DEBUNKING FUEL FILTER MYTHS | HOW TO PREDICT ECONOMY & RANGE

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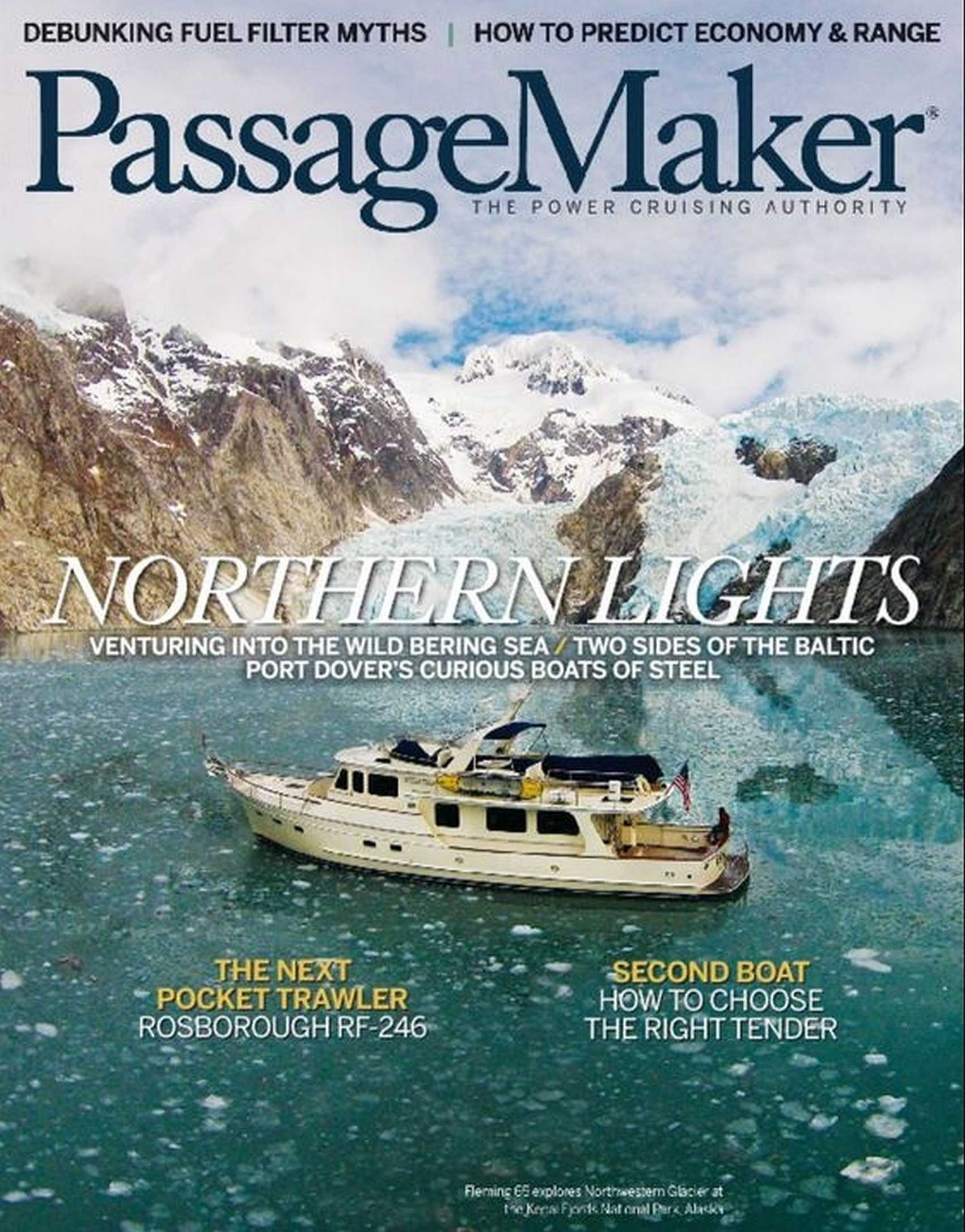

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Troubleshooter

BY STEVE ZIMMERMAN

Mythbusters: Fuel Filters

Understanding how fuel filters work will help guarantee a safer engine room.

The lower section of this filter contains the centrifuge and an accumulation of asphaltene particles can be seen on the fins. The metal shield at the bottom provides a measure of protection in the event of a fire.

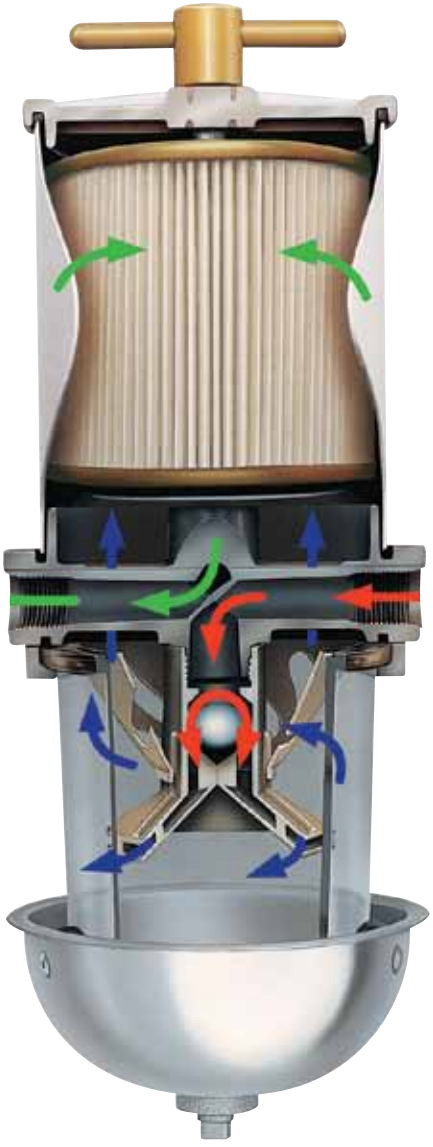

Figure 1.

Steve Zimmerman; Courtesy of Parker Hannifan

Every cruising powerboat has a primary fuel filter, and Parker Hannifan's Racor line dominates the market. At a recent TrawlerFest diesel engine class, a number of questions came up regarding these filters. Having heard these questions before, I realized that many of us do not have a clear understanding about this critical piece of equipment. Lack of clarity can lead to poor decisions.

Before we look at specific misconceptions, it will be helpful to look at the overall design. The image in *figure 1* illustrates the typical fuel-flow pattern. Diesel fuel enters through the side port and is directed down where it moves a ball out of the way and passes through a centrifuge. The fuel then flows into the upper chamber. The filter element fits onto a tube and the tube provides suction, drawing the fuel through the outside of the element into the center. This tube then draws the diesel down again, allowing it to exit directly opposite from the entry port.

UNFILTERED THINKING

The first misunderstanding about fuel filters revolves around the ball. Many believe the ball serves as a check valve

Engine room fires do happen, and having a fuel filter that meets the ABYC safety standards might be a life saver.

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to keep water from going up into the filter element. As the theory goes, the ball is plastic and floats, blocking water. In fact, the ball is aluminum, doesn't float, and has nothing to do with water.

The engineers put it there to prevent fuel from draining out of the filter and back into the supply line when the engine is shut off. The flow of fuel back toward the tank pushes the ball into a seat, acting as a check valve to stop the flow. In some applications, such as when the filter has been installed below the tank pick up, this back flow would not be a concern. But in many applications the filter can be at the high point, and fuel running back to the tank can easily lead to a loss of prime.

After the fuel flows past the ball it enters the centrifuge at the base of the assembly. A centrifuge works this way: By spinning a mixture, the denser material accelerates and moves to the outside where it falls to the bottom and can be collected and removed. Less dense material stays closer to the center and remains in the normal flow. When filtering diesel fuel, denser material consists of two compounds: water and asphaltene. Water weighs more than diesel and consequently the centrifuge separates the water out of the flow and it falls to the bottom of the bowl where it is drained off. All diesel fuel contains asphaltenes–molecular compounds found in crude oil. Asphaltenes can join together forming particles and sludge, and the process is compounded in ULSD fuel and in fuel that reaches higher temperatures (such as the fuel returned to your tank by your engine).

The term "centrifuge" leads to the second misunderstanding about filter performance. Most of us think of a

centrifuge as a spinning device, and in the absence of any spinning parts, you might wonder if the filter is working properly. If you look at the centrifuge area visible through the clear plastic base while the engine is running, you won't see any moving parts, and that leads some to wonder if it is working. The Racor's design creates a centrifugal effect by guiding the fuel into an accelerated circular flow pattern. The simplicity of no moving parts results in a more reliable device.

On most marine filters, the clear plastic base is surrounded by a metal bowl. Contrary to many opinions, that metal bowl is not designed to capture fluid spills. In order to comply with ABYC safety standards, the filter must be able to withstand 2½ minutes of exposure to burning diesel fuel, without leaking. The metal provides a critical shield between the fire and the plastic base, hopefully buying enough time for the fire suppression system to take over. Keep in mind that this requirement applies to the filter housing, as well as any fittings attached to it. Plastic nipples, for example, will melt, allowing fuel to drain out of the filter and potentially exacerbating the fire. If your filter has the designation "MA," then it meets ABYC safety standards.

Restrictions will limit the fuel flow and the pump will create a vacuum. Too much restriction and engine performance will suffer, and that is why a vacuum gauge provides you with critical information.

After leaving the centrifuge, the fuel flows into the upper chamber where suction pulls it through the outside folds of the filter element into the center. These filter elements have been carefully engineered to filter particulates to a prescribed standard (30 micron, 10 micron, 2 micron), while allowing adequate fuel flow to the engine. Keep in mind that between the filter and the engine there is a pump which draws fuel from the filter to the engine's fuel system. Restrictions will limit the fuel flow and the pump will create a vacuum. Too much restriction and engine performance will suffer, and that is why a vacuum gauge provides you with critical information. On most boats the vacuum gauge is mounted directly on the filter in the engine room, which means you won't see the reading while under way. The vacuum gauge should

The black plastic tube draws the fuel into the filter element. Air will not enter the filter unless it fills the housing down to this pickup point. The vacuum gauge on the right has a red tracer needle that will indicate the highest vacuum pressure during the day's run.

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have a tracer needle that will remain at the maximum vacuum encountered during that day's run. It pays to know the vacuum pressure with a clean filter at cruising RPM, which usually falls between 0 and 3 inches of mercury on the vacuum gauge. If it is higher than that, your system has a restriction caused by something other than the fuel filter–perhaps a clogged pick up tube or too many fittings in the supply line. Although it varies somewhat from engine to engine, once the vacuum gauge reaches 7 or higher, it is time to replace the element. At 15 inches of vacuum, diesel fuel will boil.

FURTHER CLARITY

Let's learn more about the filter element. It has been said that a slightly dirty element is more effective than a clean one. That statement is partially correct in that a 30 micron filter becomes closer to a 10 micron filter as it clogs. If, however, your engine calls for a 30 micron primary filter, there is nothing wrong with a clean filter–it will meet the spec without needing some clogging to improve it. In addition to the particle size, these filters are hydrophobic: Racor produces them with a special coating (which causes the distinctive odor that comes with each new filter) that repels water and keeps it from passing through the filter. As common rail engines have become increasingly demanding with regard to fuel quality, Racor has continually improved that coating which is now up to its seventh version. That nasty odor tells you that you are installing a highly effective replacement.

As the filter accumulates particulates, the vacuum gradually increases. Two problems can occur as a result. First, the increased resistance can affect engine performance as the flow of fuel is constrained. If you are running at cruising speed and you start to lose

RPM or performance, a clogged filter could be the culprit.

Second, whenever there is a vacuum, atmospheric pressure will tend to equalize the disparity, and air will enter the system wherever it can. That is one reason why carefully replacing the two O-rings that come with a new filter is so important–as the vacuum increases, air will enter the system through any openings, no matter how small.

Air in the filter causes concern for those servicing their own systems, and with good reason. If you have too much air in the filter your engine might shut down. Before we dispel the final myth, let's look at how air gets into the filter. The most obvious cause arises when you change the filter, but there are other ways. Bubbles of air can appear in the fuel itself, either from agitation when filling or from the return fuel dropping into the tank. Modern diesel engines cycle far more fuel than they burn, using the extra fuel for cooling and/or lubrication. An engine that burns 15 gallons per hour might be sucking 50 gallons per hour through the filter and returning the excess back into the tank. Air can also work its way into the filter as a result of the vacuum discussed above. A poorly seated O-ring or slightly loose hose fitting can provide such a path. If you suspect that air is entering the fuel system but can't find the source, you might try temporarily substituting a clear section of hose and watching for a stream of bubbles.

Assuming that your system is airtight and that aeration of the fuel is not a problem, then changing the filter remains the only way to introduce air. Some would have you believe that unless you fill the filter to the absolute top, you risk drawing air into your engine, and that is not true. Remember that a tube inside the filter creates the suction that pulls fuel through the element. As long as the fuel level remains above this pick up point, no air will get into the engine.

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On a 900 series filter, that spot is about 4 inches below the lid–even if you only have fuel within 2 inches of the top, air will not be drawn in. In boatyards we often replace elements that show contamination from the bottom to within 2 to 3 inches of the top, and which look unused above that mark. This scenario typically arises when the last person who replaced the filter element failed to add fuel to the top. No additional air entered, and the upper portion of the filter remained unused. Cover the replacement filter with fuel, but you need not fill it to the brim. On smaller filters, however, the margin for error is less: On the 500 series, the pick up point is only about one inch below the top of the filter.

FUEL FACTOR

Fuel requirements for modern diesel engines become more stringent with each generation. The precision present in electronic fuel systems enables increased performance with improved efficiency, while greatly reducing emissions. Providing clean fuel becomes critical, and it pays to know your filtration system inside and out. Don't believe everything you hear on the dock. Do your research, check your engine manufacturer requirements, and keep an eye on your vacuum gauge. ■

Steve Zimmerman is the president and founder of Zimmerman Marine, which operates four boat yards in Maryland, Virginia, and North Carolina. Zimmerman has been repairing and building boats for almost four decades.