

LPG Burner System for a 20- to 30-Cubic Foot Crossdraft Kiln

Vince Pitelka, 2019 – www.vincepitelka.com

This handout accompanies my handout on “Building a Crossdraft Soda Kiln.” The kiln described in that handout is a 20-cubic foot soda kiln, but I have the same burner system on my 30-cubic-foot soda kiln and it works great. Both kilns are all hardbrick inside, and this burner system uses three GACO MR-100 venturi burners with an adjustable regulator. The three burner ports in the kiln are each 4.5” wide, and the pillars between them are 7” wide. With this design, the burners should be on 11.5” centers, but don’t take my word for it. Every kiln is a little different, and bricks can be a little different, so always make a very accurate cardboard or posterboard template of the exact spacing of the center points of the three burner ports on your kiln. Have the template handy when you are assembling your burner manifold as described below, in particular the section with the elbow and two tees that accommodate the branches where the burners are attached. That’s the piece that establishes the spacing of the burners.

This burner system could be adapted to various configurations of crossdraft kilns. If you are building a reduction kiln that is not salt or soda, it should be constructed with a IFB interior except for hardbrick in the high-stress areas (firebox, burner ports, flue, floor, spyholes, door jambs), and in that case, two GACO MR-100 burners would be adequate on high-pressure LPG. All the parts and instructions mentioned below would still apply, except that the burner spacing would be very different.

Salt and soda firing produce highly corrosive fumes, and the burner tips are 3” from the face of the burner ports to prevent rapid deterioration of the cast iron burners. On a reduction kiln that is not salt or soda, the burners should be mounted with the tips only ½” from the face of the burner ports.

On this system, only the center burner has a pilot light and thermocouple probe. That’s fine for a home kiln installed in a detached kiln shed away from your home, but for an installation attached to the home or inside a studio, or for any institutional installation, you would normally be required to have a Baso valve, pilot light, and thermocouple probe for each burner.

If you like to preheat overnight as I do, that is accomplished with the center burner with the other two ports blocked off with half bricks. The preheat is the only time that any of the burners are operated at a pressure setting so low that there is any risk of the pilot and burner flames being extinguished by a stiff gust of wind. On the soda kiln at the Appalachian Center for Craft, we used inexpensive “target pilot burners” such as you find on a hot water heater. Those are easily blown out by a gust of wind. For that reason, on our salt kiln at the Craft Center I installed a Ransome B-1 venturi burner as the pilot, and we never had it blow out from a gust of wind. That’s the pilot burner used in this system. It costs more than one of the MR-100 burners, but it’s completely worth it. Don’t skimp on the pilot burner.

If a sudden powerful gust of wind were to blow out the pilot and center burner flames during an overnight preheat, the Baso valve would do its job. The thermocouple probe would cool, and the Baso would shut off the gas supply. At all other times in the normal operation of this system, the burners are set at a high-enough pressure that they cannot be blown out by any conceivable wind gust. The pilot burner is lit with a torch while holding down the button on the Baso valve until the thermocouple probe is heated, at which point the button can be released. When the center burner is turned on, it will be lit by the pilot burner.

When the outer burners are turned on, they must be lit with a torch. Because those two burners are always operated at higher pressure settings, red heat will develop very quickly within the firebox. It is hard to imagine the circumstance where a gust of wind could ever blow out those outer burners, but if it somehow happens, the red heat within the firebox would reignite the flame.

There is always some discrepancy in pipe fittings, especially in the degree to which they are threaded internally on the fittings or externally on each end of the straight pipe sections. My instructions below for assembling the burner manifold explain the exact fittings I used to get the correct burner spacing, but that might not work for you. The materials list for this burner system includes extra pieces which should accommodate any variation, and as you assemble your manifold, if my suggested fittings don't work, you can select the appropriate pipe nipples to give the exact spacing you need. Expect some trial and error before you find the combination that gives you the exact correct spacing. Having a burner 1/8" off center is not a big deal, but any further than that will be a problem, especially on a salt or soda kiln where the burner tips are spaced out from the ports. Leave the labels on the pipe fittings or save the packaging, and if you wish you can return the unused fittings for a refund.

Refer to the Photos

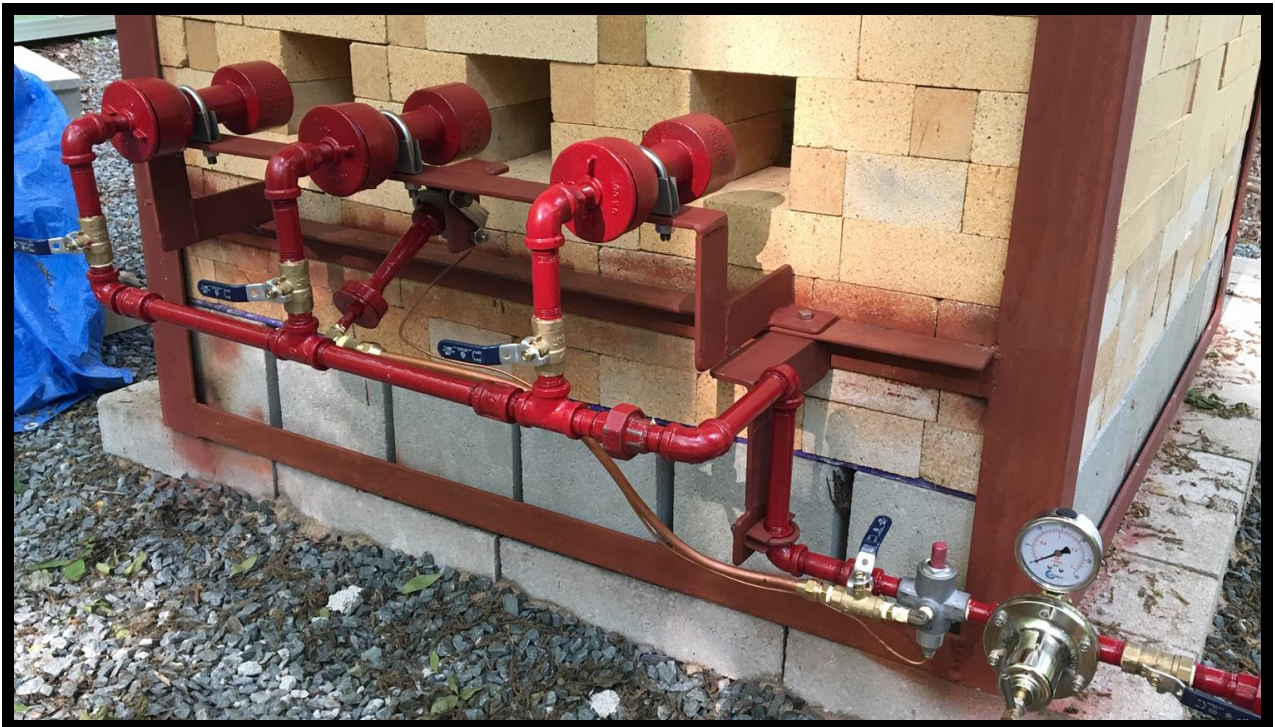
Several photos below give you a good sense of the construction of this burner system and its support frame, but while working on your system, go to my website at www.vincepitelka.com, click on "Gallery," and in the drop-down menu, click on "Studio and Soda Kiln." Scroll down to the bottom and you'll find an extensive selection of images showing details of the burner system on my soda kiln. Aside from the possible discrepancies explained in the paragraph above, all the parts and fittings listed are the same whether the kiln is 20 or 30 cubic feet or something in between.

Use the Correct Pipe and Fittings

Building and safety codes require that all above-ground plumbing in this kind of installation be done with black iron pipe, except for the gas valves, which are standard bronze ball valves with 90-degree handle movement, approved for use with gas plumbing, and the smaller brass fittings and copper tube that plumb the pilot burner. The gas valves are available at any home improvement center or

on amazon, and you can see an example by going to www.grainger.com and entering "48XH83" in the search box.

"NPT" stands for "national pipe standard," and refers to the standard pipe sizes for all black iron and galvanized pipe. All of the pipe and fittings are $\frac{1}{2}$ " NPT except for two $\frac{3}{8}$ " NPT nipples, one $\frac{1}{2}$ "- $\frac{3}{8}$ " NPT bushing reducer, and one $\frac{1}{2}$ " to $\frac{3}{8}$ " bell reducer (they go on either side of the BASO valve, which has $\frac{3}{8}$ " female NPT ports), and the pilot burner plumbing, which is all $\frac{1}{8}$ " NPT and $\frac{5}{16}$ " copper tubing.



Parts List – Pipe and Fittings

Black Iron Pipe (available from plumbing supply or home-improvement center). NPT stands for national pipe thread, and is a national standard. Note that any short NPT pipe length that is threaded on both ends is referred to as a nipple. Don't ask me why, but I am sure there is an off-color explanation. The list below includes extras in order to come up with the right combination for the spacing between the elbow and the two tees that form the burner attachments in order to place the burners squarely centered in front of the ports. Leave the labels on the individual pieces, or save the plastic packages. If you wish, you can return any that you don't use.

- 8 – close nipple, 1/2" NPT (close nipples are the shortest ones available)
- 4 – 2" nipples, 1/2" NPT
- 2 – 2 1/2" nipple, 1/2" NPT
- 6 – 3" nipple, 1/2" NPT
- 2 – 4" nipple, 1/2" NPT
- 2 – 6" nipple, 1/2" NPT
- 2 – 8" nipple, 1/2" NPT
- 2 – 2" nipple, 3/8" NPT

Black Iron Pipe Fittings (available from plumbing supply or home-improvement center)

- 7 – elbow, 1/2" NPT
- 2 – tee, 1/2" NPT
- 4 – straight coupling, 1/2" NPT (female both ends – be sure to get the heavy cast black iron straight couplings rather than the thin, smooth machined steel straight couplings)
- 1 – bell reducer, 1/2" to 3/8" NPT
- 1 – bushing reducer, 1/2" to 3/8" NPT
- 1 – union, 1/2" NPT

Brass Pipe Fittings (available from a good auto parts store such as Napa, from a home improvement center, or from amazon)

- 1 – 1/8" NPT street elbow (female one end, male the other)
- 1 – 1/8" NPT close nipple
- 1 – 1/8" NPT shutoff valve for pilot burner (female both ends)
- 1 – 1/8" NPT elbow (female both ends)
- 2 – 1/8" male NPT to 5/16" male flare connection, with flare nut

Other Fittings and Parts

- 3 – GACO MR-100 venturi burners fitted with orifices for high-pressure LPG (available from Ward Burner Systems) – burner spud is 1/2" male NPT connection
- 1 – Ransome B-1 venturi burner to serve as pilot burner (available from Ward Burner Systems) – burner spud is 1/8" male NPT connection

- 3 – 1 ½” standard U-bolt-type muffler clamps, such as the “1 1/2" Heavy Duty Saddle Style U-Bolt Muffler Clamps with Anti-Rust Coat” from amazon – these are to mount the three GACO burners to the fabricated steel burner support
- 2 – 1 1/8” standard U-bolt muffler clamp – to mount the pilot burner
- 2 – Rolls of yellow Teflon tape (for gas connections – available from plumbing supply or home-improvement center)
- 4 – Ball-type gas valves (as described above), ½” pipe (available from plumbing supply, hardware store, home-improvement center, or amazon)
- 1 – Adjustable LPG pressure regulator capable of 0-20 PSI, preferably with ½” NPT ports (available from Mark Ward or from LPG supplier). Try to get one with ½” ports. Those are not easy to find, and if you get one with smaller ports, you will need to purchase appropriate nipples and reducers for that size, installed in the same fashion as the Baso valve.
- If the above LPG regulator does not come with a pressure gauge, you will need to buy a small 0-15 PSI pressure gauge and install it in one of the ¼” NPT ports in the regulator, which usually entails removing a plug pre-installed in the port. Use Teflon tape on the threads.
- 1 – Johnson Controls model H19RA high-pressure Baso valve (3/8” NPT ports) (available from Ward Burner Systems or from gas company), OR, Baso brand model B079HPLGJ2 “3/8" Automatic Shutoff High Pressure Pilot Gas Valve” available on amazon. Either way, these are expensive, and you will pay between \$200 and \$300. Check eBay, but it’s unlikely you will find one cheaper. You MUST use a high-pressure Baso. The readily-available low-pressure ones will not work for adjustable-pressure LPG.
- 36” – 5/16” copper tubing (hardware store, home-improvement center, or auto-parts store) – for hookup from Baso valve to pilot burner
- 4 – 36” thermocouple for Baso valve (3 extras), such as the “Emerson TC36 Universal Thermocouple, 36-inch” available on amazon. These are inexpensive, and they do not last long on salt and soda kilns, so be sure to get the extras.
- 1 – ½” U-bolt-type wire rope clamp. The best I could find on amazon is a package of three – “3Pack M12 Luckyme Wire Rope Clamp Stainless Steel 1/2" Wire Rope Cable Clamp.” You only need one, but it is the best thing I found for securely mounting the thermocouple probe.
- 1 – Small tube or can of anti-seize compound, available from auto parts store. Normally used on bolts and fittings that might seize up over time from heat and/or corrosion, and those are always a problem on salt and soda kilns. You will use this compound on all the mounting bolts on the mounting frame, muffler clamps, cable clamp, and the threads on the center collar of the pipe union.
- ¼” by 2” flat bar as needed for the burner support frame.
- A strip of stiff sheet metal approximately 4” by ½” to support the thermocouple probe. The handle of a cheap stainless spoon or fork is ideal.

Required Tools for Assembly of Burner System

- Two pipe wrenches for assembly of the pipe components. I used a 12" and a 14", and that worked fine.
- 12" adjustable wrench (Crescent wrench) for the components that have flat facets, like the gas valves, Baso valve, and regulator.
- Small tubing cutter to cut the 5/16" copper tubing for connecting the pilot burner.
- Tubing flaring tool to flare the copper tubing at the connections for the pilot valve and pilot burner. The "Wostore Auto Double Flaring Tool Kit" from amazon is ideal. If you haven't used a flaring tool, get proper instruction from someone who knows how.
- Small adjustable wrench to tighten the fittings at either end of the copper tubing to the pilot burner, and to tighten the attachment nut for the thermocouple lead.

Assembling the Burner System

Except in rare cases of self-sealing connections, all of the threaded pipe connection must be sealed with the correct yellow Teflon tape approved for gas plumbing. Wrap the tape at least four times around the male pipe thread, always in a clockwise direction when looking at the end of the pipe. Note that either end of a pipe union is permanently attached to the adjacent pipe and must be sealed with Teflon tape, while the threaded collar in the center that allows the system to be disassembled at that point has a bronze seat and does not require Teflon tape on those threads. Similarly, flare nuts on copper tubing fittings have a flared seat that requires no Teflon tape on the threads.

This burner manifold is assembled from one end to the other, carefully checking the spacing between the center of each burner branch in order to ensure correct burner placement. If you need to use a configuration other than what I specify below, remember to consider the portion of the nipple that is threaded into the elbow, tee, or straight connector. As mentioned, this will take some trial and error before you get it right.

NOTE: If you have applied Teflon tape and fully tightened a connection and then need to dismantle it, you must clean the joint and apply Teflon tape again before reassembling.

As mentioned above, make a cardboard or posterboard template that shows the exact spacing of the center points of the burner ports on your kiln. **DO NOT BYPASS THIS STEP – IT IS CRITICAL!** While assembling this key portion of the burner manifold and tightening the fittings, check it against the template frequently to make sure that the side openings in the elbow and the two tees align very closely with the centers of the three burner ports.

As mentioned, below I specify a simple combination of two pipe nipples and a strait coupling that gave me the perfect burner spacing, and this will probably work on any three-burner system with the same burner spacing. If it doesn't work for you, then you will have to pick and choose among the

different lengths of pipe nipples and one straight coupling to get the correct spacing between the branch connections (and thus the burner port centers). Worst case scenario, you might have to use three shorter nipples and two straight couplings to get the correct spacing in each of the two sections between branch connections (the left elbow, the center tee, and the right tee). The supply list below includes enough straight couplings to accommodate that.

Some Notes on Tightening Plumbing Connections

There is a certain technique to properly tightening plumbing connections. Aside from the swivel connections that attach the two halves of a union or the flare fittings on the copper tubing, all plumbing pipe and fitting connections are tapered, and with Teflon tape will be properly sealed when sufficiently tightened. As they are tightened, it becomes more and more difficult to tighten them further, due to the taper of the threads. When you are assembling pipe connections, components like tees and elbows need to be tightened so that the ports point in the appropriate directions. With each connection it is your call when to stop tightening and when to go for one more complete revolution if you think the connection is not tight enough. ***NOTE: Under no circumstances should you back up the tightness of a tapered pipe connection to get the desired position.*** That will destroy the seal you have created with the Teflon tape, and the connection will leak. If you have accidentally tightened a connection beyond the ideal angle of alignment, your only choices are to continue to tighten further until you come around to the ideal angle again, or to disassemble the connection, clean off the threads, re-apply Teflon tape and reassemble the connection.

When tightening the pipe connections adjacent to the Baso valve or the LPG regulator, be aware that those two components are aluminum. Overtightening those connections could risk cracking the aluminum body. Just be cautious when installing the fittings in those components, and avoid overtightening. When installing additional fittings adjacent to the Baso valve or pressure regulator, use a pipe wrench on each side of the connection so that rotating the pipe does not further tighten the fittings in the Baso valve or the pressure regulator.

Start with the left-hand elbow that accommodates the left burner branch, and add fittings in the exact sequence and configuration identified below. Except where specified, all fittings are ½”.

- Elbow pointing upwards
- 8” nipple
- Straight coupling
- Close nipple
- Tee with side port pointing upwards
- 8” nipple
- Straight coupling
- Close nipple
- Tee with side port pointing upwards
- 2” nipple

- Pipe union to allow future disassembly of the manifold at this point
- Close nipple
- Elbow pointing back towards the kiln wall
- 8" nipple to bring the plumbing back closer to the kiln wall where it is less vulnerable to physical damage
- Elbow pointing downwards
- 6" nipple to bring the plumbing down lower where the expensive Baso valve and pressure regulator will be less exposed to heat from the burners
- Elbow pointing to the right
- 3" nipple
- ½" NPT to 3/8" NPT bell reducer
- 3/8" NPT 2" nipple
- Baso valve – be sure to observe the directional arrow or else "Inlet" and "Outlet" stamped into the housing, and install the Baso valve appropriately for the direction of gas flow. Install with the button facing upwards.
- 3/8" NPT 2" nipple
- ½" NPT to 3/8" NPT bushing reducer
- Pressure regulator – be sure to observe the directional arrow or else "Inlet" and "Outlet" stamped into the housing, and install the regulator appropriately for the direction of gas flow. Hopefully that will leave the adjustment handle facing outwards. If not, then install with the adjustment handle facing upwards, remove the pressure gauge, install a ¼" NPT street elbow, and reinstall the pressure gauge so that the gauge is vertical and facing outwards.
- 2" nipple
- Gas valve as the master shutoff valve
- 2" nipple
- Pipe cap screwed on hand-tight to keep critters out of the plumbing until the hookup is completed to the supply line from the tank. Whoever does the hookup will remove the cap and attach the necessary fittings to connect to their flexible line, which should be buried from the propane tank. If the propane company uses a plastic or copper line, be sure to place cinderblocks or some other appropriate protection around the line where it comes out of the ground and connects to the burner manifold in order to protect it from damage.

In each of the three branch connections (the first elbow and the two tees), install:

- Close nipple
- Gas valve (each burner must have its own valve) with the handle facing outwards
- 3" nipple
- Elbow pointed towards the burner ports
- GACO MR-100 burner (brass spud screwed into the elbow)

Once this assembly is completed, install the fittings for the copper tubing that will connect the pilot burner in the following order. Tear off some 2" lengths of Teflon tape and tear them down the center, or fold them in half down the center (so they are half the width). Apply these to all the male threads.

- Remove the 1/8" pipe plug from the side of the Baso Valve (if there is a plug)
- Install the 1/8" street elbow in the port on the Baso valve so that the elbow is pointing towards the burners. The pilot burner will be installed beneath the center burner.
- Install a 1/8" close nipple in the female port of the street elbow
- Install the 1/8" shutoff valve on the close nipple
- Install a 1/8" male NPT to 5/16 tubing flare fitting in the other port of the shutoff valve
- On the Ransome B-1 pilot burner, install the 1/8" elbow.
- Install the other 1/8" male NPT to 5/16 flare fitting in the other port of the 1/8" elbow.
- Wait until the whole burner assembly and support frame are installed on the kiln to cut and install the 5/16 copper tubing between the shutoff valve and the pilot burner.

Building the Support Frame

I am not providing exact dimensions for the support frame because of variations in individual kilns, but I think you'll find it easy to work with the instructions below. The photos in this handout in combination with the ones on my website show the general layout, and you can adapt as needed. The lower right-side crossmember on the kiln frame acts as a connection point for the burner support frame, and the crossmember should be mounted low enough that it is unaffected by the heat of the burners. That means that the burner support frame needs to extend outwards and upwards to support the burners, as you can see in the photos.

Aside from the small strip of stiff sheet metal that supports the thermocouple, the steel stock for the support frame is all 1/4" by 2" mild steel flat bar, which is relatively inexpensive and readily available from any steel supplier. If you have 1 1/2" or 2" by 1/8" or 1/4" angle iron available, that could be substituted for the flat bar.

- Once you have completed the burner and manifold assembly as explained above, block it up on any combination of cinderblocks, bricks, and/or wood shims so that it is positioned exactly in place, with the burner tips approximately 3" from the outside face of the burner ports and centered both vertically and horizontally in front of the ports.
- Attach one of the 1 1/2" muffler clamps to the throat (the narrow section) of each of the GACO venturi burners, with the threads of the U-bolts pointing downwards. Tighten the nuts only finger-tight.
- Cut a piece of 2" by 1/4" flat bar long enough to extend approximately 4" beyond the center of the two outer burners.
- With a straightedge and a sharpie, mark a line lengthwise down the middle of the flat bar.

- Hold the flat bar under the burners up against the threaded ends of the U-bolts with the Sharpie line on top, and carefully mark the position of all the U-bolts along that line.
- The U-bolts on muffler clamps of this size will be either ¼” or 5/16” in diameter. Each burner mount will require two holes corresponding to the two prongs of the U-bolt. Center-punch each hole location and drill the holes 1/16” larger than the U-bolt diameter, just to give a little leeway for inaccuracy. It won’t matter once the burner system is mounted on the frame and the nuts are tightened.
- After the holes are drilled, remove the nuts from the muffler clamps.
- With the U-bolts still around the throat of the burners, and the lower portion of the muffler clamp still in place on the U-bolts beneath the throat of the burner, insert the threaded portion of the U-bolts through the corresponding holes in the flat bar (with the lower portion of the muffler clamp between the burner and the flat bar).
- Install the nuts on the underside of the flat bar and snug them up tight.
- Make sure that the whole assembly is still blocked up exactly in place with the burner tips spaced 3” from the face of the burner ports and centered horizontally and vertically in front of the ports.
- Measure from the kiln right-side lower cross member outwards and upwards to the ends of the flat bar, cut appropriate lengths of flat bar, and weld them in place so that both ends of the flat bar are securely supported. As is shown in the photos, my mounting frame has a welded tab which is bolted to the side crossmember, so that the whole burner assembly including frame is removable. That is optional, and you can weld the support frame directly to the crossmember.
- As indicated in the photos, fabricate a separate bracket (or weld an extension onto the existing support frame) to support the plumbing down near the Baso valve. This is an added safety feature, because without it, there’s a lot of unsupported pipe with the weight of the Baso valve, pressure regulator, and master shutoff valve. There’s a second 1 1/8” muffler clamp in the supply list to be used on this bracket.

Building the Pilot Burner Support; Plumbing the Pilot Burner and Attaching the Thermocouple

As indicated in the photos on the website, there must be an additional extending downwards from the support frame below the center burner to support the pilot burner. The pilot burner is centered directly beneath middle burner and is aimed upwards at an angle towards the center burner port.

- Fabricate an extension arm to support the Ransome B-1 pilot burner with a 1 1/8” muffler clamp installed around the burner tip about 1” back, as is clearly shown in one photo on the website. This arm can be either welded or bolted to the burner support frame.
- Mount the pilot burner at an upwards angle so that the tip is just below and spaced a little back from the GACO burner tip, with the pilot flame aimed towards the lower part of the middle burner port. Be sure to mount the pilot burner so that the brass elbow on the spud points towards the location of the Baso valve.

- Dismantle the ½” wire rope clamp and discard the “cradle” portion, retaining the little U-bolt and the nuts.
- Find a strip of stiff sheet metal to fabricate a support for the thermocouple. The handle of a cheap stainless-steel spoon or fork is ideal.
- Cut the strip of sheet metal with length to spare in order to position the thermocouple.
- At one end of the strip (the larger end if you use a spoon or fork handle), drill a hole to fit over the lower U-bolt connection.
- At the other end of the strip, drill holes to accommodate the little U-bolt from the wire rope clamp.
- Attach one end of the strip under the nut on the lower bolt of the muffler clamp.
- Mount the thermocouple probe at the end of the strip, using the ½” wire rope clamp U-bolt inserted through the strip, with the nuts installed and tightened to hold the thermocouple probe securely in place.
- Bend the strip to position the tip of the thermocouple probe directly beneath the pilot burner nozzle, with the probe tip extending into the pilot flame about ½” away from the burner tip. There is a closeup of this on the website. You may be able to bend the strip with pliers, or you might have to remove it and bend it in a vise. The objective is to have the tip of the thermocouple probe in the pilot flame while keeping the rest of the thermocouple probe and the copper-clad lead as far as possible from the heat of the GACO burner and the burner port.

Installing the Copper Tubing to the Pilot Burner, Attaching the Thermocouple to the Baso

Once the support frame and burner system are mounted on the kiln, make sure that the brass elbow and flare fitting on the pilot burner are pointing towards the Baso valve, and the brass street elbow, shutoff valve, and flare fitting on the Baso valve are pointing towards the pilot burner.

- Measure the distance between the two flare fittings, add 6”, and cut that length of the 5/16 copper tubing.
- Slip a flare nut over one end of the tubing and use the flaring tool to create a proper flare.
- Repeat on the opposite end of the tubing.
- Bend the tubing to gracefully span the distance between the two male flare fittings, attach at both ends, and tighten securely. Do not use Teflon tape on these threads. The flare fitting is designed to be leak-proof once it is tightened.
- Bend the thermocouple copper-clad lead to conform to the path of the copper tube.
- Bend the attachment end of the thermocouple lead upwards, and screw the small attachment nut into the port on the bottom of the Baso valve. Tighten slightly with a small wench, but do not overtighten.
- Some people like to attach the thermocouple lead to the copper tubing to protect it from damage. If you decide to do this, use copper wire wrapped around the two and twisted tight.

Testing for Leaks

Once the support frame is in place and the burner system completed and permanently mounted, have an authorized person make the connection to the propane tank. Add a shot of dish detergent to a small cup of water, and put the mixture in a spray bottle (or apply with a brush). Assure that the three burner valves are in the closed position (handle at right angle to the pipe). Open the valve on the propane tank. Open the master valve, and screw in the pressure regulator handle until the pressure reads 10 PSI. Spray or brush the water/soap solution over all pipe joints and look for foaming, which indicates a leak. If there are any leaks, shut off the master valve, disassemble the offending section and tighten or replace the problem fitting or connection. If you have applied Teflon tape properly and tightened all the pipe connections properly, you won't have any leaks.