



## **XBEE IN BIOFUELS**

The **Bay Area Air Quality Management District** is one of 35 (USA) regional air pollution enforcement districts that make up **CARB**, the **California Air Resource Board**. The Bay Area includes San Francisco. This contract was funded by the District to study the feasibility of manufacturing and using biodiesel in the Bay Area. Almost half of the State's petroleum refineries reside in the Bay Area. The District designed the contract parameters around proving both the economic feasibility of refining biodiesel from local feed stocks, as well as the availability of methods to reduce  $\text{NO}_x$ , which is biodiesel's largest drawback.

It is generally accepted that test methods for diesel also effect the test itself, therefore this contract required a variety of engines, both laboratory and field testing, as well as different testing technologies, to give the most accurate overall picture of how biodiesel and emission reduction additives will perform across real world fleets.

The contractor was **Biodiesel Industries Inc.**, which was recently awarded a US patent in biodiesel refining technology, and is a member of the National Biodiesel Board.

The most obvious result of the emissions tests was that by using **Xbee** enzyme biotechnology,  $\text{NO}_x$  is substantially reduced in all formulas, and at either mix blends, B-20 or B-100. The empirical test was performed at the University of Berkeley's Combustion Analysis Laboratory and the tailpipe emissions tests were conducted in various Bay Area fleets.

In addition to  $\text{NO}_x$ , unburned hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM) also drop substantially. The most effective fuel for total emissions reductions was B-100 made from virgin soy oil, and **Xbee**.

This fuel mix reduced HC by 68%, CO by 25%, PM by 40%, and  $\text{NO}_x$  by 12%, with **Xbee** nearly doubling the emissions reductions of the neat fuel, while reducing  $\text{NO}_x$  from a 13% increase in neat fuel to a 12% decrease. One of the most notable tests was actually the **Xbee /CARB** Ultra low diesel test, without any biodiesel (line 8). Alone, **Xbee** lowered HC by 54%, CO by 14%, and PM by 37%, with no penalty in  $\text{NO}_x$ . This test demonstrates that even in the world's most highly refined fuel, CARB Ultra Low Sulfur Diesel, **Xbee** is highly effective in lowering emissions. **Xbee** is actually more effective than neat B-20 biodiesel, and at a fraction of the cost.

*Matt Cohen*  
**Solpower Corporation**

## [ CONTENTS ]

University of Berkeley's Combustion Analysis Laboratory	---	Page 3
Bay Area vehicles	---	Page 4 & 5

**Biodiesel Industries Inc.**

**Xbee** and another additive are not mentioned by name in this report as the State of California has a very strict policy against giving any type of commercial product endorsement. Please refer to **Biodiesel Industries'** cover letter for verification of **Xbee's** participation in this test.

Soltron is the name of the enzyme technology used in the United States of America and produced by our partner **Solpower Corporation**. ([www.solpower.com](http://www.solpower.com))



July 18, 2006

To whom it may concern:

The additive that was used for both (1) the testing performed by the Combustion Analysis Laboratory at UC Berkeley, and (2) the tail pipe emission study, for the Bay Area Air Quality Management District study was Soltron.

Yours truly,



Russell Teall  
President & Founder

**Biodiesel Industries**  
435 1/2 El Sueño Road, Santa Barbara, CA 93110  
805-689-8103 / fax 805-689-2192  
[www.biodieselindustries.com](http://www.biodieselindustries.com)  
email [info@biodieselindustries.com](mailto:info@biodieselindustries.com)

**University of Berkeley's Combustion Analysis Laboratory**

<i>Aggregate used vegetable oils (B20)</i>	<b>Without Xbee</b>	<b>With Xbee</b>	<b>Difference (%)</b>
HC – Hydrocarbons (ppm)	12.80	5.30	<b>-58.59</b>
CO – Carbon Monoxide (ppm)	39.20	32.40	<b>-17.35</b>
PM – Particulate Matter (mg/Nm <sup>3</sup> )	2.70	2.00	<b>-25.93</b>
NO <sub>x</sub> – Nitrogen Dioxide (mg/Nm <sup>3</sup> )	646.00	554.00	<b>-14.24*</b>

*\*The NO<sub>x</sub> emissions of this biodiesel compared to the CARB ULS Diesel oil increased by 1.6%.*

<i>Virgin soy oil (B100)</i>	<b>Without Xbee</b>	<b>With Xbee</b>	<b>Difference (%)</b>
HC – Hydrocarbons (ppm)	10.00	5.20	<b>-48.00</b>
CO – Carbon Monoxide (ppm)	36.30	32.10	<b>-11.57</b>
PM – Particulate Matter (mg/Nm <sup>3</sup> )	2.30	1.80	<b>-21.74</b>
NO <sub>x</sub> – Nitrogen Dioxide (mg/Nm <sup>3</sup> )	720.00	559.00	<b>-22.36*</b>

*\*The NO<sub>x</sub> emissions of this biodiesel compared to the CARB ULS Diesel oil increased by 13.2%.*

**Bay Area vehicles**

**Insert #11 – Tailpipe Emission Testing Results**

**Tailpipe Emission Testing:  
CARB Diesel vs. 20% Blend of Biodiesel with Additive**

Vehicle	Type/ID#	Model	Fuel	RPM	CO*	HC*	Nox*	Total %	
Benziger Winery Glen Ellen, CA	1	#1	Diesel	Idle	410	1970	128		
					746	470	168		
				B20+**	Idle	291	270	112	
						465	230	111	
	2	#2	Diesel	Idle	214	770	300		
					357	330	270		
				B20+	Idle	189	220	267	
						287	140	245	
	Total Diesel					1727	3540	866	
	Total B20+					1232	860	735	
Change					-495	-2680	-131		
Percentage Change					-28.7%	-75.7%	15.1%	119.5%	

Vehicle	Type/#ID	Model	Fuel	RPM	CO*	HC*	Nox*	Total %	
Car Rental Shuttle Oakland, CA	1	#8102	Diesel	Idle	68	380	127		
					122	570	97		
				B20+	Idle	63	180	117	
						145	530	88	
	2	#8128	Diesel	Idle	98	240	168		
					90	300	139		
			B20+	Idle	76	200	165		
					116	410	112		
3	#8142	Diesel	Idle	92	280	159			
				163	310	105			
				80	280	149			
Total Diesel					633	2080	795		
Total B20+					610	2090	730		
Change					-23	10	-65		
Percentage Change					-3.6%	0.5%	-8.2%	-11.3%	

Vehicle	Type/#ID	Model	Fuel	RPM	CO*	HC*	Nox*	Total %			
Ecology Center Berkeley, CA	1	Garbage Truck #560	Diesel	Idle	192	2180	317				
				High	338	2050	206				
			B20+	Idle	157	130	300				
				High	326	230	197				
			Total Diesel					530	4230	523	
			Total B20+					483	360	497	
			Change					-47	-3870	-26	
			Percentage Change					-8.9%	-91.5%	-5.0%	105.3%
			Peninsula Sanitation Palo Alto, CA	1	#4	Diesel	Idle	70	130	357	
							High	190	230	221	
B20+	Idle	86				0	328				
	High	256				0	240				
2	#31	Diesel				Idle	69	310	263		
						High	140	340	246		
		B20+		Idle	69	280	345				
High	141			140	240						
3	#32	Diesel		Idle	73	1200	294				
				High	159	1390	253				
		B20+		Idle	65	530	243				
				High	130	810	233				
Total Diesel					701	3600	1634				
Total B20+					747	1760	1629				
Change					46	-1840	-5				
Percentage Change					6.6%	-51.1%	-0.3%	-44.9%			
<b>TOTALS</b>											
Total Diesel					3591	13450	3818				
Total B20+					3072	5070	3591				
Change					-519	-8380	-227				
Average Percentage Change					<b>-14.5%</b>	<b>-62.3%</b>	<b>-5.9%</b>	<b>-82.7%</b>			

\*Parts per million

\*\*Blend of 20% biodiesel, 80% diesel fuel used by fleet, and additive

These results show clearly that a B20 improved with an additive to reduce the NO<sub>x</sub> can decrease the accumulated emissions by around 83% and the NO<sub>x</sub> emissions by around 6%.