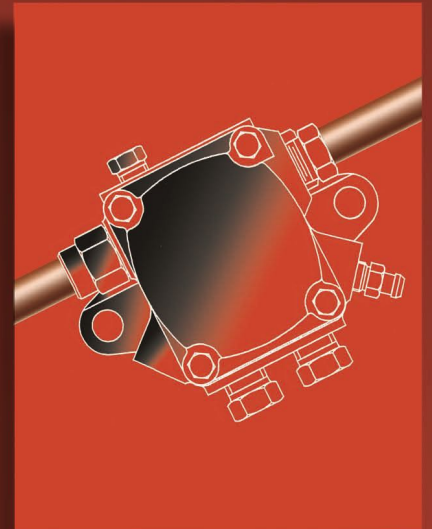


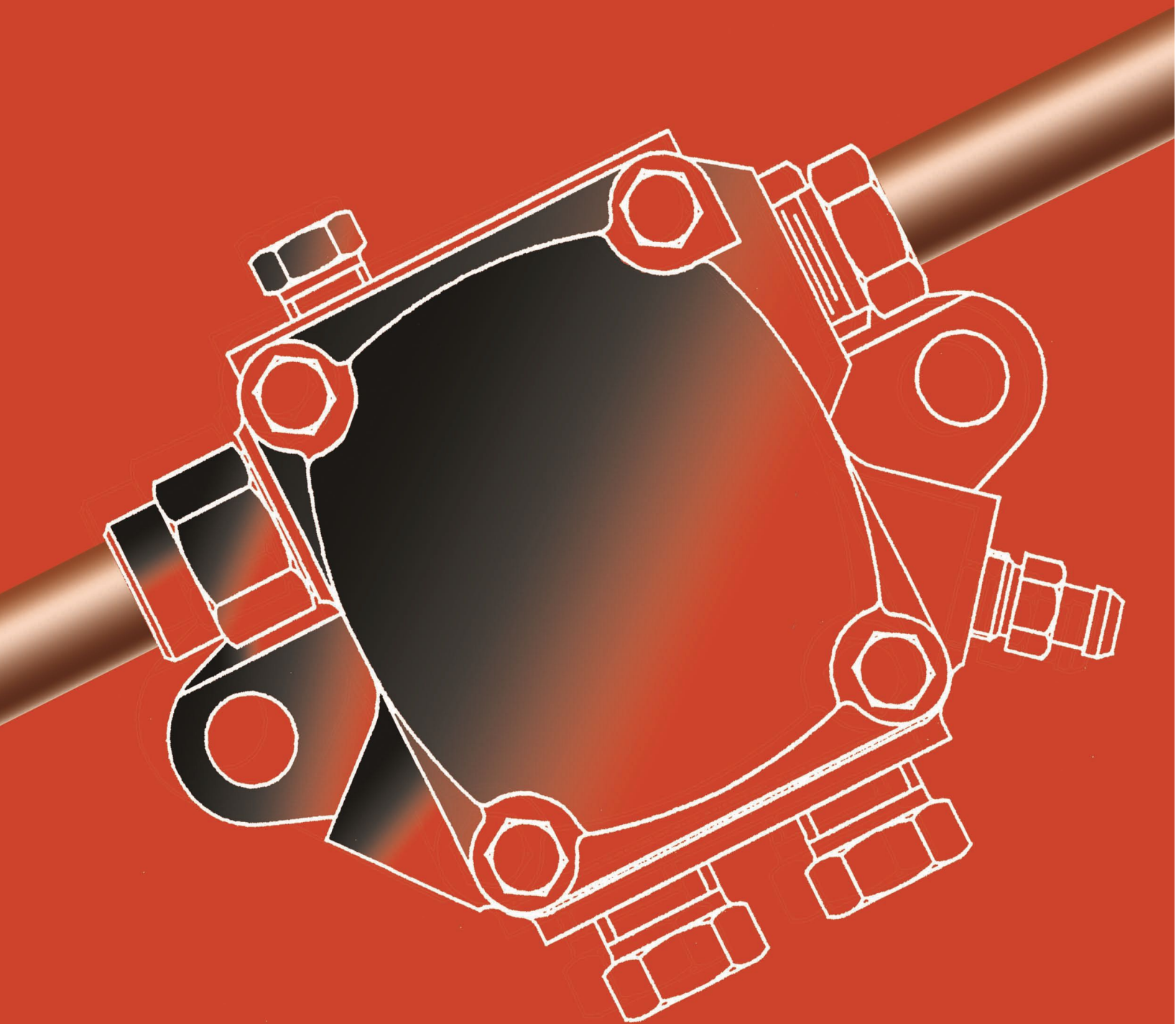
# Chapter 4

## FUEL UNITS & OIL VALVES



### IN THIS CHAPTER

- Fuel units and oil valves
- Troubleshooting oil storage and supply systems



## Chapter 4

# Fuel Units and Oil Valves

Figure 4-2:  
Cutaway of oil  
valve

### Introduction

**Function of fuel units:** These components lift the oil from the tank to the burner, deliver oil at a constant and regulated pressure to the nozzle, and provide clean cutoff of fuel.

### Component parts of the fuel unit

- The fuel unit contains a set of machined gears, which provide both vacuum and pressure. The single stage fuel

unit, Figure 4-1, contains one set of fuel pump gears.

- The pressure-regulating valve controls the pressure of the oil discharged to the nozzle. A cutaway of this valve is shown in Figure 4-2. This assembly consists of a valve body and matching piston. In the closed position, the piston is held against the nozzle discharge port by a

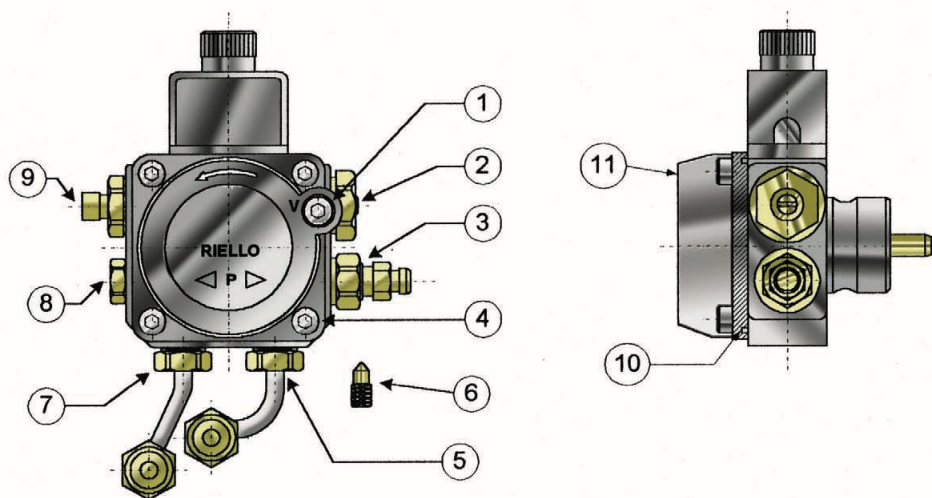
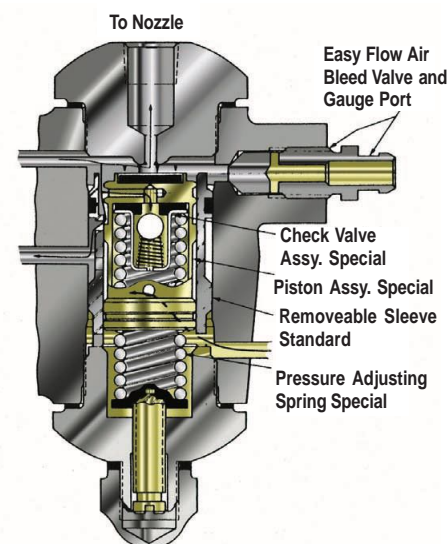


Figure 4-1: Single  
stage fuel unit

#### No. Description

- 1 Vacuum Gauge Connection Port
- 2 Pressure Regulator Adjustment Screw
- 3 Pressure Gauge Connection Port and Bleeder
- 4 Pump Cover Screws
- 5 Return Fuel Line Port

- 6 By-pass Plug
- 7 Supply Fuel Line Port
- 8 Capillary Tube Connection Port
- 9 Oil Delivery Port
- 10 Pump Cover O-ring
- 11 Pump Cover

spring located behind the piston. When the fuel pump gears develop sufficient pressure to overcome the spring tension, the piston is forced back, allowing oil to flow through the nozzle discharge port. The pressure adjusting screw regulates the spring tension controlling the pressure of the oil discharged to the nozzle.

**Figure 4-3:**  
Strainer screen  
and gasket.



- The strainer screen, see Figure 4-3, within the fuel unit reservoir, filters the incoming oil and helps to prevent any contamination from entering the nozzle.
- A solid shaft extending through the pump housing seal drives the gear pump. The end of this shaft is connected to the burner motor by a flexible coupling. (Note that the

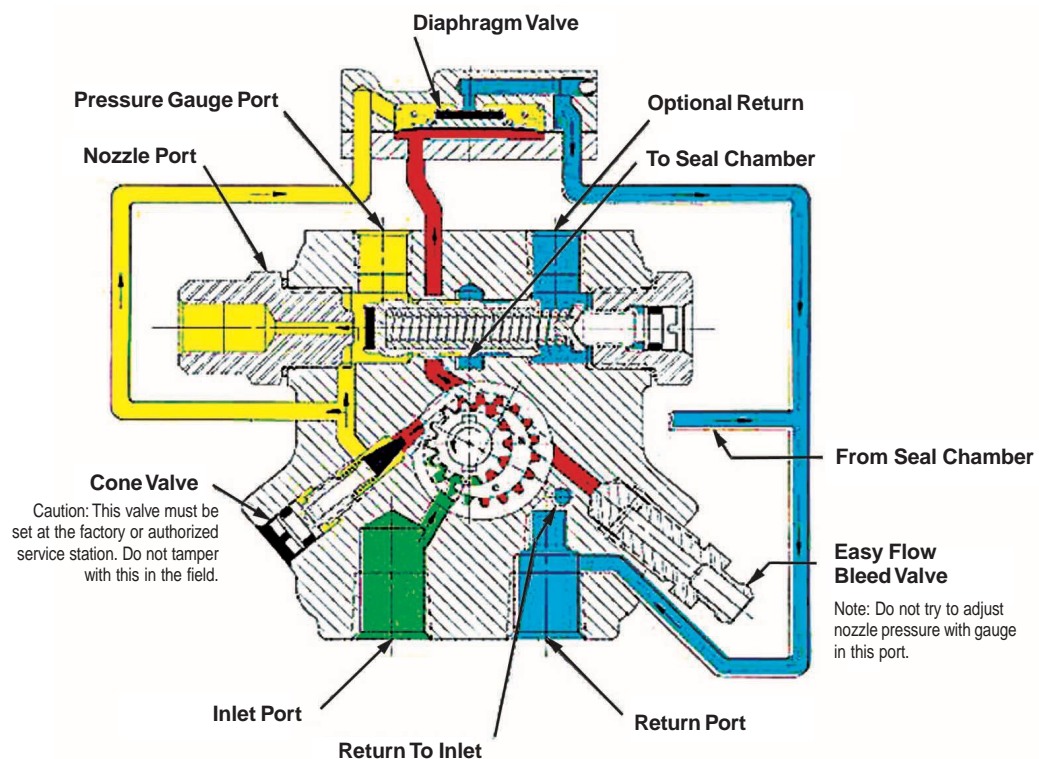
R.P.M. rating of the gear pump must be the same as the burner motor.)

- A shaft seal is provided to prevent oil from leaking out of the fuel pump housing around the rotating shaft. Lubrication is provided to this seal through internal porting.

### Operation of the single stage fuel unit

The single stage fuel pump, Figure 4-4, produces both pressure and vacuum. Pressure is the force created by the meshing of the pump gears, and is expressed in pounds per square inch (PSI). Pressure moves the oil away from the pump. Vacuum is expressed in inches of mercury, and is abbreviated as *in. Hg*. Normally we simply show the numerical value of the

**Figure 4-4:**  
Suntec Industries;  
Cutaway example  
single stage  
fuel unit





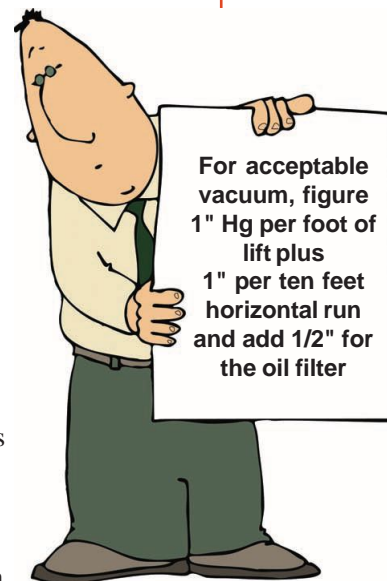
vacuum with an inch (") mark. Example: 10" of vacuum. Vacuum brings oil to the pump. We need about .75" to 1" Hg of vacuum for each foot we lift the oil, 1" of vacuum for each 10 feet of horizontal run, and 1/2" for a clean oil filter. For example, if we have 4 feet of lift from an underground tank, plus 10 feet of oil line run to the burner, and add the oil filter, the calculated vacuum reading should be 5.5". A vacuum gauge reading of from 5" to 6" is acceptable.

When the motor turns the pump shaft, oil enters the strainer chamber through the intake port, either by gravity or by the vacuum developed on the intake side of the gear pump. As the gears rotate, the teeth squeeze the oil and discharge it on the pressure side to the pressure regulating valve. The pressure adjusting screw on the regulating valve controls spring tension, which determines the pressure at which the oil will force the piston open and be discharged through the nozzle port. This pressure is about 80% to 95% of the operating pressure. The minimum factory set operating pressure is 100 PSI.

The pump can deliver 5 to 20 times the amount of oil required by the nozzle. This excess oil is bypassed by the pressure regulating system and returned to the strainer chamber. The total oil capacity of a gearset is referred to as TGSC or Total Gear Set Capacity. The bypassed oil returns through internal porting in the pressure regulating valve and pump body. As the excess return oil is no longer at pressure, some of this oil is used for the lubrication of the shaft pump seal.

In order for the excess oil to return to the strainer chamber, the bypass plug located between the pump and the strainer chamber must not be installed. If this plug were in place, the excess oil could not

return to the strainer chamber and would require a return line from the pump back to the tank. If there were no return line, the high-pressure oil would be forced into the front seal chamber, which would rupture this seal. In most pressure fuel units, this seal can only withstand 10 PSI of pressure. You should always check to be sure that the bypass plug has not been installed when using the unit on a one pipe installation. The bypass plug is only installed when using a two pipe system.

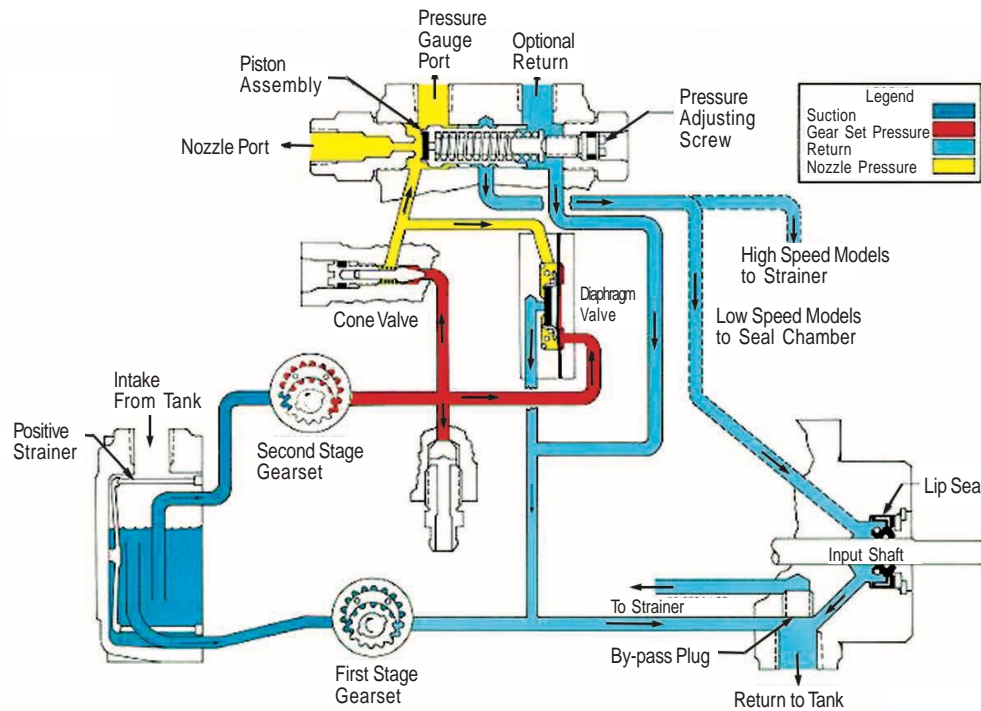


**For acceptable vacuum, figure 1" Hg per foot of lift plus 1" per ten feet horizontal run and add 1/2" for the oil filter**

## Pressure regulating valve operation

The discharge oil pressure of the fuel unit can be adjusted between 100 and 200 PSI. Normal pressure setting on a high-pressure burner is 100 PSI, but some burners are designed for higher oil pressure. For variations in this pressure setting and its resulting effect on nozzle performance, see the Nozzle Chapter # 5, of this manual. Also refer to manufacturers' specifications for recommended pump pressure on flame retention burners.

On burner shutdown, spring tension against the pressure regulating piston will cause the piston to close, shutting off oil discharge to the nozzle at a pressure approximately 20 percent below operating pressure. Therefore, if the pump pressure is adjusted to its normal operating 100 PSI, the shutoff pressure will be about 80 PSI. For pumps with high-speed cut off, the cut off pressure may be different than 20 percent. What is important is that the pressure should drop and hold.



**Figure 4-5:**  
Suntec Industries;  
cutaway example  
two-stage  
fuel unit

## One pipe system

Most of today's Oilheat systems require only a suction line to bring the oil from the tank to the burner. We call these *one pipe systems*. Older single stage fuel units should be piped only as one pipe where oil can flow to the unit under gravity conditions; that is, the burner is located level with or lower than the bottom of the oil tank.

Newer single stage pumps operate at a maximum of 6" of vacuum on a one pipe system. They can create much more, but the oil will begin to give us trouble over 6". If your calculated vacuum is less than 6" and you are using a new fuel unit, it should be installed one pipe.

## Two pipe system

If more than 6" of vacuum is required, a

single stage fuel unit should be piped with a return line to the tank or fuel de-aerator. This is called a *two pipe system*. An example of such an installation would be an abnormally long run from the oil tank to the unit. If a single stage fuel unit two pipe system has an operating intake vacuum over 10", unstable flame conditions, carboned-up firing assembly, after fire, and noisy flame may result. High vacuum may also shorten the life of the fuel unit.

## Two stage fuel unit, two pipe system

If more than 10" of vacuum is required, you should install a two stage pump or booster pump. The two-stage fuel unit has two sets of fuel pump gears. The first set purges the pump of air and supplies an

uninterrupted flow of oil to the second stage that pressurizes the oil to the nozzle. Figure 4-5 shows the oil flow in a two stage pump. The first gear set provides the vacuum to fill the strainer chamber as well as the low pressure oil supply to lubricate the shaft seal. From the shaft seal chamber, the oil flows to the low-pressure side of the pressure regulating valve and then back to the tank. The second set of gears provides the pressure for the oil taken from the strainer chamber, with the surplus oil being bypassed through the porting in the pressure regulating valve and back to the strainer chamber.

Note that the bypass plug is installed in this unit because two stage pumps must always be two pipe. If a two-stage pump is connected to one pipe, it becomes a single stage pump. The first stage will only take oil from the cover and return it to the cover. Installing two stage pumps on one-line systems is a waste of money. Not only does the pump cost more, it also uses more electricity to turn the second set of gears.

Even though single stage pumps are capable of creating 20" of vacuum, we need two stage pumps because fuel oil starts to break up or "vaporize" at vacuum levels as low as 6.7" (Figure 4-6). When this happens, foamy oil collects in the pump and the pump begins to cavitate. The pump sends this foam directly to the nozzle, causing unstable atomization, smoke, and soot. Also when the burner shuts down, the air bubbles in the nozzle expand, pushing oil out of the orifice, creating after drip. The two stage pump may correct the foaming oil problem. The first set of gears brings the oil into the pump, and returns any foam back to the tank via the return line. It is important to use the lower intake port so even at 17" of

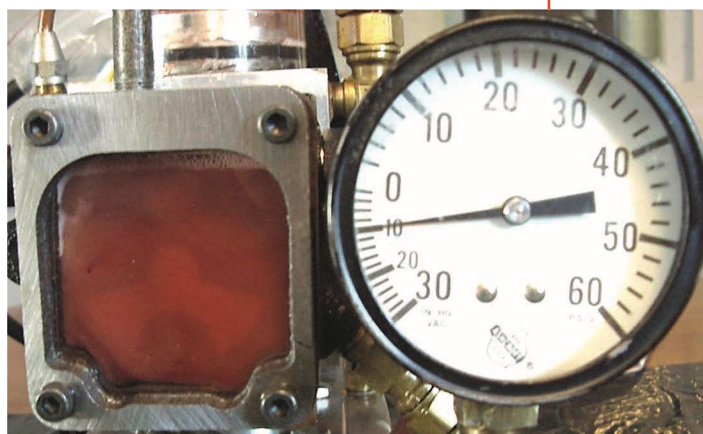
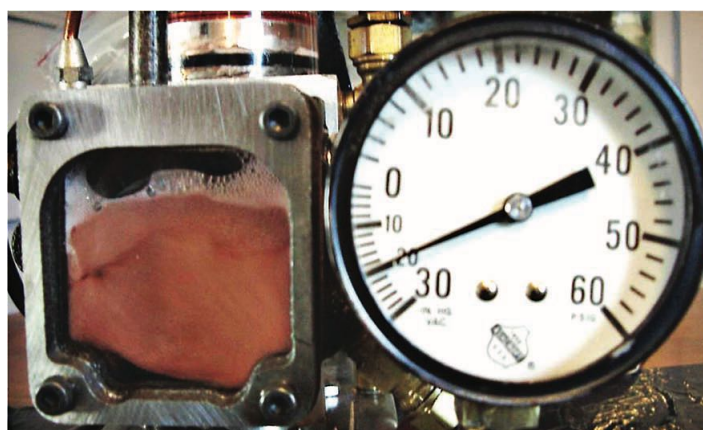


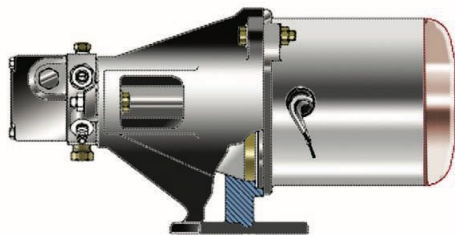
Figure 4-6

Figure 4-7



vacuum, only foam free oil is picked up and delivered to the nozzle. It is recommended that all two-stage pumps be mounted right side up so the air will collect in the top of the pump and can be sent back to the tank.

In a two pipe system with a two stage fuel unit, it is not advisable to exceed 17" of intake vacuum. Figure 4-7 shows the effect that 20" of vacuum has on a pump. With long oil line runs where excess vacuum is required, or for overhead



**Figure 4-8:**  
Booster pump

burners, the use of a booster pump is required, Figure 4-8. The installation and associated piping of a system using a booster fuel pump is fully described later in this section.

## Avoid two pipe systems

Two pipe oil systems should be avoided if possible. With a two-pipe system you are filtering way too much oil. The average oil pump, pumps over 15 gallons of oil an hour. The average burner fires at 1 gallon per hour. This means you are filtering over 15 gallons of oil for every one burned. You are using up the filter 15 times faster than needed. You are cleaning the oil tank through the filter. This is very expensive and inconvenient.

The second problem is that the average return line is under about two pounds of pressure. A lot of oil can leak out of a small pinhole under two pounds pressure in the hundreds of hours a year a burner runs. The burner will not be affected by a return line leak. The only way you know you have a leak is when the customer runs out of oil or the oil shows up in the sump pump pit. This is way too late!

If these were not reasons enough, it appears that two pipe systems are sludge machines. Copper is a catalyst that can affect hydrocarbons. Prolonged exposure to copper causes little hydrocarbon molecules to clump together into big, long hydrocarbon strings. They can plug up nozzles, strainers, and filters. Since we pump over 15 gallons an hour and burn only one, think of how many times each little hydrocarbon molecule has to travel back and forth to the burner through all that copper pipe before it is finally burned. On each trip the fuel gets a bit less stable and a few more hydrocarbon strings show up in the tank.

Most fuel pump manufacturers say that the maximum vacuum for a one pipe system is 6"; therefore to convert from two pipe to one pipe, your calculated vacuum must be less than 6". If you need over 6", consider installing a de-aerator in the oil line, especially if the line comes out of the top of the tank, so the pump will not get air bound.

## Fuel de-aerators

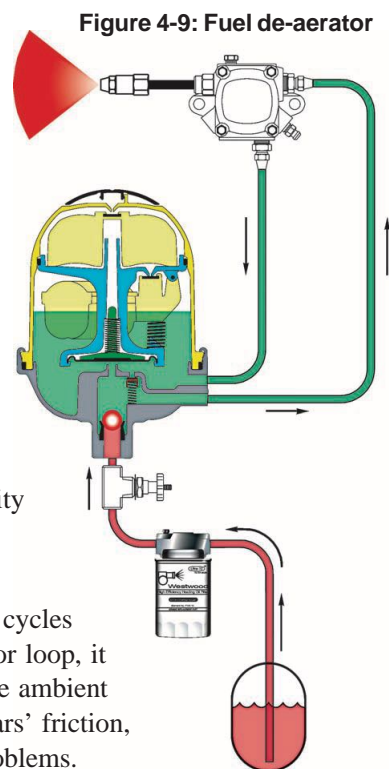
Fuel de-aerators shown in Figure 4-9 have been developed to eliminate air problems caused by excessive vacuum. Here is how the system works:

1. Oil is drawn from the tank to the de-aerators through a single pipe. A dual-pipe system, operating between the unit and the oil pump allows the device to remove the air. Only the amount of oil that is burned is replaced from the oil tank. The single pipe system eliminates the need to circulate unnecessary oil and its impurities throughout the system.

2. The surplus oil is pumped back to the de-aerator, instead of back to the tank.

3. De-aeration increases the pump's suction capacity while reducing its sensitivity to minor leaks in the suction line.

4. As surplus oil cycles through the de-aerator loop, it absorbs heat from the ambient air and the pump gears' friction, reducing cold oil problems.

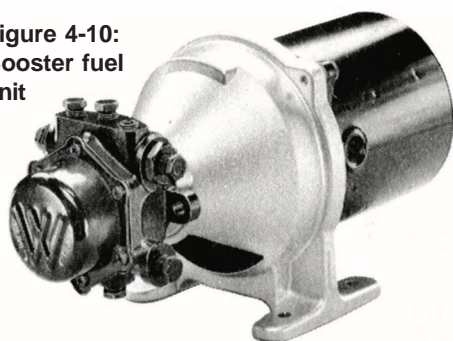




## Booster fuel units

Booster fuel units are normally used to assure an adequate supply of oil to one or more overhead furnaces. They are usually capable of lifting oil 15 feet and supplying the oil up to 35 feet above the pump. They can be used as continuous or intermittent duty transfer units for filling a small overhead feeder tank or for other similar purposes. Booster pumps are a fuel unit and motor. Figure 4-10 shows a Booster Fuel Unit.

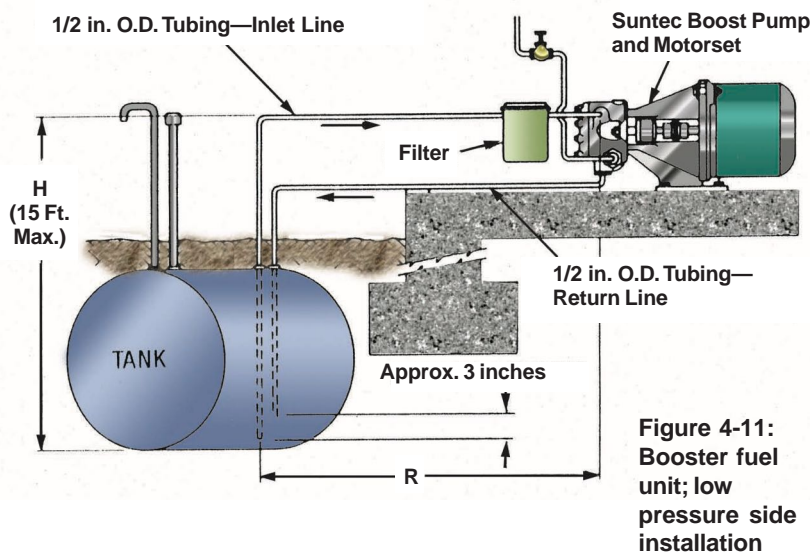
**Figure 4-10:**  
Booster fuel unit



The pressure regulating valve assembly functions as a relief valve. A vacuum breaker is recommended as a protection to insure an instantaneous supply of oil when more than one burner is being supplied.

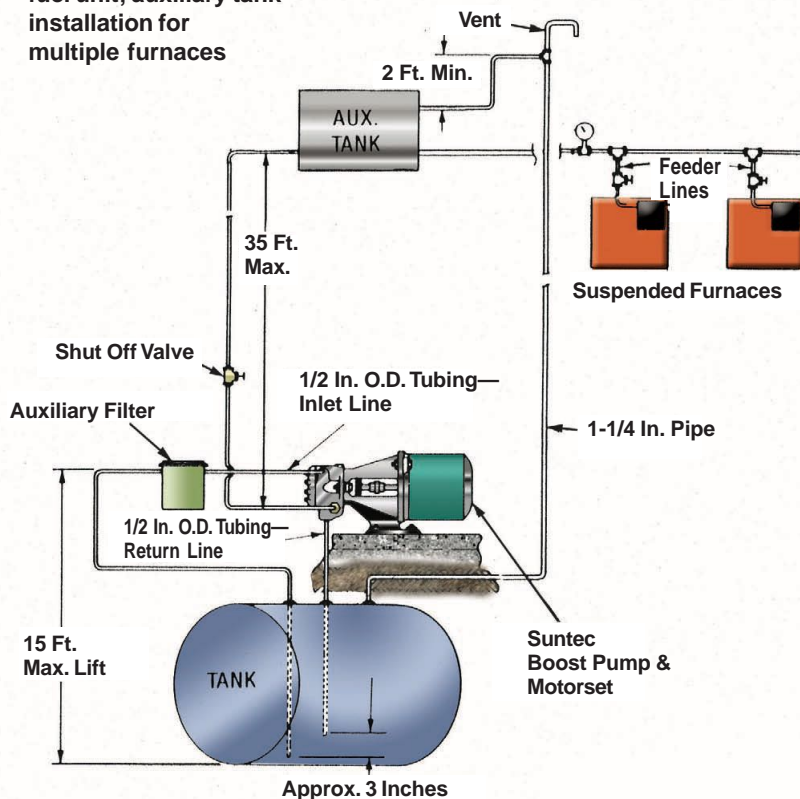
**Piping:** Suction and return lines should be sized to the specific model boost pump and lift location. Follow manufacturers' instructions. All fittings should be of the flare type. A return line from the fuel pump bypass connection to the tank is required in all installations. Extend the return line to the same depth in the tank as the suction line. Also check local code before making the installation. Figure 4-11 shows the input or low pressure side of the installation. The Auxiliary Tank Installation shown in Figure 4-12 is another way of hooking up multiple suspended furnaces.

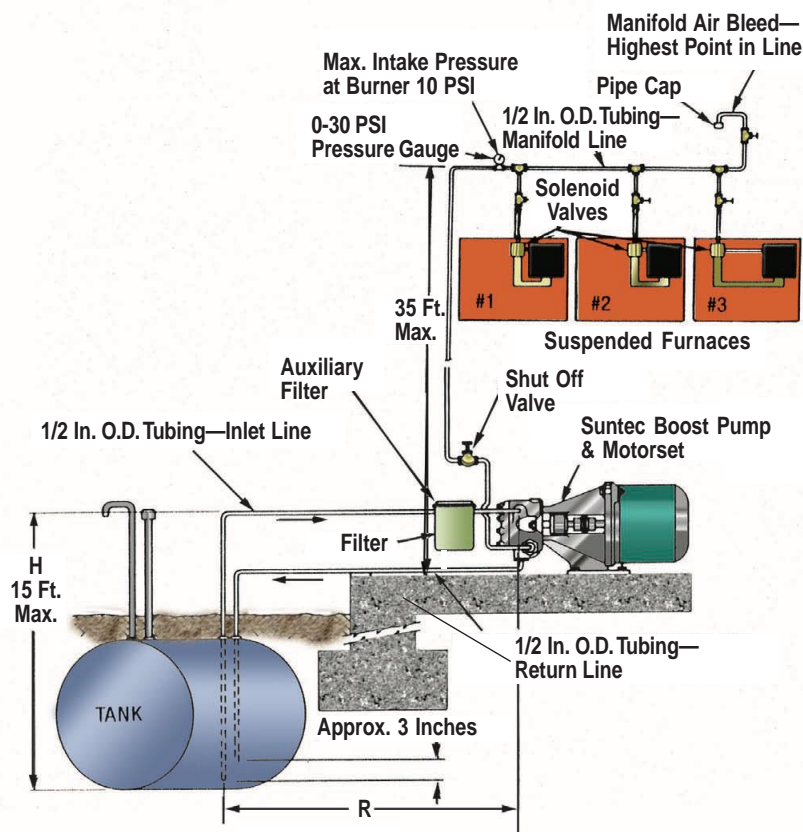
Figure 4-13 on following page shows a Pressurized System installation.



**Figure 4-11:**  
Booster fuel unit; low pressure side installation

**Figure 4-12:** Booster fuel unit; auxiliary tank installation for multiple furnaces





**Figure 4-13:**  
Booster fuel unit;  
pressurized  
system  
installation

### Fuel unit limitations

1. NFPA31, the National oilburner code, limits the shaft seal pressure to 3 PSI, although most pumps can take up to 10 PSI.
2. Single-stage pumps should not be operated beyond 6" of vacuum when hooked up one pipe. Single stage, two pipe installations should not be operated above 10" of vacuum.
3. Two-stage pumps should generally operate below 12" of vacuum because at very high vacuums, oil foams within the pump.

### Pumps with integral solenoid valves

There are two types of pumps with built in electronic shut off valves called integral solenoid valves. One is the blocking valve pump and the other is the by-pass valve pump.

The blocking valve stops the flow of oil to the nozzle just like an externally mounted solenoid valve does. With this pump, the oil is shut off two ways: with the electric valve, and the pressure regulating valve.

The by-pass valve pump has a valve that controls the flow of oil to the nozzle indirectly by diverting oil flow inside the pump. When it is time to shut off the oil flow the dumping valve opens, causing the pressure to drop quickly and the pressure regulating valve to close sooner. This is opposite the blocking valve operation. When the blocking valve opens, oil flows; when the dumping valve opens, oil stops.

Either type of valve will give you quick cutoff, but to get delayed cut-in, and cleaner starts, you need either a valve-on delay primary control, a hydro-mechanical pump delay, or an electric delay device.

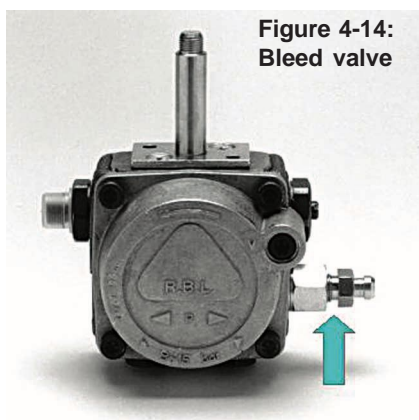
### Servicing and testing the fuel unit

#### Primary venting and bleeding

In a one pipe system, when a pump runs out of oil or picks up air due to high vacuum or a leak or break in the oil supply line, the air must be bled from the fuel unit and line after the tank is filled or the supply line is repaired. Failure to do this properly can cause pulsation, changes in flame condition, or excessive dripping at the nozzle after the burner shuts off. There are two methods for air elimination in a one pipe system. If the system is a gravity feed and

the unit is mounted so that the oil supply line enters at the bottom of the unit, the inlet port plug in the cover may be loosened and removed. This will allow the oil to flow by gravity into the unit and fill the strainer chamber. Then the intake port plug should be replaced and the burner fired.

If it is not possible to fill the strainer chamber in this manner, then the bleeder plug on the side of the regulating valve chamber should be loosened, the burner operated, and sufficient oil allowed to flow from this plug to purge the entire system of air until there is a steady stream of oil. If the pump has been completely drained of oil it may be necessary to remove the supply line and fill the unit with oil before adequate suction can be obtained. In the newer units, an Allen screw, or easy bleed plug, Figure 4-14, has been provided in this port to allow for bleeding. Continue to bleed the pump for 15 seconds after the last air bubble can be detected. After bleeding the unit, always check the flame for stability and burner shutdown to be sure all



air has been purged from the system. Venting of air is normally not necessary in a two pipe system with a two stage pump,

but may be done faster if the bleeder plug is opened to expel air.

### Vacuum power bleed

If the oil lines run above the oil tank and back down to the burner (a siphon system) proper bleeding of the pump is crucial. To bleed a pump line and everything else all the way back to the tank, do the following: First fill the pump with oil. Place a hose over the bleeder. A device like the one shown in Figure 4-15 works well for this purpose. Open the bleeder one-half turn. Make sure that the open end of the bleed hose is immersed in oil in your pail or



**Figure 4-15:**  
**Bleeder**  
**wrench**

bucket. Close the inlet valve at the tank and start the burner. Wait until the pump starts to whine. If you have a vacuum gauge inserted, it will show 20" to 25" of vacuum. (If white smoke starts coming out of the hose, you didn't fill the pump and the oil is burning.) Open the inlet valve and bleed for several minutes. After a tune-up, you would see some oil, then lots of bubbles and then air free oil. Once it's bled out, close the bleeder with the pump running.

### Field pressure and cutoff checks

Two of the most important service checks for a fuel unit are the output pressure check and the cutoff pressure





**Figure 4-16:**  
**Pressure**  
**tester**

check. These checks can be made on some pumps by inserting a pressure gauge into a nozzle port, with others a tester may have to be used, Figure 4-16. You will need a pressure gauge capable of reading at least 300 PSI.

First operate the burner to determine fuel unit pressure, which should normally be adjusted to 100 PSI or more depending on the burner manufacturer's recommendations. Turn the pressure regulator adjusting screw (normally clockwise) until the pressure increases 40 to 50 pounds (but not above 200). If the pump cannot achieve at least 150 pounds, the pump gears or regulating valve are worn out and you should replace the pump. Then back off the pressure adjusting screw (counterclockwise) to the desired operating pressure.

Uneven or fluctuating pressure can cause severe flame pulsation. A pulsating pressure reading (gauge needle jumps about from high to low) may indicate:

1. A partially clogged filter or pump strainer.
2. Air may be present in the pump caused by:
  - a. Loose strainer chamber cover or defective strainer chamber gasket.
  - b. Air leak in the suction line.
  - c. Excessive intake vacuum.
3. Slipping pump coupling.

*Note:* Slight regular vibrations of the needle are considered normal as the resonance frequency of gauges is very close to gearset frequency. Liquid filled gauges can help dampen or eliminate frequency vibrations and are preferred.

If a fuel unit operating pressure of at least 100 PSI cannot be obtained, the problem may be, in addition to the above items, one of the following:

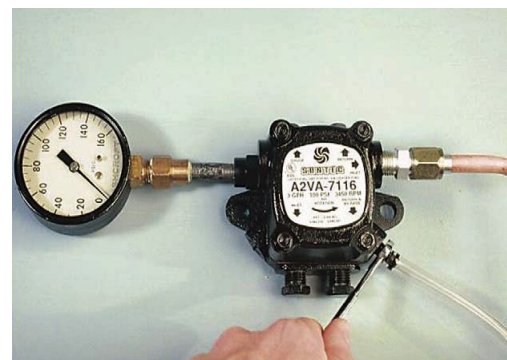
1. Worn pump gears.
2. Nozzle capacity beyond pump capacity.
3. Motor not up to speed.
4. Loose shaft coupling.
5. Defective pressure regulating valve.

#### **Pressure check at cutoff**

Once you are finished with the operating pressure check, shut off the burner. Insert a pressure gauge directly into the pump pressure port, Figure 4-17, and run the burner until the pump reaches its pressure setting and then shut the burner off.

(Note that cutoff pressure cannot be measured at the bleeder port as the pressure-regulating valve has an internal bypass system which does not hold pressure at the bleeder port on shutdown.) As soon as the burner shuts off, the pressure should drop very quickly about 10 to 25%, and then hold that pressure. The pressure cutoff reading should hold for at least five minutes without change.

**Figure 4-17: Pressure test**





Any decrease from the cutoff pressure indicates a defective or dirty pressure regulating valve (piston or piston seat) that will result in oil dribbling from the nozzle and an after fire. The fuel pump should be replaced in this case.

### Field vacuum check

While there are many reasons for the following problems, one of the leading possibilities is a leaking suction line, fittings or gaskets. If there is no other obvious cause for these problems, you should take an operating vacuum test to determine if you have a leak.

1. Pulsating pump pressure
2. Oil pump noise
3. Hard starting (ignition)
4. Poor flame retention
5. Noisy fire
6. Loss of flame during running cycle
7. Burner flame will not establish after long shutdown
8. After fire

### Checking system vacuum

The first step is calculate what the vacuum should be, then test to see what it actually is and compare the two.

To calculate the vacuum, figure about 1" of vacuum for each foot of oil lift, 1" of vacuum for each 10 feet of horizontal run, and ½" for a clean oil filter. If the actual operating vacuum is significantly less than the calculated vacuum, you probably have a leak either in the pump or somewhere in the line.

To do this test, a vacuum gauge capable of reading 30" of vacuum should be

screwed into the unused intake port. It is important that the vacuum gauge be securely tightened so that vacuum leaks will not develop around the threaded fittings.

If the unit to be tested is set up for a one-pipe system, a return oil line from the unit nozzle port should be provided to catch the oil removed from the strainer chamber during the vacuum check. Then run the burner, bleed the pump, and read the vacuum. The vacuum reading should approximate the calculated vacuum.

If the gauge reading is substantially above the calculated vacuum, there is a restriction in the oil supply that may be caused by one of the following:

1. Plugged fuel filter
2. Kinked oil supply line
3. Partially closed oil supply valve
4. Check or foot valve inoperative or sticking

*Note:* The excess vacuum caused by a partially clogged pump strainer cannot be read on the gauge. Be sure to look at the strainer through the inlet port before installing the gauge. If it appears dirty, remove the strainer and clean or replace it.

If vacuum reading is below the calculated operating vacuum, the probable causes are:

1. Clogged pump strainer
2. Air leak in the suction line or suction line fittings
3. A suction leak around strainer chamber cover plate and gasket
4. Worn pump gears

### Vacuum test

If the operating vacuum is less than the calculated figure, you have a leak to find. First determine if the pump or fittings up to the pump shut off valve are leaking by performing a Vacuum Test.

1. Fill the fuel unit with oil.
2. Shut off the valve closest to the pump. If there is no valve, disconnect the supply line at the fuel unit.
3. On a two pipe system, disconnect the return line and place an open container below the return port of the fuel unit.
4. If the system is single pipe, connect a bleed hose to the bleeder port and the opposite end in an open container.
5. Install your vacuum gauge in the alternate inlet port on the pump. (If there was no shut off and you have disconnected the suction line, install the gauge in the inlet port.)
6. Start the burner and open the bleed port. Run it until a vacuum of 15" is reached. On a single pipe system you must open the bleed port while the burner is running to raise the vacuum.
7. Once the vacuum is reached, close the bleed port. (You may need to jumper the F-F terminals on the primary control after burner start up to get the burner running long enough to reach the vacuum reading.)
8. While the burner is running and you have reached the required vacuum, on the two pipe system, plug the return port and turn the burner off. On a single pipe, close the bleed port and turn the burner off.
9. Check the vacuum reading after shut down. The vacuum should hold for at least five minutes. If the vacuum does not hold steady, you could have a leak in the pump, a leak in strainer chamber gasket, loosened strainer

chamber bolts, pump seal leak, or the pump leaking at ports, or it could be the fittings up to the shut off valve. Recheck the gasket, plugs and fittings and try again. If you are sure everything is tight, the leak may be in the unit itself, and you will have to replace it.

10. If the vacuum holds, you know that the fuel unit and all the piping up to the shut off valve are OK. Now it is time to open the shut off valve near the pump, and if there is one, shut off the valve at the tank, or at the wall where the suction line enters the building. Do the test again. If the vacuum holds, you know the leak is between the valve and the tank.

**Warning: We used to check for leaks using the pressure test method. The problem with pressurizing oil lines is it usually creates more leaks than it finds. We strongly urge you to never pressurize oil lines or tanks. This includes blowing out the lines with a CO<sub>2</sub> cartridge; instead use a hand pump to suck the line clear, Figure 4-18.**

### Visual test or sight glass test for air in oil lines

When you detect air in oil lines, you must find the source of the leak. The first step is to tighten all fittings in the suction line and tighten unused inlet port plugs in the pump. Be sure there are no compression fittings in the oil lines. Then check the filter cover and gaskets, making sure there is a good gasket on the pump cover. If none of this eliminates the air, you must start searching for the source of the leak. To confirm that there is a leak and to pinpoint the source, use the Visual Test or Sight Glass Method.

Figure 4-18:  
Hand pump



To do a visual test, use of a vacuum gauge and plastic tubing with fittings such as the Oil Watcher or Clearview, see Figure 4-19. Install the device between the pump, shut off valve and the suction line. Bleed all the air out of the lines, then run the unit and look for bubbles. One at a time, heading toward the tank, coat the fittings with lithium grease. The grease temporarily seals the leak. When the leaking fitting is covered, the air bubbles will disappear. Repair the leaking fittings and clean the grease off everything you have coated.

An easier way to find leaks is by using an electronic sight glass. The electronic sight glass is a tool used by many air conditioning technicians. It is a hand held meter that has two transducers which you can easily mount at any point in your

**Figure 4-19: Oil leak test kit**



suction line. When operating, one transducer transmits and the other receives an ultrasonic signal. The pulse the signal receives tells the unit if there is air in the pipe. If it detects air, it makes a noise. When using the electronic sight glass, attach the sensors just prior to the first fitting in the line. If no air is detected, attach the sensors just past the same fitting

and test again. Proceed in this manner until you arrive at a fitting with no air coming into it, but air after the fitting. You know that fitting is leaking. Continue on until all the leaks have been found.

#### **To check for leaks in the return line:**

More difficult to find is a leak in the return line. Over time, these can be the most troublesome leaks, because they can go for so long before being detected. When the burner is running, return lines can have up to five pounds pressure. This can add up to a lot of lost oil in a short time.

The best way to check for a leaking return line is to hook the return line up to the suction side of the fuel unit and perform the operating vacuum test. The operating vacuum on the return line, when it is hooked to the pump as the suction line, should be about the same as the operating vacuum reading for the original suction line. If the vacuum is less than the return line, it is either leaking or the original suction line is partially plugged. The potential problem with this method is that the installer may not have run the return line all the way to the bottom of the tank.

If you cannot draw oil up the return line you will not know if it is a big leak, or the line terminates at the top of the tank. Either way your next tool will be a shovel to dig up the top of the tank. (Do not hook up the suction line as a return, it could plug it up, or if there is a foot valve or other check valve in the line, it will blow the pump seal. Just vent the return oil into a bucket).

If the operating vacuum is much less than the calculated vacuum or the operating vacuum of the suction line, look for air in the oil. If air is present, there is a good chance that you have a leak. Check all fittings and joints, as well as the optional inlet plug on the fuel unit. Be sure all flare fittings are done properly and there are no

compression fittings. Be sure all oil lines that go through a wall or under concrete are sheathed in plastic tubing. Be sure to use non-hardening oil pipe dope on threads. Do not use Teflon® tape on fittings; it will void the pump warranty.

## Selection of replacement fuel units

It is good general practice to replace a fuel unit with one of a similar type, unless you have determined that there is a mismatch between the fuel unit capacities and the operating requirements of the burner. Fuel unit manufacturers attach identification plates to their units. These plates contain serial numbers that identify the units and their operational characteristics. Reference material for these identifying serial numbers is available from the manufacturers and should be included in your burner service data, as it will make selection of proper replacement units easier. When replacing fuel units, consider the following.

### Shaft rotation

Pumps are designed for either clockwise (CW) or counterclockwise (CCW) rotation and proper rotational direction is shown on the unit identification plate. With the unit shaft held toward you, clockwise rotation will be to the right, often shown by an arrow pointing to the right. Counterclockwise to the left, with an arrow pointing left. This rotation must be matched to the burner motor.

### Rotational speed

The great majority of older domestic oilburner motors operate at a speed of 1725 RPM, while most flame retention burners operate at 3450 RPM. Pump speed should be matched to motor speeds.

### Nozzle discharge port location

For ease of installation, fuel units are built with both right and left-hand nozzle or discharge ports. Again, a right or left hand port location is determined by holding the unit with the shaft pointing toward you.

### Shaft sizes

Most oil pumps have either a 5/16" shaft or a 7/16" shaft. The smaller shaft may be bushed up for substitute replacement.

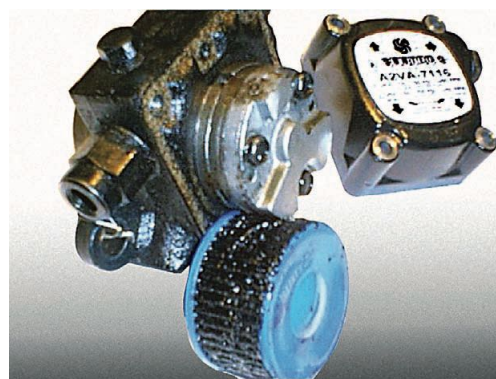
### Installation requirements

Be sure that the replacement unit is properly mounted and in line with the motor coupling. The Allen screws or flange mounting bolts, which hold the fuel unit to the burner housing, must be securely tightened. If the coupling between the motor and the fuel unit has Allen set screws, these should be securely tightened against the motor shaft, after tightening unit-mounting bolts. To do otherwise may result in a jammed coupling and damage to the pump or the motor may occur.

## Pump strainers

It is necessary to periodically clean the fuel unit strainer, Figure 4-20. To clean or replace the strainer, loosen the strainer

Figure 4-20: Dirty strainer





chamber cover bolts and remove the cover and slide out the strainer. Whenever you take the cover off the strainer, be sure to scrape off the old gasket between the cover and unit body and replace it with the proper replacement gasket. Some Webster pumps have no strainers, but they do contain chopper gears that clean the oil and the cover should be removed on a routine basis and cleaned out. Make sure you have the proper gasket before you do this.

Clean the pump strainer screen in heating oil or kerosene and reassemble, making sure to tighten all cover bolts evenly to prevent distortion of the cover. When putting the burner back into service, be sure to bleed the air from the system and check for proper flame cutoff. Remember that the strainer is a secondary filter and that a proper installation also has an external or primary filter.

### Pump gaskets

It is also important that the correct gasket be used. Using incorrect gaskets can damage the pump.

## Noise problems in fuel units, oil lines or tanks

Noise generated as a result of pump operation, or noise transmitted by oil lines, is annoying to the customer and should be eliminated.

**Pump noise:** In addition to noise created by worn internal parts in the pump, misalignment of the fuel unit and motor coupling shaft or loose installation bolts may be the source of noise problems. All fittings and bolts should be tightened securely.

**Oil line noise** is the result of improperly fastened oil lines which are allowed to

vibrate against surrounding objects such as sheet metal furnace covers, duct work, etc. If oil line noise is a result of noise transmitted from the fuel unit, check the anti-hum device in the pump. The return line on two pipe systems may occasionally provide line noises. If the suction and return lines touch each other they can create line noise.

**Tank noise:** This is not a common source of noise complaints. If such a complaint should develop, the cause can normally be traced back to transmission of noise by the oil lines. Tank noise can also be eliminated in many cases by a hum eliminator. A commonly overlooked source of tank noise is improper installation of the return line. The end of the return line of a two pipe system should be located approximately 3" above the bottom of the tank. This will permit discharge of return oil to be at a point beneath the surface of the oil, thereby eliminating the noise of return oil falling into the tank.

## Potential leaks in oil lines

**Leaking suction and return lines can cause serious problems. We all must be ever vigilant for possible pipe leaks.**

- Treat every out of oil/automatic delivery as a potential leak that should be further investigated.
- Study oil deliveries; further investigate each tank that takes more oil than projected.
- Respond quickly to any calls from customers for oil smells and concerns about increased consumption. These can be early warning signs of trouble.
- Treat every water-in-the-tank call as a potential tank leak that must be investigated.

- Operating problems with the burner can signify a leak, and any air in the oil pump call, poor pump cut-off, noisy operation, and erratic fire calls, loss of flame retention (flame pulsates on the end cone), loss of oil prime, rough starts or shut downs, pump whine and pressure fluctuation, and after drip could all indicate a leak.

In order to check for leaks in the suction pipe and fittings you must first run an operating vacuum test, covered earlier in the chapter.

## Valves

### Solenoid oil valves

Not allowing oil to flow until the burner is up to full speed and air flow into the heat exchanger has been established can make for cleaner start up. The use of a solenoid oil valve can delay fuel delivery to the nozzle for anywhere from 4 to 15 seconds after burner startup. Figure 4-21 shows an oil valve. To achieve a longer delay, a primary control with a valve-on delay feature and a non-delay valve should be used. On burner shutdown, the oil valve closes immediately, providing a much more rapid shutdown than is obtainable with the pressure control valve on the fuel unit. Figure 4-22 shows how the valve works.

In operation, this valve can solve many problems associated with poor startup and shutdown conditions such as:

1. Pulsating starts
2. Puff back
3. After fire as a result of a malfunctioning pressure regulating valve
4. Long term soot buildup in heat exchanger resulting from incomplete combustion on burner startup and shutdown

Figure 4-21:  
Delayed oil  
valve

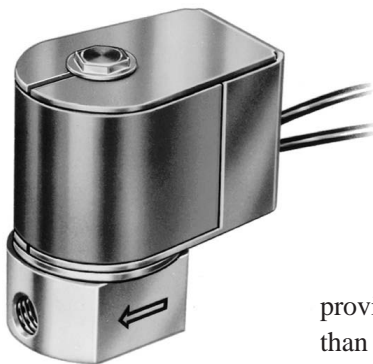


Figure 4-22: Construction detail with valve closed

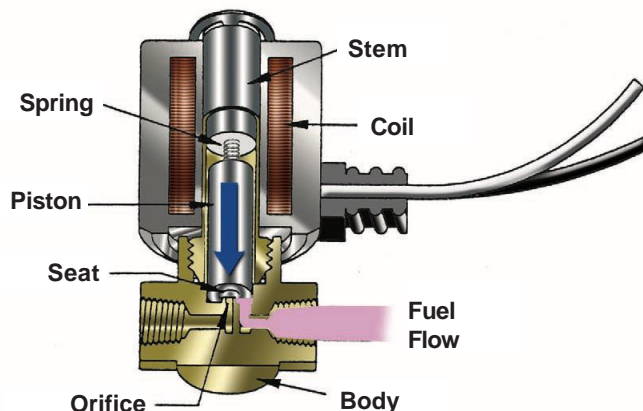
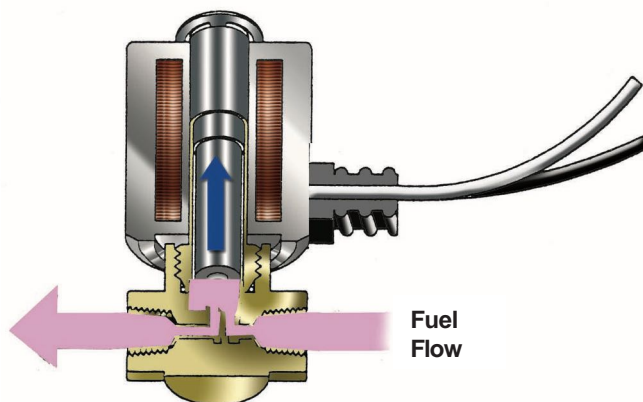


Figure 4-22: Construction detail with valve open



### Operation of the delayed action solenoid valve

The delayed oil valve may also help in preventing a puff back as a result of poor ignition. During startup, the burner motor requires a substantial starting current. This current requirement may rob voltage from the ignition system, resulting in a weak spark at the electrodes. When the motor reaches operating speed, the current requirement of the motor drops appreciably and the full supply voltage is available to the transformer. This results in maximum ignition voltage at the time the delayed oil

valve opens and oil is supplied to the nozzle.

On burner shutdown, the delayed oil valve closes immediately, shutting off the fuel supply and providing a clean cutoff of the flame. Without the delayed oil valve, the motor speed must decrease before the pressure regulating valve closes, which again causes smoke because of a lack of air.

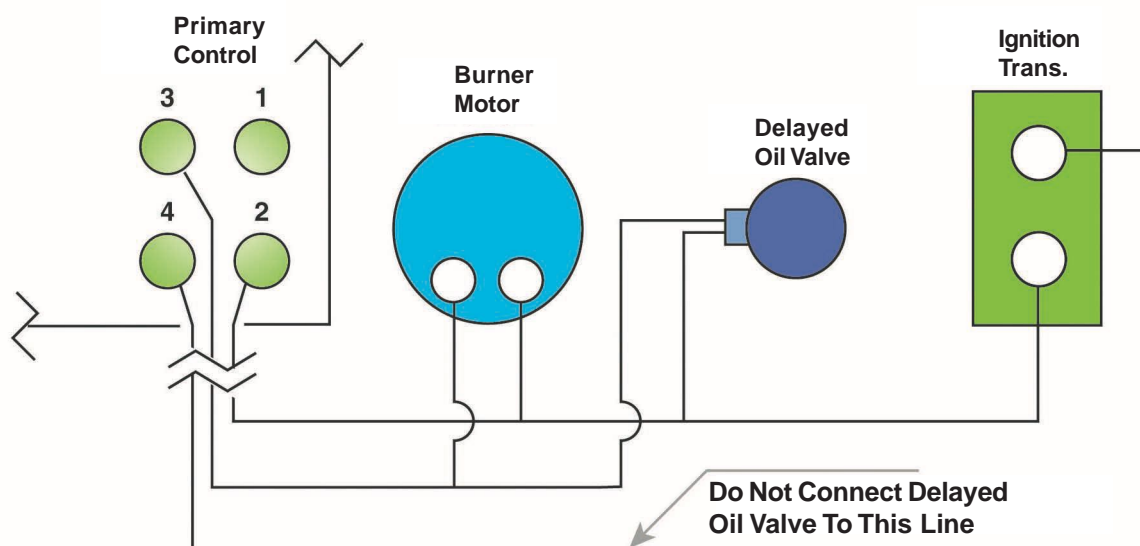
**Note:** *The delayed oil valve will only produce a clean shutdown if the oil supply system is free of entrapped air. The delayed oil valve will not control nozzle after drip that results from air in the oil supply system between the valve and the oil nozzle. This air is caused by an air leak in the suction line or pump fittings or high vacuum.*

**Installation:** The delayed oil valve is installed on the output side of the fuel unit. Standard 1/8" (I.D.) black iron pipe can be used to connect the inlet port of the delayed oil valve to the nozzle discharge port on the fuel pump. Use of the 1/8" pipe provides a rigid mounting for the valve.

The coil is electrically connected in parallel with the burner motor. See Figure 4-23 for a wiring diagram. If the burner has interrupted ignition, be sure that the solenoid valve is connected to the motor leads and not to the ignition leads. If the valve is inadvertently wired to the interrupted ignition circuit, the valve will close when ignition is cut off and burner will go off on safety lockout.

It is code in most jurisdictions, and good practice in all cases, to run the electrical leads from the delayed oil valve through Greenfield tubing to protect electrical leads from the valve to the burner junction box. The oil valve housing cover is threaded to accept Greenfield connectors or the tubing itself. Use anti-short bushings on the ends of the Greenfield. A handy device to have for the installation is a double Greenfield (BX) connector that allows two pieces of Greenfield to be connected to a single hole. This will make the electrical installation much easier in cases where the burner junction box does not have an extra outlet hole.

**Figure 4-23:**  
Delayed oil valve  
installation for  
interrupted  
ignition



A conventional fuel line flared fitting is installed in the outlet port of the delayed valve (in most cases this will be the same fitting you have removed from the nozzle discharge port) and the fuel line to the drawer assembly fuel pipe should be

the two leads of the switch together. As this field fix removes the delay feature of the valve, a new coil should be installed at the earliest possible time.

The delayed oil valve is needed on burners with older pumps. Most of the new burners utilize non-delay instant opening solenoid valves because of the relative unreliability of the thermal delay switch. Figure 4-24 shows a solenoid valve.

Manufacturers have gone to microprocessor based primary controls with Valve-Delay-On and Motor-Delay-Off, commonly known as pre- and post purge technology. The delay is built into the primary so the delay timing can be more precisely controlled. It is becoming increasingly popular for manufacturers to attach the solenoid valve, controlled by the primary, directly to the fuel unit. See Figure 4-25.

#### Anti-siphon valve and oil safety valve

If the oil tank is higher than the burner, some codes require an overhead suction line and an automatic valve that will break the siphon should an oil line leak develop. Two popular anti-siphon valves are the Webster Oil Safety Valve (OSV), and the Suntec PRV.

Figure 4-26 shows a Suntec PRV. Its job is to protect against line leaks and tank

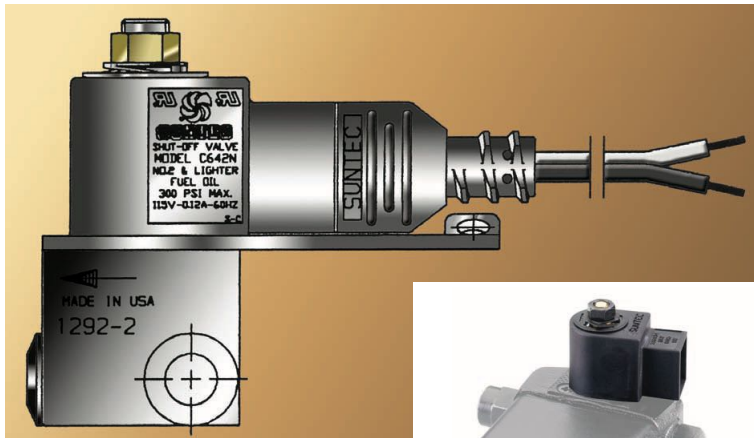


Figure 4-24:  
Drawing of a  
solenoid valve

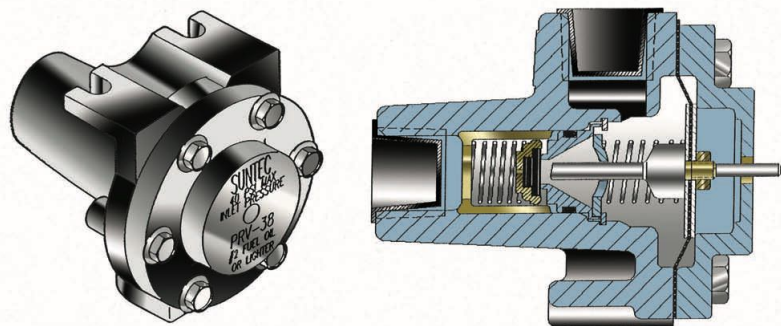


Figure 4-25: Fuel  
pump with solenoid

reinstalled. With some small amount of reworking, it should be possible to use the same fuel line that was on the burner before installation of the delayed valve.

**Servicing:** The most sensitive part of the delayed valve system is the thermal delay switch that is taped to the valve coil. Should the valve at any time fail to operate due to a defective time delay switch, it is possible to temporarily remove this switch from the circuit by removing the tape bindings and twisting

Figure 4-26: Suntec PRV





siphoning as well protect the pump from excess head pressure. When the burner comes on the pump creates a vacuum that pulls the valve stem down and opens the valve. When the burner shuts off, if there are no leaks the valve stem will stay down and remain in this position. If there is a leak between the PRV and the burner, the siphon created by the leak will close the valve, shutting off the oil supply to the line. If the red stem sticks out of the top of the valve, you know a loss of vacuum (siphon) has occurred.

If the top of the oil supply source is more than 8 feet above the fuel unit you need to install a PRV. The NFPA rating for the head pressure on a fuel unit is only 3 PSI, about 8 feet. If the tank head (height of oil supply above the unit) is greater than 8 feet, the supply oil pressure may exceed 3 PSI and thereby shorten shaft seal life. If it is necessary to locate the tank at a greater height, a pressure reducing valve or an oil safety valve should be used in the oil supply line.

#### **Thermal safety valve**

A thermal safety shut off (Firomatic) valve should be installed in the suction line at the tank. The shut off valve should be UL listed and should be equipped with a fusible type handle that melts at 165°F.

Also install a shut off valve before the filter and at the fuel pump for ease of service. If the tank is outside of the building, there should be a shutoff valve at the wall where the suction line enters the building.

#### **Foot valves**

Foot valves are check valves installed on the end of the suction line in underground tanks. They are no longer needed and not recommended; however, they were common on older installations and some are still in the field. It is not unusual for them to get stuck closed and not allow oil to flow.

There are two options in this case:

1. Run new oil lines from the tank to the burner.
2. If the return line extends to the bottom of the oil tank, you can convert the system to a one-pipe system by capping the suction line and using the original return line as the new suction line. (Remember to remove the bypass plug in the fuel pump).

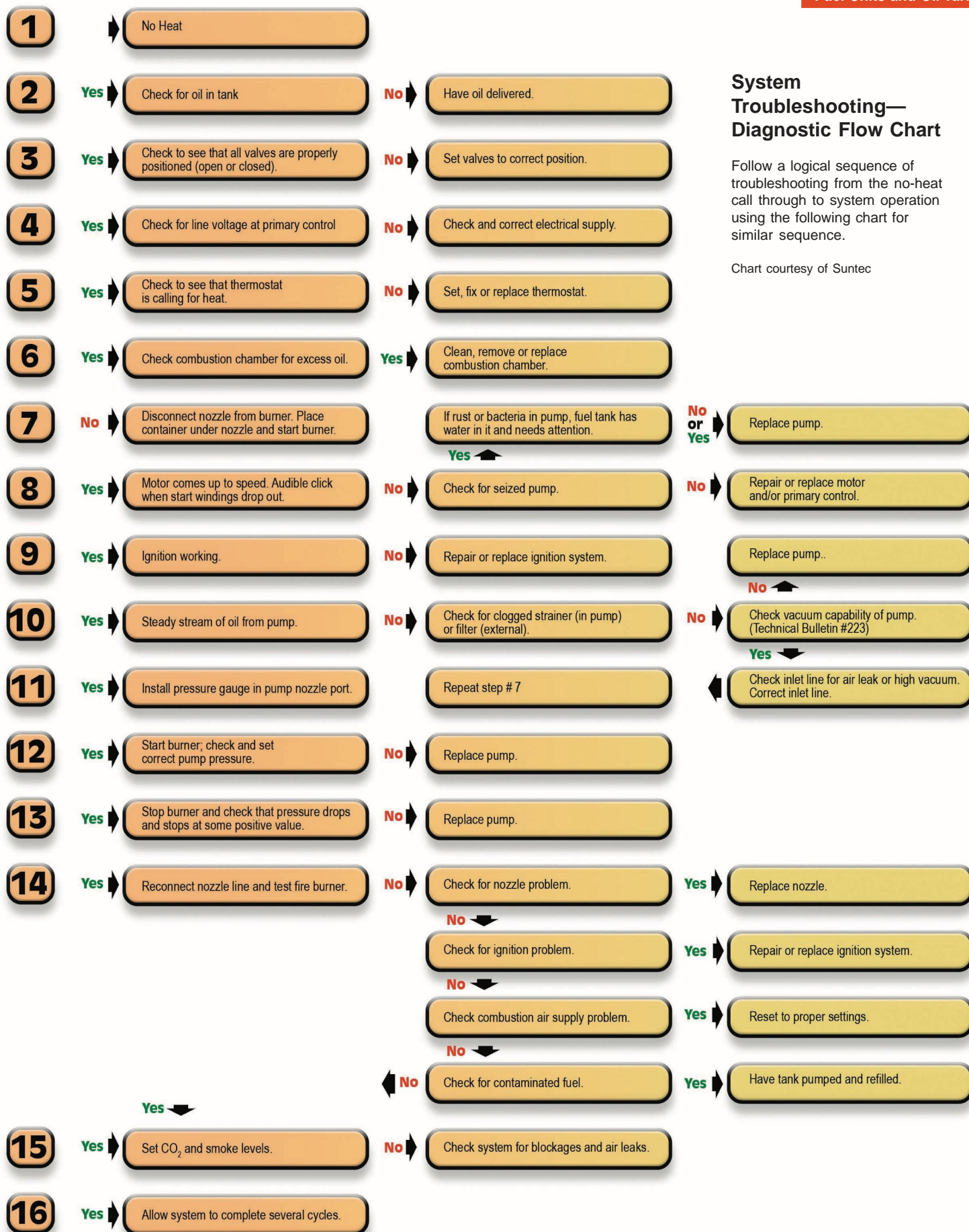
*Suntec has provided a very helpful Technical Bulletin and System Trouble Shooting Flow Chart which reviews the service procedures for both old and new style pumps, shown on pages 4-23 thru 4-25.*

Troubleshooting Fuel Units	
No Oil Flow at Nozzle	Oil level below intake line in supply tank. Fill tank with oil.
Clogged strainer or filter	Remove and clean strainer. Replace filter element.
Clogged nozzle	Replace nozzle.
Air leak in intake line	Tighten all fittings in intake line. Tighten unused intake port plug. Tighten in-line valve stem packing gland. Look for leaks in piping.
Restricted intake line	Replace any kinked tubing and check any valves in intake line.
A two-pipe system that becomes air bound	Check for bypass plug.
A one-pipe system that becomes air bound	Loosen gauge port plug, or open the bleed valve, start the burner, and drain oil until foam is gone. Check for high vacuum (over 6" vacuum). Check for air leaks in pump or oil line.
Slipping or broken coupling	Tighten or replace coupling.
Air Leak	Loose plugs or fittings. Dope with good quality thread sealer or pipe joint compound.
Leak at pressure adjusting cap nut	Fiber washer may have been left out after adjustment of pump pressure. Replace the washer.
Blown seal—One-pipe system	Check to see if bypass plug has been left in unit. Replace fuel unit.
Blown seal—Two-pipe system	Check for kinked tubing, rust in pump, or other obstructions in return line. Replace fuel unit. Check tank for water.
Noisy Operation	Bad coupling alignment, loosen fuel unit mounting screws slightly and shift unit in different positions until noise is eliminated. Retighten mounting screws or replace coupling.
Pulsating Pressure	Partially clogged strainer or filter. Remove and clean strainer. Replace filter element.
Air leak in intake line	Tighten all fittings and valve packing in intake line.
Air leaking around cover	Be sure strainer cover screws are tightened securely. Install a new gasket.
Improper Nozzle Cut-Off	To determine the cause of improper cut-off, insert a pressure gauge in the nozzle port of the pressure fuel unit. After a minute of operation, shut the burner down. If the pressure drops approximately 20% from normal operating pressure and holds at that pressure, the pump is operating properly and air is the cause of improper cut-off. If, however, the pressure drops more than 20% in 5 minutes, fuel unit should be replaced.
Air pocket remaining in nozzle line after disassembly	Run burner, bled pump, stopping and starting unit, until smoke and after-fire disappear.
Air leak in intake line	Tighten intake fittings and packing nut on shutoff valve. Tighten unused intake port plug.
Partially clogged nozzle strainer	Replace nozzle. Clean and flush out oil line and pump.

## System Troubleshooting— Diagnostic Flow Chart

Follow a logical sequence of troubleshooting from the no-heat call through to system operation using the following chart for similar sequence.

Chart courtesy of Suntec





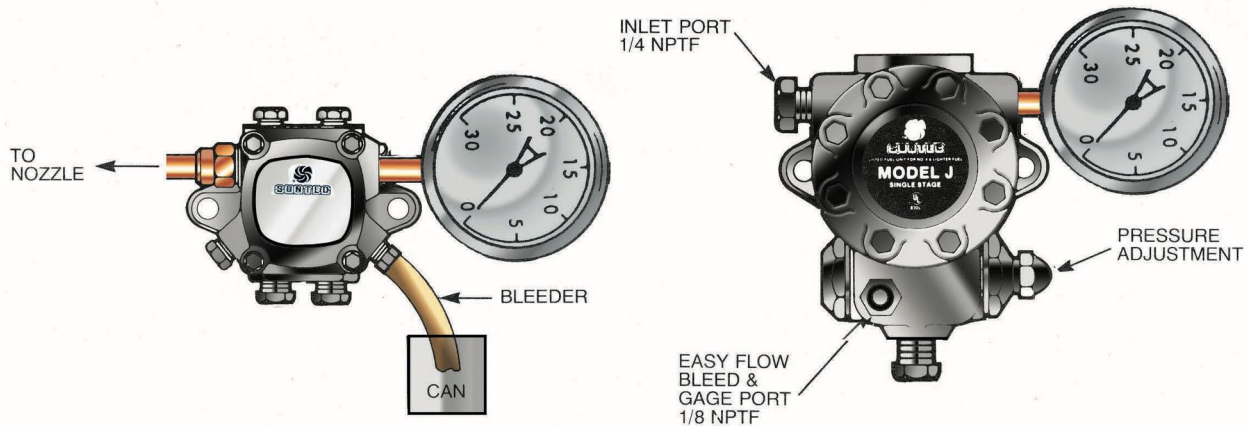
## GAGES AND FIELD SERVICE

William J. Mitchell, Manager of Field Service

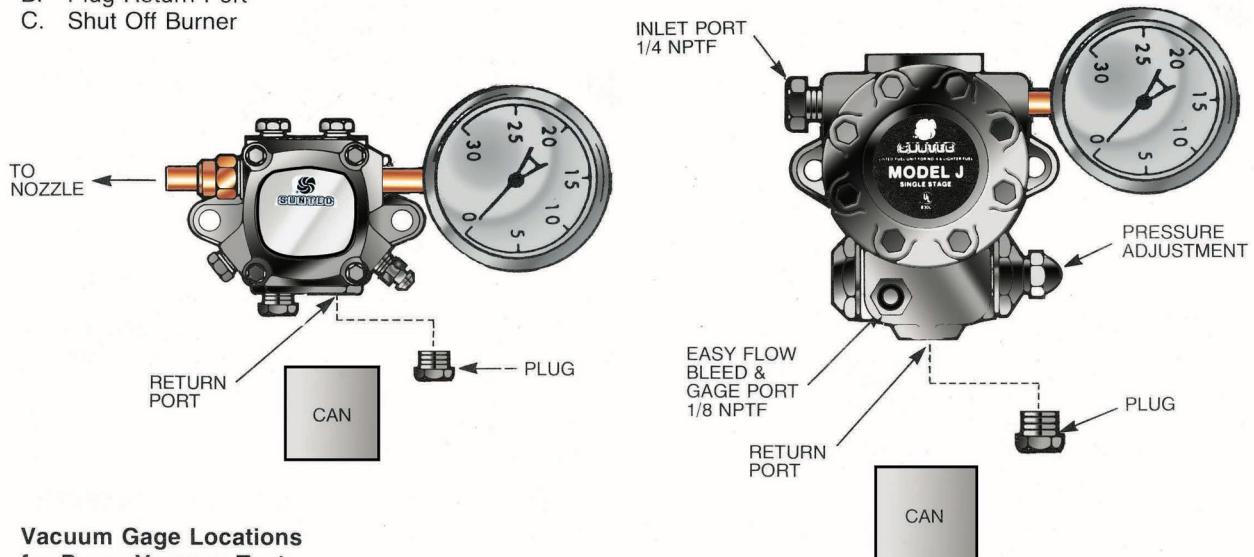
Fuel pumps have pressure, vacuum, and flow ratings for proper sizing to the application. Today's high efficiency furnaces and boilers require these parameters be checked on initial installation and service calls to insure that high efficiency is maintained. During trouble calls it is necessary to take pressure and vacuum readings to isolate pump problems from system problems.

### VACUUM TEST FOR PUMPS AND INLET LINES

1. Single Pipe Installation
  - A. Establish Vacuum With Bleeder Valve Open
  - B. Close Bleeder Valve
  - C. Shut Off Burner



2. Two Pipe Installation
  - A. Establish Vacuum With Return Port Open
  - B. Plug Return Port
  - C. Shut Off Burner



**Vacuum Gage Locations  
for Pump Vacuum Test**



## TO CHECK PUMP VACUUM:

### Single Pipe

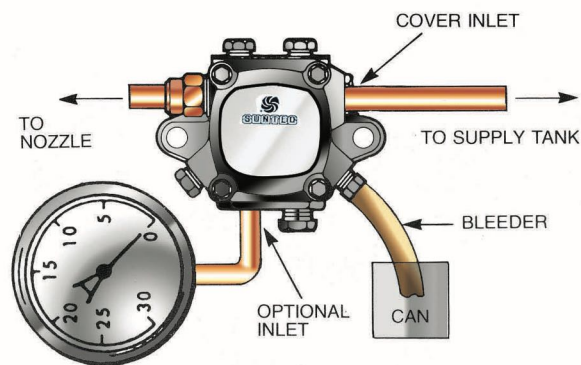
- 1) Remove inlet line and install vacuum gage in the inlet port.
- 2) Turn on burner, open bleed port. When pump reaches 15 in.Hg., close bleed port.
- 3) Pump should hold vacuum for five minutes.

### Two Pipe

- 1) Remove inlet line and install vacuum gage in the inlet port.
- 2) Remove return line.
- 3) Start burner.
- 4) When 15 in.Hg. vacuum is established, block return port and turn off burner.
- 5) Vacuum should hold for five minutes.

If pump cannot attain 15 in. Hg. or hold for five minutes, the pump should be repaired or replaced.

## TO CHECK SYSTEM VACUUM



- 1) Install vacuum gage in optional inlet or tee into supply line at pump. (If optional inlet used for line, install gage in cover inlet.)
- 2) Turn burner on.
- 3) Bleed pump if on one pipe system.
- 4) Close bleed valve and observe gage.

If vacuum reading exceeds the following specifications:

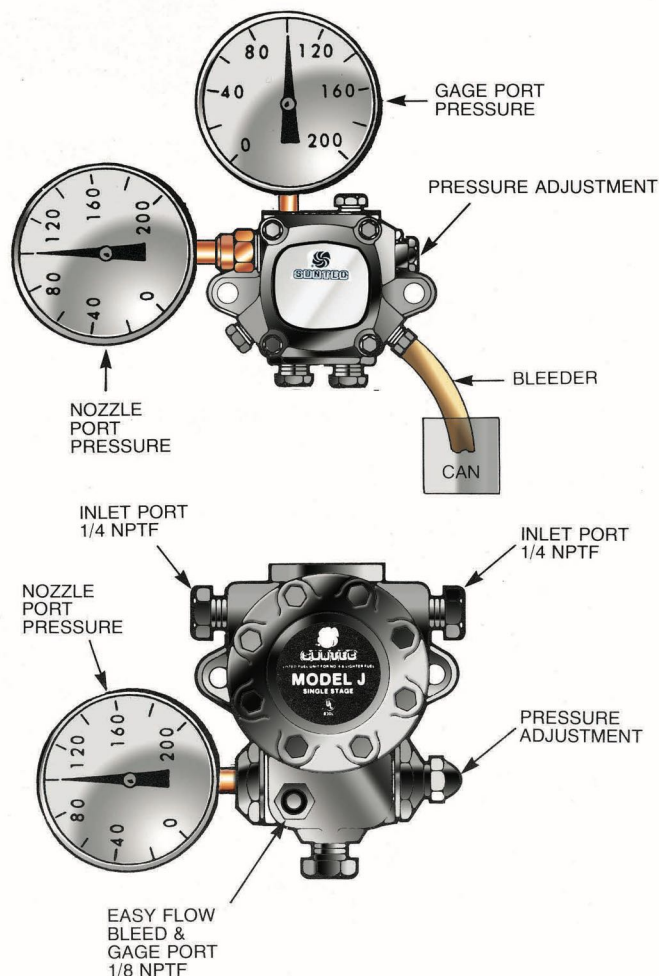
- 1) 6 in.Hg. if single pipe single stage (A or J) or two stage (B or H)
- 2) 10 in.Hg. if two pipe single stage (A or J)
- 3) 15 in.Hg. if two pipe two stage (B or H)

If there is a problem with the piping or application:

- 1) Check the installation bulletin for the pump:
  - a) Form #440100 for A's and B's.
  - b) Form #400245 for two step and high pressure B's
  - c) Form #1011 for E's and F's
  - d) Form #440041 for J's and H's
- 2) If the lift and run is not excessive for the pump model, the problem is being caused by one of the following:
  - a) Number and types of bends in the piping (includes kinks and flattening)
  - b) Number and types of fittings in the piping
  - c) Number, types, and condition of filters and strainers
  - d) Number and types of valves in the system
  - e) Level of contaminate buildup on inside walls of the piping.

If the vacuum level is not excessive, and there is air in the oil, it is usually indicative of a leak in the piping. This can be checked by closing the tank valve and pulling a vacuum on the system by the pump. Shut the burner off and the vacuum should hold five minutes.

## PRESSURE TEST OF PUMPS AND SYSTEMS



### Pressure Gage Locations for Operating Pressure Test

## TO CHECK PRESSURE WHILE OPERATING SYSTEM

- 1) Install gage in gage port
  - a) If pump is on a positive head system, shut off tank valve before installing gage.
  - b) If pump is on a lift system, single pipe, bleed pump at bleed valve following gage installation.
- 2) Turn on burner and observe gage.
  - a) Disregard slight jiggling of gage as the mechanical resonance of small gages is close to gearset frequency.
  - b) If setting is high or low, readjust pressure adjustment screw.
    - On J's and H's there can be some leakage with the acorn nut removed. This stops when the nut is replaced.
- 3) Turn off burner. The pressure should fall to zero or the amount of head on the pump.

## TO CHECK OPERATING AND CUTOFF PRESSURE

- 1) Install gage into nozzle port of the pump.
- 2) Turn on burner and observe gage. Readjust pressure if necessary.
- 3) Turn off burner and observe gage. It should fall to 80% or higher and stop.
  - a) If it continues to fall, the pump has a cutoff problem and should be repaired or replaced.