TECHNICAL REPORT

MAN DIESEL.

EVALUATION OF NO_X –EMISSIONS IN CONNECTION WITH ENGINE CONVERSION ON BOARD CAR FERRY "FLORØY"

REPORT NO. 2011-0699

REVISION NO. 0

DET NORSKE VERITAS

TECHNICAL REPORT

Date of first issue: 2011-05-25	Project No.: PP005842
Approved by: Johan Johansson-Iseskär Head Of Section	Organisational unit: DNV Advisory Services Rotating Machinery
Client: MAN Diesel.	Client ref.: Helle B. Rusbjerg

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DNV Advisory Services – Rotating Machinery, was engaged by MAN Diesel to perform NO_X emission measurements on Main Engine on board Car Ferry "Florøy".
The measurements have been carried out prior to, and after, NO_X-reducing engine conversion.

The measurement is carried out in accordance with the "Norwegian Maritime Directorate Guidelines" **/1/** and the "NO_X Technical Code 2008" **/2/**.

The measurement took place on February 9 prior to the enging rebuilding and on May 19 after the conversion was completed. Both tests were carried out at the fjord between Dale and Eikenes in Norway.

The weighted NO_X -emission for the main engine is calculated to be 50,31 kg NOx/ton fuel, corresponding to 10,8 g/kWh prior to the engine upgrade. The calculated values after refitting of the engine are 36,66 kg NOx/ton fuel and 8,1 g/kWh.
The limit for compliance of Tier II is 9,6 g/kwh for this specific engine.

DNV conclude that the engine, after conversion, is in compliance with the Marpol - Tier II

Report No.: 2011-0699	Subject Group:
Report title: Evaluation of NOx –emissions in connection with engine convertion on board car carrier "Florøy"	
Work carried out by: Håvard Bentsen	
Work verified by: Anders Hansson	
Date of this revision: 2011-05-25	Rev. No.: 0 / Number of pages: 27

Indexing terms

Key words NO_X measurements Engine conversion	Service Area Technology Qualification Market Sector General Industry

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1 CONCLUSIVE SUMMARY

DNV Advisory Services – Rotating Machinery, was engaged by MAN Diesel to perform NO_X emission measurements on Main Engine on board Car Ferry "Florøy".
The measurements have been carried out prior to, and after, NO_X-reducing engine conversion.

The measurement is carried out in accordance with the "Norwegian Maritime Directorate Guidelines" **/1/** and the "NO_X Technical Code 2008" **/2/**.

The measurement took place on February 9 prior to the enging rebuilding and on May 19 after the conversion was completed. Both tests were carried out at the fjord between Dale and Eikenes in Norway.

The weighted NO_X -emission for the main engine is calculated to be 50,31 kg NOx/ton fuel, corresponding to 10,8 g/kWh prior to the engine upgrade. The calculated values after refitting of the engine are 36,66 kg NOx/ton fuel and 8,1 g/kWh.
The limit for compliance of Tier II is 9,6 g/kwh for this specific engine.

DNV conclude that the engine, after conversion, is in compliance with the Marpol - Tier II requirements.

2 INTRODUCTION

MAN Diesel was engaged to carry out a NOx-reducing engine conversion on board car ferry "Florøy". The conversion was performed to have the main engine in compliance with the by Marpol defined Tier II requirements.

DNV Advisory Services – Rotating Machinery, was engaged by MAN Diesel to perform a verification of the NO_X-reducing engine conversion.
The measurements have been carried out prior to, and after, NO_X-reducing engine conversion.

3 VESSEL DATA

Ship name:	Florøy
IMO number:	6827606
Ship owner:	Fjord1 Fylkesbaatane AS
Ship type:	Car Ferry
Year of build:	1968
Length oa:	49,08 m
Breadth, moulded:	10,52 m
Main Engine type:	1x MAN 6L23/30
No. of cylinders:	6
Rated power:	625 kW
Rated speed:	750 RPM
Test cycle:	E2

4 MEASUREMENT

The emission measurement of the main engine was carried out between the ship's ordinary routes.
The first trip was carried out at 100% load, the next tree load points followed in a reducing chronologic order from the MARPOL E2 test cycle.
Each measurement sequence contained a warm up time for the engine to stabilize at thermal equilibrium followed by at least 10 minutes recording of the emission-measurement.

Calibration of the gas analyzer was carried out before and after the tests to verify that the measurement equipment showed stable readings and had the necessary accuracy. Calibration values are given in APPENDIX D.
At the end of the measurements it was discovered that the O2-content of the span gas is not correct, based on verification readings with fresh air. The calibration values however confirm that the sensor has had the required stability throughout the measurements. The O2 measurements have been corrected for the wrong adjustment by linear interpolation.

4.1 MEASUREMENT EQUIPMENT

4.1.1 Emission measurement

Test carried out 2011-02-09, before engine conversion:

Equipment manufacturer:	Horiba
Model:	PG-250
Instrument ID:	1002
Piping:	Heated hose@ 200°C, teflon-hose and an Ø10mm probe
Latest linearity calibration:	2010-11-15 (See APPENDIX F)
Span/Zero Gas:	YaraPraxair (See APPENDIX B)

Test carried out 2011-05-19, after engine conversion:

Equipment manufacturer:	Testo AG
Model:	Testo 350-Maritime
Instrument ID:	1983716/1987322 (APPENDIX E)
Piping:	Testo high flow hose with Ø15mm probe
Span/Zero Gas:	YaraPraxair (See APPENDIX B)

4.1.2 Ambient condition measurement

Measured component	Manufacturer + model	Range
Intake air humidity	testo 610	0 to 100%rH
Intake air temperature	testo 610	-10 to 50℃
Atmospheric pressure	testo 511	300-1200hPa

Table 1 List of equipment for measurement of ambient conditions

4.2 SAMPLING POINT

The sampling point was located more than 10 times the diameter of the exhaust pipe from the turbocharger and more than 3 times the pipe diameter from the exit of the exhaust system, according to common praxis.

4.3 MEASUREMENT PERFORMANCE

4.3.1 Engine Performance Data

The load points for the Main Engine was determined by attending MAN service engineer and based on the test bed report in consultation with algorithms developed by MAN. The Specific Fuel Oil Consumption were also determined by the custom made calculation sheet. (see Appendix C, Figure 1)

The fuel rack readings and calculation principles were witnessed by DNV and found to be reliable.

4.3.2 Ambient Condition

Temperature, air humidity and barometric pressure of the intake air were measured continuosly throughout the tests with portable equipment as described above (see 4.1.2).

4.3.3 Gaseous Emissions

The engine was kept at the load point of interest until thermal equilibrium was achieved before a data recording sequence of at least 10 minutes took place. The measurement and data recording of the gaseous emissions was done continuously. The values used in the calculations is a mean value of the last 75 seconds or more of the measurement sequence.

5 MEASUREMENT RESULTS

5.1 RESULTS

The calculation of the weighted NO_X -emission (g/kWh) calculated as follows according to "NO_X Technical Code 5.12.5.1":

$$GAS_X = \frac{\sum_{i=1}^{n} M_{GAS_i\,i} \cdot W_{F_i}}{\sum_{i=1}^{n} P_i \cdot W_{F_i}} [g/kWh]$$

Where
M_{GAS} = NO_X value [g/h]
W_F =Weighing factor [-]
P =Power [kW]
Power and Fuel consumption is based on calculations made by MAN Service Engineer. (see APPENDIX C).

Included is also the weighted NO_X -emission (kg/Ton fuel) is made in a spreadsheet done by "The Norwegian Maritime Directorate" (see APPENDIX A).

The NOx-emission presented in g/kWh is calculated with a reference charge air temperature equal to the measured temperature in air receiver according to DNV-praxis.
The NOx-emission presented in kg/Ton fuel is calculated with a reference charge air temperature of 25ºC according to guideline from the Norwegian Maritime Directorate. **/1/**

	Engine		Weighted Nox-Emission	
	Cycle	RPM	kg/Ton fuel	g/kWh
Main Engine before conversion.	E2	750	50,31	10,8
Main Engine after conversion	E2	750	36,66	8,1

Table 2 Calculated NOx-emission

5.1.1 Main engine before conversion.

Main Engine Running Condition E2-Cycle - before engine modification					
Load point	**100**	**75**	**50**	**25**	%
Engine speed	750	750	750	750	rpm
Engine Load	625	469	313	156	kW
Charge air pressure	119	76	48	21	kPa g
Charge air temperature	39	37	37	35	C
Measured values					
CO2	5,55	5,47	5,40	4,69	%
O2	13,00	13,10	13,17	14,18	%
CO	48	57	84	120	PPM
NOx	976	939	932	815	PPM
Ambient conditions					
Relative humidity	15,5	16,7	17,5	18,0	%
Temperature at air inlet	21,1	22,2	24,3	26,4	C
Barometric pressure at air inlet	101,87	101,85	101,80	101,82	kPa
Weighing factor	0,2	0,5	0,15	0,15	-
Result from calculations					
Calculated Nox-emission/kWh	10,51	10,59	11,43	12,89	g/kWh
Weighted NOx-emission/kWh	**10,8**				g/kWh
Calculated Nox-emission/Ton Fuel	50,42	49,78	50,56	51,68	kg/Ton
Weighted NOx-emission/Ton Fuel	**50,31**				kg/Ton

Table 3 Summary of measured values and calculated result for Main Engine before conversion

5.1.2 Main engine after conversion.

Main Engine Running Condition E2-Cycle - after engine modification					
Load point	**100**	**75**	**50**	**25**	%
Engine speed	749	748,8	749,5	749,7	rpm
Engine Load	630	468	326	179	kW
Charge air pressure	132,2	80,9	52,1	24,1	kPa g
Charge air temperature	43	39	38	40	C
Measured values					
CO2	5,68	5,65	5,61	5,27	%
O2	13,02	13,07	13,14	13,62	%
CO	68	86	106	161	PPM
NOx	741	705	669	566	PPM
Ambient conditions					
Relative humidity	30,7	32,3	31,9	31,5	%
Temperature at air inlet	25,0	24,3	23,6	23,0	C
Barometric pressure at air inlet	100,57	100,64	100,70	100,69	kPa
Weighing factor	0,2	0,5	0,15	0,15	-
Result from calculations					
Calculated Nox-emission/kWh	8,23	8,04	8,06	7,93	g/kWh
Weighted NOx-emission/kWh	**8,1**				g/kWh
Calculated Nox-emission/Ton Fuel	38,87	37,5	35,71	31,85	kg/Ton
Weighted NOx-emission/Ton Fuel	**36,66**				kg/Ton

Table 4 Summary of measured values and calculated result for Main Engine after conversion

6 REFERENCES

/1/	Veiledning on NO_X -avgift Rev.10, by:Sjøfartsdirektoratet
/2/	NO_X Technical Code (2009 Edition) included in REVISED MARPOL ANNEX VI. Regulation for the Prevention of Air Pollution from Ships

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APPENDIX A-CALCULATIONS

SJØFARTSDIREKTORATET
Norwegian Maritime Directorate

Skjema for rapportering av kildespesifikk utslippsfaktor for skip

Antall sider	2

Målefirma

Kompetent aktør	Det Norske Veritas AS
Måling utført av	Anders Hansson
Dato	09/02/2011
Sted	Dale - Eikenes

Kontakt informasjon

Telefon	+4790896579
E-post	anders.hansson@dnv.com

Skip

Skipsnavn	Florøy
IMO nummer	6827606
Rederi	Fjord1

Kontaktinformasjon rederi

Kontaktperson	Sigfred Nøttingnes
Telefon	91133981
E-post	Sigfred.Nottingnes@fjord1.no

Måleutstyr

	Instrument		Kalibreringsgass	
Avgass	ID	Måleprinsipp	ID	sertifikatverdi
CO2	Horiba PG-250	Ndir	83268031-02-K-572017	9,8
CO	Horiba PG-250	Ndir	83268031-02-K-572017	451
NOx	Horiba PG-250	CLD	83268031-01-K572023	1222
Lufttemperatur	testo 610	Termistor		
Luftfuktighet	testo 610	Kapacitiv		

Dato 25/5-2011 ***Signatur***

MOTOR

	Nom. Effekt	Nom turtall	Applikasjon	Antall
MAN 6L23/30	625	750	Main	1

Drivstoff (MGO/HFO/LNG)	% H	% C	% S	% N	% O	Referanse
MGO	13,6	86,2	0,17	0	0	ISO 8178

Test syklus (E2/E3/D2)
E2

		1	2	3	4
DRIFTSPARAMETRE					
Lastpunkt	%	100	75	50	25
Turtall	rpm	750	750	750	750
Last	kW	625	469	313	156
Ladeluft trykk	kPa g	119	76	48	21
Ladeluft temp	C	39	37	37	35
Referansetemp ladeluftkjøler	C	25	25	25	25
MÅLTE VERDIER					
CO2	%	5,55	5,47	5,40	4,69
CO	ppm	48	57	84	120
NOx	ppm	976	939	932	815
Relativ luftfuktighet	%	15,5	16,7	17,5	18
Lufttemperatur	C	21,1	22,2	24,3	26,4
Barometrisk trykk	kPa	101,87	101,85	101,83	101,82
Ureaforbruk	l/h				
TILLEGGSINFORMASJON (for fartøy med SCR-anlegg)					
SFOC	g/kWh				
BEREGNINGSRESULTAT					
Metningstrykk omgivelser	kPa	2,50	2,68	3,04	3,44
Absolutt luftfuktighet Ha	g/kg	2,38	2,74	3,26	3,81
Korreksjon for vann i inntaksluft KW2		0,00381	0,00439	0,00522	0,00608
Korreksjonsfaktor for tørr til våt gass KWr2		0,98741	0,98743	0,98658	0,98611
Nox Korreksjon for luftfuktighet og temperatur Khd		0,86959	0,87961	0,88903	0,90349
Våt gass konsentrasjon					
CO2	%	5,48	5,40	5,33	4,62
CO	ppm	47,40	56,28	82,87	118,33
NOX	ppm	963,71	927,20	919,49	803,68
NOX korrigert	ppm	838,03	815,57	817,45	726,11
NOx	Kg/tonn fuel	50,42	49,78	50,56	51,68
Vekting		0,2	0,5	0,15	0,15

Vektet NOx utslipp	Kg/tonn fuel	50,31
Vektet Urea forbruk	l/h	0

SJØFARTSDIREKTORATET
Norwegian Maritime Directorate

Skjema for rapportering av kildespesifikk utslippsfaktor for skip

Antall sider	2

Målefirma

Kompetent aktør	Det Norske Veritas AS
Måling utført av	Håvard Bentsen
Dato	19/05/2011
Sted	Dale - Eikenes

Kontakt informasjon

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Skip

Skipsnavn	Florøy
IMO nummer	6827606
Rederi	Fjord1

Kontaktinformasjon rederi

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E-post	Sigfred.Nottingnes@fjord1.no

Måleutstyr

	Instrument		Kalibreringsgass	
Avgass	ID	Måleprinsipp	ID	sertifikatverdi
CO2	Testo 350 Maritime	Ndir	83268031-02-K-572017	9,8
CO	Testo 350 Maritime	Ndir	83268031-02-K-572017	451
NOx	Testo 350 Maritime	CLD	4836183-01-K-541353	1200
Lufttemperatur	testo 610	Termistor		
Luftfuktighet	testo 610	Kapacitiv		

Dato 25/5 - 2011 ***Signatur***

MOTOR	Nom. Effekt	Nom turtall	Applikasjon	Antall
MAN 6L23/30	625	750	Main	1

Drivstoff (MGO/HFO/LNG)	% H	% C	% S	% N	% O	Referanse
MGO	13,6	86,2	0,17	0	0	ISO 8178

Test syklus (E2/E3/D2)
E2

		1	2	3	4
DRIFTSPARAMETRE					
Lastpunkt	%	100	75	50	25
Turtall	rpm	749	748,8	749,5	749,7
Last	kW	630	468	326	179
Ladeluft trykk	kPa g	132,2	80,9	52,1	24,1
Ladeluft temp	C	43	39	38	40
Referansetemp ladeluftkjøler	C	25	25	25	25
MÅLTE VERDIER					
CO2	%	5,68	5,65	5,61	5,27
CO	ppm	68	86	106	161
NOx	ppm	741	705	669	566
Relativ luftfuktighet	%	30,7	32,3	31,9	31,5
Lufttemperatur	C	25	24,3	23,6	23
Barometrisk trykk	kPa	100,57	100,64	100,66	100,69
Ureaforbruk	l/h				
TILLEGGSINFORMASJON (for fartøy med SCR-anlegg)					
SFOC	g/kWh				
BEREGNINGSRESULTAT					
Metningstrykk omgivelser	kPa	3,17	3,04	2,91	2,81
Absolutt luftfuktighet Ha	g/kg	6,07	6,12	5,79	5,51
Korreksjon for vann i inntaksluft KW2		0,00967	0,00975	0,00923	0,00879
Korreksjonsfaktor for tørr til våt gass KWr2		0,96748	0,97219	0,97627	0,97982
Nox Korreksjon for luftfuktighet og temperatur Khd		0,90392	0,91224	0,90973	0,90094
Våt gass konsentrasjon					
CO2	%	5,50	5,49	5,48	5,16
CO	ppm	66,23	83,31	103,66	157,86
NOX	ppm	717,00	685,29	652,64	554,76
NOX korrigert	ppm	648,11	625,14	593,72	499,80
NOx	Kg/tonn fuel	38,87	37,50	35,71	31,85
Vekting		0,2	0,5	0,15	0.15

Vektet NOx utslipp	Kg/tonn fuel	36,66
Vektet Urea forbruk	l/h	0

APPENDIX B-CERTIFICATES

YARA YARAPRAXAIR

Sertifikat

26

Side 1 av 1

Kunde:		Sertifikat nr.:	Flaske vannvolum (l):	Flaskenummer:
DNV - Høvik		83268031-01-K-572023	10	K-572023
Kunde referanse:	**Kvalitetsklasse:**	**Anbefalt trykkregulator:**	**Flaskeventilgjenger:**	**Fylletrykk v/20°C (bar g):**
Bjørn Brekke	2	Ultraserien (SS)	DIN 477 No. 10	150

Komponenter	Bestilt sammensetning ppm-mol	Sertifisert sammensetning ppm-mol	Usikkerhet % relativ
NO	1200	1226	2
Nitrogen	Rest	Rest	

100 % LEL i luft (vol %):	Konfidens intervall:	Sporbarhet klasse 1:	Kondensasjonstemp. ved fylletrykk (°C)	Stabilitetstid (måneder):
	95 % (k=2)	SI-enhet for masse	< - 20	36
Laveste anbefalte brukstrykk (bar g):	**Anbefalt lager og brukstemp. (°C)**	**Spesielle opplysninger:**		
5	20			
For HMS datablad, se vår hjemmeside www.yarapraxair.com		**Ved mistanke om utkondensering må flasken lagres horisontalt ved romtemperatur i 14 dager, eller rulles horisontalt i 8 timer ved > 60 omdreininger/min før bruk.**		

Rjukan (Produksjonssted) 29-3-10 (Dato) Terje Svanheim (Ansvarlig)

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Telefax:
+47 24 15 64 29

YARA YARAPRAXAIR

Sertifikat

13

Side 1 av 1

Kunde:		Sertifikat nr.:	Flaske vannvolum (l):	Flaskenummer:
DNV Sertifisering AS		4836183-01-K-541353	10	K-541353
Kunde referanse:	**Kvalitetsklasse:**	**Anbefalt trykkregulator:**	**Flaskeventiltjenger:**	**Fylletrykk v/20°C (bar g):**
Bjørn Brekke	2	Ultraserien (SS)	DIN 477 No. 10	150

Komponenter	Bestilt sammensetning ppm-mol	Sertifisert sammensetning ppm-mol	Usikkerhet % relativ
NO	1200	1198	2
Nitrogen	Rest	Rest	

100 % LEL i luft (vol %):	Konfidens intervall:	Sporbarhet klasse 1:	Kondensasjonstemp. ved fylletrykk (°C)	Stabilitetstid (måneder):
	95 % (k=2)	SI-enhet for masse	< - 20	36
Laveste anbefalte brukstrykk (bar g):	**Anbefalt lager og brukstemp. (°C)**	**Spesielle opplysninger:**		
5	20			
For HMS datablad, se vår hjemmeside www.yarapraxair.com		**Ved mistanke om utkondensering må flasken lagres horisontalt ved romtemperatur i 14 dager, eller rulles horisontalt i 8 timer ved > 60 omdreininger/min før bruk.**		

Rjukan 8/6-09
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YARA PRAXAIR

Sertifikat

30

Side 1 av 1

Kunde:		Sertifikat nr.:	Flaske vannvolum (l):	Flaskenummer:
DNV - Høvik		83268031-02-K-572017	10	K-572017
Kunde referanse:	**Kvalitetsklasse:**	**Anbefalt trykkregulator:**	**Flaskeventilgjenger:**	**Fylletrykk v/20°C (bar g):**
Bjørn Brekke	2	Ultraserien (messing)	DIN 477 No. 10	150

Komponenter	Bestilt sammensetning ppm-mol	Sertifisert sammensetning ppm-mol	Usikkerhet % relativ
CO	450	451	3
CO2	10 mol %	10,0 mol %	2
Nitrogen	Rest	Rest	
Oksygen	10 mol %	10,0 mol %	2

100 % LEL i luft (vol %):	Konfidens intervall:	Sporbarhet klasse 1:	Kondensasjonstemp. ved fylletrykk (°C)	Stabilitetstid (måneder):
	95 % (k=2)	SI-enhet for masse	< - 20	36

Laveste anbefalte brukstrykk (bar g):	Anbefalt lager og brukstemp. (°C)	Spesielle opplysninger:
5	20	
For HMS datablad, se vår hjemmeside www.yarapraxair.com		Ved mistanke om utkondensering må flasken lagres horisontalt ved romtemperatur i 14 dager, eller rulles horisontalt i 8 timer ved > 60 omdreininger/min før bruk.

Rjukan 30/3-2010 Tor Morten Hammel

(Produksjonssted) (Dato) (Ansvarlig)

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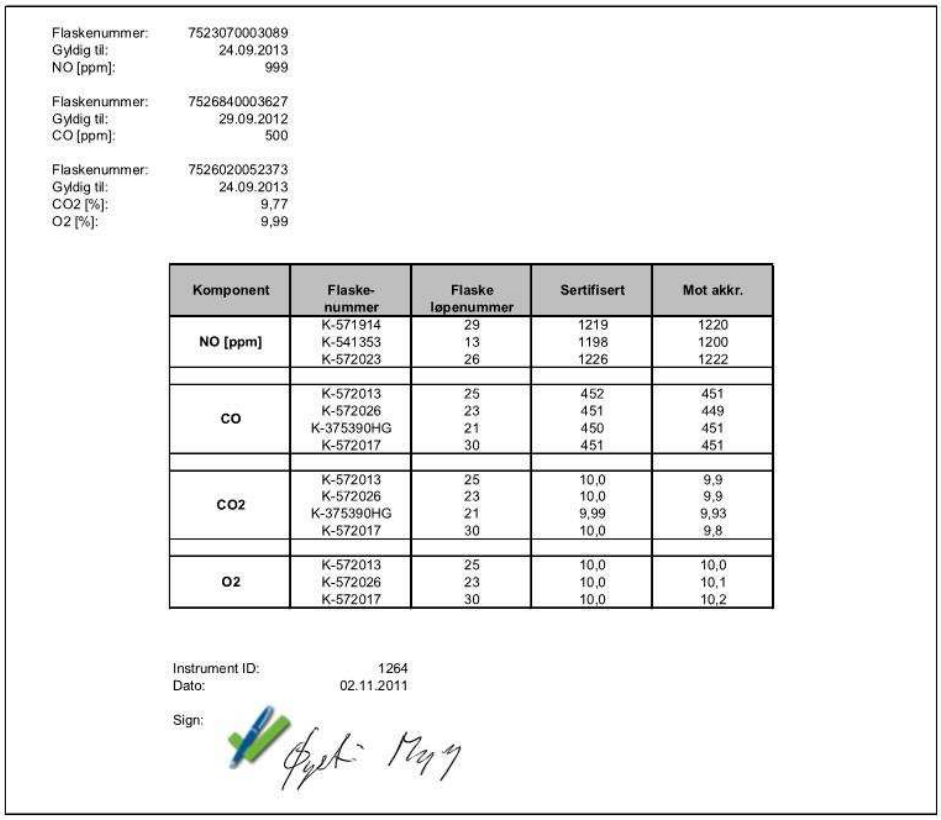


Flaskenummer: 7523070003089
Gyldig til: 24.09.2013
NO [ppm]: 999

Flaskenummer: 7526840003627
Gyldig til: 29.09.2012
CO [ppm]: 500

Flaskenummer: 7526020052373
Gyldig til: 24.09.2013
CO2 [%]: 9,77
O2 [%]: 9,99

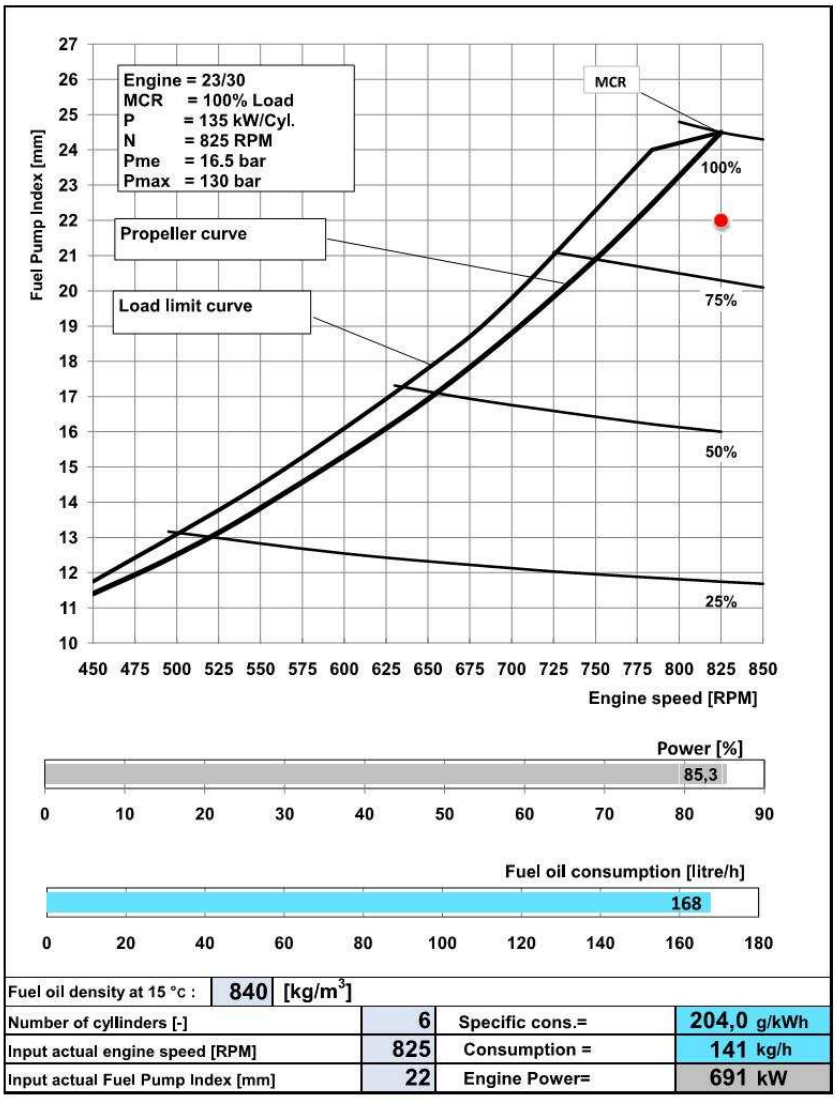
Komponent	Flaske-nummer	Flaske løpenummer	Sertifisert	Mot akkr.
NO [ppm]	K-571914	29	1219	1220
	K-541353	13	1198	1200
	K-572023	26	1226	1222
CO	K-572013	25	452	451
	K-572026	23	451	449
	K-375390HG	21	450	451
	K-572017	30	451	451
CO2	K-572013	25	10,0	9,9
	K-572026	23	10,0	9,9
	K-375390HG	21	9,99	9,93
	K-572017	30	10,0	9,8
O2	K-572013	25	10,0	10,0
	K-572026	23	10,0	10,1
	K-572017	30	10,0	10,2

Instrument ID: 1264
Dato: 02.11.2011
Sign:

Table 5 – Validation of gas-concentration to accredited gas.

APPENDIX C- SFOC AND TEST BED REPORT

MAN Diesel



Version 0 / John Andersen Operation
RPM-FuelIndex-forbrugskurve-2330-135.xlsm/05-03-2010

Figure 1 An example of MAN calculation sheet for estimation of power and SFOC.

MAN B&W Diesel A/S

SHOP TEST REPORT

MAN B&W DIESEL, Alpha Diesel

PLANT INFO	S-no: 5232 Engine no: 18039 Customer: FYLKESBAATANE I SOGN OG FJORDANE. Yard :

ENGINE INFO		TEST INFO	
Type	:6L23/30A-D	Test date	: 95.02.13
		Test stand no.	: 2
MCR power	: 625 kW	Tested by	:Orla Christensen
at	: 750 rpm		
Direct.of rotation	: CLOCKWISE	Fuel type	: MDO
Camshaft pos. A:	-0,50	Lower cal. value	: 42,82 MJ/kg
B:		Lub. oil type	: BP DS3-153
		Built-on pumps	: FW [X]
			SW [X]
			Bilge[ ]
			Fuel [X]
			L.O. [X]
			Other[ ]
Idle speed	: 500 rpm		
GEAR INFO		Waterbrake	: L 6
Type	:		
No.	:		
TURBOCHARGER INFO		**GOVERNOR INFO**	
Make -	: M.A.N. B&W	Make:	: Woodward
	191	Type:	: UG 8 L
Type	: NR 20/R~~188~~	Serial no.	: 2610360
Serial no.A-bank:	~~1181822~~ 11182160		
B-bank:		Compensation	: 4
Max. speed	: 44000 rpm	Overspeed adj.	: 1050 rpm
Max.temperature	: 550 °C		

REMARKS:

Approved by: [signature]

* Ny turbolader 11182160
monteret uge 37 1996

Alpha

MAN B&W Diesel A/S

Test date:95.02.13	SHOP TEST REPORT	Engine no: 18039
Test no: 1	MAN B&W DIESEL, Alpha Diesel	Engine type: 6L23/30A-D
Tested by:Orla Christensen		

Load, Power, Fuel		
Load:	%	100,0
Engine speed:	RPM	750
Propeller speed:	RPM	
Power engine:	kW	625
Power Gear flange:	kW	
Mean press:	bar	14,0
Fuel consump:	g/kWh	201,6
Fuel index (avrg.)	mm	20,9
Exhaust temp.(avrg.)	°C	298

Lub. oil		
Press. after filter:	bar	3,8
Temp., inlet:	°C	58
Temp., outlet:	°C	65

Instrument panel		
Lub.oil pres.bef.filter:	bar	4,2
Lub.oil pres.aft.filter:	bar	3,8
Fuel oil press.:	bar	1,8
Ch. air press.:	bar	0,90
Ch. air temp aft.cooler:	°C	
LT.cooling water press.:	bar	2,15
HT.cooling water press.:	bar	1,90

Turbocharger		A	B
Turbine, RPM:	RPM		
Turbine Exh.temp.outlet:	°C	325	
Temp. after compressor:	°C	108	
Ch. air cooler loss:	mmWc	69	
Exhaust back press.:	mmWc	58	
Ch.air.temp.after cooler:	°C	33	
Ch.air pressure:	bar	1,00	

Cooling system LT, HT			
LT.cooling water press.:	bar	2,15	
LT. Inlet air cooler:	°C	24	
LT. Outlet air cooler:	°C	25	
LT. Outlet, F.W. cooler:	°C	35	
HT. cooling water press.:	bar	1,90	
HT. cooling water inlet:	°C	76	
HT. cooling water outlet:	°C	77	
Crankcase pressure:	mmWc	6	

Ambient			
Fuel oil temp.:	°C	16	
Air inlet temp:	°C	22	
Barometric pressure:	mbar	1006	

	Cyl. no.	1	2	3	4	5	6	7	8	9
Fuel pump - Index [mm]	A-bank	20,5	21,0	21,0	21,0	21,0	21,0			
	B-bank									
Max. press. [bar]	A-bank	99	100	99	99	99	100			
	B-bank									
Comp. press. [bar]	A-bank	66	66	66	66	65	66			
	B-bank									
Exhaust temp. [°C]										
(Dial) (NiCr-Ni)	A-bank	290	310	300	300	290	300			
	A-bank									
(Dial) (NiCr-Ni)	B-bank									
	B-bank									

Page 1

Alpha

Figure 2: Test Bed Report.

APPENDIX D-CALIBRATION

	Zero Gas	Span Gas	Before measurements, 09/02-2011		Maximum Deviation
	PPM/%		Zero	Span	
O2	0	10.20*	0	10.20	0 %
CO2	0	9.80	0	9.80	0 %
NO	0	1222	0	1222	0 %
CO	0	451	0	451	0 %

	Zero Gas	Span Gas	After measurements, 09/02-2011		Maximum Deviation
	PPM/%		Zero	Span	
O2	0	10.20*	0.10	10.29	1 %
CO2	0	9.80	0.04	9.73	1 %
NO	0	1222	-1	1201	2 %
CO	0	451	4	457	1 %

	Zero Gas	Span Gas	Before measurements, 19/05-2011		Maximum Deviation
	PPM/%		Zero	Span	
O2	0	20.90	-0.1	20.90	0 %
CO2	0	9.80	0	9.84	0 %
NO	0	1200	0	1202	0 %
CO	0	451	0	447	1 %

	Zero Gas	Span Gas	After measurement completed, 19/05-2011		Maximum Deviation
	PPM/%		Zero	Span	
O2	0	20.90	-0.01	20.87	0 %
CO2	0	9.80	0.01	9.83	0 %
NO	0	1200	6	1185	1 %
CO	0	451	0	458	2 %

* See Part 4.

Table 6 Measured values from checks and calibration of equipment.

APPENDIX E– EQUIPMENT CERTIFICATE

testo

EG-Konformitätserklärung

Für das nachfolgend bezeichnete Produkt:

Messsystem testo 350 MARITIME

Measuring System (Set)
Control Unit
Analysis Box

Control Unit Seriennummer/Serial number: 1983716

Analysis Box Seriennummer/Serial number: 1987322

wird bestätigt, daß es der Richtlinie 96/98/EG über Schiffsausrüstung, in der geänderten Fassung Richtlinie 2009/26/EG entspricht.
Das Produkt wurde auf Einhaltung folgender Richtlinien und Prüfnormen geprüft:

Gemäß / as per:
Typ Prüfung (Modul B) Zertifikatsnummer /
Type Examination (Module B) certificate No.
Überwachungszertifikat-/Bericht (Modul D) Nr. /
Surveillance certificate/report (Module D) No.
Ausgestellt durch / Issued by
Diese Erklärung wird für:

EC declaration of conformity

We confirm that the following product:

measuring system testo 350 MARITIME

Best. Nr.: / Order No.: 0563 3500
Best. Nr.: / Order No.: 0563 3508
Best. Nr.: / Order No.: 0563 3509

complies with the Marine Equipment Directive 96/98/EC, as amended, last amended by Directive 2009/26/EC.

This equipment has been tested to verify compliance with the following Regulations and Testing standards:

Guidelines for Performance of Type Approvals, Chapter 2, Edition 2003 MARPOL Annec VI and NOx Technical Code; MEPC.103(49)

94366 – 10 HH

94414 – 10 HH

Germanischer Lloyd
This declaration is given in responsibility for:

Testo AG
Postfach / *P.O. Box* 1140
79849 Lenzkirch / Germany
www.testo.com

abgegeben durch / *by*:

Herr Walleser (Name) — *Mr. Walleser (name)*

Vorstand (Stellung im Betrieb des Herstellers) — *Managing Director (Position in the company of the manufacturer)*

Lenzkirch, 16.06.2010
(Ort, Datum / *place, date*)

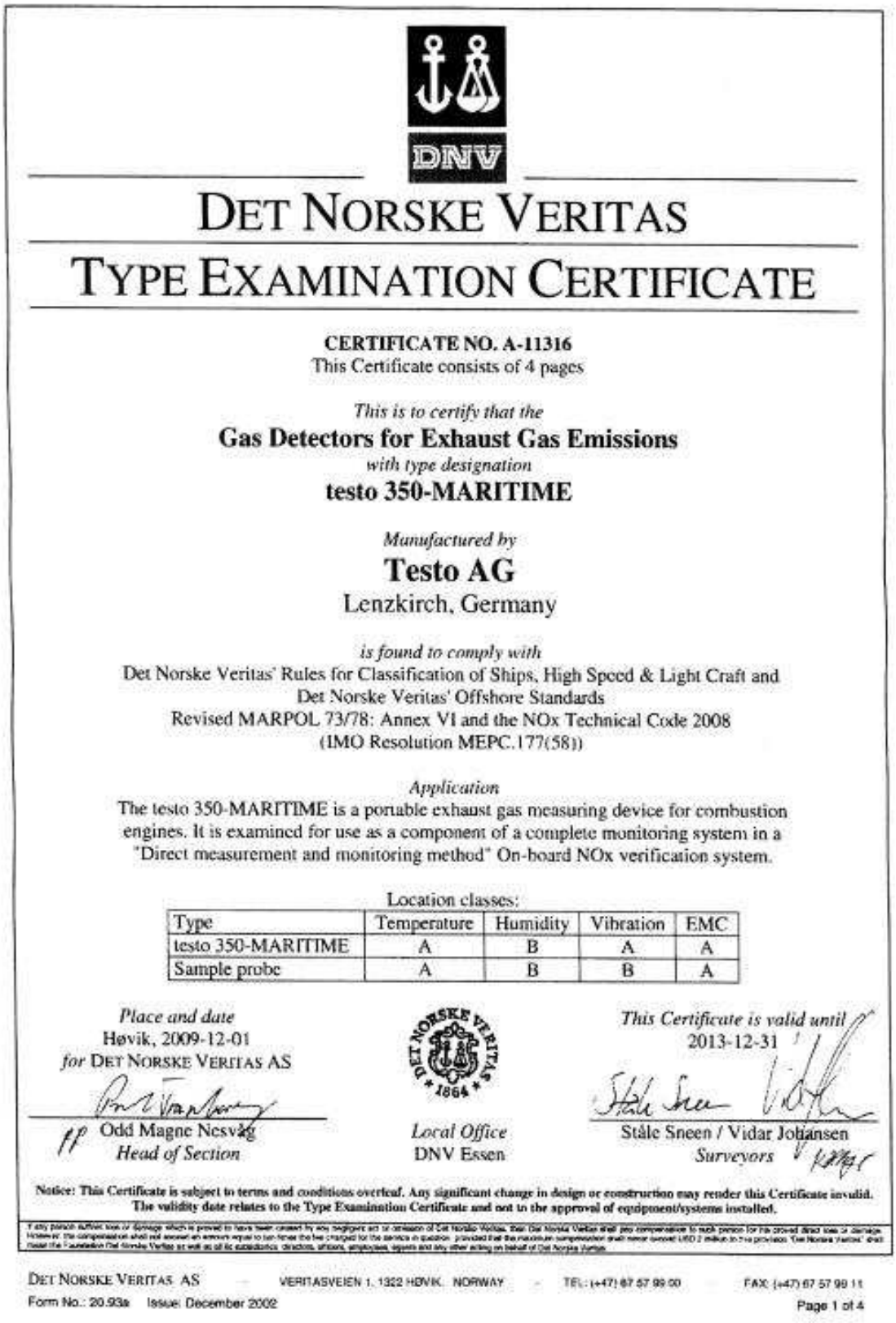
(Rechtsgültige Unterschrift / *Legally valid signature*)

ISO 9001 TESTO QUALITY certified

ein zertifiziertes Qualitätssicherungssystem nach DIN ISO 9001
The manufacturer operates a certified quality assurance system according to DIN ISO 9001

0098 Nummer der benannten Stelle die Zertifizierung durchführte/Notified Body number undertaking quality surveillance
0098/yy yy Letzten beiden Ziffern Jahreszahl Anbringung der Kennzeichnung/Last two digits of year in which the mark is affixed

0975 0030 de_en 01



DET NORSKE VERITAS

TYPE EXAMINATION CERTIFICATE

CERTIFICATE NO. A-11316
This Certificate consists of 4 pages

This is to certify that the
Gas Detectors for Exhaust Gas Emissions
with type designation
testo 350-MARITIME

Manufactured by
Testo AG
Lenzkirch, Germany

is found to comply with
Det Norske Veritas' Rules for Classification of Ships, High Speed & Light Craft and
Det Norske Veritas' Offshore Standards
Revised MARPOL 73/78: Annex VI and the NOx Technical Code 2008
(IMO Resolution MEPC.177(58))

Application
The testo 350-MARITIME is a portable exhaust gas measuring device for combustion engines. It is examined for use as a component of a complete monitoring system in a "Direct measurement and monitoring method" On-board NOx verification system.

Location classes:

Type	Temperature	Humidity	Vibration	EMC
testo 350-MARITIME	A	B	A	A
Sample probe	A	B	B	A

Place and date
Høvik, 2009-12-01
for DET NORSKE VERITAS AS

Odd Magne Nesvåg
Head of Section

Local Office
DNV Essen

This Certificate is valid until
2013-12-31

Ståle Sneen / Vidar Johansen
Surveyors

Notice: This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The validity date relates to the Type Examination Certificate and not to the approval of equipment/systems installed.

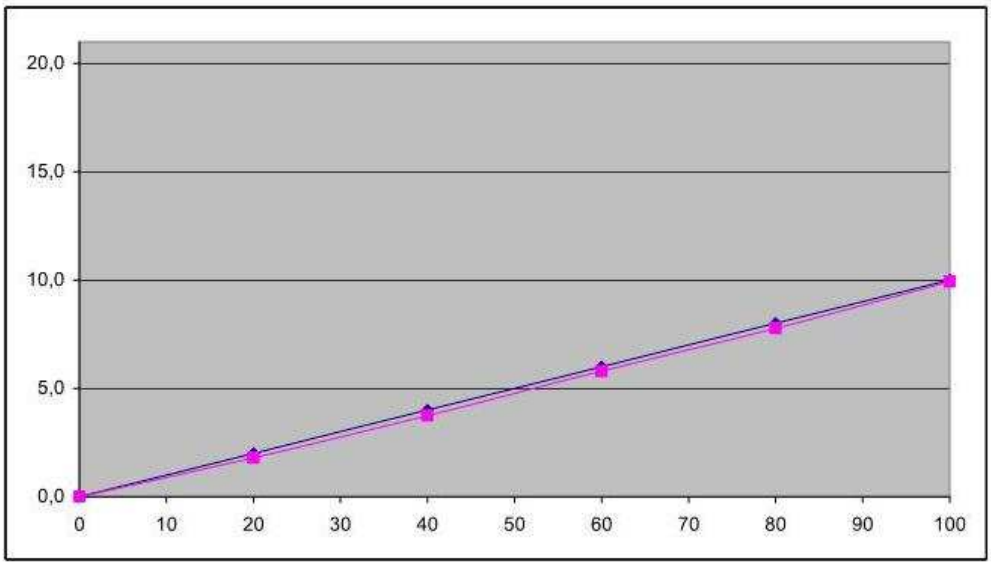
DET NORSKE VERITAS AS — VERITASVEIEN 1, 1322 HØVIK, NORWAY — TEL: (+47) 67 57 99 00 — FAX: (+47) 67 57 99 11
Form No.: 20.93a Issue: December 2002 Page 1 of 4

Figure 3: Certificate for Testo 350 Maritime

APPENDIX F–LINEARIZATION TEST

Instrument ID: 1002 **Range:** 25
Gass ID: 25
Parameter: O2

[%]	flaske [%]	avlest [%]	avvik [%]
0	0,0	0,00	0,0
20	2,0	1,80	-0,8
40	4,0	3,74	-1,0
60	6,0	5,80	-0,8
80	8,0	7,77	-0,9
100	10	9,93	-0,3
			-0,6

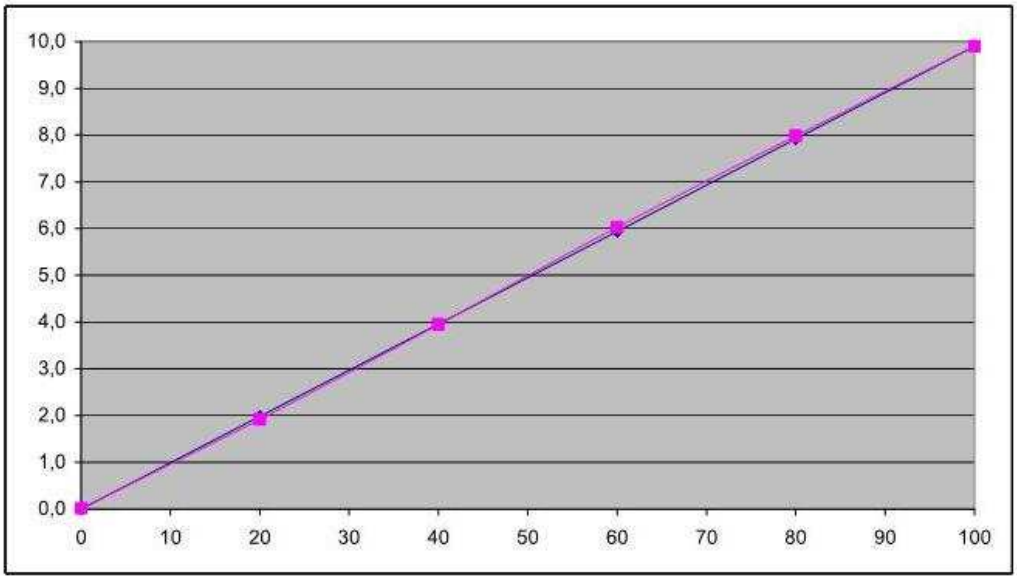


Dato: 15.11.2010
Sign:

Table 7 Linear test of measurement equipment (O_2)

Instrument ID: 1002 **Range:** 20
Gass ID: 25
Parameter: CO2

[%]	flaske [%]	avlest [%]	avvik [%]
0	0,00	0,02	0,1
20	1,98	1,92	-0,3
40	3,96	3,95	0,0
60	5,94	6,03	0,4
80	7,92	7,98	0,3
100	9,9	9,90	0,0
			0,1

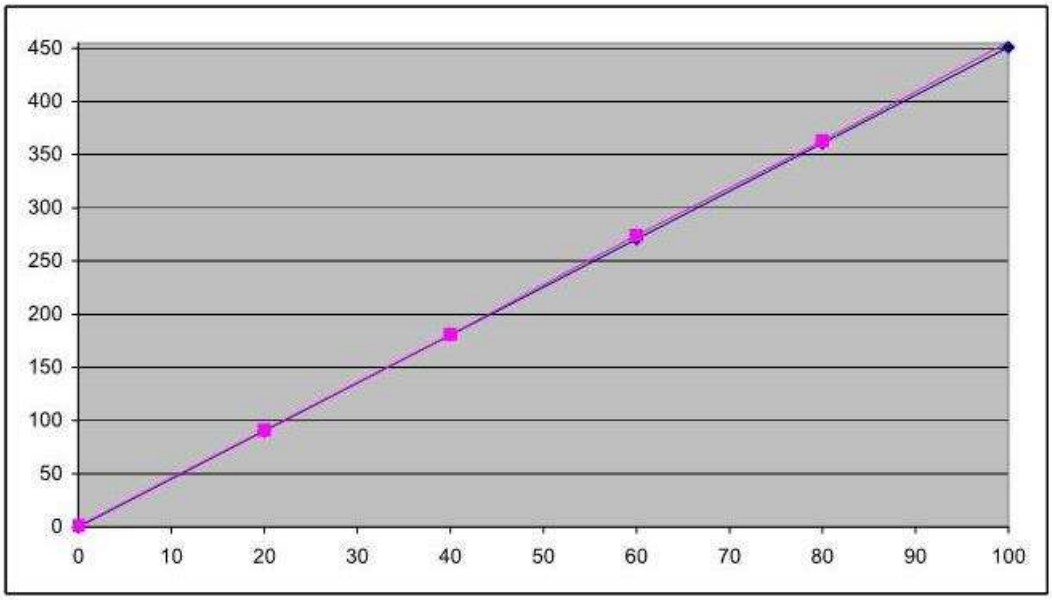


Dato: 15.11.2010
Sign:

Table 8 Linear test of measurement equipment (CO_2)

Instrument ID: 1002 **Range:** 1000
Gass ID: 25
Parameter: CO

[%]	flaske [ppm]	avlest [ppm]	avvik [%]
0	0	1	0,1
20	90	91	0,1
40	180	181	0,1
60	271	274	0,3
80	361	363	0,2
100	451	456	0,5
			0,2

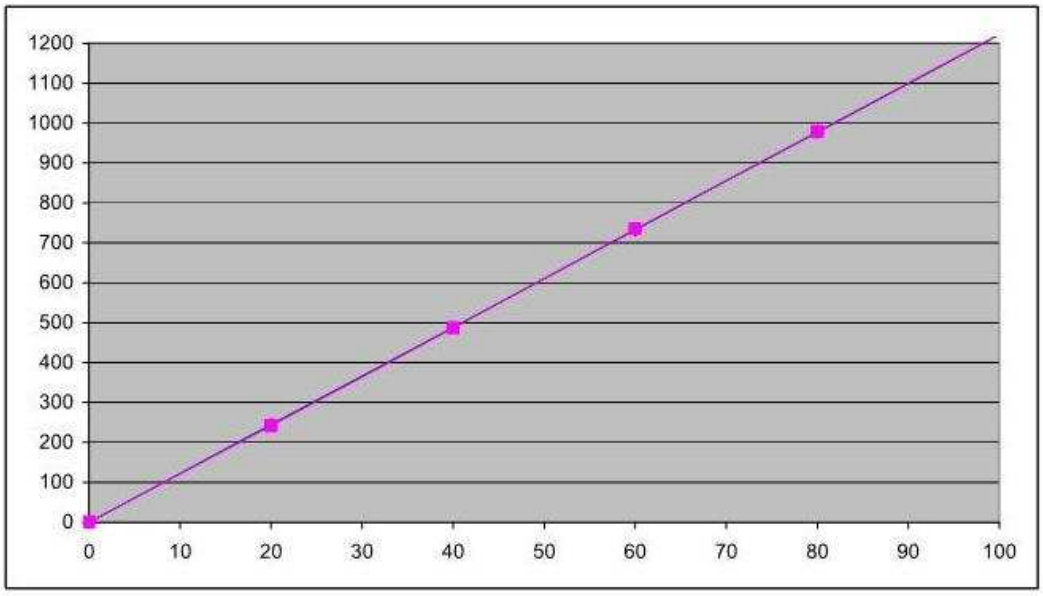


Dato: 15.11.2010
Sign:

Table 9 Linear test of measurement equipment (CO)

Instrument ID:	1002	**Range:**	2500
Gass ID:	26		
Parameter:	NO		

[%]	flaske [ppm]	avlest [ppm]	avvik [%]
0	0	1	0,0
20	244	242	-0,1
40	489	487	-0,1
60	733	735	0,1
80	978	979	0,1
100	1222	1223	0,0
			0,0



Dato: 15.11.2010
Sign:

Table 10 Linear test of measurement equipment (NO)