The Phenomena of Air Separation in Diesel Fuel

Fact #1: There is AIR entrained in diesel fuel.

Fact #2: A very slight pressure drop can cause air to form visible bubbles.

Fact #3: Air can cause problems.

Fact #4: Air entrained in diesel fuel is not the same as diesel fuel vapor.

Fact #5: Air, once freed from fuel, will <u>not</u> go back into solution. Fuel vapor, however, CAN go back into solution (solid fuel).

The Problem

When fuel is in storage and quiescent, air is not visible. Depending on how much air is present in molecular form, more or less will separate from fuel as it moves through any torturous path, such as a fuel filter, and collects in any high point in its path.

If this collection point is above the outlet of the filter, the air will collect until the bubble is large enough to reach down to the outlet. The air will begin to extend beyond the outlet orifice due to its surface tension until forces are great enough to break part of the air bubble free. It then passes into the outlet line as a significant size bubble.

In the past, the average size engine never noticed air bubbles passing through its injection system because the absence of solid fuel was of such a short duration, the kinetic forces kept the engine running while missing a few power strokes until solid fuel reentered the injection system. In the vocabulary of diesel fuel injection engineering there is a term called IEB (Interrupted Exhaust Beat). One cause of IEB is air bubbles passing into the fuel injection system; other causes are not relevant here.

For small engines, the problem will often result in an engine shutdown, because the amount of fuel for each injection is so small that the air bubble lasts during too many injections and the engine will stall before solid fuel reenters the system.

With the advent of electronic controls, the problem can become even greater. In some of those systems, the air bubble may be sensed as "fuel exhaustion" and the engine goes into shutdown mode.

Many smaller engines, however, use rotary distributor type fuel injection pumps and these, due to their design, can often handle the incoming air bubble. The air escapes into the governor cavity before being metered to the high pressure pumping plungers.

The Solution

The simplest and best solution is to use a filter head that has the outlet line exiting directly from the top, with no place for air bubbles to collect. In this solution, air is not stopped from coming out of fuel, but as each minute bubble forms, or coalesces on the downstream side of the filter media and passes to the top side of the element, it will pass out of the filter as a very tiny bubble. These bubbles seen in clear tubing may appear in a minuscule stream as champagne type gas bubbles.

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Note: fuel lines leading to the injection system must not have any areas where air can collect or the solution will be defeated.

Racor has two filter assemblies available that will solve the problem. The 600 Series has an outlet directly on top that, when connected with an orifice fitting, will send any air directly to the return system. An air vent must be fitted with an orifice between 0.020 to 0.040 inches (0.5 to 1.0 mm). This filter series is available in four sizes and can handle flow rates up to 120 GPH (454 LPH).

Models 325 and 330 provide a location for an air vent fitting that is designed to do the same thing. The air vent must be fitted with an orifice as mentioned above. These models will handle flow rates up to 75 GPH (284 LPH).

If it is not convenient to change to a different filter head, another solution is to provide a tee fitting in the outlet or outlet line with one of the tee's ports aiming straight up and connected to a line leading to the return system. This air venting port of the tee fitting must be fitted with an orifice as mentioned above.

Simple Illustration of the Phenomena

Many years ago this writer was challenged by two separate customers on two different occasions to prove that a filter from which they could see air bubbles exiting, did not have leaks allowing air to be drawn into the filter. The demonstration consisted of using an open top 50 gallon drum filled with diesel fuel to submerge the filter in. The filter inlet had no fittings, but was simply exposed to the fuel in which the filter was submerged. The outlet was connected by means of a clear line to the inlet side of an electric fuel pump as planned to be used in the production vehicle. The outlet of the pump was directed to the top of the drum of fuel. After completely filling the test filter with fuel, the filter was turned upside down so that the sediment collection bowl was on the top end of the assembly in the drum of fuel. The prediction that in 20 minutes the fuel filter assembly would float to the top of the drum was met with skepticism. But in about 20 minutes, up it came! The customer's engineers were finally convinced that the bubbles were the result of entrained air being coalesced out of the fuel, and not from leaks.

Some visible bubbles can be the result of fuel going into a vapor. Depending on the fuel temperature, at about 12 inches of mercury, diesel fuel will begin to vaporize and a stream of bubbles may be seen emanating from the point of the lowest negative pressure. Fuel vapor bubbles disappear as soon as the negative pressure is removed or after the fuel is pressurized on the pressure side of the transfer pump. The proof that air bubbles are air and not vapor is that they appear when there is very little negative pressure involved. They also do not disappear after being pressurized by a lift pump, unless of course the pressure is high enough to compress them beyond the point of visibility (about 50 microns or less).

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