



The marine transport company **Navigasa** operates three cargo vessels: *M/V Mandeo* and the sisterships *M/V Finita R* and *M/V Manuela E* running on IFO 180.

After having used the chemical additive Aderco during four years, the company decided to evaluate the XBEE Enzyme Fuel Technology on board *M/V Finita R*.

In order to ensure a precise and reliable follow up of the experiment, the following operations have been carried out:

- September 2011 -> ship main engine emissions (Wärtsilä 6L32) have been measured before the use of the XBEE technology in the fuel.
- February 2013 -> main engine emissions have been measured again after 1,680 running hours with a fuel improved by the XBEE enzymes.
- November 2013 -> ship overhaul after a total of 21,268 running hours of the main engine.
- November 2015 -> ship main engine emissions have been measured for the third time after 27,992 running hours.



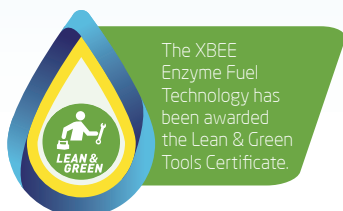
About Navigasa
 Navigasa fleet is composed of 3 units:

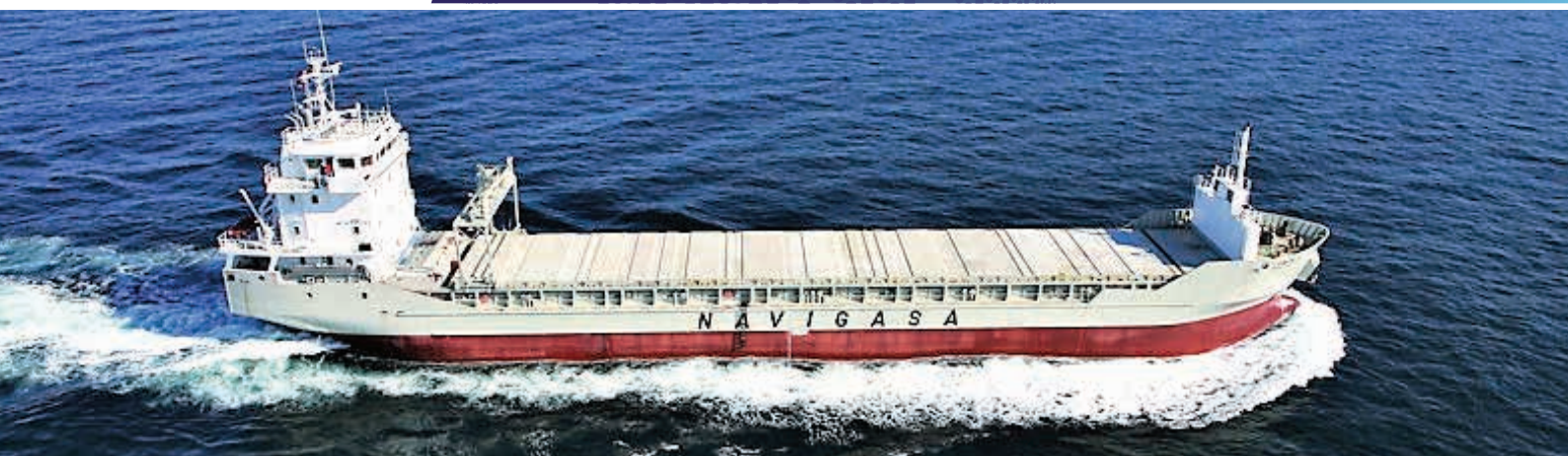
- M/V Mandeo;
- M/V Manuela E;
- M/V Finita R.



Both greenhouse gas emissions have been measured and controlled by the accredited laboratory Dekra.

Parameters	09/20/11	02/28/13	Difference
Temperature (C°)	296.00	253.90	-14.22%
Humidity (%)	4.80	4.10	-14.58%
Flow (Nm ³ /h) dry gas	15.02	15.50	3.18%
Gas emissions	09/20/11	02/28/13	Difference
O ₂ (%)	13.00	15.20	16.92%
CO ₂ (%)	6.50	5.60	-13.85%
CO (ppmv)	62.00	54.00	-12.90%
CO (kg/h)	1.20	1.05	-12.50%
NOx (mg/Nm ³ eq. NO ₂)	1,866.00	814.00	-56.38%
NOx (kg/h)	28.00	12.61	-54.96%
SO ₂ (mg/Nm ³)	1,984.00	702.00	-64.62%
SO ₂ (kg/h)	29.80	10.88	-63.49%





Further measurements by Coterena

About Coterena

COTERENA is a company specializing in repair, installation, commissioning, service and supply of spare parts for the marine and industrial sector.



COTERENA

With over 25 years of experience, the company has established the quality of its own brand through an integrated repair and mechanical maintenance, technical and energy optimization service as well as a conscious commitment to develop new techniques and focused technologies offering intelligent and innovative solutions to its customers.

Measurements have clearly demonstrated that in both instances vessels have substantially reduced emissions when using XBEE: after six months (1,680 hours) and after three years (10,930 hours).

Furthermore in November 2015, after 28,000 running hours, ship main engine emissions levels are lower than those established by Wärtsilä protocol as far as CO and CO₂ are concerned (at 25, 50 and 75% engine loads) and almost the same for NO_x: 10.74 g/kWh compared with 10.60 g/kWh according to manufacturer's protocol.

Also, main engine specific fuel oil consumption has been reduced thanks to the use of XBEE, in comparison with manufacturer's test bench data:

Power	Test bench data	November 2015 measurements	Evolution %
25%	230.68 g/kWh	200.50 g/kWh	-13.08%
50%	198.91 g/kWh	193.90 g/kWh	-2.52%
75%	190.71 g/kWh	186.90 g/kWh	-2.00%

Ship overhaul carried out in November 2013 after 4,500 hours running on IFO 1810 improved with the XBEE Enzyme Fuel Technology has showed that tanks and engine were in optimal cleanliness and maintenance conditions (see photos next page).

***Pictures of the engine – Wärtsilä 6L32 – 2,760 kW
21,268 running hours on November 29, 2013 (last 5,000 with XBEE fuel).***



***Pictures of the engine – Wärtsilä 6L32 – 2,760 kW
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21,268 running hours on November 29, 2013 (last 5,000 with XBEE fuel).***



REPORTS:
REGISTRY OF EMISSIONS
SAILING

TEST REPORT
Nº 15E025

SHIP
“FINITA R”



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- **SISTEMAS DE PROPULSION INTEGRALES**
- **MAQUINARIA AUXILIAR CÁMARA DE MÁQUINAS**
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- **VERIFICACIÓN DE NOx MARPOL.**

COMPANY

“NAVIGASA”



COTERENA



INSTALACIÓN Y
REPARACIÓN
MECÁNICA

REGISTRY OF EMISSIONS SAILING

TEST NUMBER 15E025

TEST ESPECIFICATIONS

Applicant: NAVIGASA.

Object: Registration of gaseous emissions during navigation.

Installation:

Vessel:	FINITA R
IMO:	9400162
Type:	Gearless Container / Multipurpose
Loa:	99,8 m
Beam:	14,0 m
Tonnage:	3.778 GT
Main Engine (1):	2760 kW
Model:	W6L32

AIM

The aim of the present report is verify the gaseous emissions of vessel "FINITA R" while navigation between Marín Port to Avilés Port in Spain. Test dates are 17 and 18 November 2015.

The parameters of propulsion system were also registered during the test.

PROCEDURE

The following parameters were registered online during the sailing

- Torque by means of strain gages installed on tail shaft.
- Shaft speed by means of optical tachometers and simultaneous recording on tail shaft.
- Register of charge air pressure and temperature.
- Register of position and speed signals of ship by means of a GPS receiver installed in the main deck
- Register of gaseous emissions through combustion analyzer.

Torque signal was measures in the tail shaft, by deformation of one strain gage, recording this information through one torsionmeter.

The speed of tail shaft was measured with one optical tachometer on line.

The ship speed and route was recorded through an external GPS.

Load and pitch signals were form Berg central unit.

All these signals were collected through a portable Ethernet net installed on board into a computer where was monitored the sailing and registered the data sheets included in this report.

MEASUREMENT EQUIPMENT

The measurements were registered with the following equipment:

- **Register of torque by telemetry**

- TAIL SHAFT**

- Emitter**

- Model: KTR

- Man N°: 18

- Receiver**

- Model: KTR

- Man N°: 18

- Strain gage**

- Manufacturer: VISHAY

- Model: CEA-06-250-US-350

- Lot n°: A86AD881

- Gage factor 2,11 ±1,0%

- **Tachometer online**

- TAIL SHAFT**

- Model: RS 1501

- Serial number: 08140773 / TA-04-L

- **GPS**

- MAIN DECK**

- Model: 18X PC

- Serial number: 19N021755

- **Charge air pressure**

- INTAKE MANIFOLD**

- Model: MBS 3000

- Sensor: P6

- **Charge air temperature**

- INTAKE MANIFOLD**

- Model: MBT 5250

- Sensor: T02

PROPULSION DESCRIPTION

MAIN ENGINE (1)

Manufacturer: WÄRTSILÄ
Model: W6L32
Serial Number: PAAE050205
Nominal Power: 2760 kW
Nominal Speed: 750 1/min

GEARBOX (1)

Manufacturer: REINTJES
Model: LAF 4545
Serial number: 70913
Transmission ratio: 1:4,429
Losses: 2,5% (estimated)

VARIABLE PITCH PROPELLER (1)

Manufacturer: BERG
Model: BCP 850
Type: HDX-500
Serial number: 5354

TAIL SHAFT CHARACTERISTICS IN THE TESTED AREA

External diameter: $\varnothing$ 260,00 mm
Internal diameter: $\varnothing$ 72,00 mm
Shaft Material: Steel
Shear modulus: 80192,3 N/mm² (estimated)

SHIP CONDITIONS

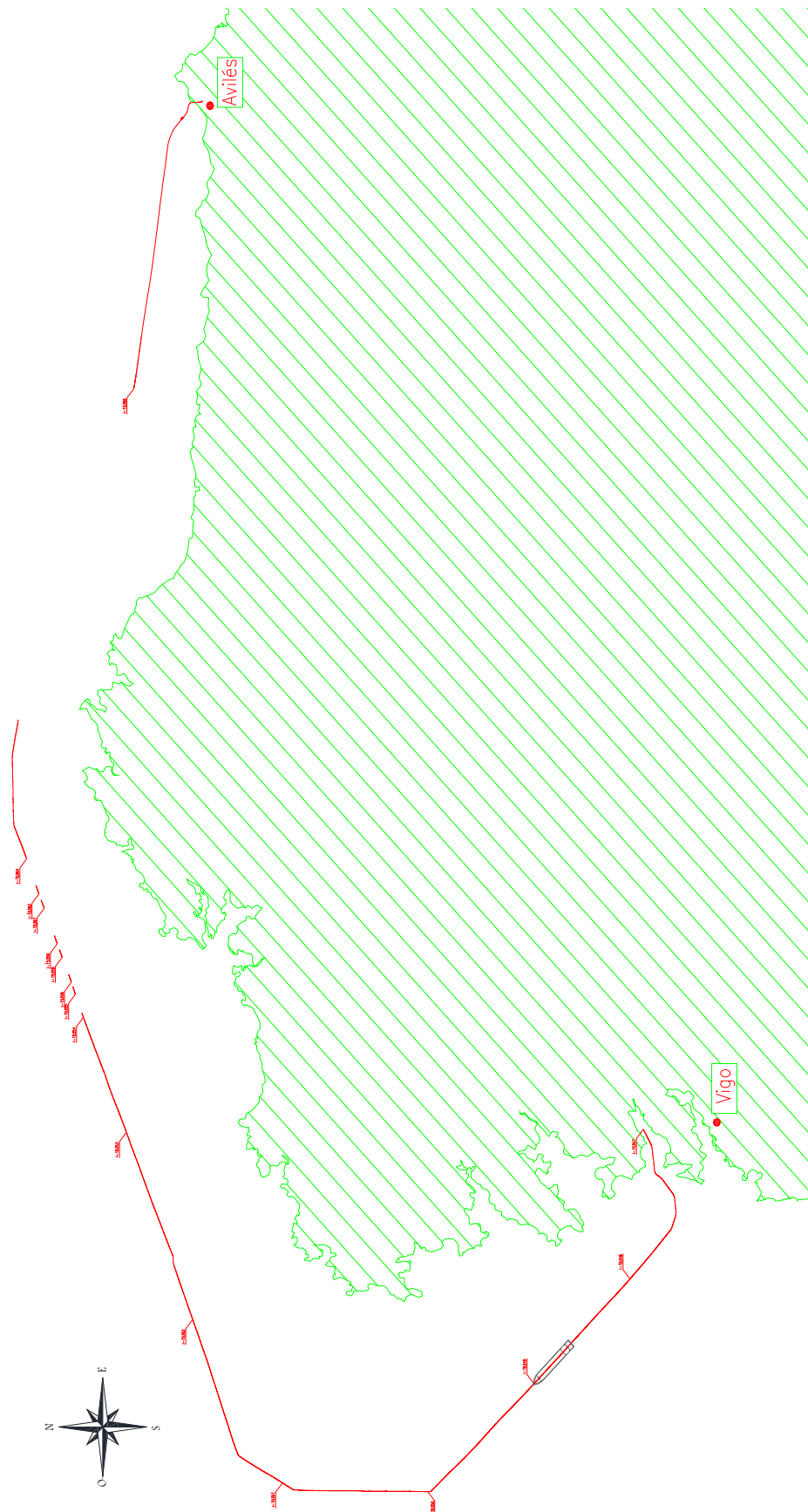
Loa: 99,8 m
Breadth: 14,0 m
Tonnage: 3.778 GT.
Forward draft: 3,40 m
Stern draft: 4,20 m

ENGINE HISTORICAL MAINTENANCE

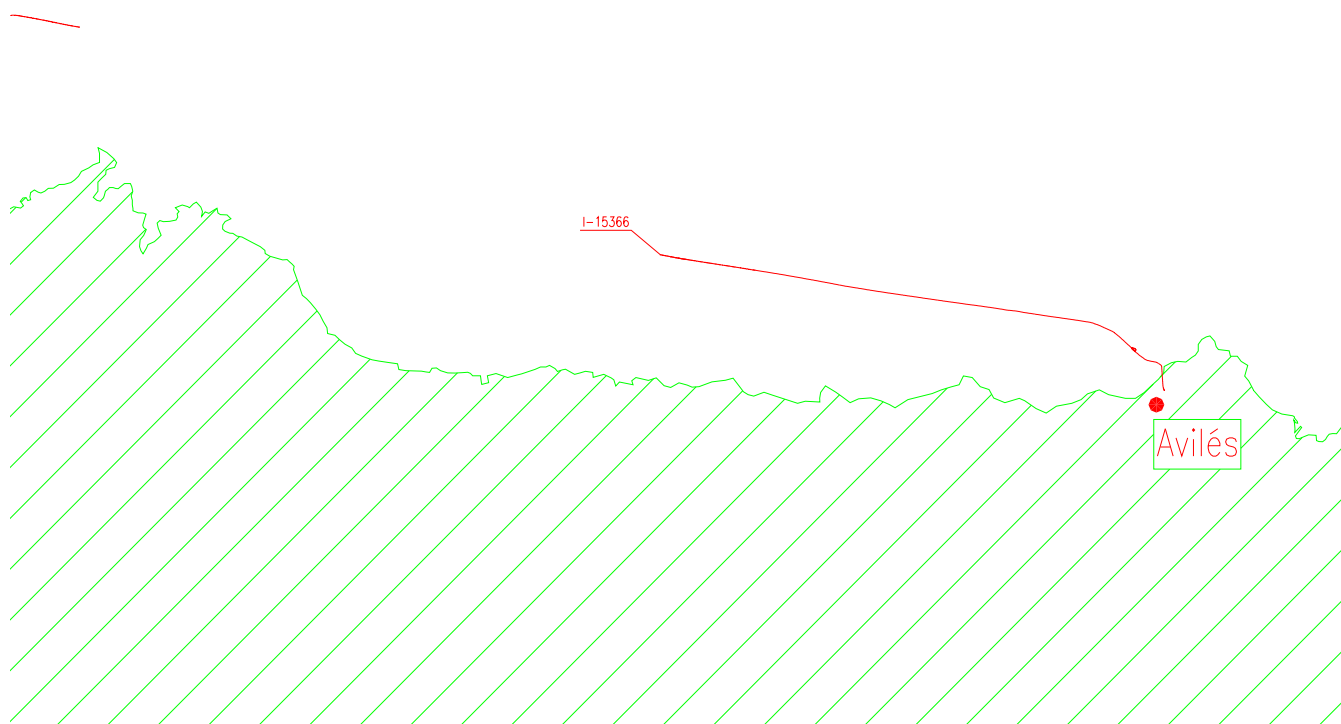
Number hours engine operation: 27.992 h (17/11/2015)
Change Injectors with 18.320 h (26/02/2013)
Change Injectors with 21.268 h (10/12/2013)
Turbo-charger reconditioning: 27.402 h (25/09/2015)
Cylinder head reconditioning: 21.268 h (December 2013)
Injectors hours: 6.724 h (26/11/2015)



NAVIGATION ROUTE







REPORTS RELATION

Records of gaseous emissions are made in different percentages of engine load.

Below are attached the records obtained in the measurements:

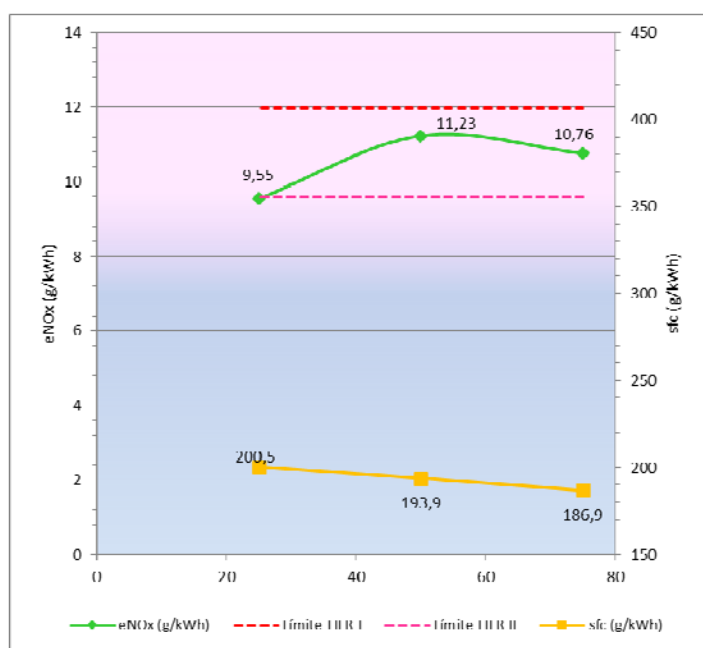
ENGINE POWER (kW)	424,26	609,01	699,23	717,43	1477,84	1646,81
ENGINE SPEED (rpm)	754,4	755,79	757,5	757	754,7	753,9
SFC (g/kWh)	202	201	200,5	200,3	193,9	191,9
O2D (%)	14,8	13,73	14,08	13,99	13,1	12,98
CO2D (%)	4,57	5,47	5,17	5,14	5,85	6,04
COD (ppm)	149	152	142	141	94	83
NOXD (ppm)	553	790	746	727	1032	1036
SO2D (ppm)	475	534	530	512	591	569
GNOx (kg/h)	3,443	5,591	6,390	6,282	15,586	16,700
GCO (kg/h)	0,557	0,678	0,768	0,787	0,920	0,868
GCO2 (kg/h)	268,429	383,504	439,249	450,380	899,125	991,870
GO2 (kg/h)	632,069	700,612	869,787	891,299	1463,948	1549,824
GSO2 (kg/h)	4,061	5,458	6,554	6,530	13,221	13,600
eNOx (g/kWh)	8,116	9,181	9,138	8,756	10,546	10,141
eCO (g/kWh)	1,314	1,112	1,099	1,097	0,623	0,527
eCO2 (g/kWh)	632,698	629,721	628,190	627,768	608,405	602,298
eO2 (g/kWh)	1489,814	1150,417	1243,921	1242,350	990,600	941,106
eSO2 (g/kWh)	9,572	8,962	9,373	9,102	8,946	8,259

ENGINE POWER (kW)	1848,22	1941,15	2107,14	2261,74	2587,02
ENGINE SPEED (rpm)	753,2	752,4	752,2	752	751,6
SFC (g/kWh)	189,4	188,3	186,9	186,8	188,1
O2D (%)	12,84	12,86	12,79	12,69	12,55
CO2D (%)	6,11	6,05	6,2	6,17	6,34
COD (ppm)	78	106	69	65	72
NOXD (ppm)	1087	1078	1087	1131	1115
SO2D (ppm)	593	585	578	607	603
GNOx (kg/h)	19,152	20,509	21,239	23,741	26,130
GCO (kg/h)	0,893	1,279	0,876	0,890	1,105
GCO2 (kg/h)	1098,785	1146,347	1236,312	1326,472	1527,881
GO2 (kg/h)	1678,907	1771,705	1854,373	1983,648	2199,044
GSO2 (kg/h)	15,522	16,134	16,776	18,994	21,151
eNOx (g/kWh)	10,362	10,565	10,079	10,497	10,101
eCO (g/kWh)	0,483	0,659	0,416	0,393	0,427
eCO2 (g/kWh)	594,510	590,550	586,725	586,483	590,595
eO2 (g/kWh)	908,391	912,709	880,043	877,045	850,030
eSO2 (g/kWh)	8,398	8,311	7,961	8,398	8,176

The next table is obtained with previous records. This table is the calculation of weighting eNOx.

Speed (%)	100	100	100	100
Power (%)	100	75	50	25
Factor weighting		0,63	0,19	0,19
Speed (rpm)		752,2	754,7	757,5
Speed (%)		100,3	100,6	101,0
Power (kW)		2107,1	1477,8	699,2
Power (%)		76,3	53,5	25,3
sfc (g/kWh)		186,9	193,9	200,5
GFUEL (kg/h)		393,8	286,6	140,2
NOxd (ppm)		1087,0	1032,0	746,0
GNOx (g/h)		22669,0	16602,2	6674,4
eNOx (g/kWh)		10,76	11,23	9,55

eNOx Weighting (g/kWh) 10,74



To determine the NOx emissions on board it must be followed the procedure of chapter 6 *procedures for NOx emission measurements on board, MARPOL Annex VI Technical Code*. Test cycle type E2 for controllable-pitch propeller.

The following points are considered to do a comparative analysis with previous given registers:

- The equipment with the previous measurements were performed is different from that is used in this measurement. The measurement process of previous equipment is by chemiluminescence (for NO_x emissions), and the current test is by measuring electrochemical cells.
- The results of previous studies lack information about the power, pitch percentage or specific consumption so the comparative analysis is made in the vessel's usual navigation.
- Concentrations provided in the present study are in dry concentration. Dry concentration is higher than the same concentration but in wet basis because water vapor is subtracted.
- For the calculation of mass gaseous emission, the specific consumption and the power developed are used.

The usual sailing recorded during the sea-crossing between Marín and Avilés is around 65% of power, according to measurement; this is the power that matches with economic speed vessel (graph page 16). Below the comparative between previous records and current ones is shown:

	20/09/2011	28/02/2013		18/11/2015
ENGINE POWER (kW)			ENGINE POWER (kW)	1848,22
ENGINE SPEED (rpm)			ENGINE SPEED (rpm)	753,2
SFC (g/kWh)			SFC (g/kWh)	189,4
O ₂ (%)	13	15,2	O ₂ D (%)	12,84
CO ₂ (%)	6,5	5,6	CO ₂ D (%)	6,11
CO (ppmv)	62	54	COD (ppm)	78
NO _x (ppm)	909	368	NO _x D (ppm)	1087
SO ₂ (ppm)	694	222	SO ₂ D (ppm)	593
GNO _x (kg/h)	28,00	12,61	GNO _x (kg/h)	19,152
GCO (kg/h)	1,20	1,05	GCO (kg/h)	0,893
GCO ₂ (kg/h)			GCO ₂ (kg/h)	1098,785
GO ₂ (kg/h)			GO ₂ (kg/h)	1678,907
GSO ₂ (kg/h)	29,80	10,88	GSO ₂ (kg/h)	15,522
eNO _x (g/kWh)			eNO _x (g/kWh)	10,362
eCO (g/kWh)			eCO (g/kWh)	0,483
eCO ₂ (g/kWh)			eCO ₂ (g/kWh)	594,510
eO ₂ (g/kWh)			eO ₂ (g/kWh)	908,391
eSO ₂ (g/kWh)			eSO ₂ (g/kWh)	8,398

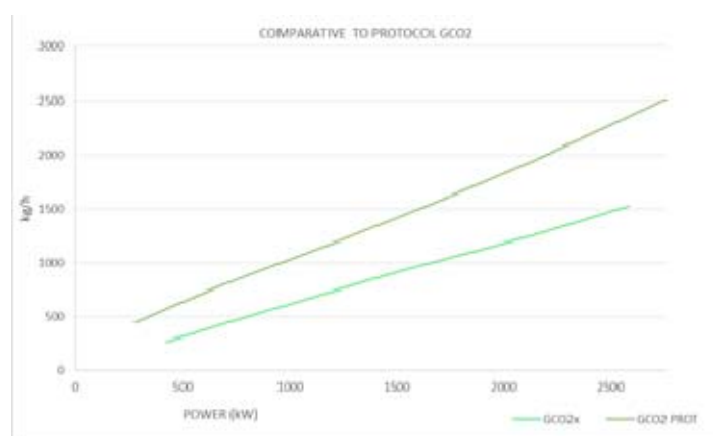
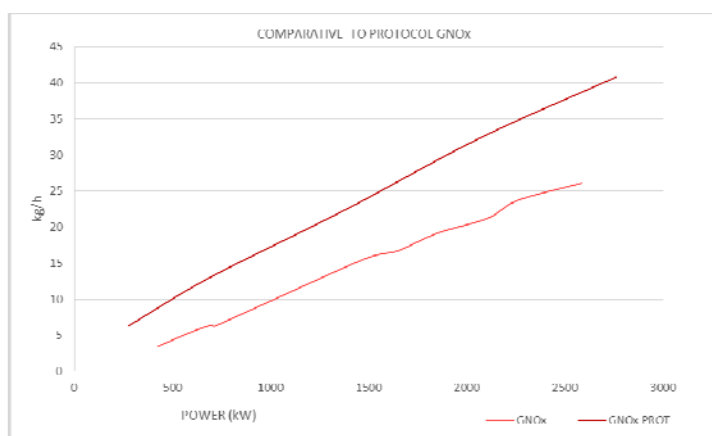
In relation to registered values in 2011 a decrease in mass emissions values is shown. Regarding register in 2013 it supposes that register has been carried out in low load parameters due to very low NOx concentrations, so it is not considered a reference measurement.

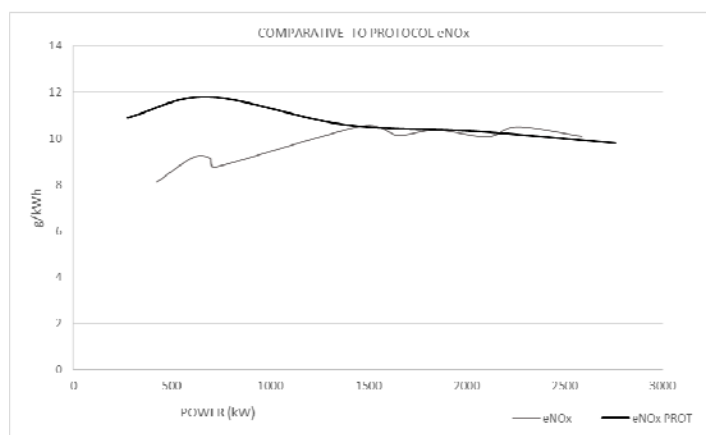
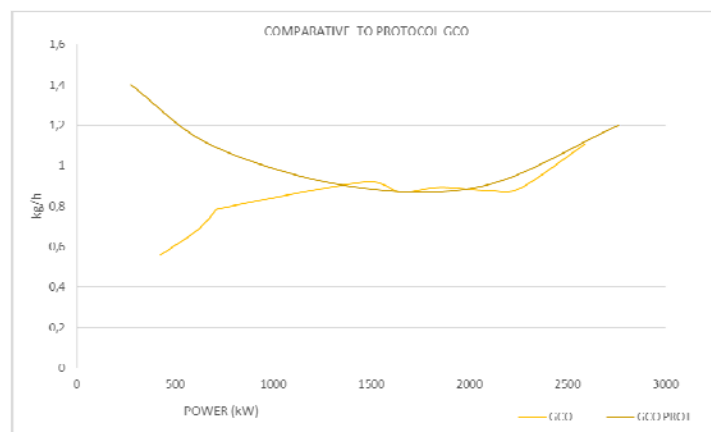
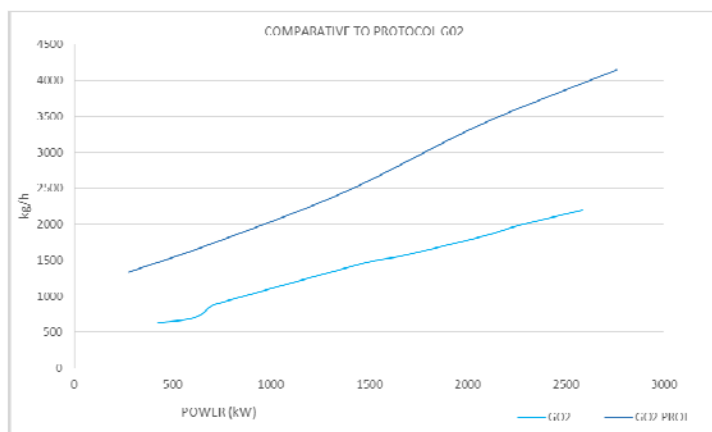
	REGISTERED VALUES			COMPARATIVE	
	20/09/2011	28/02/2013	18/11/2015	2011 - 2015	2013 - 2015
GNOx (kg/h)	28,00	12,61	19,152	-31,60%	51,88%
GCO (kg/h)	1,20	1,05	0,893	-25,57%	-14,93%
GCO2 (kg/h)			1098,785		
GO2 (kg/h)			1678,907		
GSO2 (kg/h)	29,80	10,88	15,522	-47,91%	42,67%

Below are the comparisons between the test values by Factory emission and the data recorded in the current test in navigation.

	25%			50%			75%		
	PROTOCOL	MEASURED	DIFFERENCE	PROTOCOL	MEASURED	DIFFERENCE	PROTOCOL	MEASURED	DIFFERENCE
ENGINE POWER (kW)	690			1380			2070		
ENGINE SPEED (rpm)	749,9			749,9			750		
SFC (g/kWh)	230,68			198,91			190,71		
GNOx (kg/h)	13,0	6,50	-50,0%	22,4	14,40	-35,7%	32,4	21,00	-35,2%
GCO (kg/h)	1,1	0,77	-30,0%	0,9	0,90	0,0%	0,9	0,88	-2,2%
GCO2 (kg/h)	795,0	430,00	-45,9%	1319,1	840,00	-36,3%	1885,0	1220,00	-35,3%
GO2 (kg/h)	1722,7	850,00	-50,7%	2454,3	1390,00	-43,4%	3389,3	1820,00	-46,3%
eNOx (g/kWh)	11,8			10,6			10,3		

The next comparative graphs are of the gaseous emissions





In the course of the sea-crossing sailing registrations are made in free running speed with readings of main engine power which is already included the tail shaft power, temperature and charge air pressure, pitch percentage, charge and speed developed by the vessel.

Below tables are the mean, maximum and minimum values of the records:

TEST: I-15.347

Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T ^a CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2111,00	76,50	772,20	103,00	2058,20	174,40	51,00	1,75	84,43	32,97	13,14
MEAN	1745,82	63,25	755,46	100,73	1647,03	170,57	50,42	1,33	73,24	27,04	10,92
MIN	1261,50	45,70	741,40	98,90	1121,10	167,40	49,36	0,77	64,15	14,55	7,87

TEST: I-15.348

Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T ^a CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2007,90	72,70	775,40	103,40	1848,80	175,10	50,63	1,58	76,03	31,83	13,20
MEAN	1459,04	52,86	755,94	100,79	1313,65	170,68	49,87	1,00	64,67	24,05	9,72
MIN	987,70	35,80	738,00	98,40	854,10	166,60	49,31	0,59	58,90	12,77	6,90

TEST: I-15.349
Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	1828,80	66,30	772,20	103,00	1674,20	174,40	50,17	1,40	69,58	29,86	12,18
MEAN	1435,08	52,00	754,77	100,63	1290,29	170,41	49,96	0,93	64,36	23,55	9,75
MIN	1008,80	36,50	733,20	97,80	874,60	165,50	49,62	0,56	59,47	11,33	7,12

TEST: I-15.350
Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2170,60	78,60	766,70	102,20	2007,40	173,10	51,07	1,71	78,22	34,95	13,85
MEAN	1770,46	64,15	752,50	100,33	1617,29	169,90	50,54	1,28	71,98	27,16	11,77
MIN	1265,60	45,90	738,80	98,50	1125,00	166,80	49,62	0,76	60,81	19,41	9,06

TEST: I-15.351
Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2147,60	77,80	764,50	101,90	1985,00	172,60	51,13	1,73	76,37	33,32	13,81
MEAN	1863,68	67,52	751,91	100,25	1708,18	169,77	50,98	1,38	75,82	28,18	12,32
MIN	1519,00	55,00	739,00	98,50	1372,10	166,90	50,87	1,04	70,84	20,89	10,61

TEST: I-15.352
Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2153,80	78,00	765,90	102,10	1991,00	172,90	51,13	1,74	76,37	35,29	13,55
MEAN	1859,18	67,36	752,39	100,32	1703,79	169,88	50,99	1,38	75,48	28,21	12,28
MIN	1550,20	56,20	737,20	98,30	1402,50	166,40	50,82	1,05	68,99	20,44	10,67

TEST: I-15.353
Test description: SAILING

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2157,40	78,20	765,30	102,00	1994,50	172,80	51,26	1,74	76,37	34,12	13,42
MEAN	1742,20	63,12	752,82	100,37	1589,73	169,98	51,05	0,55	68,86	26,90	11,98
MIN	651,40	23,60	741,40	98,90	526,20	167,40	50,30	0,00	29,66	12,83	6,22

TEST: I-15.354
Test description: 25% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	794,10	28,80	764,50	101,90	665,40	172,60	50,30	0,32	30,04	16,95	8,23
MEAN	737,93	26,74	757,33	100,97	610,57	170,99	50,14	0,30	29,96	16,02	7,06
MIN	661,60	24,00	748,30	99,80	536,20	169,00	49,96	0,26	29,62	13,04	5,94

TEST: I-15.355
Test description: 50% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	1604,90	58,10	763,70	101,80	1461,00	172,40	49,70	1,13	64,09	27,88	11,98
MEAN	1494,00	54,13	754,68	100,62	1358,97	170,40	49,63	1,02	64,02	24,67	11,72
MIN	1311,80	47,50	745,70	99,40	1175,30	168,40	49,57	0,83	63,85	21,45	11,41


TEST: I-15.356
Test description: 60% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	1789,30	64,80	764,30	101,90	1661,60	172,60	50,04	1,34	68,35	29,27	12,48
MEAN	1640,14	59,43	754,31	100,57	1516,15	170,31	49,95	1,17	68,32	26,19	12,07
MIN	1461,40	52,90	748,10	99,70	1341,90	168,90	49,83	0,96	68,14	22,14	11,68

TEST: I-15.357
Test description: COMPLETE

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	1789,30	64,80	764,30	101,90	1661,60	172,60	50,04	1,34	68,38	29,27	12,48
MEAN	1556,97	56,41	754,45	100,59	1427,00	170,34	49,76	1,08	66,07	25,32	11,83
MIN	1271,90	46,10	745,70	99,40	1136,40	168,40	49,57	0,81	63,72	20,89	4,71

TEST: I-15.358
Test description: 68% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	1971,30	71,40	763,20	101,80	1839,00	172,30	50,58	1,54	73,51	31,72	12,89
MEAN	1787,36	64,76	753,70	100,49	1659,70	170,17	50,52	1,33	73,48	27,68	12,54
MIN	1537,40	55,70	743,80	99,20	1416,00	167,90	50,45	1,07	71,83	23,79	12,19

TEST: I-15.359
Test description: 75% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2310,90	83,70	764,50	101,90	2170,10	172,60	51,07	1,93	79,65	36,69	13,37
MEAN	2037,73	73,83	752,79	100,37	1903,81	169,97	50,92	1,63	79,58	30,61	12,91
MIN	1723,30	62,40	745,40	99,40	1597,30	168,30	50,76	1,27	79,16	25,73	12,54

TEST: I-15.361
Test description: 80% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2418,80	87,60	765,10	102,00	2275,40	172,70	51,93	2,05	82,05	37,50	13,97
MEAN	2218,33	80,37	752,93	100,39	2079,90	170,00	51,82	1,81	81,95	32,27	13,37
MIN	1821,00	66,00	744,10	99,20	1692,50	168,00	51,70	1,42	81,60	26,64	13,08

TEST: I-15.362
Test description: 95% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2743,00	99,40	766,40	102,20	2591,40	173,00	52,40	2,39	87,19	37,50	14,22
MEAN	2504,68	90,75	751,71	100,23	2359,08	169,72	52,28	2,13	87,15	35,40	13,90
MIN	2184,30	79,10	742,70	99,00	2046,70	167,70	52,16	1,74	86,41	28,67	13,55

TEST: I-15.364
Test description: 70% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T° CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2187,20	79,20	766,40	102,20	2049,60	173,00	52,24	1,82	79,86	36,28	13,41
MEAN	1930,36	69,94	754,48	100,60	1799,12	170,35	51,34	1,50	76,30	29,35	12,62
MIN	1560,10	56,50	743,00	99,10	1438,10	167,80	51,07	1,11	71,26	22,08	11,46

TEST: I-15.365

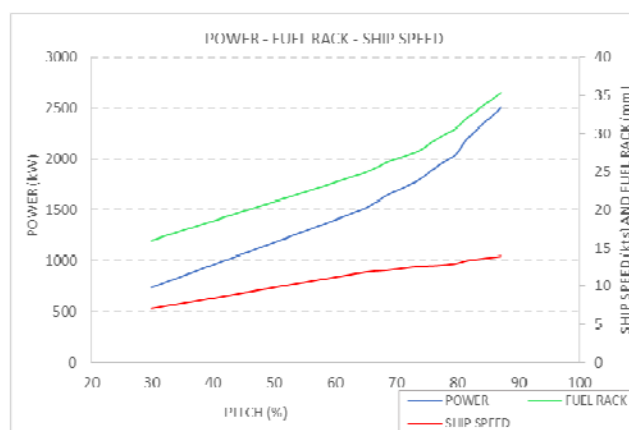
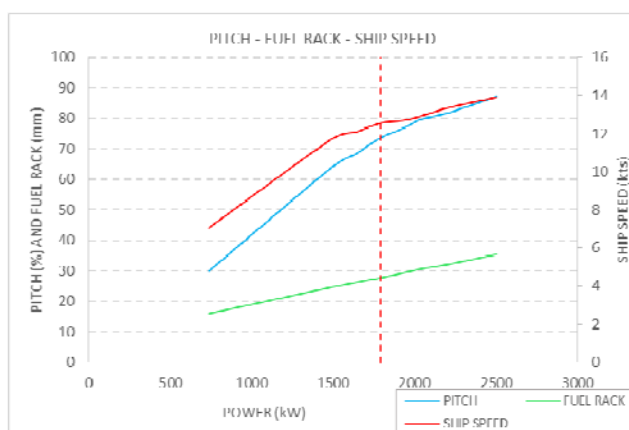
Test description: 80% POWER

	ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	SHAFT POWER (kW)	SHAFT SPEED (rpm)	T ^a CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
MAX	2389,50	86,60	763,50	101,80	2280,70	172,40	51,88	2,05	85,61	36,63	13,49
MEAN	2162,52	78,35	751,13	100,15	2092,55	169,60	51,83	1,82	82,66	32,44	12,68
MIN	1873,40	67,90	740,90	98,80	1806,00	167,30	51,77	1,49	79,84	26,51	11,66

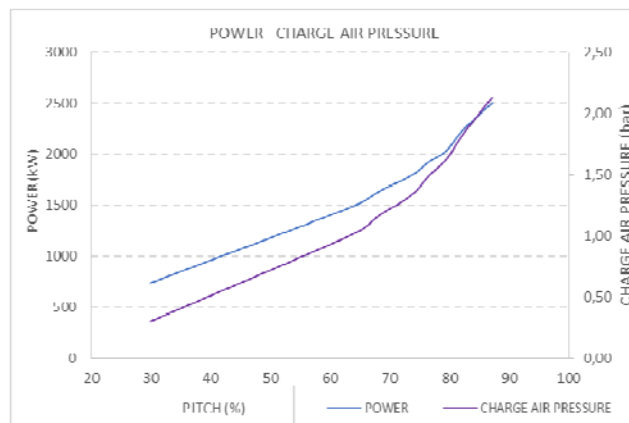
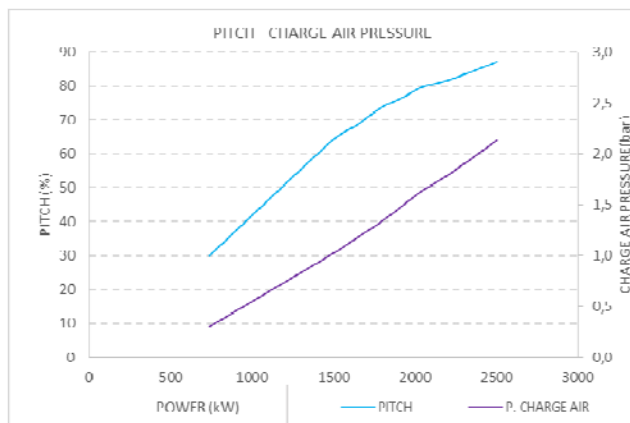
The following summary table is prepared for the evaluation of the measurements:

ENGINE POWER (kW)	ENGINE POWER (%)	ENGINE SPEED (rpm)	ENGINE SPEED (%)	T ^a CHARGE AIR (°C)	P. CHARGE AIR (bar)	PITCH (%)	FUEL RACK (mm)	SHIP SPEED (kt)
737,93	26,74	757,33	100,97	50,14	0,30	29,96	16,02	7,06
1494,00	54,13	754,68	100,62	49,63	1,02	64,02	24,67	11,72
1640,14	59,43	754,31	100,57	49,95	1,17	68,32	26,19	12,07
1787,36	64,76	753,70	100,49	50,52	1,33	73,48	27,68	12,54
1932,28	70,01	753,04	100,40	50,71	1,50	76,74	29,35	12,69
2037,73	73,83	752,79	100,37	50,92	1,63	79,58	30,61	12,91
2218,33	80,37	752,93	100,39	51,82	1,81	81,95	32,27	13,37
2504,68	90,75	751,71	100,23	52,28	2,13	87,15	35,40	13,90

Immediately charge, pitch and speed developed by the vessel graphs in function of main engine power and pitch are shown.



Next it presents a graph with charge air pressure in function of power and pitch percentage.



CONCLUSIONS

In view of registered values (weighted average eNOx 10,74 g/kWh) it is obtained that the motor is within the emission limit eNOx established in the regulation of NOx Technical Code 2008 for main propulsion (Tier I 11,97) and very close to the reference values of manufacturer (according to factory protocol is 10,6 g/kWh)

According to data provided by the owner of last maintenances performed and still pending perform cylinder heads and injectors maintenances, as recommended by the manufacturer, engine is in correct parameters emission, meeting as mentioned above with Marpol regulations.

REPORTS RELATION

Relation of measurements:

<u>REPORT N°</u>	<u>DESCRIPTION</u>
I-15.347	Sailing
I-15.348	Sailing
I-15.349	Sailing
I-15.350	Sailing
I-15.351	Sailing
I-15.352	Sailing
I-15.353	Sailing
I-15.354	25% Power
I-15.355	50% Power
I-15.356	60% Power
I-15.358	68% Power
I-15.359	75% Power
I-15.361	80% Power
I-15.362	90% Power
I-15.364	70% Power
I-15.365	80% Power
I-15.366	Sailing

Vigo, (Spain), 27 November 2015

COTERENA