1) Maintenance and cleaning:

CEC develops procedures to test performances of fuels, lubricants and other fluids. This is the European organization considered as an international reference and agreed by more than fifty car manufacturer, gas companies and oil producers.

1.1 _ Diesel engines

For Diesel engines, procedure CEC F-23-A-01 controls the formation of deposits on the injector nozzles of an indirect injection diesel engine (PSA Peugeot XUD9 – A/L 4 cylinders – 1.9 l). These two consecutive tests have been performed by the English laboratory **Prodrive** on July 17 and 18, 2005 under control of Garry Polkinghorne.
Nozzle cocking level must be comprised between 85% and 95% to be officially recognized by the companies mentioned in page two: **Xbee** enzyme technology makes the fuel at 92% and 91% respectively within only 10 hours.

1.2 _ Gasoline engines

For Gasoline engines, procedure CEC F-05-A-93 evaluates the formation of carbon deposits on the intake valves of an injection gasoline engine (Mercedes-Benz M102.982 – 4 cylinders – 4 strokes – 2.3 l), equipped with Bosch KE-Jetronic fuel injection equipment. As the first test, this one has been performed by the English laboratory **Prodrive** on July 22, 2005 under the same control.
Inlet valve deposits level must be comprised between 4.5 (extremely heavy) and 10 (clean) to be officially recognized by the below mentioned professional associations: **Xbee** enzyme technology makes the fuel at 8.07 in only 60 hours, i.e. 287 mg in average (lowest at 215 mg) against 314.25 mg for the same fuel in the same engine without **Xbee**.

1.3 _ Eliminating bacteria

Intertek Analyses Chalon realized some tests on the beginning of 2006 to demonstrate the efficiency of the **Xbee** enzyme biotechnology to eliminate the contamination in a heavily polluted road diesel fuel. Results in CFU (Colony forming Unit).

	Bactéria		
	D Day	D Day + 15	D Day + 60
Gazole Xbee 1:4000	$1,5.10^8$ (150 000 000)	$2,6.10^7$ (26 000 000)	$3,4.10^4$ (34 000)
Gazole Xbee 1:500	$1,5.10^8$ (150 000 000)	$2,2.10^7$ (22 000 000)	$3,3.10^4$ (33 000)

	Yeast		
	D Day	D Day + 15	D Day + 60
Gazole Xbee 1:4000	$1,0.10^6$ (1 000 000)	$1,0.10^6$ (1 000 000)	$4,0.10^4$ (40 000)
Gazole Xbee 1:500	$1,0.10^6$ (1 000 000)	$5,0.10^5$ (500 000)	$4,0.10^3$ (4 000)

	Mold		
	D Day	D Day + 15	D Day + 60
Gazole Xbee 1:4000	$1,4.10^7$ (14 000 000)	$2,7.10^7$ (27 000 000)	$2,0.10^4$ (20 000)
Gazole Xbee 1:500	$1,4.10^7$ (14 000 000)	$1,5.10^7$ (15 000 000)	$4,0.10^4$ (40 000)

2) Savings in fuel consumption:

A regulatory test under the New European Driving Cycle (NEDC, directive 98/69CE) implementing sampling procedure ECE 15 as specified in directive 91/441/CEE, the cycle being subdivided into two cycles, the Urban Driving Cycle (UDC) and the Extra-urban Driving Cycle (EUDC).

Each of these experiments were carried out in three times in strictly identical conditions to guarantee the repeatability of the results. The NEDC (UDC + EUDC) results compare a standard fuel with Xbee diesel oil: Carbon Monoxide -4.8%, Unburned hydrocarbons -3.3%, Nitrogen Dioxide +6.9%, Carbon Dioxide -2.4%, Particles -2.4% and fuel consumption -2.4%… for only 6,500 Km!

3) Gas emissions:

3.1 _ **Bay Area Air Quality Management District**, California (USA). Laboratory **University of Berkeley's Combustion Analysis**.

Run	Reference Fuels-Run in 5.9L, 6 Cylinder, Cummins	Blend	Fuel Filter	Xbee	Xbee Dosage	Speed (RPM)	Load (%)	Nox (ppm)	Nox (%)
1	CARB ULS Diesel	N/A	No	No	N/A	1800	80	636	0.0%
2	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	No	No	N/A	1800	80	646	1.6%
3	Biodiesel Produced from Virgin Soy Oil	B100	No	No	N/A	1800	80	720	13.2%
4	Biodiesel Produced from Virgin Soy Oil	B20	No	No	N/A	1800	80	645	1.4%
5	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	No	N/A	1800	80	656	3.1%
6	Biodiesel Produced from Virgin Soy Oil	B20	No	Yes	1:2000	1800	80	576	-9.4%
7	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	No	Yes	1:2000	1800	80	559	-12.1%
8	CARB ULS Diesel	N/A	No	Yes	1:2000	1800	80	632	-0.6%
9	CARB ULS Diesel	N/A	Yes	No	N/A	1800	80	510	-19.8%
10	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	Yes	No	N/A	1800	80	530	-16.7%
11	Biodiesel Produced from Virgin Soy Oil	B20	Yes	No	N/A	1800	80	528	-17.0%
12	Biodiesel Produced from Virgin Soy Oil	B100	Yes	No	N/A	1800	80	591	-7.1%
13	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	Yes	No	N/A	1800	80	601	-5.5%
14	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	Yes	Yes	1:2000	1800	80	515	-19.0%
15	Biodiesel Produced from Virgin Soy Oil	B20	Yes	Yes	1:2000	1800	80	505	-20.6%
16	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	Yes	1:2000	1800	80	560	-11.9%
17	Biodiesel Produced from Virgin Soy Oil	B100	No	Yes	1:2000	1800	80	563	-11.5%
18	Biodiesel Produced from Virgin Soy Oil	B100	No	Yes	1:1000	1800	80	610	-4.1%
19	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	Yes	1:1000	1800	80	550	-13.5%
20	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	Yes	1:4000	1800	80	554	-12.9%
21	Biodiesel Produced from Virgin Soy Oil	B100	No	Yes	1:4000	1800	80	559	-12.1%

3.2 _ **Brittany Ferries**, France. Laboratory **Ascal – Air Liquide.**

	Without Xbee	With Xbee	Difference (%)
Flow (Nm^3/h)	22 536.00	22 521.00	***-0.07***
CO_2 – Carbon Dioxide (%)	6.10	4.70	***-22.95***
CO – Carbon Monoxide (mg/Nm^3)	98.40	56.20	***-42.89***
NO – Nitrogen Oxide (ppmv)	1 094.00	826.00	***-24.50***
NO_x – Nitrogen Dioxide (ppmv)	1 125.00	851.00	***-24.36***
O_2 – Oxygene (%)	12.60	14.70	***+16.70***
Particulates (mg/Nm^3)	99.30	59.65	***-39.93***
SO_2 – Sulfur dioxide (mg/Nm^3)	1 222.00	1 002.00	***-18.00***
VOC – Volatile Organic Compounds (mg/Nm^3)	76.90	45.60	***-40.70***

3.3 _ **Mak/Caterpillar**, Germany. Research & Development Department.

Performance from driven Propellers

	100%	75%	50%	35%	25%	10%	
Performance levels (%)	**100%**	**75%**	**50%**	**35%**	**25%**	**10%**	
KiloWatt (kW)	**1980**	**1481**	**990**	**698**	**495**	**198**	
Number of revolutions	**750**	**681**	**595**	**529**	**476**	**357**	**Average**
Specific consumption (be) — Without Xbee	184.50	183.50	189.90	196.90	205.50	210.70	195.17
With Xbee	184.30	183.10	188.90	196.70	200.00	207.80	193.47
	-0.11%	-0.22%	-0.53%	-0.10%	-2.68%	-1.38%	**-0.87%**
Specific air volume (le) — Without Xbee	7.20	7.03	6.46	6.26	6.07	8.69	6.95
With Xbee	7.31	7.04	6.50	6.30	6.44	9.28	7.15
	1.53%	0.14%	0.62%	0.64%	6.10%	6.79%	**2.78%**
Nitrogen oxide (Nox ppm) — Without Xbee	1,060.00	1,155.00	1,250.00	1,210.00	1,320.00	1,610.00	1,267.50
With Xbee	900.00	995.00	1,050.00	1,075.00	1,175.00	1,315.00	1,085.00
	-15.09%	-13.85%	-16.00%	-11.16%	-10.98%	-18.32%	**-14.40%**
Nitrogen oxide in the exhasut (Nox gKW/h) — Without Xbee	12.45	13.43	13.13	12.29	13.00	20.66	14.16
With Xbee	10.84	12.08	11.65	11.33	12.03	16.89	12.47
	-12.93%	-10.05%	-11.27%	-7.81%	-7.46%	-18.25%	**-11.94%**
Density number of soot particles (FSN) — Without Xbee	0.18	0.13	0.15	0.20	0.21	0.30	0.20
With Xbee	0.11	0.09	0.12	0.12	0.14	0.23	0.14
	-38.89%	-30.77%	-20.00%	-40.00%	-33.33%	-23.33%	**-30.77%**

3.4 _ **Frinsa del Noroeste**, Spain. Laboratory **Dekra**.

	Without Xbee	With Xbee	Difference (%)
Flow (Nm3/h)	73 525.00	68 197.00	***-7.25***
CO_2 – Carbon Dioxide (%)	7.40	5.43	***-26.62***
CO – Carbon Monoxide (ppm)	70.33	40.00	***-43.12***
NO_x – Nitrogen Dioxide (mg/Nm3)	2 340.67	2 023.67	***-13.54***
O_2 – Oxygen (%)	13.03	11.77	***-9.67***
Particulates (mg/Nm3)	50.27	40.90	***-18.64***
SO_2 – Sulfur dioxide (mg/Nm3)	486.47	500.17	***+2.82***
VOC – Volatile Organic Compounds (mg/Nm3)	18.03	14.27	***-20.85***

3.5 _ **Jan de Nul**, Belgium. Fleet Management Department.

	Without Xbee	With Xbee	Difference (%)
Flow (Nm3/h)	392.00	385.75	***-1.59***
Temperature (°C)	367.50	361.75	***-1.56***
Excess of air (%)	132.45	146.15	***+10.34***
CO_2 – Carbon Dioxide (%)	6.70	6.30	***-5.97***
CO – Carbon Monoxide (mg/Nm3)	79.50	66.50	***-16.35***
NO – Nitrogen Oxide (mg/Nm3)	735.50	633.25	***-13.90***
NO_x – Nitrogen Dioxide (mg/Nm3)	772.00	665.25	***-13.83***
O_2 – Oxygen (%)	11.90	12.40	***+4.20***

3.6 _ **Royal Boskalis**, the Netherlands. Laboratory **Envirotech**.

Power	**Without Xbee**			With **Xbee**			Difference %	
%	kW	Nox (g/kWh)	Nox (kg/MT)	kW	Nox (g/kWh)	Nox (kg/MT)	Nox (g/kWh)	Nox (kg/MT)
100%	2610	9.68	40.66	3029	8.30	36.17	-14.26	-11.04
75%	2005	8.90	37.55	2034	7.79	33.33	-12.47	-11.24
50%	1375	9.82	38.14	1695	7.65	33.45	-22.10	-12.30
25%	838	12.52	46.27	1195	6.80	30.02	-45.69	-35.12
E2 average		10.20			7.60		-25.49	

Coastway

These measurements were performed in compliance with the E2 norm as described by the IMO. It must be said also that measurements were done in two different seasons in Bahrein with a difference close to 15°C ambient temperature, that might impact the figures.

Yet, having said that, it is clear that **Xbee** improved the combustion parameters of this engine as we can observe the increase of power at the same load when NOx emissions are all reduced.

The E2 weighted average weighs the results for each power levels according IMO standards. This is the following:

Power	**Weighing factor**
100%	0.20
75%	0.50
50%	0.15
25%	0.15

3.7 _ **Veolia Transport**, France. Laboratory **Ascal – Air Liquide**.

	Without Xbee	**With Xbee**	**Difference (%)**
Flow (Nm^3/h)	151.60	104.80	***-30.87***
CO_2 – Carbon Dioxide (%)	1.52	1.36	***-10.53***
CO – Carbon Monoxide (mg/Nm^3)	342.20	262.60	***-23.26***
NO – Nitrogen Oxide (mg/Nm^3)	415.60	380.60	***-8.42***
NO_x – Nitrogen Dioxide (mg/Nm^3)	821.20	719.40	***-12.40***
VOC – Volatile Organic Compounds (mg/Nm^3)	113.00	105.40	***-6.73***

The laboratory measured five different buses at the idle to observe the above displayed results, gas emissions per Nm^3.

Sources:

3.1 _ **Bay Area Air Quality Management District**, California (USA). Laboratory **University of Berkeley's Combustion Analysis**.
Testing was done under the direction of Professor Robert Dibble at the Combustion Analysis Laboratory at the University of California at Berkeley__DdeLink__644_844010212. Professor Dibble ran the testing protocols on a Cummins 5.9 liter diesel installed at the Combustion Analysis Laboratory in September 2005.

The reference diesel fuel used for the tests was CARB ultra low sulfur diesel (ULSD) procured from the British Petroleum distributor in San Jose, Western States Oil. The biodiesel used was made using the Mini Modular Production Unit from feedstocks acquired in the Bay Area consisting of virgin refined soybean oil and used fryer oil. These two types of biodiesel were selected because research published by the USEPA suggests tha NOx emissions would be highest with soy based biodiesel and lowest with used fryer oil based biodiesel. Various blends of biodiesel and ULSD were tested, including 100% ULSD, 20% biodiesel with 80% ULSD, and 100% biodiesel. Additional tests were run to test the effects of Xbee and a fuel/lubricating oil filtration system.

The emission testing equipment was obtained from Clean Air Instruments, and was a CARB and USEPA approved device, a Testo 350 M/XL. The device was calibrated before the tests were begun and was purged between tests on each vehicle. Protocols establised for the device were followed to allow for readings to stabilize before they were recorded.

3.2 _ **Brittany Ferries**, France. Laboratory **Ascal – Air Liquide**.
Testing was done under the direction of Emmanuel Moulin, Technical Air Engineering Manager at Ascal Bâtiment, on the stack of the MaK main engine number 4 of the *M/F Mont Saint-Michel*, operated by the Brittany Ferries. The ship is equipped with four engines with a power of 5,400 kW each, 6 cylinders, powered by HFO 380.

The first measures were done on October 8, 2006, prior to using the Xbee biotechnology. From 13 October, during each bunkering operation, the Enzyme Fuel Treatment was added at a rate of 4,000:1 (1 liter of Xbee for 4,000 liters of fuel). The second displayed measures were done on December 13, 2006, after two months of using Xbee fuel.

Measuring NO and NOx was done in compliance with the norms NF X 43-300 and NF X 43-018. Sampling: Made by pumping with a stainless steel sounding rob. The sampled gas is conveyed via a heated line with PTFE core at 180°C. The sampling device is also equipped with a filter and a cold group to filter the sampling and dry it before being put into the device.
Analysis: Continuous measure analyzer, mark COSMA model TOPAZE 3000, equipped with luminescent chemical sensor for determining NO and NOx. Numeric data recording is automatic with agil acquisition or SAM by Environnement SA.

3.3 _ **Mak/Caterpillar**, Germany. Research & Development Department.
Testing was done under the direction of Malte Rautenstrauch, R&D Engineer at Caterpillar Motoren GmbH & Co.__DdeLink__678_844010212, on a bench engine Mak 6M25 as an ISO 3046 ship engine _ running at constant speed and as fixed propeller law. The fuel used during the 15 hours running work was standard MDO.

The emission data were mearsured in April 2003 with equipment and methods as described in ISO 8178.

3.4 _ **Frinsa del Noroeste**, Spain. Laboratory **Dekra**.
Testing was done under the direction of Emilio Aldao, Director of Dekra Ambio, on the stack of the generators: two Wärtsilä 8SWR80 of 9.5 mW each. The plant is powered by HFO 380.

The first measures were done on November 19, 2008. The plant started to treat all its fuel November 25. The second measures were done on May 15, 2009 after six months of treatment.

Measuring NOx emissions was done in compliance with the norm UNE EN 14792:2006, using a gaz analyzer model PG-250 by Horiba.

3.5 _ **Jan de Nul**, Belgium. Fleet Management Department.
Testing was done under the direction of Freddy Devolder, Fleet Manager at Jan de Nul B.V., on the stack of the main engines of the *M/V Manzanillo II*. The dredger is equipped with two SEMT Pielstick 8PA6 L280 engines with a total power of 12,140 kW, powered by Diesel oil.

The first measures were done on April 29, 2009. The second measures were done on October 3rd, 2009. Both using the same gas analyzer KM900+ by Kane-May.

3.6 _ **Royal Boskalis**, the Netherlands. Laboratory **Envirotech**.
Testing was done under the direction of Coen Smits at the Royal Boskalis Westminster nv, when gas measurement was done by Mr. Ponnuchamy at Envirotech Consultancy WLL, on the stack of the starboard engine of the *M/V Coastway*. The ship is equipped with Wärtsilä W6L32B engines of 2,760 kW each, powered with MDO.

The first measures were done on July 19, 2008 and the second measures on December 15, 2008, after almost four months of fuel treatment.

Measuring NOx emissions was done in compliance with the US EPA CTM 034 reference method, using a gaz analyzer model Landcom Series III by Land Combustion.

3.7 _ **Veolia Transport**, France. Laboratory **Ascal – Air Liquide**.
Testing was done under the direction of Emmanuel Moulin, Technical Air Engineering Manager at Ascal Bâtiment, on the exhaust pipes of five buses operated by Veolia Transport. Three buses were built by Renault in 1985, 1988 and 1990 respectively, and two buses were built by Heuliez in 2001 and comply to norm Euro 2.

The first measures were done on April 27, 2005 at the idle. The whole fleet used Xbee Diesel oil from the main storage tank afterwards. The second measures were done on July 5th, 2005.
Measuring NO and NOx emissions was done in compliance with the norms NF X 43-300 and NF X 43-018 respectively, using an analyzer Topaze 3000 by Cosma.

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