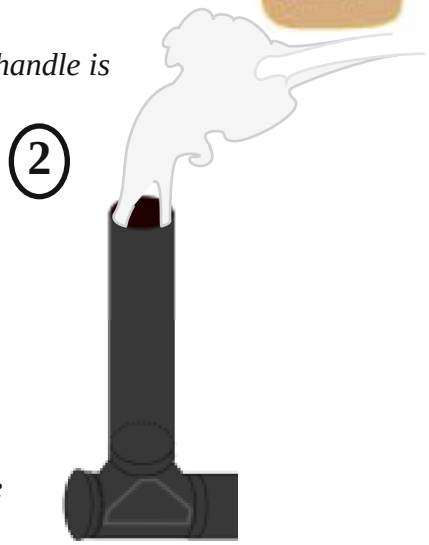
Bypass dampers usually follow the general valve convention: when the handle is lined up with the pipe, the damper is open for flow in that direction.

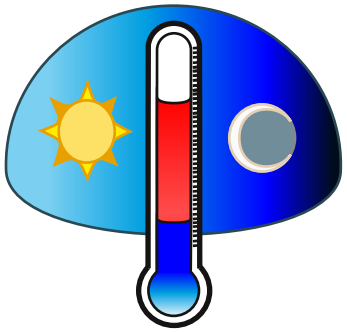


HORIZONTAL DUMP: a workaround

A few systems have a horizontal exhaust exit that opens outdoors, such as a cleanout at the bottom of the exit chimney. On a calm day, it may be easier to start the heater with this cleanout open, 'dumping' the cold exhaust (1) until the thermal mass warms.

Once the exhaust coming out feels nice and warm, gradually replace the cap and watch the exhaust rise up the chimney. (2)





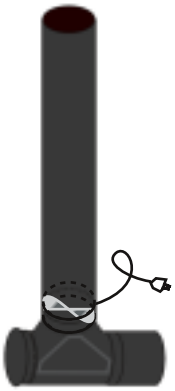
WEATHER WATCH METHOD: adapt to actual

For the first fire of the year, wait until the cool of the evening, or start the fire early in the morning. Since the mass reverts to the average *ambient temperature, not the coldest temperature, there is usually a time of day when the outside air is colder than the indoor mass.*

Passive-solar building design can allow the heater to soak up sun rays during winter days, stacking the deck so you never have a cold start.

POWER ASSIST METHODS: Normally we don't advocate electronic gadgets on wood-fired heaters. (What good is wood heat if it doesn't work in a power failure?) However, a cold-start booster which is only needed occasionally might be an exception. Fans wear out quickly in the hot, corrosive atmosphere of combustion exhaust, but small ones are cheaply available.

An electrical pre-heater can be run remotely to avoid cold starts. An improvised chimney warmer can be as simple as an incandescent light bulb. Of course, the lamp must be removed before lighting the fire, and not replaced until the firebox is cool and clean.



DESIGN FEATURES: The following make heaters more likely to draft strongly in all conditions, including cold starts:

- a self-priming exit chimney next to the warm barrel (with or without a bypass)
- shorter heat-exchange ducting
- taller and better-insulated exit chimneys and heat risers

FUEL SELECTION AND STORAGE

All fuel must be dry: below 15% moisture content, the drier the better.

To check your firewood's moisture content, split a log and weigh the pieces. Then dry them on 'low' in a bake-oven for a few days, or indoors with a fan for about 2 weeks. Weigh them again. The lost weight (water) should be less than 10% of the total (some water may remain trapped in the wood, depending on indoor humidity).

Season natural firewood in dry storage for at least 6 months prior to burning, (up to 2 years if possible). Good wood storage provides:

– excellent ventilation below and beside the wood
– protection from rain and snow
– space to separate last year's dry wood from this year's green harvest

Firewood stored in contact with the ground, or wrapped in plastic, does not dry.
An ideal woodshed also includes tool storage and room to swing an ax in the shade.

Recommended fuels: *Any dry, natural wood fuel that fits in your fuel feed (taller pieces are a fire hazard). Hardwoods, softwoods, fruitwoods, scrap lumber*, and brushy scrub fuels are all fine. Split cordwood works great.*

Waste fuels often make great rocket fodder, arbor and orchard wastes, dead branches, coppiced wood (straight "suckers" from pruned trees), project scraps (*if your local lumber is not treated with drying agents or salts).

If you want to get competitive about efficiency, track your fuel usage by dry weight, not volume. Pound for pound, oak and pine are roughly the same BTU value even though they are quite different by volume.

Tinder/Light fuels: *Use these sparingly to start fires; overuse leads to excess ash. Paper, grease paper, dry plant wastes like leaves, straw, corn husks, reeds, etc.*

Small fuel scraps: *Any clean, dry, natural cellulose–type fuel can be burned. Most won't self-feed like straight log fuels. Chips, wood pellets, dried dung, nutshells, block scraps, pine cones, and bark can be burned alongside other fuels in a mixed fire, or by using specially-adapted mechanical or gravity feeders.*

Tricky fuels: *Fuel/air imbalances can cause smoke problems indoors and out, and maintenance nightmares with creosote in the pipes. If you have an excess of poor fuels, try mixing small pieces in with a larger amount of good, clean fuel.*

Avoid wet wood*, punky rotten wood, too-long pieces, very pitchy wood, wide flat pieces shaped like chimney dampers, and forked or knobby wood sections.*

"Presto-Logs" (cakes of sawdust & wax) have not been tested; use caution.

BAD IDEA fuels: can damage your heater and/or poison your household
DO NOT USE painted, varnished, or treated wood; plywood; or pressboard.
DO NOT USE concentrated fossil fuels such as oil or coal.
DO NOT USE volatile/explosive fuels, trash, metals, or plastics.

Tracking the performance of your heater over time is the most accurate way to estimate fuel needs.

RECOMMENDED LOCAL FUEL SOURCES:

…….
…….
…….
…….

Our heater's best-performing size and type(s) of fuel:

…….
…….
…….
…….
…….

HEATER PERFORMANCE TRACKING:

Tracking performance over time helps get the most from your heater, anticipate fuel needs and maintenance, and document your bragging rights.

Use this space to record the performance of your heater. Note the fuel type, weather and outdoor temperatures, length of burn, heater and room temperatures (especially nearby combustibles/cushions), and whether any smoke is observed in exhaust. Record any problems or discoveries. Changes in performance from one heating season to the next may give early warning of maintenance issues.

Log the performance until you feel comfortable with the heater (1-3 months). After that, log a week or two when you want to check for performance changes, compare a new fuel type, or unusual weather.

OBSERVATION LOG:

Date	*Time*	*Wind/weather*	*Fuel*	*Observations*
2/1/08	*6pm-9pm*	*NE / raining*	*21 lbs Oak/cherry*	*:-)whole house is warm*
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
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…	…	…	…	…

ASH CLEANING LOG:

FIRE BOX:

….…..…

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….…..…

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….…..…

….…..…

MANIFOLD/DUCTS:

….…..…

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MAINTENANCE

ASH CLEANING

Daily or Weekly:

Over time, excess wood ash can build up into a hard mass, reducing the air volume and choking your heater. Before you start a new fire, scoop out the accumulated ash in your burn tunnel. Leave up to 1/4" of loose ash, to insulate the fire and protect the bricks.

Tools for scooping out firebox ashes: hands, sardine can, bent–handle shovel.

Annual cleaning is a dirty job, yet quickly done with a vacuum hose and good filters / outdoor ventilation. Shown: removable upper barrel. Not shown: dust mask, geek-chic goggles.

Annually/As Needed:

Fly ash builds up like snow in the manifold and downstream, especially from burning paper. Cleaning time may be indicated by changes in performance: slow draft, weird slow burn, increasing backdraft/"smokeback," changes in air settings or burn times, or the sound of scrabbling vermin which must be removed promptly.

The manifold/barrel base is a critical area to clean regularly. The nearby cleanout may be a capped pipe, door, or removable tile built into the barrel or brickwork. Some heaters are built to allow removing the barrel itself, or the lid.

♦ Protect nearby furniture if needed, then open the cleanout access.

♦ Remove ash and soot using a Shop-Vac with good filters, or a snake and brush. Inspect as you go for any damaged, sticky, or loose areas.

♦ Work your way down the heater, making sure that all channels are clear of obstructions. White ash or black soot are normal, and a small amount of moisture condensation may occasionally be present. Pooling liquids, sticky tar, or enamel-like creosote indicate a problem requiring further work.

♦ Replace all caps and re-seal any mortar or gasket joints that were disturbed, making sure no hardened residues remain that could prevent an airtight seal.

For removable bells and lids, use suitable, non-flammable seal materials such as:

Braided or woven woodstove door gasket (seated metal lips)
Mortar (clay-sand), cob, earthen or lime plasters (masonry areas)
Foil tape*, furnace cement*, or chimney cement* (metal-on-metal)

*Check temperature ratings for suitability. Materials rated for 1000°F or higher may be used on upper barrel, but 300°F foil tape is only suitable for lower areas.

CLEANOUT LOCATIONS:

….….

….….

….….

….….

….….

(sketch or include a photo)

INSPECTION AND REPAIRS

Any object collects a certain amount of damage through use and abuse.
The most common repairs for rocket heaters are surface dings and chips, cracking or loosening of the bricks around the fuel feed, and upholstery cleaning and repairs.

Good condition

Masonry Surface Inspection:

Since the outer masonry is the only visible part, it is the first defense against leaks or cracking. Inspect before each heating season for cracking, damp, or other signs of damage, and repair as needed.

The most common surface cracking will occur within the first few months after an installation, and may indicate improper materials or methods (excess clay), settling in the foundation, or hurried work. We generally allow the core to dry completely before beginning the outer casing, so that any cracks can be repaired or stabilized and the final layers protected from associated stresses.

Cracking that occurs years into the useful life of the heater may indicate a more serious problem, such as a heavy impact or eroded foundations.

All surface cracks of unknown extent should be treated as critical to the air-seal of the heater until proven otherwise. At a minimum, wet earthen materials and press down to fill the crack. Repair methods for traditional masonry are described below, and in the resources listed.

Needs repair

Upholstery:

Never use combustible materials around the combustion-unit and manifold, or anywhere that surface temperatures routinely exceed 120°F.

Areas of the heater that remain below about 120°F (50 C) can have wood trim, cushions, blankets, or other comfortable padding added. Monitor closely during the first few burn cycles, and again during any unusually long burn, to verify that the temperatures under the insulating cushions stay within acceptable ranges. Place a hand or thermometer below the cushions; it should be comfortably warm, not painfully hot.

All fabrics and padding should be heat-tolerant: such fabrics can be ironed or tumble-dried on 'Medium' or 'High' settings (350 to 450°F). For the safest results, we prefer natural fabrics like denim, cotton canvas, wool, or linen, and natural batting such as cotton or wool. If these materials do overheat, they scorch rather than melt. But many satisfied owners have used durable synthetic upholstery fabrics. Avoid delicates like rayon or acrylic, and no spray treatments like Scotch-Gard.

The only reported problems with fabric or wood trim in contact with the heat-exchange benches have been localized 'hot spots' where a heat-exchange pipe was less than 3” below the masonry surface, and the heater was fired for more than 5 hours. If your heater has any such trouble spots, you may be able to fix them with additional masonry thickness or a pad of non-combustible insulation.

Follow fabric directions for upholstery cleaning. Most owners clean their rocket mass heater bench much the same as they do their sofa: a quick vacuum or sweeping of the grunge under the cushions, occasional spot-cleaning, or removing the cushion covers for a more serious washing if needed.

Bridge Brick:

The most frequently-replaced part of a rocket mass heater is the first brick in the burn tunnel. This brick is exposed to cold incoming air, very hot flames, and thumps and grinding from incoming fuel. It may develop a vertical crack over time.

Bridge brick starting to crack, but not yet in need of replacement

It is generally not necessary to replace the cracked brick unless any part of it becomes actually loose, threatening to fall into the burn tunnel during a fire. When it is time to replace this brick, carve away any loose material nearby until you can remove the broken pieces and slide a whole, new brick into the same place.

Fixing It Better: Replacing a single, standard firebrick is a pretty simple job. Improved methods may offer slightly better longevity, if you wish.

To help protect from thermal expansion, you can bed the sides of this brick in flexible refractory wool or woodstove gasket. Paint-on refractory coatings may also help to reflect heat away from the bottom surface. To protect from careless fuel loading, it may be helpful to cut wood smaller or provide a slightly proud 'lip' above this brick to take the initial shock.

Loose bricks can be re-set using the same type of mortar. Clean off old mortar, chip back any protrusions, wet the surface, and re-apply fresh mortar in a ridge or series of small lines. Set the brick back in place, and gently tap it until it is plumb, level, and square.

MASONRY AND PLASTER REPAIRS

Among the critical factors in masonry repair are design for repairability, structural integrity, and dust protection. Dust protection can be achieved with masks, curtains, and dampening of material and tools during the work.

Masonry repair is a skill that is best developed with practice. Brief tips are offered below, in the 'troubleshooting' section (particularly question 4 and 6), and in the resources at the end of this manual. Local masons and building contractors may be your best resource for renovations and repairs on conventional masonry.

Batch Recipes:

Record amounts and ingredients used for locally-sourced materials:

MORTAR(s):	*THERMAL MASS / SANDY COB:*	*STRUCTURAL / STRAW COB:* ... ...
INSULATION(s):	*FINISH PLASTER(s):*	... ...

TRADITIONAL EARTHEN MASONRY:

Many rocket mass heater builders use the original masonry heating materials: local stone, earth, and clay-bound masonry. Compatible finishes include earthen plaster, lime plaster, or taadelac (a beautifully burnished lime-marble finish).

When working with local materials, especially site-sourced mineral soils, record the source details, amendments, and any other useful information (such as the phone number for delivered materials).

Thermal Cob / Clay-Sand Mortar

Two to five parts sharp sand
One part clay-rich *dirt*
Water as needed

Mix thoroughly with a kneading motion, usually accomplished by rolling and treading on a tarp. In structural areas, add

Straw, hair, or other fiber as needed (as much as can be completely mixed in without clumping).

Testing cob (wet-formed earthen masonry)

A handful has a solid, crunchy center; does not goosh out excess clay or water when squeezed.

Ball drop: holds together when dropped from 4' height

Smear: sticks to lath or fingers, even upside-down.

Self-supporting: stand on it, does it make you taller?.

DOES NOT CHANGE when mixed further by hand.

Test the cob texture, and make sample bricks of several proportions to find the best mix (shrinkage or cracking indicates excess clay, crumbling indicates silt or sand, and both together indicate not enough mixing). Depending on the stickiness of the available clay, we may use unaltered local mineral soils, or sandy blends from 1:1 up to 10:1 sand:clay.

Small amounts of leftover material may be dried and stored for later repairs. To re-use saved material, moisten the dried material in a bucket or basin (without too much excess water) and work it until pliable. Too much water can wash away clay, weakening the material. Work any excess water back into the mix with additional dry material.

Work the material until it reaches a dough-like consistency. For plaster and mortar, work in enough water to make a thick batter or frosting-like texture. For structural repairs, stiffer material (like shortbread or cookie dough) will fill bigger gaps and shrink less.

Methods and instructions for working with earthen masonry can be found in:

- Chapter 2 and Appendix A1 of the *Rocket Mass Heater Builders' Guide*;
- natural building references such as *The Cobber's Companion, The Hand-Sculpted House, The Cob Builder's Handbook,* or *The Natural Plasters Book*
- members of the Natural Building Network, www.nbnetwork.org, and builders trained through local center such as Cob Cottage Company, www.cobcottage.com.

Material Sources for This Heater:

Local earth/clay source: ……

Local sand/gravel source: ……

Other material sources: ……

(ceramic clay, mineral pigments, etc) ……

……

……

Samples/patch material: ……

(where did we store them?)

TROUBLESHOOTING: Burning Questions

The most common or easiest solution is given first, followed by the increasingly 'bad news' solutions. For detailed troubleshooting and unusual systems, see references below.

1) My Heater Won't Light! (or Draft!)

The fire just burns straight up into the room, or goes out.

a) If the heater has not been used recently, try the 'Cold Start' instructions (p. 4.16-17).

b) Check your fuel and tinder. Modern printer paper has so much clay sizing that it is nearly useless for lighting a fire. Try brown paper bags, shredded natural fiber such as wood shavings, or greased paper such as butter wrappers. Of course, the wood must be nicely dry. Practice your technique outside to be sure the fuel and tinder catch easily.

c) If the weather is warm or gusty, wait a few hours. Calm, cold outside air offers the best chimney draft for the first fire of the year.

d) Clean the system thoroughly to check for blockages. Clean the ash out of both firebox and manifold, leaving up to 1/4" of ash on the firebox floor to insulate the fire. Check all channels for blockages (nesting vermin, paper ash). Snake out any hidden obstructions. Remove the barrel or lid and check for blockages within the barrel and manifold, such as ash buildup on the heat-riser rim. Also check for dislodged insulation or other damage to the heat riser and manifold.

e) Check for building/chimney problems such as:

negative pressure (open a window; turn off vent fans or close upstairs windows)

blocked chimneys or clogged spark-arrestor screens

correct chimney height and temperature. An outdoor chimney which is cold to the touch, or shorter than nearby roof vents, may have poor draft. Tall, warm chimneys draft upwards, but cold chimneys tend to backdraft downwards.

f) Consult a reputable builder for help checking the system design and dimensions. In rare cases, a system built to a proven plan may still be unsuitable for a particular building or climate.

2) My Heater Smokes Back Into the Room!

We were able to light it, but now it's letting out puffs of smoke.

a) See question (1), above, for fuel choice, priming, and cold starts. Warming the system slowly during a cold start helps to establish good draft before filling the firebox.

b) Does the smoke occur about 15 minutes after lighting the fire, as the kindling burns away? It is common to place kindling narrow-end down, causing it to wedge instead of dropping when the lower part burns away. Rattle the kindling to encourage half-burned pieces to drop, and load more wood behind.

c) Is the firewood properly sized, clean and dry, and properly loaded? Follow lighting instructions on p. 4.14-4.15. All fuel must fit within the firebox. Too-tall fuel can create 'chimneys' that allow flames to rise into the room, above the downdraft air. Rich fuels like paint, varnish, grease, or pitch can also cause flames to escape the firebox. Pitchy wood is best cut down to smaller sizes and mixed with dry, clean fuel. If needed, use the air-control lid to force air between the smoking wood. Watch the fire closely until the troublesome wood burns down, then wait a little to let the feed cool somewhat before loading fresh fuel. Push burning fuel toward the

burn tunnel and load fresh fuel behind it.

d) Wet fuel will steam and boil out the ends.

e) Is there enough fuel for self-regulating draft? Keep the firebox full of wood for self-regulation, or use the air control lid to set the opening proportional to the fuel load. Most rocket heaters burn best with a full load of fuel, which forces air between all the fuel ends equally. When burning a reduced fuel load, use the air control lid to close off up to 50% of the feed opening and force the air to draw past the remaining fuel. Most heaters operate best with the air between fully open and 1/3 open; leave at least a 1" slot at all times while the fire is burning.

f) Are unusual shapes such as sawn lumber interfering with the even flow of air? Check your fuel for "dampers" (wide, flat pieces placed to block the air), and “chimneys” (vertical channels between hot pieces of wood, that concentrate the heat while blocking downdraft air). Use natural split wood, or round pole wood, to separate sawn pieces and distribute the downdraft air flow evenly between all the fuel pieces.

g) Is your heater choking? Check for piled-up ash, embers, or charcoal blocking the burn tunnel, and bore an air hole through any such blockage with the fireplace tools. To avoid this problem, clean the firebox before lighting the fire if ash is more than 1/2" deep.

It is a common misconception that rocket stoves require very small, split fuel. Once the firebox is hot, a load of pure kindling or paper tinder will quickly incinerate and collapse into piles of embers and ash. Use larger wood once the firebox is hot, to allow the fire to self-feed without choking. One large log can burn on its own embers (with a piece or two of kindling as needed to keep the flames bright). Or try several medium-sized splits or pole sections, big enough that three or four pieces fill the firebox.

h) If the heater used to run great, but recently it has started smoking back, it's cleaning time. Stop feeding the fire. Once the embers are out, CLEAN EVERYTHING (inside & out). Give special attention to possible blockages in the heat riser, manifold, chimney (top and bottom), and at any bends in the heat-exchange ducts.

Construction Issues: If the above methods don't remedy the problem, it's possible there is a design or construction problem.

i) Stagnation: If the problem occurs about 30-45 minutes after starting the fire, every single time, with not just puffs but clouds of smoke, the problem is likely a construction error or subsequent damage to the heat riser, barrel, or manifold. Air leaks, inadequate insulation on the heat riser, or decorative materials that cause the barrel to overheat, can all cause this problem. Remove the lid or barrel and inspect for missing or damaged insulation, or dislocated bricks, or cracks in the heat riser or manifold. If the insulation is clearly adequate (1" refractory blanket, 2" perlite, or 4" vermiculite, no settling or bald patches), consider using a fresh layer of earthen plaster to seal any unseen cracks.

j) Negative building pressure: If the building is drawing air strongly due to tall attic vents, mechanical ventilation, severe wind pressure, or imbalanced weather seals, the unbalanced pressure can draw air and smoke backwards through the heater.

Open a window or door in the heater's room. Shut any upstairs windows. Turn off exhaust fans, such as kitchen or bathroom vent fans. Did it help? Negative pressure in the house can affect any combustion device, including natural gas appliances. If adjusting the available air fixes the problem, a permanent air intake for make-up air or outside combustion air may be the solution.

k) Chimneys: Is your exit chimney detailed properly? Most conventional homes call for a conventional chimney: warm, tall, insulated from wherever it exits the building to well above the ridgeline. Chimneys opening too near the eaves are subject to incredible wind pressures and directional gusts. If the heater performance changes with the wind and weather, your chimney may need improvement.

We test the surface temperature of our rocket mass heater chimneys on first firing, looking for at least 100°F, or at least 50 degrees above the outdoor temperature during heating season. Typical masonry heater exhaust is in the 200-300°F range, to stay above the dew point of steam. Even the driest possible wood produces about half its weight in water vapor when burned completely. Water fog is denser and heavier than clear steam.

Some builders minimize the exhaust temperature for efficiency; but this reduces chimney draft. Exhausts below 70°F can be difficult to vent out of the building in any kind of windy conditions.

l) Proportions: Is your heat riser insulated well enough, and is it tall enough? Is your firebox too long, too small, or choked with ash? Does the manifold provide a generous flow area from barrel to duct, even when a layer of fly ash starts to accumulate? Has corrugated material been used in place of smooth ducting for the heat-exchange channels? Are there weird turns, bottlenecks, or mismatched ducting anywhere in the heater? The wrong proportions can cause a heater to have routine and dangerous performance problems.

3) My heat-exchange mass leaks smoke, or smells funny!

a) Newly built heaters often steam gently until the cob dries out, which takes time. The easiest way to distinguish smoke from steam is by smell. Earthy = normal, smoke or mildew = problem.

b) Does the problem occur mainly when the heater is cold? Building pressure issues can draw smoky smells backwards down any chimney.*

Open a nearby window in the same room, or on the same side of the building, as the heater. If this relieves the smoky smells, look into providing outside air to the heater, make-up air to the lower floors of the building, or balance the building itself with better air-sealing up high and more air infiltration down low.

c) If smoke or smoky smells leak from the body of the heater during firing, ventilate the room well with outside air, and try to find the source of the leak (check the barrel, manifold, and cleanout areas first).

When the heater cools, patch the leak inside and out. Re-point casing masonry, or give the entire surface a fresh coat of plaster. See question 4) for more detail on repairing cob.

d) Mildew and mold occur in damp conditions with inadequate ventilation. Most clay-based masonry heaters remain marvelously dry; the clay even helps regulate interior moisture. However, damp problems can occur in any building, often associated with blocked gutters, improper foundation details and ground damp, leaking pipes, improper chimney or window detailing, or any other source of flooding.

First remedy the damp problem: every building needs adequate flashing and storm collars around chimneys, wide roof eaves to protect walls and windows, dry foundations, and good drainage away from the building site. Sometimes buildings can collect damp from condensation

of warm indoor air as it contacts cold outside walls or windows. The proper balance of insulation and ventilation for a given climate may call for local expertise. Observe during cold and damp conditions, and improve the building until no further damp can penetrate the area.

Remove any remaining moldy or damaged material. Treat the remaining, structurally sound material with hydrogen peroxide solution and Borax solution to destroy and inhibit mold spores. Borax may also be added to natural plasters or paints to retard surface mold.

Repair the damaged area with similar materials. (Do not be tempted to use waterproofing on the outside of damaged masonry, as this can trap moisture inside and compound the problem).

**A Note about Smoke: Many people enjoy the smell of woodsmoke, and most people can survive a brief exposure to burning bacon. Prolonged, indoor exposure to wood smoke or any combustion products, however, is a different matter.*

Any fire consumes oxygen, and releases gases unsuitable for breathing in its place. Even small doses of carbon monoxide (CO) can build up in the blood over time, severely depleting the body's ability to absorb fresh oxygen. Be aware of the signs of CO exposure or depleted oxygen (fatigue, irritibility, headache, nausea, lethargy, dizziness or faintness, passing out or being hard to wake up). If anyone experiences these symptoms, ventilate the area with fresh air, and get everyone outside as soon as possible. Even the oxygen depletion from a camp lantern or brewery yeast can make people pass out.

Never leave the fire unattended. Don't "store" smoke in the heater. Allow the fire to burn out completely, with adequate air, before shutting the heater down at bedtime.

One of the benefits of thermal mass heat is that you can freshen the air as much as you want, without losing heat. Clear the air as soon as possible after any smoke exposure, even cooking.

4) How do I take something apart to clean it, repair it, or re-decorate the heater?

a) If your heater was built with maintenance in mind, it should be easy to remove cleanout caps, open the barrel lid, or access any part of the heater through a built-in cleanout port.

b) Permeable surface finishes like earth or lime plaster can be re-finished with a compatible, porous plaster or natural paint. Scratch the surface lightly, to a depth similar to the thickness of new material you want to add. For plasters, prime with clay slip immediately before plastering, working wet onto wet. For earthen or lime paints, paint directly onto the dry surface.

c) To chase down a smoke leak, look for black soot streaks outside the ducting. Or look for traces of air leaks in the soot on the inside of the heating channels.

Most air leaks occur near exposed pipe such as cleanout caps, and are best fixed with better-sealing caps. Use woven woodstove gasket to line any metal-to-metal or metal-to-masonry connections that you suspect may leak.

If it is necessary to bore into the masonry in order to replace a damaged or leaking section of work, follow the soaking method outlined below (d) . Carefully chip away and work loose any necessary masonry, taking care not to damage the lined channels inside.

Replace, repair, or re-seal any parts as needed. Test-fire the heater before you rebuild to ensure that it’s working, then restore the masonry and finish.

d) To bore into the masonry for deep repairs, to anchor large new facing stones or tiles, or to replace a sculpted detail such as an arm rest, wait until the heater is cool (ideally during warm

weather).

Soak the earthen masonry with water. One method is to put damp towels on it overnight, draped into a bucket of water. Cover this “sponge” in plastic if your climate is dry, to encourage moisture penetration into the masonry.

The next day, start carefully digging in with a trowel, garden fork, pry bar, flat spade, old handsaw, or similar tools until you get to the trouble spot. Avoid damaging any ducting or other parts buried in the masonry. Continue soaking the cob as you work. Dry cob is almost as hard as concrete, and gives off large amounts of dust during demolition. Wet cob is much easier and safer to remove. Ventilate the space while working, and/or use dust protection.

When you have removed the desired amount of material, leave the surface rough to accept new material.

To rebuild, wet the exposed surface with clay slip or water, then apply fresh cob or plaster. See resources under 'Traditional earthen masonry,' above, for further detail.

5) I have a small child/frail elder/pet. How can I keep them from getting burned?

Rocket mass heaters are generally safer than metal woodstoves and fireplaces, especially for toddlers. The fire is not exposed, and it takes deliberate effort for a small child to reach high enough up the barrel, or low enough into the firebox, to risk a severe burn. Most adults, children, and pets have no difficulty staying clear of the hottest parts, and can safely enjoy the warmth of the zero-clearance bench area.

a) Adapting people to be safe around a new heater:

A rocket mass heater naturally teaches kids to be careful around the heat. Toddlers are likely to first touch the lowest part of the barrel, which is hot but not lethal - usually under 200°F. As they grow, children learn from experience to avoid the hotter, higher surfaces. The hottest surface is located up high, where it is difficult to fall onto it by accident.

DO NOT allow a child to climb up toward hotter upper areas of bell (400-800°F), or to reach into the firebox. Neither children nor fire should be left unsupervised, especially not together.

Allowing a child to explore their world and occasionally experience pain, while protecting them from permanent harm, is the 'natural consequences' school of child-rearing. NEVER harm a child to teach them a lesson. The primary lesson learned from this kind of abuse is to distrust you (or all adults); it rarely helps the child respond appropriately to the original danger.

Burn treatment: Minor burns and painful heat experiences (no visible damage beyond a slight reddening of skin) can be soothed immediately with cool water. In case of serious injury such as a burn with welts, blisters, or broken skin, or if a painful area does not improve within a few days, seek medical help.

b) Adapting a new heater to protect people: If someone in the house is subject to uncontrolled movement, falling, inebriation, or difficulty remembering previous experiences, you may want physical barriers to protect them from direct contact with heated surfaces.

We sometimes use heat shielding around the upper barrel, stout fireplace screens, or a thicker masonry hearth around the combustion area. Some families with very sensitive individuals have divided the heater into separate rooms, passing the zero-clearance bench through a suitably heat-tolerant wall, so that the sensitive person can enjoy the heat without risking any contact with the combustion unit.

c) DO NOT cover the barrel with insulating or heat-absorbing material. The barrel must shed heat for the heater to draft properly. Heat shielding may be added provided that it allows enough heat to escape through convective air circulation or radiant heat.

Any heat shielding must not cause air leaks in the barrel, and must have at least a 1" air gap behind, below, and above to allow circulating air to cool the barrel for proper draft. This natural air circulation can also be used to provide warm room air to other parts of the home.

6) I'm tired of this weird mud bench/big steel drum in my living room. How do I hide it, make it look better, or get rid of it?

The bench and heater are a unit; removing part of the bench can cause the heater to overdraft or burn unclean. Removing the barrel or covering it inappropriately can cause immediate performance failure.

a) Aesthetic remedies:

If you are satisfied with the performance but find the aesthetics lacking, consider refinishing with a different masonry material such as tile or tinted plaster (lime, gypsum, or earthen plaster). Areas of the bench with suitably low temperatures could also have a choice of wood trim, upholstery, or other heat-tolerant coverings.

DO NOT coat the entire barrel with cob or insulative materials. The barrel must shed heat in order for the system to draft properly. The barrel can be painted, decorated, or hidden behind a suitable heat shield such as fireplace screen, ceramic tile, or decorative metal panels. Or it can be replaced with a custom metal bell. See the Barrel Deco Design Challenge, Appendix A6.

b) To remove or replace the entire heater, follow the demolition methods outlined in (4), using a pickaxe or jackhammer in place of hand tools.

c) **Safety note:** Because rocket mass heaters exhaust at a lower temperatures, the through-roof or through-wall fittings used by an RMH installer may not be suitable for a woodstove or other appliance. **Please have a qualified person inspect before re-using an existing chimney.**

7) We changed the heater, and now it doesn't work right. How do I make it work?

a) Change it back.

b) See the *Rocket Mass Heater Builder's Guide* to check whether a proposed change falls within the workable parameters for this type of heater. We recommend testing any proposed changes, one at a time, on an outdoor mockup before altering a working, indoor heater. Be aware that the building itself may influence the heater's behavior; most heaters are customized to the building.

8) At first my heater didn't warm up, but now it's working again. What's going on?

a) That's normal. The storage mass of the heater is like a battery—it takes time to charge up, then gives steady output for a long time. The mass stores both heat and cool, kinda like a Thermos bottle (how does it know?). We call this long, slow power-up and power-down the "thermal flywheel" effect. Mass is great at stabilizing temperature, but as a result it doesn't respond quickly to changes.

When starting from scratch to heat a cold heater mass, it usually takes a day or two to reach full operating temperature. This is the same time lag that works in our favor overnight, and allows us to neglect the house for a day or two without the pipes freezing.

Time lags vary from one heater to another, so please use your own observations for critical decisions (like how long you can go on holiday, in what kind of weather, without bursting the pipes). You can burn the heater a little extra ahead of time, if needed for a cold snap or absence. The hottest surface temperatures may occur 4 to 6 hours after the hottest point in the burn cycle, so don't overdo it on a first firing.

Masonry heaters work best when used routinely (several times per week). If possible, don't ever let the mass cool completely during the heating season. As warmer weather arrives, run the heater minimally (twice per week, for an hour or so) until you are sure heat is no longer wanted. Then stop running it, and allow the mass to cool for the season.

The cool mass provides summer comfort. Thermal mass stays closer to the average ambient temperature instead of the current air temperature. (Ambient includes daytime highs, nighttime lows, plus ground temperature under the house). Since the average temperature is more comfortable than the worst heat of the day, thermal mass is popular in hot climates. Locate the mass in the shade (out of direct summer sun), or even cool it artificially, for best effect.

b) If the heater just doesn't put out heat like it used to, something may have changed in the system. A blockage such as fly ash can reduce the intensity of the fire: time for maintenance. Sometimes a change in weather can have a similar effect: the heater will draft strongest on cold, calm days, but may not draft as hard during mild weather.

c) If you've changed something yourself, like wrapping the barrel in decorative plaster or adding cushions, you may have blocked some of the warmth from reaching the room. (Feel under the cushions to find where it's hiding!).

d) Fuel quality also affects the heat production. If you've switched to lighter or wetter wood, expect to get less heat from the barrel and heater.

9) There's smoke coming out my chimney/soot in the pipes. Is that bad?

a) Is it smoke, or fog?

Rocket mass heaters should never smoke during the main part of the burn cycle, if at all. White fog or clear steam can be part of a normal, clean burn. White fog that is mostly water will dissipate (dissolve and disappear) within a few minutes of leaving the chimney area. Clean exhaust smells like nothing, or faintly like damp charcoal.

Smoke is colored (blue, grey, black, pale whitish, or even brown). The color remains in the air as the plume moves away from the chimney. It may spread out, but does not disappear. Smoke also has a distinctive smell.

b) Slight smoke is normal during the first 3 minutes of the fire, or when adding cold wood to scant coals. Reduce the initial smoke output by using very dry kindling and good-quality tinder (shredded fiber, not greasy or printed material), and by calibrating the air supply to the available wood. Smoke often deposits inside the heater as black soot. A small amount of dry (not sticky) soot is normal, though less is better.

c) Dry wood is essential for any fire to be clean and efficient. Make sure your woodshed keeps the firewood off the ground, out of the weather, and allows good air movement. Cut and store firewood a full year ahead of need (two years in damp climates), and never burn wet, frozen, green, or unseasoned wood.

d) If the performance has changed recently, or if you are seeing/smelling creosote (sticky, tar-

like deposits), something is wrong. Something may be blocked or damaged, keeping the fire from drawing enough air for complete combustion.

e) A recent change in fuel may be part of the problem. You might have to adjust your operating technique for the new fuel, or mix it with better materials. Pitchy wood is rich and hard to burn clean; punky or rotten wood provides poor fuel and is often damp (damp kills fire).

f) The heater might be drawing far too much air, cooling the fire beyond its clean burn temperature. You can temporarily adjust this by slightly restricting the air, while watching (or having someone watch) from outside to guide your calibration. We see over-draft in heaters that are too short horizontally, or have a too-tall heat riser or exit chimney in a cold climate. It may be possible to re-model the heater to balance the draft, if manual controls don't answer.

g) If the heater draws too little air, you may notice a tendency for the fire to creep up the fuel, or occasional wisps of smoke into the room. You can temporarily control this problem by reducing the air intake (reducing the escape paths for the smoke, but also reducing the available air). But this restriction may just make the smoke worse and force it outside. Check for underlying problems like a blockage or overdue cleaning, poor fuels, or a heater with too much drag for a mild climate. If the heater doesn't start properly during the coldest time of day, it may need repairs or remodeling.

10) My heater doesn't behave in ____ weather conditions.

a) The most common reason for weather-related heater problems is an inadequate chimney. Ianto Evans's original rocket mass heaters books advocated shorter, horizontal exhausts—but these don't work in many situations. Chimneys opening near the eaves, or less than half the height of a tall building, are particularly prone to problems. Follow local chimney conventions for reliable results. (Good chimneys are taller than the roof ridge and any nearby structures. Any exposed sections outside the building must be well-insulated.)

b) If the effect is unrelated to wind, but has some relationship to temperature or pressure, you may have an over or under-draft problem as described above.

c) You may have a building pressure or occupant issue that only occurs in certain weather. (Like someone opening upstairs windows when it gets too hot, instead of shutting the stairwell door; or automatic vents on a greenhouse that open and affect the building/heater draft balance.)

11) Our cob cracked a lot as our heater dried out. Can we just patch it?

Cracks often result from too much clay in the mix. The longer your clay soaks and hydrates, the better it works, and you may only realize halfway through the project how little clay you actually need. Some "fat" brick clay we've used can bind 10 times its volume of sand. The first thing I'd do if I spot my cob cracking is to mix a lot more sand into any remaining batches, and boost the sand content of any plaster or patching material I use from there out. Depending how bad the cracks were, I'd then pull any unstable material, and set about patching or reinforcing the material that seems good enough to save.

Stuffing the cracks will often work. To keep the new patch from pulling away from the edges of the old crack, be sure to coat dried areas with clay slip before adding the new material. Painting the clay slip on with a stiff brush also helps remove loose material. For a more invisible patch, you can carve out some 'keys' and make the crack more jagged at the edges, so the patch comes

out almost like a jigsaw puzzle piece. Interlocking edges create a stronger bond and a more discreet, less crack-prone join between old and new materials. Once the patch has dried and appears stable while the heater is running, plaster over the patched cracks for a smooth finish. A plaster with good fiber content can be used for minor patching and filling.

Do any cracks expand when the stove is hot, then shrink or disappear when the stove cools? Thermal expansion cracking occurs when the inside of the stove gets hotter and expands more than the outside. For tiny cracks, a simple fix can be to patch the crack while the heater is hot. Fill the expanded crack while it's at its widest, forcing sandy plaster or cob into it so it can't shrink as it cools.

You can build in room for thermal expansion from the start, especially if using metal or refractory mortars. Lay a piece of flexible refractory insulation, or woven fiberglass gasket, around the corners or edges of metal and bricks, to make room for these elements to expand without straining the outer (cooler) masonry layers. When building with a good fiber-rich cob, we just fire up the heater several times while the cob is still pliable, using thermal expansion to set the finished dimensions. Most masons would consider this cheating, but it works for us.

Unproven Design Disclaimer: This manual cannot cover all possible alterations to rocket mass heater designs. New designs need careful prototyping and calibration. Sharing the information we've gained from our experiments does not make us responsible for others' work.

RESOURCES

The performance of a rocket mass heater reflects its builders' skill and intentions, the operator's attention to fire-tending and maintenance, and the knowledge available when it was built.

For more details, read through the *Rocket Mass Heater Builder's Guide*, by E&E Wisner (the book in which this manual appears); and the original developers' book *Rocket Mass Heaters: Super-Efficient Woodstoves You Can Build (And Cuddle Up To)* by Ianto Evans and Leslie Jackson. Ongoing research and discussion may be found online: www.rocketstoves.com, www.permies.com, www.ErnieAndErica.info

It should be noted that rocketstove.com (singular) is a reference for smaller, lightweight cooking and portable 'rocket stoves,' and at the time of this writing does not contain current information on rocket mass heaters for thermal-mass heat storage.

FURTHER HELP

If you need help assessing or remodeling your heater, completing all the blank sections of this manual will give you a very good place to start, before contacting experrts for advice. Most of the current experts can be found through the above sources, and through the Cob Cottage Company (541-396-1825).