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- REPORT -

XMILE Europe B.V. Results of the emission measurements at the MS Catharina

January 16th 2013, baseline

August 27th 2014, with XMILE additive

SGS registration	
Our reference	EZMO/11/0027-2_rap
Version no.	1
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Author	John van Middelkoop

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Version	**01-12-2014**	**Changes**
0		
1		
2		
3		

Project details	
General information	
Company name	XMILE Europe B.V.
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Client reference number	MS Catharina
SGS reference number	EZMO/11/0027-2

Plant details	
Location	MS Catharina
Plant	MAK 6Mu451 AK located Tolkamer, the Netherlands
Production details	E3 Test Cycle

Measurement details	
Kind of measurement	Emission measurements, O2, CO2, CO, NOx, PM
Measurement period	January 16, 2013 and August 27, 2014
Measuring staff	John van Middelkoop and Joop Kleverwal

Signatures	
Project Manager	Technical Manager

Quality

For a list of the accredited activities (RvA L092) of the SGS Nederland BV Environmental Services Department in Arnhem, The Netherlands, we refer to the last three pages of the Dutch Accreditation Council RvA website (http://www.rva.nl/?p=cins0200).

Disclaimer

Terminology

°C	degrees Celsius
% by weight	percentage by weight
h	hours
ind	in normal condition dry (101.3 kPa, 273 K)
inm	in normal condition moist (101.3 kPa, 273 K)
K	Kelvin
kg	kilogrammes
kPa	kilo Pascal
m	metres
vppm	volume parts per million
mg/m03	milligrammes per normal cubic metre
m3	cubic metres
mg	milligrammes
vol%	volume percentage
g	grammes
GJ	gigajoules
m3/h	flow under normal operating conditions
m03/h	normalized flow (273 K, 1013 hPa, current % O2 and dry flue gas)
m03/h @ x vol% O2	normalized flow (273 K, 1013 hPa at X vol% O2 and dry flue gas)
sD	standard deviation of the differences Di between the measurements being compared
Di	difference between the ith measured value of the SRM and the corresponding calibrated (corrected) value of the AMS
σo	uncertainty derived from the requirements of the law
AMS	Automatic Measuring System
JC / AST	Annual Check / Annual Surveillance Test
ELV	Emission Limit Value
QAL1	First Quality Assurance Level
QAL2	Second Quality Assurance Level
QAL3	Third Quality Assurance Level
SRM	Standard Reference Method
Kv	These are the measurement values from an x2 test with a β value of 50%, a factor of 0.9161-0.9521 (depending on the number of measurements). Is a value from a table and depends on the number of measurements. Varies between 0.91 and 0.98.
t0.95	Confidence interval of 95%
t0.95(N-1)	Is a value from a table and depends on the number of measurements. Generally varies between 2.1 and 1.8.

Summary

Commissioned by XMILE Europe B.V., SGS Nederland BV, Environmental Services, executed emission measurements on the propulsion engine of the MS Catharina.

XMILE Europe B.V. wants to reduce the emission of engines. The product of XMILE is an additive in the fuel. The Ms Catharina is using the product of XMILE since January 2013 after the base line measurement were performed.

Purpose of the measurements

The purpose of the measurements is to get information about the emissions of the engine during the use of the XMILE product in the fuel. Therefore a base line measurement is executed 16 January 2013. On August 27th 2014 the measurements are repeated with the additive of XMILE in the fuel.

A summary of the results of the emission measurements is given in the table below. The measurements are performed with the cycle E3 at different loads.

Table 0.1 Summary Pollutant Discharge Test Results		
Engine		
Manufacturer	MAK	
Type	6Mu451 AK	
Number	24652	
Location	MS Catharina	
Cycle	E3: 882 kW @ 375 rpm	
Emissions	**Measured base**	**With XMILE additive**
NOx relative emisson (g/kWh)	**17.7**	**16.7**
CO2 relative emisson (g/kWh)	**641**	**599**
Weighted relative emission (g/kWh)	**0,38**	**0,04**

Table of Contents

1 Introduction

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A short description of the supplier and the engine details are included in chapter 2. Chapter 3 describes the measuring equipment and measurement methods. The measurement program is given in chapter 4. The results of the measurements are presented in chapter 5. In chapter 6 the conclusion is given. The report concludes with a calculation of the degree of error for the measurements in chapter 7.

2 Measurement object details

This chapter contains a short description of the site of the measurement location.

2.1 XMILE

XMILE is a fuel additive which unique characteristics are discovered by more and more companies and consumers. XMILE can be summarized as an advanced enzyme-based biological solution for increasing fuel efficiency and reliability. In fact, by adding XMILE the fuel quality improves so combustion is better and more complete.

By this:
- Lower fuel consumption
- Reduced emissions
- Improved engine performance
- Cleaner engine, less maintenance

These effects as a result of using XMILE have a positive effect on reducing costs and improve environmental performance.

2.2 Engine details

In table 2.1, the information of the engine is given

Table 2.1 Engine data	
Components	**Engine**
Manufacturer	MAK
Type	6Mu451 AK
Serial number	24652
Emission class	CCNR
Number of cilinders	6
Line / V	Line
Charging	Turbo
Intercooler	Yes
Rated power kW	882
Rated speed rpm	375
Year of construction	1972
Cycle(s)	E3

Table 2.2 General Information	
Principal representative(s)	M. Overbeeke
SGS Technician(s)	J. Kleverwal J.F. van Middelkoop
Test Location	MS Catharina

3 Description of measuring equipment and measurement methods

This chapter describes the measuring equipment and the measurement methods.

3.1 Measuring equipment

The following measuring equipment was used for the measurements.

Table 3.1 Measurement equipment				
Component	**Analyzer**	**Identification**	**Measuring principle**	**Standard**
Component	Analyzer	Identification	Measuring principle	Standard
Oxygen	Testo 350 Maritime	SGS 13-276	Chemical cell-	Carbon dioxide
Carbon dioxide	Testo 350 Maritime	SGS 13-276	Infrared	-
Carbon monoxide	Testo 350 Maritime	SGS 13-276	Chemical cell-	Nitrogen oxides
Nitrogen oxides	Testo 350 Maritime	SGS 13-276	Chemical cell-	Particulate Matters
Particulate Matters	Dilution Method	SGS 11-033	Dilution method	ISO 8178

3.2 Measurement methods

The following paragraphs describe the measurement methods. The measurements are performed using the procedures of the MARPOL 73/78 test cycle E3.

3.2.1 Gaseous flue gas components
The flue gas of the diesel engine was continuously sampled in the outlet. After filtration of the flue gas the

sample flow is lead to a "testo 350-MARITIME portable flue gas analyzer". The concentrations of O2, CO2, CO and NOx in the filtered and dried flue gas sample flow was analyzed.

3.2.2 Determination of particulate matter
First measurement.

A partial flue gas stream flow is taking out of the exhaust gas flow with a sample probe. The exhaust gas

flow is going through a mixture housing with dry cool air. Before the flue gas/air mixture is reaching the glass fibre filter the exhaust gas temperature is below 54 degrees Celsius.

Because of this dilution method the existing condensable particles are catched inventially on the filter. The filter will be weighed at standard conditions before and after the measuring.

3.2.3 Determination of the flue gas temperature
The flue gas temperature was determined using a calibrated type K thermocouple and recording unit.

3.3 Suitability of the measurement plane

The measurement points for the emission measurements are located in a horizontal duct. The measurement points are located at a height of 1.5 meters. Before and after the measurement location more than 5 times the diameter of straight duct exists. The sample port has a 1 inch and a half inch opening with ball valves.

4 Measurement Program and deviation from the standard

4.1 Measurement Program

The measurement objective is to determine the effect of XMILE fuel additive on the emissions of the engine. In order to determine this effect SGS is asked to determine the emission characteristics of the engine on the MS Catharina before and after adding XMILE fuel additive. The test procedure of a test cycle E3 as defined in the MARPOL 73/78 is used to determine the emission characteristics.

The MARPOL states that for an E3 cycle the program below should be done:

Table 4.1 Test cycles type E3				
Propeller-law heavy-duty engines for ship propulsion without limitation of length				
Speed	100%	91%	80%	68%
Power	100%	75%	50%	25%
Weighting factor	0.20	0.50	0.15	0.15

4.2 Deviation from the standard

The emission measurements are done in compliance with the test procedure described in the MARPOL 73/78. The emissions measurements are done using a TESTO 350 maritime. According to Germanischer Lloyd (GL) the systems complies with the regulations MEPC 103(49) MARPOL Annex VI and he NOx technical code.

The PM measurements on August 27, 2014 are performed indicatively. The measurement principle differs from the one that is stated in the standard to be used. Therefore the results are not included.

Fuel flow measurement is not present on the MS Catharina. Data sheets of the engine are used for the fuel use of this test.

5 Results

In this chapter the summary of the measurements are given.

5.1 Emission characteristics

In this paragraph the results of the E3 cycle measurements with and without fuel treatment are presented.

Table 5.1	**Summary results without fuel treatment**		
Engine			
Manufacturer	MAK		
Type	6Mu451 AK		
Number	24652		
Location	MS Catharina		
Cycle	E3: 882 kW @ 375 rpm		
Emissions	**Measured**	**Demand**	**Comply**
NOx relative emisson (g/kWh)	**17.7**	**10.8**	**No**
CO relative emisson (g/kWh)	**0.6**	**3.5**	**Yes**
Particle relative emission (g/kWh)	**0.38**	**0.2**	**No**

Table 5.2	**Summary results with fuel treatment**		
Engine			
Manufacturer	MAK		
Type	6Mu451 AK		
Number	24652		
Location	MS Catharina		
Cycle	E3: 882 kW @ 375 rpm		
Emissions	**Measured**	**Demand**	**Comply**
NOx relative emisson (g/kWh)	**16.7**	**10.8**	**No**
CO relative emisson (g/kWh)	**0.9**	**3.5**	**Yes**

5.2 Emission results

The results are summarised in table 5.3.

The PM measurements on August 27, 2014 are performed indicatively. The measurement principle differs from the one that is stated in the standard to be used. Therefore the results are not included

Table 5.3 Summary of measurements			
Component	**Without fuel treatment January 16, 2013 (g/kWh)**	**With fuel treatment August 27, 2014 (g/kWh)**	**Delta (%)**
NOx			
100%	16.8	15.1	- 10
75%	17.8	16.9	- 5
50%	18.9	18.6	- 2
25%	17.9	18.2	2
PM			
100%	0.56		
75%	0.29		
50%	0.38		
25%	0.49		
CO			
100%	0.80	0.97	21
75%	0.52	1.00	92
50%	0.47	0.40	- 15
25%	0.67	0.40	- 40
CO2			
100%	626	573	-9
75%	630	589	-7
50%	645	606	-6
25%	663	628	-6

6 Conclusion

The results of the measurements are summarized in the following table.

Table 6.1 Summary of measurements			
Component	**Without fuel treatment January 16, 2013 (g/kWh)**	**With fuel treatment August 27, 2014 (g/kWh)**	**Delta (%)**
Emissions			
NOx (g/kWh)	17.7	16.7	-6
CO (g/kWh)	0.6	0.9	50
PM (g/kWh)	0.38		
CO2 (g/kWh)	641	599	-7

Conclusion

The results of the emission measurements show that the MAK 6Mu451 AK engine with number 24652 has a decrease of 1 g/kWH NOx emission, the CO reduction is increasing with the fuel additive and the CO2 has a decrease of 7%.

As the PM is not measured with the official dilution set during the measurements on August 27, 2014, the results cannot be given.

7 Discussion of errors

7.1 Purpose of discussion of errors

When carrying out a measurement one always needs to be aware that there will be errors in the final results. This is not only true for the measurements, errors may also occur in the calculations.

An 'error' is defined as every deviation from the actual value. By carrying out an evaluation of errors, the influence of the error can be determined. This evaluation must be carried out both before and after the measurement. Before the measurement it is called an errors prognosis and after the measurement it is called an errors calculation. The errors discussion serves the following purposes:

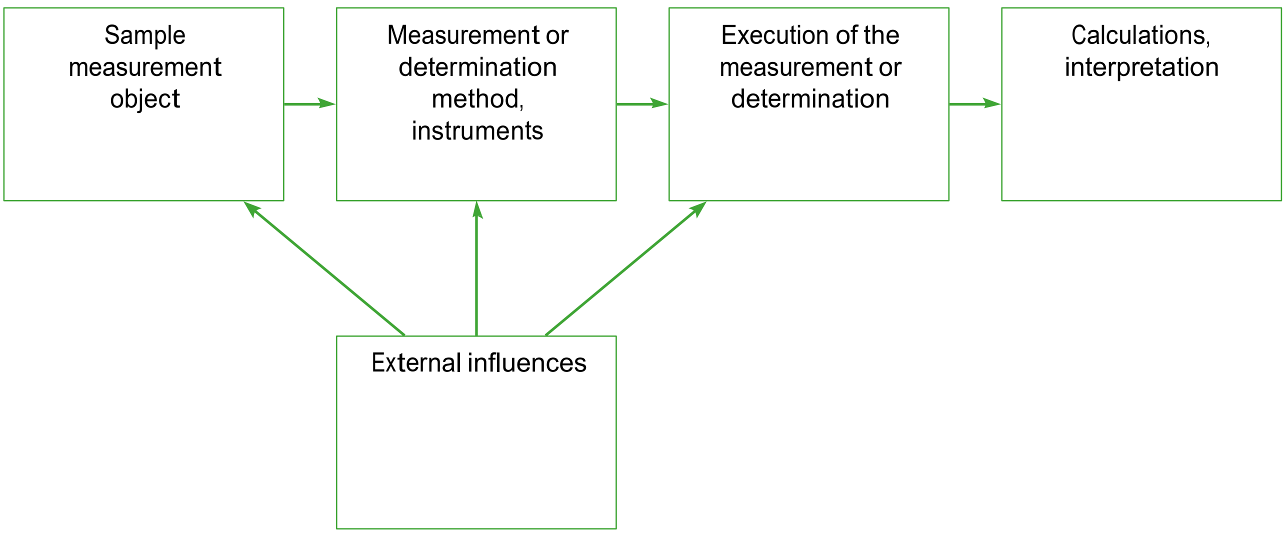
Determination of the accuracy of a result
A measurement result for which the accuracy is unknown, is useless. If one wants to express the result of a test as an objective number, one will also want to express the accuracy as an objective number. By doing so, we will discover the boundaries within which the true value of the result.

Selection of the method and the instruments
Using the desired accuracy and the measurement method, the carrying out of an errors prognosis can determine whether the measurement meets the required accuracy. If the desired accuracy is not achieved, sources of error will need to be removed or a completely different measurement method will need to be found.

By ensuring that the experiments are carried out in an efficient manner, and by mainly focusing on the element that is the greatest source of inaccuracy, better results can be obtained and less time is wasted.

7.2 Classification of errors

The following figure gives a schematic overview of a number of steps in which errors may occur.



7.2.1 Errors related to measurement object
Sources of errors are often already present in the measurement object, for example:
- Lack of homogeneous composition of a gas.
- No long enough straight area for a volume measurement.
- A temperature measurement done on the 'shade side'.

7.2.2 Errors in the measurement or determination method
These so-called method errors often lead to wrong measurement or analysis results. It is hidden in the way the work is done. The measurement influences the value to be measured. e.g. when doing a velocity measurement in a small pipe, the pitot tube blocks a large part of the pipe so that a wrong velocity is measured.

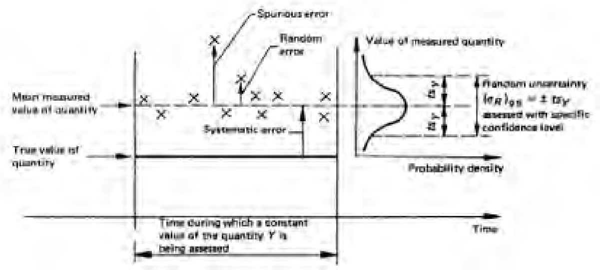
7.2.3 Instrument errors
These mistakes hide in the instruments used. They can be the result of calibration errors or adjustment errors. It is also quite common for the zero point or reference point of a measuring device to not be constant.

7.2.4 Errors that are created during the execution of the measurement
This type of error is mainly created by the person carrying out the measurement and can be avoided through correct and careful carrying out of the measurement.

7.2.5 Errors resulting from external influences
This type of error is created outside of the actual execution of the experiment, and yet influence the result, for example:
- magnetic fields around measuring equipment
- vibrations
- humidity
- weather conditions

7.2.6 Errors in the interpretation of the errors
In this respect, one must ask oneself whether what one is measuring is actually what one thinks one is measuring. One must be certain that the method used is the correct one for what needs to be determined.

7.3 Kinds of errors that may occur
The errors that may occur during a measurement can be subdivided into the following categories:
- *Systematic errors*
- *Chance errors*
- *Parasitic errors*



7.3.1 Systematic errors
Systematic errors are errors that influence a measurement in the same way every time. They always result in a value that is either too high or too low. The error is not reduced by repeating the measurement many times.

The systematic errors are mainly errors in the measuring equipment and are the result of the wrong calibration of an instrument or by a null setting that is incorrect.

The systematic errors can be subdivided into two large groups:

a) Constant systematic errors
These are normal for all measurements executed under the same circumstances and are constant over time but, depending on the nature of the error, they can vary with the value resulting from the measurement.

b) Variable systematic errors
These can be the result of not keeping the conditions under which the measurement is being executed constant. For instance, if the temperature rises near a measuring instrument that has been calibrated for a certain temperature.

A second type of variable systematic error can result from measuring with a digital instrument on a continually varying value.

7.3.2 Chance errors, replicability

Chance errors are defined as errors for which the magnitude and direction are completely dependent on chance and which can therefore be different for each and every measurement. If many measurements are conducted, the errors can partially compensate each other.

Another term that is often used in this context is replicability: the correspondence between several measurements of the same value with the same method. If something is replicable, it does not automatically mean that there is no systematic error. A systematic error can only be tracked down by carrying out the measurement with a different method.

It won't always be possible to put an error into one of these two groups because, on the one hand, subjective criteria are used to classify the error and, on the other hand, the errors that occur are often partially systematic and partially due to chance.

7.3.3 Parasitic errors

Parasitic errors are errors like human error or errors that result from the temporary failure of a measuring instrument. The observations that suffer from this kind of error should not be included in the averaging of the measurement values because they can produce large deviations in the results.

7.4 Measurement uncertainties

The following measurement uncertainties have to be taken into account:

Table 7.1 Overview of measurement uncertainties

	Total unc.
NOx	**10%**
O2	**10%**
CO2	**10%**
CO	**10%**
PM	**50%**

APPENDICES

Appendix A. Calculations performed as per MARPOL

Before Treatment

Table A.1 Results environmental measurements

Engine					
Type		6Mu451 AK			
Number		24652			
Location		MS Catharina			
Fuel 1 Oil					
Type		LFO			
Test					
Date		16-1-2013			
Start	(hh:mm)	10:05	10:19	10:33	10:51
End	(hh:mm)	10:15	10:29	10:43	11:01
Engine conditions					
P Load	(kW	782	676	430	224
nd Number of revolutions	(rpm	352	340	302	240
qmf Fuel consumption (oil)	(l/h	188.00	165.00	108.00	58.00
Ta Suction air temperature	(°C	13	13	14	14
LT cooling w ater before engine	(°C	22	20	18	17
Ignition angle	(°				
pc Charge air pressure	(bar)	0.90	0.74	0.42	0.15
Tsc Charge air temperature	(°C)	45	43	36	23
Ambient air					
Atmospheric pressure	(mbar)	1009	1009	1010	1009
Temperature	(°C)	14	14	14	15
Relative humidity	(%)	44	43	40	39
Results flue gas measurements					
Texh Temperature	(°C)	329	326	308	261
O2	(vol% dry flue gas)	14.5	14.5	14.5	15.5
CO2	(vol% dry flue gas)	4.7	4.7	4.6	3.9
CO	(vppm dry flue gas)	94	60	53	62
NOx	(vppm dry flue gas)	1,339	1,402	1,441	1,127
Particle measurement					
Filternumber		ME 488	ME 481	ME 482	ME 483
Tare w eight	(g)	1.105	1.111	1.127	1.109
Gross w eight	(g)	1.166	1.142	1.160	1.164
Sampling volume	(m03 dry flue gas)	0.87	0.85	0.71	1.11

Table A.2 Calculated air and combustion data

Engine					
Type		6Mu451 AK			
Number		24652			
Location		MS Catharina			
Air data					
Atmospheric pressure	(mbar	1009.4	1009.4	1009.5	1009.4
Temperature	(°C	14.0	13.8	14.0	14.5
Relative humidity	(%	44.0	43.0	40.0	39.0
Absolute humidity	(vol%	0.69	0.67	0.63	0.63
Absolute humidity (Ha)	(g/kg dry air	4.34	4.18	3.94	3.97
Water saturation pressure at Rt	(mbar)	95	86	59	28
Absolute humidity Turbo (Hsc)	(g/kg dry air)	33	32	27	15
Fuel					
Oil type		LFO			
Identification code		EN-590			
Density at 15 °C	(kg/l	0.840			
Net caloric value	(MJ/kg	42.66			
Carbon-content	(% m/m	86.00%			
Hydrogen-content	(% m/m	13.00%			
Nitrogen-content	(% m/m)	0.10%			
Sulphur-content	(% m/m)	0.00%			
Calculated stoichiometric combustion data		Fuel 1			
Dry air demand	(m3/kg)	11.07			
Dry flue gas flow	(m3/kg)	10.35			
Wet flue gas flow	(m3/kg)	12.07			
Fuel 1 Oil consumption	(kg/h)	158	139	91	49
Calculated actual combustion data					
Air factor EAF		3.10	3.10	3.11	3.63
Dry flue gas flow	(m3/kg)	33.6	33.6	33.8	39.5
	(m3/h)	5299	4651	3063	1924
Wet flue gas flow	(m3/kg)	35.2	35.2	35.4	41.1
	(m3/h)	5557	4876	3210	2004
Water concentration	(vol% w et flue gas)	4.6	4.6	4.6	4.0

Table A.3 Correction factors

Testconditions					
Fa-factor (mechanically charged)		0.96	0.96	0.96	0.96
Fa-factor (turbo charged)		0.93	0.93	0.93	0.93
CCNR					
NOx correction for humidity and temperature KHDIES					
KHDIES	Applicable	0.901	0.900	0.899	0.899
Particle correction for humidity and fa					
Particle correction factor (Kp)		1.093	1.095	1.099	1.098
Particle correction factor (Kfa)		1.073	1.042	1.042	1.041
Aid factor Kfa 1		0.176	0.171	0.169	0.155
Aid factor Kfa 2		0.164	0.164	0.163	0.154
EAFref		2.886	2.970	2.990	3.487
Aid factor Kfa 3		1.075	1.040	1.038	1.004
Applicable correction factors					
NOx correction					
KHDIES applicable		0.901	0.900	0.899	0.899
Particle correction					
Kp		1.093	1.095	1.099	1.098
Kfa		1.073	1.042	1.042	1.041
PTcorr		0.000			

Table A.4 Emission concentrations at standard conditions

Engine					
Type		6Mu451 AK			
Number		24652			
Location		MS Catharina			
Standard flue gas conditions					
Moisture	(vol %	0.0			
Temperature	(°C	0			
Pressure	(mbar	1013			
Molar volume	(m3/kmol)	22.40			
Oxygen concentration	(vol% dry flue gas)	15			
Test					
Date		16-1-2013			
Start	(hh:mm)	10:05	10:19	10:33	10:51
End	(hh:mm)	10:15	10:29	10:43	11:01
Results in flue gas at standard conditions					
CO	(vppm)	86.6	55.3	48.7	67.2
NOx	(vppm)	1233	1291	1336	1221
Flue gas flow	(m3/h)	5754	5050	3305	1775
Relative emissions					
CO2	(g/kWh)	626	630	645	663
CO	(g/kWh)	0.80	0.52	0.47	0.67
NOx	(g/kWh)	18.63	19.81	21.08	19.88
Weighed relative emissions					
NOx	(g/h	2914	6695	1360	668
NOx (Khdies corrected)	(g/h	2627	6025	1222	600
Load	(kW)	156.40	338.00	64.50	33.60
E3	factor	0.20	0.50	0.15	0.15
Weighed relative emission per sample (corrected)	(g/kWh)	16.80	17.82	18.94	17.87
Weighed relative emission	(g/kWh)	19.64			
Weighed relative emission (corrected)	(g/kWh)	17.68			
CO	(g/h)	124.53	174.41	30.15	22.36
Load	(kW)	156.40	338.00	64.50	33.60
E3	factor	0.20	0.50	0.15	0.15
CO Weighed relative emission per sample	(g/kWh)	0.80	0.52	0.47	0.67
CO Weighed relative emission	(g/kWh)	0.59			
Particles					
Sample w eight	(mg)	61	31	33	55
Particles	(mg/m03 dry flue gas)	70	37	47	50
Particles (at standard conditions)	(mg/m03 dry flue gas)	65	34	44	54
Particle	(g/kWh)	0.48	0.25	0.34	0.43
Particle corrected Kp, Kfa	(g/kWh)	0.56	0.29	0.38	0.49
Particle	(g/h)	74.55	85.46	21.67	14.34
Particle (Corrected; Kp en Kfa)	(g/h)	87.39	97.54	24.80	16.40
Load	(kW)	156.40	338.00	64.50	33.60
E3	factor	0.20	0.50	0.15	0.15
Weighed relative emission	(g/kWh)	0.33			
Weighed relative emission (corrected)	(g/kWh)	0.38			

After Treatment

Table A.5 Results environmental measurements

Engine					
Type		6Mu451 AK			
Number		24652			
Location		MS Catharina			
Fuel 1 Oil					
Type		LFO			
Identification code		EN-590			
Test					
Date		27/08/14			
Start	(hh:mm)	8:47	9:05	9:28	9:58
End	(hh:mm)	8:57	9:15	9:38	10:08
Engine conditions					
P Load	(kW	782	676	430	224
nd Number of revolutions	(rpm	355	341	305	235
qmf Fuel consumption (oil)	(l/h	188.00	165.00	108.00	58.00
Ta Suction air temperature	(°C	24	25	25	27
LT cooling w ater before engine	(°C	64	65	65	65
Ignition angle	(°				
pc Charge air pressure	(bar)	0.95	0.80	0.45	0.14
Tsc Charge air temperature	(°C)	55	62	48	39
Ambient air					
Atmospheric pressure	(mbar)	1013	1013	1014	1014
Temperature	(°C)	21	22	23	23
Relative humidity	(%)	53	50	48	50
Results flue gas measurements					
Texh Temperature	(°C)	364	353	328	281
O2	(vol% dry flue gas)	13.8	14.1	14.3	15.3
CO2	(vol% dry flue gas)	4.8	4.6	4.5	3.8
CO	(vppm dry flue gas)	127	123	47	38
NOx	(vppm dry flue gas)	1,252	1,310	1,356	1,086

Table A.6 Calculated air and combustion data

Engine					
Type		6Mu451 AK			
Number		24652			
Location		MS Catharina			
Air data					
Atmospheric pressure	(mbar	1013.4	1013.4	1013.6	1013.9
Temperature	(°C	20.9	22.3	22.7	22.7
Relative humidity	(%	52.7	49.6	48.0	50.0
Absolute humidity	(vol%	1.28	1.31	1.30	1.35
Absolute humidity (Ha)	(g/kg dry air	8.05	8.26	8.18	8.53
Water saturation pressure at Rt	(mbar)	157	218	111	70
Absolute humidity Turbo (Hsc)	(g/kg dry air)	54	85	51	40
Fuel					
Oil type		LFO			
Identification code		EN-590			
Density at 15 °C	(kg/l	0.840			
Net caloric value	(MJ/kg	42.66			
Carbon-content	(% m/m	86.00%			
Hydrogen-content	(% m/m	13.00%			
Nitrogen-content	(% m/m)	0.10%			
Sulphur-content	(% m/m)	0.00%			
Calculated stoichiometric combustion data		Fuel 1			
Dry air demand	(m3/kg)	11.07			
Dry flue gas flow	(m3/kg)	10.35			
Wet flue gas flow	(m3/kg)	12.07			
Fuel 1 Oil consumption	(kg/h)	158	139	91	49
Calculated actual combustion data					
Air factor EAF		2.79	2.92	3.01	3.52
Dry flue gas flow	(m3/kg)	30.1	31.6	32.6	38.3
	(m3/h)	4761	4386	2962	1866
Wet flue gas flow	(m3/kg)	31.9	33.5	34.5	40.2
	(m3/h)	5045	4639	3128	1960
Water concentration	(vol% w et flue gas)	5.6	5.5	5.3	4.8

Table A.7 Correction factors

Testconditions					
Fa-factor (mechanically charged)		0.99	0.99	0.99	0.99
Fa-factor (turbo charged)		0.99	0.99	0.99	1.00
CCNR					
NOx correction for humidity and temperature KHDIES					
KHDIES	Applicable	0.966	0.971	0.970	0.979
Particle correction for humidity and fa					
Particle correction factor (Kp)		1.037	1.034	1.035	1.030
Particle correction factor (Kfa)		1.000	1.000	1.011	1.006
Aid factor Kfa 1		0.188	0.176	0.170	0.154
Aid factor Kfa 2		0.185	0.174	0.168	0.154
EAFref		2.754	2.894	2.980	3.503
Aid factor Kfa 3		1.000	1.000	1.000	1.000
Applicable correction factors					
NOx correction					
KHDIES applicable		0.966	0.971	0.970	0.979
Particle correction					
Kp		1.037	1.034	1.035	1.030
Kfa		1.000	1.000	1.011	1.006
PTcorr		0.000			

Table A.8 Emission concentrations at standard conditions

Engine					
Type		6Mu451 AK			
Number		24652			
Location		MS Catharina			
Standard flue gas conditions					
Moisture	(vol %	0.0			
Temperature	(°C	0			
Pressure	(mbar	1013			
Molar volume	(m3/kmol)	22.40			
Oxygen concentration	(vol% dry flue gas)	15			
Test					
Date		27/08/14			
Start	(hh:mm)	8:47	9:05	9:28	9:58
End	(hh:mm)	8:57	9:15	9:38	10:08
Results in flue gas at standard conditions					
CO	(vppm)	105	107	42.1	39.9
NOx	(vppm)	1036	1138	1215	1142
Flue gas flow	(m3/h)	5754	5050	3305	1775
Relative emissions					
CO2	(g/kWh)	573	589	606	628
CO	(g/kWh)	0.97	1.00	0.40	0.40
NOx	(g/kWh)	15.65	17.46	19.18	18.58
Weighed relative emissions					
NOx	(g/h	2448	5900	1237	624
NOx (Khdies corrected)	(g/h	2366	5731	1199	611
Load	(kW)	156.40	338.00	64.50	33.60
E3	factor	0.20	0.50	0.15	0.15
Weighed relative emission per sample (corrected)	(g/kWh)	15.13	16.96	18.60	18.19
Weighed relative emission	(g/kWh)	17.23			
Weighed relative emission (corrected)	(g/kWh)	16.72			
CO	(g/h)	151.17	337.19	26.10	13.30
Load	(kW)	156.40	338.00	64.50	33.60
E3	factor	0.20	0.50	0.15	0.15
CO Weighed relative emission per sample	(g/kWh)	0.97	1.00	0.40	0.40
CO Weighed relative emission	(g/kWh)	0.89			
Particles					
Particles	(mg/m03 dry flue gas)	8	6	3	2
Particles (at standard conditions)	(mg/m03 dry flue gas)	7	5	2	2
Particle	(g/kWh)	0.05	0.04	0.02	0.02
Particle corrected Kp, Kfa	(g/kWh)	0.05	0.04	0.02	0.02
Particle	(g/h)	7.81	12.50	1.11	0.56
Particle (Corrected; Kp en Kfa)	(g/h)	8.09	12.92	1.16	0.58
Load	(kW)	156.40	338.00	64.50	33.60
E3	facto	0.20	0.50	0.15	0.15
Weighed relative emission	(g/kWh	0.04			
Weighed relative emission (corrected)	(g/kWh	0.04			

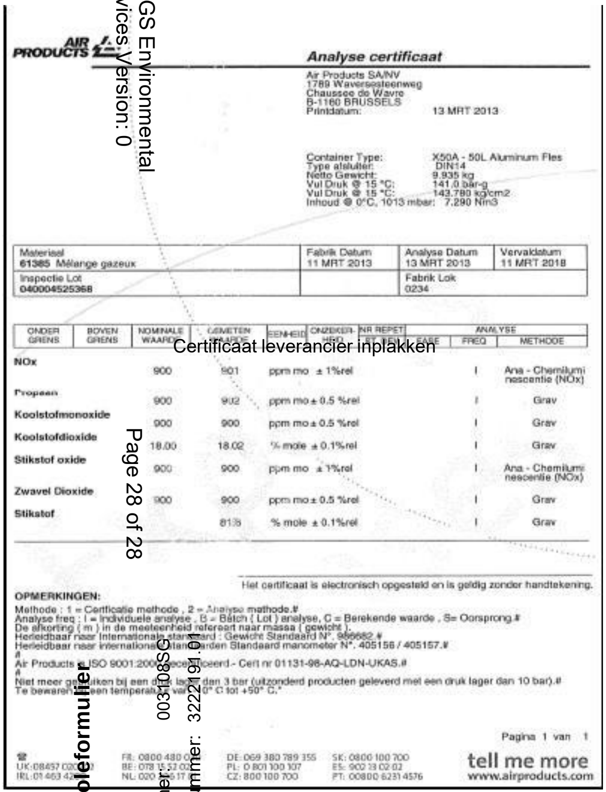
Appendix B. Zero and span check TESTO 350

Reference gas used 040004525368

Projectnumber	EZMO-11-0027
Projectlocation	MS Catharina
Date	27/8/2014
Performer(s)	JMI

Tagnumber(s)							
		O_2 vol%	CO_2 vol%	CO vppm	NO_x vppm	SO_2 vppm	C_xH_y vppm
Range analyser		25	20	1000	1000		
Spangasconcentration	40004525368	20.95	18.19	894	904.8		
Control gas conc.	identification						
Leaktest performed	Satisfies	Yes					
Calibration 1	**time Calibration**						
zero	16:30	0	0	0	0		
span	16:45		17.88	901	901		
control gas							
	26-8-2014						
Calibration 2	**time Calibration**						
zero before calibration	15:15	0	0.1	1	3		
zero after calibration							
span before calibration	15:25	20.78	17.92	899	902		
span after calibration							
deviation in % zero		0.0	0.5	0.1	0.3		
deviation in % span		0.8	1.5	0.6	0.3		
	27-8-2014						

Appendix C. Calibration gas



AIR PRODUCTS

Analyse certificaat

Air Products SA/NV
1789 Waversesteenweg
Chaussee de Wavre
B-1160 BRUSSELS
Printdatum: 13 MRT 2013

Container Type: X50A - 50L Aluminum Fles
Type afsluiter: DIN14
Netto Gewicht: 9.935 kg
Vul Druk @ 15 °C: 141.0 bar-g
Vul Druk @ 15 °C: 143.780 kg/cm2
Inhoud @ 0°C, 1013 mbar: 7.290 Nm3

Materiaal 61385 Mélange gazeux	Fabrik Datum 11 MRT 2013	Analyse Datum 13 MRT 2013	Vervaldatum 11 MRT 2018
Inspectie Lot 040004525368		Fabrik Lok 0234	

Certificaat leverancier inplakken

	ONDER GRENS	BOVEN GRENS	NOMINALE WAARDE	GEMETEN WAARDE	EENHEID	ONZEKERHEID	NR REPET ST. DEV.	ANALYSE FASE	ANALYSE FREQ	ANALYSE METHODE
NOx			900	901	ppm mo	± 1%rel			I	Ana - Chemiluminescentie (NOx)
Propaan			900	902	ppm mo	± 0.5 %rel			I	Grav
Koolstofmonoxide			900	900	ppm mo	± 0.5 %rel			I	Grav
Koolstofdioxide			18.00	18.02	% mole	± 0.1%rel			I	Grav
Stikstof oxide			900	900	ppm mo	± 1%rel			I	Ana - Chemiluminescentie (NOx)
Zwavel Dioxide			900	900	ppm mo	± 0.5 %rel			I	Grav
Stikstof				81.5	% mole	± 0.1%rel			I	Grav

Het certificaat is electronisch opgesteld en is geldig zonder handtekening.

OPMERKINGEN:

Methode : 1 = Certificatie methode , 2 = Analyse methode.#
Analyse freq : I = Individuele analyse , B = Batch (Lot) analyse, C = Berekende waarde , S= Oorsprong.#
De afkorting (m) in de meeteenheid refereert naar massa (gewicht).
Herleidbaar naar Internationale standaard : Gewicht Standaard N°. 986682.#
Herleidbaar naar internationale standaarden Standaard manometer N°. 405156 / 405157.#
#
Air Products is ISO 9001:2000 gecertificeerd.- Cert nr 01131-98-AQ-LDN-UKAS.#
#
Niet meer gebruiken bij een druk lager dan 3 bar (uitzonderd producten geleverd met een druk lager dan 10 bar).#
Te bewaren bij een temperatuur van -10° C tot +50° C.

Pagina 1 van 1

UK: 08457 020 202 | IRL: 01 463 42.. | FR: 0800 480 0.. | BE: 078 15 52 02.. | NL: 020 .. 17 ..
DE: 069 380 789 355 | PL: 0 801 100 107 | CZ: 800 100 700
SK: 0800 100 700 | ES: 902 13 02 02 | PT: 00800 6231 4576

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www.airproducts.com

IJkgas controleformulier

RvA ijkgasfles

IJkgas flesnummer: 003108SG

RvA certificaatnummer: 3222191.01

IJkgas controleformulier

RvA ijkgasfles

IJkgas flesnummer: 003108SG

RvA certificaatnummer: 3222191.01

IJkgas controleformulier

RvA ijkgasfles

IJkgas flesnummer: 003108SG

RvA certificaatnummer: 3222191.01

IJkgasfles

Concentratie ijkgas: hoog

Leverancier: Air Products

IJkgasflesnummer: 040004525368

Houdbaarheidsdatum: 11-Mar-18

Resultaten		**RvA [mol]**	**RvA [Vol]**	**Certificaat [mol]**	**Certificaat [Vol]**	**Controle**
NO_x	ppm					
NO	ppm	913	914.3	901	902.2	**904.80**
C_xH_y	ppm	900	882.3	902	884.3	**880.34**
CO	ppm	901	902.3	900	901.3	**894.31**
CO_2	%	17.99	17.90	18.02	17.93	**18.19**
SO_2	ppm	904	886.8	900	882.8	**872.43**

Uitgevoerd door: T.Hermsen

Gecontroleerd KAM:

Controle datum: 7/3/2013

Controle datum: 7/31/2013