Chapter 4

FUEL UNITS & VALVES


INLET
ROTATION
PATENT PENDING
RETURN &
BY-PASS

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Chapter 4

Fuel Units & Valves

Figure 4-1: Strainer screen and gasket

Introduction

The fuel unit draws fuel from the tank to the burner, delivers it at a constant and regulated pressure to the nozzle, and provides fast and complete cutoff of the fuel on burner shutdown.

Fuel units develop both vacuum and pressure, vacuum to draw the fuel from the tank and pressure to deliver the fuel to the nozzle.

Fuel units are available in either single-stage or two-stage models. The single-stage unit has one set of gears to both draw fuel from the storage tank and pressurize it for delivery to the nozzle.

The two-stage unit has two sets of gears, one to draw fuel from the tank and return it, the other to pressurize the fuel. This allows the two-stage unit to provide higher lift capability than the single-stage unit.

Component parts of the fuel unit

Fuel units contain:

- Machined gears which provide vacuum and pressure
- A pressure-regulating valve which controls the pressure of the fuel discharged to the nozzle and provides fuel cut-off at the end of a call for heat
- A strainer screen (Figure 4-1) which filters the incoming fuel to protect the gears and prevent contamination from entering the nozzle
- A solid shaft that extends through the fuel unit housing seal and drives the gears. The end of this shaft is connected to the burner motor by a flexible coupling.
- A shaft seal to prevent fuel from leaking out of the housing around the rotating shaft. Lubrication is provided to this seal through internal porting.

In addition, most fuel units introduced since 2001 have integral solenoid valves to provide faster cutoff and provide valve-on and motor-off delays. (See pages 44 & 50 for more info on solenoid valves.)

Understanding fuel unit pressure

Fuel unit pressure is the force created by the meshing of the fuel units gears and is expressed in pounds per square inch (PSI). Pressure moves the fuel from the fuel unit to the nozzle. Fuel units can provide pressures up to their maximum rating, typically 200-300 pounds per square inch (PSI).

Fuel unit pressure can be adjusted by turning a screw on the pressure regulating valve, Figure 4-2.

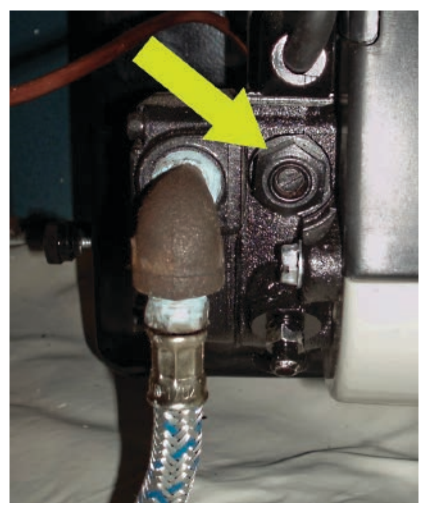

Figure 4-2: Pressure adjusting screw

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Understanding vacuum

Vacuum is "negative pressure" and is measured in inches of mercury (inHg). It is a function of the resistance the fuel unit must overcome to draw fuel from the tank. Vacuum is not "set", it is dependent on the location of the burner in relation to the level of fuel storage tank, the condition of the fuel supply piping and the condition of components installed in the suction line (filters, valves etc.) Normally, the numerical value of the vacuum is shown with an inch (") mark. Example: 5" of vacuum.

Approximately .75" to 1" Hg of vacuum is generated for each foot the fuel is lifted; 1" of vacuum for each 10 feet of horizontal run; 2" to 4" for an oil safety valve; and ½" for a clean fuel filter. For example, if there is 4 feet of lift from an underground tank, plus 10 feet of fuel line run to the burner and a clean fuel filter, the calculated vacuum reading should be approximately 5.5". In this situation, a vacuum gauge reading of 4" to 6" would be normal.

It's important to keep in mind that a vacuum reading is a diagnostic tool and not something to be adjusted (like fuel pressure)

To correctly calculate what vacuum should be, the level of fuel in the tank must be known. A buried tank that is covered with 3 feet of dirt requires 3" of vacuum to lift the fuel from the top of the tank to ground level. If the tank is 48" high and half full of fuel, another 2" of vacuum required to lift it from the level in the tank to ground level so a total of 5" is required just to lift it to ground level.

If the fuel tank is above the burner and fuel does not have to be lifted, the fuel flows to the burner by gravity and there is no vacuum generated. This type of arrangement is ideal because vacuum can cause air bubbles to be released from the fuel which can lead to combustion problems and/or burner shutdown. While vacuum is necessary in many situations, it is best to install systems in a manner that minimizes the amount required.

Operation of the fuel unit

When the motor turns the fuel unit shaft, fuel enters the strainer chamber through the intake port either by gravity or by the vacuum developed by the fuel unit. As the gears rotate, fuel is moved to the pressure regulating valve. The pressure adjusting screw on the regulating valve controls spring tension which determines the pressure at which the fuel 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 fuel unit can deliver as much as 40 times the amount of fuel required by the nozzle.

It is important to understand that all of the fuel that enters the gears of the fuel unit MUST be discharged by those gears. Therefore, any excess fuel not delivered to the nozzle must be bypassed either internally (single pipe—back to the strainer chamber) or externally (two pipe—back to the tank.)

For the excess fuel to return to the tank, a bypass plug must be installed in the fuel unit. With this plug in place, the excess fuel travels through a "return line" from the fuel unit back to the tank.

If the bypass plug is installed without providing a return line, the excess volume of fuel from the gearset will over-pressurize the fuel unit causing it to malfunction and/or leak.

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Pressure regulating valve operation

A cutaway of this valve is shown in Figure 4-3. This assembly consists of a valve body and matching piston. The pressure adjusting screw regulates the spring tension controlling the pressure of the fuel discharged to the nozzle. The discharge pressure can typically be adjusted between 100 and 200 PSI. The minimum pressure setting is 100 PSI, but almost all burners operate at higher pressures, normally 120 to 190 PSI.

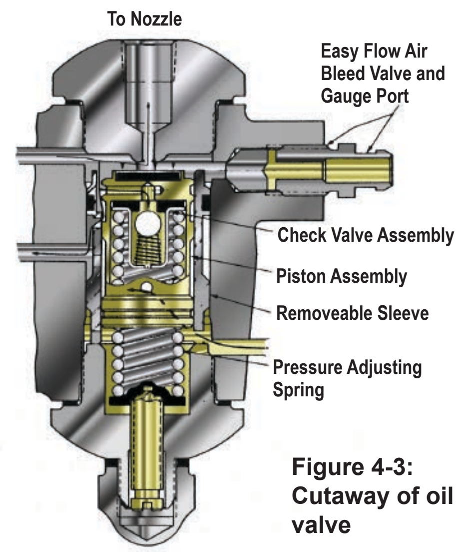

Figure 4-3: Cutaway of oil valve

In the closed position (when the burner is off), the piston is held against the nozzle discharge port by a spring located behind the piston. When the fuel unit's gears develop sufficient pressure to overcome the spring tension, the piston is forced open allowing fuel to flow through the nozzle discharge port. On burner shutdown, spring tension against the piston will cause it to close, shutting off fuel discharge to the nozzle at a pressure approximately 20% below operating pressure. Therefore, if the fuel unit pressure is adjusted to 100 PSI, the shutoff pressure will be about 80 PSI. The cut off pressure may be different from 20% with some fuel units. However, what is important is that the pressure should drop and then hold.

One-pipe systems (internal bypass)

Most of today's systems require only one fuel line to bring the fuel from the tank to the burner. These are called one-pipe systems. With these, excess fuel drawn from the tank, but not sent to the nozzle, is bypassed internally back to the fuel unit's strainer chamber.

Single-stage fuel units should operate at a maximum of 6" of vacuum on a one-pipe system. They can create much higher vacuum, but the fuel will begin to foam over 6 inHg. If the calculated vacuum is less than 6 inHG, it is best to connect the system with a one-pipe connection to the fuel tank.

Two-pipe systems (external bypass)

If more than 6" of vacuum is required, a fuel unit should be piped with a return line to the tank. This is called a two-pipe system. With these, excess fuel, not sent to the nozzle, is bypassed externally back to the tank. This requires that a by-pass plug be installed in the fuel unit. An example of such an installation would be an abnormally high lift or long run from the fuel tank to the burner. If a single-stage fuel unit on a two-pipe system has an operating vacuum over 10", unstable flame conditions, a carboned-up firing assembly, an after-fire, and/or a noisy flame may result. If more than 10" of vacuum is required, a two-stage fuel unit should be installed.

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Two-stage fuel unit, two-pipe system

The two-stage fuel unit has two sets of gears. The first set purges the unit of air and supplies an uninterrupted flow of fuel to the second stage that pressurizes the fuel to the nozzle. Figure 4-4 shows the fuel flow in a two-stage fuel unit. The first gear set provides the vacuum to fill the strainer chamber and provides a low pressure fuel supply to lubricate the shaft seal. The second set of gears provides the pressure for the fuel taken from the strainer chamber and sent to the nozzle.

If a two-stage fuel unit is connected to one-pipe, it functions as a single-stage unit. The first stage will only take fuel from the strainer chamber and return it to the strainer chamber. Since two-stage fuel units cost significantly more than single-stage units, installing them on one-pipe systems is a waste of money.

Even though single-stage fuel units are capable of creating 20" of vacuum, two-stage fuel units are needed because fuel starts to break up or “vaporize” at vacuum levels as low as 6" (Figure 4-5). When this happens, foamy fuel collects in the single-stage fuel unit and it begins to cavitate. The fuel unit 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 assembly expand, pushing fuel out of the orifice creating an after drip. The two-stage

Figure 4-5

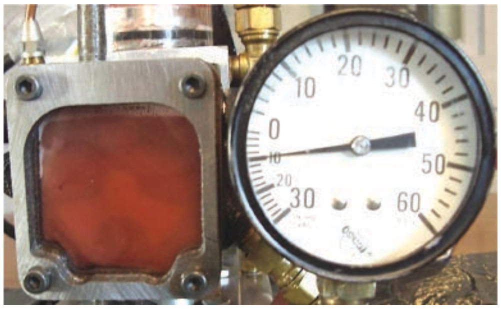
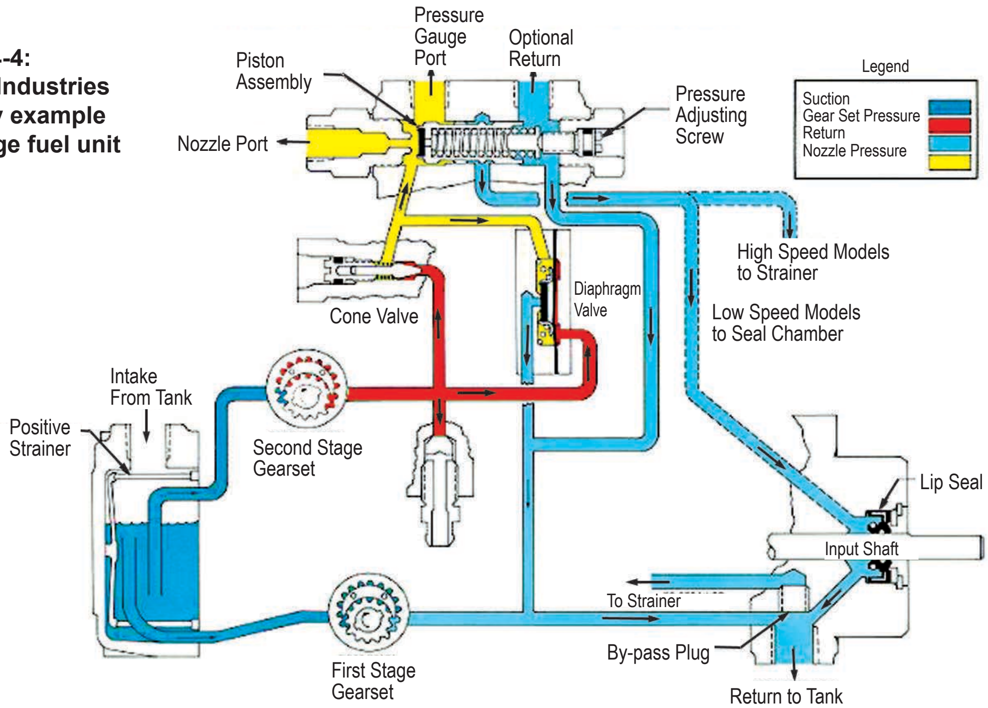


Figure 4-4: Suntec Industries cutaway example two-stage fuel unit



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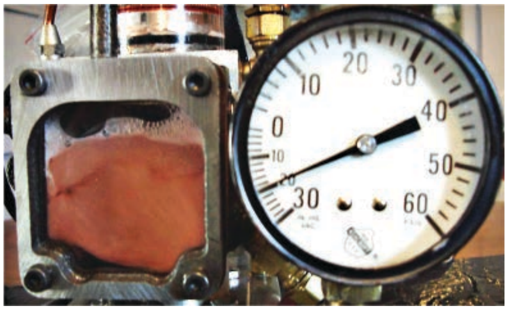
fuel unit is designed to correct the foaming fuel problem. The first set of gears brings fuel into the fuel unit and returns any foam back to the tank via the return line. It is advisable to use the lower inlet port of the fuel unit (Figure 4-6) so even at relatively high vacuum, foam free fuel is delivered to the nozzle.

Figure 4-6:
Lower inlet port

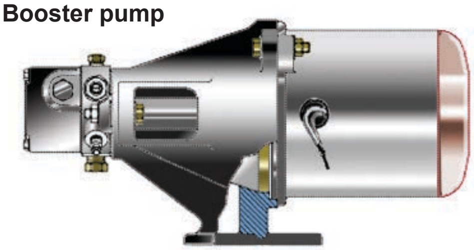
In a two-pipe system with a two-stage fuel unit, it is not advisable to exceed 17" of vacuum. Figure 4-7 shows the effect that

Figure 4-7



20" of vacuum has on a fuel unit. With high lift or long fuel line runs where excessive vacuum is required, the use of a booster pump (Figure 4-8) or fuel-deaerator may be required. The installation and associated piping of a system using a booster fuel pump is described later in this chapter.

Figure 4-8:
Booster pump



Avoid two-pipe systems

Two-pipe systems should be avoided whenever possible. The average fuel unit can move over 15 gallons of fuel an hour and the average burner fires at 1 gallon per hour. With a two-pipe system, over 15 gallons of fuel are moved from the tank to the burner for each gallon burned and filters become clogged 15 times faster.

In addition, while a suction line leak will cause burner problems, the burner will not be affected by a return line leak. The average return line is under about two pounds of pressure which will allow a large quantity of fuel to leak out of a small pinhole in the hundreds of hours a burner runs each year. With a two-pipe system returning fuel to the tank, the only way to know if there is a return line leak when the customer runs out of fuel early or fuel shows up somewhere on the property.

Also, it appears that two-pipe systems facilitate sludge formation. Copper is a catalyst that affects all fuels. Prolonged exposure to copper fuel lines causes fuel molecules to clump together and plug up nozzles, strainers and filters.

Fuel de-aerators & hybrid piping systems

Fuel de-aerators (shown in Figure 4-9) have been developed to reduce the prob-

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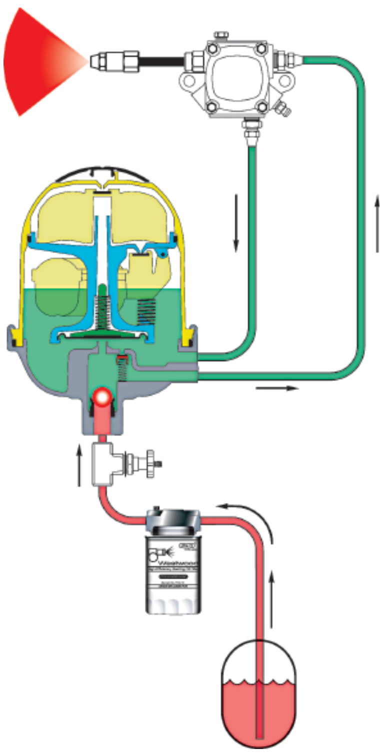
Figure 4-9: Fuel de-aerator



lems with two-pipe systems and to eliminate air problems caused by excessive vacuum. Many service professionals recommend that they be installed on all systems in which fuel needs to be lifted from the tank.

With a de-aerator installed, the piping system is a combination of a one-pipe and a two-pipe system. The de-aerator has a one-pipe connection to the fuel tank and a two-pipe connection to the burner.

This eliminates the liability of a leak in the return line to the tank, greatly reduces the amount of fuel circulating from the tank to the burner and extends the life of fuel filters.

Although a de-aerator eliminates the return line to the fuel tank, the fuel unit must be fitted with a bypass plug because a two-pipe system is required between the de-aerator and the fuel unit.

Here is how a de-aerator works:

1. Fuel is drawn from the tank to the de-aerator through a single pipe so that only the amount of fuel that is burned is replaced from the tank.
2. The surplus fuel is pumped back to the de-aerator, instead of back to the tank.
3. As surplus fuel cycles through the de-aerator loop, it absorbs heat from friction and its surroundings, reducing cold fuel problems.

Fuel unit limitations

1. NFPA 31, the National Fire Protection Association's *Standard for the Installation of Oil-Burning Equipment*, limits the shaft seal pressure to 3 PSI, although most fuel units are rated at 10 PSI inlet or return line pressure by the manufacturers. Oil Safety Valves (OSVs) can be used to protect the fuel unit from excessive pressure when required by site conditions. See page 51 for additional information regarding OSV valves.
2. Single-stage fuel units should not be operated beyond 6" of vacuum when installed for one-pipe use. Single-stage, two-pipe installations should not be operated above 10" of vacuum.
3. Although manufacturers rate two-stage fuel units at up to 17" of vacuum, **NORA recommends that they should operate below 12" of vacuum to minimize foaming.**

Fuel units with integral solenoid valves

When the burner shuts off, the fuel must also shut off quickly and completely. To do this, most fuel units incorporate an integral solenoid valve. There are also two types of fuel units with built in electro-magnetic shut off (integral solenoid) valves. One is the blocking valve fuel unit and the other is the by-pass valve fuel unit.

The blocking valve fuel unit features a normally closed valve that stops the flow of fuel to the nozzle just like an externally mounted solenoid valve does. With this fuel unit, the fuel is shut off in two ways:

1. By an electric valve
2. By the pressure regulating valve

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The by-pass valve fuel unit is a normally open valve that controls the flow of fuel to the nozzle indirectly by diverting fuel flow inside the fuel unit. When it is time to shut off the fuel flow, the 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, fuel flows. When the by-pass valve opens, fuel flow stops.

Either type of valve will enable a quick cutoff. However, to get delayed fuel flow on start-up, either a valve-on delay primary control or an electronic delay device is required. These devices enable cleaner starts-ups by allowing the burner motor to get up to full speed, turning both the fan and fuel unit at their rated rpm so that full air flow and full fuel pressure are provided on ignition. Figure 4-10.

Figure 4-10

Servicing and testing the fuel unit

Primary venting and bleeding

When air enters a one-pipe system it must be bled from the fuel unit to restore the burner to proper operation. Failure to do this completely can cause pulsation, changes in flame condition, or excessive dripping at the nozzle after the burner shuts off.

To eliminate air in a one-pipe system:

1. Attach a small hose to the bleed valve and connect the other end to a suitable container.
2. Open the valve one turn counter-clockwise
3. Run the burner until foam and air bubbles stop and clear fuel flows from bleeder valve for 15 seconds and close the valve.

If the fuel unit has been completely drained of fuel, it may be necessary to remove the supply line and fill the unit with fuel before adequate suction can be obtained. After bleeding the unit, always check the flame for stability and clean 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 fuel unit, but venting may be faster if the bleeder valve is opened to expel air.

Vacuum power bleed

If the fuel lines run above the tank and back down to the burner, proper bleeding of the fuel unit is crucial. To bleed a fuel unit, line and everything else all the way back to the tank, perform the following:

1. Fill the fuel unit with fuel and place a hose over the bleeder. A device like the one shown in Figure 4-11 works well for this purpose.

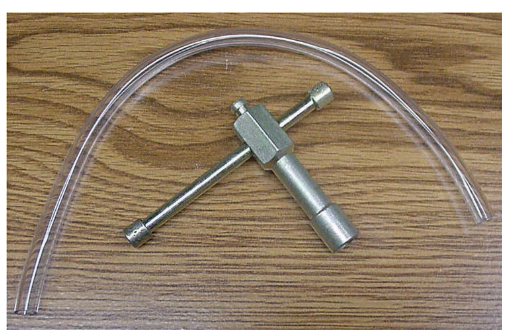

Figure 4-11: Bleeder wrench

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2. Open the bleeder one full turn. Make sure that the open end of the bleed hose is immersed in fuel in a pail or bucket.
3. Close the fuel valve at the tank and start the burner.
4. Wait until the fuel unit starts to whine. If a vacuum gauge is installed, it will show 20" to 25" of vacuum. (If white vapor starts coming out of the hose, the fuel unit is dry and needs to be refilled with fuel).
5. Open the fuel valve and bleed for several minutes. Some fuel will appear, then bubbles, then air free fuel.
6. Once all the air is bled out, close the bleeder with the fuel unit running.

Note: De-aerators are often successfully used to eliminate the need for power bleeding.

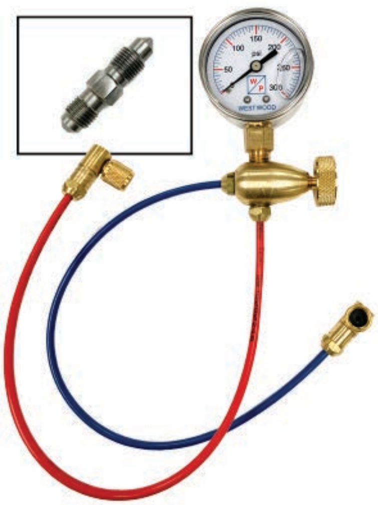

Figure 4-12: Pressure gauge, with Riello adapter (inset)

Field pressure and cutoff checks

Two of the most important service checks for a fuel unit are a)the output pressure check and b) the cutoff pressure check. These checks can be made on most fuel units by inserting a pressure gauge into the nozzle port. With Riello burners, a gauge adapter is necessary. Figure 4-12.

Output pressure check

1. Operate the burner to determine fuel unit pressure which should be set to manufacturer's recommendations.
2. Turn the pressure regulator adjusting screw clockwise until the pressure increases 40 to 50 PSI (but not above 200 PSI). If the fuel unit cannot achieve at least 150 PSI, the gears or regulating valve are worn out and the fuel unit should be replaced. Figure 4-13.

Figure 4-13: Fuel unit at 150 PSI

3. After confirming that the pressure can be raised to an appropriate level, back off the pressure adjusting screw 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:

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

Note: Slight fluctuations of the needle are considered normal in a non-liquid filled gauge.

Cutoff pressure check

Once the operating pressure check has been completed:

1. Leave the gauge in the nozzle port.
2. Run the burner until the fuel unit reaches its pressure setting and then shut the burner off.
3. As soon as the burner shuts off, the pressure should drop very quickly by about 10 to 20% (to cut-off pressure of approximately 80%) and then hold that pressure.

Note: Some fuel units have a cut-off pressure of less than 80%. The important point is that the pressure drops to some value and holds.

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Field vacuum check

There are several situations that can indicate either an air leak or "outgassing" due to high vacuum, among these are:

- Pulsating fuel unit pressure
- Fuel unit noise
- Delayed ignition
- Poor flame retention
- Noisy fire
- Loss of flame during running cycle
- Burner flame will not establish after long shutdown
- After fire

If there is no obvious cause for these problems, an operating vacuum test should be conducted to diagnose the problem.

Checking system vacuum

It is best to be sure that a clean filter and strainer are in place before conducting the test.

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

Actual vacuum is approximately 0.75" per foot of lift and for each 10 feet of suction line. To simplify the math, 1" is used to ***approximate*** calculated vacuum.

To calculate the approximate vacuum, assume about 1" of vacuum for each foot of fuel lift, 1" for each 10 feet of horizontal run, 2 to 4" for an OSV valve and ½" for a clean fuel filter.

If the actual operating vacuum is significantly less than the calculated vacuum, there is a leak either in the fuel unit or somewhere in the fuel line. Insert a vacuum gauge capable of reading 30" of vacuum into an unused inlet port. It is important that the vacuum gauge be securely tightened so that vacuum leaks will not develop around the threaded fittings.

Next, run the burner, bleed the fuel unit, 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 fuel supply that may be caused by of one of the following:

- Plugged fuel filter
- Kinked fuel supply line
- Partially closed fuel supply valve
- Check valve or foot valve inoperative or sticking

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

- Clogged fuel unit strainer (if not previously checked)
- Air leak in the suction line or suction line fittings
- A suction leak around strainer chamber cover plate and gasket
- Defective fuel unit

Vacuum test

If the operating vacuum is significantly less than the calculated figure, determine if the fuel unit or fittings up to the shut off valve are leaking by performing a Vacuum Test.

The test is slightly different for single and two-pipe systems.

1 pipe systems

1. Remove the inlet line from the fuel unit, fill the unit with fuel and install a vacuum gauge in the inlet port.

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2. Turn the burner on and open the bleeder.
3. When the vacuum reaches 15", close the bleeder.
4. Turn the burner off, the fuel unit should hold the vacuum level for 5 minutes.

(If the fuel unit cannot attain 15" or hold that vacuum for 5 minutes, it should be replaced.)

2 pipe systems

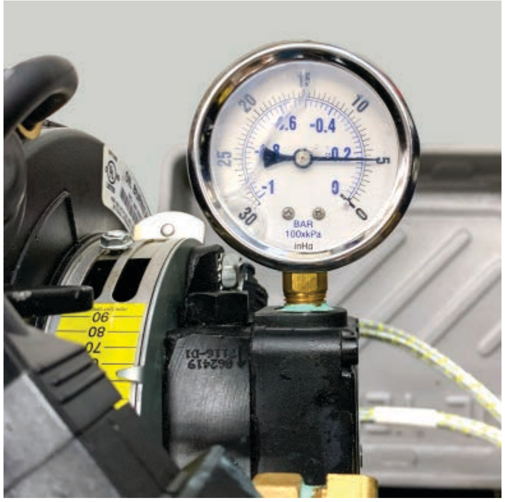
1. Remove the inlet line from the fuel unit, fill the unit with fuel and install a vacuum gauge in the inlet port.
2. Remove the return line and its fitting. Put a container under the return port to catch any fuel drippings. Apply pipe dope to a fuel unit plug and put aside.
3. Turn the burner on.
4. When the vacuum reaches 15", insert the plug into the return port.
5. Turn the burner off, the fuel unit should hold the vacuum level for 5 minutes.

(If the fuel unit can't attain 15" or hold that vacuum for 5 minutes, it should be replaced)

If the vacuum does not hold, there could be a leak in the fuel unit. Recheck the gasket, plugs and fittings and try again. If everything is tight, the leak is in the fuel unit and it will have to be replaced.

If the vacuum holds, the fuel unit is not the problem. Remove the vacuum gauge and reconnect all fittings and fuel lines. Insert the vacuum gauge into an unused suction port or inline, see Figure 4-14.

Figure 4-14: Vacuum gauge



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, the fuel unit and the suction line between the fuel unit and the valve are not leaking, the leak is between the valve and the tank.

Warning: NORA recommends that fuel lines and tanks should NEVER be pressurized. This includes blowing out the lines with a CO_2 cartridge. Instead, use a hand pump to suck the line clear, Figure 4-15.

When using a hand pump to clear the line, always pull fuel from the line and pump the blockage into a bucket. Never push the dirty fuel back to the tank.

Visual test or sight glass test for air in fuel lines

When an air leak is suspected in the suction line, the source of the leak must be found. The first step is to tighten all fittings in the suction line and tighten unused port plugs in the fuel unit.

Be sure there are no compression fittings

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Figure 4-15: Hand pump

in the fuel lines. Then check the filter cover and gaskets making sure there is a good gasket on the fuel unit cover. If none of this eliminates the problem, confirm that there is a leak and to pinpoint the source, use the Visual Test or Sight Glass Method.

To do a visual test, use a vacuum gauge and plastic tubing with fittings such as the Oil Watcher or Clearview, see Figure 4-16. Install the device between the fuel unit shut off valve and the suction line. Bleed all the air out of the lines, if bubbles appear, there is a leak. 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 that was coated.

Figure 4-16: Vacuum gauge

An easier way to find leaks is by using an electronic sight glass. It is a handheld meter that has two transducers which can be easily mounted at any point in the 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 arriving at a fitting with no air coming into it, but air after it. That fitting is leaking. Continue until all the leaks have been found.

Selection of replacement fuel units

Failed fuel units should be replaced with the manufacturers specified model. Reference material for model numbers and date codes is available from the manufacturer and should be carried in the service vehicle and/or on the technicians mobile device as it will make selection of proper replacement units easier. When replacing fuel units, consider the following:

Shaft rotation

Fuel units are designed for either clockwise (CW) or counterclockwise (CCW) rotation and proper rotational direction is shown on the unit identification plate. When facing the shaft of the fuel unit, clockwise rotation is to the right, often shown by an arrow pointing to the right. Counterclockwise is to the left, with an arrow pointing left.

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The rotation of the fuel unit must be the opposite of the burner motor. If a burner motor shaft rotates clockwise, the fuel unit shaft MUST rotate counterclockwise.

Rotational speed

Most residential burners operate at 3450 RPM, some older burners operate at 1725 RPM. It is important that the burner motor and fuel unit both are rated for the same RPM.

Nozzle discharge port location

For ease of installation, fuel units are built with either right or left-hand nozzle or discharge ports. As with shaft rotation, a right- or left-hand port location is determined while facing the shaft end of the fuel unit.

Shaft sizes

Most fuel units 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 burner coupling. The flange mounting bolts, which hold the fuel unit to the burner housing, must be securely tightened.

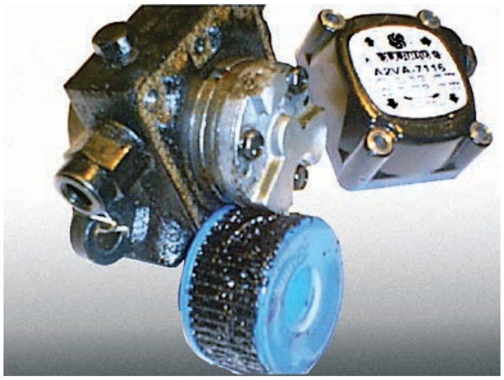
Most couplings connecting the burner motor to the fuel unit are of the “slip on” type. If the coupling between the motor and the fuel unit has hex set screws, first tighten the fuel unit mounting bolts, then securely tighten the hex screws against the motor shaft. To do otherwise may result in a jammed coupling and damage to the fuel unit or the motor may occur.

Strainers

It is necessary to periodically clean the fuel unit strainer, Figure 4-17. To clean or replace the strainer, loosen the strainer chamber cover bolts, remove the cover and slide out the strainer. Whenever the cover is taken off the strainer, be sure to scrape off the old gasket or o-ring and replace it with the proper replacement gasket or o-ring.

Although strainers can be cleaned, most technicians simply replace them during preventive maintenance or when they become clogged. Be sure to tighten all cover bolts evenly after reinstalling.

Figure 4-17: Dirty strainer



Valves

External solenoid valves

Solenoid valves enable cleaner burner start-ups by preventing the flow of fuel to the nozzle until the burner is generating full fuel pressure and air flow. The use of a solenoid valve can delay fuel delivery to the nozzle for anywhere from 4 to 15 seconds after the burner is powered. Figure 4-18 shows a solenoid valve. To achieve a longer delay, a primary control with a valve-on delay feature and a non-delay type valve should be used.

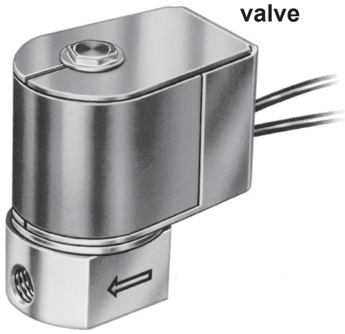


Figure 4-18: Delayed oil valve

Most new fuel units since 2000 include integral solenoid valves. If a fuel unit does not include an integral solenoid, an external solenoid may be present on the system or added on to provide the features and benefits explained in this section.

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33:16

Upon burner shutdown, the solenoid valve closes immediately shutting off the fuel supply and providing a clean cutoff of the flame. Without the solenoid valve, the motor speed must decrease before the pressure regulating valve closes which causes smoke due to a lack of combustion air. Figure 4-19 shows how the valve works.

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

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

When used with an obsolete 3 or 4 wire primary control, the coil is electrically connected in parallel with the burner motor, see Figure 4-20. See Figure 4-21 on following page for a wiring diagram. Newer controls have a designated spade for the valve.

Oil safety valve

When the fuel tank is higher than the burner, some codes require an automatic valve that will break the siphon should a fuel line leak develop. Two popular anti-siphon valves are the Webster OSV, and the Suntec PRV.

Figure 4-22, on following page, shows an oil safety valve. Its job is to protect against line leaks and tank siphoning as well as to protect the fuel unit from excess inlet pressure. When the burner comes on, the fuel unit creates a vacuum that pulls the valve stem down and opens the valve.

Figure 4-19: Construction detail with valve closed

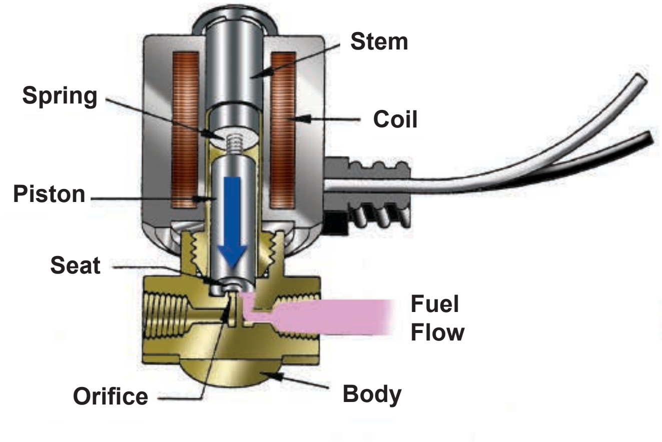
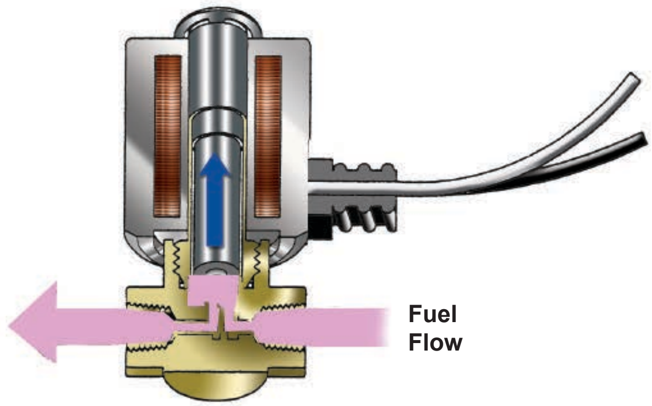


Figure 4-19: Construction detail with valve open



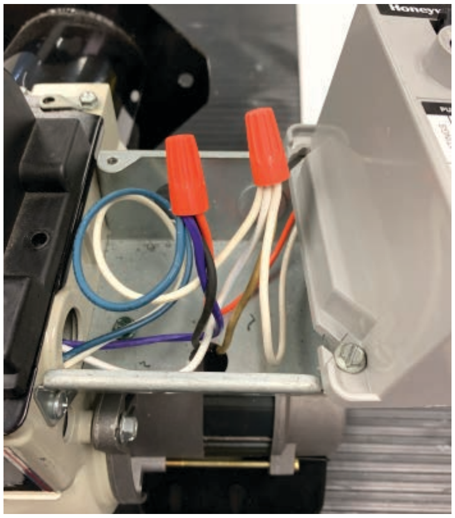


Figure 4-20

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Figure: 4-21: Delayed oil valve installation for interrupted ignition

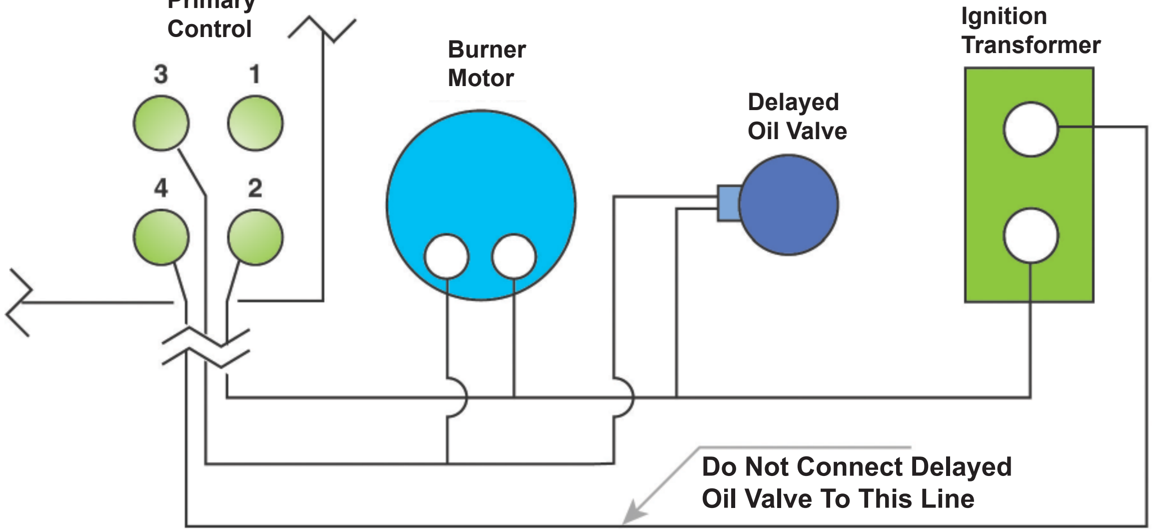
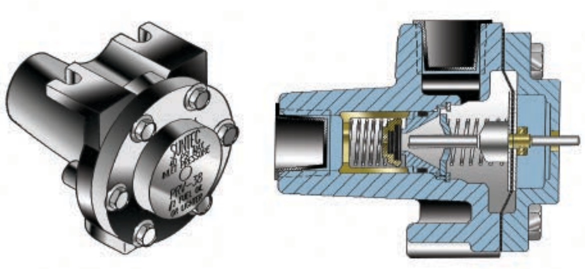


Figure: 4-22: Oil safety valve



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 fuel supply to the line. If the orange stem sticks out of the top of the valve, a loss of vacuum (siphon) has occurred.

If the top of the fuel supply source is more than 8' above the fuel unit, an oil safety valve must be installed. The NFPA rating for the inlet pressure on a fuel unit is only 3 PSI, about 8 feet. If the height of fuel supply above the unit is greater than 8 feet, the supply fuel pressure may exceed 3 PSI and shorten shaft seal life. If it is necessary to locate the tank at a greater height, an oil safety valve should be used in the fuel supply line.

Oil Safety Valves are recommended whenever the tank is higher than the fuel unit.

Thermal safety valve

NFPA 31 requires that fusible link safety shutoff valves be installed in the suction line at the tank before the filter and at the burner. If the tank is outside of the building, a fusible link shutoff valve is required at the wall where the suction line enters the building.

Check valves and foot valves

A properly installed oilheat system does NOT require check valves for proper operation.

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37:01

Check valves prevent fuel flow from the suction line back to the tank. In cases of thermal expansion, inlet line pressure may increase and the high pressure can result in shaft seal damage.

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, preventing fuel flow.

Booster fuel units

Booster fuel units are normally used to assure an adequate supply of fuel to one or more overhead furnaces. They are usually capable of lifting fuel 15 feet and supplying the fuel up to 35 feet above the fuel unit. 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 consist of a fuel unit and motor. Figure 4-23 shows a booster fuel unit.

Piping: Follow manufacturers' instructions. Suction and return lines should be sized to the specific model boost pump and lift location. A return line from the fuel pump bypass connection to the tank is required in all installations. Extend the return line to a depth in the tank slightly higher than the suction line. Figure 4-24 shows the input or low-pressure side of the installation. The auxiliary tank installation shown in Figure 4-25, on following page is another way of hooking up multiple suspended furnaces.

Figure 4-23: Booster fuel unit

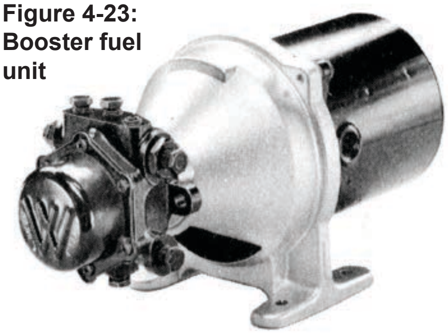
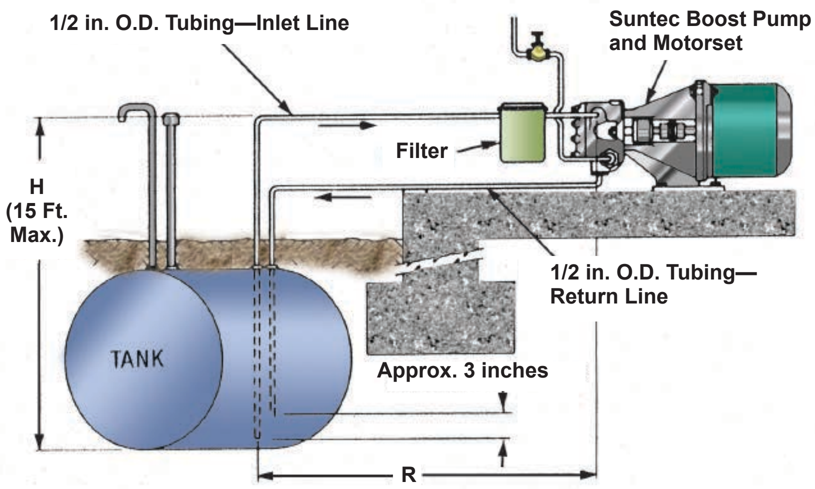


Figure 4-26 on following page shows a Pressurized System installation.

Figure 4-24: Booster fuel unit; low pressure side installation



Troubleshooting Fuel Units

Noise problems in fuel units, lines or tanks

Noise generated because of fuel unit operation, or noise transmitted by fuel lines, is annoying to the customer and should be corrected.

Fuel unit noise: In addition to noise created by worn internal parts, misalignment of the burner coupling or loose installation bolts may be the source of noise problems. All fittings and bolts should be tightened securely.

Fuel line noise: This is often the result of improperly fastened lines which vibrate against surrounding objects such as sheet metal appliance covers, duct work, etc. If the suction and return lines touch each other they can create line noise.

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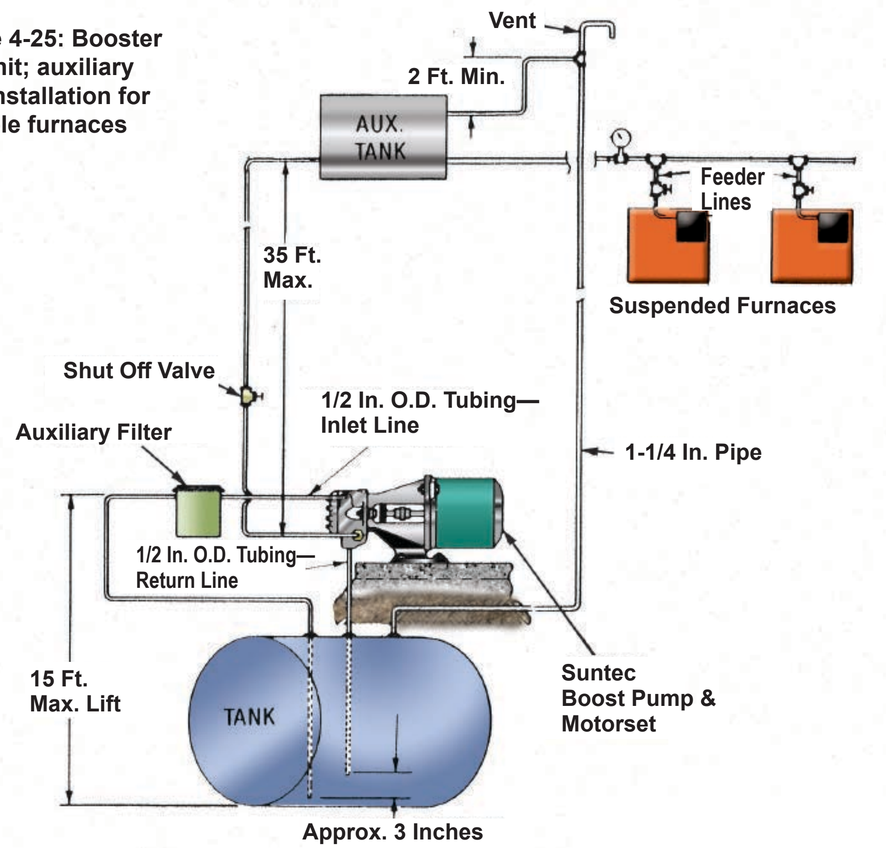
39:33

Figure 4-25: Booster fuel unit; auxiliary tank installation for multiple furnaces



Tank noise: This is not a common source of noise complaints. The cause can normally be traced back to transmission of noise by the fuel lines. 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" higher than the inlet line. This will prevent air from the return line from entering the suction line while also eliminating the noise of fuel returning into the tank.

Potential leaks in fuel lines

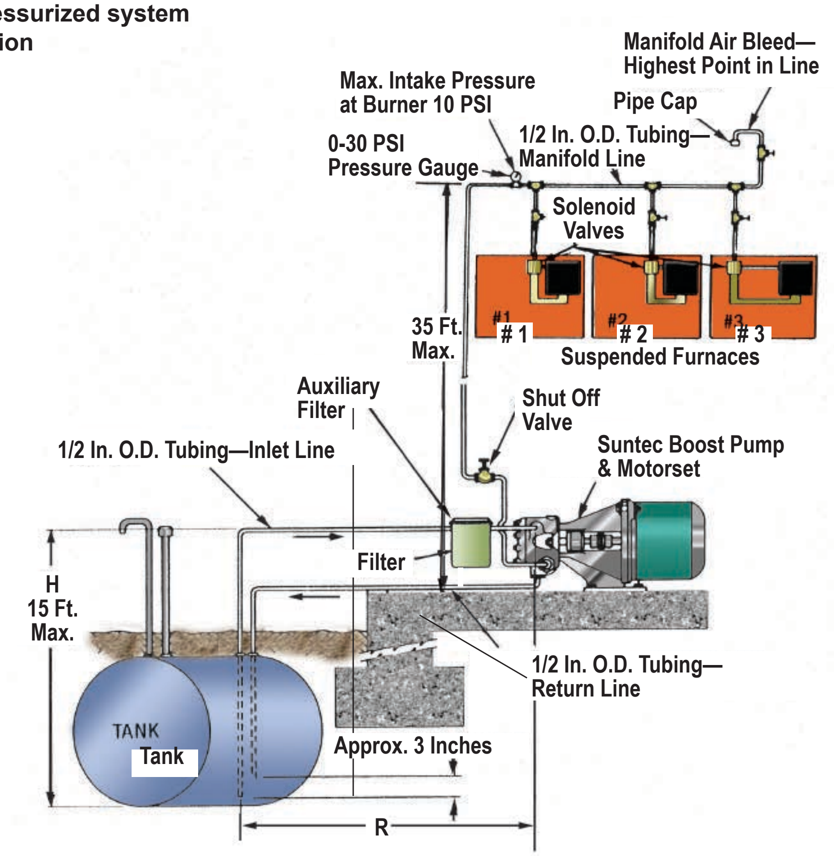
Leaking suction and return lines can cause serious problems.

- Treat every out-of-fuel call as a potential leak that should be investigated.
- Study fuel deliveries. Investigate each tank that takes more fuel than projected.
- Respond quickly to any calls from customers about fuel odors 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.

Any of the following operating problems with the burner can signify a leak:

- airbound fuel unit (loss of prime)
- poor cut-off
- noisy operation
- erratic fire
- flame pulsation
- rough starts or shutdowns
- pressure fluctuation
- after drip

Figure 4-26: Booster fuel unit; pressurized system installation



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 fuel units, shown on following pages.

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

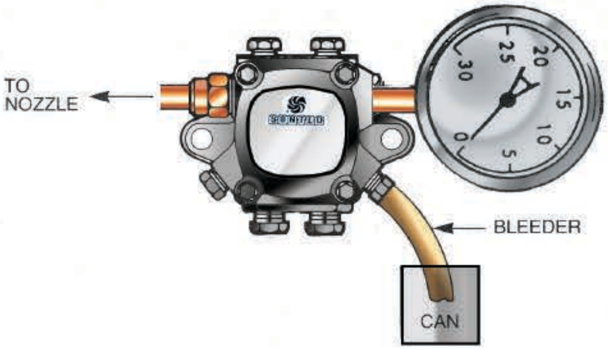
William J. Mitchell, Manager of Field Service

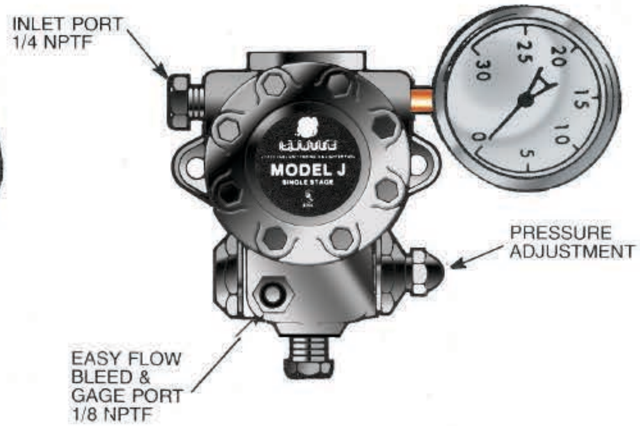
Fuel pumps have pressure, vacuum, and flow ratings for proper sizing to the application. Today's high efficiency furnaces and boilers require these parameters be checked on initial installation and service calls to insure that high efficiency is maintained. During trouble calls it is necessary to take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

VACUUM TEST FOR PUMPS AND INLET LINES

1. Single Pipe Installation

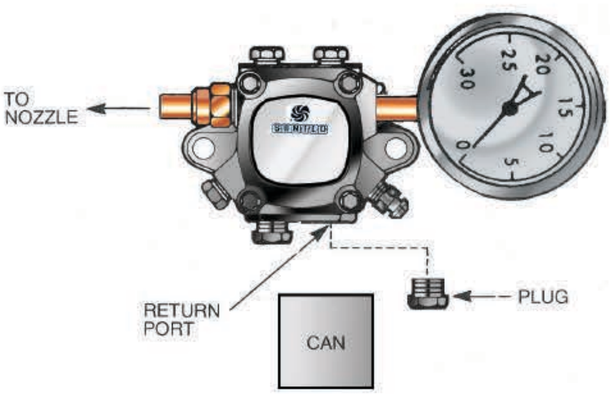
A. Establish Vacuum With Bleeder Valve Open
B. Close Bleeder Valve
C. Shut Off Burner

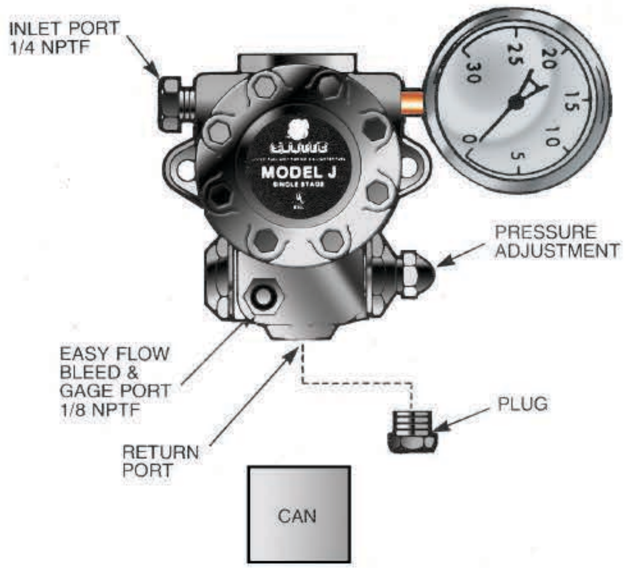




2. Two Pipe Installation

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

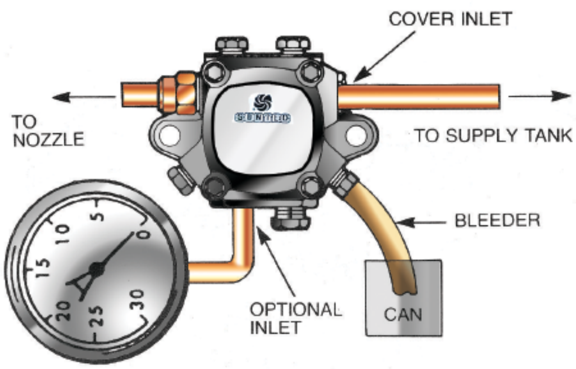
1) Remove inlet line and install vacuum gage in the inlet port.
2) Turn on burner, open bleed port. When pump reaches 15 in.Hg., close bleed port.
3) Pump should hold vacuum for five minutes.

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:

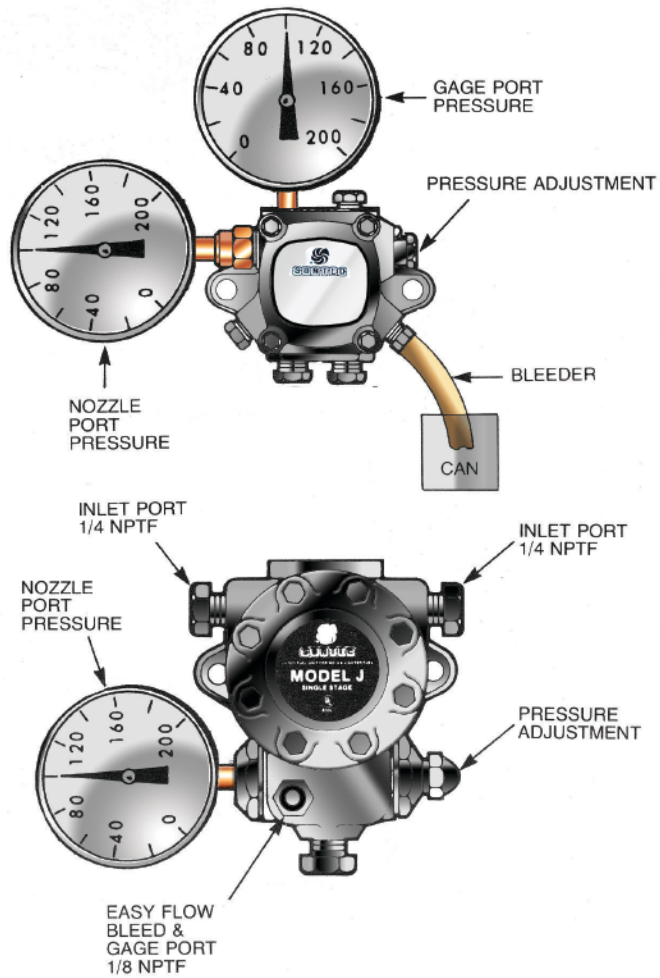
1) 6 in.Hg. if single pipe single stage (A or J) or two stage (B or H)
2) 10 in.Hg. if two pipe single stage (A or J)
3) 15 in.Hg. if two pipe two stage (B or H)

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.

Chapter 4: Additional Resources

NORA has compiled a library of additional technical resources for your continued education. Scan the QR code or go to the web address. Check back often, as NORA will continually add content as it becomes available.

You will find:

- Videos
- Technical Bulletins
- Instructions
- and More

https://Learning.NORAweb.org/fuel_units