Building the Appalachian Center for Craft 20-Cubic-Foot Cross-Draft Soda Kiln

Vince Pitelka, 2012

This is a tried-and-true design for a simple, LPG-fired cross-draft soda kiln of 21 cubic feet displacement and approximately 16 cubic feet of stacking space, designed for two 12” by 24” silicon carbide shelves on each level. The narrative and accompanying plans include most of the information you need to build this kiln, but they also assume a general knowledge of kiln construction. You may need to get a copy of my book, Clay: A Studio Handbook and/or Fred Olson’s The Kiln Book to provide necessary supplemental information about kiln-building.

Note Regarding the Kiln Plans:
The plans in this handout were done in Microsoft Paint, which does not allow for much adjustment of size, thus the scale is only approximate - one inch on the drawing equals approximately one foot on the actual kiln. Everything is otherwise to scale, but the indications of individual brick placement are generalized. It is important to consult the section on kiln construction in the books mentioned above, specifically in regards to stretcher and header rows in constructing the kiln walls. Adjustments must always be made when placing bricks at the corners and around the burner ports and flue in order to minimize the alignment of seams in each layer. Note that the kiln uses IFB (insulating firebrick) on the outside wherever possible – everywhere except the header courses (which pass all the way through the wall and therefore must be hardbrick) and the bricks that surround the burner ports, charging ports, accessory ports, door, and flue, which are all hardbrick.

The Hotface: Hard Brick versus IFB
After working with a series of soda kilns that were at least partially IFB on the interior, I have come to the conclusion that it is not feasible to use IFB on the hotface of a soda kiln that is going to receive fairly heavy use. In several previous soda kilns at the Appalachian Center for Craft we experimented with an IFB hotface sprayed with ITC-100 thermal coating, and those kilns lasted 150 to 200 firings before needing a rebuild. With the frequency of our soda firings, that isn’t enough. Rebuilding a kiln is expensive and time-consuming, and I want a soda kiln that will last at least five years before rebuild. We get that kind of life with a hardbrick hotface, and the accompanying plans are for such a kiln.

Building This Kiln with an IFB Hotface
Considering the price of fuel, if you will only be firing your soda kiln once or twice a month, you may wish to use 2600-degree IFB for the hotface except for high-duty hardbrick in the high-stress areas like the floor (upper layer only), firebox, bag wall, and the ports, flue, door sill, and door. If you are confident of your ability to treat IFB gently in loading the kiln and stacking the door, and in removing and replacing spyhole plugs, you can use IFB in some of those areas as well. The floor, bagwall, and firebox walls up to the top of the bagwall must be hardbrick, and the burner ports, charging ports, and flue must be hardbrick for the full thickness of the kiln walls.

The brick list at the end of this narrative is for a hardbrick hotface. If you decide to build you kiln with an IFB hotface you will have to extrapolate from the plans and brick list in order to
figure how many 2600-degree IFB to substitute for hardbrick. All IFB on the outside layer should be the less-expensive 2300-degree brick.

**Spraying the Hotface with a Vapor Barrier**
If you build this kiln with IFB, spray the entire interior with a thin saturating coat of ITC-100. Don’t build it up at all – just soak the surface. On our current kiln, we sprayed the hardbrick hotface with ITC-100, but with an all-hardbrick salt or soda kiln I have come to believe that it is just as effective to spray the hotface with a thin saturating coat of any cone 10 shino glaze, which will help seal the surface from the start to reduce sodium vapor penetration into the brick, and is similar in composition to what will accumulate on the hotface with time anyway.

**The Foundation**
The kiln is elevated on a single layer of cinderblock (with holes facing upwards) to reduce back-strain during loading and unloading. In order to get the configuration of block you need, use any combination of available cinderblock sizes, including standard block, half block, narrow block, and the solid cap blocks standing on edge. You can also leave spaces between the blocks to fine-tune the outer dimensions of the block base. I like to have the block base exactly the dimensions of the kiln footprint in order to allow the steel frame to extend all the way to the concrete slab. A layer of cement board on top of the blocks provides a smooth surface upon which to lay the brick. The cement board can be cut with an abrasive blade on a skillsaw. Be sure to wear appropriate safety goggles and respirator.

**The Kiln Floor**
The kiln floor is composed of two layers of IFB (we used a mix of new and used, whole and broken) followed by a layer of high-duty hardbrick as the hotface floor to withstand the abrasion and soda attack and support the weight of the set. This kiln is all dry-stacked. No mortar is used anywhere in the construction.

**NOTE:** When laying the floor, be sure to leave a ½” space front to back in the bottom layer of IFB where the kiln floor meets the chimney floor, to allow a piece of ¼” by 2” steel flat-bar to be slipped through flush with the outside wall of the kiln as the lower left cross-member on the steel frame.

**The Walls**
As mentioned, this kiln is dry-stacked with no mortar. If you are building with a hardbrick hotface and encounter a slight discrepancy in height between the hardbrick and IFB, you have two alternatives. If the IFB are higher, set several harbrick on a flat surface with an IFB between them, and use another harbrick or a piece of cinderblock to abrade the surface of the IFB down to the height of the hardbrick. This is tedious, dusty work (wear a respirator), but may be necessary. If the hardbrick are higher than the IFB, you can apply a thin skim of mortar on the IFB to adjust the height as you build up the walls. If so, use a mortar of 40 parts fireclay and 60 parts extra-fine grog. Moisten the brick surfaces with water, and apply the mortar very sparingly. This should only be done on the outside layer. If you use this mortar on the inside layer it will shrink in firing, leaving gaps that allow sodium vapor penetration into the walls.
The walls are 9"-thick (a standard brick is 9" long by 4 ½" wide by 2 ½" high), and are built from a mix of header and stretcher courses of bricks. Each header course will begin and end with a soap (a brick that is as long as a standard brick but half as wide – 9” by 2 ¼” by 2 ½”) in order to minimize alignment of seams with the layers below and above. Adjustments must be made in laying bricks at the corners and over the burner ports and flue, and alignment of seams should be minimized at all times in order to get the strongest locked wall.

The Burner Ports and Flue Opening

The burner ports, flue opening, and chimney must be accommodated as soon as you start laying bricks on top of the floor level. The burner ports are at floor level and are 4.5” wide (½ brick) and 5” high (2 bricks). Remember that the flue opening and burner ports are all lined with hardbrick through the full 9" thickness of the walls. When laying the left side wall, the chimney must be constructed simultaneously, so as to tie the bricks in with the side wall.

You will need to cut hardbrick to produce half-bricks, and will need to do some custom cutting to accommodate the spacing of the three burner ports. Use a brick saw if possible, but if you do your cuts with a hammer and brick chisel, plan your chisel cuts so that they are not exposed within the flue and burner ports. In either case, wear appropriate safety goggles and respirator.

As shown on the plans, the flue opening leading to the chimney is 9" wide by 7 1/2" high (three bricks), and you can bridge this with two hardbricks meeting at the center, with a larger refractory piece, or with a custom piece made from commercial castable refractory.

The Chimney and Damper Slot

The chimney is 9” by 9” inside, and is hard brick to one brick above the flue opening, and IFB to just above the top of the arch. At that point you can change over to steel pipe, such as inexpensive galvanized iron culvert. The chimney should extend a minimum of eight feet above the top of the arch, no matter what kind of burner system you use. On a normal oxidation or reduction kiln equipped with power burners, the chimney could stop right above the arch, but in a salt or soda kiln you need the convection-tower effect of the chimney to pull the sodium vapor through the set in order to allow maximum flexibility in firing effects.

When you get to the appropriate level for the damper slot, as indicated on the plans, you need to accommodate this rather specialized and precise feature. In all the years I have been designing and building kilns, I have come up with only one satisfactory system, but it works very well. Purchase several new ¾” mullite or high-alumina kiln shelves of any square or rectangular shape, and one new 1” mullite or high-alumina kiln shelf of any square or rectangular shape. The shape does not matter, because you will be using an abrasive or preferably diamond blade on a skill saw to cut strips from these shelves. It is important to use a new shelf, because a used shelf will be very difficult or impossible to cut. If you saturate the shelf with water and wipe off all excess water before cutting, the saw will cut easier with less dust. Depending on the hardness of the shelves and the type of saw blade you use, it may be difficult to cut through the whole thickness of the shelf. If you encounter this problem, just make a shallow cut on each side of the shelf at exactly the same spot, and then tap along the shelf with a small hammer. If you do this carefully, the shelf will break along the cut.
Since the chimney shares the side wall of the kiln, the layers of bricks must continue to line up horizontally as you build the damper slot. One brick is 2 ½” high. By using shims made from these kiln shelves, you will lay a course of ¾” shims, a course of 1” shims that creates the damper slot, and then another course of ¾” shims, totaling 2 ½”. Note that this shim system is not indicated on the plans.

The first course of ¾” shims is 4 ½” wide and extends all the way around the chimney. You can cut the ¾” shim pieces to the size of bricks (9” by 4 ½”), or if the shelves you use are large enough you can cut four 4 ½” by 13 ½” pieces.

On top of the first layer of shims, lay a course of 1” shims that are 3 ¾” wide around three sides of the chimney, leaving a ¾” ledge on top of the first course of shims on the inside of the chimney. Lay these shims only on the front wall, right side wall (the kiln wall) and back walls of the chimney, leaving the damper opening on the left side as you are facing the front of the kiln. On top of the 1” shims, lay another course of ¾” by 4 ½”” shims all the way around the chimney, and lay them to minimize alignment of seams with the previous layer. With this layer of shims you will need to cut a 4 ½” by 18” by ¾” shim to span the damper opening. That’s a little risky, though, and with time it may crack from the weight of the bricks above it, so a far better solution is to cast a custom piece from hard castable refractory that is 18” by 4 ½” by 5 ¾” high and use it in place of the strip of ¾” kiln shelf and the next two courses of bricks on the side of the chimney above the damper slot. Otherwise, once you get above the damper level, continue with all IFB.

The point of this system of shims is to create a durable, abrasion-resistant slot 1” high and 10.5” wide to accommodate a damper that is ¾” thick and 10” wide. The damper can be either silicon-carbide kiln shelf or mullite, but in either case keep a close watch on the condition of the damper, looking out for any warpage or cracking, and replace the damper at the first sign of damage.

When you get above the level of the arch, you can switch over to steel pipe as mentioned above, but you will need a flange and collar to match the pipe to the brick chimney and support the weight of the pipe. Purchase or cut an 18” by 18” square of 1/8” steel plate with a 9 ½” hole in the center. Weld on a 9 ½” outside-diameter vertical collar 2” tall, fabricated from 1/8” by 2” steel flat-bar. The 10” inside-diameter steel pipe or culvert chimney extension will fit over this collar. Make sure to get your piece of pipe or culvert first in order to assure that the vertical collar will fit inside the pipe. The pipe extension will have to be replaced periodically due to the corrosive exhaust gases, but the price is still minimal compared to the time and expense required to build an all-brick chimney.

**The Charging Ports and Spyholes**

Be sure to note the placement of charging ports in the front and back walls of the firebox, plus the four spyholes in the back wall. The charging ports should be 4.5” wide and 2.5” high in order to allow easy access with the metal spray-wand of the garden sprayer. The spyholes should be 2.5” square, and the simplest way to make spyhole plugs is to fashion them from IFB with a taper so that the sit securely and snugly in the spyholes. There are obviously more spyholes than are needed for your cone packs, but they can also serve as charging ports for
those wanting heavy surface effects on particular pieces. The charging ports and spyholes are lined with hardbrick through the entire thickness of the kiln wall.

All charging of soda solution is done through the main charging ports directly into the firebox, or through the smaller ports in the back wall or the door. Avoid charging through the burner ports under any circumstance, as it will result in rapid deterioration of the burner ports and corrosion of the main burners and pilot burners. The charging ports are provided specifically to introduce soda solution into the firebox. These ports are located low down, so that the direct impact of soda solution is confined to the hardbrick hotface surfaces of the floor and adjacent wall.

When building the walls, proceed right up to the level of the skew bricks on the side walls, but leave the back wall and the partial front wall one brick lower until after installing the arch. You will partially support the arch form on these surfaces, and you need that space on top of the back wall and partial front wall to install shims and wedges to support the arch form.

The Steel Frame
Once the walls are completed up to the level of the skews, it is time to build the steel frame, since the arch cannot be sprung until the frame is in place to absorb the outward thrust of the arch. You will need to refer to Olson’s The Kiln Book or to Clay: A Studio Handbook for specifics about building kiln frames.

A steel frame is essential on any sprung-arch kiln to absorb the outward thrust of the arch. On a salt or soda kiln a sturdy welded frame is important because with time, such kilns start to move. In the high-stress areas, brick become saturated with flux and expand, and a frame helps to keep everything in place. The frame is standard mild-steel stock arc-welded at all joints. The corner verticals, front upper and lower cross-members, the arch-buttressing cross-members, and the front vertical to the right of the door are all ¼” by 2” by 2” angle iron. The lower right-side cross-member is also the burner support, and is ¼” by 4” by 4” angle iron. The other cross members are ¼” by 2” flat bar.

Note that on the sides there are three cross-members, because of the inclusion of the arch-buttressing cross-members. I believe in having continuous cross-members all the way around the top of the frame to help stabilize everything. Those members are flat-bar on the sides and back, but angle iron on the front, because it needs that rigidity to support the angle-iron vertical to the right of the door. The bottom cross member on the front is also angle-iron, to serve as a door-sill reinforcement, and because it requires rigidity for the same reason as the upper front cross-member.

The angle-iron cross-member beneath the door and the one that supports the burners serve as lower cross-members on those two sides. On the back side, the flat-bar lower cross-member should be placed at the same level as the front lower cross-member.

NOTE: On the left side, the lower cross-member (flat-bar) must be placed below the floor level to get it away from the hotface where the flue passes into the chimney. When laying up the floor on top of the cement board, be sure to leave a ½” gap front to back where the kiln floor meets the chimney floor in the first layer of IFB to accommodate the left cross-member. When you build the steel frame, you will need to slip a piece of ¼” by 2” flat bar through this
gap so that it lays on edge flush against the outside wall of the kiln to serve as a cross-member on that side, connecting the left-front and left-rear vertical corner angle-iron members.

The vertical angle-iron member to the right of the kiln door is very important. This is a high stress area, and without that vertical, the stub-wall will often warp or lean outwards with time.

Note that the plans show placement of the burner-support cross-member so that its upper surface is one brick below the burner ports, in order to protect it from excessive heat-exposure.

Note that the left-hand buttressing angle fits directly up against the skew bricks inside the kiln wall, with short flat-bar braces connecting it to the corner angles outside the kiln, and thus it is hidden from view inside the kiln wall when the kiln is completed. Normally, this cross-member would be placed outside the kiln wall as with the other cross-members. In this design, the kiln and chimney share the same 9” wall, and thus if the cross member were on the outside of the kiln wall it would be exposed to the heat and corrosive flue gases inside the chimney and would fail quickly. In this design, it is inside the kiln wall, spaced away from both the kiln hotface and the chimney interior.

The Arch
This kiln features a 4 1/2” hard brick arch plus a 4” layer of castable insulating refractory, with a single thickness of aluminum foil separating the two. The arch extends the full distance from the outside front face to the outside back face of the kiln, and the kiln is five bricks deep front to back on the outside.

This kiln is four bricks wide inside, which is 36”. Using the specifications in the A.P. Green Pocket Refractory Handbook, an ideal 36”-span arch for this kiln has a rise of 2.3” per foot, a center rise of 6 15/16”, and an inside radius of 2’ 15/16”. This arch requires 18 #1 arch bricks and straight brick to the other to get the appropriate curvature and span. That means 18 front-to-back rows of #1 arch bricks and 1 row of straight bricks. With this configuration, the straight brick would always be placed as the key-brick row at the top, but it never fits perfectly, and a preferable solution is to omit the straight bricks and cast the key-brick row at the top with A.P. Green Mizzou castable or another high-duty hard castable.

The arch tables provided in Olsen or in a refractory supplier’s information are always just a generalized guideline, and sometimes when you are laying the arch you will find that adjustments must be made. There is often a little discrepancy in the size of bricks, and it is logical to assume that this is also true of the arch brick taper. The slightest discrepancy in angle can make a big difference in how many rows of straight bricks are needed in the arch. Always watch the joints between bricks and make sure that each one represents a true radius of the curve. In building this arch from the #1 arch bricks we have been using, we have find that the arch bricks start tilting off-radius about four or five rows up from either side unless we add a row of straight bricks at that point on either side. At the top of this arch the key-brick row ends up being about 1 ¼” wide, and we always cast it with Mizzou castable. This gives us an arch composed of sixteen rows of #1 arch bricks, two rows of straights, and the cast key-row at the top.
Building the Arch Form
The arch form is a temporary structure that supports the arch while the bricks are laid. Be sure to save your arch form. Generally, by the time a soda kiln needs to be rebuilt, the arch bricks cannot be re-used for other than landfill, and the arch can be knocked down without using the arch form. But of course you will use it again if/when you rebuild the kiln.

To build your arch form you will need a sheet of ¾” plywood, one 8-foot 2x4, a sheet of 1/8” Masonite or some other similar, flexible sheet material, several dozen 3” drywall screws, a box of 100 1” drywall screws, and a yardstick. It will also help to have two electric drills – one for drilling pilot holes and the other for installing the drywall screws.

The flexible sheet provides a smooth, sturdy curved surface over the plywood ribs, and before proceeding you must subtract the thickness of this material from the radius given above, so that your finished arch form will come out with the correct radius. Assuming you are using 1/8” Masonite, the corrected radius for making the ribs would be 2’ 2 13/16”.

You can easily adapt the yardstick to serve as a compass to make the initial rib for your arch form. Drill a pencil-size hole near one end and affix a pencil. Measure exactly 2’ 2 13/16” and install a drywall screw protruding from the same side as the point of the pencil.

Near one edge of the plywood sheet, draw an arc with this compass. With the yardstick, measure a point across the arc that is exactly 35 ½” and draw a line. The width is only 35 ½” to give clearance for easy placement and removal of the arch form. This initial measurement gives you an idea of the size of each rib, and you can now reposition if necessary to make the best use of the plywood. Cut out the first rib and use it as a template to trace and cut four more ribs. Six inches in from either end of the straight edge of each rib, cut a notch the size of a 2x4 (remember that the standard 2x4 is actually 1 ½” by 3 ½” but measure yours to be sure).

The arch is five bricks deep from front to back, which is 45”. Cut two 45” pieces of 2x4, and fasten them in the notches of the ribs with 3” drywall screws. Drill a pilot hole in each case to prevent the plywood and the 2x4s from splitting. When this assembly is done and sitting upright on the ground, the two 2x4s will be laying parallel inset into the notches in the plywood ribs, and the ribs will be standing vertically, one placed right at each end of the 2x4s, and the other three ribs evenly spaced between, creating a series of curves corresponding to the underside of the arch.

Carefully measure the length of the curved edge of one rib, and cut a piece of Masonite to this length and 45” wide. Masonite is quite hard, and you will probably need to drill a pilot hole for each screw as you proceed. Starting at one edge of the curve, attach the Masonite to the ribs with 1” drywall screws. This will require two people, one bending the Masonite tightly against the curve while the other one drills holes and installs the screws.

With good quality plywood and with screws installed as close as possible to the ends of each rib, it is possible to hold the Masonite tightly against the ribs even at the ends. If this proves problematic, a solution is to inset a piece of 2x2 stock parallel to the 2x4s in notches at each end of each rib and trim one edge to conform to the curve of the ribs in order to provide a front-to-back support to attach the edge of the Masonite with row of 1” drywall screws.
Placing the Arch Form and Laying the Arch
The arch form will be supported by the back wall of the kiln and by the front stub-wall on the right, but on the left you will have to build up a temporary support with cinderblocks and bricks. In all cases, you will achieve the final level for placement of the arch form by using wood shims and a set of four wood wedges. The wedges should be six inches long and should taper from 1” to ¼” over that length. Do not taper the wedges down to a knife edge, because you need a flat surface to drive them out in order to “spring the arch.” Set the arch form in place, and raise it up with a combination of shims and wedges to visually get the outer edges of the arch form level with the lower leading edge of the skew bricks. Place arch bricks in the correct position at the front and back ends of the first row on either side of the arch form, adjust the height of the arch form until the lower edges these arch bricks line up perfectly with the lower edge of the skew bricks at all four corners of the arch.

Lay the arch from both sides simultaneously and work towards the center, beginning and ending every other course with a half-brick in order to stagger the seams and produce a locked arch. If any brick are trimmed, be sure to brush or blow off all dust, preferably with compressed air. If you neglect this, the dust will inevitably sift down on wares being fired.

If you were building with IFB, you would lay up the necessary rows of arch bricks on either side right to the top, and then trim some IFB to size to form the final row of key bricks. As mentioned earlier, with a hardbrick arch it only makes sense to cast the key-row with a hard high-duty castable like Mizzou. With a long bar clamp you can clamp a scrap piece of board to the front and back ends of this gap before you cast the key row. It is also a good idea to make a series of tapered wood wedges and gently tap them into this gap to spread the bricks before casting the key row. Do not tap in the wedges too tightly, or it will cause gaps to open up at the lower edges arch bricks further down the arch, which would result in a loose arch.

Soak the adjacent rows of arch brick liberally with water before casting the key row. All air-set castables must retain their moisture while they set, which generally takes at least 24 hours.

Springing the Arch
Once the arch is constructed and the key bricks are snugly in place (or the castable key row has air-set to maturity), the tapered wedges are driven out, which drops the arch form and “springs the arch.” The wedges should be driven out a little at a time at all four corners so as to drop the arch form slowly and evenly.

The Insulation Layer Over the Arch
Since the arch is hardbrick, the insulating layer is essential for heat retention, and it also provides critically important rigidity, lessening the flexing of the arch. That reduces the amount of material sifting down on the wares, and makes the arch last longer. However, for proper expansion and contraction of the two layers, they should not be bonded. This is easily prevented by laying down a layer of aluminum foil before adding the insulating layer.

There is no reason to pay the price for commercial castable insulating refractory for an external insulating layer over an arch. You can easily make your own insulating castable with a mixture of 40% sand or grog (builders sand, river sand, crushed scrap bisqueware, or crushed scrap IFB), 40% sawdust or perlite, and 20% fireclay. For an arch exposed to the
weather, reduce the sand or grog to 30% and add 10% Portland cement. If your kiln is in an open shed, you can use sawdust or crushed walnut shells. This is only viable on a kiln in an open shed, because the combustibles will continue to create considerable smoke over many firings as they slowly burn out. Any of these mixtures without Portland cement will shrink considerably in drying. Just go back with the same mixture and fill the cracks until no more cracks form.

The Bagwall
In some gas kilns, bagwalls are not necessary, but they are almost always present in salt and soda kilns in order to provide a specific firebox area of maximum heat and turbulence to encourage effective vaporization of the salt or soda before it affects the wares, and to prevent the sodium vapors from hitting the wares too directly. Bagwalls are always necessary in gas kilns with side-mounted burners, in order to keep the flames from impinging directly upon the wares. In a salt kiln, the bagwalls must be constructed from hardbrick laid flat, giving a 4 1/2” thickness. Soda is less corrosive, and the bagwalls may be constructed from hardbrick laid on edge, giving a 2 1/2” thickness. The brick should be laid with no gaps in the areas directly in front of the burners, but with gaps opposite the pillars between the burners, and with plenty of gaps above the level of the burners. Since the burner ports are fairly closely spaced in this kiln, the first row of bag wall bricks will have to be cut to size in order to position the gaps directly in front of the burner ports. Two straight brick with 2 ½” cut off each end should be placed directly against the front and back walls, with a full hardbrick in the center. This leaves appropriate gaps directly in front of each of the pillars between the burner ports. For us, a bagwall three bricks high (13.5”) has worked well in this kiln.

When building the bagwall, all contact surfaces between bricks and where they touch the kiln walls and floor should be coated with appropriate salt-soda shelf wash (40% EPK, 10% ball clay, 50% alumina). This will greatly simplify the inevitable occasional reconstruction of the bagwall. As your kiln becomes well-used and the floor of the firebox becomes saturated with soda, the bag wall will tend to tilt quickly towards the burner ports. When that happens, lay the first course of hardbrick flat with no spaces to provide a foundation, and then proceed as described above.

The Stacked Door
This kiln is designed to have a loose stacked door 9” thick. The two courses should be laid simultaneously, with frequent bricks laid header-style tying the two layers together. All contact surfaces on these bricks and the mating surfaces of the door jambs and arch should be coated with salt-soda shelf-wash, and with repeated firings should be recoated as soon as they start to stick together or show any soda accumulation. Some people just use the ports in the back of the kiln to observe their cone packs and pull draw rings, but you may have reason to leave additional spyholes as you stack the door.

Build the door up to the bottom of the arch with all hardbrick, and then use IFB wherever you have to shape a brick to fit the arch. When you coat the mating surfaces with kiln wash, also coat the inside surface of the IFB to make them last longer.
Once the stacked door is in place, all larger cracks or gaps in the exterior face should be sealed with a caulking mixture of equal parts recycle slurry, sand, and sawdust, stiffened with dry crushed clay if necessary to get appropriate plastic clay consistency.

I recommend building a heavy-duty rack to accommodate the door bricks stacked in reverse order, especially if you want spyholes in consistent locations in the door from one firing to the next. The rack should incorporated a well-reinforced vertical or slightly back-tilted panel of ¾” plywood the size of the door, and a curved base extending from the lower edge of the plywood, matching the curve of the arch. As you unstack the door, place the bricks upside-down in order on this rack, and you will be ready to brick up the door very efficiently each time you fire. Such a rack drastically simplifies the task of stacking and unstacking a loose-bricked door.

**Burner Systems**

We use a burner system with three GACO MR-100 venturi burners, available from Ward Burner Systems, equipped with Baso valves and target pilot lights. The MR-100 is a very reasonably-priced venturi burner, and on high-pressure LPG with a pressure regulator at the kiln it produces plenty of BTUs. The regulator is located where the feed line from the tank reaches the kiln. After the regulator, the line divides into three, with a Baso valve and then a burner valve for each burner. The small target pilots tend to be very troublesome on salt and soda kilns, and the added expense of venturi pilots is well worth it. It is impossible to give all the details of the burner system or give detailed instructions for assembly here, so once you purchase the main parts (burners, burner valves, Basos, pilots, and pilot valves) from Marc Ward you may have to get some help in designing and assembling the rest of the burner system and plumbing.

With a hardbrick kiln, this burner system must be operated on high-pressure LPG with an adjustable regulator, so be sure to specify high-pressure LPG when ordering the burners, target pilots, and Baso valves. This kiln with this burner system will not work on low-pressure natural gas unless you decide to do an IFB hotface as described above. If you do want to build this kiln with the hardbrick hotface and wish to run it on natural gas, your only recourse would be to eliminate the center burner port, move the remaining ports in a bit towards center from the front and back walls, and install two Marc Ward power burners, which can be ordered in a configuration to deliver as many BTUs as you wish.

If you build this soda kiln with an IFB hotface and are firing on LPG with an adjustable regulator at the kiln, you can get away with two burner ports and two MR-100 burners. On natural gas, this kiln with an IFB hotface would still require three ports and MR-100s, or two ports with two power-burners.

The burner system should be assembled so that the face of each burner tip is about 1 ¼” from the face of the burner port. When the burner system is assembled you can temporarily support it in place with bricks and blocks while you finish the permanent support. Under no circumstances should you rely solely on the plumbing for support, and brick supports should only be used as a temporary measure.
The burners are attached to the angle-iron cross-member with standard automotive muffler clamps, available from any auto supply store. You will need 3”-inside-diameter clamps to fit around the tips of the MR-100 burners. The burner-support cross-member is 4” angle in order to extend far enough out from the kiln face to allow installation of the muffler clamps spaced back from the burner tip far enough to protect them from excessive heat and corrosion.

When the clamps are assembled around the burner tips, the steel cross-piece portion of the clamp will be at the bottom, with the threaded studs pointing downwards. I tell you this just to visualize the position of the clamps, but before you assemble them, weld the heads of two 3/8” by 4” bolts to the underside of the clamp cross-piece, just in towards the center from the stud holes so that the threaded shaft of each bolt points straight down. With the burner system blocked up in place, and with the clamps assembled loosely on the burner tips, mark and drill holes for the welded-on bolts in the burner-support cross-member. Place the clamps as far as possible from the burner tip while still within the range where the bolts can fit through holes drilled in the burner-support cross-member.

When you are ready to install the burner system, tighten the muffler clamp on each burner. Screw a 3/8” nut all the way up each of the threads of the welded-on bolts, lower the bolts through the holes in the burner-support cross-member, and screw another nut onto the threads below the cross-member. By changing the position of these two nuts, you can control the height of the burner tips in relation to the burner port.

The burners should be centered in front of the ports both horizontally and vertically, and as mentioned, the burner tip face should be 1 ¼” from the burner port face. Once you have all the adjustments correct, tighten the nuts on either side of the burner-support cross-member to lock the system in place. I recommend that you spray the burners, clamps, bolts, and nuts with a good high-heat aluminized paint, and re-spray them as soon as the paint shows sign of corrosion. The paint will burn off the burner tips almost immediately and you needn’t worry that about, but if you re-spray the rest of the burner system and the bolts and clamps frequently you can significantly retard corrosion on these parts.

**Brick List**
This list includes all of the brick needed plus extras. If you are planning to incorporate used brick, subtract accordingly from these amounts. You only need a few of the soaps at the ends of the header courses to minimize alignment of seams with bricks above and below, but they are ideal 9” kiln posts for salt and soda firing, and I have included plenty of extra. Cut standard hardbrick into fourths for 4 ½” posts, cut soaps into fourths for 2 ½” posts, and cut scrap kiln shelves into shims for fine adjustment of shelf height.

As mentioned earlier, this list is for an all-hardbrick hotface. If you choose to build your kiln with a hotface that is partially IFB, you will need to extrapolate from the plans to determine how many IFB to substitute for hardbrick. These brick are all the standard 2.5” series, which refers to the height of the brick when it is laid in place, or to the maximum thickness (not width) of the arch bricks.
### Type of Brick

<table>
<thead>
<tr>
<th>Type of Brick</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-duty hard fire brick - #1 arch, 2.5” series</td>
<td>100 pieces</td>
</tr>
<tr>
<td>High-duty hard fire brick - straights, 9”x4.5”x2.5”</td>
<td>650 pieces</td>
</tr>
<tr>
<td>High-duty hard fire brick - soaps, 9”x2.5”x2.25”</td>
<td>50 pieces</td>
</tr>
<tr>
<td>High-duty hard fire brick - 45-degree skew bricks, 2.5” series</td>
<td>12 pieces</td>
</tr>
<tr>
<td>Insulating fire brick, 2300-degree, 9”x4.5”x2.5</td>
<td>425 pieces</td>
</tr>
<tr>
<td>High-Duty Castable Refractory (for casting the key at top of arch and for damper-slot lintel in chimney)</td>
<td>200 lbs dry-mix (mix strictly according to manufacturer’s instructions)</td>
</tr>
</tbody>
</table>

### Steel List

This list includes the steel needed for the welded frame and the chimney adaptor where the steel pipe starts. There is extra of most types in order to facilitate cutting whole pieces rather than splicing scraps together. This is all standard mild steel.

<table>
<thead>
<tr>
<th>Steel Stock Type and Size</th>
<th>Amount</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>¼” by 2” by 2” angle iron</td>
<td>60’</td>
<td>Corner verticals, front upper and lower cross-members, door sill vertical, arch buttressing cross-members</td>
</tr>
<tr>
<td>¼” by 4” by 4” angle iron</td>
<td>4’</td>
<td>Burner support cross-member – also acts as right side lower cross-member</td>
</tr>
<tr>
<td>¼” by 2” flat bar</td>
<td>30’</td>
<td>Rear upper and lower cross-members, left side upper and lower cross-members, right side upper cross-member</td>
</tr>
<tr>
<td>1/8” by 2” flat bar</td>
<td>3’</td>
<td>Chimney adaptor collar</td>
</tr>
<tr>
<td>1/8” plate</td>
<td>1 pc. 18” by 18”</td>
<td>Chimney adaptor base plate</td>
</tr>
</tbody>
</table>
Downdraft, Crossdraft Soda Kiln
Gas Fired, 21 Cu. Ft.
16 Cu. Ft. Stacking Space
Vince Piteika, 2005
Appalachian Center for Craft
Scale - Approx. 12:1

Front View, Showing
Door, Stub Wall, Charging
Port, and Steel Frame

Color Key
Hardbrick -----
Softbrick-----
Castable ------
Steel----------
Cinderblock ----
Plumbing ------
Downdraft, Crossdraft Soda Kiln
Gas Fired, 21 Cu. Ft.
16 Cu. Ft. Stacking Space
Vince Pitelka, 2005
Appalachian Center for Craft
Scale - Approx. 12:1

Back View, Showing Charging Ports/Spyholes and Bricklaying Patterns

Color Key
Hardbrick ----
Softbrick ----
Castable ----
Steel ----------
Cinderblock --
Plumbing ------
Steel Chimney Extending 6' Inside Hood Duct

Cast Insulation Layer Over 4 1/2" IFB Arch

Damper

Dotted Line Indicates Location of Flue From Firing Chamber to Chimney

Side View, Showing Brick Chimney, Steel Chimney Extension, Damper, and Location of Flue

Color Key
- Hardbrick
- Softbrick
- Castable
- Steel
- Cinderblock
- Plumbing

Downdraft, Crossdraft Soda Kiln
Gas Fired, 21 Cu. Ft.
15 Cu. Ft. Stacking Space
Vince Pitelka, 2005
Appalachian Center for Craft
Scale - Approx. 12:1