REPORT:
BRITTANY FERRIES
2006 - 2007

Summary

Better fuel,
better performance.
Better combustion,
better emissions.
XBEE: naturally better.

Context

In the early 2000s, the IMO set in place restrictions on the sulfur content of heavy fuel oils used by marine vessels. The purpose of this regulation was to reduce the emissions of sulfur oxides at the exhaust.

This is the main reason why Brittany Ferries turned to **XBEE Enzyme Fuel Technology** in order to measure its impact on greenhouse gas emissions. This program consisted in measuring the atmospheric emissions on the main engine n°4 of the ferry *Mont Saint-Michel*.

Measurements have been carried out by Ascal. This laboratory, now known under the name Kali'Air, was approved then by decree of the French Ministry of Ecology, Sustainable Development and Energy, and also accredited by Cofrac (French Accreditation Committee).

All the measurement campaigns took place during the ship's regular operations, sailing between Ouistreham in France and Portsmouth in the United Kingdom. The first campaign was carried out on Wednesday October 11, 2006 on the ME4, a MaK engine, model 6M43 of 5,400 kW powered on heavy fuel oil 380 LS.

Starting on October 13, 2006, the crew treated the fuel during bunkering at the recommended dosage of 1 litre of XBEE for 4 m³ of fuel oil. It should be noted that the ship had been equipped upstream with a sprayer to treat the fuel oil during the bunkering operation before its arrival in the storage tanks.

The next measurement campaigns were carried out respectively on Wednesday November 8 and December 13, 2006, as well as on Thursday March 29, 2007, i.e. one month, two months, and five and a half months after the start of treatment.

Data

1 | Engine load

During the measurement campaigns, the engine turned between 498 and 500 revolutions per minute at a constant load ranging from 94.2% to 90.7%. In the meantime, power delivered by the couple of engines 3 and 4 was recorded in kWh/m.

2 | Measured parameters

Ascal laboratory monitored and reported an extensive list of parameters:

- Flue gas temperature (°C)
- Flue gas speed (m³/h)
- Speed (RPM)
- Power (kWh/m)
- O_2 (%)
- CO_2 (%)
- SO_2 (mg/m³)
- Particles (mg/m³)
- CO (ppmv and mg/m³)
- NO and NO_x (ppmv and mg/m³)
- VOC (ppmv and mg/m³)

Data analyses

Taking into account the data measured by Ascal, we can see that **XBEE Enzyme Fuel Technology** reduces significantly emissions of carbon dioxide, sulfur oxides, nitrogen oxides and particles in engines powered on heavy fuel oil:

Parameters	Without XBEE	Average with XBEE	Diff.
Temperature (°C)	306	290	-5.23%
Flue gas speed (m³/h)	23,475	23,014	-1.96%
Power (kWh/m)	8,427	8,319	-1.28%
O_2 (%)	12.57	14.24	+13.28%
CO_2 (%)	6.10	5.53	-9.33%
Particles (mg/m³)	121.70	63.94	-47.46%
CO (mg/m³)	98.43	66.35	-32.59%
NO_x (mg/m³)	2,310.33	2,221.90	-3.83%
TVOC (mg/m³)	41.17	33.45	-18.73%

It should be noted that the above gas emission measurements were first weighted according to the power delivered on the main engines torque 3 and 4. Then, these data were then reduced to a factor of 1 m³ of emitted gas.

See the details of the raw data and the calculations in the annexes.

Conclusions

CO₂

-9.3%

Particles

-47.5%

NO$_x$

-3.8%

Obviously, **XBEE Enzyme Fuel Technology** had a strong impact on the combustion of HFO 380 on board the ferry *Mont Saint-Michel*.

The reduction in emissions of carbon monoxide and dioxides, nitrogen oxides, particles and volatile organic compounds demonstrates a more complete combustion and a reduction in fuel oil consumption.

It can be observed that the measurements made in winter, when sea conditions were the most comparable to each other, are the ones that show the best results: **XBEE** has made it possible, after two months of treatment, to reduce CO_2 emissions by almost 10%. NO_x emissions have been reduced by almost 4%.

XBEE Enzyme Fuel Technology is global partner with Green Marine environmental program and allows shipowners to improve the performance of their ships on at least three key indicators!

GREEN MARINE
PARTNER

Annexes

Fuel treatment

The technical crew installed a sprayer connecting the XBEE drum to the bunkering line. The key parameter was to treat each batch of fuel consumed by the ship during the evaluation period, in order to clean the entire fuel system, starting with the HFO 380 storage tanks.

Characteristics of the fuel system:

· Two tanks of 212.5 m³

· Two settling tanks of 101.6 m³

· Two daily tanks of 72.9 m³
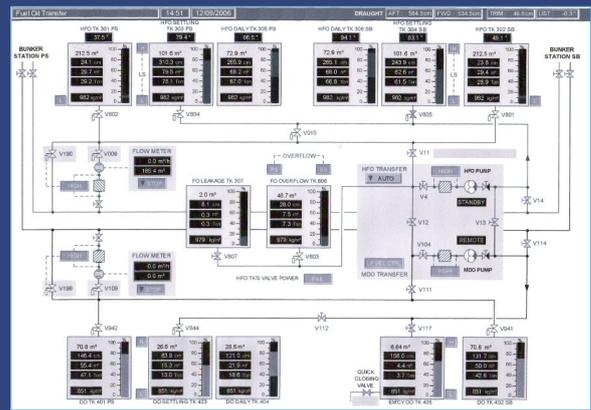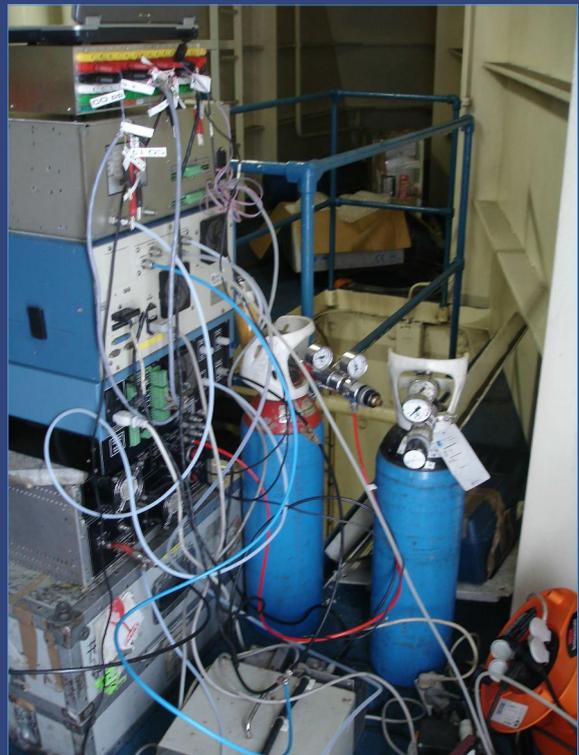
Complete set of data measured by ASCAL

1 / raw data

2 / weighted data based on power

3 / data calculated per m³ of emitted gas

Analyse des données brutes du *Mont Saint-Michel*	Mesure I 11 oct. 20006	Mesure II 8 nov. 2006	Différence II vs I	Mesure III 13 déc. 2006	Différence III vs I	Mesure IV 29 mar. 2007	Différence IV vs I	Moyennes II+III	Moyennes II à IV	Différences vs I II+III	Différences vs I II à IV
Température (°C)	306.00	300.00	-1.96%	267.00	-12.75%	303.00	-0.98%	283.50	290.00	-7.35%	-5.23%
Durée des essais (mn)	30.00	30.00		30.00		30.00		30.00	30.00		
Débit moyen en m3/h sur humide	23475.00	23476.00	0.00%	23146.00	-1.40%	22421.00	-4.49%	23311.00	23014.33	-0.70%	-1.96%
Puissance délivrée MP3 + MP4 en kWh/m*	8427.00	8268.00	-1.89%	8140.00	-3.41%	8549.00	1.45%	8204.00	8319.00	-2.65%	-1.28%
Tours par minute	499.00	500.00	0.20%	498.00	-0.20%	498.00	-0.20%	499.00	498.67	0.00%	-0.07%
Régime moteur	94.20%	92.40%	-1.91%	90.70%	-3.72%	90.70%	-3.72%	91.55%	91.27%	-2.81%	-3.11%
Oxygène moyen (O2) en %, sur sec	12.57	14.00	11.41%	14.70	16.98%	12.60	0.27%	14.35	13.77	14.19%	9.55%
Dioxyde de carbone (CO2) en %, sur sec	6.10	5.60	-8.20%	4.67	-23.50%	5.80	-4.92%	5.13	5.36	-15.85%	-12.20%
Poussières											
Au filtre (mg/m3, sur sec)	77.20	51.10	-33.81%	53.33	-30.92%	48.83	-36.74%	52.22	51.09	-32.36%	-33.82%
Au rinçage (mg/m3, sur sec)	44.50	10.50	-76.40%	10.37	-76.70%	11.40	-74.38%	10.43	10.76	-76.55%	-75.83%
Totales (mg/m3, sur sec)	121.70	61.60	-49.38%	63.70	-47.66%	60.23	-50.51%	62.65	61.84	-48.52%	-49.18%
Monoxyde de carbone (CO)											
Concentration (ppmv, sur sec)	78.73	55.73	-29.21%	44.93	-42.93%	53.53	-32.01%	50.33	51.40	-36.07%	-34.72%
Concentration (mg/m3, sur sec)	98.43	69.67	-29.22%	56.20	-42.91%	66.90	-32.04%	62.93	64.26	-36.07%	-34.72%
Oxydes d'azote (Nox)											
Concentration NO (ppmv, sur sec)	1093.67	1073.00	-1.89%	825.67	-24.50%	1148.67	5.03%	949.33	1015.78	-13.20%	-7.12%
Concentration NO (mg/m³, sur sec)	1464.67	1437.00	-1.89%	1106.00	-24.49%	1538.00	5.01%	1271.50	1360.33	-13.19%	-7.12%
Concentration Nox (ppmv, sur sec)	1124.67	1119.67	-0.44%	850.67	-24.36%	1173.67	4.36%	985.17	1048.00	-12.40%	-6.82%
Concentration Nox (mg/m³, sur sec)	2310.33	2300.00	-0.45%	1746.67	-24.40%	2410.33	4.33%	2023.33	2152.33	-12.42%	-6.84%
Composés organiques volatiles totaux (COVT)											
Concentration en CH4 (ppmv, sur humide)	<9	<9		<9		<9					
Concentration en CH4 (mg/m3, sur humide)	<5	<5		<5		<5					
Concentration en COV (ppmv, sur humide)	76.87	71.33	-7.20%	59.70	-22.33%	59.70	-22.33%	65.52	63.58	-14.77%	-17.29%
Concentration en COV (mg/m3, sur humide)	41.17	38.23	-7.13%	24.40	-40.73%	34.67	-15.79%	31.32	32.43	-23.93%	-21.21%

Analyse des données du *Mont Saint-Michel* pondérées sur la puissance délivrée	Mesure I 11 oct. 20006	Mesure II 8 nov. 2006	Différence II vs I	Mesure III 13 déc. 2006	Différence III vs I	Mesure IV 29 mar. 2007	Différence IV vs I	Moyennes II+III	Moyennes II à IV	Différences vs I II+III	Différences vs I II à IV
Température (°C)	306.00	300.00	-1.96%	267.00	-12.75%	303.00	-0.98%	283.50	290.00	-7.35%	-5.23%
Durée des essais (mn)	30.00	30.00		30.00		30.00		30.00	30.00		
Débit moyen en m3/h sur humide	23475.00	23476.00	0.00%	23146.00	-1.40%	22421.00	-4.49%	23311.00	23014.33	-0.70%	-1.96%
Puissance délivrée MP3 + MP4 en kWh/m*	8427.00	8268.00	-1.89%	8140.00	-3.41%	8549.00	1.45%	8204.00	8319.00	-2.65%	-1.28%
Tours par minute	499.00	500.00	0.20%	498.00	-0.20%	498.00	-0.20%	499.00	498.67	0.00%	-0.07%
Régime moteur	94.20%	92.40%	-1.91%	90.70%	-3.72%	90.70%	-3.72%	91.55%	91.27%	-2.81%	-3.11%
Oxygène moyen (O2) en %, sur sec	12.57	14.27	13.55%	15.22	21.10%	12.42	-1.17%	14.74	13.97	17.32%	11.16%
Dioxyde de carbone (CO2) en %, sur sec	6.10	5.71	-6.43%	4.83	-20.80%	5.72	-6.27%	5.27	5.42	-13.62%	-11.17%
Poussières											
Au filtre (mg/m3, sur sec)	77.20	52.08	-32.54%	55.21	-28.48%	48.14	-37.65%	53.65	51.81	-30.51%	-32.89%
Au rinçage (mg/m3, sur sec)	44.50	10.70	-75.95%	10.73	-75.88%	11.24	-74.75%	10.72	10.89	-75.92%	-75.53%
Totales (mg/m3, sur sec)	121.70	62.78	-48.41%	65.95	-45.81%	59.37	-51.21%	64.37	62.70	-47.11%	-48.48%
Monoxyde de carbone (CO)											
Concentration (ppmv, sur sec)	78.73	56.81	-27.85%	46.52	-40.92%	52.77	-32.98%	51.66	52.03	-34.38%	-33.92%
Concentration (mg/m3, sur sec)	98.43	71.01	-27.86%	58.18	-40.89%	65.95	-33.01%	64.59	65.04	-34.38%	-33.92%
Oxydes d'azote (Nox)											
Concentration NO (ppmv, sur sec)	1093.67	1093.63	0.00%	854.78	-21.84%	1132.27	3.53%	974.21	1026.90	-10.92%	-6.11%
Concentration NO (mg/m³, sur sec)	1464.67	1464.63	0.00%	1145.00	-21.83%	1516.05	3.51%	1304.81	1375.23	-10.91%	-6.11%
Concentration Nox (ppmv, sur sec)	1124.67	1141.20	1.47%	880.66	-21.70%	1156.92	2.87%	1010.93	1059.59	-10.11%	-5.79%
Concentration Nox (mg/m³, sur sec)	2310.33	2344.23	1.47%	1808.25	-21.73%	2375.94	2.84%	2076.24	2176.14	-10.13%	-5.81%
Composés organiques volatiles totaux (COVT)											
Concentration en CH4 (ppmv, sur humide)	<9	<9		<9		<9					
Concentration en CH4 (mg/m3, sur humide)	<5	<5		<5		<5					
Concentration en COV (ppmv, sur humide)	76.87	72.71	-5.41%	61.80	-19.59%	58.85	-23.44%	67.26	64.45	-12.50%	-16.15%
Concentration en COV (mg/m3, sur humide)	41.17	38.97	-5.34%	25.26	-38.64%	34.17	-16.99%	32.11	32.80	-21.99%	-20.32%

Les données des mesures II, III et IV sont pondérées sur la puissance délivrée par les moteurs principaux 3 et 4 lors de la mesure I :
Donnée gaz / puissance de la mesure x 8 427 kWh

Analyse des données pondérées du *Mont Saint-Michel* ramenées sur 1 m³ de gaz émis	Mesure I 11 oct. 20006	Mesure II 8 nov. 2006	Différence II vs I	Mesure III 13 déc. 2006	Différence III vs I	Mesure IV 29 mar. 2007	Différence IV vs I	Moyennes II+III	Moyennes II à IV	Différences vs I II+III	Différences vs I II à IV
Température (°C)	306.00	300.00	-1.96%	267.00	-12.75%	303.00	-0.98%	283.50	290.00	-7.35%	-5.23%
Durée des essais (mn)	30.00	30.00		30.00		30.00		30.00	30.00		
Débit moyen en m³/h sur humide	23475.00	23476.00	0.00%	23146.00	-1.40%	22421.00	-4.49%	23311.00	23014.33	-0.70%	-1.96%
Puissance délivrée MP3 + MP4 en kWh/m*	8427.00	8268.00	-1.89%	8140.00	-3.41%	8549.00	1.45%	8204.00	8319.00	-2.65%	-1.28%
Tours par minute	499.00	500.00	0.20%	498.00	-0.20%	498.00	-0.20%	499.00	498.67	0.00%	-0.07%
Régime moteur	94.20%	92.40%	-1.91%	90.70%	-3.72%	90.70%	-3.72%	91.55%	91.27%	-2.81%	-3.11%
Oxygène moyen (O_2) en %, sur sec	12.57	14.27	13.54%	15.43	22.82%	13.00	3.48%	14.85	14.24	18.18%	13.28%
Dioxyde de carbone (CO_2) en %, sur sec	6.10	5.71	-6.44%	4.90	-19.67%	5.99	-1.87%	5.30	5.53	-13.05%	-9.33%
Poussières											
Au filtre (mg/m³, sur sec)	77.20	52.08	-32.54%	56.00	-27.46%	50.40	-34.72%	54.04	52.83	-30.00%	-31.57%
Au rinçage (mg/m³, sur sec)	44.50	10.70	-75.95%	10.88	-75.54%	11.77	-73.56%	10.79	11.12	-75.75%	-75.02%
Totales (mg/m³, sur sec)	121.70	62.78	-48.41%	66.88	-45.04%	62.16	-48.92%	64.83	63.94	-46.73%	-47.46%
Monoxyde de carbone (CO)											
Concentration CO (ppmv, sur sec)	78.73	56.80	-27.85%	47.18	-40.08%	55.25	-29.83%	51.99	53.08	-33.97%	-32.59%
Concentration CO (mg/m³, sur sec)	98.43	71.00	-27.87%	59.01	-40.05%	69.05	-29.86%	65.01	66.35	-33.96%	-32.59%
Oxydes d'azote (Nox)											
Concentration NO (ppmv, sur sec)	1093.67	1093.59	-0.01%	866.93	-20.73%	1185.50	8.40%	980.26	1048.67	-10.37%	-4.11%
Concentration NO (mg/m³, sur sec)	1464.67	1464.57	-0.01%	1161.27	-20.71%	1587.32	8.37%	1312.92	1404.39	-10.36%	-4.12%
Concentration Nox (ppmv, sur sec)	1124.67	1141.15	1.47%	893.18	-20.58%	1211.30	7.70%	1017.16	1081.88	-9.56%	-3.80%
Concentration Nox (mg/m³, sur sec)	2310.33	2344.13	1.46%	1833.95	-20.62%	2487.63	7.67%	2089.04	2221.90	-9.58%	-3.83%
Composés organiques volatiles totaux (COVT)											
Concentration en CH4 (ppmv, sur humide)	<9	<9		<9		<9					
Concentration en CH4 (mg/m³, sur humide)	<5	<5		<5		<5					
Concentration en COV (ppmv, sur humide)	76.87	72.70	-5.42%	62.68	-18.45%	61.61	-19.84%	67.69	65.67	-11.93%	-14.57%
Concentration en COV (mg/m³, sur humide)	41.17	38.97	-5.34%	25.62	-37.77%	35.78	-13.09%	32.29	33.45	-21.56%	-18.73%

Les données des mesures II, III et IV sont pondérées sur la puissance délivrée par les moteurs principaux 3 et 4 lors de la mesure I :
Donnée gaz / puissance de la mesure x 8 427 kWh

Puis, elles sont ramenées à une valeur au m³ :
Donnée gaz / débit moyen en m³/h x 23 475 m³

XBEE
ENZYME FUEL TECHNOLOGY

8, am Wapp
3841 Schifflange
Luxembourg

customerservice@xbee.com
+352 691 668900

www.XBEE.com