

## CATERPILLAR MOTOREN GmbH

April 2003. **Caterpillar** engineers of the Research and Development department have tested the **Xbee** Enzyme Fuel Technology and its effects on the fuel. The experiment has been operated on a 6M25 engine in compliance with the norm ISO 3046 and burning Marine Diesel Oil.

The gas emissions have been measured with equipment and methods in compliance with the norm ISO 8178 after only 15 hours of work.



**Moteur MAK/Caterpillar 6M25**  
*Performance from driven propellers*

	<b>100%</b>	<b>75%</b>	<b>50%</b>	<b>35%</b>	<b>25%</b>	<b>10%</b>	
<b>Performance level (%)</b>	<b>100%</b>	<b>75%</b>	<b>50%</b>	<b>35%</b>	<b>25%</b>	<b>10%</b>	
<b>KiloWatt (kW)</b>	<b>1980</b>	<b>1481</b>	<b>990</b>	<b>698</b>	<b>495</b>	<b>198</b>	
<b>Number of revolutions</b>	<b>750</b>	<b>681</b>	<b>595</b>	<b>529</b>	<b>476</b>	<b>357</b>	
	<b>Without Xbee</b>						<b>Average</b>
	<b>With Xbee</b>						
<b>Specific consumption (be)</b>	184.50	183.50	189.90	196.90	205.50	210.70	195.17
	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%
<b>Specific Air volume (le)</b>	7.20	7.03	6.46	6.26	6.07	8.69	6.95
	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%
<b>Exhaust gas temperature before turbine (tAvT)</b>	477.00	468.00	501.00	519.00	515.00	368.00	474.67
	472.00	465.00	496.00	516.00	511.00	387.00	474.50
	-1.05%	-0.64%	-1.00%	-0.58%	-0.78%	5.16%	-0.04%
<b>Exhaust gas temperature after cylinder (tAnZ)</b>	346.00	335.00	353.00	361.00	364.00	303.00	343.67
	341.00	332.00	349.00	359.00	359.00	311.00	341.83
	-1.45%	-0.90%	-1.13%	-0.55%	-1.37%	2.64%	-0.53%
<b>Exhaust gas temperature after turbine (tAnT)</b>	290.00	315.00	386.00	429.00	427.00	345.00	365.33
	291.00	320.00	385.00	432.00	446.00	385.00	376.50
	0.34%	1.59%	-0.26%	0.70%	4.45%	11.59%	3.06%
<b>Nitrogen oxide (Nox ppm)</b>	1,060.00	1,155.00	1,250.00	1,210.00	1,320.00	1,610.00	1,267.50
	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%
<b>Nitrogen oxide in the exhaust (Nox gKW/h)</b>	12.45	13.43	13.13	12.29	13.00	20.66	14.16
	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%
<b>Carbon monoxide (ppm)</b>	102.00	94.00	142.00	268.00	318.00	170.00	182.33
	94.00	92.00	208.00	384.00	326.00	212.00	219.33
	-7.84%	-2.13%	46.48%	43.28%	2.52%	24.71%	20.29%
<b>Carbon dioxide</b>	5.22	5.38	6.22	6.78	7.48	5.86	6.16
	5.08	5.06	5.78	6.44	6.78	5.60	5.79
	-2.68%	-5.95%	-7.07%	-5.01%	-9.36%	-4.44%	-5.96%
<b>Density number of soot particles (FSN)</b>	0.18	0.13	0.15	0.20	0.21	0.30	0.20
	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%



**CATERPILLAR®**

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**Test Bench Results with Xbee**

Dear Mr. Frey, dear Mr. Filler!

The department of motor development and testing of MaK/Caterpillar has been requested by your company to test the fuel additive Xbee for its efficacy with diesel combustion engines.

We have concluded this test in April 2003 with these results:

The test engine, a medium speed type M25, has been tested for all relevant operating data and at the same measuring points firstly without and thereafter with your additive Xbee.

The evaluation proved considerable improvements at all measuring points (see the testing records) which was a very positive surprise for us.

We suppose that any deposits of carbons will be considerably reduced using this additive and that the intervals of maintenance could be extended due to the reduction of the quantity of soot particles (up to 40%) within the exhaust gas.

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We could not state any damages at the engine having mixed this additive with the diesel fuel.

For our part we do not see any problem for the use of Xbee with all of our engines and we herewith issue a general release for its use.

We believe that using this fuel additive with diesel engines the operating characteristics of the engines will be improved considerably. Due to the reduction of emissions there will be a positive effect for the environment too.

Therefore we may recommend that our customers could use this fuel additive.

With kind regards

  
i. A. Kuo