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Springboard Biodiesel

SpringFlow 250 Shell & Tube Heat Exchanger

Installation and Use Tips

The SpringFlow 250 shell & tube heat exchanger has many uses including, but certainly not limited to, biodiesel usage and production. Biodiesel makers and users will find the SpringFlow 250 especially useful due to its full stainless steel construction. Most economically priced heat exchangers incorporate red metals such as copper, brass, or bronze, which are not compatible with biodiesel. (For more information, see the document titled *Biodiesel Compatibility with Copper and Brass.*) With the SpringFlow 250, you are protected from the problems and complications that come from material incompatibility, and have the ability to transfer heat to and from a wide variety of other substances as well.

The primary applications discussed in this document are:
1 – Automotive biodiesel preheating
2 – Biodiesel preheating for home heating furnaces

Before branching into these separate applications, here are a few tips regarding installation and plumbing.

The SpringFlow 250 can be mounted in any orientation. The integral mounting plate is designed to allow maximum mounting flexibility. In situations where a wide, flat surface is available, it may be desirable to mount the unit by is base, as shown at left.

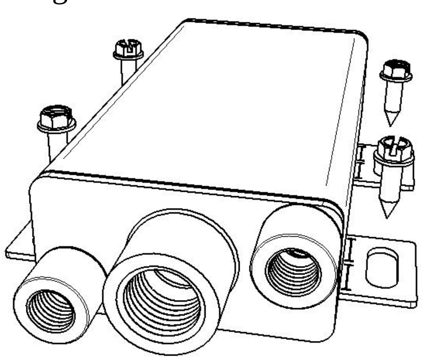

Figure 1 **BASE MOUNTING**

In some instances, it may not be possible to anchor the SpringFlow 250 at all four flanges. Due to its light weight, it is not a problem to anchor it by only two of the flanges, provided that they are diagonally opposed to each other.

The mounting slots are sized to provide clearance for fasteners as large as 5/16” (8mm). The slots will also allow for ½” of back/forth movement.

In other situations, where there is a narrower surface on which to mount the SpringFlow 250, side mounting may be desirable, as shown at right. The opposing flanges, if not used, may be bent up against the body of the unit to keep them out of the way, as shown. The flanges can be bent by hand, but most find it easier to use a vise or a pair of pliers.

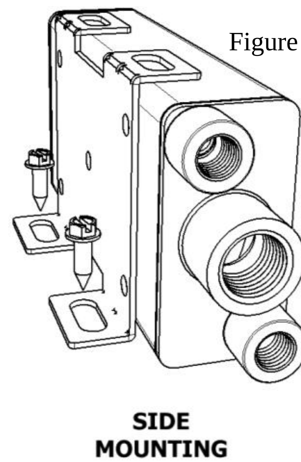

Figure 2

Once the mounting position of the SpringFlow 250 is determined, then the plumbing of the fluids to and from the unit take place. The shell side of the SpringFlow 250 is configured with ½” NPT female fittings, allowing maximum flexibility for attaching various types of plumbing. Flow direction through the shell is not critical. Choose one of the ½” connects to be the shell inlet, and the other will be the shell outlet. The tube side of the SpringFlow 250 uses ¼” NPT female fittings, and again, the flow direction is not critical. In some applications involving very slow flow rates through the tube, it may be desirable to position the SpringFlow 250 horizontally (see figure 2) in a base mounting position, with the lower of the two ¼” fittings as the inlet and the other as the outlet, as this will encourage any air to bleed out. In most typical applications however, the air will easily bleed out of the tube regardless of the orientation of the unit and the choice of inlet vs. outlet.

In most applications where biodiesel is being warmed by another fluid (such as by engine coolant in an automotive setting), the biodiesel will flow through the tube and the warming fluid will flow through the shell. When using biodiesel, make sure that all other plumbing is chemically compatible. Various stainless steel hose barb adapters are available from Springboard Biodiesel (www.springboardbiodiesel.com/store).

<u>Automotive Fuel Preheating</u>

The driving force behind the development of the SpringFlow 250 was the common need to warm biodiesel when used in an automobile in cold weather. As the temperature drops, biodiesel (and to a somewhat lesser extent, petroleum based diesel) can begin to ‘gel.’ Gelling is a generic term which describes the formation of solid ‘frozen’ crystals of fuel. Neither biodiesel nor diesel have a sharply defined freezing point the way many pure substances, such as water, do. This is because diesel and biodiesel are both made up of a mixture of similar, but slightly different molecules, all of which crystallize at different temperatures. So gelling is a somewhat gradual process, as the fuel transitions from a clear, fully liquid substance, all the way to eventually becoming a solid. Below are several terms that define gelling in its various stages.

Cloud Point: This is the temperature at which solid crystals begin to form and become visible to the eye. Fuel that is just below the cloud point typically behaves very similarly to fuel that is just above the cloud point – the ratio of solid to liquid is so small as to have very little impact. However, when fuel reaches the cloud point it is a good indicator that complications are likely to occur should the fuel temperature drop much further.

Cold Filter Plugging Point (CFPP): As the name suggests, this is the temperature at which a fuel filter will plug due to the presence of solid fuel crystals. The fuel filter is the first point on the automobile at which 'gelling' becomes apparent. It tends to 'strain out' the solidified fuel crystals. The greater the amount of solids in the fuel, the more of it will be prevented from flowing through the filter. This eventually is manifest to the driver of the automobile as a loss of power, particularly under load (when the engines demand for fuel is higher). In addition to adversely affecting operation of the vehicle, a plugged filter can, in some vehicles, eventually cause some damage to injection components. Many injection pumps are lubricated by fuel, and so when they are starved of fuel, they can also become starved for lubrication, resulting in faster wear.

Of course, the actual definition of CFPP applies to a specific test arrangement, in which the filter is of a particular configuration and plugging is defined by a specific set of circumstances. Automotive fuel filters vary tremendously. Additionally, the amount of resistance to flow through the fuel filter which causes the fuel system to behave as though it is 'plugged' can vary a great deal. So the tested CFPP may not correlate directly to the real temperature at which an automobile starts to be adversely affected by resistance to flow through the filter.

Pour Point: This is the minimum temperature at which fuel can be poured. More practical from an automotive standpoint, it is the minimum temperature at which fuel will flow as a liquid and can be pumped.

Except in very cold weather, the majority of complications associated with cold weather usage of biodiesel are related to the cold filter plugging point, rather than the pour point. If the ambient temperature will be below the pour point of the fuel to be used for an extended period of time, then extensive equipment including heated/insulated fuel lines, a fuel tank heater, etc., will be needed to use the fuel successfully. If, however, the fuel is still liquid enough to flow when pumped, then the SpringFlow 250 can likely bring it above its Cold Filter Plugging Point. The *SpringFlow 250 Technical Specifications* shows the warming performance of the SpringFlow 250 in a typical automotive application.

Automotive Installation Tips

It is usually best to supply the shell side of the SpringFlow 250 with engine coolant from one of the heater hoses. Although it goes without saying, just to be sure, DON'T try to plumb the SpringFlow 250 into any of the radiator hoses. This could interfere with engine cooling and cause very expensive damage.

Many cars have more than one heater hose to choose from. The flow to one or more of these hoses may be regulated by the heater controls inside the cab. If you want to be able to control the coolant flow through the SpringFlow 250 using your cab heater controls, then install it in line with one of these hoses. This is a popular method, since you generally don't need your SpringFlow 250 in conditions where you wouldn't want your heater running. If you want coolant to flow through your SpringFlow 250 at all times, then choose a heater hose which is not subject to the position of your heater valve.

Since the shell side of the SpringFlow 250 is exposed to coolant, not biodiesel, there is no harm in using brass fittings here to connect to your heater hose. Adapters from ½" pipe thread to ½, 5/8, and ¾" hose barbs are available from Springboard Biodiesel at (www.springboardbiodiesel.com/store).

When plumbing in your fuel line, be sure to position the SpringFlow 250 *ahead* of your fuel filter, otherwise it will have little helpful impact. If using biodiesel, be sure not to use brass or copper fittings for your fuel. Stainless steel adapters from ¼" pipe thread to ¼, 5/16, and 3/8 hose barbs are also available from Springboard Biodiesel.

There is little point in insulating the SpringFlow 250 in an automotive application. The engine has plenty of extra heat to spare (hence the radiator), and if there is a steady flow of coolant through the SpringFlow 250, the amount lost to the surroundings will have a negligible affect on the capacity to warm fuel.

When examining the performance graphs in the *SpringFlow 250 Technical Specifications,* two conclusions quickly become evident. First, the unit has adequate heat transfer capacity to significantly warm fuel at a high flow rate. Secondly, that as the flow rate diminishes, the temperature of the exiting fuel goes up steeply. For instance, at a 60 degree inlet temperature and a flow rate of 1.5 liters/minute, the exiting fuel temperature will be approximately 95 degrees F. For the same inlet temperature, though, and a flow rate of 0.5 liters/minute, the exiting fuel temperature will be about 121 degrees F. The fuel flow rates across the wide spectrum of automotive applications can differ drastically. And so, while the SpringFlow 250 has enough capacity to keep up with the warming needs of most of these applications, for some, there will be significant *excess* capacity.

Excess capacity may or may not pose an issue, depending on the amount of excess and the particular application. In some situations, there are advantages to some excess heating; this can result in lower viscosity and better atomization of the fuel as it is injected into the engine, in turn resulting in better fuel economy. On the other hand, if viscosity gets too low, it may result in increased slippage in some injection pumps, which in newer vehicles may trigger computer error codes or other issues.

There is no 'right answer' in terms of what is the maximum temperature at which diesel or biodiesel should enter an injection pump. Injection pumps and injectors are different and different fuels have different temperature/viscosity relationships. Winterized diesel fuel contains high blends of kerosene, which have a lower viscosity than standard diesel fuel #2. Diesel fuel #2 also has some range of viscosities at any given temperature, and of course a large variance in viscosity through changing temperatures. Biodiesel and biodiesel blends tend to have somewhat higher viscosities than diesel fuel #2, and these also vary in viscosity with temperature. At the extreme end of the spectrum, straight vegetable oil (SVO) has a much higher viscosity than any of the aforementioned fuels and must be heated to around 180 degrees F just to attain tolerable injection conditions.

(Springboard Biodiesel does not endorse the use of straight vegetable oil in diesel engines. For more information on why, please visit www.springboardbiodiesel.com/biobasics/svovsbio.)

According to the National Renewable Energy Laboratories (NREL) the *minimum* allowable viscosity for blends of winterized diesel is 1.3 cSt at 40 degrees C (104F). NREL's chart, below, depicts the relationship between the temperature of biodiesel blends and their viscosity.

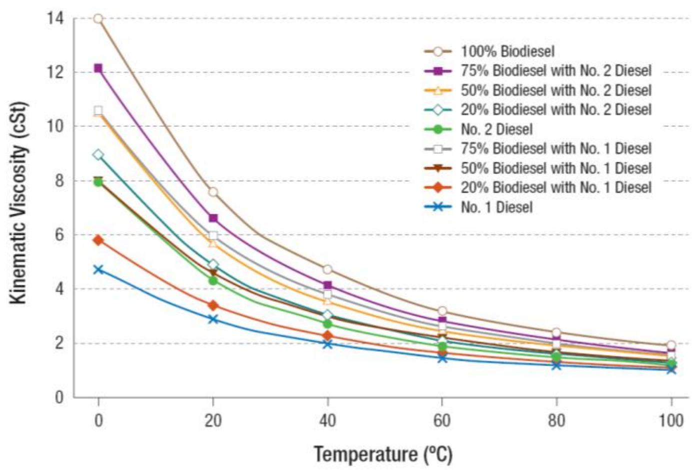

Figure D-2. Kinematic Viscosity for a Commercial Biodiesel in Various Blends

In view of the tremendous variation that in all of these factors, and the almost limitless combinations of factors, Springboard Biodiesel cannot offer specific guidance on appropriate heating for specific applications. **It is the responsibility of the user to determine whether excess heating of fuel will occur in their application, and if so, whether it needs to be limited.** The published charts in the *SpringFlow 250 Technical Specifications* can aid the user in determining what kind of fuel temperature to expect from his SpringFlow 250.

If the user does decide to have some control over the heating capacity of the SpringFlow 250, the control should be accomplished through regulating the flow of the hot coolant through the unit. (It should not be accomplished by bypassing the fuel flow past the unit. If the fuel flow is bypassed around the unit to control its temperature, this will result in a quantity of fuel left inside the heat exchanger for an extended period of time at high temperature, which will lead to its eventual oxidative degradation.) The simplest way to control the flow of the hot coolant through the unit would be with a shutoff valve, as shown at right. For best coolant flow, it is recommended that the shutoff valve be a ball valve. With this valve in place, if the fuel is adequately heated, and no more heating of the fuel is desired, then the ball valve can simply be closed, preventing

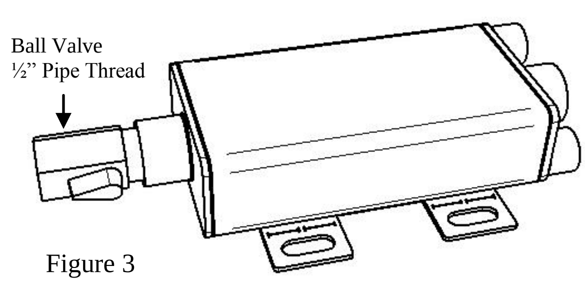

Figure 3

any more coolant from passing through the shell and transferring heat to the fuel. While most metal ball valves are adequate for this application, Springboard Biodiesel does offer a very compact and economical valve.

It should be noted that in the shutoff valve configuration mentioned above, if the shutoff valve is closed, then the flow through that heater hose will also be stopped. In most cases, this will result in the automobile's heater being disabled until the valve is opened again. It is important to make sure that shutting off the flow through the heater hose will not prevent coolant flow to any vital components requiring coolant flow.

If the user wants to be able to shut off coolant flow to the SpringFlow 250 without interrupting flow through the heater hose, then the unit may be plumbed with a bypass circuit, basically a parallel path that the coolant can take if the flow through the heat exchanger is shut off. Again, this can be plumbed fairly simply with two ball valves. Figure 4 below shows a recommended bypass configuration available from Springboard Biodiesel.

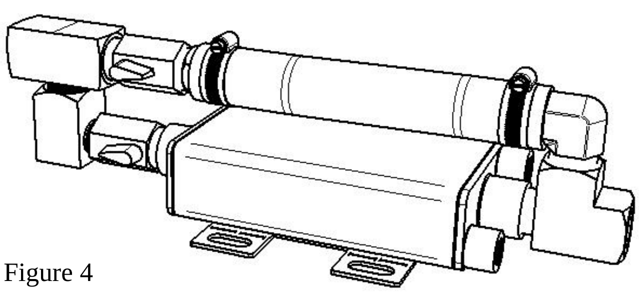

Figure 4

One advantage of a bypass setup like the one pictured is that in addition to independent control of the flow through the heat exchanger and the heater hose, the two valves can also be used to adjust the flow rate through the heat exchanger. For instance, if the bypass valve is fully open, and the head exchanger valve is only opened slightly, then a very slow flow rate of coolant through the SpringFlow 250 can be achieved, resulting in less heat being transferred to the fuel.

These are, of course, only a select group of recommended methods for limiting the amount of heat transfer to the fuel; there are many more possible ways of achieving this.

Furnace Fuel Preheating

While biodiesel is usually first thought of as an automotive fuel, it also performs very well as a fuel for furnaces and boilers which normally run on fuel oil. However, one significant drawback often prevents its use in such systems. The majority of fuel oil-fired furnaces and boilers operate primarily when the weather is cold. And, as already discussed at length, when it gets cold, biodiesel has a tendency to gel. The SpringFlow 250 can enable biodiesel usage in these devices by transferring the necessary heat to the fuel.

The easiest way to implement this solution is by means of a hot water loop, plumbed through the shell of the SpringFlow 250. Hot water can be moved, using a recirculating pump, from a hot water heater tank, through the SpringFlow 250, and back. It is important to note that the nameplate on the SpringFlow 250 specifies 30 psi as the maximum operating pressure for the shell. However, typical residential and commercial water pressure usually runs between 40 and 60 psi. The maximum pressure rating on the SpringFlow 250 nameplate applies to liquids or gases. Referencing the *SpringFlow 250 Technical Specifications* document, the maximum pressure for liquids only in the shell is 75 psi, which encompasses standard water line pressure.

Regarding fuel flow through the SpringFlow 250, one common configuration is to simply plumb the fuel through the SpringFlow 250 on its way from the storage tank and prior to the filter and the burner. This is adequate if the fuel in the storage tank stays above its pour point.

On the other hand, if there is a risk of the stored fuel falling below its pour point, then it may be beneficial to set up an additional SpringFlow 250 with a recirculating loop coming from and back to the fuel storage. This keeps the fuel in the tank warmed and liquid, while the other heat exchanger warms the incoming fuel to ensure passage through any filters and good combustion in the burner. This is best set up with the warm fuel return line entering the tank near the bottom, to prevent thermal stratification in the tank.

When used for warming burner fuel, it is recommended that the SpringFlow itself be kept insulated, as any heat lost will be money lost as well. Additionally, just as with other plumbing, it is important to keep any water in the SpringFlow 250 from freezing, as this will likely cause the unit to burst.

<u>Miscellaneous</u>

It should be noted that in this, or any other application, if more heating capacity is required, then this is easily accomplished by adding additional units. If higher temperature is desired, then the units should be plumbed in series. If more bulk heat transfer is desired, then the units should be plumbed in parallel. If the units are plumbed in series, then for maximum effectiveness the hot fluid and the fuel should be plumbed counter-flow. For instance, if there are *n* units in series, and they are labeled a, b, c, ….n, then the hot fluid should be plumbed from its source to a shell port on unit 'a' and exit a shell port on unit 'n.' The cold fuel should enter a tube port on unit 'n,' and exit a tube port on unit 'a.'

The SpringFlow 250 can be used just as well for cooling as for heating. If a hot substance needs to be cooled down, it can be pumped through the tube ports and cool water can be pumped through the shell. For instance, in biodiesel production, the mixing of methanol with potassium hydroxide is exothermic, giving off significant heat. To keep the methanol from overheating while the mixing takes place, it can be circulated through the tube side of the SpringFlow 250, and cold water can be run through the shell side. Due to its construction from stainless steel, the SpringFlow 250 can handle the caustic nature of the methoxide.

Additionally, the SpringFlow 250 can be useful in condensing vapors. The gas can be plumbed through the shell, and a cold fluid can be circulated through the tube. Again, in biodiesel production, this can be applied to the condensation of methanol from a gas phase to a liquid phase.

The SpringFlow 250's stainless steel construction gives it excellent corrosion resistance and thus a very broad range of suitable applications. It is vital to remember, however, that stainless steel is not impervious to all chemical attack. Corrosion of the unit will eventually result in loss of structural integrity, which puts the user at risk of a dangerous spill or other failure. Therefore, it is vital to avoid subjecting the SpringFlow 250 to any chemicals or substances which could corrode or weaken 304 stainless steel.