Trucking's Dirty LITTLE SECRET

A MAJOR DIESEL ENGINE PROBLEM HAS GONE UNDETECTED. AND IT'S DESTROYING FUEL SYSTEMS. IT'S DIRTY FUEL.

By Steve Sturgess, Senior Editor & George Morrison, Contributor

The mandate to reduce diesel engine emissions and increase engine performance and fuel economy has resulted in major technological advances in diesel engine fuel system design and sophistication.

The modern diesel engine is smoother running, quieter, more powerful, and yet much more environmentally friendly. The system can even diagnose its own problems.

This is all well and good. But a major diesel engine problem is currently going undetected – and it is destroying these precision fuel systems.

The problem is dirty fuel.

Ten years ago, maximum diesel fuel system pressures seldom exceeded 3,000 psi. Today's state-of-the-art fuel system pressures can be as high as 30,000 psi.

And therein lies the problem.

The issue became apparent some 20 years ago – not in fuel systems – but in newly developed high-pressure hydraulic systems that utilized servo valves. It was noted that hydraulic system component life was drastically reduced in the new high-pressure systems. And for no readily apparent reason.

Pumps and valves that had previously lasted tens of thousands of hours in low-pressure systems were failing in only hundreds of hours in the new high-pressure systems.

How does this relate to you and your vehicles? The modern diesel fuel system is essentially an ultra high-pressure hydraulic system. So the same issues and parts failures apply here.

In the case of the high-pressure hydraulic systems, it was determined that ultra fine particles that had not been a problem in lower pressure (1,000 psi or less) hydraulic systems were the cause of reduced pump, valve and component life.

Particles in the 5 to 10 micron size were determined to be the most abrasive particle size group and were the cause of severely reduced component life.

In particular, the 7 micron particle was the perfect fit between the micro-machined clearances and would grind away on metal surfaces, causing accelerated wear. This would result in reduced pump pressures, servo valve orifice erosion and degraded system performance.

As a result of this hydraulic system research, an International Standards Organization cleanliness coding system was developed that enabled lubrication engineers to establish target cleanliness levels for systems with operating pressures beyond 3,000 psi. By using these cleanliness levels, system life was extended and brought back to normal.

The ISO coding system addressed three particle size groups that were found to most affect high pressure component life – namely the 2 micron, 5 micron and 15 micron size ranges. By utilizing ultra-fine fluid filtration, the harmful particles could be eliminated and systems would be less vulnerable to failure as a result of contamination.

Since the modern diesel fuel system is essentially an ultra-high-pressure hydraulic system, the same requirements for ultra-fine cleanliness should apply directly to our fuel systems, right?

Wrong.

The fuel cleanliness issue begins at the refinery. There, the final fuel output filtration is typically 30 microns. Particles smaller than 30 microns are unfiltered and still remain in the fuel.

And the problem only gets

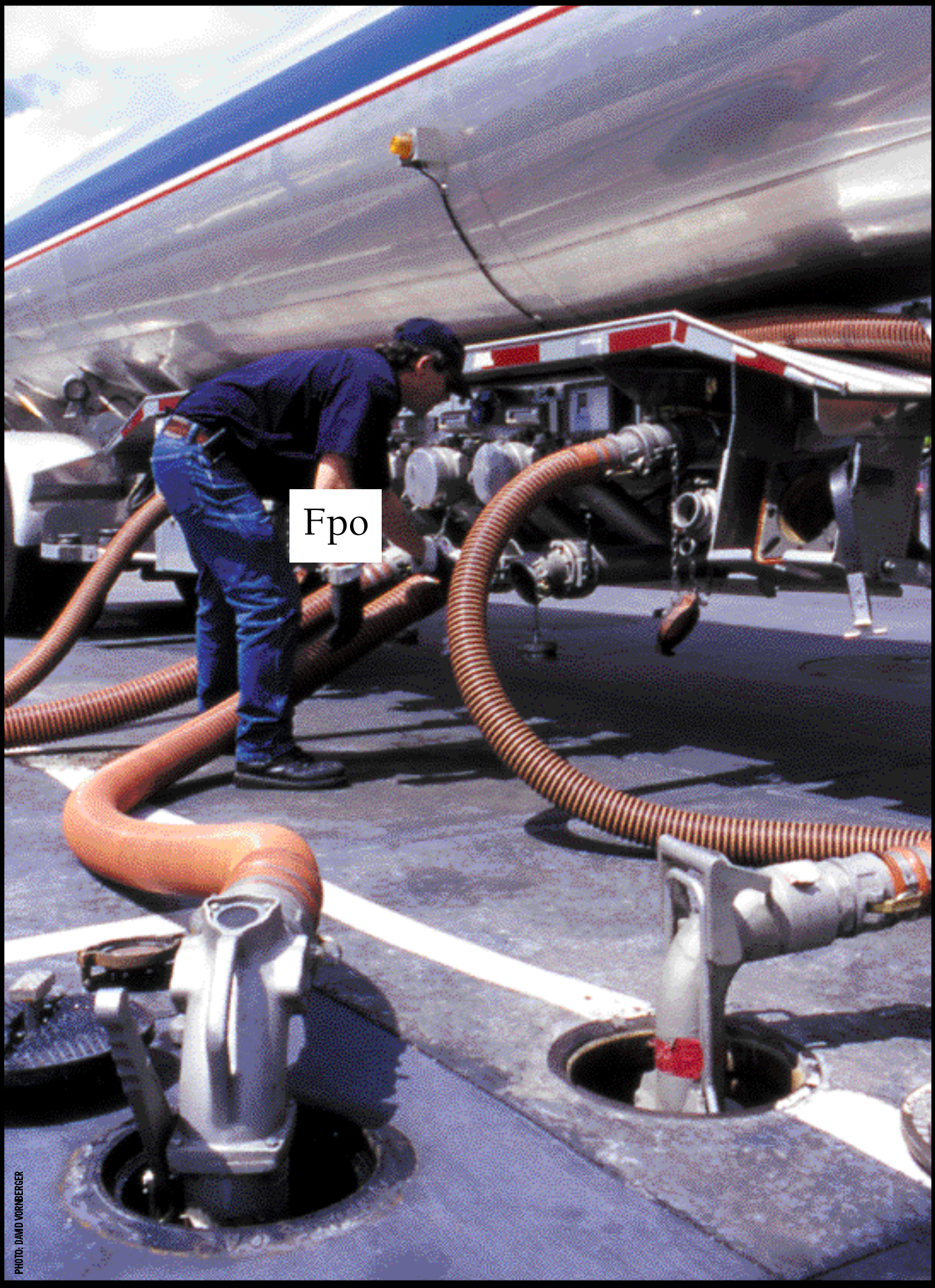
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PHOTO: DAVID VORNBERGER

worse. After the diesel fuel has been taken from the refinery it goes through several transfers until it ends up in its final tank for distribution to vehicles. By this time, the fuel has picked up even more contaminants.

Poor ISO cleanliness levels can mean that for every gallon of diesel fuel entering that fuel system there are 263,719,875 particles greater than 2 microns, 49,163,365 particles greater than 5 microns, and 1,006,810 particles greater than 15 microns.

All of these particles are going right through your fuel pumps and fuel injectors.

Controlling Fuel Quality

Fuel filters at truckstops typically catch only 30 micron units and above. Consequently, they don't filter any of the most abrasive 5- to 10-micron particles.

The same is true for truck engine filters – most of which are nominal 15-micron filters.

For most diesel engines, with every gallon of diesel fuel burned hundreds of millions of abrasive particles have cut their way through the fuel pump and injector system.

As a result of this high amount of ultra-fine dirt contamination, high-pressure fuel pump and injector life is going to be greatly reduced.

Silently and gradually the fuel system degradation proceeds until decreased performance finally becomes noticeable or the truck just quits running.

All during this process the truck uses more fuel, creates more pollution, develops less horsepower, and becomes less efficient each day.

To this point, the typical truck operator is unaware of the problem. But there is much that can be done to protect sensitive fuel systems from dirt and contamination by way of quality control and good housekeeping with fuel stored at terminals.

First, the fleet must test the diesel fuel source to find out exactly what it is purchasing. Diesel fuel is the trucking industry's No. 1 commodity cost of operation. Yet very few companies regularly test their diesel fuel quality.

The recommended fuel tests should be for cetane index plus ISO cleanliness code.

If a trucking or construction company has its own fuel tanks, fuel tests should be run for both incoming and output fuel from the tanks. Often, fuel is being contaminated by dirt already present in storage tanks.

Poorly maintained storage tanks can also contain significant amounts of water, which results in microbe and algae growth that can cause fuel filter clogging. The acidic by-products of microbe life causes tank inner wall corrosion, further increasing fine fuel contaminants.

Once fuel quality and contamination are determined, a plan can be implemented to reduce contaminant levels.

Read the story beginning on page 82 to learn how to clean up that dirty fuel.

Co-author George Morrison, was vice president of surface mechanicals for a large coal mining concern for 18 years. His job also included the maintenance planning of over-the-road truck fleets. For the past 15 years, he's been the owner of an ExxonMobil distributorship in Columbus, Ohio.

THE HIGH PRICE OF INJECTOR FAILURES

Because of the fine filtration, a two-micron filter clogs easily. Dealing with this problem, fleets simply increase the filter screen, but at the cost of many thousands of dollars in fuel system deterioration that will manifest itself as poor engine performance, fuel dilution of lube oil, failed pumps and, more and more frequently, it seems, failed injectors.

Typically, the injector failure from solids contamination is progressive. A gradual loss of performance and increase in smoke may well go unidentified. However, as the injector spray holes erode, the precise combustion is degraded. Ultimately, wear in the injector leads to slobbering and increased fuel in the lubricating oil. At the same time, fuel economy falls.

Water contamination, though, may well be more dramatic, resulting in the tip of the injector being blasted off.

And over the years, the cost of an injector has escalated in parallel with its increasing complexity and closer manufacturing tolerances. An electronic unit injector is a significant service item. Some maintenance managers are saying injector maintenance is a new line-item in their budgets, with replacement at lower mileages accounting for as much as a 75-cents-per-mile increase in operating costs.

This injector failed due to contaminant exposure. Note the damage to the tip.

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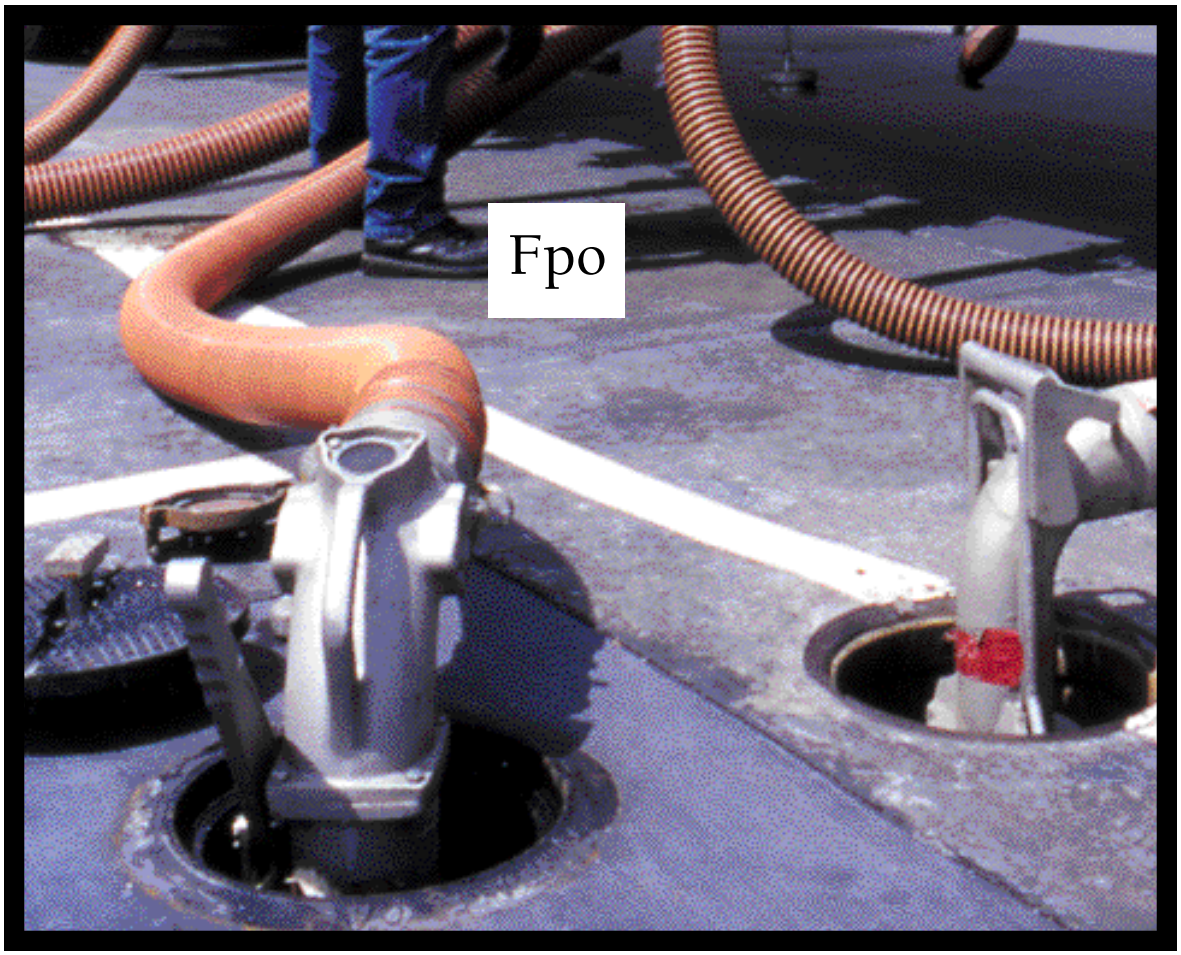
Keeping Fuel Clean

THAT CAN BE EASIER SAID THAN DONE, DEPENDING ON HOW MUCH CONTROL YOU HAVE OVER VEHICLE REFUELING AND WHETHER IT'S ON-SITE OR AT GAS STATIONS AND TRUCKSTOPS.



Fleets can save themselves a lot of trouble and expense by making sure that diesel injectors receive clean, water-free fuel. This may be easier said than done, depending on how much control you have over vehicle refueling, and whether it's on-site or at gas stations and truckstops. The type of fuel filter used and its micron rating also has a major bearing on fuel cleanliness.

If your fleet has its own fuel storage tanks and buys by tank-truck loads, make sure you know what's being delivered and check it. Some fleets take fuel samples at the time fuel is dropped, marking the brand, delivering carrier, time and date. These samples are stored for at least three delivery cycles and regularly checked to see if any water has settled to the bottom of the bottles, or if the fuel itself is discolored or cloudy. If fuel is suspicious, it is sent to a lab for analysis and appropriate action is taken against the fuel provider and/or the delivering trucker.

Jim Winsor
Executive Editor

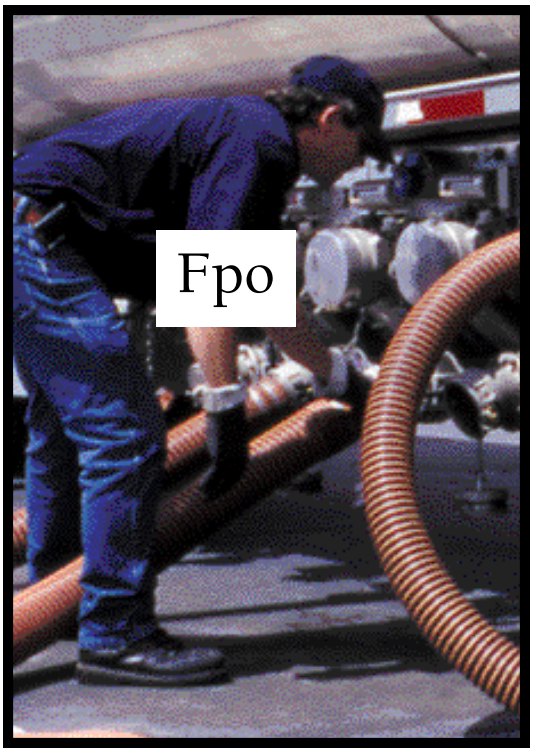
The next step is to make

sure fuel island dispensing pumps each have functioning fuel filters – the lower micron rating the better without affecting the pumps' delivery rates. Make sure these filters are changed at regular intervals. Stick in-ground storage tanks with water-detecting paste or make sure your delivering trucker does. This procedure will give a "heads-up" to any in-tank contamination. And if any is found, have it chemically treated and/or pumped.

When are your vehicles fueled? Ideally, it should be at the end of day or run because today's diesel engines – depending on make – recirculate as much as 90% of the fuel delivered to the engine. Each "trip" to the engine and back increases fuel temperature, and sources tell *HDT* that in-tank fuel can reach well over 100 degrees F. Hot fuel in a mostly empty tank leaves hot air, which cools and condenses, forming water droplets that are added to the fuel. Refueling before parking for the night or weekend is desirable.

Today's truck fuel tanks, with few exceptions, no longer have sumps. Sumps are the low point in the tank where dirt and water collect. Sumps made it easier to drain off contaminants during preventive maintenance (PM) servicing. Even without sumps, more and more fleets tell *HDT* that loosening the tank plug and draining off a small amount of fuel is a smart procedure.

A trick some fleets use is to park vehicles on a slight slope overnight or weekends. Any water or dirt will tend to settle to the low point in the tank where it can be drained off. Roadway Express' late vice president of maintenance Don Dawson, even went to the trouble of having tractor fuel tanks mounted with a 3-degree pitch to the rear. Water and dirt would settle there and could easily be drained off. It was one of dozens of "Dawsonisms" he invented to reduce maintenance needs and costs.



FOR VEHICLES THAT ARE FUELING AT TRUCKSTOPS, THE ONLY DEFENSE IS THE USE OF SUPPLEMENTAL FUEL FILTRATION IN THE VEHICLE.

If your fleet doesn't have on-site fueling and must rely on local service stations or on-road truckstops, it's even more important to check for water/dirt in the fuel. Ask your drivers to report any fueling locations that don't have in-hose filters at their fuel islands. *HDT* has learned there are occasions where fueling personnel – with and without management approval – have removed filters because they'd detected a slowdown in pumping rate. Rather than replace a partially-plugged filter, they remove it to get vehicles through service islands faster.

One fleet manager we interviewed found that his own personnel were removing filters to speed up the evening refueling rush when trucks came in. When drivers do their own refueling, they should report any "slow" pumps so filters can be replaced – not removed.

Maintenance managers should review PM procedures to make sure fuel tanks and fuel filters are serviced regularly. Darry Stuart, who has managed many fleet maintenance operations over the past 30 years, says a fleet's PM program should be designed so vehicles can make it from one PM service to the next without road calls or returning to the shop. When it comes to water in fuel, he says he is still a firm believer of adding a pint or more of isopropyl alcohol (rubbing alcohol) to truck fuel tanks at each PM service and more frequently during extremely cold temperatures where fuel line freeze-ups may be a problem. Alcohol absorbs water.

Stuart now has his own business advising fleets with hands-on management leadership.

He says that while there are a number of good fuel additives on the market, most of them are alcohol-based and more expensive than buying cases of isopropyl alcohol at the local drugstore. "I have never had problems with it affecting seals or O-rings, and it quickly absorbs water, emulsifying it into the fuel and carrying it to the fuel filter which, hopefully, will contain it and eliminate ice crystals from forming

on filter media during sub-freezing temperatures.

"I've seen actual cases where tractors with 200-gallon fuel tanks would arrive back in New England in the winter loaded with water. I thought it was bad fuel. I discovered the hard way that some of these rigs fueled over 1,000 miles away, and by the time they reached Massachusetts, the remaining fuel in their tanks had climbed to over 100 degrees. With ambient temperatures in the teens, these tanks were sweating the way a glass of ice water does on a summer day. We drained up to two quarts of water out of these tanks at times. That convinced me that we really needed to trap water before water-laden fuel hit the injectors.

"It used to be that standard OE fuel filters were adequate, but as injection pressures have gone up, and the price of injectors with it, anything but the cleanest and driest fuel is risky. I personally don't think 12 – 15 micron filters are enough. About three years ago I started adding secondary fuel filters with water separators and heaters. I'm now shooting for 3 – 5 micron filtration in my specs.

"Did you know a human hair averages about 40 microns in diameter? Injector orifices today are a lot smaller than that. What we did with our old mechanical injection systems won't fly today. Consider that 2 microns is 200 times smaller than 5 microns. You can't even see two microns.

By the time the 2007 diesels get here, we may be dealing with this kind of stuff. It's already worrisome just thinking about that. The question is, are we reaching the point that today's fuel, as we receive it, may have to be re-refined to a higher level on the vehicle?"

At Dunbar Armored, a national armored truck service headquartered in Hunt Valley, Md., Director of Fleet Maintenance Doug White is making changes in his PM program. He's changed fuel filtration specs as a result of increasing downtime and failed injectors.

Dunbar Armored operates in nearly every state. Many operations have less than a dozen vehicles, making it cost prohibitive to have central shops. White relies on outside vendors and truck dealers, and he uses in-house shops and mechanics for his bigger operations.

Adding to his problems is the fact that almost all fueling is done at in-

city "mom and pop" service stations – often a different one every day as armored car routes vary daily. He has little control over fueling practices. In the armored car business, security is the No. 1 priority and drivers are told to get in and out of fueling stops as quickly as possible.

Almost all of Dunbar's trucks are Class 6 or 7 with the International DT-466 and 530 the predominant engines. It wasn't until he surveyed all his locations and had fuel tank sampling done that White found out many, if not most, truck tanks had accumulated water. And fuel filters were not always being drained or changed because of their awkward location under the firewall. They were hard to get to, and mechanics often got a diesel bath when changing them.

White also surveyed injector replacements to learn how many were high-engine-hour replacements (armored cars never shut off) and how many weren't. He put his supervisors on alert to collect bad or failed injectors. That's how he discovered he had a problem that he thinks may be water-related. He currently has experts analyzing several injectors to get an independent and impartial answer. He thinks some blown injector tips may be caused by water in the fuel.

In the meantime, White has directed that all fuel tanks be drained of all accumulated water at each truck's PM service. He also is looking for an alternative OE fuel

FINER FILTRATION: IS IT THE ANSWER?

While Caterpillar has reduced its filtration size all the way down to two microns, and Volvo's is at five microns, Cummins is bucking the trend to finer filtration. Injection specialist Ray Amlung says the Celect fuel system used on earlier Cummins engines had secondary filtration down to 15 microns. But with the early ISX, this was relaxed to 25 microns, although it is back down again to 15 microns now. Amlung says the new HPI injection system is designed and tested to withstand the assault of available fuel, although there could be some edge erosion on metering ports. "Lots (of people) run 25 microns with no issues," he says, and the fuel injection system is designed to last the life of the engine.

Ironically, it was a Cummins N14 with Celect injection that was the basis for the SwRI research into wear particle size. In SAE paper 980869, Gary Bessee and others conclude the "Fuel Filtration Cooperative R&D program has determined that the critical particle size in a high-pressure Celect injection system is 6 to 7 microns."

Diesel fuel will, over time, become contaminated with asphaltenes, which drop out and cause a sludge that may be mistaken as biological contamination. According to Cummins' Amlung, asphaltenes are formed when diesel fuel is heated and pumped, so any injection system – especially one with a high return flow – will create these heavier ends of the diesel fuel. In his experience these are more likely to cause fuel filter clogging problems rather than debris and dirt.

This is also described in the Detroit Diesel Engine Requirements manual 7SE70 0209. "Diesel fuel oxidizes in the presence of air, it says, resulting in the formation of undesirable gums and black sediment. Such undesirable products can cause gumming and lacquering of the injection system components, with reduced engine performance and fuel economy."

The asphaltene sludge can be mistaken for bacterial contamination, but it obviously will not be eliminated by a biocide. Accordingly, says Dieselcraft sales manager John Nightingale, if you're experiencing filter plugging, you should test to see what is causing the problem. To that end, Dieselcraft is just now launching a test kit that can be found at diesel hard parts stores.

The "Fuel Bug" kit is simple to use and will indicate whether a maintenance manager should treat fuel for bacterial contamination. Fuel is merely added to a culture medium in a test bottle. If bacteria are present, growth will be apparent within 30 hours. After 72 hours, mold or fungus can be seen.

Nightingale says there is a general lack of understanding and little concern for these problems, even though fuel condition can cause significant loss of performance, roadside service calls and long-term fuel pump and injector damage.

Acknowledging the problem of injector erosion, Detroit Diesel offers a tune-up kit for the Series 60 under the Power Pack name. Promoted in a small brochure, there are electron micrographs of typical injector tip hole erosion. It recommends replacing all six injectors when the rocker cover is removed for a single bad injector, because the time taken is only two hours more to "restore the original power and performance engineered into your Detroit Diesel engine."

Detroit endorses the use of the Fuel Pro 382 and recommends it be installed at the same time as injectors are replaced. With the Detroit Diesel branded filter element, the unit is claimed to double the life of the on-engine filtration. Stanadyne, too, is offering a filter that is used on off-road equipment with two-micron filtration and water separation to protect the high-pressure injection systems featured on construction equipment from Ford, John Deere and Liebherr.

filter because the present one "isn't doing the job." And to make life easier for all service personnel, he plans to spec fuel filter locations on a frame rail where they're visible, easier to get at and at a level where mechanics won't get a diesel shower when they change them.

In July, he started installing the new WEBB VorMax fuel filter, which uses cyclonic action to spin out up to 97% of water and solids. That's before fuel reaches the standard OEM spin-on filter element, which is built into the VorMax mounting manifold. In addition, it has a built-in filter restriction gauge that shows when the filter element needs changing because of pressure drop.

Webb VorMax fuel filter uses cyclonic action to spin out up to 97% of water and solids.

This eliminates many premature filter changes. A translucent collection bowl with a drain is built into the base of the water separator to show the amount of accumulated water and contaminant removed from the fuel before it passes on to the spin-on filter element.

White is initially installing a dozen of these VorMax units in trucks located in different parts of the country. He wants to get regional feedback as to how bad his fuel situation is.

White reported that with the first two units, the bowls had nearly filled with water within two weeks.

"I'm learning a lot in a hurry," he said. "If the failed injector analysis tells me that watered fuel is my main problem, I think I can get that under control.

"I just hope a lot of damage hasn't set in already." ■