FUEL OIL DELIVERY SYSTEMS

As burner technicians it is very important that we try and achieve maximum efficiency from every unit we work on. This doesn't mean setting the oil pressure, cutting back on the air until we start smoking, and settling for the CO_2 as the best we can get. We have to aim high, sometimes settle for less, but not until we have exhausted everything within our means to give the customers what they deserve - Good, Quality Service.

Understanding the various burner systems is very important. There are actually only five basic burner systems, classified by the type of fuel oil delivery system, we must concern ourselves with:

1. Simplex, single nozzle system
2. Low, Medium, High, multiple nozzle system
3. Low, High single nozzle system
4. Back pressure metering system
5. Air Atomizing system

Our first step when entering the boiler room is to visually inspect the equipment. If it is an unfamiliar piece of equipment this may take 10 or 15 minutes, but it is well worth every minute. A person who rushes into the boiler room, pushing buttons, and throwing switches, is not a technician. While you are inspecting the equipment you can ask the building engineer, or maintenance man, about the problem. However, until you understand what you are working on do not touch it! We are not trying to simply correct the existing problem and run out the door. We are also looking for, and correcting, potential problems. We are leaving the equipment operating better than it was before, even to the point of running an efficiency test before we leave. If we can increase the efficiency, while we correct his existing problem, that's great! The customer will love us.

With a packaged boiler/burner unit we usually do not have a problem reaching an acceptable CO_2. However, more and more older boilers are being modified with newer burners. It is becoming more common to find installations where the acceptable is not existing. For example:

1. Good CO_2 in all firing ranges
2. No smoke
3. Smooth light off
4. Overall efficient and problem free operation

In many instances these problems are due to a poor burner application or improper burner sizing. All burners operate at maximum CO_2 at maximum design firing rate. If we install a 350 HP burner on a 300 HP boiler we are asking for trouble. Underfiring the burner is our most common low CO_2 problem. In order to obtain acceptable conditions we must understand the system, and adaptability of the equipment. We will attempt to investigate each type of system and identify it's benefits as well as it's drawbacks.

Simplex Single Nozzle System:

This system is probably the most ideal from a standpoint of combustion, as well as ease in operation. Most of these systems are designed to operate at 100 psi, however, some of them may go as high as 300 psi. There are two checks we can make to be certain the burner is firing at the proper pressure. One is to check the nozzle gph rating, this rating is at 100 psi from the nozzle manufacturer. If the burner is rated at 10 gph and you have a 10 gph nozzle then you are seeking 100 psi pressure. The other method is to check the oil pump. If you have a 300 psi pump it is very likely you will have to supply 300 psi. Never take anything for granted and go by the settings when you arrive.

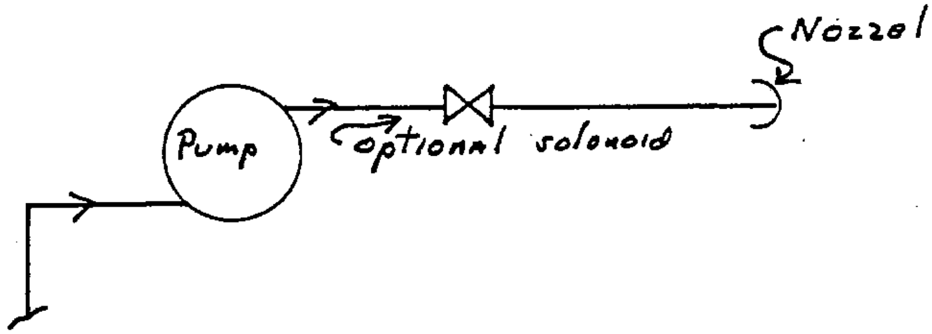

Figure 1: Simplex Single Nozzel System

Remember you are going to be able to achieve maximum CO_2 at the maximum firing rate. This is due to the velocities needed for the proper mixing of the air and fuel. The air diffuser delivers air around the oil spray at a certain velocity. With the proper oil pressure for atomizing and the proper air shutter setting you will get the results the factory designed for.

Lowering the oil pressure will lessen the atomizing, giving you larger droplets, which will not evaporate in time for good combustion. Lowering the air supply will lower the air velocity so you will not supply the air as designed, to penetrate the oil spray and surround the droplets.

A problem we frequently run into is a boiler rated at 10 gph input with a burner rated at between 7 gph and 14 gph. We can drop our nozzle size to 10 gph. We next will adjust our oil pressure at 100 psi, if that is design pressure. We now have proper atomization for 10 gph. Our problem, in this instance, will be air velocity. We will be dropping our maximum design by 40% so our air velocity will drop considerably. Our CO2 will be lower because we will have to add excess air to penetrate the flame, and make up for our drop in velocity. Some manufacturers allow for this by changing diffuser, or nozzle, depths for various firing rates. If we have the time we can make adjustments such as: nozzle setting, diffuser setting, possibly close up the diffuser air spacing, etc. to compensate for the changes.

Combustion is a very exact science. It is not simply spraying oil into a combination chamber, adding air, and not smoking. Every service technician should have a library on his truck of service manuals for all common manufacturers of equipment that he comes in contact with. Nozzle spray angle and spray pattern are very important! If the burner was designed for a 60 degree solid nozzle that should be our starting point. We should always stay with the manufacturers design as much as possible. Our air pattern, formed by the diffuser, is such that we will have a good air/oil mix at the designed spray angle and pattern.

Let's take the 60 degree solid nozzle as an example. At maximum firing rate the air will penetrate the center of the flame, and the edges, at the proper time, for good combustion. When we lower our air velocity we will not penetrate to the center of the flame as we should. We will smoke in the center, due to lack of air, and have good combustion around the outside of the flame. If we try and compensate, to clean up the center, we will have good combustion in the center with excess air around the outside.

If we are firing capacity with a hollow nozzle we will penetrate the flame and there will be no oil in the center. If we try to cut back the air supply, so we do not penetrate so deep into the flame, we will starve the outside of the flame for air. If we have an 80 degree spray angle and our burner was designed for 60 degrees our air pattern will not cover the width of the flame. In order to clean up the outside of the flame we will have to add excess air to the center of the flame. These spray angle and spray pattern problems are not limited to this system alone, the same problem exists with every system.

The simplex, single nozzle system is easier to figure out and troubleshoot. We usually have a direct spark ignition and no pilot to be concerned with. There are two basic drawbacks to the system. One is that you can only ignite a certain volume of oil smoothly so you are limited to the lower firing ranges. The second is that you only have one firing rate so you have an on/off operation and cycle continuously. This system is best suited for residential and light commercial use.

Low, High, Single Nozzle System:

This system allows us to light off smoothly and then go to the burner capacity. It is an inexpensive system when we need a higher firing rate than will light off smoothly. Normally our pump will be a 300 psi model and will be set at that pressure. You will notice in Table 1 that at 300 psi we have 1.73 times our nozzle rating for flow. This means that if we have a 10 gph nozzle firing on the burner we will be actually firing 17.3 gph in high fire. This becomes our burner design firing rate, and conditions. First, as with the simplex system, lowering the pressure lowers our velocity and atomization. We have a certain velocity and droplet size at 300 psi and this is where our best combustion will take place as this is what our air diffuser is designed for.

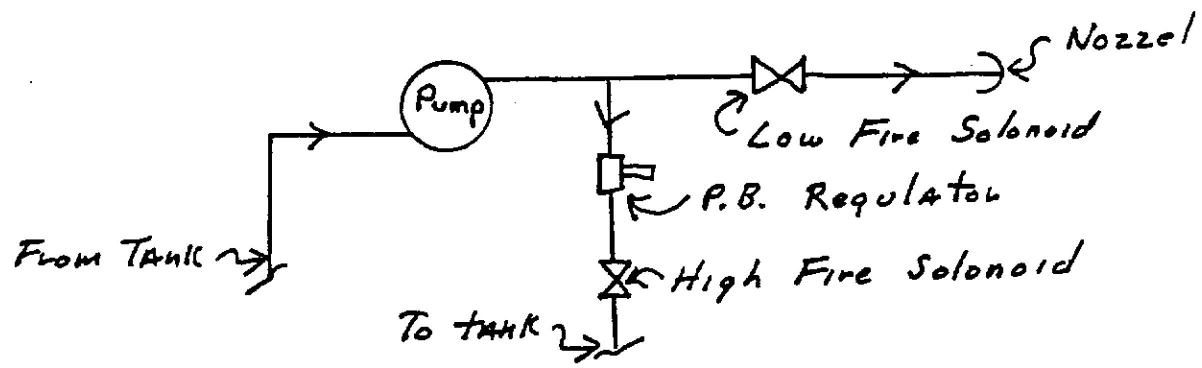

Figure 2: Low, High, Single Nozzel System

The solenoid valve is of the normally open type on the return line. The regulator, in the return line is set for 100 psi. The burner will spark ignite at 100 psi and the normally open solenoid will allow the excess oil to be returned to the tank. Either by use of a time delay relay, or through the programming control, we will close the by-pass solenoid valve in five to ten seconds of the cycle. Once the by-pass valve is shut we will operate off the pump pressure, 300 psi, thus giving us high fire.

PRESSURE VERSES FLOW RATE

Pressure	100	125	150	200	250	300
Flow Rate Factor (gph)	1.0	1.12	1.23	1.41	1.58	1.73

This type of burner will usually have a hydraulic air shutter valve to operate the air volume. When 300 psi is exerted against the hydraulic cylinder the air damper will open. The burner can usually be ordered two ways: Low-High-Off or Low-High-Low. The only real difference being an aquastat, or pressuretrol, added to the system to interrupt the by-pass solenoid at a prescribed temperature or pressure. Shutting off in low fire will be smoother and some efficiency may be gained, depending on the CO_2 and boiler efficiency in low fire.

Low, Medium, High Multiple Nozzle System:

This system is used to try and obtain a better turn down ratio, ratio between high fire and low fire. Again it is found on larger burners and may only be a two nozzle system with low and high fire. We will discuss three nozzle system because our problems will be the same. With this system we use one pressure, usually 100 psi. We then open solenoid valves to nozzles as we wish to increase fire. The most common way to control the valves is through end switches in the modulating motor, which is controlling the air damper.

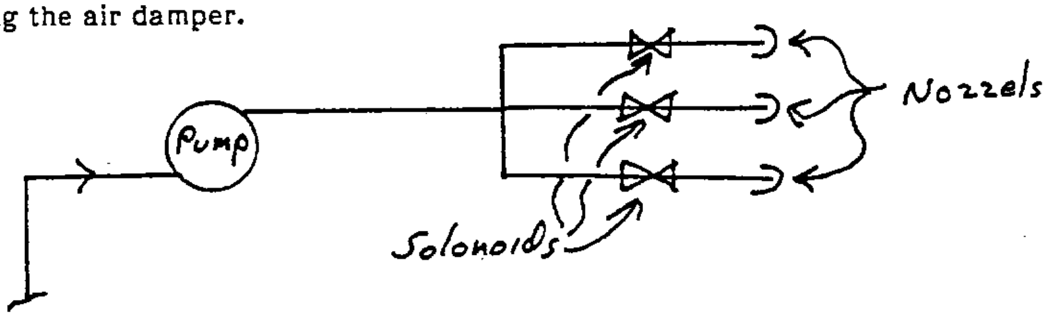

Figure 3: Low, Medium, High, Multiple Nozzel System:

There are a few problems to be aware of with this system. One is that the nozzles are not centered in the diffuser. When we have one, or two nozzles firing we are trying to penetrate the flame off center. At the same time our air shutter is partially closed so we cannot get enough velocity for good CO_2. As with all other cases best CO_2 is obtained at the highest firing rate.

Another problem is that our modulating motor moves relatively slowly as it opens the air damper. What basically happens is:

1. Open first valve, air shutter in low fire position
2. Shutter starts to open until it reaches mid fire position
3. Snap-mid fire valve opens
4. Shutter continues to open until it reaches high fire position
5. Snap-high fire valve opens

In between the valves opening we are adding excess air until the next valve opens. Theoretically we are adding double the air needed for good combustion just prior to the next valve opening. The only time we have a good mix is at the moment the mid fire valve opens, that is quickly lost as our modulating motor continues to open the air damper. We are relatively OK at low fire and high fire, it is during the modulating process we have a problem.

Sometimes it is very hard to adjust the stroke of the damper and the opening of the valves because we almost blow the fire out before the next valve opens and upon opening have a tendency to smoke.

Back Pressure Modulating System:

This system is used to provide a smoother operation than the previous one when traveling from low to high fire, and back. It is similar in design to the Low-High Single Nozzle System, with the exception we have replaced the back pressure regulating valve and solenoid valve with a back pressure metering valve. This metering valve is connected to the modulating motor which drives the air damper, so both the air and oil supply move together.

As we modulate to high fire we slowly close off the by-pass line so that when we reach that position the by-pass is totally shut off. There are two gages needed on this

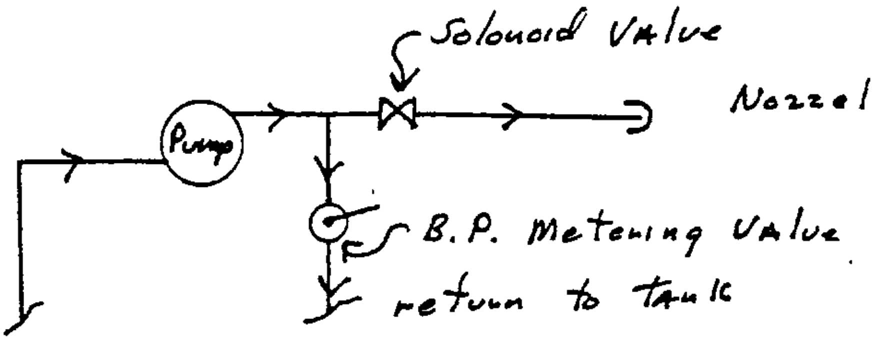

Figure 4: Back Pressure Modulating System

system to adjust the oil. One on the pump which is usually set at 100 psi and the other on the by-pass line before the metering valve. On low fire the back pressure gage will usually read 30 to 40 psi. On high fire it should usually read close to 100 psi. The pump gage should remain at 100 psi throughout.

Our turndown ratio on this type of system is approximately 2 to 1. We again will have problems obtaining a good CO_2 on low fire for the same reasons as the other single nozzle systems, with lower than design pressures. The thing we gain is a smoother operation. We can modulate the burner from low to high and back to low with a nice even fire.

Air Atomizing System:

This system works much the same as the back pressure modulating system. The main difference being that instead of metering on the by-pass line we meter on the supply line to the nozzle. This is the only system we have discussed that can be used on heavy oil. Our nozzle is considerably larger and our atomizing is accomplished using an air compressor verses oil pump pressure. The air compressor supplies less than 10% of the air needed for combustion. This is still mostly accomplished with the diffuser. Depending on the equipment, turndown ratios of as high as 10 to 1 may be obtained, however 4 to 1 is most common.

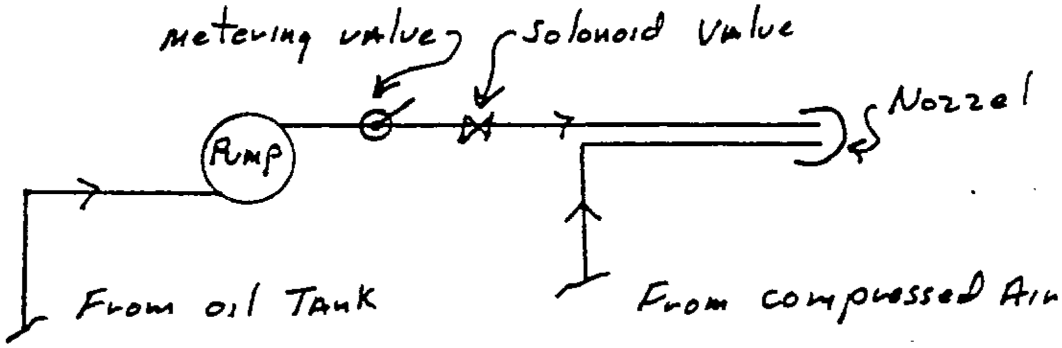

Figure 5: Air Atomizing System

With this system we will have four gages to be concerned with. An oil pump gage usually set at 100 psi, air compressor gage usually set at 17 psi. An oil nozzle gage, and an air nozzle gage. We want to maintain 15 psi on the nozzle compressed air gage. The oil. gage will increase as our firing rate increases. Usually low fire will be between 15 and 17 psi on the nozzle oil pressure gage. In high fire this pressure will usually increase to 36 to 40 psi.

Again this system allows for smooth modulation from low to high fire, and back to low fire. It also gives us the capability to burn heavy oils. Again the same problems exist in the low fire range as with all the other systems.

Always remember that burner efficiency is measured by CO_2, 0_2, and CO. Boiler efficiency is a measurement of the boiler stack temperature. Together we get thermal efficiency of the unit. If the CO_2 is low and the stack temperature is low you can still have good thermal efficiency. However, as combustion technicians our aim has to be a high CO_2 first. We cannot adjust a boiler's extraction of the heat we induce into it except by inducing less heat or a slight difference by adjusting the draft.

It is always best to start our adjusting process at the manufacturers recommended settings. This means a library in every service truck of the common burners in the area. A serviceman who does not need these manuals is not a technician. Our goal in life should be to be the best at what we do, the rest will follow. In our business it takes a lot of work to be the best, a middle of the road mechanic is both costly to the employer and dangerous.