Scott Grossbauer, Donaldson Co. Inc., USA, explains how efficient fuel filtration can pay dividends for surface mining equipment.

Effective fuel filtration for off-road equipment – especially mining equipment – has never been more important. If mining maintenance managers are not already seeing major problems related to ‘dirty’ diesel with new Tier 4 engines, they will see them soon. Huge changes are coming to the way engines react to diesel fuel that is less than ‘pristine’ clean – and they are coming sooner than one might think.

History has proven the need
In 2007, the Heavy Duty Highway Diesel programme (the 2007 Highway Rule) created new emission standards for large-scale on-road diesel vehicles, prompting a sea change in the way engines are built. The 2007 diesel engine emissions restrictions led to significant engineering changes for every on-highway commercial diesel engine offered in the US market.
These engineering changes brought with them changes in the standards for acceptable diesel fuel cleanliness standards. With the higher fuel pressures and tighter tolerances required to meet the new emissions standards, diesel fuel had to be cleaner than ever for on-highway vehicles to function properly. If even the smallest dirt particles or other contaminants were allowed into the engine, catastrophic injector failure was not just likely; it was probable. Efficient, effective filtration became a must.

And now, the sea change has come to off-road vehicles and equipment. In 2004, the US Environmental Protection Agency signed the rule introducing Tier 4 Emission Standards, to be phased-in from 2008 – 2015. These standards require a massive reduction of particulate matter (PM) and nitrogen oxides (NOx), and the subsequent changes to the way engines are built are already similar to those required by the 2007 – 2010 standards for on-highway engines.

In short, without effective, precise filtration both on and off the vehicle, off-road operations will begin to see significant downtime as onboard fuel filters begin to plug quickly (at best) or injectors begin to fail.

**What you cannot see can hurt you**

Today’s Tier 4 engines use high-pressure common rail (HPCR) fuel injection systems that operate upwards of 40 000 psi. These systems require very clean fuel to operate as-designed for their entire service interval (up to 20 000 hr in some cases). Unfortunately, most fuel that is dispensed from storage tanks into equipment is hundreds of times dirtier than what is recommended for many injection systems.

Knowing that emissions standards are ever-evolving globally, diesel engine fuel system manufacturers and filter manufacturers have cooperated in research efforts at Southwest Research Institute (SwRI) to determine the level of filtration required to protect these advanced fuel system components from hard particle damage.

“We see Tier 4 engines being more and more sensitive to dirt and other contaminants that can be picked up by fuel as it makes its way from the refinery to its eventual use,” said Jim Doyle, Development Engineer – Donaldson Clean Fuel & Lubricant Solutions. Donaldson is a leading worldwide provider of filtration systems and a participant in this research. “Just like the saying ‘garbage in, garbage out’, the same holds true with fuels and lubricants. If you put dirty fuel or oil into your equipment, ultimately there will be breakdowns that cost time and money.”

But what is dirty diesel? Until these new standards took effect, standard ISO cleanliness tests could be used to determine if diesel was clean enough for use. But the SwRI research efforts proved that this is no longer the case.

The most recent phase of these research efforts was completed in 2011 and summarised in the white paper: ‘Summary of industry cooperative
The 2011 SwRI research was conclusive, it was also conducted in a controlled environment. As anyone who has ever been involved with a mining operation knows, the typical real-world working environment is anything but controlled. Coal dust, for example, can be anywhere from sub-micron to 100 μm in size. And it is just one of the many potential jobsite contaminants that can change diesel fuel from the substance that keeps equipment running into the very thing that brings an entire operation to a halt.

Laboratory results prove bigger real-world dangers
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Contamination comes in many forms, from many places
Fuel contamination can be separated into two broad categories: inorganic and organic. Inorganic contaminant is typically hard particulate (dirt) picked up throughout distribution. From the refinery, fuel is typically clean to acceptable standards, but as it gets transported throughout distribution (which can include pipelines, terminals and delivery trucks) it gets more and more contaminated. Once onsite, as it is stored in bulk tanks and moved for distribution and use, it picks up contamination from infrastructure and ambient conditions, such as through vent pipes with inadequate filtration.

Organic contaminant represents anything carbon-based, typically hydrocarbons with various chemicals attached. These organic contaminants can also come from a variety of sources at or downstream of the refinery: lubricity improvers, cold flow improvers, biodiesel and corrosion inhibitors, etc. (While coal dust is in fact organic, it does not fall under the category of an organic contaminant because it lacks the hydrogen component, as well as the functional additive chain).

“It is very important for fuel additives to be dosed at the right levels and under the right conditions to ensure the best overall fuel stability, otherwise these additives can become insoluble and therefore unfilterable,” Doyle explained.

Generally speaking, hard particulate (inorganic contaminant, such as was used in the SwRI study or particles like coal dust) will cause permanent damage to the injector system, while softer particulate (organic contaminant, such as glycerin or various precipitates caused by adverse fuel chemistry reactions) will cause fouling, i.e. deposits building up on the injectors. In both cases the engine does not run as-designed and can result in a
A decrease in fuel economy, an increase in emissions and a decrease in power.

**A two-step approach for maximum protection**

Because unscheduled downtime can be incredibly costly on a mining operation, choosing the best available onboard fuel filters is to protect injectors. And providing effective projection for injectors can sometimes create additional challenges. Contaminated fuel can cause rapid plugging of onboard filters, which means unscheduled trips to the maintenance garage for haul trucks, dozers, loaders and other heavy-duty mining equipment.

Traditionally, only top performing on-engine filters would be used to remove the contamination in the fuel to meet injection system fuel cleanliness specifications. But the requirements for HPCR fuel are so clean that a four-step filtration approach, with a new focus on bulk storage tanks, is often needed to maintain service intervals and achieve consistent cleanliness:

- Filter fuel from the supplier, as it goes into the bulk storage tank.
- Protect the fuel while it is stored.
- Filter it again as it is dispensed before use in the equipment.
- Filter it again as a last layer of protection with efficient on engine filters.

By current standards, bulk filters should remove contamination in fuel down to a cleanliness level of ISO 14/13/11, whether the contaminant present is hard or soft. It should be noted that all on-engine fuel filters are designed with the goal of removing hard inorganic particles typically found in fuel. They will also filter soft organic materials; however, filter life can be drastically reduced when excessive amounts of organic material are present.

Besides meeting HPCR fuel cleanliness requirements, the use of bulk filtration also provides necessary protection against any highly contaminated fuel that may be delivered (ongoing or as a one-time occurrence). By filtering before use in the equipment, the bulk filtration system will stop excess organic and inorganic particulate from being delivered into equipment’s tanks, ensuring the onboard filters can meet the expected service intervals.

“If excessive fuel contamination does exist, it may plug up the bulk filters, but save the on-engine filters,” Doyle said. “This helps eliminate costly unscheduled downtime and makes operation and maintenance much more predictable.”

**Conclusion**

Use of high-efficiency filtration at the inlet of a fuel storage tank infrastructure will help protect against taking delivery of dirty fuel. Additionally, adding an effective breather filter on the tank will help combat the entrance of ambient dirt and moisture.

Ensuring fuel is clean before storage is a must, but one should recognise that contamination happens within storage tanks as well. Therefore, filtering fuel as it is being dispensed into the equipment will help safeguard machinery. This will be the best chance to protect against any contamination that may have been introduced in storage – tank scaling, contamination from piping, or general fuel/additive stability problems.

In conclusion, today’s engines – Tier 4 and otherwise – are more sophisticated than ever and require cleaner fuel than ever before.