The Effect of Samarium Cobalt Rare Earth Fuel Filters on Fuel Economy and Pollution
A study performed at the NCAT Pavement Test Track, Auburn University

Dr. Fred Pullen
Executive Vice President, Vostecs Inc. Key Biscayne Florida
fpullen@vostecs.com

Abstract

The NCAT Pavement Test Track at Auburn University was established to test asphalt pavement mixtures, but in the accomplishment of the primary goal, other research opportunities were afforded the Engineering department. The NCAT program used five 60 Series Freightliner Columbia Series tractors with 435 HP Detroit Diesel engines which ran approximately 700 miles per day around a 1.7 mile track and carried a load of 160,000 pounds each for a total mileage of over 200,000 miles each. Two of the five trucks were fitted with a SuperVos Flame® model 550 samarium-cobalt fuel filter directly in the fuel line, after baseline fuel economy and exhaust studies were performed. The fuel filters were installed in December 2004, and load weight adjusted to 160,000 pounds each in February 2005. The trucks ran for 140,000 miles after installation. Fuel consumption was reduced an average of 6.5% up to a total of 9% and total pollution was reduced over 50% when compared to a control truck.. Carbon monoxide was reduced 62%. Particulate matter was reduced to almost nil. A one year cost savings of approximately $4550.00 per truck was obtained (fuel at $2.00/gallon) Fuel efficiency was determined by the Technology and Maintenance Council of the American Trucking Association TMC/SAE Type II formula recommended #1102 fuel consumption test procedures.

Introduction

One of the many product verification studies performed at the NCAT Pavement Test Track was to use high powered Vostecs SuperVos Flame® (SV Flame) Samarium-Cobalt fuel filters for fuel treatment. These fuel filters (heat tolerant to 200 degrees Celsius) were donated by Vostecs Incorporated (www.vostecs.com) for the purpose of evaluation of their claim to promote fuel economy and pollution control in diesel engines. It had been estimated to decrease fuel consumption from five to ten percent and decrease pollution by NOx and CO up to 50%.

Trucking

This type of research is known as accelerated performance testing (APT) because a design lifetime of truck traffic was applied (typically 10-15 years) in 2 years. Trucking was initiated on October 21,2003, utilizing a single rig, however, soon after this NCAT purchased 5 new Freightliner tractors with 435 hp Detroit Diesel engines specifically for the Tracks rigorous environment and a trucking coordinator was appointed to maintain equipment and manage drivers. Full trucking using NCAT drivers over 18 hours per day began about December 1 2003 and continued until December 17, 2005, with total mileage for each tractor over 200,000 miles, pulling a load of 160,000 pounds.. Test trucks with installation of the SV Flame® each had over 140,000 miles after installation and one year of evaluation. ***See Figure 1***.

Figure 1

Fuel and the SuperVos Flame Fuel filters
How does it work?

Diesel fuel is one of a group of liquid hydrocarbons consisting of carbon and hydrogen atoms which combust freely in the presence of oxygen. The action the SV Flame® exerts on the fuel leads to a reduction of the bond energy between these atoms which leads to an increase in energy with less use of Oxygen as well as an increase in turbulence in the flow and therefore there are more atoms of fuel exposed to the combustion process. There has also been shown a decrease in viscosity in thicker oils. The decrease in viscosity is similar to the heating of thick oils such as Bunker C.

The main effects are similar to the burning of coal. If one large lump of coal is set on fire, only the outer carbon will combust, whereas if the coal is ground up into a fine dust the entire lump may combust easily and quickly with almost complete combustion. This has been used in industrial sites with a coal slurry being the preeminent form used in electricity generation. This also accounts for our results found by the decrease in combustible particulate matter in the exhaust. Because of the better combustion, valves are expected to remain cleaner, as would the combustion chambers and exhaust manifolds. There should be an increase in efficiency and a longer life of the elements of the engine, but, firstly, as was found, polluting emissions and fuel consumption decrease. Cold weather starts of Diesel engines will be easier, even if the temperature is very low.

The SV Flame® (**Figure 2**) can be installed on any type of engine: trucks, motorcycles, buses, sea-engines, heavy equipment, as well as generators. Boilers and furnaces that burn hydrocarbon fuels such as fuel oil, bunker C and natural gas also show a decrease in consumption and pollution. See: www.vostecs.com **Figure 3** shows the installation and placement in these trucks.

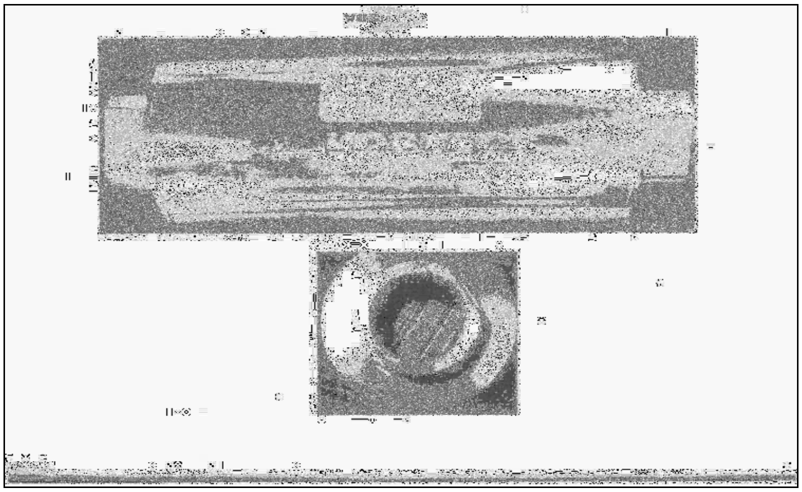


Figure 2
SuperVos Flame for Diesel Trucks

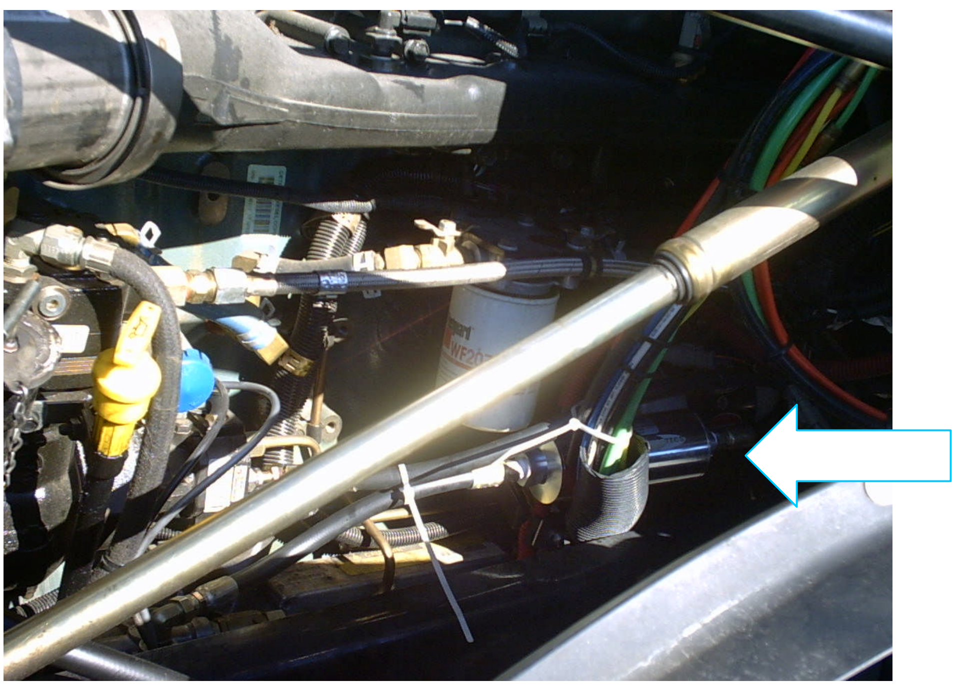


Figure 3
SuperVos Flame in Place

Fuel Economy testing

Each truck ran approximately 700 miles per day and exact fuel consumption and fuel replacement was charted daily. The records were kept and subjected to a complete analysis on a weekly basis. The exact amount of fuel consumed per mile was calculated on a daily basis. Analysis of fuel economy was tested by the Technology and Maintenance Council/SAE recommended practice #1102 and is shown below in **tables 1 and 2**. The decrease in fuel consumption averaged over 6.5% for 140,000 miles. The consumption decreased up to 9% at the completion of the one year study, probably due to the engine cleaning action of the filters. ***In cost saving that equated to a savings of 2275 gallons or $6825.00 per truck at $3.00 per gallon***.

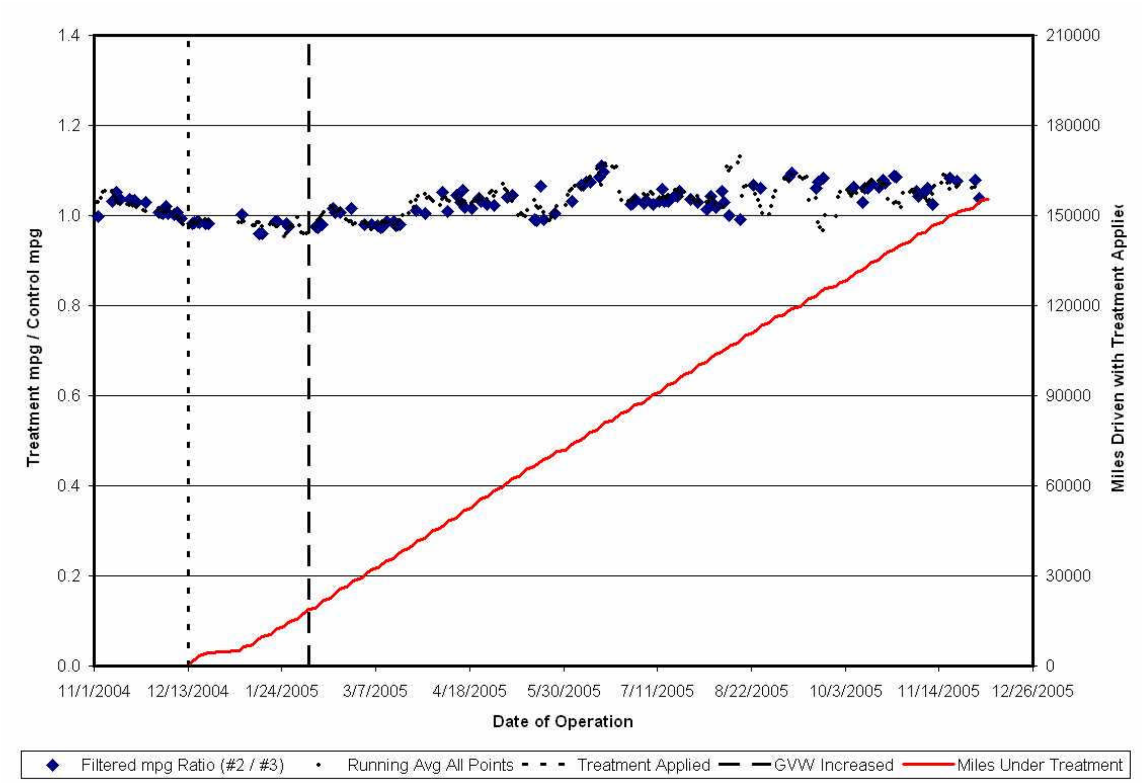


Table 1
Treated mpg/Control mpg over course of experiment

Fuel Savings TMC/ATA Formula
Treatment mpg/control mpg

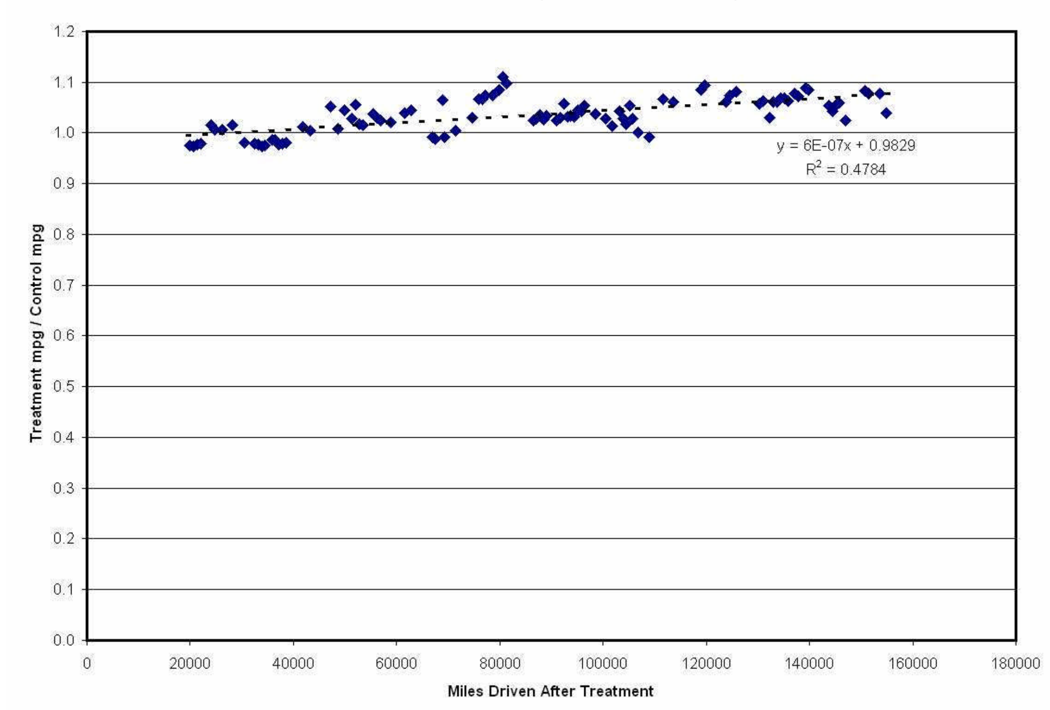


Table 2

Emissions Testing and Sampling

In conjunction with the Civil Engineering Department at Auburn University a series of pre- and post installation emissions testing was performed on each of the two trucks with fuel filters installed and one control vehicle. The testing procedure consisted of obtaining gaseous emissions and collecting particle emissions form the exhaust of the truck. At the end of the project particle emissions were also collected. Each method of exhaust sampling is described below.

These samples were obtained on each truck by using a calibrated vacuum canister. This canister was calibrated, cleaned and the emissions were calculated by the Civil Engineering department at Auburn University. The emissions vacuum tube was attached to the exhaust stack of the truck where the end of the tube was placed in the exhaust stream. The truck was traveling at a consistent rate of speed when the vacuum was released from inside the cab by the driver. At a consistent rate, the vacuum canister sucked the exhaust into the canister until the pressure equalized from negative twenty-five pounds per square inch (PSI) to zero. The canister was then sealed off with the emissions sample inside.

This procedure was repeated two to three times with each of the test trucks and the test was performed at the same location of the track to provided consistency of samples. The results of the before and after emissions samples are listed in Table 3. Results of the final emission tests performed in December 2005 upon completion of the experiment are found in **Table 4**. The decreased exhaust pollution analysis compared to the control are found in **Table 5**.

EXHAUST ANALYSIS				PRE-TREATMENT			POST TRMT			% DECREASE		
				Magnet Treatment		CONTROL ADJUSTED	Magnet Treatment		Control	Magnet Treatment		Control
Sample Type	Parameter	Description	Units	Truck 2	Truck 5	Truck 3	Truck 2	Truck 5	Truck 3	Truck 2	Truck 5	Truck 3
Gaseous	ALKANES	methane	mg/cm	13.4	14	13.7	9.3	8.5	10.2	31%	39%	26%
		ethane	mg/cm	26.8	24.1	25.45	18.5	16.2	23.8	31%	33%	6%
		propane	mg/cm	12.4	9.9	11.15	8.2	6.9	9.1	34%	30%	18%
		butane	mg/cm	9.7	5.4	7.55	5.8	5.5	7.2	40%	-2%	5%
		pentane	mg/cm	16.8	7	11.9	11.3	5.8	15.9	33%	17%	-34%
		hexanes	mg/cm	6	5	5.5	5.6	3.9	7.1	7%	22%	-29%
		nonanes	mg/cm	5.6	3.9	4.75	5	3.7	4.2	11%	5%	12%
		decanes	mg/cm	6.2	4.5	5.35	5.4	4.1	5.8	13%	9%	-8%
		undecanes	mg/cm	3.6	3.1	3.35	2.4	1.9	2.7	33%	39%	19%
		dodecanes	mg/cm	5.3	5.2	5.25	4.2	3.7	5.1	21%	29%	3%
		tridecanes	mg/cm	4.1	4.1	4.1	3.8	3.3	3.9	7%	20%	5%
		hexadecanes	mg/cm	7.9	5.3	6.6	5.9	4.1	6.5	25%	23%	2%
		octadecanes	mg/cm	14.1	6.8	10.45	8.7	6.5	9	38%	4%	14%
		C20-29	mg/cm	7	5.4	6.2	4.5	3.6	4.7	36%	33%	24%
		>C30	mg/cm	4	4.3	4.15	3.6	3.2	3.8	10%	26%	8%
						0						
	BTEX	Benzene	mg/cm	0.5	0.2	0.35	0.3	0.2	0.4	40%	0%	-14%
		Ethylbenzene	mg/cm	0.8	1.2	1	0.8	0.7	1.1	0%	42%	-10%
		Toluene	mg/cm	2.4	0.8	1.6	1.4	0.8	1.5	42%	0%	6%
		Xylenes	mg/cm	1.3	0.8	1.05	0.9	0.7	1.1	31%	13%	-5%
				5.6	3.9	4.75	5	3.7	4.2	11%	5%	12%
						0						
	PAH	polynuclear aeromatic hydrocarbons	mg/cm	0.1	ND	ND	ND	ND	ND			
						0						
	NOx	nitrogen oxides	mg/cm	3.7	3.1	3.4	2.7	2.6	3.1	27%	16%	9%
	SOx	sulfur oxides	mg/cm	9.8	8.5	9.15	8.2	6.7	9.2	16%	21%	-1%
						0						
	CO2	carbon dioxide	%	1.6	1.7	1.65	1.2	1	1.3	25%	41%	21%
	O2	oxygen	%	16.5	14.1	15.3	15.2	16.7	14.8	8%	-18%	3%

Table 3. Emissions, Pre and post 30,000 miles

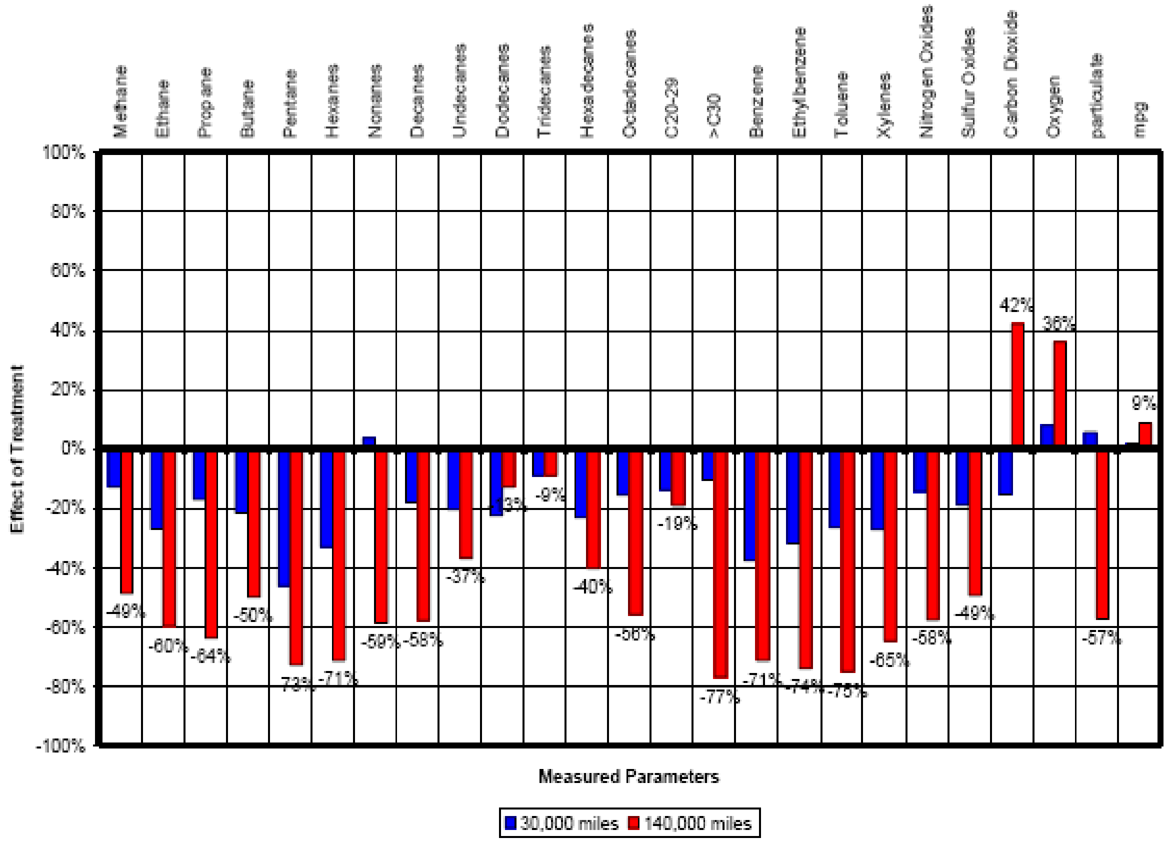


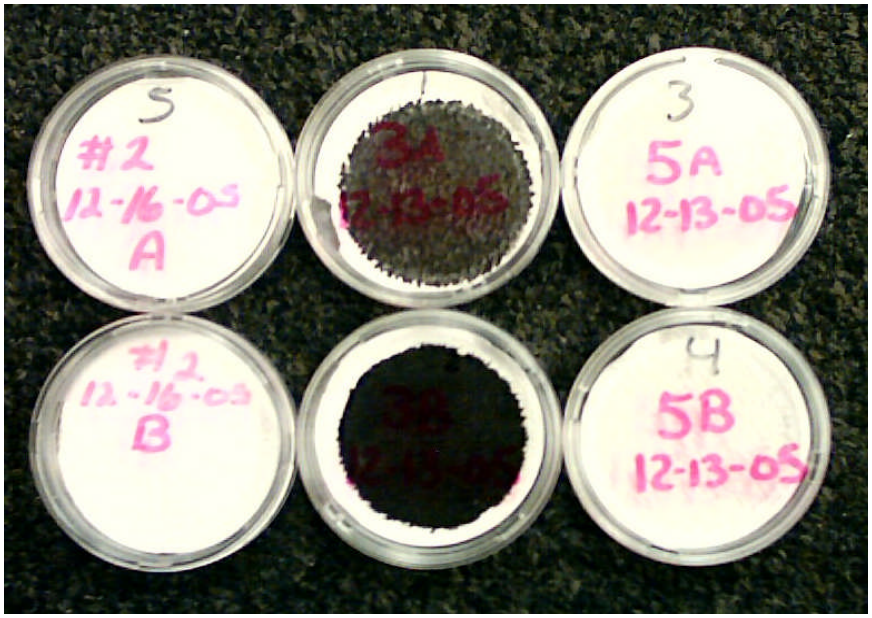
Table 4, Emission decrease at 30,000 and 140,000 miles

EMISSIONS DECEMBER 2005 TREATED FUEL/TRUCKS COMPARED TO CONTROL	
HC totals	**58% less**
NOx	**58% less**
SOx	**50% less**
CO	**62.5% less**
PM<1µm	**58% less**
Volatile PM<1µm	**62% less**

Table 5

Particulate Emissions Testing

These samples were obtained by placing a device in the exhaust stream with a pre-weighed filter paper. The filter paper is placed in a device that holds the paper against a vacuum flow. The device is mounted in the exhaust flow in the same manner as the emissions test and the vacuum **pulls the exhaust for an hour for each sample**. Two samples were taken for each truck before and after the installation of the SuperVos fuel filters. This picture (***Figure 4***) is of the last particulate test performed December 2005 after 140,000 miles for all trucks. Trucks #2 and #5 are SuperVos Flame® fuel filter fitted test trucks. The center two results are the control truck #3. Testing of the other non fuel filter trucks was performed in January 2006 and results were similar to the control, e.g. black soot was found.



FUEL FILTER TREATED CONTROL FUEL FILTER TREATED

Figure 4, Particulate Exhaust Emissions

Summary

The National Center for Asphalt Technology Pavement Test Track evaluation of the SuperVos Flame® Fuel Filter fuel treatment proved that fuel savings of up to 9 percent were confirmed by the TMC/SAE type II formulas. Hydrocarbon, NOx and Carbon Monoxide emission levels were reduced significantly. Particulate matter was decreased well over 50%. The optimum results were found after one or two months of use, most likely due to the cleaning action on the engine and valves. The total fuel cost savings to the NCAT test track was over $9000. for the year after installation on the two test vehicles.