



FILTRATION

Improving Diesel Engine Life:

**Fuel Filtration to Clean Up the
Diesel Industry**

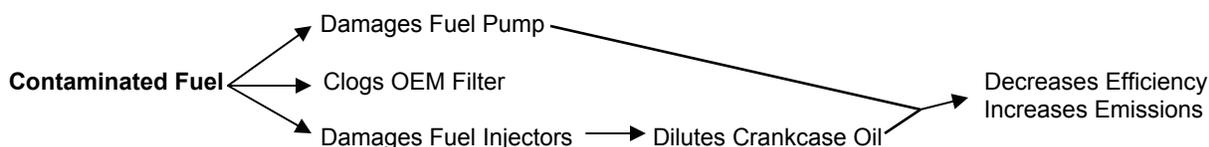
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The Problem - Diesel engines have made incredible progress in recent decades. Along the way, they have become more compact while offering better performance, fuel efficiency and lower emissions. Unfortunately for consumers, some of the great benefits of recent diesel engine improvements are lost due to dirty diesel fuel damaging the engines. One of the primary reasons for these vast improvements in diesel engines has been the massive improvements to the capability of the fuel injectors, which can now operate at 25,000 PSI (1723 bar) or greater. The problem arises when diesel fuel made available by most distributors, generally rated at an ISO cleanliness level of 23/21/19, slowly destroys various components. Don't expect the OEM fuel filter to provide protection. It is likely rated at 30 micron and will capture as much contamination as possible, but quickly becomes clogged, requiring replacement, costing money and causing downtime. The injectors, operating at such high pressures, will have their internal nozzle diameters increased as abrasive 10 micron and smaller particles are rushed past the OEM filter and through the injectors at high speed. Replacing injectors again costs money and increases downtime. Neglecting to do so releases un-burned fuel into the crankcase oil, increasing exhaust emissions and robbing the engine of performance. Fuel consumption will rise as excess fuel is wasted and more frequent crankcase oil changes will be necessary. The final part of the engine adversely affected by the high amount of contaminants is the fuel pump, which will be pulverized by small abrasive particles rushing through at high speeds. It is easy to imagine the type of damage caused by contaminated fuel as if it were liquid sandpaper running through the engine and it's various components.



The cost of malfunctioning machinery is not the only impact that contaminated diesel fuel has. As an engine becomes damaged by dirty fuel, it doesn't run as efficiently. This loss of efficiency and increase in emissions creates more pollution by releasing unburned fuel into the air, and creating more contaminated oil to be disposed of when crankcase oil changes occur. Even those who consider environmental protection as a non-factor in making business decisions should be aware that governments worldwide are increasing regulations and penalties involving almost every type of pollution, but especially pollution from fossil fuels. In some regions, public perception of pollution has changed so much that industries feel pressure from the public sector to become more environmentally friendly.



The Costs & Opportunity - The fuel injector pictured to the right has failed due to its nozzle being damaged by contaminants <30 microns in diameter passing through at high pressures. Replacement fuel injectors for diesel engines often cost between \$500 and \$700 each. The price of fuel and oil is rising right along with the cost of proper disposal of used oil and filters. As fuel passes through widened injector nozzles, more is left unburned to enter the crankcase and dilute the crankcase oil, requiring more frequent new oil purchases and old oil disposals. Standard filter changes occur more often as elements become clogged. Add to all of these problems the lost production while the machine is under repair or in maintenance and the cost of labor to repair and maintain equipment, and operation expenses can quickly skyrocket above original expectations. The opportunity exists to protect engine components and reduce operation costs and pollution by setting and meeting a target ISO cleanliness level for the fuel. Achieving cooperation between fuel suppliers and consumers is also important to insure the fuel operators are putting into their equipment continues to be of the best quality.



The Solution - A target ISO cleanliness level is chosen. In this case a goal of 16/14/12 was set for the fuel. A review of how ISO codes are determined is included on page 4. Two possible solutions exist from this point: replace the OEM 30 micron filters on all equipment with 1 micron filters or filter the fuel to 1 micron before it reaches the equipment. The first solution is impractical when one considers how expensive finding a supply of filters for every piece of equipment could be and the time and effort necessary to make the swap from 30 to 1 micron filters. The second solution is the best, with three steps to solve the fuel contamination problem detailed on the next page.



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Step 1 - Filters are installed on each of the fuel reservoir tanks that distribute fuel to the equipment. These filters are rated at 1 micron and continuously filter the fuel in the reservoirs to insure the fuel always maintains a certain level of cleanliness. To ensure that no contamination occurs from the air, a desiccant breather element should be installed on the reservoir as well. An analysis is made of the fuel at this point as a benchmark for further progress.

Step 2 - Filters are also installed on all fuel dispensers either from stationary reservoirs or those mounted on tanker trucks and again are rated at 1 micron. Oversized elements can maintain higher flow and remove more contaminant from fuel for longer periods of time than smaller elements, giving them a distinct advantage. The LF housing at right was placed on such a dispenser.



Step 3 - The OEM 30 micron rated filters are retained on all of the equipment as a last screen of defense for the engines. Continuous fuel filtration on the machines themselves isn't incorporated because, unlike lubrication oil, fuel is constantly being used and replaced and has little chance to retain contaminants. Also at this stage, data is collected again and analyzed to determine what gains have been made in engine efficiency, emissions reduction and cost reduction. Facts do not lie and fuel filtration becomes the clear choice over continual maintenance and repair.

The Results - After the three stages of filtration are implemented, the ISO cleanliness level should reach the target of 16/14/12. As a result of properly operating injectors, the injector's life span increases, fuel dilution of the crankcase oil decreases, onboard OEM fuel filter changes decrease in frequency, and a more efficient and cleaner engine and undamaged fuel pump increases fuel efficiency. All of these aspects combine to reduce costs, downtime and emissions into the environment. Another added benefit is that in disposing of fuel filters that have been used with cleaner rated fuels, and disposing of crankcase oil not as contaminated with fuel, the disposal charge can often drop, saving additional money even after the fuel has been consumed.

Individual operators should always filter their fuel upon arrival and continue to filter the fuel to insure that their equipment continues to operate to its maximum capacity. Diesel consumers should also be encouraged to put pressure on fuel suppliers to deliver cleaner filtered fuel. Until suppliers are held accountable for delivering fuel at a certified ISO cleanliness level, consumer filtration remains a must. Keeping fuel cleaner with filtration is just another step in realizing the diesel engine's full potential.

What You Should Know, Environmentally - Although environmental awareness and activism hasn't come to the forefront in every region worldwide, as it has in Europe and the United States, it is important for operators everywhere to realize that environmental awareness and laws passed by governing bodies are growing with each year to include more and more of the globe. This pressure from both government agencies and from public perception adds a monetary motivator to the desire to keep the environment clean. An operator that produces large amounts of diesel pollution may find business affected by environmental activists, public pressure, and government penalties until their pollution is reduced. This doesn't happen every day to every operator yet, but the trend of environmental awareness is always growing.



- The United States Environmental Protection Agency lists particulate matter as one of the top three problem elements of diesel fuels. A fuel filtration system reduces particulate matter, not only reducing operation cost, but also protecting the environment.
- Dozens of organizations, who gain more influence every day, exist worldwide to promote and lobby against air pollution and pressure industries, such as construction, to clean up their diesel emissions.
- Some diesel operators, to speed up refueling or avoid filter replacement, punch holes in or completely remove fuel filters. This creates higher levels of pollution and damage to equipment. This can occur because they are unaware of the availability of larger filters, more extensive filtration systems or the savings associated with better filtration of diesel fuels.

Why use a large element? - An oversized element can be the solution to the problem of diesel operators removing or intentionally damaging fuel filters, because oversized elements offer extra filtration and a higher flow rate. Oversized elements also have the advantage of a longer service life because they have more media area to absorb and trap contaminants. As a result of these durability and flow advantages, the filtration level can be made finer for an even higher degree of contaminant reduction. Combined with a well-thought-out filtration system, like the one installed by Hy-Pro and AV Lubricants, larger filter elements with more levels of defense create greater protection for the operator, equipment and revenue. With filter elements, the old adage remains true: "bigger is better."

Understanding ISO Codes - The ISO cleanliness code (per ISO4406-1999) is used to quantify particulate contamination levels per milliliter of fluid at 3 sizes $4\mu_{[c]}$, $6\mu_{[c]}$ and $14\mu_{[c]}$. The ISO code is expressed in 3 numbers (example: 19/17/14). Each number represents a contaminant level code for the correlating particle size. The code includes all particles of the specified size and larger. It is important to note that each time a code increases the quantity range of particles is doubling.

ISO 4406:1999 Code Chart		
Range Code	Particles per milliliter	
	More than	Up to/including
24	80000	160000
23	40000	80000
22	20000	40000
21	10000	20000
20	5000	10000
19	2500	5000
18	1300	2500
17	640	1300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64

Sample 1 (see photo 1)

Particle Size	Particles per milliliter	ISO 4406 Code range	ISO Code
$4\mu_{[c]}$	151773	80000~160000	24
$6\mu_{[c]}$	38363	20000~40000	22
$10\mu_{[c]}$	8229		
$14\mu_{[c]}$	3339	2500~5000	19
$21\mu_{[c]}$	1048		
$38\mu_{[c]}$	112		

Sample 2 (see photo 2)

Particle Size	Particles per milliliter	ISO 4406 Code range	ISO Code
$4\mu_{[c]}$	492	320 ~ 640	16
$6\mu_{[c]}$	149	80 ~ 160	14
$10\mu_{[c]}$	41		
$14\mu_{[c]}$	15	10 ~ 20	11
$21\mu_{[c]}$	5		
$38\mu_{[c]}$	1		

Photo 1: ISO code 24/22/19

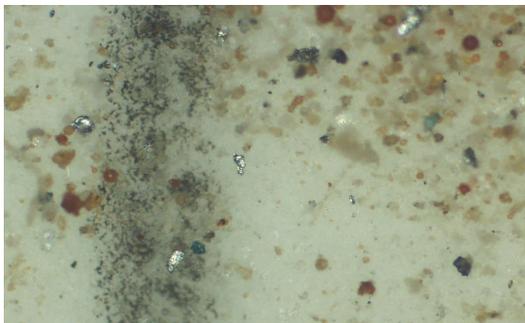
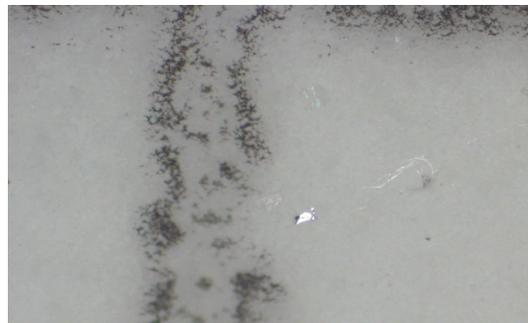


Photo 2: ISO code 16/14/11

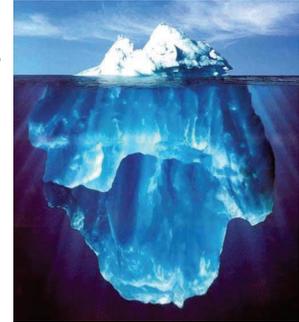


Succeed with a Total Systems Cleanliness Approach

Developing a Total System Cleanliness approach to control contamination and care for fluids from arrival to disposal will ultimately result in more reliable plant operation and save money. Several steps to achieve Total Systems Cleanliness include: evaluate and survey all hydraulic and lubrication systems, establish an oil analysis program and schedule, insist on specific fluid cleanliness levels for all new fluids, establish a baseline and target fluid cleanliness for each system, filter all new fluids upon arrival and during transfer, seal all reservoirs and bulk tanks, install high quality particulate and desiccant breathers, enhance air and liquid filtration on existing systems wherever suitable, use portable or permanent off-line filtration to enhance existing filtration, improve bulk oil storage and handling during transfer, remove water and make a commitment to fluid cleanliness.

The visible cost of proper contamination control and total systems cleanliness is less than 3% of the total cost of contamination when not kept under control. Keep your head above the surface and avoid the resource draining costs associated with fluid contamination issues including:

- Downtime and lost production
- Component repair/replacement
- Reduced useful fluid life
- Wasted materials and supplies (\$)
- Root cause analysis meetings
- Maintenance labor costs
- Unreliable machine performance
- Wasted time and energy (\$)



Reference: "Trucking's Dirty Little Secret" George Morrison
Newport's Heavy Duty Trucking; Oct. 2003

Reference: "Why Is Clean Diesel Fuel Important?" Dana Rinehart
Kokosing Newsletter; 6.5.06

Reference: www.epa.gov/otaq/regs/fuels/diesel/diesel.htm

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