

Waste Oil Burner Instruction Sheet



This Instruction sheet is designed to help you convert a Beckett AF or AFG model burner to burn all types of waste oil. This conversion could be done on a new or a used burner. Most used burners are quite dirty so now would be a good time to disassemble and clean all the components. The step by step instructions walk you through the process of assembling a burner that has been completely disassembled. If you did not completely disassemble the burner, you may need to skip some steps. Burning waste oil may be dangerous. Most localities do not allow waste oil to be burned in a residence. Doing so would most likely void a homeowners insurance policy and you would be doing so at your own risk.

Safety Disclaimer:

We are in no way responsible for damages to you, your family, your property or anyone else's property caused by modifying your heating system. You are doing this at your own risk. If you are not familiar with heating systems and how they work, you should **NOT** be trying to modify one. Please be safe and think about the consequences of your actions, insurance is not going to pay for your house when they find out your botched heating system burned it down. Even worse, you cannot bring a loved one back from the dead if something happened. Please be responsible.

Nozzle Sizing

-5	.5gph	70k-80k BTU
-7	.65gph	91k-100k BTU
-8	.75gph	105k-115k BTU
-9	.85gph	119k-130k BTU
-11	1.00gph	140k-160k BTU
-15	1.50gph	210k-230k BTU
-20	2.00gph	280k-310k BTU (needs 2 stages of air)
-25	2.50gph	350k-390k BTU (needs 2 stages of air)

List of parts needed for conversion

1. Beckett AF or AFG burner (new or used) - **we highly recommend not modifying your ONLY burner**
2. Preheater block
3. Siphon nozzle
4. Cartridge heater
5. New Retention head (turbine style) - the factory retention head will not work for waste oil
6. Digital temperature controller
7. Solid state relay
8. Thermocouple (k-type) m6x1 (blocks are marked M6) if no marking, it is ¼-20 thread
9. Air solenoid, air pressure regulator, 0-15psi pressure gauge
10. Larger electrical box (4 11/16" x 4 11/16" x 2 1/4") may need extension box too
11. Float tank - you can make one using:
 - Ammo can (50cal.)
 - 3/8" float valve (McMaster-Carr part number 4652K11)
 - float (McMaster-Carr part number 9775k61)
 - float rod (McMaster-Carr number 90281a094)
 - ball valve (McMaster-Carr number 47865k41)
 - bulkhead fittings (McMaster-Carr number 5454k87)
 - mesh strainer (McMaster-Carr number 9875k512)
 - Reducing bushing (McMaster-carr number 4429k413)
12. 2" PVC test plug to block fuel pump opening
13. Fittings: ¼ NPT close nipple, ¼ NPT quick connect, ¼-1/8 NPT reducer,
14. 2 conduit nuts, 1/2" NPT close nipple, 7/8" washer to secure electrical box to housing
15. Wire restraint for electrical box (3/4")
16. Conduit fitting to secure air solenoid (not required if you are using on board air)
17. 3" or 4" NPT pipe nipple for fuel line through blast tube.
18. New blast tube if yours is not long enough or it is a V1 or L1 retention head style.
19. Beckett electrode holder part number 5653 (Only if your burner has an L1 or V1 retention head)

1. Install air inlet guide (pictured on the right) into burner chassis (AFG models only) using the pictured screws.



2. Install motor/blower wheel assembly onto burner chassis with 3/8" hex head slotted screws. The motor cord should be at the 11 o'clock position in order to go into the electrical box that will be mounted later.

3. Install tape or a strip of roof flashing (1.375" x 15.5") under the air band and install onto burner. The air band uses a short hex head slotted screw (faces up) and square nut (underside) to cinch properly. This cuts down on the amount of air the blower wheel moves.



4. Install air shutter with short hex head screws. This will most likely require some tape to get the air low enough when tuning the burner. The long tab points toward the housing.



5. Glue in 2" PVC test plug. Install the 3/8" hex head slotted screws where the pump mounted. The blower wheel should rotate freely. Leave the coupling out.



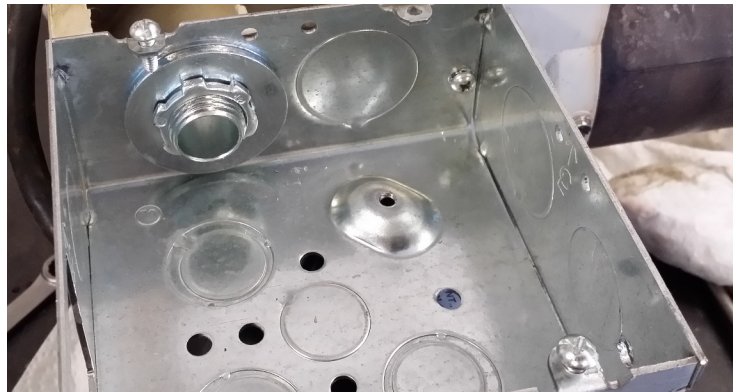
6. Install escutcheon plate as pictured with short hex head screw. Don't tighten at this time. The hole should be as far back as the slot in the burner housing will allow



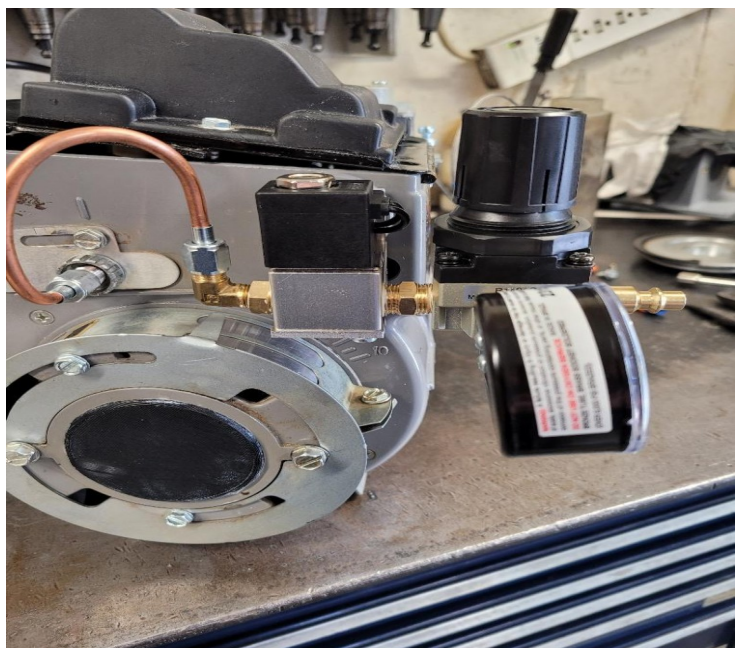
7. Install blast tube with four 1/4" hex head slotted screws. If your burner has an L1 or V1 retention head, you will need to remove the venturi from inside the blast tube. You can either drill out the spot welds or replace the tube. You will need to purchase a Beckett electrode holder to hold the electrodes and center the assembly in the blast tube if you had a V1 or L1 retention head.

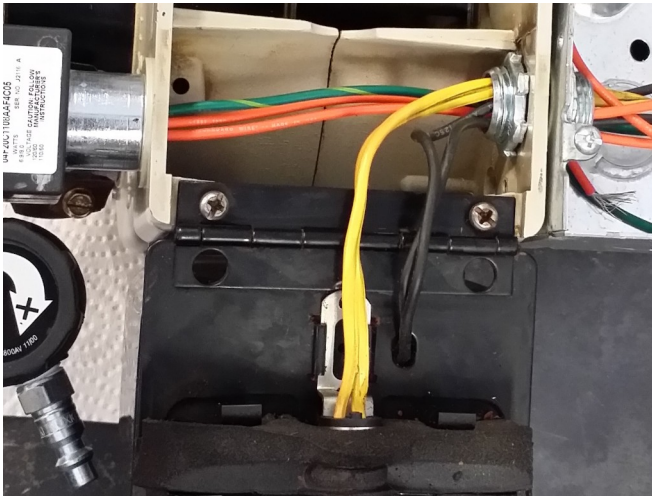
8. Use a larger electrical box with a cutout for the digital temperature controller. (4 11/16" x 4 11/16" x 2 1/4"). Drill hole in electrical box for mounting to the burner chassis. Use the existing hole in the housing as a guide. (8a in right picture) You should also drill a hole in the back of the box for a 1/4"-20 screw to mount the solid state relay (lower right corner of right picture). Mount electrical box with a 1/2" NPT close nipple that is 1 1/8" long with conduit nuts and a 7/8" washer. I like to use a 1/8" shim between the box and burner chassis where the screw goes thru to keep the box spaced out.

8a



9. Remove the small flare fitting off of the oil pump outlet (fitting on the left). Assemble the air end. Use thread tape or pipe sealant on the pipe connections. **DO NOT LET SEALANT OR TAPE GO OVER THE END OF THE THREAD AS IT CAN CLOG THE SOLENOID.** Install into the burner housing using a conduit fitting and run the solenoid wires into the electrical box.





- 10. Install ignition transformer using short Phillips head screws. The cad cell should be mounted under the transformer and all the wires put through into the electrical box. Make sure the eye of the cad cell is clean. Used ones are often sooted up and won't see light as well. In rare cases, the cad cell may need to be relocated into the blast tube to see light better. When doing this, use one of the blast tube mounting holes and a #6 screw and nut to mount the cad cell bracket and blast tube at the same time.

11. Disassemble the J-tube, electrodes, electrode holder and remove the nozzle holder from the J-tube. A word of caution here - many times this nozzle holder has Loctite on it and applying too much force will snap the end of the J-tube off in the nozzle holder. If it doesn't want to come off, you can try applying heat to the brass nozzle holder, but it has to go over about 450 degrees to break down the Loctite. If it does break, you can either re-thread the end of the J-tube (1/8" NPT) or make a new assembly up from pipe fittings. Remove the static plate from the electrode holder. Some plates are more round than this one. Remove set screw that secures this assembly to the j-tube. Give everything a good cleaning.



12. Drill out the end of the J-tube using a 1/4" drill to remove the filler rod that is inside. We don't want this restriction as this tube will now be carrying air.



13. Notch the bottom of the electrode holder to make clearance for the cartridge heater wires. You can use an electric grinder, air grinder or even a file. Be sure to deburr all sharp edges so the wire coverings don't get damaged and short out. You may need to add a chamfer to the other side to give even more clearance for the wires.



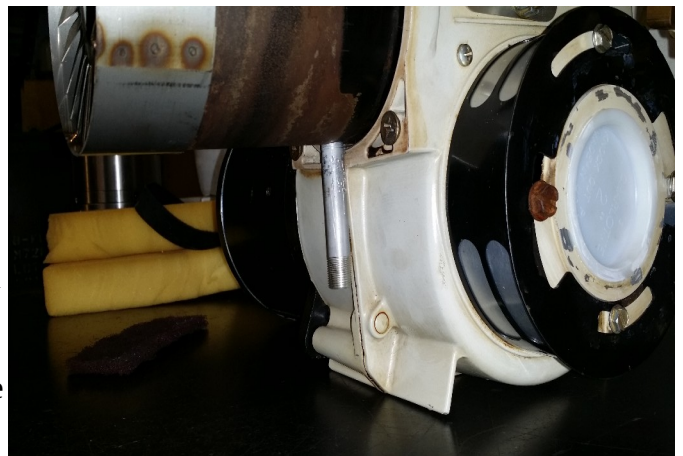
14. Re-point electrodes using a grinder or file. This helps to make the spark more consistent and stable. The points will wear over time.

15. Oil the o-ring on the new siphon nozzle and thread into the preheater block. It doesn't have to be super tight as it only seals a few pounds of air pressure. A light snug with a wrench is all that is needed. Repeated over-tightening will damage the preheater block. Always make sure the o-ring is lubricated.



16. Install the 1/4"-20 set screw in the top along with the electrode clamp and the 1/4"-20 nut. This will secure the assembly to the j-tube instead of the small set screw underneath. Install the electrode holder onto the J-tube with the centering plate facing away from the block so the electrode securing nut is accessible from the front of the blast tube. Thread the J-tube into the top port of the preheater block. It doesn't have to be very tight as we are just checking and marking positions.

17. Insert the preheater and J-tube assembly into the burner housing thru the end of the blast tube. You will probably have to slide the escutcheon plate all the way to the rear. You want the nozzle to be flush with the end of the blast tube. 1/8" further in or out is ok. If you are close, put the nut on the J-tube that secures it to the housing finger tight. Now you will need to figure out where the fuel tube will go down through the blast tube. **IT MUST GO STRAIGHT DOWN THRU THE BLAST TUBE.** If you try to run it up into the housing and out the side, there will be air pockets and the preheater will not drain properly along with nozzle drip problems. Included in the kit are two elbows and three different lengths of pipe. Ideally the fuel line will go down through the blast tube just in front of the burner housing. Mark and drill the hole thru the blast tube at this time. A 7/16-1/2" hole is required. Be sure to deburr the hole. If you just can't make your blast tube work, you can make a new longer one with 4" exhaust pipe.



18. Remove and disassemble the J-tube from the preheater block.

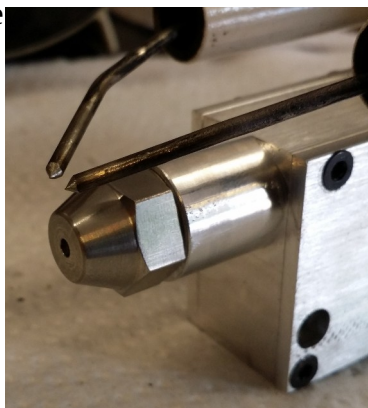
19. Modify static plate to allow cartridge heater leads, fuel line, and thermocouple to pass thru.

(A static plate is a sheet metal plate that mounts on the electrode holder . It allows for a high static air pressure from the blower wheel but offers a restriction of the air so that the retention head does not see the high pressure air. It allows for a much easier ignition as well as controls and evens out air flow to the head for smooth, efficient combustion. I highly recommend installing one during your conversion if your burner doesn't already have one. The 3 5/8" (pictured, recommended) round plate requires modification to allow the cartridge heater leads, thermocouple, and oil line to pass thru it. A 3 3/8" plate is also common in these burners and will work also. See the attached pictures for modification and installation.)



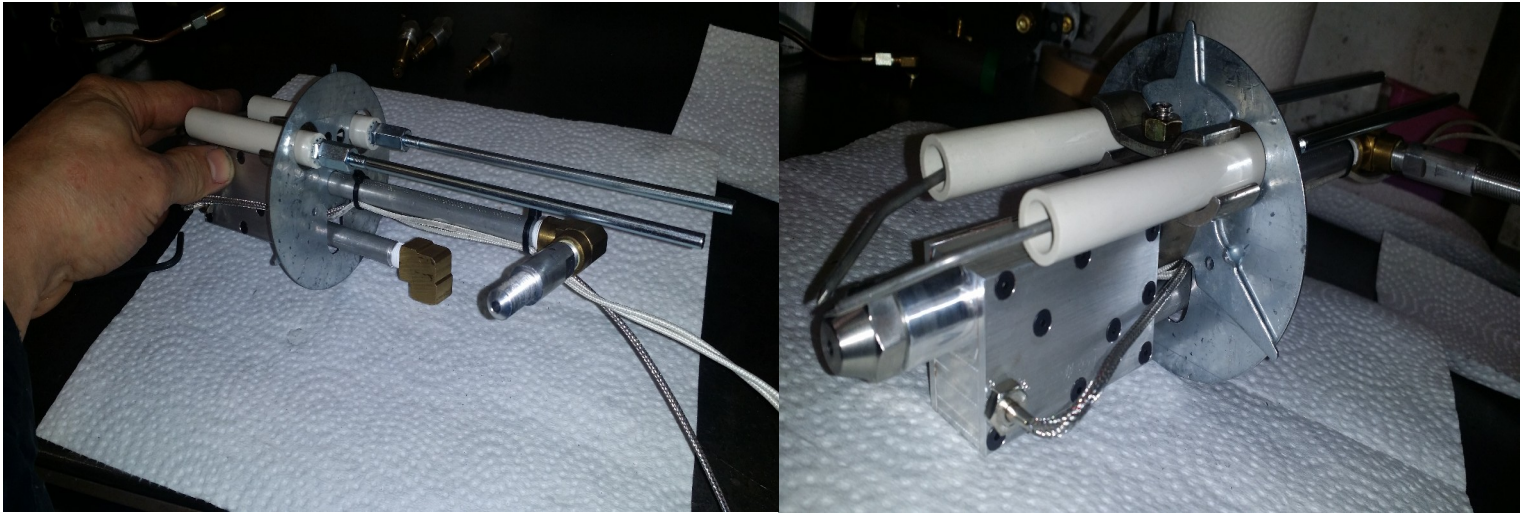
19. Preheater assembly:

- a. Install the modified static plate onto the electrode holder spider. (three point sheet metal side)
- b. Insert the cartridge heater. Make sure it is clean and do not use thermal paste here.
- c. Use thread tape or sealant on the J-tube threads on the straight end as well as the fuel line fittings.
- d. With the electrode holder loose on the J-tube, thread the J-tube into the preheater block and tighten. Make sure the bend points perfectly 90 degrees away from the side of the heater block. With the electrode holder pushed tight against the cartridge heater, tighten the set screw that secures the electrode holder to the J-tube.
- e. Install the fuel line fittings/elbow onto the preheater block.
- f. Make sure the fuel line is pointing straight down and the J-tube points straight out the side. Be careful not to damage the cartridge heater wires during this process.
- g. Install the electrodes into the holder and adjust the point dimensions. You may have to bend the electrodes around to gain more length. **You are looking for the tips to be 5/32" apart, 3/8" above the nozzle center line and 1/16" forward of the nozzle.** A note of caution here - the back of the electrodes needs to have at least 1/8" clearance to the metal electrode holder. If they do not, you may get random fail to start occurrences because the electrodes are shorting in the back and not at the tips where the fuel spray is. If your electrode tips are too short to bend appropriately, purchase new Beckett part number 5780 electrodes.



- h. Thread the thermocouple into the preheater block. DO NOT OVERTIGHTEN. The thermocouple **must bottom out in the hole** and not rotate for proper thermal conductivity. If it still rotates, put a small amount of aluminum foil in the hole. The retaining nut is very thin and fragile so be cautious as you tighten.
- i. Zip-tie the thermocouple and cartridge heater leads to the J-tube just before the bend. Make sure the cartridge heater is pushed into the block all the way before doing this. This also helps to retain the cartridge heater in the block.

20. At this point your preheater assembly should look like this. This particular unit has a replacement j-tube

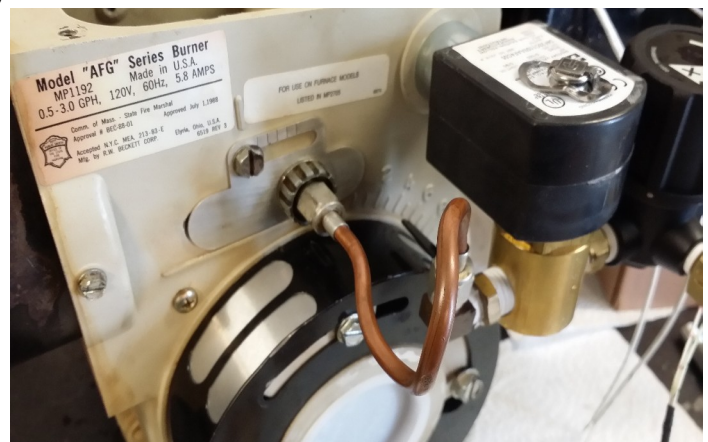


21. Insert the preheater assembly into the burner and put the escutcheon splined nut on the J-tube but do not tighten at this time. Run the wires into the electrical box.

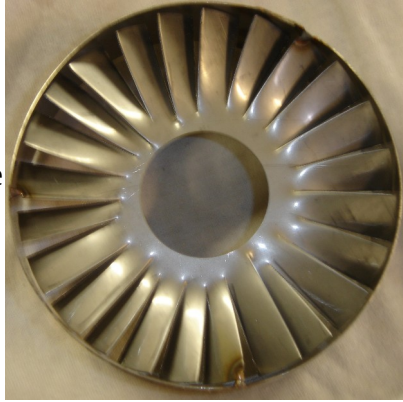
22. Install the fuel tube through the bottom of the blast tube and into the elbow attached to the preheater block. Be sure to use thread tape or sealant here but do not allow it to be on the very end of the tube where it could get in the fuel passage.

23. Make sure the nozzle is in the right position with the end of the blast tube and tighten the escutcheon nut. (flush to 1/8" inside blast tube and centered in the tube)

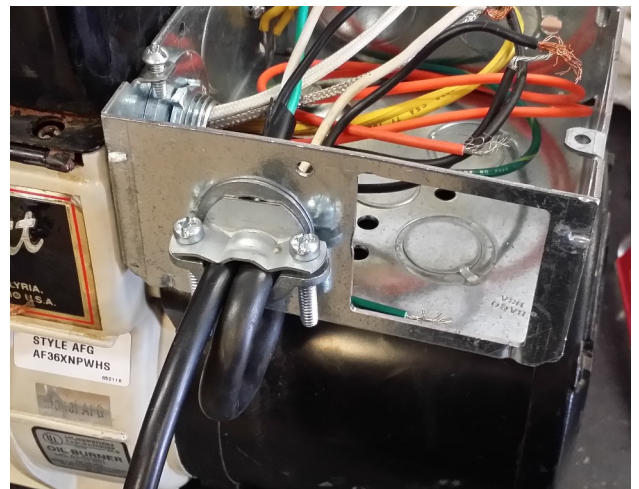
24. Install the 3/16" copper tube between the solenoid and the J-tube as pictured. Some bending will be required, be careful not to kink the tube.



25. Install the retention head. It just slips onto the blast tube. If the head is too loose, you can kink the band a bit to make it fit more snugly on the blast tube. **The nozzle should be flush with the inside of the head to 1/4" behind the head.** (you can bend the head in or out some if necessary). Make sure the nozzle is centered in the retention head. Sometimes you need to gently force the preheater to one side or another.



26. Close the transformer and check if the springs will touch the electrodes. Most times, the electrodes will need some length added here. You can use 10-32 all thread and coupling nuts. Alternatively, you can use 1/4" copper tube. In some cases, you can just bend the spring forward a bit. You just want a good connection between the transformer spring and electrode. When finished, close the transformer and secure it with the screw and or strap.



27. Install a wire restraint into the electrical box and insert motor wire and power cord as pictured.

28. Combine ground wire from power cord and solenoid (if necessary) and secure to box using green screw from original box.



29. Wire burner according to wiring schematic.

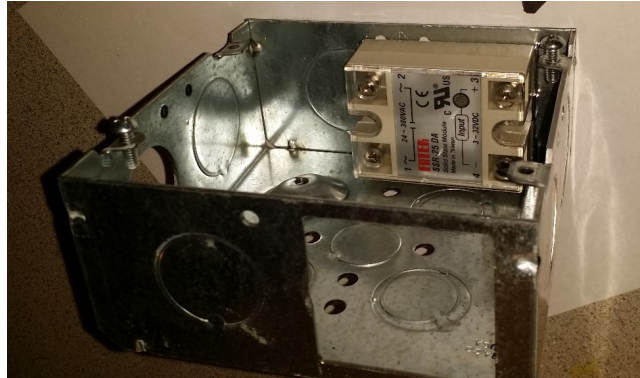
TIPS:

A. Make sure you observe + and - on the thermocouple leads (red is positive), or it will not work correctly. (NOTE: the temperature counts backwards)

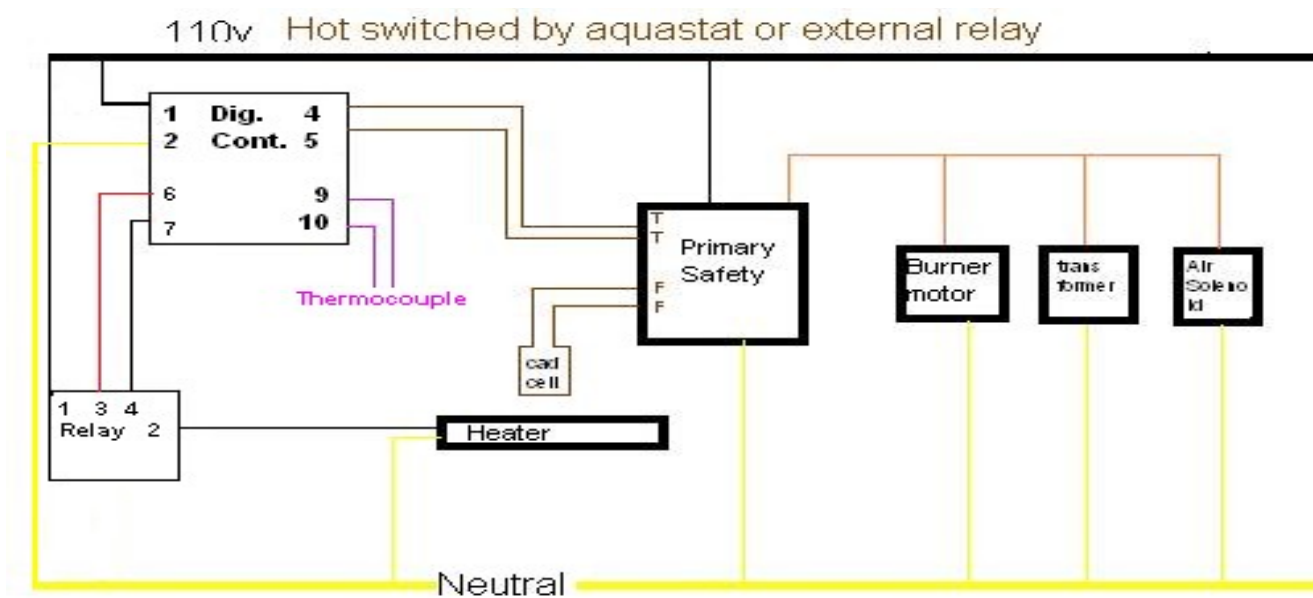
B. Tap ¼"-20 threads in the solid state relay so it can be bolted to the back of the electrical box.

C. Snip off the bottom retainer tabs on the digital controller so it can be more easily removed if it has to be replaced.

D. Set temperature on the digital controller to 140-200° F. Set alarm output to 20° less than the temperature setting. **ALL CONTROLLERS WE SELL ARE PRE-TESTED AND PROGRAMMED.** See included schematic for controller and condensed manual at the end of this guide. **Run TT terminals**



on primary safety through the alarm contact terminals on the digital temp controller; this will keep the burner from starting until the heater block reaches operating temperature. You cannot connect a thermostat to the safety anymore. See 24v schematic on page 14.



Pin numbers on controller and relay are for my units, others may vary
This is for the TET612/JLD612 Digital temp controller

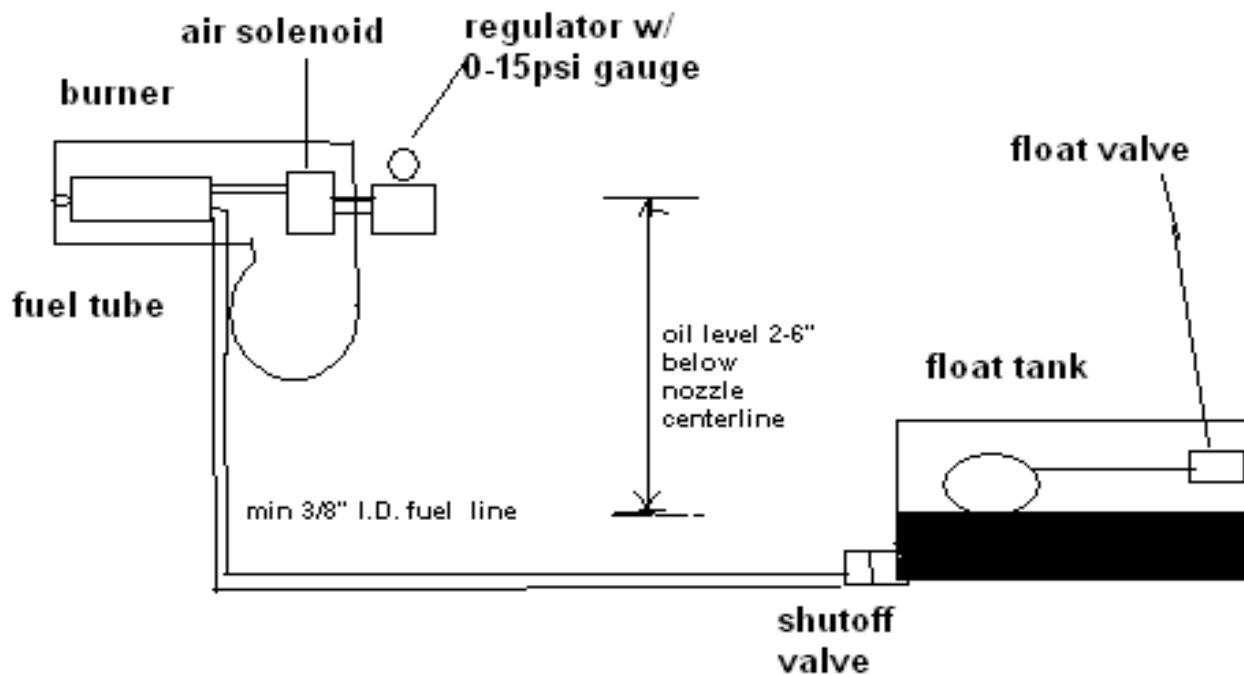
THE ABOVE SCHEMATIC IS FOR SOLID STATE RELAYS

******If your Primary safety has a delay or pre-purge, you MUST wire the air solenoid to the valve terminal******
(so that the cad cell does not see flame during the pre-purge or the safety will shut the burner down)
We recommend that the ignition transformer be wired with the motor so that there is constant spark anytime the motor is running.

30. You will need a float tank or other constant level device to maintain the oil level 2- 6" below the nozzle center line. You can use an ammo container for the tank. **Use minimum 3/8" inside diameter line** to connect the tank to the fuel inlet on the bottom of the blast tube and keep the fuel line length under 3'. Do not use push to connect fittings as the o-rings can leak under vacuum. The closer the oil level is to the nozzle center line, the higher the firing rate. You should filter oil to 50 micron or better and use a mesh filter before it goes into the float tank. We recommend a stainless mesh filter from McMaster-Carr. The float tank must be vented. Either drill a 1/8" hole in the lid or leave the lid unlatched. Failure to do this will cause nozzle drip while the burner is not running.



Plumbing Schematic



Tuning the burner

1. When tuning the burner, the air adjustment is critical to achieve a clean, low soot burn as well as efficiency of the boiler/furnace. In our experience, with a good airtight chamber, you will need to put aluminum foil or tape under the air shutter and air band. Only leave one set of slots for adjusting the air or only use the air shutter. The actual air adjustment will depend on the retention head as well as many other factors. We suggest setting the burner up with a meter. Our preference is to use a digital instrument to measure carbon monoxide, CO₂, O₂ as well as stack temperature and efficiency. If you do not have access to an instrument, we recommend cutting the secondary blower air (not air pressure) down until the flame gets lazy and orange and whisps upward or even goes out completely. A rumbling sound while firing is a sign that the air is low enough to allow this to occur. Only then do you have a starting point for the air adjustment and you can add just enough back in to make it burn cleanly. On motor oil or ATF, you should get a lot of light to medium gray ash in the chamber. If the ash is black, that's a sign that there is insufficient oxygen or the nozzle is not spraying properly.

2. Air pressure should be 5-15 psi. More air pressure atomizes better but also increases firing rate and flame length. More air pressure is also more difficult for consistent light offs (over 10psi). If your compressor has a large pressure differential, it is advisable to regulate the air down to 40psi going to the burner and then have the regulator on the burner take the air down to the required 5-15psi. This will make the air pressure much more consistent to the nozzle.

3. Oil quality and burner tune will have the biggest effect on maintenance intervals. Keep your oil storage at least 50°, cold oil causes a lot of problems. The cleaner the oil, the less you will need to service it. Waste veg oil tends to varnish up the nozzle and retention head and may have to be cleaned as often as once a week. Do not use brand new motor oil or transmission fluid for testing, it does not burn. If you are blending more flammable liquids with oil, you may have to lower the preheat temperature. The more flammable the fuel, the closer to room temp you will need to be. If you run straight diesel or heating oil, the preheater should be no more than 80 degrees. Motor oil should be 140-180 degrees. WVO should be 160-180 degrees.

4. Some chambers, especially wet base boilers (bare cast iron walls), are prone to unburnt oil on the floor and walls. Our suggestion here is a chamber liner made of stainless steel. You can test this inexpensively by using a piece of 6-8" flue pipe from the hardware store. It should only be 6-10" long and be about 1-2" away from the burner door or insertion wall. The nozzle and retention head should only be inside this liner by a half inch or so. It just needs to surround the root of the flame. This will allow some re-circulation of hot gasses and keep the area around the flame much hotter which helps to vaporize the oil. 6" well casing or schedule 40 pipe works fine too for the liner.

5. Do not overheat the block, if it is heated more than 350° the nozzles have a tendency to gall the threads and strip when removed. The nozzles do not have to be that tight, as they do not seal oil pressure, only a few pounds of air pressure.

6. The retention head may need to be cleaned once a month (use a propane torch to burn off deposits). This is usually the case with vegetable oil and not motor oil.

7. Exhaust temperatures measured with a thermometer in the flue pipe (**NOT AN INFRARED**), should be over 325°F. This will keep the exhaust from condensing into sulfuric acid. We prefer to keep the exhaust below 450°F as you will just be wasting heat at that point. A base line temp should be taken with the furnace/boiler cleaned and free of soot build up. Monitoring the exhaust temps can be a good indicator of when a cleaning is necessary. If you notice the digital controller temperature slowly climbing, this is a sign you are either putting too many BTU's into the chamber or the heat exchanger needs cleaned.

Condensed manual for TET612/JLD612 digital temperature controller

These controllers do not function well below 32 degrees F.

All controllers purchased from ckburners are Programmed and tested. NO WARRANTY!

OUT light on means the heater is energized

AL1 light means the TT terminals are closed and allowing the burner to start.

All three parameter groups must be set if you purchased elsewhere

Parameter Setting (you must set all three groups of parameters)

1. Press (SET) to enter setting mode, enter (0001 or 0036 or 0089) then press (SET) again.
2. Press (v) or (^) and then (SET) to select parameters.
3. Press (SET) to confirm entry or to select
4. Press (^) until "End" appears in red display, press SET to exit parameter setting loop.
5. If no keys are pressed within 30sec, parameters are not saved and controller will exit.

Parameters 0001

Symbol	Description	Setting
Su	Target Temp.	140-210 (180)
AH1	Relay Closed	120-190 (160)
AL1	Relay Opened	119-189 (159)
AH2	Relay Closed	120-190 (160)
AL2	Relay Opened	119-189 (159)
End	Exit	

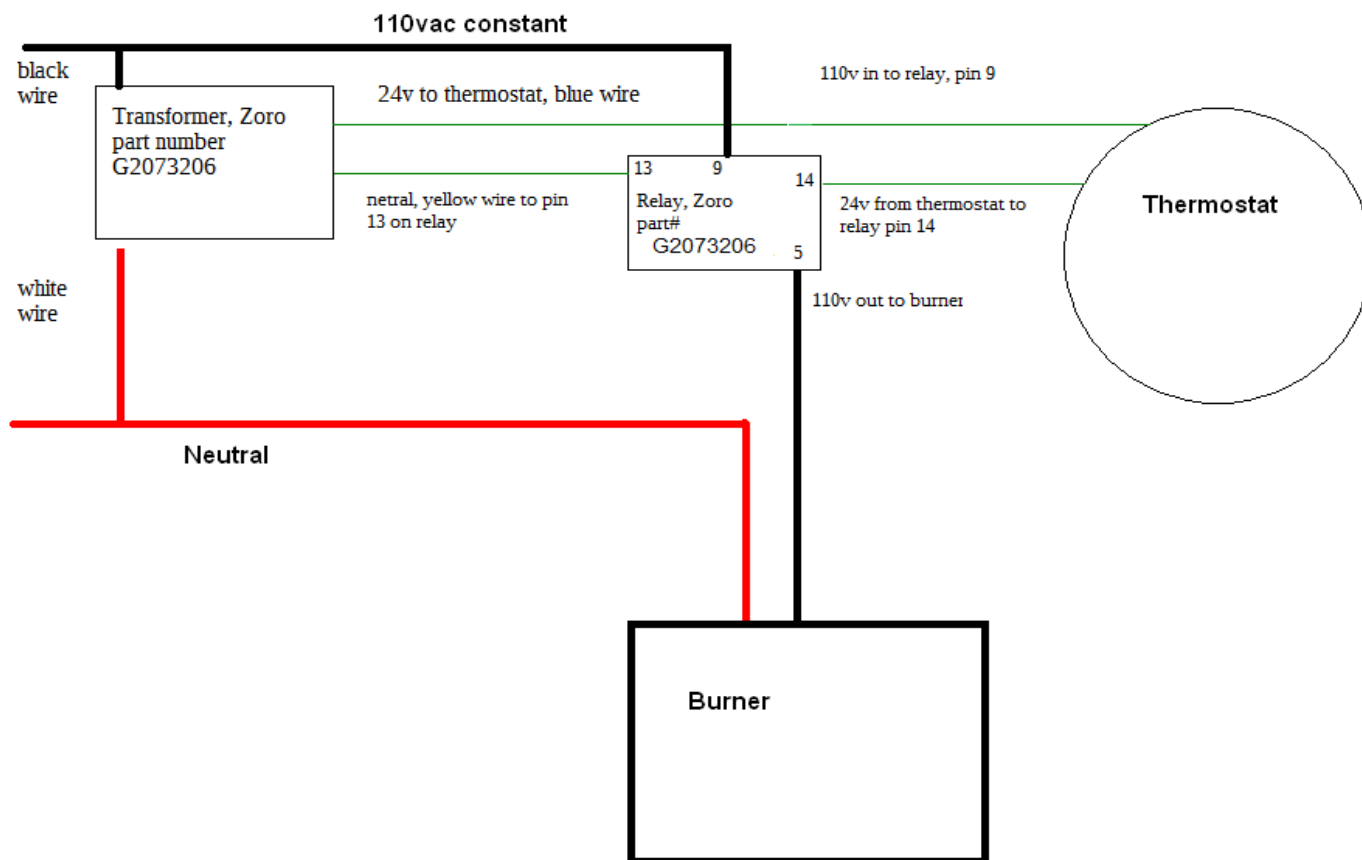
Parameters 0036

Symbol	Description	Setting
P	Proportional Band	1.5
I	Integration Time	0020
D	Differential Time	030
SouF	Overshoot Suppression	0.5
Ot	Control Period	002
Filt	Digital Filtering Strength	0
End	Exit	

Parameters 0089

Symbol	Description	Setting
Inty	Temp. sensor	K(looks like upside down h)
Outy	Method of controlled output	2
HY	AT skew	0000
PSb	Temp sensor error correction	000
Rd	Heating=0;Cooling=1	0
CorF	Celsius=0;Fahrenheit=1	1
End	Exit	

To make the 24v switching circuit to use a thermostat on a furnace and switch the main power on the top of the main schematic on page 10, use Zoro part number G2073206 for the transformer, and Zoro part number G1898696 for the 24vac relay.



The burner must be wired according to the schematic on page 10. This schematic is only to switch the 110v to the burner using a thermostat and relay. If you are using this on a boiler, the aquastat should already switch the 110v to the burner on a call for heat.

Trouble Shooting Guide

**ALWAYS FIRE INTO A COMBUSTION CHAMBER NOT IN OPEN AIR.
FIRING IN OPEN AIR WILL GIVE POOR RESULTS.**

Problem	Possible causes
Burner is smoking.	Improper combustion air adjustment. Clogged nozzle. Poor chamber design. Oil-soaked combustion chamber.
Flame is small.	Fuel line is restrictive. Insufficient air pressure. Clogged nozzle. See page 16 Nozzle exit orifice is gummed up. Nozzle is too small. Too much combustion air Fuel level too far below nozzle. Incoming oil too cold – never store oil below 50*
Heater block will not heat up. (see flow chart next page)	Faulty digital controller (output 1). Faulty relay. Faulty cartridge heater.
Flame has pulsation.	Nozzle O-ring is defective. Air leak in fuel line or fittings. Insufficient combustion air (usually a rumble) Too much preheat temperature
Build-up on retention head.	Improper air adjustment. Improper draft. Poor retention head position. Clogged nozzle. Poor oil quality. Insufficient heat reflected on retention head.
Burner motor will not start – heater is up to temperature.	Cad cell is seeing light. Bad cad cell or wire Bad primary safety. Digital controller not closing alarm contacts. (TT)
Burner starts but does not light.	Poor retention head position. Clogged nozzle Poor electrode adjustment Improper combustion air adjustment. Insufficient pre-heat temperature. Poor combustion chamber – try adding a liner. No atomizing air. Spark shorting to ground or the nozzle, retention head, etc. Too high of a pre-heat temperature
Failed start	Electrodes shorted and no spark at the tips Clogged nozzle Gummed up nozzle affecting spray pattern No air pressure Insufficient preheat Too much preheat Float tank sludged up water in oil Bad oring
Chamber wet with oil	Needs chamber liner (see tuning #4) Trash in nozzle affecting spray pattern Chamber not hot enough Not enough preheat and/or air pressure

Nozzle cleaning procedure

1. Remove nozzle
2. Blow air backwards thru the nozzle onto a white paper towel to see if anything comes out.
3. Look thru nozzle and make sure you can see light. Look VERY closely for any thin sliver of metal that may be lodged in the tip.
4. It may be necessary to disassemble the nozzle for cleaning. Unscrew the brass stem from the nozzle head. Be careful not to lose the very small tip with angular slots cut in it. When reassembling, hold the stem vertically and place the tip in the stem. Screw the head on while keeping the stem vertical, then tighten slightly. The tip makes a metal to metal seal onto the stem. If there is any damage to the surface on the end of the brass stem, the nozzle will most likely leak air back to the float tank.
5. It's a good idea to inspect the oring while the nozzle is out. This oring should be changed at least once a season. The higher the preheater temperature, the more often the oring will need to be changed.
6. Sometimes it is necessary to take the fuel line off and blow air forwards thru the heater block while the nozzle is out to remove the offending piece of trash. (gets sucked back out of nozzle into preheater when the burner shuts off and oil in preheater drains back to the float tank)

Burner will not start

