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Evaluation of Ferox - Fuel Catalyst for Reducing Exhaust Emissions and Increasing Fuel Economy

One of the solutions for reducing the exhaust emissions from heavy duty diesel engines is the modification or reformulation of existing diesel fuels. A recent example of the latter was the introduction of low sulfur diesel fuels. For the modification of fuels, a technique that is employed is to add small volume percentages of chemicals to the existing fuel. In general, these additives/catalysts have been designed to modify the combustion process with the targeted benefits of reduced fuel consumption and exhaust emissions. The following information concerns a testing program that was conducted on such a product. Ferox, a fuel catalyst developed by Parrish Chemical in the US and distributed in Canada by MEA Technologies of Hamilton was the focus of a collaborative government/industry urban bus exhaust emissions and fuel consumption evaluation program.

The Mobile Sources Emissions Division, Environment Canada, agreed to support a testing program to evaluate Ferox under laboratory controlled conditions to determine its effectiveness for reducing exhaust emissions and fuel consumption. Three DDC 6V92 engine powered urban buses of the same vintage and configuration, one as a control and the other two using diesel fuel treated with Ferox, were laboratory chassis dynamometer tested for exhaust emissions after 0, 400 and 1000 hours of regular inservice operation. At each of these points, all three buses were tested over simulated driving cycles designed to generally represent a city/suburban operation. The exhaust emissions that were determined included total hydrocarbons(THC), carbon monoxide(CO), oxides of nitrogen(NOx), particulate mass(PM), carbon dioxide(CO2), volatile organic compounds(VOC), carbonyls and polycyclic aromatic hydrocarbons(PAH). The first three compounds are referred to as the criteria emissions as they are regulated by both the Canadian and United States federal governments. The remaining emissions except for CO2 are unregulated constituents of the exhaust stream. Fuel economy was determined by the carbon balance method which involved a calculation based on the measurements of the carbon compounds in the fuel.

As Ferox was developed to improve the combustion characteristics of an inuse engine over a period of time, it was expected that the maximum benefits accruing from the use of the catalyst would occur by 1000 hours of engine operation. Thus, the differences determined in the exhaust emissions and fuel economy between the zero hours(baseline) and 1000 hours represents the expected improvements with the use of the product. For purposes of taking into consideration normal engine/vehicle variability over time, the control bus results served as the average that would be expected over this length of time. Any changes outside of this range would then be attributable to the Ferox.

The test design consisted of the three buses to be tested over two cycles ie. the Central Business District(CBD) and the New York Bus Composite(NYBC). The test plan required that each bus undergo a total of four 'hot start' repeats of each cycle, on both the diesel control fuel and the diesel fuel treated with Ferox. While the buses were in normal inservice accumulation, the fuel used was the same as supplied to the local transit authority plus the recommended quantity of Ferox added by an MSED technician.

The results from this evaluation indicate that fuel economy consistently improved with the continual use of the Ferox treated diesel fuel. The average increases for the treated buses at 1000 hrs were 7.0% for the CBD and 4.6% for the NYBC. With the control bus being factored in, the results indicated increases of up to 6.1% for the CBD and up to 5.5% for the NYBC. The variability in these increases could be attributable to maintenance conducted on one of the Ferox treated buses (#8919) and the control bus which could have resulted in the smaller percentage gains. For bus #8919, a number of maintenance problems including the replacement of a fuel injector on two separate occasions, were experienced. The bus specific results are found in the following table

Table Percentage Increases in Fuel Economy

BUS	CBD	NYBC	AVERAGE
8919	1.6	0.8	1.2
8939	**12.3**	**8.4**	10.4
8915 (control)	**6.2**	**2.9**	4.6

Note. Bold values are statistically significant

With respect to the exhaust emissions, the data indicated a consistent reduction in CO2 corresponding to the increases in fuel economy. For NOx, though the average results increased over time, these values were less than the increases as measured from the control bus. The particulate mass measurements resulted in a decrease in this criteria emission for three of the four test sequences. The control bus indicated the same trend but with larger percentage decreases. The CO results were more variable, with decreases for the CBD and increases for the NYBC. THC data from one of the buses indicated an average statistically significant reduction of 8.8%. The following table summarizes the results for the criteria exhaust emissions and CO2.

Exhaust Emissions at 1000 hr (gm/mi) and % change compared to Zero hr.

Bus	Cycle	THC	CO	NOx	PM	CO2
8919	**NYBC**	2.89	13.7	20.1	3.06	2652
	% chg	[+10]*	[+22]	[-4.7]	[+35]	[-1]
	CBD	2.16	7.1	15.9	2.11	2578
	% chg	[+5]	[-12]	[+8]	[-1]	[-2]
8939	**NYBC**	3.0	13.2	18.65	2.60	2608
	% chg	[-8]	[+3]	[+17]	[-6]	[-8]
	CBD	2.39	6.88	15.2	1.98	2493
	% chg	[-9]	[-4]	[+2]	[-14]	[-18]

*Note. [+] refers to an increase

The other known compounds in the exhaust stream are not regulated at this time although a number of these are on Canada's Priority Substance List. The carbonyls, VOC and PAH discussed above were included in this study as they are known to exist in diesel engine exhaust streams and contain specific compounds known to be hazardous to human health. The carbonyls, consisting primarily of formaldehyde and acetaldehyde were measured and analyzed using pre-prepared cartridges and liquid chromatography. The results indicated that for the total carbonyl analysis, the Ferox treated buses had slightly greater reductions than the control bus. For acetaldehyde, the average reductions of 41% were twice that indicated by the control bus. Formaldehyde, which is normally 50 to 90% of the total carbonyls in the exhaust stream followed the same trend but the reductions were only approximately 5% larger than the control bus.

The second important category of unregulated exhaust emissions from these vehicles is PAH, of which 15% is in the gaseous form and the remaining 85% adheres to the particulate. During the baseline testing an average of 14 compounds were identified. This decreased to 10 at the 1000 hr point with 4 being at the non-detectable level for the analysis instrumentation The 1000 hr testing also indicated that all of the identified PAH compounds were decreased when the Ferox treated fuel. This was the case for both buses with reductions in the range of +50% for three of these compounds.

In summary, based on the methodology and vehicles used in this program, the Ferox treated fuel was effective in increasing fuel economy and reducing some of the compounds in the tailpipe exhaust stream including THC, NOx, CO2, formaldehyde, acetaldehyde and PAH.

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