TÜV IMMISSIONSSCHUTZ
UND ENERGIESYSTEME GMBH

Translation of the report on the Suitability test of the Measuring System Oxymitter 4000 (with operator interface LOI) with automatic calibration system IMPS 4000 for the measured component O_2 of the company Emerson Process Management

TÜV-Report-No.: 936/21203476/A
Cologne, July 11, 2005

TÜV Immissionsschutz und Energiesysteme GmbH holds an accreditation under the terms of DIN EN ISO/IEC 17025 and DIN EN ISO 9002 in the following field of work:

- Determination of emissions and immissions of air pollutants and odorants;
- Verification of the correct installation and the function as well as the calibration of continuous operating emission measuring systems including systems for data evaluation and remote monitoring of emissions;
- Suitability testing of measuring systems for continuous monitoring of emissions and immissions as well as for electronic systems for data evaluation and remote monitoring of emissions

The accreditation is valid up to 04-12-2005.
DAR-Registration number: DAP-PL-3856.99.

OVERVIEW

The company Emerson Process Management has commissioned TÜV Immissionsschutz und Energiesysteme GmbH with the performance of a suitability test of the emission measuring system Oxymitter 4000 (with operator interface LOI) with automatic calibration system IMPS 4000 for the measured component O_2 according to the guidelines for continuous emission measurements [1].

The measuring system is a zirkonia-dioxide-probe with accompanying electronic evaluation unit. Within the scope of the suitability test, the tested version of the measuring system contains additionally a calibration system IMPS 4000, which allows an automatic adjustment of the measuring system.

The test work took place in the laboratory and during a field test with a duration of three months as an endurance test in a waste incineration plant. The tested measuring range was:

Component		Measuring range
Oxygen	O_2	0 - 25 Vol.-%

The minimum requirements have been fulfilled in the suitability test.

Therefore the TÜV Immissionsschutz und Energiesysteme GmbH proposes the publication as a suitability-tested measuring system for continuous monitoring of the reference quantity-oxygen content in the waste gas for plants, that are subject to licensing, and plants according to 27th BImSchV.

Akkreditiertes Prüfinstitut

DAP-PL-3856.99

Translation of the report on the Suitability test of the Measuring System Oxymitter 4000 (with operator interface LOI) with automatic calibration system IMPS 4000 for the measured component O_2 of the company Emerson Process Management

Tested measuring system:	Oxymitter 4000 (with operator interface LOI) with automatic calibration system IMPS 4000
Manufacturer of the instrument:	FROMEX S.A, de C.V. Fisher Regulators of Mexico -a division of Emerson Process Management- Avenida Industrias No. 6025 Parque Industrial Finsa Nuevo Laredo, Tamaulipas, Mexico 88275
Sales and service in Germany:	Emerson Process Management GmbH & Co. OHG Industriestraße 1 63594 Hasselroth Germany
Time period of testing:	December 2004 to July 2005
Date of report:	July 11, 2005
Number of report:	936/21203476/A
Scope of report:	altogether 313 pages appendix from page 76 manual from page 84 with 230 pages

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1.1 Summary of test results

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2.1	General requirements on measuring and evaluation systems for the determination of particulate and gaseous emissions				
2.1.1	General				
2.1.1.1	Normative references	Observation of the valid guidelines.	The suitability test was performed with attention to the mentioned guidelines.	fulfilled	27
2.1.1.2	Complete measuring system	The test must enclose the complete measuring system including the manual in German language.	The suitability-tested version encloses the complete measuring system, including sampling system, analysers, data output and manual in German language.	fulfilled	28
2.1.1.3	Fulfilment of the minimum requirements	Two identical measuring systems. Laboratory and three-months field test.	The laboratory test was successfully finished. The endurance test was performed at one single plant from April 11, 2005 to July 11, 2005.	fulfilled	29
2.1.1.4	Analytical function	Statistically secured correlation between instrument reading and reference method.	A statistically secured correlation between the reference method and the instrument reading could be proved.	fulfilled	32
2.1.1.5	Linearity	Deviation of the actual values from the nominal values of the device characteristic ≤ 2 % of measuring range.	Not appropriate in this case. Please refer to point 6 [2.4.1.8 Linearity].	-	38
2.1.1.6	Adjustment of settings	Protection against unauthorized or inadvertent maladjsutment of the measuring system.	The adjustment of the measuring device (operator interface LOI) is only possible with keys, activated through previous use of the arrow keys in the correct sequence "Z".	fulfilled	39
2.1.1.7	Position of zero-point (live zero-point)	Position of zero-point at 10 % or 20 %, position of reference-point at 70 % of full scale.	The position of the zero-point was set to 4 mA. The position of the reference-point can be adjusted to the measuring range with the choice of the concentration of the test gas.	fulfilled	40
2.1.1.8 2.1.1.9	Zero-point-drift in maintenance intervall Reference-point-drift in maintenance intervall	Zero-point drift, related to measuring range, ≤ 3 %. Reference-point drift, related to measuring range, ≤ 3 %.	Not appropriate in this case, because the requirements on the reference quantity O_2 are considered in point 6 [2.4.1.7 Drift in the maintenance interval].	-	41

Minimum requirement	Requirement	Test results	Evaluation	Page
2.1.1.10 Indicating range	Indicating range 1,5-times the limit value.	The indicating range of the tested measuring systems can be freely set between 0 – 40 Vol.-% O_2 at the measuring system with operator interface LOI.	fulfilled	42
2.1.1.11 Measured value output	Possibilities for connection of recording device.	The connection of further measuring and peripheral devices to the systems is possible over the corresponding connectors.	fulfilled	43
2.1.1.12 Status signals	Transmission of operating status through status signals stand-by, maintenance, malfunction.	The measuring system has got the required status signals.	fulfilled	44
2.1.1.13 Availability	Availability during suitability test ≥ 95 %.	The systems show an availability of 99,85 %. Thus they are clearly above the required value of 95 % within the scope of the suitability test. The number of the maximum generated, invalid half-hour-mean values because of the necessary control and adjustment works during normal operation, is below the maximum allowed number of invalid half-hour-mean values according the requirements on plants according to 13. BImSchV as well as according to 17. BImSchV.	fulfilled	45
2.1.1.14 Maintenance interval	Maintenance interval has to be determined and must be > 8 days.	The results of the drift investigations can be found under point 6 [2.4.1.7 Drift in the maintenance interval] in the report in hand. For device 85, there have been drift effects at the reference point of > 0,2 Vol.-% in a time period of 8 weeks after adjustment of the reference point with test gas. For device 84, there have been no drift effects > 0,2 Vol.% in a time period of 12 weeks. Thus there is a maintenance interval of 4 weeks for the tested measuring system.	fulfilled	47
2.1.1.15 Reproducibility RD	The reproducibility RD has to be determined from paired measurements.	The reproducibility RD was determined during the field test with two identical measuring systems in the smallest measuring range.	fulfilled	48

Minimum requirment	Requirement	Test results	Evaluation	Page
2.1.1.16 Nominal conditions of use	Requirements must be fulfilled under the nominal conditions of use according to DIN 43745 for a) Mains voltage b) Relative air humidity c) Content of liquid water in air d) Vibration.	Re a) For mains voltage fluctuations between 190 to 250 V, no influences on the measured signal bigger than 0,25 % of measuring range could be determined. Re b) The influence of air humidity was not investigated separately. Due to the design of the device, it has to be assumed, that it is insensitive to air humidity as long as the dew point is not fallen below. Re c) The analyser is protected against spray water, it should not be used unprotected at locations with liquid water in the air. Re d) During the endurance test, the instruments were exposed to the vibrations and shocks occuring at the point of measurement. No perceptible influences on the device function could be detected. As a precaution, the place of installation of the analyser should be as vibration-free as possible.	fulfilled fulfilled fulfilled fulfilled	49
2.1.1.17 Automatic readjustment	The maximum allowed range of correction has to be determined.	The functioning of the automatic readjustment of the measuring system was tested in the laboratory. It is functioning and delivers a status signal in case of exceeding the maximum allowed deviations.	fulfilled	51
2.1.1.18 Ambient temperature range	For outdoor installation: -20 to 50 °C, for installation at temperature-controlled sites: 5 to 40 °C.	Not appropriate in this case. Please refer to point 6 [2.4.1.4 Temperature drift].	-	52
2.1.1.19 Influence of sample gas flow rate	Influence on the measured signal < 1 % of indicating range.	The measuring system is operating directly in the duct.	not applicable	53
2.1.1.20 Excursion of measurement beam	For optical methods, maximum influence of 2 % of upper limit of measuring range on the measured signal in angle range of 0,3°.	The measuring system is not based on optical methods and determines the content of oxygen in the waste gas spot-related.	not applicable	54

Minimum requirement	Requirement	Test results	Evaluation	Page
2.1.1.21 Soiling check	For optical methods, soiling check during operation	The measuring system is not based on optical methods and determines the content of oxygen in the waste gas spot-related.	not applicable	55
2.1.1.22 Automatic recording of zero-point and reference-point	Measuring systems shall have an appliance for the automatic recording of zero and reference-point.	Not applicable, because the measuring system has no possibility for an automatic recording of zero-point and reference-point.	not applicable	56
2.1.1.23 Response time	The t_{90}-time has to be ≤ 200 s.	There are t_{90}-times of approximately 9 sec for the tested measuring systems. Thus the required t_{90}-time is met.	fulfilled	57
2.1.1.24 Multiple-component measuring systems	Requirements must be fulfilled for each single component.	The measuring system Oxymitter 4000 only determines O_2.	not applicable	58
2.1.1.25 Digital interface	Digital interface must be completely described in the relevant standards and guidelines.	Not applicable, because there is still no authorized digital interface.	not applicable	59
2.1.1.26 Measurement uncertainty	Determination of extended measurement uncertainty according to DIN EN ISO 14956, comparison with laid down requirements.	As there are no total uncertainties laid down for reference quantities to this day, this test point is not applicable.	not applicable	60
2.2 Additional requirements on measuring systems for the determination of dust-like emissions				
not applicable in this case				
2.3 Additional requirements on measuring systems for the determination of gaseous emissions				
not applicable in this case				
2.4 Additional requirements on measuring systems for the determination of reference quantities				
2.4.1 Measuring systems for the determination of the oxygen content				
2.4.1.1 Availability	Availability during the suitability test ≥ 98 %	The devices show an availability of 99,85 %. Thus they are clearly above the required value of 98 % for oxygen within the scope of the suitability test.	fulfilled	61
2.4.1.2 Detection limit	≤ 0,2 Vol.-% O_2	For the measuring systems, detection limits of 0,06 Vol.-% O_2 and 0,04 Vol.-% O_2 were determined	fulfilled	62
2.4.1.3 Reproducibility R_D	Reproducibility R_D ≥ 70	The reproducibility R_D was determined for the measuring range 0 to 25 Vol.-% O_2. There resulted a value of 177.	fulfilled	63

Minimum requirement	Requirement	Test result	Evaluation	Page
2.4.1.4 Temperature drift	Change in zero-point and reference-point reading ≤ 0,5 Vol.-% O_2 , based on 20 °C over the complete temperature range	Two devices of the type Oxymitter 4000 were exposed to temperature fluctuations between - 20 °C und + 50 °C in a climate chamber. There have been deviations of at maximum -0,07 Vol.-% O_2 at the zero-point and deviations of at maximum -0,48 Vol.-% O_2 at the reference-point.	fulfilled	65
2.4.1.5 Cross-sensitivity	The sum of cross-sensitivities has to be ≤ 0,2 Vol.-% O_2 .	Within the scope of this test, minor effects on the measuring systems could be detected. For device 84 a maximum cross-sensitivity of 0,05 Vol.-% O_2 was determined and for device 85 -0,08 Vol.-% O_2, each at the reference-point. At the zero-point no adequate effects could be detected. Thus the cross-sensitivities are below the maximum allowed cross-sensitivity of von 0,2 Vol.-% O_2 .	fulfilled	67
2.4.1.6 Sampling	Proper solid filtration, entrainement effects avoided to a great extent.	The measuring system is operating directly in the duct. Effects on the surfaces on the measured signal were not noticed.	fulfilled	69
2.4.1.7 Drift in the maintenance interval	≤ 0,2 Vol.-% O_2	The zero-point drift was for both candidates at no point of time of the field test larger than 0,10 Vol.-% O_2. The reference-point drift for device 84 was less than 0,2 Vol.-% O_2 during the test period. For device 85 the allowed range of drift was exceeded after 8 weeks, which means that the reference-point had to be re-adjusted at that point.	fulfilled	70
2.4.1.8 Linearity	Deviation of the actual values from the nominal values of the device characteristic ≤ 0,3 Vol.-% O_2	The linearity was checked for the measuring range 0-25 Vol.-%. No deviations larger than - 0,20 Vol.-% could be found.	fulfilled	72

1.2 Proposal for declaration of suitability

Due to the positive achieved results, the following recommendation for declaration of suitability as suitability-tested measuring system is given:

1.2.1	**Measurement task**	**:**	Determination of the reference quantity O_2 in waste gas
1.2.2	**Name of device**	**:**	Oxymitter 4000 with automatic calibration system IMPS 4000
1.2.3	**Measured components**	**:**	O_2
1.2.4	**Manufacturer**	**:**	FROMEX S.A. de C.V., Nuevo Laredo, Mexico
1.2.5	**Suitability**	**:**	For plants, that are subject to licensing, and for plants according to 27th BImSchV
1.2.6	**Measuring ranges in the suitability test**	**:**	**Component** / **Measuring range** Oxygen O_2 0 - 25 Vol.-%
1.2.7	**Software version**	**:**	- Version 5.01 B
1.2.8	**Restrictions**	**:**	-
1.2.9	**Remarks**	**:**	1. The measuring system is also distributed by ROSEMOUNT Analytical. 2. The oxygen content is measured in wet waste gas. 3. The device can be operated with or without the automatic calibration system IMPS 4000, which controls the offering of test gases. 4. It was tested the device configuration with operator interface LOI.
1.2.10	**Test institute**	**:**	TÜV Immissionsschutz und Energiesysteme GmbH, Köln TÜV Rheinland Group
1.2.11	**Test report**	**:**	936/21203476/A of July 11, 2005

2 Terms of reference

2.1 Kind of testing

On behalf of the company Emerson Process Management, TÜV Immissionsschutz und Energiesysteme GmbH performed a suitability test according to the guidelines for continuous emission measurements [1] for the measuring system.

2.2 Objective

The operative range of the measuring device is primarily the monitoring of emissions in the cleaned-up gas as well as in the raw gas; the use for process controlling is possible, too. The measuring range

Component		Measuring range	
Oxygen	O_2	0 - 25	Vol.-%

was tested.

3 Description of the tested system

3.1 Measuring principle

The measuring system Oxymitter 4000 determines the oxygen content in waste gases. The oxygen measuring cell, that is installed in this measuring system, is a zirkonia-dioxide-measuring cell. The working principle of this measurement is described in the following.

The oxygen measuring cell of the measuring system Oxymitter 4000 is working according the zirkonia-dioxide principle. Here it is made use of the fact, that zirkonia-dioxide, if it is hot, becomes an electric conductor because of the arising mobility of the oxygen ions in its crystal lattice.

If the ceramic oxide-ion-conductor is sintered to a total gasproof body, it is possible with that, by putting up porous layers of noble metal on opposite surfaces of such a body, to produce galvanic cells, suitable for oxygen measurement. The cell voltage U is hereby the difference of the inner electric potentials between the left and the right end phase of the galvanic cell.

At constant temperature, the output signal of the cell is calculated as follows:

Equation 1: $$U = \frac{R \cdot T}{4 \cdot F} \cdot \ln \frac{P2}{P1} + C$$

with:

with:	U	:	cell voltage
	P1	:	partial pressure of oxygen of measured gas on one side of the cell (e. g.: side of waste gas),
	P2	:	partial pressure of oxygen of reference gas on the other side of the cell (e.g.: instrument or ambient air),
	R	:	gas constant,
	F	:	Faraday's constant,
	T	:	absolute temperature in K,
	C	:	cell constant.

The reference gas is instrument or ambient air. If there are different oxygen contents on measurement side and reference side of the measuring cell, there is a wandering of oxygen ions from the higher to the lower partial pressure side. The output signal of the cell is inversely proportional to the oxygen content of the measured gas. If the oxygen content in the measured gas decreases, then the respective signal of the measuring cell increases.

On condition that the total pressures of the gases at both electrodes are the same (in this case calculations can be done with volume concentrations instead of partial pressures), the equation for the determination of the oxygen concentration results after inserting the numerical values for the constants in equation 1.

Equation 2: $$O_2 = O_{2*} \cdot e^{\left(\frac{U-c2}{c1 \cdot T}\right)}$$

with:

O_2	:	oxygen concentration in the measured gas in Vol.-%
O_2*	:	oxygen concentration in the reference gas in Vol.-%
U	:	difference of potential in mV
T	:	temperature of measurement in K
c1,c2	:	cell constants

3.2 Extent and set-up of the measuring system

The oxygen measuring system tested here consists on principle of a measuring probe with integrated evaluation and control unit (In-Situ O_2-Transmitter Oxymitter 4000) as well as optional an automatic calibration system IMPS 4000. The probe is installed directly in the waste gas stream and is directly connected to the evaluation and control unit.

Because of the direct connection of evaluation and control unit to the measuring probe, the installation of separate probe cables and electronic units is reduced to a minimum. The evaluation and control electronics fulfils among others the following tasks:

- Regulation of the temperature of the measuring cell on a constant temperature of approximately 736 °C
- Measuring and processing of the cell voltage and thermo couple signal of the probe
- Operator´s interface for the measuring system
- Display and output of measured value, status and errors
- Cyclic testing of the measuring cell
- Controlling of the calibration of the probe (manually or automatic combined with IMPS 4000)

For the tested version, the operation of the measuring system is performed with the following interface:

1. Operator interface (LOI Local Operator Interface)

   The operator interface is a blue, background-illuminated LCD display. The LOI has got an infrared LED source and detectors for each key, so that settings through the glass window are possible. There is the possibility of direct access to sensor values, input/output configurations, information on system parameters and status of device as well as the performance of a calibration.

Within the scope of the suitability test, the two candidates were operated with heated probes. The tested heated probes have got a second gas inlet, on which a known test gas for checking purposes and possible calibration can be offered. Thus an in-situ check of the sensor element is possible.

The measuring probe itself consists of the head of the probe, the flange of the probe, the probe with measuring cell and heating. In waste gases with high dust contents, the manufacturer additionally recommends the use of protection tubes.

The complete evaluation- and control unit of the measuring system is located in the head of the probe. All necessary output signals can be achieved here, too. The connection for test gas for the offering of calibration gases is located next to the connection for the reference air at the bottom directly in front of the head of the probe.

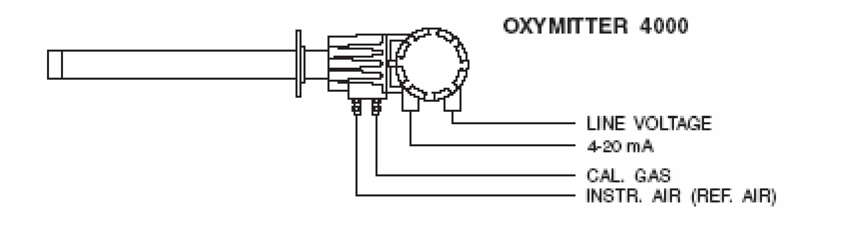

Figure 1 Basic configuration Oxymitter 4000

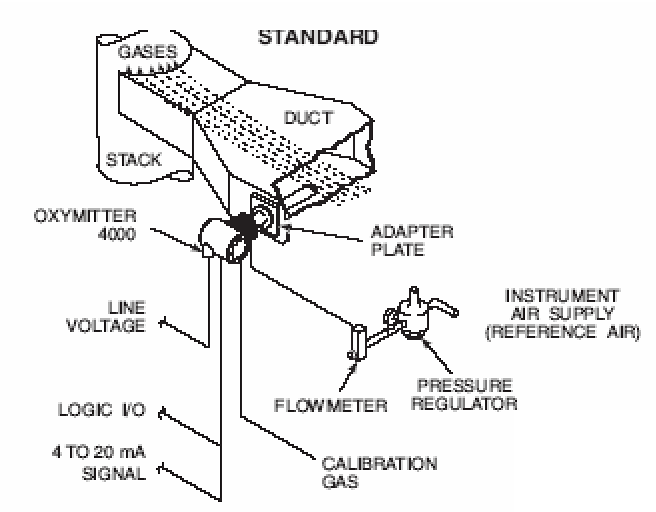

Figure 2: System installation Oxymitter 4000, standard

The calibration of the measuring systems can be done manually or half- respectively fully automatically by means of the calibration system IMPS 4000. The auto calibration system IMPS 4000 is controlled by SPS and has the capability of automatic calibration of up to 4 Oxymitter 4000. The connection with the Oxymitter is done via the Logic-I/O. Esentially, the auto calibration system IMPS 4000 consists of SPS, PC-Board, pressure reducer for instrument air, solenoid valves and pressure sensors fort he test gas connections.

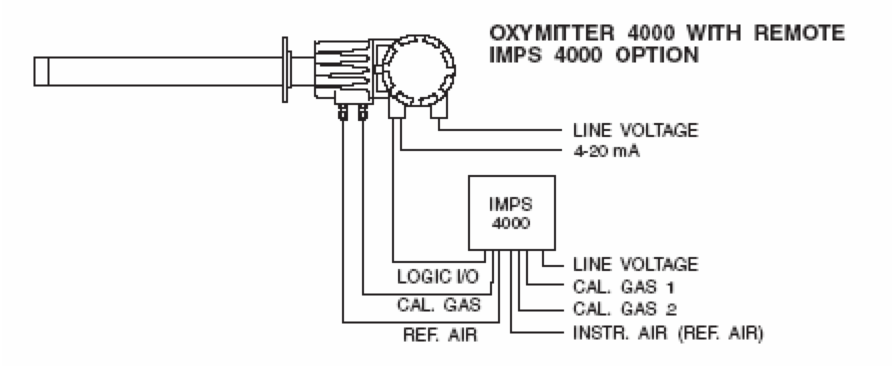

Figure 3: Configuration Oxymitter 4000 with IMPS 4000

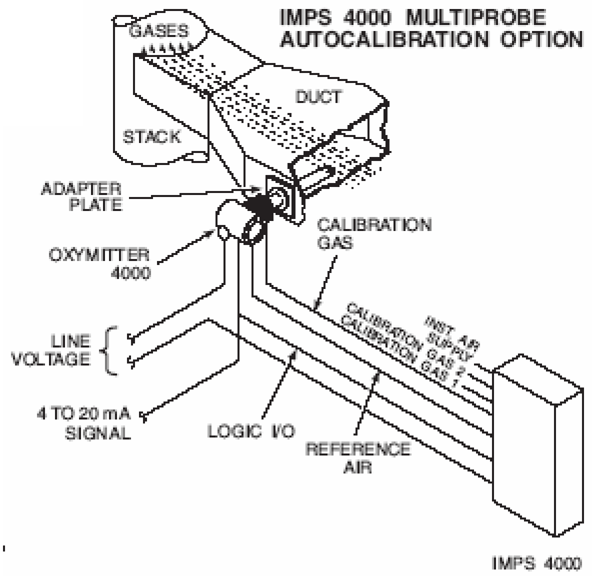

Figure 4: System installation Oxymitter 4000 with IMPS 4000

With the help of an operator interface, the software sequences, necessary for the calibration, can be programmed, e.g. introduction and course of time of the calibration. The digital information between the respective Oxymitter 4000 and the IMPS 4000 for the controlling of the calibration are interchanged via hand-shake procedure. For displaying respectively controlling the reference and calibration gas stream, the IMPS 4000 has got for each connected Oxymitter one flowmeter at a time. Pressure sensors in front of the calibration gas solenoid valves monitor, if there is sufficient pressure from the test gas bottles available. An automatic calibration can be controlled in three different ways:

1. time-controlled
2. via pressing the key directly at the Oxymitter 4000
3. if requested automatically, as soon as there is the demand for calibration present at the Oxymitter 4000

The auto calibration system IMPS 4000 was part of this suitability test. Furthermore the possibility of manual calibration was tested at the measuring system, too.

Figure 5 shows the measuring system Oxymitter 4000 with LOI-operator interface. In Figure 6 the calibration system IMPS 4000 is shown. Figure 7 shows the combination of Oxymitter 4000 (with LOI) with the automatic calibration system IMPS 4000.

Figure 5: Measuring system Oxymitter 4000 with operator interface LOI (2 times)

Figure 6: Calibration system IMPS 4000, cover opened

Figure 7: Oxymitter 4000 (with LOI) with IMPS 4000

4 Test program

4.1 Laboratory test

The laboratory test was carried out with two identical, complete devices of the type Oxymitter 4000 with the serial numbers:

Device 1:	Oxymitter 4000 with LOI	SN F-04003084 (short 84)
Device 2:	Oxymitter 4000 with LOI	SN F-04003085 (short 85)
as well as		
Device 1 & 2:	Automatic calibration system IMPS 4000	SN R-04002482

According to the guidelines [1], the following test program in the laboratory was established:

- Determination of the device characteristic with test gases,
- Determination of the cross-sensitivity of the measuring system against accompanying substances in the waste gas,
- Check of the stability of the zero-point and reference-point in the permissible ambient temperature range,
- Determination of changes in mains voltage on the measured signal,
- Check of the influence of relative air humidity, content of liquid water in the air, vibrations and mounting position.

4.2 Field test

The field test took place in the waste gas of a waste incinerator with two identical, complete devices of the type Oxymitter 4000. There were used the same systems as in the laboratory test.

The endurance test was carried out from April 11, 2005 until July 11, 2005. In the meantime, the devices were adjusted as follows:

Component		**Measuring range 1**	
Oxygen	O_2	0 - 25	Vol.-%

The measuring range has got an analogue output with 4 to 20 mA.

For the field test the following test program was established:

- Functional check of the general device functions,
- Functional check of the measuring systems at the beginning and at the end of the field test,
- Determination of the ability of calibration,
- Determination of the detection limit,
- Determination of lag and response time,
- Determination of reproducibility R_D,
- Determination of the drift behaviour at zero-point and reference point,
- Determination of maintenance interval,
- Determination of availability.

5 Reference method

5.1 Measuring method (continuous measuring methods)

Measured object:	Oxygen (O_2)
Measuring method / VDI guideline:	Paramagnetism / -
Analyser:	TÜV-Measuring system
Manufacturer:	Servomex OA 570A
Measuring range set:	0 – 25 Vol.-%
Device type suitability-tested:	yes
Measuring set-up:	O_2
Particle filter:	heated by waste gas
Suction probe:	heated
Sample gas line in front of gas preparation:	heated, 160 °C
Length:	3 m
Sample gas line behind gas preparation:	
Length:	2 m
Material of parts in contact with the sample gas:	Titanium, stainless steel and PTFE
Sample gas preparation:	Sample gas cooler
Manufacturer / Type:	M. & C. / PSS-5
Temperature adjusted to:	5 °C
Drying agent:	Silica gel
90%-response time of the complete measuring set-up in s:	< 15
Recording of measured values:	
with a measured value recorder (PC), manufacturer / type:	Yokogawa / DX100

5.2 Determination of general waste gas conditions

Differential pressure in the waste gas duct:	Müller Messinstrumente / MP6KSR
Static pressure in the waste gas duct:	Müller Messinstrumente / MP6KSR
Ambient pressure at the height of the sampling point:	Lufft, aneroid
Last check / calibration:	In each case before the measurements
Waste gas temperature:	NiCr-Ni-thermocouple , type K
Measuring device for temperature, manufacturer, type:	Kane May / KM 45
Humidity content in the waste gas (waste gas humidity):	Adsorption on silica gel with subsequent gravimetric determination.
Waste gas density:	ρ = 0,85 kg/m³, actual conditions, wet

The determination of the aforementioned general waste gas conditions was necessary to determine a representative measuring point for the comparison measurements according to VDI 4200.

5.3 Test gases

Used test gases for the adjustment of the devices (candidate and TÜV measuring systems) during the test:

(The mentioned test gases were used during the entire test and, if necessary, diluted with the help of a sample divider respectively a mass-flow-controller-station.)

Zero gas:	Nitrogen N_2
Test gas O_2:	2,04 Vol.-%
Number of test gas bottle:	366200
Manufacturer / date of manufacture:	Messer / December 29, 2004
Stability guarantee / certified:	36 months / yes
Check of certificate through / on:	TÜV laboratory / January 17, 2005
Rel. uncertainty according certificate:	± 2 %
Test gas O_2:	2,05 Vol.-%
Number of test gas bottle:	7864 C
Manufacturer / date of manufacture:	Messer / November 27, 2002
Stability guarantee / certified:	36 months / yes
Check of certificate through / on:	TÜV laboratory / December 18, 2002
Rel. uncertainty according certificate:	± 2 %
Test gas O_2:	17,90 Vol.-%
Number of test gas bottle:	A 7138
Manufacturer / date of manufacture:	Messer / August 20, 2003
Stability guarantee / certified:	36 months / yes
Check of certificate through / on:	TÜV laboratory / August 26, 2003
Rel. uncertainty according certificate:	± 2 %
Test gas O_2:	17,80 Vol.-%
Number of test gas bottle:	7869 H
Manufacturer / date of manufacture:	Air Liquide / September 14, 2004
Stability guarantee / certified:	36 months / yes
Check of certificate through / on:	TÜV laboratory / September 21, 2004
Rel. uncertainty according certificate:	± 2 %
Synthetic air:	20,50 Vol.-%
Manufacturer:	Messer

6 Test results

[2.1 General requirements on measuring and evaluation systems for the determination of particulate and gaseous emissions]

[2.1.1 General]

6 [2.1.1.1 Normative references]

6.1 Minimum requirement

The suitability test has to be performed with attention to Guideline series VDI 4203.

6.2 Equipment

The corresponding standards and guidelines were there during the test work.

6.3 Performance of test

The suitability test was performed with attention to the mentioned guidelines.

6.4 Evaluation

Not required for this minimum requirement.

6.5 Findings

Because of the observance of the mentioned guidelines during the test work, this minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.2 Complete measuring system]

6.1 Minimum requirement

The suitability test encloses the complete measuring or evaluation system, including sampling, sample preparation and data output. The manual of the manufacturer, which has to be available in German language, has to be included in the suitability test.

6.2 Equipment

Two complete and identical measuring systems of the type Oxymitter 4000 with automatic calibration system IMPS 4000.

6.3 Performance of test

The measuring systems and the manual were checked for completeness.

6.4 Evaluation

A specific evaluation is not necessary for this test point.

6.5 Findings

The suitability-tested version encloses the complete measuring system, including sampling system, analysers, data output and manual in German language. Thus the minimum requirement is fulfilled.

6.6 Presentation of test results

The tested measuring systems Oxymitter 4000 with automatic calibration system IMPS 4000 consists of the following parts:

- In-Situ O_2-Transmitter Oxymitter 4000, consisting of heated sampling probe + evaluation and control unit, operator interface LOI,
- Automatic calibration system IMPS 4000 (as option)
- Manual in German language.

Pictures of the measuring systems are shown in point 3.2.

6 [2.1.1.3 Fulfilment of the minimum requirements]

6.1 Minimum requirement

The fulfilment of the minimum requirements during the suitability test shall be proved with at minimum two identical complete measuring and evaluation systems during a laboratory test and a field test, which is lasting at least three months. The field test shall be performed wherever possible at one single test site during one uninterrupted time period. Only in cases of exception, shorter test periods of applications at different testing sites can be taken into account for the field test.

6.2 Equipment

Two complete identical measuring systems of the type Oxymitter 4000 with the serial numbers:

F-04003084 (short device 84) and F-04003085 (short device 85) for the laboratory and field test

as well as the automatic calibration system IMPS 4000 with the serial number

R-04002482 for the laboratory and field test.

For the continuous recording of the measured signals and the status signals, a data recording system of the type Yokogawa was used.

6.3 Performance of test

During the laboratory test, the following test program was established:

- Determination of the device characteristic with test gases,
- Determination of the cross-sensitivity of the measuring system against accompanying substances in the waste gas,
- Check of the stability of the zero-point and reference-point in the permissible ambient temperature range,
- Determination of changes in mains voltage on the measured signal.

The endurance test was performed over three months in the waste gas of a municipal waste incineration plant. The plant conditions can be characterised as follows:

Kind of plant:	Municipal solid waste incineration plant
Waste gas cleaning unit:	The plant consists of three incineration lines, each equipped with a spray cooler and an electrostatic precipitator for pre-cleaning of the waste gas. The waste gas of the three boilers is lead via an collecting bar to the waste gas cleaning unit, consisting of three lines. The waste gas cleaning lines consists each of a multistage scrubber, fabric filter with preceding injection of adsorbent and SCR-unit:
Mounting situation of the measuring devices:	The measuring locations are situated in a horizontally running, circular waste gas channel in front of the entering to the stack. The chosen measuring locations fulfil the requirements concerning the inlet and the outlet conditions stated in Guideline VDI 4200. The measurement cross-section is 2,27 m² at a diameter of 1,7 m. The measurement ports are situated lateral at the bottom side of the channel. The sampling point for both candidates is fixed due to the length of the sampling probes. The length of the probe during the suitability test was 3 ft = 91,4 cm. The sampling point for the comparison measurements was determined as a representative measuring point according Guideline VDI 4200 before the respective measurements.
General waste gas conditions: humidity: temperature: dust content:	 approx. 20 Vol.-% approx. 130 °C approx. < 5 mg/m³

6.4 Evaluation

The evaluation of the results of the laboratory and field tests are presented at the respective test points.

6.5 Findings

The laboratory test was successfully finished. The endurance test was performed at one single plant from April 11, 2005 to July 11, 2005. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Refer to the respective chapters of this report.

Figure 8: Installation of the candidates in field, view no. 1

Figure 9: Installation of the candidates in field, view no. 2

6 [2.1.1.4 Analytical function]

6.1 Minimum requirement

In the suitability test, the correlation between the instrument reading and the value of the measured quantity in the waste gas, obtained by a standard reference method – for example as mass concentration, volume concentration or volume flow – has to be determined by regression calculation (analytical function). Each measuring device must be supplied with a device characteristic, determined by the manufacturer. The device characteristic has to be checked against Guideline DIN EN 14 181 (August 2004).

6.2 Equipment

The calibration measurements were carried out with the instruments and methods according to point 5: Reference method of this report.

6.3 Performance of test

At the outset and in the end of the field test, comparison measurements with the reference method, described in point 5, were performed. For the check of the device characteristic, it is refered to point 6 [2.4.1.8 Linearity] of this report. The content of humidity in the waste gas was taken into consideration for the calculation of the calibration curves. The measuring device for comparison measurements operates with dry sample gas according the paramagnetic measuring principle with a preceding measured gas cooler. For the set up of the calibration curve, the measuring results of the measuring device for comparison measurement were refered to wet waste gas in standard condition

6.4 Evaluation

To determine the correlation between the results of the reference method and the instrument reading, a regression calculation according to Guideline VDI 3950 Sheet 1 was carried out. The results of this evaluation are described in Table 1 as well as in Figure 10 to Figure 13.

6.5 Findings

A statistically secured correlation between the reference method and the instrument reading could be proved. The requirements on the variability test according to Guideline DIN EN 14181 were not to be tested for the measured component oxygen, because no allowed total uncertainty has been laid down. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

The single values of the comparison measurements are presented in the appendix in Table 13 and Table 14.

Table 1: Results of the regression calculation between the candidates and the reference method fort he component oxygen, measuring range 0 - 25 % ≙ 4 - 20 mA

	Device 84		Device 85	
	Start of endurance test	End of endurance test	Start of endurance test	End of endurance test
Number of spot checks (incl. 3 zero-points)	18	18	18	18
Measuring range (arithmetical according calibration)	0 – 25,3	0 – 25,0	0 – 25,0	0 – 25,2
Arithmetical mean value of the measured values of the measuring system in mA	9,50	9,15	9,56	9,10
Arithmetical mean value of the measured values of the reference method in Vol.-%	8,70	8,04	8,70	8,04
Slope of the regression line in Vol.-% / mA	1,58	1,56	1,56	1,58
Ordinate intercept of the regression line in Vol.-%	-6,32	-6,25	-6,26	-6,30
Standard deviation of the regression line in Vol.-%	0.1	0,1	0,1	0,1
Correlation coefficient r	1,00	1,00	1,00	1,00

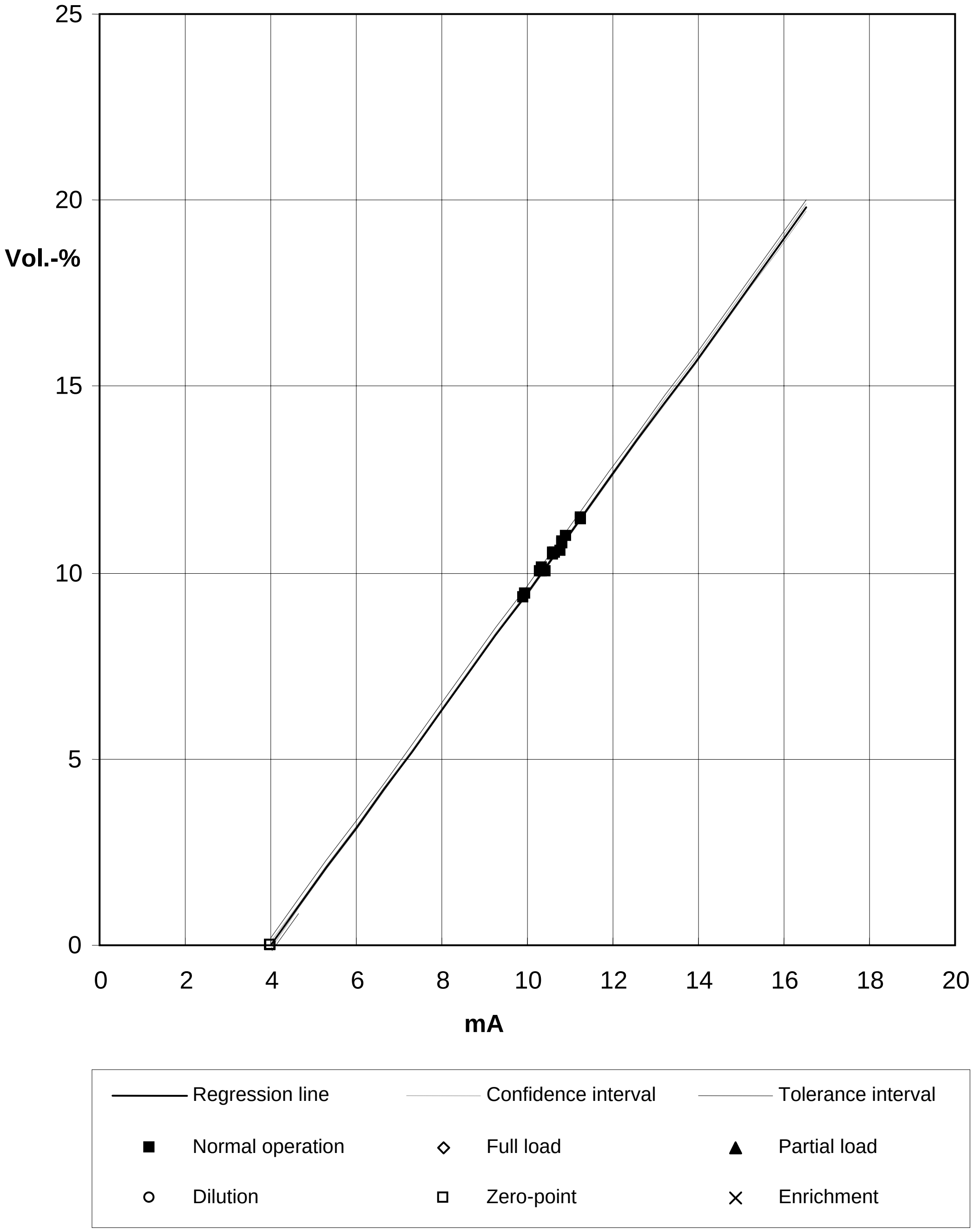

Figure 10: **Calibration curve (analysis function) for device 84 at the beginning of the field test for the component oxygen, measuring range 0 - 25 Vol.-% ≙ 4 - 20 mA**

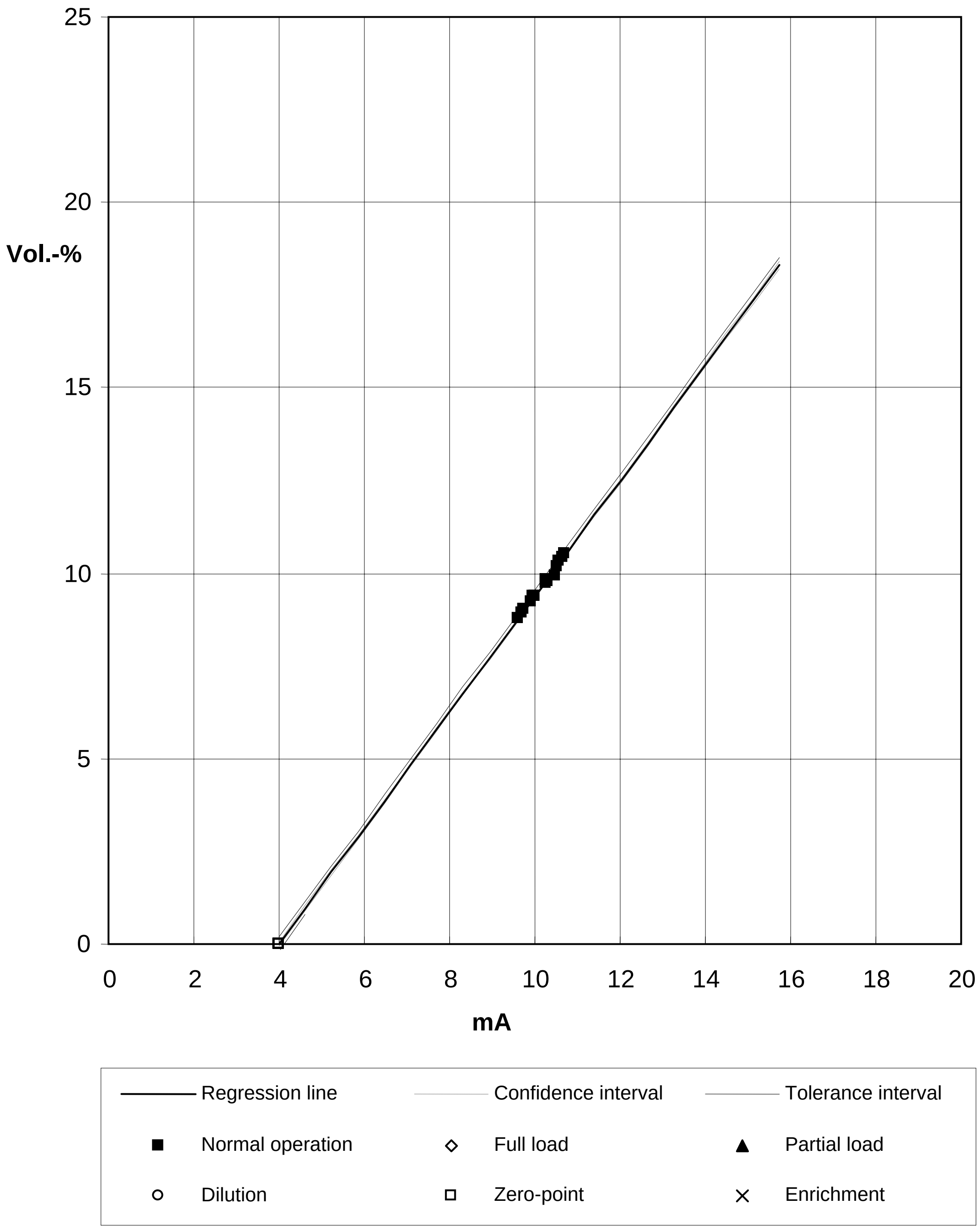

Figure 11: **Calibration curve (analysis function) for device 84 at the end of the field test for the component oxygen, measuring range 0 - 25 Vol.-% ≙ 4 - 20 mA**

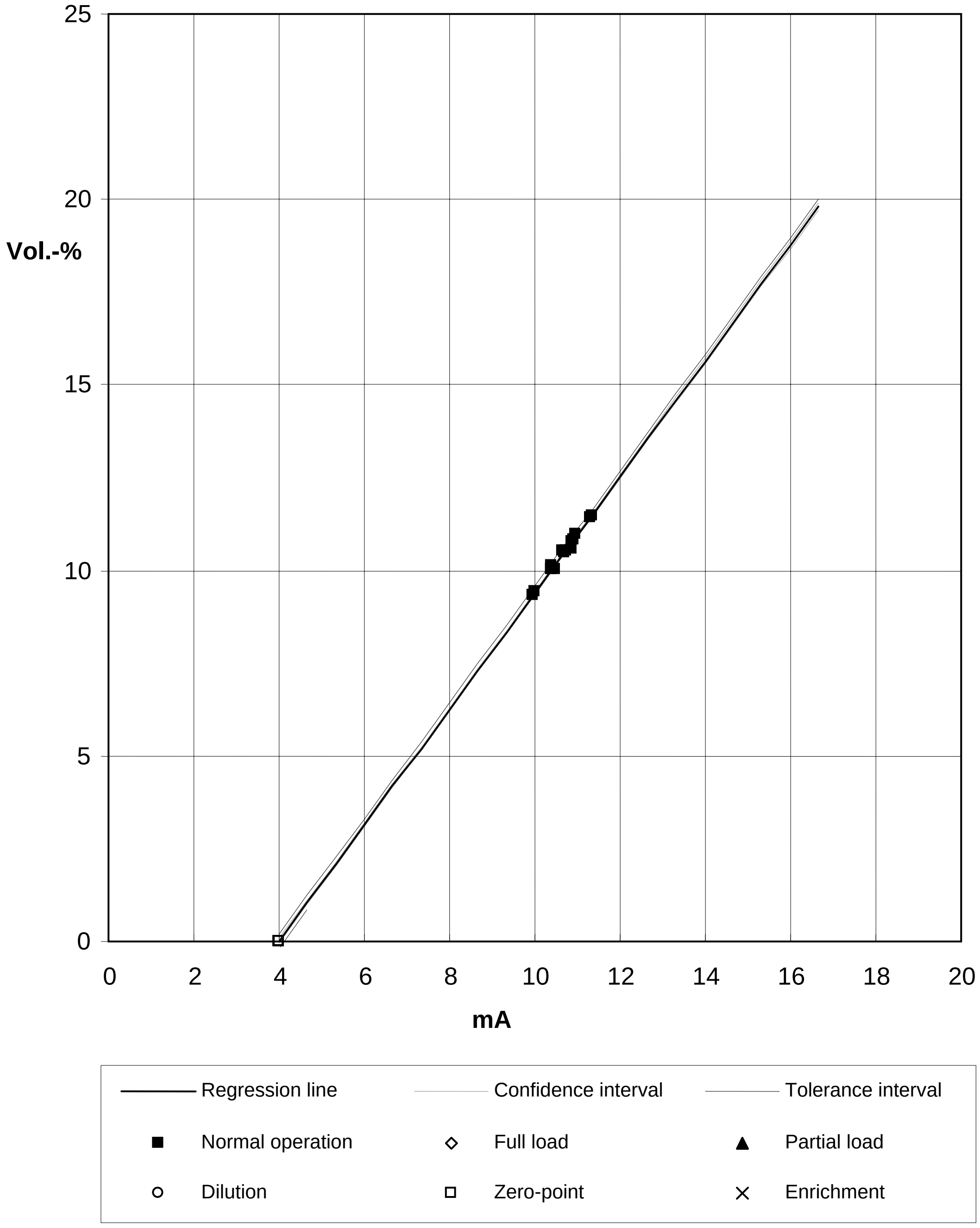

Figure 12: Calibration curve (analysis function) for device 85 at the beginning of the field test for the component oxygen, measuring range 0 - 25 Vol.-% ≙ 4 - 20 mA

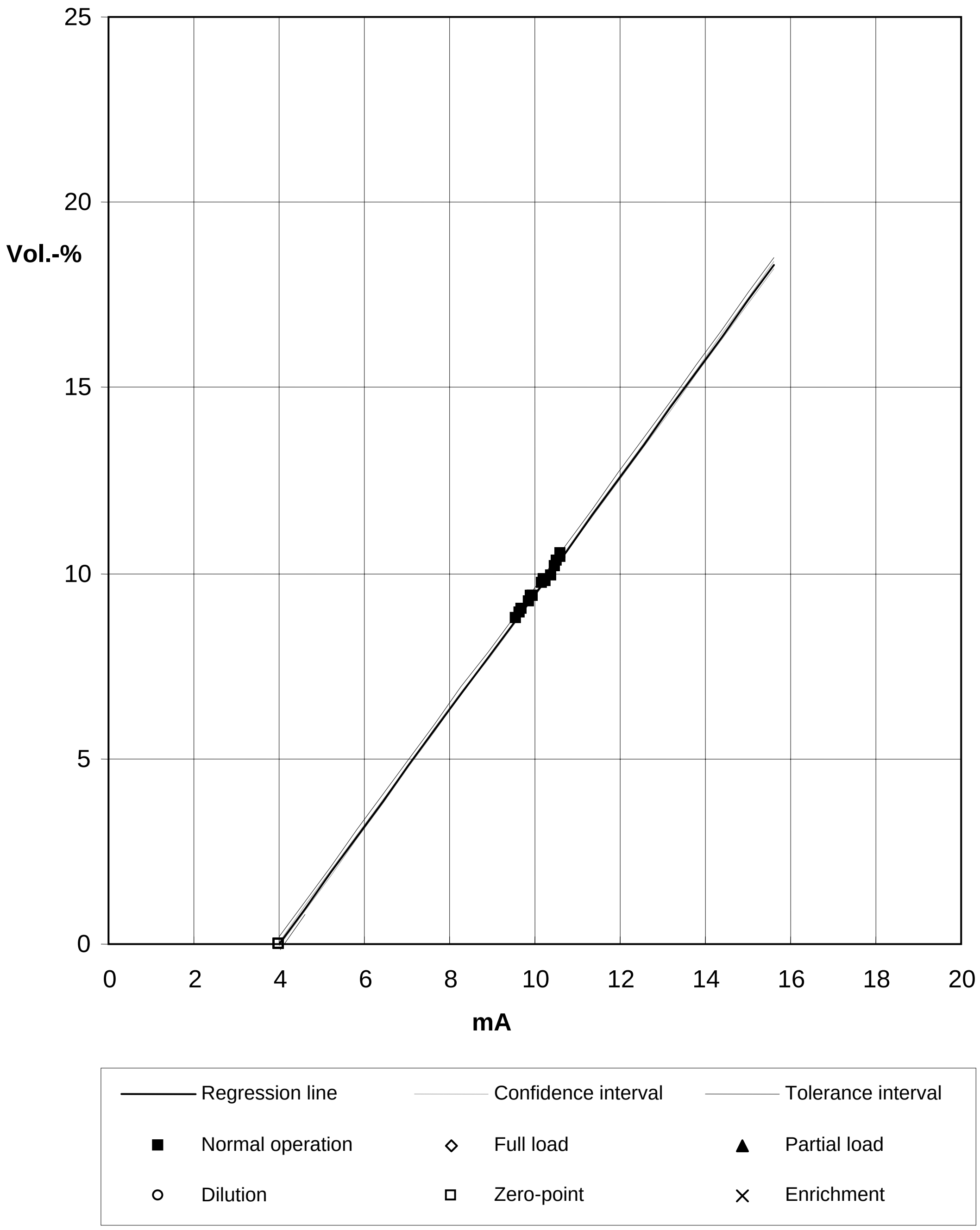

Figure 13: Calibration curve (analysis function) for device 85 at the end of the field test for the component oxygen, measuring range 0 - 25 Vol.-% ≙ 4 - 20 mA

6 [2.1.1.5 Linearity]

6.1 Minimum requirement

The amount of deviation of the actual values from the nominal values of the device characteristic, according to number 1.1.4 must not be more than ± 2 % of the upper limit of measuring range.

6.2 Equipment

Not appropriate in this case. Please refer to point 6 [2.4.1.8 Linearity].

6.3 Performance of test

Not appropriate in this case. Please refer to point 6 [2.4.1.8 Linearity].

6.4 Evaluation

Not appropriate in this case. Please refer to point 6 [2.4.1.8 Linearity].

6.5 Findings

Not appropriate in this case. Please refer to point 6 [2.4.1.8 Linearity].

6.6 Presentation of test results

Not appropriate in this case. Please refer to point 6 [2.4.1.8 Linearity].

6 [2.1.1.6 Adjustment of settings]

6.1 Minimum requirement

The adjustment of the measuring and evaluating systems shall possibly be protected against unauthorized or inadvertent maladjustment during operation.

6.2 Equipment

No additional equipment is necessary for the test of this minimum requirement.

6.3 Performance of test

The measuring system Oxymitter 4000 in the version with operator interface LOI is protected against unauthorized or inadvertent maladjustment as follows:
The LOI has a protection system (Lockout), which prevents an unintentional change of parameters. The protection system is automatically active, if no arrow key is activated for 30 s. To deactivate the lockout, the operator has to draw a „Z“, that means he has to press for first the upper left arrow key, then the upper right arrow key, then the lower left and finally the lower right arrow key. The message „LK“ in the upper right corner of the display disappears and the keys are unlocked.

6.4 Evaluation

Without the previous use of the arrow keys in the correct sequence („Z“) in order to activate the keys, the adjustment of the measuring system with operator interface LOI is not possible.

6.5 Findings

The adjustment of the measuring device (operator interface LOI) is only possible with keys, activated through previous use of the arrow keys in the correct sequence “Z”. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.7 Position of zero-point (live zero-point)]

6.1 Minimum requirement

The position of zero-point (live zero-point) of the instrument reading has to be at approximately 10 % or 20 %, the position of the reference-point at approximately 70 % of full scale.

6.2 Equipment

The test was performed with the described adjustment aids (zero gas/test gas). To record the analogue signal of the measuring system, a multimeter was used.

6.3 Performance of test

With the recording of the analogue signals during zero gas and test gas offering, it was checked, if the measuring range to be tested is set and meets the requirements.

6.4 Evaluation

The zero-point is with 4 mA at 20 % of the analogue output of the device. The reference-point is, corresponding to the offered test gas, at approximately 60 to 80 % of the instrument reading and the a-companying mA-value at the analogue output of the device.

6.5 Findings

The position of the zero-point was set to 4 mA. The position of the reference-point can be adjusted to the measuring range with the choice of the concentration of the test gas. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.8 Zero-point-drift in maintenance intervall]

6 [2.1.1.9 Reference-point-drift in maintenance intervall]

6.1 Minimum requirement

The amount of the change of the zero-point reading and the reference-point reading as a function of time
must not exceed at maximum ± 3 % of the upper limit of the measuring range during the maintenance interval.

6.2 Equipment

Not appropriate in this case, because the requirements on the reference quantity O_2 are considered in point 6 [2.4.1.7 Drift in the maintenance interval].

6.3 Performance of test

Not appropriate in this case, because the requirements on the reference quantity O_2 are considered in point 6 [2.4.1.7 Drift in the maintenance interval].

6.4 Evaluation

Not appropriate in this case, because the requirements on the reference quantity O_2 are considered in point 6 [2.4.1.7 Drift in the maintenance interval].

6.5 Findings

Not appropriate in this case, because the requirements on the reference quantity O_2 are considered in point 6 [2.4.1.7 Drift in the maintenance interval].

6.6 Presentation of test results

Not appropriate in this case, because the requirements on the reference quantity O_2 are considered in point 6 [2.4.1.7 Drift in the maintenance interval].

6 [2.1.1.10 Indicating range]

6.1 Minimum requirement

The measuring system has to be designed in that way, that the indicating range can be adjusted to the measuring task at hand. As a rule, the indicating range has to be 1,5 times the current emission limit value for the half hour mean value.

6.2 Equipment

No additional equipment is necessary for the test of this minimum requirement.

6.3 Performance of test

It was checked, if the desired measuring ranges, with regard to the measurement task, can be set at the measuring systems.

6.4 Evaluation

The indicating range of the tested measuring systems can be freely set between 0 – 40 Vol.-% O_2 at the measuring system with operator interface LOI.

6.5 Findings

The indicating range of the tested measuring systems can be freely set between 0 – 40 Vol.-% O_2 at the measuring system with operator interface LOI. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.11 Measured value output]

6.1 Minimum requirement

The measuring systems must have suitable measured value outputs, to which further display or recording systems can be connected.
If there is an analogue measured value output, it shall have a 20-mA loop with live zero-point at 4 mA.

6.2 Equipment

The test was performed with using a digital multimeter of the type Fluke 85.

6.3 Performance of test

The multimeter was connected to the analogue outputs of the measuring system. The test was performed with the comparison of the recorded measured signal with the nominal value during the test gas offering. During the complete test, the measured values were offered and recorded at the analogue outputs.

6.4 Evaluation

The recorded measured values correspond to the expected nominal values.

6.5 Findings

The connection of further measuring and peripheral devices to the systems is possible over the corresponding connectors. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.12 Status signals]

6.1 Minimum requirement

The measuring systems must be able to transmit their current operating status (stand-by, maintenance, malfunction) to a downstream evaluating system with a status signal.

6.2 Equipment

The available status signals were tested with the help of a digital multimeter.

6.3 Performance of test

The measuring system Oxymitter 4000 offers the following possibilities for status transmission:

1. In case of start-up or in case of malfunction, a signal with the choice of 3,5 mA or 21,6 mA can be generated at the analogue outputm Falle.
2. At the logic-I/O, different modes of output for alarm states can be configured.
3. In case that the logic-I/O is used for the connection of the automatic calibration system IMPS 4000, status signals concerning the status of calibration of the Oxymitter can be achieved over the status relay of the IMPS 4000. For this configuration, alarm messages can only be offered at the analogue output according to 1.

The operating status maintenance and malfunction were generated by an intervention in the measuring system. It was checked, if the respective status messages were correctly reported by the systems.

6.4 Evaluation

The status signals are correctly displayed over the corresponding relay contacts respectively the analogue output.

6.5 Findings

The measuring system has got the required status signals. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.13 Availability]

6.1 Minimum requirement

The availability of the measuring systems must be 95 % in the suitability test.

For measuring or evaluating systems for the application in plants according 13. BImSchV a statement has to be done, if these fulfil the availability according appendix II of 13. BImSchV, for the application in plants according 17. BImSchV a statement has to be done, if these fulfil the availability according Art. 11 Par. 11 of the Directive 2000/76/EG of the European Parliament and of the Council about the incineration of waste (ABl. of EC from 28.12.2000 No. L 33291, corrected by ABl. of 31.05.2001 No. L 145, P.52).

6.2 Equipment

During the field test, all measured values of the measuring systems were recorded with a data recording system of the type Yokogawa. Additional equipment was not required in this case.

6.3 Performance of test

The field test was performed from April 11, 2005 until July 11, 2005. This corresponds to a total time of 2178 hours.

External failures (power failure in the plant) run up to 1,5 hours in total. The measuring systems cannot be blamed for this. Therefore the total operating time is reduced to approximately 2176 hours.

Adjustment work at the measuring systems within the scope of the suitability test took up approximately 3,5 hours in total for each system.

No device failures were observed.

For the assessment of the availability according the requirements of 13. and 17. BImSchV, the demand of time for maintenance work in the maintenance interval was estimated and the corresponding outage time was calculated. This was compared to the requirements afterwards.

6.4 Evaluation

The total operating time was calculated from the difference between end time and start time of the field test. The evaluation was done on the basis of half-hour mean values by using the 2/3-rule, this means that device-internal cycles, which take less than 10 minutes of the integration time, will not be judged as outage times. During the field test, no corresponding cycles were activated.

The necessary control and adjustment works during normal operation lead to failures of at maximum 20 min at a piece (complete check of zero-point / reference-point + adjustment, if required (manually or auto calibration)). If these works are carried out on one day without interruption, there will be at maximum 1 invalid half-hour-mean value.

According to 13. BImSchV, a day will be considered as invalid, if there are more than 6 half-hour-mean values invalid because of malfunction or maintenance of the continuous measuring system.

According to Directive 2000/76/EG (relevant for plants according to 17. BImSchV), a day will be considered as invalid, if there are more than 5 half-hour-mean values invalid because of malfunction or maintenance of the continuous measuring system.

6.5 Findings

The systems show an availability of 99,85 %. Thus they are clearly above the required value of 95 % within the scope of the suitability test. The number of the maximum generated, invalid half-hour-mean values because of the necessary control and adjustment works during normal operation, is below the maximum allowed number of invalid half-hour-mean values according the requirements on plants according to 13. BImSchV as well as according to 17. BImSchV. Thus the minimum requirements is fulfilled.

6.6 Presentation of test results

Table 2: Availabilities during the field test

		Device 84	**Device 85**
Total operating time	min	130587	130587
Outage time			
Device-internal setting times	min	-	-
Device malfunctioning and repair	min	-	-
Maintenance, adjustment	min	202	202
Availability	**%**	**99,85**	**99,85**

During the field test, the following demand of time for control and adjustment works was determined:

Table 3: Overview on the demand of time for maintenance work (gas offering) in the field test

Measured component	Manual test gas offering at zero-point with 2,04 Vol.-% O_2	Manual test gas offering at reference-point with 17,9 respectively 17,8 Vol.-% O_2	Adjustment*
O_2	approx. 2 min	approx. 3 min	approx. 15** min / approx. 15** min
Maximum demand of time at a piece	**approx. 20 min**		

* Adjustment manually / auto calibration

** Consisting of 2 x 5 min purge time test gas, 1 x 3 min purge time process gas (at the end of the calibration) and approx. 2 min for intermediate times

The mentioned time periods cover the time period between the ending of normal measurement operation and the resumption of the normal measurement operation.

6 [2.1.1.14 Maintenance interval]

6.1 Minimum requirement

The maintenance interval for the measuring systems has to be determined and stated. The maintenance interval must be at least 8 days.

6.2 Equipment

During the field test all measured values of the measuring systems were recorded with the data recording systems of the type Yokogawa. No additional equipment was required in this case.

6.3 Performance of test

For the performance of test please refer to
point 6 [2.4.1.7 Drift in the maintenance interval].

6.4 Evaluation

For the evaluation of test please refer to
point 6 [2.4.1.7 Drift in the maintenance interval].

The maintenance interval results from the time period, in which the drift without correction does not exceed the allowed 0,2 Vol.-%.

6.5 Findings

The results of the drift investigations can be found under point 6 [2.4.1.7 Drift in the maintenance interval] in the report in hand. For device 85, there have been drift effects at the reference point of > 0,2 Vol.-% in a time period of 8 weeks after adjustment of the reference point with test gas. For device 84, there have been no drift effects > 0,2 Vol.% in a time period of 12 weeks. Thus there is a maintenance interval of 4 weeks for the tested measuring system. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

The individual results of the drift checks are described in Table 10 and Table 11 in point 6 [2.4.1.7 Drift in the maintenance interval].

6 [2.1.1.15 Reproducibility R_D]

6.1 Minimum requirement

The reproducibility R_D has to be determined from paired measurements and to be calculated according the following equation:

$$R_D = \frac{\text{Upper limit of measuring range}}{s_D \cdot t_{f;0,95}}$$

s_D: standard deviation derived from paired measurements,
$t_{f;0,95}$: student factor; statistical confidence 95 %.
The paired measurements have to be carried out with two identical, complete measuring systems simultaneously at the same measurement point. The reproducibility R_D must be determined in the smallest measuring range.

6.2 Equipment

The test was carried out with an electronic data recording system of the type Yokogawa.

6.3 Performance of test

During the field test, the analogue outputs of the measuring systems were recorded continuously by the data recording system.

6.4 Evaluation

The data, which had been recorded during the field test, were integrated in half-hour mean values and evaluated with the help of an Excel sheet. The detailed evaluation is described in point 6 [2.4.1.3 Reproducibility R_D].

6.5 Findings

The reproducibility R_D was determined during the field test with two identical measuring systems in the smallest measuring range. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

The results of the reproducibility R_D are described in point 6 [2.4.1.3 Reproducibility R_D].

6 [2.1.1.16 Nominal conditions of use]

6.1 Minimum requirement

The minimum requirements must be met under the following stated nominal conditions of use according to DIN EN 60539 (Version September 2002), nominal range of use II:

a) Mains voltage,
b) Relative air humidity,
c) Content of liquid water in air,
d) Vibration.

For the mounting position, the manufacturer has to lay down the tolerance limits.

6.2 Equipment

To check the dependence on mains voltage, a transformer with a control range from 190 V to 250 V was used. The measuring system Oxymitter 4000 operates with 230 V alternating current.

6.3 Performance of test

Re a)

To check the dependence on mains voltage, the measuring systems were operated with different mains voltages in the range of 190 V to 250 V in steps of 10 V and zero and test gas was offered at each step.

Re b-d)

Regarding the test points „relative air humidity“, „content of liquid water in air“ and „vibration“, the behaviour of the measuring system during the field test was assessed.

6.4 Evaluation

Re a)

The measured values at different mains voltages are related to the value, that is measured at the reference mains voltage of 230 V, and the deviations are determined.

6.5 Findings

Re a)
For mains voltage fluctuations between 190 to 250 V, no influences on the measured signal bigger than 0,25 % of measuring range could be determined.

Re b)
The influence of air humidity was not investigated separately. Due to the design of the device, it has to be assumed, that it is insensitive to air humidity as long as the dew point is not fallen below.

Re c)
The analyser is protected against spray water, it should not be used unprotected at locations with liquid water in the air.

Re d)
During the endurance test, the instruments were exposed to the vibrations and shocks occuring at the point of measurement. No perceptible influences on the device function could be detected. As a precaution, the place of installation of the analyser should be as vibration-free as possible.

The manufacturer does not specifically mention the mounting position of the analyser; it is defined by the design of the device. Within the scope of the test, the measuring system was operated upright standing as well as lying. An influence on the measured result was not observed and is not to expect.

Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Table 4 shows the results of the mains voltage tests.
The individual results of the mains voltage test can be found in the appendix in Table 16.
Regarding the other test points, the presentation of further results is not necessary.

Table 4: Influence of the mains voltage on the measured signal
Measured component O_2, Measuring range 0-25 Vol.-%
Deviation from 230 V in % of measuring range

	Measured component:		*O2*		*0*	*to*	*25*	*Vol.-%*
	Device 84				*Device 85*			
	Zero point		**Reference point**		**Zero point**		**Reference point**	
Mains voltage	**Reading*) in mA**	**Dev. in % measured range**	**Reading*) in mA**	**Dev. in % measured range**	**Reading*) in mA**	**Dev. in % measured range**	**Reading*) in mA**	**Dev. in % measured range**
230 V	5,31	-	15,45	-	5,30	-	15,46	-
220 V	5,31	-0,02	15,46	0,06	5,30	0,00	15,48	0,08
210 V	5,30	-0,04	15,47	0,08	5,28	-0,12	15,49	0,19
200 V	5,30	-0,04	15,47	0,10	5,29	-0,04	15,49	0,15
190 V	5,29	-0,12	15,49	0,23	5,27	-0,17	15,50	0,25
230 V	5,31	-	15,46	-	5,32	-	15,46	-
240 V	5,30	-0,02	15,47	0,04	5,30	-0,08	15,47	0,06
250 V	5,30	-0,06	15,49	0,17	5,30	-0,08	15,48	0,13

*) Mean value of three-time repetition

6 [2.1.1.17 Automatic re-adjustment]

6.1 Minimum requirement

For measuring systems with automatic functional check and re-adjustment, these functions must be included in the suitability test. The maximum allowed range of correction, in which a re-adjustment is possible, must be determined. If it is exceeded, a status signal must be generated.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

The measuring system Oxymitter 4000 was equipped with an automatic calibration system IMPS 4000 during the test. It offers the possibility of automatic zero and reference point adjustment. It was not activated during the field test, but was tested for functionality in the laboratory. It was checked, if the automatic zero and reference point adjustment is correctly performed at the desired time and if a status signal is generated in case of exceedance of the maximum allowed range of correction. For this purpose, it was offered intentionally to the measuring system a different concentration at the zero and reference point than laid down as nominal value.

6.4 Evaluation

The automatic zero and reference point adjustment of the measuring system Oxymitter 4000 is functioning. The intended automatic zero and reference point adjustments were performed correctly at the desired time. The calibration process is aborted in case of the following deviations:

- Invalid slope : characteristic change in the cell voltage outside of the range 35 – 52 mV – error code 13
- Invalid constant : cell constant outside of the specification (-4 mV – 10 mV) – error code 14
- Both slope and constant outside of specification – error code 15

In case of exceeding the maximum allowed deviations, a status signal is generated.

6.5 Findings

The functioning of the automatic re-adjustment of the measuring system was tested in the laboratory. It is functioning and delivers a status signal in case of exceeding the maximum allowed deviations. Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.18 Ambient temperature range]

6.1 Minimum requirement

The application of the measuring and evaluating systems must be possible in the following ambient temperature ranges:

- components for outdoor installation (unprotected ambient conditions) -20 °C to 50 °C,
- components for installation at temperature-controlled sites + 5 °C to + 40 °C.

6.2 Equipment

Not appropriate in this case. Please refer to point 6 [2.4.1.4 Temperature drift].

6.3 Performance of test

Not appropriate in this case. Please refer to point 6 [2.4.1.4 Temperature drift].

6.4 Evaluation

Not appropriate in this case. Please refer to point 6 [2.4.1.4 Temperature drift].

6.5 Findings

Not appropriate in this case. Please refer to point 6 [2.4.1.4 Temperature drift].

6.6 Presentation of test results

Not appropriate in this case. Please refer to point 6 [2.4.1.4 Temperature drift].

6 [2.1.1.19 Influence of sample gas flow rate]

6.1 Minimum requirement

For extractive-type measuring systems, the influence of alterations of the sample gas flow rate on the measured signal has to be stated. The change in the measured signal shall not exceed at maximum 1 % of the upper limit of the measuring range. In case of exceeding the permissible value, a status signal must be generated.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

The measuring system is operating directly in the duct.

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

The measuring system is operating directly in the duct. Thus the minimum requirement is not appropriate in this case.

6.6 Presentation of test results

Not appropriate in this case.

6 [2.1.1.20 Excursion of measurement beam]

6.1 Minimum requirement

If the measuring principle is based on optical methods (in-situ application), the disturbing influence in case of excursion of the measurement beam has to be stated. The change in the measured signal shall be at maximum 2 % of the upper limit of the measuring range in an angle range of 0,3°.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

The measuring system is not based on optical methods and determines the content of oxygen in the waste gas spot-related.

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

The measuring system is not based on optical methods and determines the content of oxygen in the waste gas spot-related.
Minimum requirement not appropriate.

6.6 Presentation of test results

Not appropriate in this case.

6 [2.1.1.21 Soiling check]

6.1 Minimum requirement

If the measuring principle is based on optical methods (in-situ application), the measuring system must have a facility, which allows a check of soiling during operation.
If necessary, the optical boundary surfaces have to be protected against soiling by a suitable method.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

The measuring system is not based on optical methods and determines the content of oxygen in the waste gas spot-related.

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

The measuring system is not based on optical methods and determines the content of oxygen in the waste gas spot-related.
Minimum requirement not appropriate.

6.6 Presentation of test results

Not appropriate in this case.

6 [2.1.1.22 Automatic recording of zero-point and reference-point]

6.1 Minimum requirement

The measuring systems shall have an appliance, which allows an automatic recording of the zero and reference-point in periodical intervals. For optical measuring systems with transmission method and with automatic correction of zero-point, the amount of correction shall be recorded as a measure of soiling.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

The measuring system has no possibility for an automatic recording of zero-point and reference-point.

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

Not applicable, because the measuring system has no possibility for an automatic recording of zero-point and reference-point.
Minimum requirement not appropriate.

6.6 Presentation of test results

Not appropriate in this case.

6 [2.1.1.23 Response time]

6.1 Minimum requirement

The response time (90 %-time) of the measuring systems, including the sampling system, shall be not more than 200 seconds.

6.2 Equipment

The test was performed with zero and test gases from gas cylinders.

6.3 Performance of test

The test was carried out with the offering of test gases and zero gas at the test gas inlet of the measuring probes during the field test. The change in the measured signal was recorded as a function of time after suddenly changing from zero to test gas. The tests were carried out three time in total within the scope of the field test. The measuring system offers continuously a new measured value.

6.4 Evaluation

The time period between the sudden change of the test gas offering and reaching the 90 % of the expected value of the measured-value reading was determined.

There are t_{90}-times of approximately 9 sec for the tested measuring systems.

6.5 Findings

There are t_{90}-times of approximately 9 sec for the tested measuring systems. Thus the required t_{90}-time is met.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

The results of the determination of the response time off the measuring systems is described in Table 5.

Table 5: Response time (90 %-time) of the measuring systems for the measured component O_2

O_2	Device 84	Device 85
	t_{90}-time / s	t_{90}-time / s
18.04.2005	9	9
31.05.2005	10	10
13.06.2005	8	9
Mean value:	**9**	**9**

6 [2.1.1.24 Multiple-component measuring systems]

6.1 Minimum requirement

Multiple-component measuring systems must fulfil the requirements on each single component, also with all measurement channels operating simultaneously.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

The measuring system Oxymitter 4000 only determines O_2.

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

The measuring system Oxymitter 4000 only determines O_2.
Thus the minimum requirement is not appropriate.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.25 Digital interface]

6.1 Minimum requirement

The external available measured value according to 2.1.1.11, the status signals according to 2.1.1.12, 2.1.1.17 and 2.1.1.19 and information like type of device, measuring range, component and unit can also be transmitted from the measuring device to the evaluation system via a suitable digital interface. The single analogue outputs can be dropped in this case. The digital interface must be completely described in the relevant standards and guidelines.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

There is no digital interface described at the moment.

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

Not applicable, because there is still no authorized digital interface.
Thus the minimum requirement is not appropriate.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.1.1.26 Measurement uncertainty]

6.1 Minimum requirement

The fundamental suitability of the measurement system for the measurement task has to be proved with the comparison of the extended measurement uncertainty, determined according to DIN EN ISO 14956 (Version January 2003), with the requirements, laid down for the measurement tasks.

6.2 Equipment

Not appropriate in this case.

6.3 Performance of test

Not appropriate in this case

6.4 Evaluation

Not appropriate in this case.

6.5 Findings

As there are no total uncertainties laid down for reference quantities to this day, this test point is not applicable.

6.6 Presentation of test results

Not appropriate in this case.

[2.2 Additional requirements on measuring systems for the determination of dust-like emissions]

not appropriate in this case

[2.3 Additional requirements on measuring systems for the determination of gaseous emissions]

not appropriate in this case

[2.4 Additional requirements on measuring systems for the determination of reference quantities]

[2.4.1 Measuring systems for the determination of the oxygen content]

6 [2.4.1.1 Availability]

6.1 Minimum requirement

The availability of the measuring systems must be 98 % in the suitability test.

6.2 Equipment

Please refer to point 6 [2.1.1.13 Availability]

6.3 Performance of test

Please refer to point 6 [2.1.1.13 Availability]

6.4 Evaluation

Please refer to point 6 [2.1.1.13 Availability]

6.5 Findings

The devices show an availability of 99,85 %. Thus they are clearly above the required value of 98 % for oxygen within the scope of the suitability test.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Please refer to point 6 [2.1.1.13 Availability]

6 [2.4.1.2 Detection limit]

6.1 Minimum requirement

The detection limit of the measuring system shall not exceed the volume fraction of 0,2%.

6.2 Equipment

Test gas from a gas cylinder was used. Test gas with 2,04 Vol.-% O_2 was used.

6.3 Performance of test

The detection limit of the devices was determined with repeated offering of zero gas at the test gas inlet of the measuring probe during the field test with the results, described in Table 6.

6.4 Evaluation

The determination of the detection limit is based on the Guideline VDI 2449, Page 1 (approach of Kaiser/Specker). For each measuring system, the standard deviation (spot sample) was calculated from the determined 30 zero values. The product of the standard deviation of the zero values and the student factor was used for the detection limit with regard of the device characteristic.

6.5 Findings

For the measuring systems, detection limits of 0,06 Vol.-% O_2 and 0,04 Vol.-% O_2 were determined Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Table 6: Detection limits for the component oxygen

Measured component	**O2**	Device 84	Device 85
No. of values n		30	30
Mean of zero values x	mA	5,32	5,32
Standard deviation of zero values s	mA	0,02	0,01
Measured value at det. limit	mA	5,36	5,35
Detection limit*	**Vol.-%**	**0,06**	**0,04**

* with regard to device characteristic

The individual values for the determination of the detection limit are described in the appendix in Table 17.

6 [2.4.1.3 Reproducibility R_D]

6.1 Minimum requirement

The reproducibility R_D according to 2.1.1.15 shall not be less than 70.

6.2 Equipment

Please refer to point 6 [2.1.1.15 Reproducibility R_D]

6.3 Performance of test

Please refer to point 6 [2.1.1.15 Reproducibility R_D]

6.4 Evaluation

Please refer to point 6 [2.1.1.15 Reproducibility R_D]

6.5 Findings

The reproducibility R_D was determined for the measuring range 0 to 25 Vol.-% O_2. There resulted a value of 177.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

During the suitability test, the smallest measuring range was 0 to 25 Vol.-%. The reproducibility R_D is shown in Table 7. In Figure 14 the graphical presentation of the reproducibility R_D can be found.

Table 7: Reproducibility R_D of paired measurements for O_2, Measuring range 0 to 25 Vol.-% ≙ 4 – 20 mA, field test

Criterion of selection	No. of paired values	R	Range of values mA
Values field test (half-hour mean) (all values)	4340	177	Device 84: 9,49 – 17,37 Device 85: 9,48 – 17,46

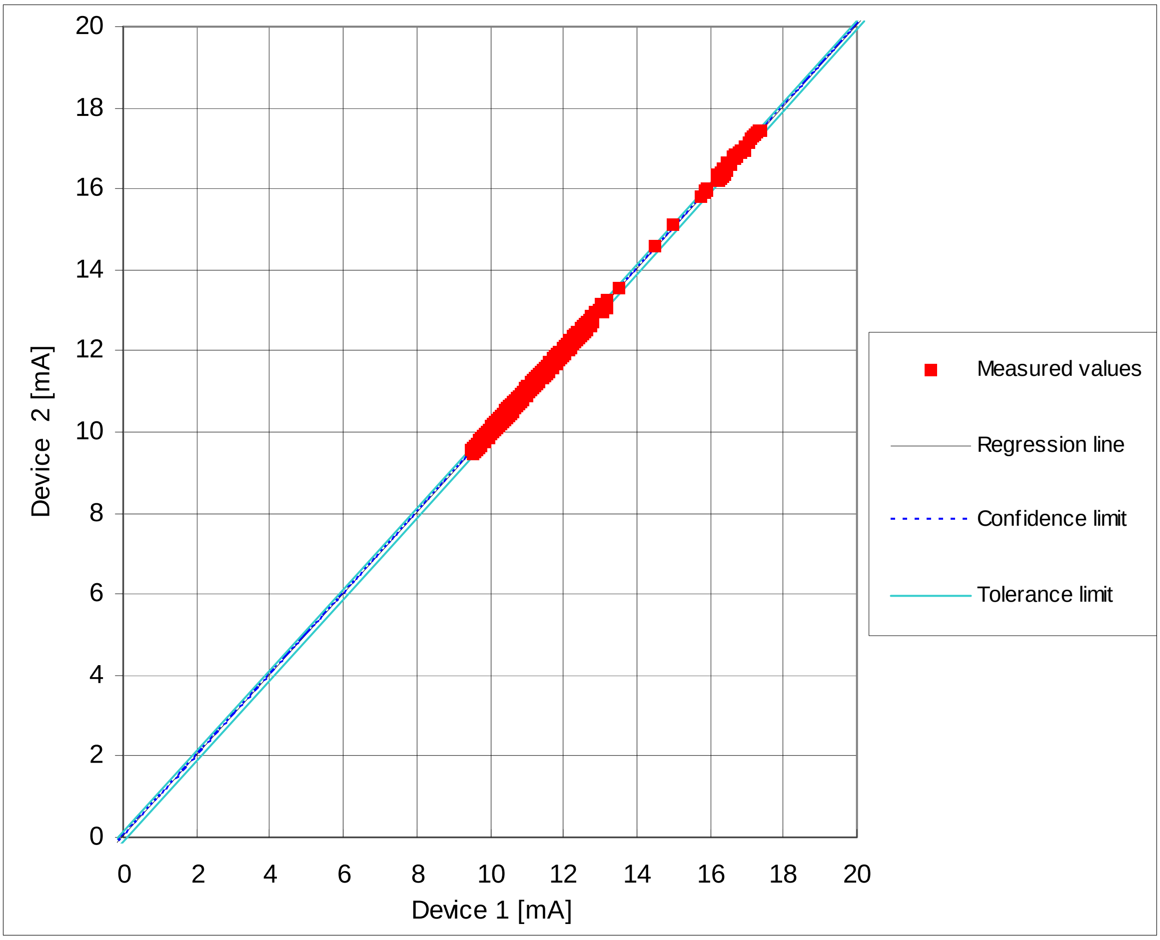

Figure 14: Graphical presentation of the values for the reproducibility R_D out of paired measurements, Oxymitter 4000, O_2, Measuring range 0 to 25 Vol.-% ≙ 4 – 20 mA, field test

The reproducibility R_D is 177 and thus larger than 70.

6 [2.4.1.4 Temperature drift]

6.1 Minimum requirement

The change in the zero-point and reference-point reading have to be determined over the complete temperature range, stated in 2.1.1.18. These changes shall not exceed the volume fraction of 0,5 % over the complete temperature range, based on 20 °C.
An influence on the zero or reference point caused by changes in the temperature of the material under analysis has to be compensated with suitable measures.

6.2 Equipment

The investigations were carried out in a climate chamber for the temperature range – 20 °C to + 50 °C.

6.3 Performance of test

In the permissible temperature range from -20 °C to + 50 °C the two measuring devices were offered test gas and zero gas. The ambient temperatures were varied in steps of 10 °C respectively 5 °C in a climate chamber. The relative humidity of the ambient air was kept constantly at approximately 60 % (relative). The adjustment was done with nitrogen and test gas at a start temperature of 20 °C. The inertia period for each temperature step was at minimum 2 hours. At each temperature setting, zero gas (N_2) and test gas was offered three times at the measured gas inlet. The test programme was altogether carried out three times.

6.4 Evaluation

A mean value of the individual measurements were made at each temperature point. The mean values for each running through the test programme were compared with the requirements.

6.5 Findings

Two devices of the type Oxymitter 4000 were exposed to temperature fluctuations between - 20 °C und + 50 °C in a climate chamber. There have been deviations of at maximum -0,07 Vol.-% O_2 at the zero-point and deviations of at maximum -0,48 Vol.-% O_2 at the reference-point.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

The results of the temperature test are described in Table 8. The mean values of the deviations at the different temperature points for the single runnings of the test programme are described here.

The individual values of the temperature test are described in Table 15 in the appendix of this report.

Table 8: Influence of the ambient temperature on the measured signal of O_2 ; Measuring range (indicating range): 0 to 25 Vol.-% Deviation from 20 °C in Vol.-% O_2

	Measured component:		*O2*		*0*	*to*	*25*	*Vol.-%*
	Device 84				*Device 85*			
	Zero-point		**Reference-point**		**Zero-Point**		**Reference-point**	
Temp. range	**Reading*) in mA**	**Dev. in Vol.-%**	**Reading*) in mA**	**Dev. in Vol.-%**	**Reading*) in mA**	**Dev. in Vol.-%**	**Reading*) in mA**	**Dev. in Vol.-%**
20°C	5,27	-	15,38	-	5,28	-	15,37	-
10°C	5,26	-0,01	15,32	-0,09	5,27	-0,01	15,32	-0,08
0°C	5,25	-0,03	15,25	-0,19	5,27	-0,01	15,29	-0,14
-10 °C	5,25	-0,03	15,22	-0,24	5,26	-0,04	15,25	-0,19
-20 °C	5,22	-0,07	15,07	-0,48	5,24	-0,06	15,07	-0,48
-10 °C	5,25	-0,03	15,20	-0,27	5,25	-0,04	15,22	-0,23
0°C	5,26	-0,02	15,23	-0,23	5,26	-0,03	15,25	-0,19
10°C	5,27	0,01	15,39	0,03	5,27	-0,01	15,33	-0,06
20°C	5,27	-0,01	15,33	-0,07	5,28	0,01	15,34	-0,06
30°C	5,28	0,02	15,37	-0,02	5,30	0,03	15,37	0,00
40°C	5,27	0,00	15,40	0,03	5,26	-0,03	15,33	-0,05
50°C	5,27	0,00	15,47	0,16	5,26	-0,03	15,39	0,04
40°C	5,28	0,01	15,44	0,10	5,27	-0,02	15,38	0,01
30°C	5,27	0,01	15,40	0,02	5,27	-0,01	15,36	-0,02
20 °C	5,26	-0,01	15,33	-0,06	5,26	-0,02	15,30	-0,10

*) Mean value of three-time repetition

6 [2.4.1.5 Cross-sensitivity]

6.1 Minimum requirement

The amount of the interfering influence caused by cross-sensitivity to accompanying substances in the material under analysis, at mass concentrations normally appearing in waste gases, shall not exceed altogether more than 0,2 % as volume fraction. If this requirement cannot be met, the influence of the respective interfering component on the measured signal shall be taken into account by appropriate measures.

6.2 Equipment

The test was carried out with zero and test gas from gas cylinders. To provide test gas mixes, the different test gases from gas cylinders could be mixed with the help of a mass flow controller station. For the component H_2O, a test gas generator of the type HOVACAL was used.

6.3 Performance of test

The cross-sensitivities to accompanying substances, which normally appear in waste gases, have been determined with test gases with known quantity. With the help of a gas mixing station, the following test gases were offered to the analysers:

Component		Concentration		
Oxygen	O_2	3	Vol.-%	in N_2
		21	Vol.-%	in N_2
Water vapour	H_2O	30	Vol.-%	in N_2
Carbon monoxide	CO	300	mg/m³	in N_2
Carbon dioxide	CO_2	15	Vol.-%	in N_2
Methane	CH_4	50	mg/m³	in N_2
Dinitrogen monoxide	N_2O	20	mg/m³	in N_2
(fluidised-bed firing)		100	mg/m³	in N_2
Nitrogen monoxide	NO	300	mg/m³	in N_2
Nitrogen dioxide	NO_2	30	mg/m³	in air
Ammonia	NH_3	20	mg/m³	in N_2
Sulphur dioxide	SO_2	200	mg/m³	in N_2
(coal-fired power plants without desulphurisation)		1000	mg/m³	in N_2
Hydrogen chloride	HCl	50	mg/m³	in N_2
(coal-fired power plants)		200	mg/m³	in N_2

The offering of the test gases was performed at the test gas inlet of the measuring probe. To verify the influence of water vapour on the measured signals, a chamber around the tip of the measuring probe was installed and the moistened test gas was offered at the tip of the probe.

6.4 Evaluation

The change in the reading when offering the respective accompanying substance was determined.

6.5 Findings

Within the scope of this test, minor effects on the measuring systems could be detected. For device 84 a maximum cross-sensitivity of 0,05 Vol.-% O_2 was determined and for device 85 -0,08 Vol.-% O_2, each at the reference-point. At the zero-point no adequate effects could be detected. Thus the cross-sensitivities are below the maximum allowed cross-sensitivity of von 0,2 Vol.-% O_2 .
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

The determined cross-sensitivities are put together in Table 9. The investigations were performed in December 2004 / January 2005 during the laboratory investigations.

Table 9: Influence of accompanying substances on the measured signal at zero and reference-point, measured component O_2 , measuring range 0 to 25 Vol.-%

Accompanying substance	Deviation in Vol.-% O_2 – Measured component **O2**			
	Zero-point Device 84	Reference-point Device 84	Zero-point Device 85	Reference-point Device 85
O_2 (3 Vol.-%)	-	-	-	-
O_2 (21 Vol.-%)	-	-	-	-
H_2O	<0,02	<0,02	<0,02	<0,02
CO	<0,02	<0,02	<0,02	<0,02
CO_2	<0,02	0,05	<0,02	0,03
CH_4	<0,02	<0,02	<0,02	-0,02
N_2O (20 mg/m³)	-	-	-	-
N_2O (100 mg/m³)	<0,02	<0,02	<0,02	<0,02
NO	<0,02	<0,02	<0,02	<0,02
NO_2	-	-0,04	-	-0,05
NH_3	<0,02	<0,02	<0,02	<0,02
SO_2 (200 mg/m³)	-	-	-	-
SO_2 (1000 mg/m³)	<0,02	<0,02	<0,02	<0,02
HCl (50 mg/m³)	-	-	-	-
HCl (200 mg/m³)	<0,02	<0,02	<0,02	<0,02
Sum of positive deviations	**0,00**	**0,05**	**0,00**	**0,03**
Sum of negative deviations	**0,00**	**-0,04**	**0,00**	**-0,08**

6 [2.4.1.6 Sampling]

6.1 Minimum requirement

With respect to material and heating, sampling and sample conditioning has to be designed in a way, that a proper solid filtration is reached and reactions and entrainment effects, due to adsorption and desorption effects, shall be avoided.

6.2 Equipment

No additional equipment is necessary for the test of this minimum requirement.

6.3 Performance of test

The measuring system is operating directly in the duct. The measuring cell itself is heated to 736 °C. In waste gases with high dust contents, the manufacturer recommends the use of protective tubes.

6.4 Evaluation

The influence of effects on the surfaces on the measured result were estimated and evaluated.

6.5 Findings

The measuring system is operating directly in the duct. Effects on the surfaces on the measured signal were not noticed.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Not required for this minimum requirement.

6 [2.4.1.7 Drift in the maintenance interval]

6.1 Minimum requirement

The amount of the changes as a function of time of the zero respectively the reference-point reading shall not exceed 0,2 % as volume fraction in the maintenance interval.

6.2 Equipment

During the field test, all measured values of the measuring systems were recorded with a data recording system of the type Yokogawa. The test was carried out with zero and reference gas from gas cylinders.

6.3 Performance of test

To determine the drift behaviour, the periodical manual performed zero and test gas offerings during the field test were evaluated.

Zero and reference point were adjusted at the beginning of the test. The check of the zero and reference-point (sensitivity) was performed at the face with test gases in different intervals. The test gas offering was performed at the test gas inlets of the devices. The results of these investigations are put together in Table 10 and in Table 11.

Besides the evaluation of the periodical manual performed zero and test gas offerings, the operation behaviour of the measuring system and the maintenance instructions of the manufacturer were taken into account for the determination of the maintenance interval.

6.4 Evaluation

For the evaluation, the respective measured values were compared with the nominal values and out of this the deviations were determined.

6.5 Findings

The zero-point drift was for both candidates at no point of time of the field test larger than 0,10 Vol.-% O_2. The reference-point drift for device 84 was less than 0,2 Vol.-% O_2 during the test period. For device 85 the allowed range of drift was exceeded after 8 weeks, which means that the reference-point had to be re-adjusted at that point. Because of the measuring principle, uncertainties at higher O_2-concentrations are larger than at lower ones. The maintenance interval corresponds according to point 6 [2.1.1.14 Maintenance interval] to 4 weeks.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

In Table 10 and in Table 11, the results of the periodical test gas offerings during the field test are presented.

Date	Interval	*Measured component*		*O2*		*0*	*to*	*25*	*Vol.-%*
		Device 84							
		Zero-point				**Reference-point**			
		Actual value	**Nominal value**		**Adjustment**	**Actual value**	**Nominal value**		**Adjustment**
	d	**Vol.-%**	**Vol.-%**	**Dev. in Vol.-%**	**yes/no**	**Vol.-%**	**Vol.-%**	**Dev. in Vol.-%**	**yes/no**
11.04.2005	-	2,04	2,04	-	yes	17,9	17,9	-	yes
18.04.2005	7	2,08	2,04	0,04	no	18	17,9	0,10	no
26.04.2005	8	2,03	2,04	-0,01	no	18,05	17,9	0,15	no
10.05.2005	14	2,03	2,04	-0,01	no	17,99	17,9	0,09	no
17.05.2005	7	2,04	2,04	0,00	no	17,96	17,9	0,06	no
31.05.2005	14	2,14	2,04	0,10	no	18,08	17,9	0,18	no
13.06.2005	13	2,03	2,04	-0,01	no	17,84	17,9	-0,06	no
28.06.2005	15	2,06	2,04	0,02	no	18,09	17,9	0,19	no
08.07.2005	10	2,08	2,04	0,04	no	17,98	17,8	0,18	no

Table 10: Results of drift investigations within the scope of the field test for device 84, measured component O_2

Date	Interval	*Measured component*		*O2*		*0*	*to*	*25*	*Vol.-%*
		Device 85							
		Zero-point				**Reference-point**			
		Actual value	**Nominal value**		**Adjustment**	**Actual value**	**Nominal value**		**Adjustment**
	d	**Vol.-%**	**Vol.-%**	**Dev. in Vol.-%**	**yes/no**	**Vol.-%**	**Vol.-%**	**Dev. in Vol.-%**	**yes/no**
11.04.2005	-	2,04	2,04	-	yes	17,9	17,9	-	yes
18.04.2005	7	2,11	2,04	0,07	no	17,98	17,9	0,08	no
26.04.2005	8	2,07	2,04	0,03	no	18,09	17,9	0,19	no
10.05.2005	14	2,02	2,04	-0,02	no	17,95	17,9	0,05	no
17.05.2005	7	2,05	2,04	0,01	no	18,06	17,9	0,16	no
31.05.2005	14	2,04	2,04	0,00	no	17,91	17,9	0,01	no
13.06.2005	13	2,07	2,04	0,03	no	18,15	17,9	0,25	yes
28.06.2005	15	2,07	2,04	0,03	no	17,92	17,9	0,02	no
08.07.2005	10	2	2,04	-0,04	no	17,78	17,8	-0,02	no

Table 11: Results of drift investigations within the scope of the field test for device 85, measured component O_2

6 [2.4.1.8 Linearity]

6.1 Minimum requirement

The amount of the deviation of the actual values from the nominal values of the device characteristic according to point 2.1.1.4 must not be more than 0,3 % as volume fraction.

6.2 Equipment

The linearity checks were performed with the help of test gases from gas cylinders. For the setting of the nominal concentrations, a mass flow controller station was used.

6.3 Performance of test

The device characteristic shows the correlation between the measured value and the given quantity of the measured object. For this purpose, ten test gas concentrations of known quality and quantity of the measured component, evenly distributed over the measuring range, were offered to the analysers via a mass flow controller station. Nitrogen was used as dilution gas. The results can be found in Table 12.

6.4 Evaluation

The deviation of the actual values from the nominal values of the device characteristic in Vol.-% O_2 was determined.

6.5 Findings

The linearity was checked for the measuring range 0-25 Vol.-%. No deviations larger than - 0,20 Vol.-% could be found.
Thus the minimum requirement was fulfilled.

6.6 Presentation of test results

Table 12: Individual values of the linearity check for O_2 (measuring range 0 – 25 Vol.-% = 4 – 20 mA)

Test gas Nominal value		Device 84	Deviation	Device 85	Deviation
Vol.-%	mA	mA	Vol.-% O2	mA	Vol.-% O2
20,5	17,12	17,12	0,00	16,99	-0,20
18,5	15,81	15,85	0,07	15,74	-0,11
16,4	14,50	14,56	0,10	14,45	-0,07
14,4	13,18	13,26	0,12	13,17	-0,02
12,3	11,87	11,95	0,12	11,87	0,00
10,3	10,56	10,63	0,11	10,57	0,02
8,2	9,25	9,32	0,11	9,27	0,03
6,2	7,94	7,99	0,08	7,96	0,04
4,1	6,62	6,66	0,06	6,64	0,02
2,1	5,31	5,34	0,04	5,33	0,03
0,0	4,00	4,02	0,03	4,04	0,06

7 Recommendations for the use in practice

7.1 Work in the maintenance interval

The work in the maintenance interval are restricted to the usual activities like visual inspection, test gas offerings and so on. For the rest it is to pay attention to the instructions of the manufacturer.

On grounds of the measuring principle of the measuring system, a test gas <2 Vol.-% O_2 instead of nitrogen is used for the adjustment and check of the zero-point.

7.2 Functional check and calibration

For the performance of the functional check respectively before the calibration according to Guideline DIN EN 14181, the following procedure is recommended:

- Visual inspection of the complete measuring system.
- Check of the tightness through offering of zero gas and reference gas at the probe.
- Check of linearity with zero and test gas,
- Check of zero-point and reference-point drift in the maintenance interval.
  (Check of the long-term drift after a basic calibration),
- Determination of lag and response time,
- Check of the data transmission (analogue and status signals) to the evaluation system.

Further details concerning the functional check and the calibration have to be taken from Guideline DIN EN 14181 (September 2004) respectively VDI 3950, sheet 1 (July 1994); furthermore it is to pay attention to the advices of the manufacturer.

Department of Environmental protection

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Cologne, July 11, 2005
936/21203476/A ple-hä

8 Literature

[1] Uniform Federal Practice for Emission Monitoring; Guidelines for:

- the suitability test of measuring and evaluating systems for continuous emission measurements and the continuous recording of reference respectively operating quantities and for the continuous monitoring of emissions of specific substances
- the installation, the calibration and the maintenance of continuous operating measuring and evaluating systems
- the evaluation of continuous emission measurements

The Federal Ministry of the Environment, Conservation and Nuclear Safety and the supreme state agencies responsible for air pollution control in the Air Pollution Control Committee of Germany´s federal states have reached agreement on the following guidelines:

Federal Ministry of the Environment circular dated June 13, 2005 – IG I 2 – 45 053/5. Published in GMBI 2005, No. 38 of June 24, 2005, page 795,

[2] Guideline VDI 4203 Sheet 1, October 2001, Testing of automated measuring systems - General concepts

[3] Guideline VDI 4203 Sheet 2, March 2003, Testing of automated measuring systems – Test procedures for measuring systems of gaseous and particulate emissions

[4] Guideline DIN EN ISO 14956, January 2003, Air quality – Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty

[5] Guideline DIN EN 14181, September 2004, Stationary source emissions – Quality assurance of automated measuring systems

9 Appendix

Appendix 1: Measured and calculated values

Appendix 2: Manuals

Table 13: Individual values of the calibration measurements, measured object O_2 at the start of the field test, Measuring range 0 – 25 Vol.-% ≙ 4 – 20 mA

No.	Measured value reading		Result Comparison measurement	
	Device 84 mA	Device 85 mA	Vol.-% O_2 standard, dry	Vol.-% O_2 standard, wet
1	10,79	10,86	12,57	10,57
2	10,35	10,40	12,14	10,01
3	9,95	10,00	11,67	9,41
4	9,91	9,96	11,58	9,31
5	10,42	10,48	12,26	10,04
6	10,85	10,91	13,17	10,84
7	10,67	10,74	12,76	10,53
8	10,90	10,97	13,24	10,96
9	10,60	10,66	12,78	10,53
10	10,34	10,41	12,38	10,11
11	10,32	10,38	12,41	10,04
12	11,25	11,32	13,91	11,42
13	11,27	11,34	13,75	11,47
14	10,81	10,88	12,95	10,79
15	10,62	10,69	12,60	10,48
16	4,00	4,00	0,00	0,00
17	4,00	4,00	0,00	0,00
18	4,00	4,00	0,00	0,00

Table 14: Individual values of the calibration measurements, measured object O_2 at the end of the field test, Measuring range 0 – 25 Vol.-% ≙ 4 – 20 mA

No.	Measured value reading		Result Comparison measurement	
	Device 84 mA	Device 85 mA	Vol.-% O_2 standard, dry	Vol.-% O_2 standard, wet
1	10,59	10,52	12,38	10,32
2	10,68	10,62	12,68	10,53
3	10,65	10,59	12,52	10,43
4	10,27	10,21	11,78	9,81
5	10,52	10,46	12,29	10,19
6	9,97	9,91	11,63	9,38
7	10,01	9,96	11,54	9,37
8	10,01	9,95	11,49	9,38
9	9,93	9,87	11,29	9,23
10	10,47	10,41	12,02	9,94
11	10,25	10,19	12,02	9,73
12	9,76	9,70	11,18	9,02
13	9,69	9,64	11,18	8,94
14	9,63	9,57	10,92	8,77
15	10,31	10,25	11,98	9,76
16	4,00	4,00	0,00	0,00
17	4,00	4,00	0,00	0,00
18	4,00	4,00	0,00	0,00

Table 15: Individual results of the climate chamber test, measured component O_2

	Measured component		*O2*		*0*	*to*	*25*	*Vol.-%*
	Device 84				***Device 85***			
	Zero-point		**Reference-point**		**Zero-point**		**Reference-point**	
Temp. range	**Reading*) in mA**	**Dev. in Vol.-%**	**Reading*) in mA**	**Dev. in Vol.-%**	**Reading*) in mA**	**Dev. in Vol.-%**	**Reading*) in mA**	**Dev. in Vol.-%**
20°C	5,27		15,39		5,28		15,38	
	5,27		15,38		5,28		15,38	
	5,27		15,36		5,28		15,36	
Mean value	5,27	-	15,38	-	5,28	-	15,37	-
10°C	5,26		15,34		5,28		15,35	
	5,26		15,31		5,27		15,31	
	5,27		15,31		5,27		15,31	
Mean value	5,26	-0,01	15,32	-0,09	5,27	-0,01	15,32	-0,08
0°C	5,25		15,25		5,27		15,30	
	5,25		15,26		5,28		15,29	
	5,26		15,25		5,27		15,27	
Mean value	5,25	-0,03	15,25	-0,19	5,27	-0,01	15,29	-0,14
-10 °C	5,25		15,22		5,26		15,28	
	5,25		15,23		5,26		15,25	
	5,25		15,21		5,25		15,23	
Mean value	5,25	-0,03	15,22	-0,24	5,26	-0,04	15,25	-0,19
-20 °C	5,22		15,08		5,24		15,08	
	5,22		15,06		5,24		15,09	
	5,23		15,07		5,25		15,03	
Mean value	5,22	-0,07	15,07	-0,48	5,24	-0,06	15,07	-0,48
-10 °C	5,25		15,19		5,26		15,23	
	5,25		15,21		5,25		15,23	
	5,25		15,21		5,25		15,21	
Mean value	5,25	-0,03	15,20	-0,27	5,25	-0,04	15,22	-0,23
0°C	5,25		15,22		5,26		15,25	
	5,26		15,23		5,27		15,25	
	5,26		15,24		5,26		15,25	
Mean value	5,26	-0,02	15,23	-0,23	5,26	-0,03	15,25	-0,19
10°C	5,28		15,41		5,28		15,35	
	5,27		15,39		5,27		15,33	
	5,27		15,38		5,27		15,32	
Mean value	5,27	0,01	15,39	0,03	5,27	-0,01	15,33	-0,06
20°C	5,27		15,34		5,28		15,35	
	5,25		15,33		5,28		15,34	
	5,28		15,32		5,29		15,32	
Mean value	5,27	-0,01	15,33	-0,07	5,28	0,01	15,34	-0,06
30°C	5,30		15,36		5,32		15,37	
	5,28		15,37		5,29		15,38	
	5,27		15,37		5,28		15,37	
Mean value	5,28	0,02	15,37	-0,02	5,30	0,03	15,37	0,00
40°C	5,27		15,38		5,27		15,35	
	5,27		15,40		5,26		15,35	
	5,27		15,40		5,26		15,33	
Mean value	5,27	0,00	15,39	0,03	5,26	-0,03	15,34	-0,05
50°C	5,27		15,49		5,26		15,41	
	5,27		15,48		5,26		15,40	
	5,27		15,47		5,26		15,39	
Mean value	5,27	0,00	15,48	0,16	5,26	-0,03	15,40	0,04
40°C	5,27		15,43		5,27		15,38	
	5,28		15,45		5,27		15,38	
	5,28		15,44		5,27		15,38	
Mean value	5,28	0,01	15,44	0,10	5,27	-0,02	15,38	0,01
30°C	5,28		15,38		5,28		15,36	
	5,27		15.41		5,27		15.37	
	5,27		15,40		5,27		15,36	
Mean value	5,27	0,01	15,39	0,02	5,27	-0,01	15,36	-0,02
20 °C	5,26		15,35		5,27		15,32	
	5,27		15,34		5,27		15,31	
	5,26		15,32		5,26		15,29	
Mean value	5,26	-0,01	15,34	-0,06	5,27	-0,02	15,31	-0,10

Table 16: Individual results of the mains voltage tests, measured component O_2

	Measured component		*O2*		*0*	*to*	*25*	*Vol.-%*
	Device 84				***Device 85***			
	Zero point		**Reference point**		**Zero point**		**Reference point**	
Mains voltage	**Reading*) in mA**	**Dev. in % measured range**	**Reading*) in mA**	**Dev. in % measured range**	**Reading*) in mA**	**Dev. in % measured range**	**Reading*) in mA**	**Dev. in % measured range**
230 V	5,31		15,46		5,30		15,46	
	5,31		15,45		5,31		15,47	
	5,31		15,45		5,29		15,46	
Mean value	5,31	-	15,45	-	5,30	-	15,46	-
220 V	5,31		15,46		5,30		15,46	
	5,30		15,47		5,30		15,48	
	5,31		15,46		5,30		15,49	
Mean value	5,31	-0,02	15,46	0,06	5,30	0,00	15,48	0,08
210 V	5,30		15,46		5,28		15,49	
	5,30		15,47		5,27		15,50	
	5,31		15,47		5,29		15,49	
Mean value	5,30	-0,04	15,47	0,08	5,28	-0,12	15,49	0,19
200 V	5,30		15,48		5,29		15,49	
	5,30		15,46		5,30		15,48	
	5,31		15,47		5,29		15,49	
Mean value	5,30	-0,04	15,47	0,10	5,29	-0,04	15,49	0,15
190 V	5,28		15,50		5,27		15,50	
	5,30		15,49		5,27		15,52	
	5,29		15,48		5,28		15,49	
Mean value	5,29	-0,12	15,49	0,23	5,27	-0,17	15,50	0,25
230 V	5,31		15,45		5,31		15,46	
	5,30		15,47		5,32		15,46	
	5,31		15,46		5,32		15,47	
Mean value	5,31	-	15,46	-	5,32	-	15,46	-
240 V	5,31		15,46		5,30		15,48	
	5,29		15,47		5,31		15,47	
	5,31		15,47		5,30		15,47	
Mean value	5,30	-0,02	15,47	0,04	5,30	-0,08	15,47	0,06
250 V	5,30		15,48		5,30		15,48	
	5,30		15,49		5,30		15,48	
	5,29		15,49		5,31		15,49	
Mean value	5,30	-0,06	15,49	0,17	5,30	-0,08	15,48	0,13

Table 17: Determination of the detection limit, measured component O_2

Measured component O2		**Device 84** mA	**Device 85** mA
	1	5,31	5,31
	2	5,33	5,35
	3	5,30	5,32
	4	5,30	5,31
	5	5,31	5,32
	6	5,31	5,31
	7	5,31	5,32
	8	5,31	5,31
	9	5,31	5,31
	10	5,32	5,31
	11	5,31	5,31
	12	5,33	5,34
	13	5,37	5,31
	14	5,30	5,32
	15	5,32	5,32
	16	5,29	5,33
	17	5,34	5,34
	18	5,34	5,33
	19	5,34	5,33
	20	5,35	5,34
	21	5,35	5,32
	22	5,30	5,32
	23	5,32	5,32
	24	5,29	5,33
	25	5,34	5,34
	26	5,31	5,31
	27	5,31	5,32
	28	5,31	5,31
	29	5,31	5,31
	30	5,32	5,31
Mean value	mA	5,32	5,32
Standard deviation	mA	0,02	0,01
Student factor (95%)	-	2,05	2,05
Measured value at det. limit	mA	5,36	5,35
Detection limit*	Vol.-%	0,06	0,04
Minimum requirement	Vol.-%	0,20	0,20

*with regard to the device characteristic

Figure 15: Display of the actual software version

The following version of the instrument is suitability-tested:

1. Oxymitter 4000 (with operator interface LOI) with/without automatic calibration system IMPS 4000,
   Measuring component O_2

Cologne, July 13, 2005

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