CASE STUDY

APPLIED Industrial Technologies®

CUSTOMER
WEST FRASER

LOCATION
SMITHERS, BRITISH COLUMBIA, CANADA

EQUIPMENT
DIESEL POWERED EQUIPMENT

APPLICATION
DIESEL FUEL

PROVEN RESULTS:

BEFORE:
Particle count **491/143/8**

AFTER:
Particle count **367/112/5**

"The diesel for this site is handled 6 times before it arrives here. If you can capture contamination at the pump, you can control contamination throughout the equipment systems. **Now we can remove contamination below 1 micron in size, significantly improving combustion, reducing emissions and operational costs.** Reduced contamination under 1-4 microns in fuel results in increased engine efficiency, improved fuel burn and dramatically less wear on engine components."

— Glen Cullen
Shop Manager, West Fraser

PROBLEM

Contaminated fuel is a major source for hard particle ingression into the fuel system and engine oil through blowby. It also inhibits the burn resulting in unspent fuel being exhausted. Contamination ingression occurs with every transfer to and from contaminated storage tanks on site.

Figure 1: OEI ADD-Vantage 924 series installed on the fuel dispenser.

CHALLENGE

OEI was tasked to demonstrate the effectiveness of the OEI Magnetic Filtration technology when implemented on diesel fuel.

SOLUTION

An outside-in flow OEI ADD-Vantage 924 series was installed post traditional filtration on the diesel fuel dispenser on site. Three 1-liter samples of Diesel fuel were tested: The first sample represented the initial, unfiltered Diesel fuel, the second sample was taken after passing through the traditional tank filtration system but before the OEI magnetic filter, and the third sample was obtained after undergoing OEI magnetic filtration.

To prove substantial decrease in hard particle contamination within the diesel fuel, OEI contacted Ins SEMx, a third-party lab, to preform X-ray Diffraction (XRD), Elemental Dispersive Spectroscopy (EDS), Particle Size Distribution (PSD), Scanning Electron Microscopy (SEM), and TSS (total suspended solids) analysis on all three 800ml diesel samples. Additionally, Metro-Tech, a third-party lab, was contracted to perform ISO44 testing.

Figure 3: Picture of OEI magnetic scrubber element with captured contamination from diesel.

RESULTS

Before filtration, the log yard diesel fuel had a total suspended solids count of 5.76 mg/kg (ppm) composing primarily of various silicone oxide compounds (~80%) with aluminum, iron, and salts (<15%). The most frequent particles size in this sample was between 6.859 - 8.748 micron. 32.8% of total particles were found to be under 1 micron and 53.8% of particles were found to be under 4 microns. The ISO test was 20/18/14 and the particle count was 6479/2129/132.

The implementation of traditional filtration resulted in remaining total suspended solids count of 2.72 mg/kg (ppm) with the most common particle size remaining in fuel ranging from 0.228 - 0.290 microns. 70.2% of particles remaining were below 1 micron and 89.0% of remaining particles were below 4 microns. The ISO test showed a rating of 16/14/10, and the particle count was 491/143/8.

In contrast, OEI magnetic filtration significantly improved the results, reducing the total suspended solids count to 1.84 mg/kg (ppm) with the most common particle size remaining at 0.140 - 0.179 microns. The particle distribution shifted, with 82.9% of total remaining particles below 1 micron and 94.4% of remaining below 4 microns.

Particles under 4 microns in size are the most detrimental to equipment longevity, so it is important to review the D90* values below in table 1. After traditional filtration, 90% of particles were below 4.3 micron, where OEI magnetic filtration reduced these particles to an even lower level (90% below 2.6 micron). The ISO test demonstrated substantial enhancement, achieving a rating of 16/14/9, with a particle count of 367/112/5. Figures 4-6 illustrate the particle size distribution of contamination differences between traditional filtration and OEI filtration.

	Size (um)								
Statistical Value	**D10**	**D25**	**D50**	**D75**	**D90**	**Max**	**Min**	**Mean**	**Mode**
Log Yard Sample (Before all Filtration)	0.19	0.45	3.44	8.86	16.67	1006.11	0.05	9.22	6.859 - 8.748
After Tank Filter, Before OEI Filter	0.10	0.16	0.34	1.56	4.34	81.00	0.04	2.23	0.228 - 0.290
After OEI Filtration (Fuel Nozzle to Engine)	0.08	0.12	0.22	0.47	2.60	38.17	0.02	0.91	0.140 - 0.179

D90 * - 90th percentile – size for which 90% of the grains are smaller
Mean*- average particle size (μm)

Median* - the middle value in a set of numbers (μm)
Mode* - particle value that occurs most often (μm)

Figure 4: Particle Size Distribution of unfiltered diesel fuel

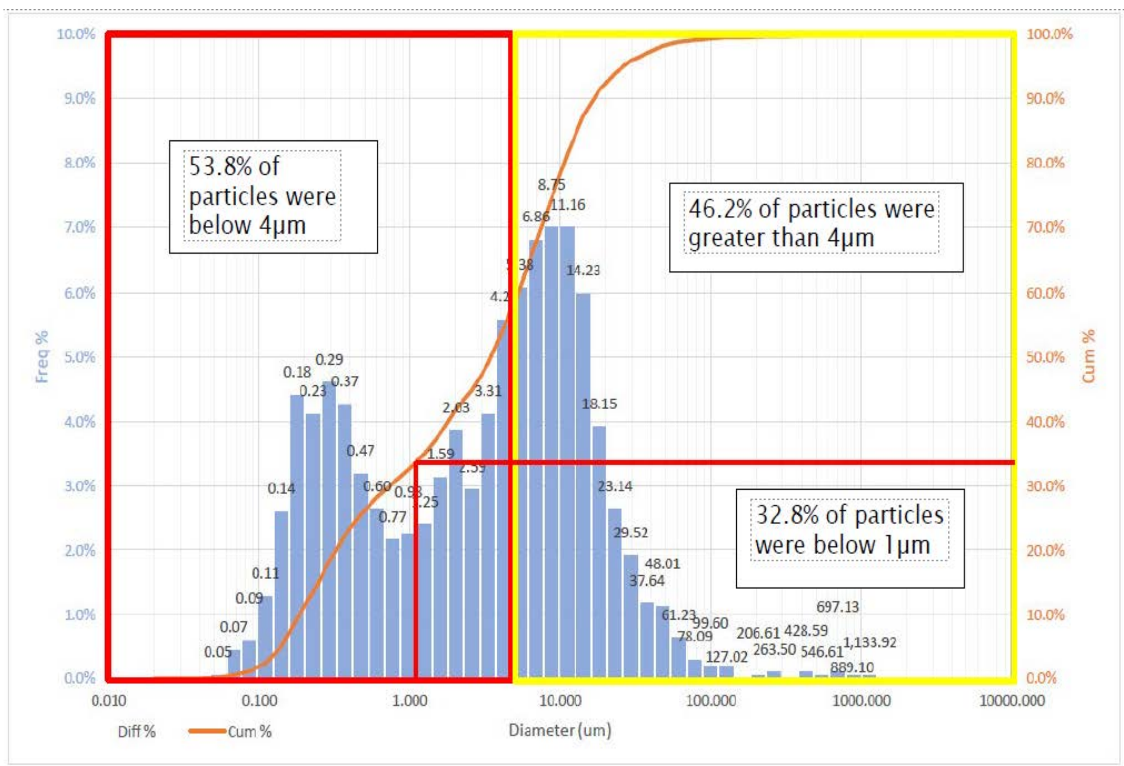


Figure 5: Particle Size Distribution for After Tank Filter, Before OEI Filter.

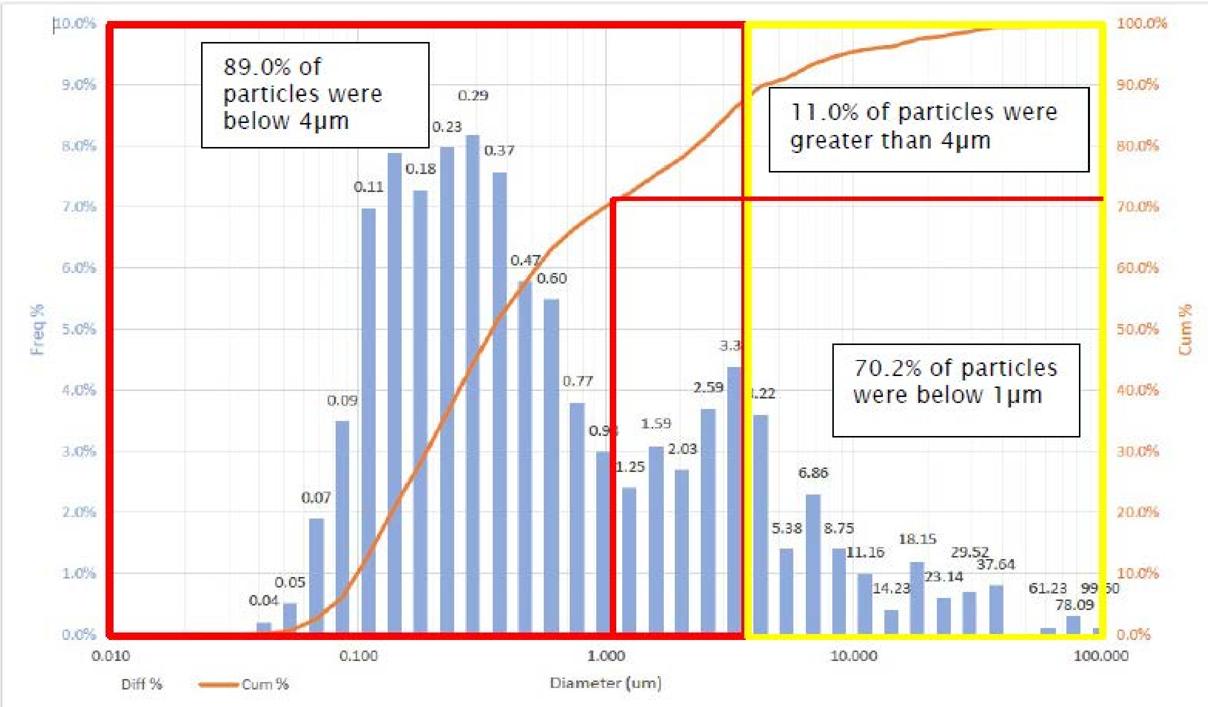
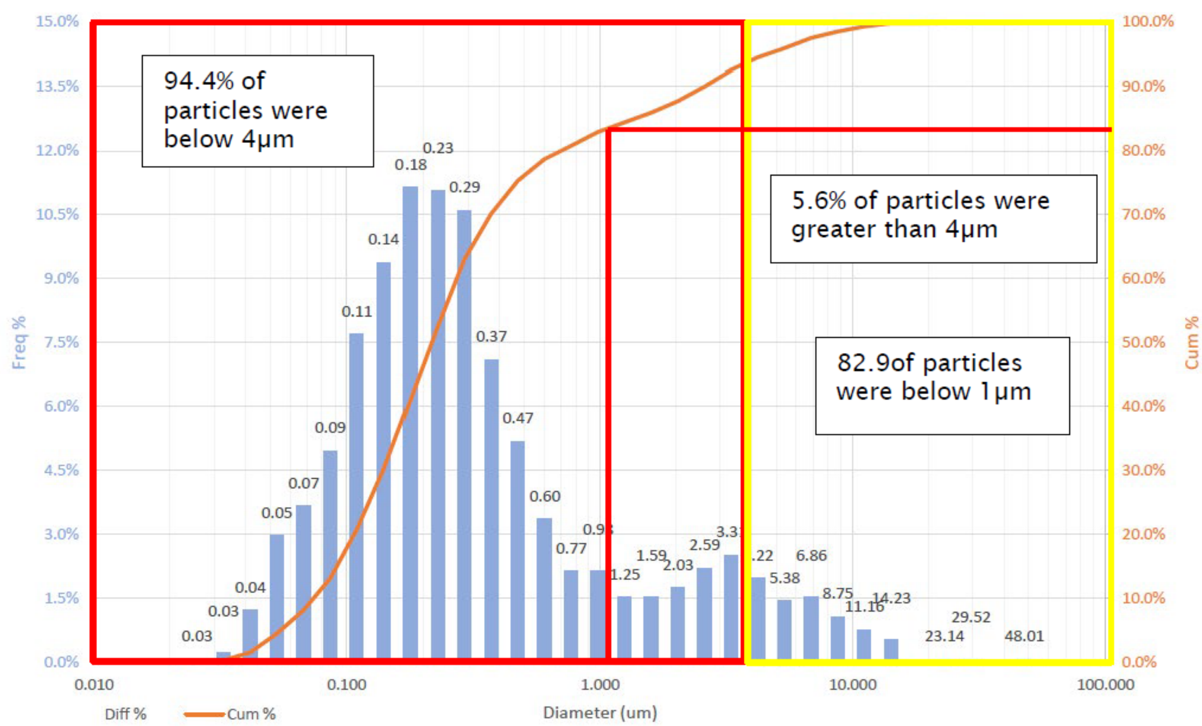


Figure 6: : Particle Size Distribution After OEI Filtration (Fuel Nozzle to Engine)



The wear contamination consisted of substantial levels of silicone and various silicone oxide compounds, which were effectively removed from the system by approximately 80%. Additionally, the analysis indicated lower levels of aluminum, iron, and salts, all below 15%. The OEI filtration technology achieved complete removal of the following compounds, which the traditional filtration had failed to capture: Halite, Cancrinite, Kaolin, Böhmite, Coesite, and Palygorskite. Additionally, OEI magnetic filtration significantly reduced Calcium Aluminum Silicate levels. Table 2 provides a summary of the wear contamination effectively removed by OEI Magnetic Filtration technology after traditional filtration.

Table 2: XRD Analysis Results on the wear contamination captured by the magnetic filter.

Sample ID	**Log Yard Sample (Before all Filtration)**	**After Tank Filter, Before OEI Filter**	**After OEI Filtration (Fuel Nozzle to Engine)**
	Quantitative Weight %		
Quartz - SiO2	25.4	38.6	43.9
Calcium Aluminum Silicate / Ca2.02 (Al3.9Si8.1O24)		11.2	4.2
Halite- NaCl	0.5	7.7	0.5
Cancrinite - Na6 Ca1.5 Al6 (SiO4)6 (CO3)1.5		9.2	
Kaolin - Al2 Si2 O5 (OH)4	18.4	8.8	
Böhmite - AlO (OH)	0.1	0.9	
Illite/Mica - (K, H3O) Al2 Si3 Al O10 (OH)2	3.6	6.4	8.8
Aluminum Copper -Cu5.64 Al4.61	0.1	3.3	7.8
Anorthite - Ca Al2 Si2 O8	2.0	7.1	22.1
Coesite - SiO2	0.6	0.7	
Palygorskite - Mg Al Si4 O10 (OH) (H2O)4	0.9	5.9	
Goethite - FeOOH			3.3
Calcium Aluminum Silicate / Ca51.33 (Al96Si96O384)			2.3
Silicon Oxide - SiO2			5.0
Rutile - Ti O2	1.2		
Albite - Na0.98 Ca0.02 Al1.02 Si2.98O8	29.1		
Magnetite - Fe3 O4	0.3		
Hematite - Fe2 O3	0.8		
Iron Sulfite Hydrate - Fe (SO3) (H2O)3	2.6		
Cristobalite - Si O2	11.3		2.5

The ISO 4406 analysis performed by Metro-tech shows the significant improvement in quality of diesel fuel after traditional filtering and OEI filtration. The results are summarized in table 3 below.

Table 3: Comparison of the log yard fuel ISO analysis before filtration, after traditional filtration and after OEI magnetic filtration

	Size (um)
Statistical Value	**Counts**
Log Yard Sample (Before all Filtration)	6479/2129/132
After Tank Filter, Before OEI Filter	491/143/8
After OEI Filtration (Fuel Nozzle to Engine)	367/112/5

ISO Range	Particle Count Range
20	10,000-5,001
18	2,500-1,301
17	1,300-641
16	640-321
14	160-81
10	10-6
9	5-2.6

CONCLUSION

The quantity of contamination removed along with the results of the XRD/EDS and PSD/SEM demonstrate the effectiveness of OEI Magnetic Filtration Technology in capturing wear contamination down to the sub-micron level. The benefits of superior fuel filtration are reduced internal engine friction, thereby reducing fuel consumption and emissions; Additionally cleaner diesel fuel means reduced hard particle ingression into engine oil, extending oil and engine component life across the whole site. The added benefit of OEI is a product with a 22+ year service life, further reducing operational costs thereby improving profitability.