Clean Air Fleet INCORPORATED

CLEAN AIR FLEET PROGRAM

EMISSIONS SYSTEM MAINTENANCE REPORT

CASE STUDY FLEET - OSD TRANSPORT - LAFARGE WISCONSIN
FLEET TRUCKS - FREIGHTLINER CASCADIA - DETROIT DD15 ENGINES
MAINTENANCE MANAGER - COREY JENSEN

The owner and maintenance manager at OSD transport had been having a number of issues with the fuel and emission control systems on their entire fleet and decided to find a solution that was not available at the dealership to solve their problems.

The failures were related to the following components; high pressure fuel pump, fuel injectors, DPF 7th injector, DPF filter, NOx sensor, delta-P sensor, DEF system.

In 2016 OSD Transport implemented the Clean Air Fleet Program to their entire fleet and documented their findings. They specifically identified a test and control truck to compare the detailed data throughout the entire process.

CONTROL UNIT: 2015 Freightliner Cascadia with Detroit DD15 Engine; 350,000 miles using #2 ULSD Diesel Fuel with the stock 30 micron OEM oil filter.

TEST UNIT: 2015 Freightliner Cascadia with Detroit DD15 Engine; 400,000 miles using The Clean Air Fleet Program utilizing the CAF-15 Engine Oil Purifier, CAF Premium Diesel Fuel Additive and CAF Fuel Additive Doser Tank system for 100,000 miles in total.

TEST UNIT: 2015 Freightliner Cascadia with Detroit DD15 Engine

DPF 7th INJECTOR COMPARISON:

CONTROL TRUCK: 7th INJECTOR

TEST TRUCK: 7th INJECTOR

DPF 7th INJECTOR NOTES:

The Control Truck 7th injector is mostly covered with hard carbon or soot when using regular #2 ULSD only. This soot clogs the nozzle obstructing the spray pattern preventing it to operate correctly. When the injector nozzle is clogged, it causes the DPF regeneration process to function improperly and the ECM will spray more fuel in order to compensate. At this point, the regeneration process is not able to burn off the particulate in the filter and requires maintenance. A clogged injector in this state requires replacement according to OEM specifications.

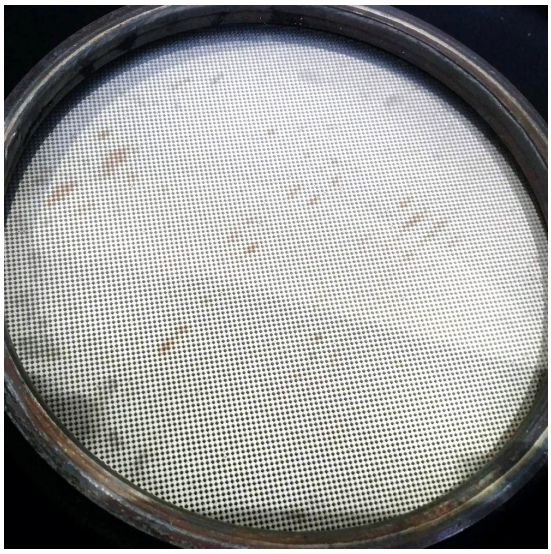
The Test Truck 7th injector is free of built up soot, and upon close inspection the nozzle is clear and open to spray normally. The detergent combined with the cleaner burn of the CAF Premium Diesel Fuel Additive keeps the soot buildup to a minimum. This allows for the 7th injector to spray like new and burn off particulate in the DPF as it was designed to do. The temperatures readings in the DPF regeneration reach higher temps faster when the injector is clean and burning soot free. The diesel fuel burns better with atomization of smaller droplets versus a stream of fuel that can't burn completely. The DPF 7th injector operating more efficiently results in less fuel use from regenerations.

Replacing the DPF 7th injector costs around $900-1000 per unit including labor. Their fleet was replacing 1-2 injectors per month on average. Manually cleaning the injector was the only way to slow down the failure rates, and that would average a minimum of one hour to remove, scrub and replace the part. After using the CAF Premium Diesel Fuel Additive, the fleet was experiencing a lot less 7th injector issues, and upon continued visual inspection confirmed that the nozzles were noticeably cleaner and no longer required the manual cleaning they needed before.

With the DPF experiencing fewer regenerations with the CAF Premium Diesel Fuel Additive, the Test Truck increased its fuel economy of 2 to 3 tenths of a mile per gallon.

DPF FILTER COMPARISON:

CONTROL TRUCK: DPF FILTER



TEST TRUCK: DPF FILTER

DPF FILTER NOTES:

The Control Truck DPF Filter is fully covered in black soot and partially clogged in the center. They were used to seeing this carbon buildup and it was just expected according to the OEM standards. When a DPF filter gets so clogged with soot, eventually the regeneration process will not be able to burn it out and sends a check engine code to the ECM. At that point it is necessary to remove the DPF filter and take it to the dealership to either have cleaned at their facility, or sent to Freightliner where it undergoes a more complete cleaning process, or replaced with a new filter altogether.

The dealership cleaning cost is around $500 on average and comes without a warranty. This is not including the labor to remove and replace the filter, but just cleaning the part. When the filter no longer passes inspection due to cracks or other damage, the DPF filter needs to be replaced. A remanufactured filter replacement with labor will cost $2000 on average. A new filter replacement estimated cost is between $3500-4000.

The Test Truck DPF Filter has very little soot present upon inspection. The service manager at the dealership refused to believe that this filter is the original DPF filter from this truck, he said it looked like a newly remanufactured filter and could not understand how a used DPF filter could be this clean because he hasn't seen anything like it before.

There are few reasons why the filter is this clean, the first is an overall cleaner burning fuel with the CAF Premium Diesel Fuel Additive. CAF treated fuel has been shown to reduce smoke or particulate matter when compared to base #2 ULSD. The second is the cleaner DPF 7th injector that has a new like spray pattern allows the fuel to atomize and therefore burn more completely reaching ideal temps and burning off deposits in the filter more completely. The third reason is that the CAF Oil Purifier prevents wear, deposits and blow-by in the engine. When blow-by oil gets burned in the combustion chamber the result is increased emissions, smoke and particulate.

ECM INJECTOR REPORT COMPARISON:

CONTROL TRUCK: INJECTOR REPORT

TEST TRUCK: INJECTOR REPORT

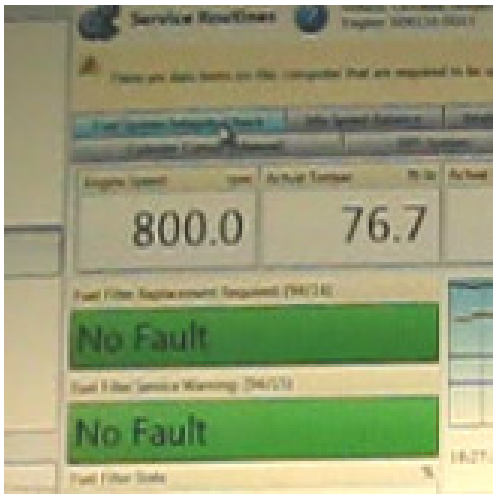
ECM INJECTOR REPORT NOTES:

The ECM injector report shows the air/fuel ratio for each cylinder, a reading of zero indicates a perfect air/fuel mix. A negative number indicates a lean mixture, and a positive number is rich. The air/fuel ratio measures the mass of air divided by the mass of fuel supplied to the engine at a given time. The chemically correct air/fuel ratio is the exact ratio necessary to burn all of the carbon and hydrogen into carbon dioxide and water with no oxygen remaining. A lean mix with more air and less fuel increases fuel economy and reduces exhaust emissions. A slightly rich mix with less air and more fuel generates maximum engine power, while an overly rich mix causes power loss, excessive fuel consumption and increased emissions.

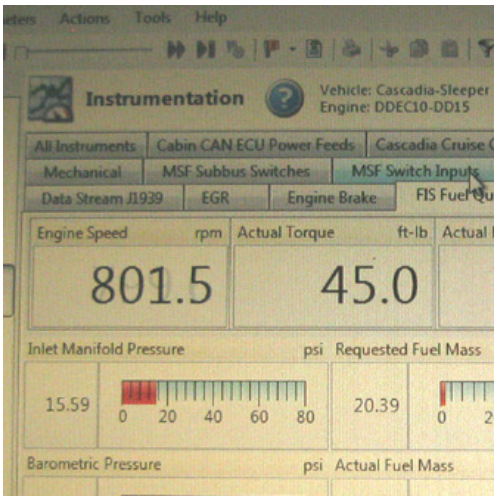
The Control Truck injector report shows that all but one of the cylinders is running a highly lean or rich mixture of air to fuel with 4 of the 6 figures in double digits. Over time the injectors will accumulate deposits and cavitations preventing the proper spray pattern of fuel into the cylinder negatively effecting the injector efficiency.

The Test Truck injector report indicates much improved air/fuel ratios and injector efficiency with the CAF Premium Diesel Fuel Additive, with 3 cylinders running perfectly. These figures are difficult to achieve even with new injectors, because with #2 ULSD the combustion properties are not ideal. The improved cetane, detergents and lubricity provide desired conditions for the injectors and engine to function. The high pressure common rail injection system operates with very tight tolerances leaving little room for error and with dry 15 ppm ultra low sulfur diesel, the injector's plunger and needle are subjected to excessive wear. ULSD is also proven to contain double the amount of water than high sulfur diesel did, which causes scoring and cavitations in the injector tips further altering the spray pattern. The Clean Air Fleet Premium Diesel Additive disperses water completely, while providing lubricity equal to 3000 ppm sulfur diesel fuel.

ECM TORQUE REPORT COMPARISON:



CONTROL TRUCK: TORQUE REPORT



TEST TRUCK: TORQUE REPORT

ECM TORQUE REPORT NOTES:

The torque report figure shows the force required to operate the engine at high idle of 800 RPM. The torque number indicates the overall efficiency of the engine, and how much resistance it is overcoming to produce 800 RPM.

The Control Truck used 76.7 foot pounds of torque and the Test Truck required only 45 pounds of torque to operate the engine at 800 RPM. This is evidence that with the Clean Air Fleet Program with improved lubrication from the oil and fuel that the engine is working easier and more efficiently.

NOX SENSOR NOTES:

The NOx sensor is a critical component in the emission control system, and over time it becomes too coated with soot to function properly. Prior to starting the Clean Air Fleet Program, the fleet was experiencing 3-4 NOx sensor failures per month. With a replacement cost in the range of $900-1000 depending on the severity of the repair, with the potential of the 1 box replacement if threads go out with sensor, which costs $6000. The costs accumulating from the NOx sensor replacements were a major concern for the entire operation of the fleet.

Once they started the program and allowed the CAF Premium Diesel Fuel Additive to clean up the entire fuel and emission systems, they began to see a dramatic reduction in NOx sensor related problems. They said that it was first indicator that something very positive was taking place under the new program. Over the span of the next 6 months they had only one NOx sensor code, and that was the result of the wiring connection, not the actual sensor itself. They went from 3-4 NOx failures per month, to just one in 6 months effectively eliminating this issue from their entire fleet.

DELTA P SENSOR NOTES:

The Delta P sensor is another critical component in the emission control system, it reads the EGR pressure controlling the EGR, which in turn controls all of the other components in the emission system. When the sensor gets too covered with carbon it is not be able to read the pressure correctly and sends the EGR incorrect information causing it to operate out of specification. When the Delta P sensor is not operating correctly there is an exponential effect on multiple components in the emission control system.

The replacement cost of the Delta P sensor itself is $900-1000 on average and has the potential to require changing the doser block if that fails with it, adding more cost.

EGR NOTES:

The fleet would get multiple EGR related codes before the CAF program, and after implementation were not getting any codes or EGR related issues. One of the main issues with the EGR is the butterfly valve that gets stuck in the open position and doesn't fully close. This prevents the actuation of the valve to operate properly and causes the resulting malfunction.

The valve sticks due to the recirculation of exhaust through the EGR in the process of re-burning emissions. The unburned hydrocarbons or soot in the exhaust stick to the internal components and build up deposits over time causing the moving parts to seize and malfunction. The more complete burn and reduced smoke and particulate matter from the CAF Premium Diesel Fuel Additive decreases the build up allowing the parts to operate correctly again.

DEF NOTES:

The fleet reports using 25% less DEF fluid with the Clean Air Fleet Program than before. With less DPF regenerations taking place, the system is using less DEF as a result. The only emission system related codes they get are from the DEF system, which is the only part of the emission controls not in contact with the CAF Premium Diesel Fuel Additive.

FUEL PUMP NOTES:

Today's common rail engines with high pressure fuel pumps operate at around 6300 PSI at idle, under load the fuel pressures can reach 38,000 PSI. These high pressures are generated with very tight tolerances in the pump components, and with ultra lower sulfur diesel the lubricating components are missing leaving the moving parts vulnerable to excessive wear. ULSD is also known to hold twice the water than regular sulfur fuel, and bio-diesel increases the water presence even more. The water causes ice and gelling in cold weather which also increases damage and wear in the pump.

The same holds true for the debris known as asphaltenes in diesel fuel. Black tar-like asphaltenes are pin sized and are commonly mistaken for algae and often misdiagnosed and improperly treated. Today's ULSD manufacturing process leaves the diesel fuel

susceptible to water and degradation, forming the asphaltenes which cause fuel filter issues, injector damage, and pump failures.

Prior up to implementing the Clean Air Fleet Program the fleet had lost a fuel pump causing the entire fuel system to require a complete rebuild from top to bottom. All of the components including, fuel pump, fuel filter module, fuel injector lines, high pressure fuel rail feed lines, fuel injectors, high pressure flange and all fuel filters. In addition, all of the fuel lines, return lines, fuel rail, fuel filter assembly and fuel tanks need to be completely cleaned of all metal as a result of the fuel pump failure.

Before implementing the CAF Premium Diesel Fuel Additive, upon routine inspection of the pre-filter screen leading to the pump, they would find small metal particles indicating wear which required cleaning and maintenance. With the 3000 ppm sulfur equivalent lubricity added back into the fuel, the fuel system and pump were getting properly lubricated. And upon inspection of the pre-filter screen they are not finding any visible metal or wear particles.

OIL ANALYSIS NOTES:

The CAF Engine Oil Purification system is an ultra fine, 1 micron absolute oil bypass system that is designed to remove 99.98% of moisture, acids, varnish as well as soot, dust and particulate that is 1 micron and larger in size.

The baseline sample taken prior to installation shows there was elevated silicon in the oil at 24 ppm, the test sample showed the purifier had lowered the silicon to 4.9 ppm.

The soot remained at an acceptable level for the miles, as the system will prevent the soot from getting to an unacceptable level which prevents excess carbon and blow-by.

The ISO 4406 particle count shows there was less debris in the oil with 3 times as many miles on it, the system had removed the new contamination from combustion and wear, while cleaning up the engine and oil as a whole.

There was basically no change in the oil additive package which indicates there was no additive depletion or aging of oil after the purifier was installed.

The viscosity remained unchanged as well, as combustion takes the place the viscosity will either increase with ingress of dirt and carbon, or will drop when fuel dilution is present as a result of blow-by.

The oxidation scarcely changed indicating that the oil had hardly aged in 20,000 miles.

The TBN remained at acceptable levels, which is an indicator of alkaline reserves left in the oil after neutralization of acids takes place. The oil purifier is designed to remove acids as they form from combustion and the combination of moisture and metal particles.

The wear metals show a trend of slowed accumulation indicating less wear, cleaner oil creates less friction and abrasion resulting in less wear metals from engine components.

MOB II

WEAR CHECK

MOBILE OIL ANALYSIS REPORT

CONTAMINATION	NORMAL
OIL CONDITION	NORMAL
WEAR	NORMAL

134387 - Diesel Engine

Unit Make : FREIGHTLINER
Unit Model : CASCADIA
Comp Make : DETROIT
Comp Model : DD15

Serial No : {n/a}
Cust. Ref No. : {n/a}

Date Rec'd : Oct 3, 2016
Sample Date : Sep 26, 2016

RECOMMENDATION

Resample at the next service interval to monitor.

Sample Date			08/01/16	Current	UOM
Time on Unit			377656	396610	mls
Time on Oil			11240	30194	mls
Time on Fltr			0	0	mls
Oil Maint.			n/a	n/a	---
Filter Maint.			n/a	n/a	---

CONTAMINATION

There is no indication of any contamination in the component. The amount and size of particulates present in the system is acceptable.

Sample Date			08/01/16	Current	Abn
Silicon			**24**	4.9	20
Fuel (%)			<2.0	<2.0	5
Glycol			---	---	0.06
Water (%)			<0.1	<0.1	0.2
Soot (%)			0	0.3	3
>4µm(c)			667	628	---
>6µm(c)			363	342	---
>14µm(c)			61	58	---
>21µm(c)			20	19	---
>38µm(c)			3	3	---
>70µm(c)			0	0	---
ISO 4406(c)			17/16/13	16/16/13	---

OIL CONDITION

Oil Type: SHELL SEMI-SYNTHETIC 5W30

The BN result indicates that there is suitable alkalinity remaining in the oil. The condition of the oil is suitable for further service.

Sample Date			08/01/16	Current	Base
Boron			7.4	2.7	---
Barium			0.0	0.0	---
Calcium			1184	1169	---
Magnesium			812	790	---
Molybdenum			55	52	---
Sodium			2.3	2.9	---
Phosphorus			956	849	---
Sulfur			1520	2028	---
Zinc			1075	1068	---
Visc 40°C (cSt)			---	---	---
Visc 100°C (cSt)			11.2	11.2	---
VI			---	---	---
Oxidation (%)			44	48	---
AN (mg/KOH/g)			---	---	---
BN (mg/KOH/g)			9.45	7.41	---

WEAR

All component wear rates are normal.

Sample Date			08/01/16	Current	Abn
PQ			---	---	65
Iron			7.6	11	80
Nickel			0.7	0.9	2
Chromium			0.7	0.6	5
Titanium			2.0	2.3	---
Copper			24	38	150
Aluminum			3.8	4.3	30
Tin			3.4	1.4	5
Lead			0.7	0.3	30

TEST TRUCK OIL REPORT: Wear Check USA Third Party Independent Oil Analysis

CONCLUSION:

Both the owner and maintenance manager at OSD Transport have reported a dramatic improvement in their fleet maintenance expenses since beginning the Clean Air Fleet Program in 2016. They were spending around $5000 per month on emission related parts and labor, not including the downtime and related loss of revenue.

The drivers also realized the benefits from reduced breakdowns and related delays on their routes, allowing them to make their deliveries on time with greater success. They especially appreciate not dealing with check engine lights or driving on the shoulder of the freeway as the engine is de-rated due to DPF regenerations or other emission related problems.

They also had the advantage of not needing to use small bottles to pour fuel additive in their tanks, instead using the CAF Fuel Additive Doser Tank installed on each truck allowing them to treat their fuel in about 10 seconds total, with no mess or guessing.

Since beginning the program they have doubled their oil drain intervals effectively cutting their oil change costs in half and netting $30,000 in oil savings annually with the CAF Oil Purifier systems. With the CAF Premium Diesel Fuel Additive requiring less DPF regenerations, as well as increased lubricity and more complete fuel burn, gave the fleet an increase of 2 to 3 tenths of a mile per gallon for the year.

According to OSD Transport, the Clean Air Fleet Program was clean and efficient to implement and has already paid for itself multiple times over.

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