RAP-216

Certificate on Product Conformity (QAL1) for AR500 for NO_2, SO_2 and O_3

No. of Certificate: 0000025927_02, TÜV Rheinland Energie und Umwelt GmbH, Cologne, Germany, 2 February 2015

OPSIS®

Umwelt Bundesamt

TÜVRheinland®
Precisely Right.

CERTIFICATE

of Product Conformity (QAL1)

Certificate No. : 0000025927_02

Certified AMS:	AR500 with ER120 for NO_2, SO_2 and O_3
Manufacturer:	Opsis AB Skytteskogsvägen 16 244 02 Furulund Sweden
Test Institute:	TÜV Rheinland Energie und Umwelt GmbH

This is to certify that the AMS has been tested and found to comply with:

EN 14211: 2005, EN 14212: 2005, EN 14625: 2005, EN 15267-1: 2009 and EN 15267-2: 2009

Certification is awarded in respect of the conditions stated in this certificate (see also the following pages).

TÜVRheinland® CERTIFIED

Suitability Tested
Complying with
2008/50/EC
EN 15267
Regular
Surveillance

www.tuv.com
ID 0000025927

Publication in the German Federal Gazette (BAnz.) of 2 March 2012

This certificate will expire on:
11 February 2020

German Federal Environment Agency
Dessau, 2 February 2015

i. A. Dr. Marcel Langner

TÜV Rheinland Energie und Umwelt GmbH
Cologne, 30 January 2015

ppa. Dr. Peter Wilbring

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Accreditation according to EN ISO/IEC 17025 and certified according to ISO 9001:2008.	

Test report:	936/21211350/B of 7 October 2011
Initial certification:	12 February 2010
Certificate:	renewal (previous certificate 0000025927_01 of 16 March 2012 valid until 11 February 2015)
Date of expiry:	11 February 2020
Publication:	BAnz. 2 March 2012, no. 36, p. 920, chapter IV, no. 2.1

Approved application
The certified AMS is suitable for the continuous monitoring of concentrations of nitrogen dioxide, sulphur dioxide, and ozone in ambient air (stationary operation).

The suitability of the AMS for this application was assessed on the basis of a laboratory test and a three-month field test.

The AMS is approved for the temperature range of +5 °C to +40 °C.

Any potential user should ensure, in consultation with the manufacturer, that this AMS is suitable for ambient air applications at which it will be installed.

Basis of the certification
This certification is based on:

- test report 936/21211350/B dated 7 October 2011 of TÜV Rheinland Energie und Umwelt GmbH
- suitability announced by the German Federal Environment Agency (UBA) as the relevant body
- the ongoing surveillance of the product and the manufacturing process
- publication in the German Federal Gazette (BAnz. 2 March 2012, no. 36, p. 920, chapter IV, No. 2.1, UBA announcement of 23 February 2012)
- publication in the German Federal Gazette (BAnz AT 5 March 2013 B10, chapter V, notice 11, UBA announcement of 12 February 2013)

AMS designation:
AR500 with ER120 for NO_2, SO_2 and O_3

Manufacturer:
Opsis AB, Furulund, Sweden

Field of application:
For the continuous monitoring of concentrations of nitrogen dioxide, sulphur dioxide and ozone in ambient air (stationary operation)

Measuring ranges during the performance test:

Component	Certification range	supplementary measurement ranges	Unit
NO_2	0 - 400	0 - 1800	µg/m³
SO_2	0 - 700	0 - 1000	µg/m³
O_3	0 - 360	0 - 500	µg/m³

Software version:
7.21

Restrictions:
None

Notes:
1. The measuring path length during performance testing was 320 m.
2. The maintenance interval is four weeks.
3. Equivalence with the reference measurement methods according to the guideline „Demonstration of Equivalence of Ambient Air Monitoring Methods" has been demonstrated for the components NO_2, SO_2 and O_3.
4. Functional tests by external sample gas feeding are possible.
5. The report on the performance test is available online at www.qal1.de.
6. Supplementary testing (Demonstration of Equivalence for the component SO_2 according the guideline "Demonstration of Equivalence of Ambient Air Monitoring Methods") as regards Federal Environment Agency notices of 25 January 2010 (BAnz. p. 552, chapter III no. 1.1).

Test report:
TÜV Rheinland Energie und Umwelt GmbH, Cologne
Report no.: 936/21211350/B dated 7 October 2011

11 Notification as regards Federal Environment Agency notices of 23 February 2012 (Federal Gazette (BAnz.) p. 920, chapter IV, no. 2.1)

The AR500 measuring system with ER120 for NO_2, SO_2 and O_3 manufactured by Opsis AB can also be operated with the transmitter/receiver units ER 110 and ER150.

Statement of TÜV Rheinland Energie und Umwelt GmbH of 10 October 2012

Certified product
This certificate applies to automated measurement systems conforming to the following description:

The measurement system AR500 operates on the basis of the Differential Optical Absorption Spectroscopy (DOAS). The DOAS measuring principle uses the characteristic radiation absorption by gaseous components for quantification of the respective concentrations.

The DOAS monitor AR500 with ER120 consists of a combined transmitter-receiver unit, a reflector unit and an analyser. The absorbed light is transferred from the transmitter-receiver unit to the analyser via fibre optic cable.

Combined transmitter-receiver Unit ER 120
The combined transmitter-receiver unit ER120 comprises the optical components, the xenon light-source and the power supply PS150 for igniting the xenon light-source.
The used high-pressure xenon lamp is a point light source. The light is generated by ignition of ultra pure xenon gas at a pressure of approx. 30 bar. The lamp is powered by a stabilised D.C. voltage source and requires a short high-voltage ignition pulse.

The radiation of the lamp includes the ultraviolet, the visible, and the infrared range. The wavelengths are continuously distributed over the entire spectrum, with the exception of some peaks in the near infrared range.

General notes
This certificate is based upon the equipment tested. The manufacturer is responsible for ensuring that on-going production complies with the requirements of the EN 15267. The manufacturer is required to maintain an approved quality management system controlling the manufacture of the certified product. Both the product and the quality management systems shall be subject to regular surveillance.

If a product of the current production does not conform to the certified product, TÜV Rheinland Energie und Umwelt GmbH must be notified at the address given on page 1.

A certification mark with an ID-Number that is specific to the certified product is presented on page 1 of this certificate. This can be applied to the product or used in publicity material for the certified product is presented on page 1 of this certificate.

This document as well as the certification mark remains property of TÜV Rheinland Energie und Umwelt GmbH. With revocation of the publication the certificate loses its validity. After the expiration of the certificate and on requests of the TÜV Rheinland Energie und Umwelt GmbH this document shall be returned and the certificate mark must not be employed anymore.

The relevant version of this certificate and the validity is also accessible on the internet: **qal1.de**.

Certification of the AR500 with ER120 for NO_2, SO_2 and O_3 is based on the documents listed below and the regular, continuous monitoring of the Quality Management System of the manufacturer:

Initial certification according to EN 15267:

Certificate No. 0000025927: 10 March 2010

Validity of the certificate: 11 February 2015

Test report: 936/21211350/A of 26 October 2009,
TÜV Rheinland Energie und Umwelt GmbH, Cologne

Publication: BAnz. 12 February 2010, no. 24, p. 552, chapter III, no. 1.1
UBA announcement of 25 January 2010

Supplementary testing according to EN 15267:

Certificate No. 0000025927_01: 16 March 2012

Validity of the certificate: 11 February 2015

Test report: 936/21211350/B of 7 October 2011,
TÜV Rheinland Energie und Umwelt GmbH, Cologne

Publication: BAnz. 2 March 2012, no. 36, p. 920, chapter IV, no. 2.1
UBA announcement of 23 February 2012

Notifications

Statement of TÜV Rheinland Energie und Umwelt GmbH of 10 October 2012
Publication: BAnz AT 5 March 2013 B10, chapter V, notification 11 (additional transmitter/receiver)
UBA announcement of 12 February 2013

Renewal of the certificate

Certificate No. 0000025927_02 2 February 2015

Expiry date of the certificate: 11 February 2020

Table 1: Total expanded uncertainty with the results of the laboratory test according to EN 14211 (component NO_2) for system 1329

Device:	AR500	Serial No:	1329		
Component:	NO_2	1h-limit value:	104,6		nmol/mol

No.	Performance characteristic		Criterion	Result	Uncertainty		Square of uncertainty
1	Repeatability at zero	≤	1,0 nmol/mol	0,000	$u_{r,z}$	0,00	0,0000
2	Repeatability at concentration ct	≤	3,0 nmol/mol	2,000	$u_{r,th}$	0,04	0,0015
3	"lack of fit"	≤	4,0% of measured value	0,800	$u_{l,th}$	0,48	0,2334
4	Sensitivity coefficient of sample gas pressure	≤	8,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000
5	Sensitivity coefficient of sample gas temperature	≤	3,0 nmol/mol/K	0,026	u_{gt}	0,04	0,0016
6	Sensitivity coefficient of surrounding temperature	≤	3,0 nmol/mol/K	-0,050	u_{at}	-0,06	0,0036
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	-0,021	u_V	-0,07	0,0046
8a	H20 with concentration 21 mmol/mol	≤	5,0 nmol/mol	0,000	u_{H2O}	0,00	0,0000
8b	CO2 with concentration 500 µmol/mol	≤	5,0 nmol/mol	0,001	$u_{int,pos}$ or $u_{int,neg}$	0,48	0,2304
8c	O3 with concentration 200 nmol/mol	≤	2,0 nmol/mol	0,002			
8d	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,002			
9	Averaging effect	≤	7,0% of measured value	-0,600	u_{av}	-0,36	0,1313
18	Difference sample/calibration port	≤	1,0%	0,000	$u_{\Delta pc}$	0,00	0,0000
21	Converter efficiency	≥	98%	100,000	u_{CE}	0,00	0,0000
22	Increase of NO2 concentration due to residence time	≤	4,0 nmol/mol	0,000	u_{dr}	0,00	0,0000
23	Uncertainty calibration gas	≤	3,0%	2,000	u_{cg}	1,05	1,0941

combined standard uncertainty	u_c	1,3046	nmol/mol
expanded uncertainty	U_c	2,6092	nmol/mol
expanded uncertainty actual	$U_{c,rel}$	**2,49**	%
expanded uncertainty required	$U_{req,rel.}$	15	%

Table 2: Total expanded uncertainty with the results of the laboratory test and field test according to EN 14211 (component NO_2) for system 1329

Device:	AR500	Serial No:	1329		
Component:	NO_2	1h-limit value:	104,6		nmol/mol

No.	Performance characteristic		Criterion	Result	Uncertainty		Square of uncertainty	
1	Repeatability at zero	≤	1,0 nmol/mol	0,000	$u_{r,Z}$	0,00	0,0000	
2	Repeatability at concentration ct	≤	3,0 nmol/mol	2,000	$u_{r,lh}$	not respected because, ur,lh = 0,075 < ur,f	-	
3	"lack of fit"	≤	4,0% of measured value	0,800	u_{llh}	0,48	0,2334	
4	Sensitivity coefficient of sample gas pressure	≤	8,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000	
5	Sensitivity coefficient of sample gas temperature	≤	3,0 nmol/mol/K	0,026	u_{gt}	0,04	0,0016	
6	Sensitivity coefficient of surrounding temperature	≤	3,0 nmol/mol/K	-0,050	u_{at}	-0,06	0,0036	
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	-0,021	u_V	-0,07	0,0046	
8a	H20 with concentration 21 mmol/mol	≤	5,0 nmol/mol	0,000	u_{H2O}	0,00	0,0000	
8b	CO2 with concentration 500 µmol/mol	≤	5,0 nmol/mol	0,001	$u_{int,pos}$ or $u_{int,neg}$	0,48	0,2304	
8c	O3 with concentration 200 nmol/mol	≤	2,0 nmol/mol	0,002				
8d	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,002				
9	Averaging effect	≤	7,0% of measured value	-0,600	u_{av}	-0,36	0,1313	
10	Reproducibility under field conditions	≤	5,0% of the average of 3 Mon.	4,720	$u_{r,f}$	4,94	24,3752	
11	Long term drift at zero level	≤	5,0 nmol/mol	-1,420	$u_{d,l,z}$	-0,82	0,6721	
12	Long term drift at span level	≤	5,0% of max. of certification range	0,430	$u_{d,l,lh}$	0,26	0,0674	
18	Difference sample/calibration port	≤	1,0%	0,000	uDsc	0,00	0,0000	
21	Converter efficiency	≥	98%	100,000	uCE	0,00	0,0000	
22	Increase of NO2 concentration due to residence time	≤	4,0 nmol/mol	0,000	uctr	0,00	0,0000	
23	Uncertainty calibration gas	≤	3,0%	2,000	ucg	1,05	1,0941	
					combined standard uncertainty	u_c	7,1546	nmol/mol
					expanded uncertainty	U_c	14,3093	nmol/mol
					expanded uncertainty actual	$U_{c,rel}$	**13,68**	%
					expanded uncertainty required	$U_{req,rel}$	15	%

Table 3: Total expanded uncertainty with the results of the laboratory test according to EN 14211 (component NO_2) for system 1330

Device: AR500 Serial No: 1330

Component: NO_2 1h-limit value: 104,6 nmol/mol

No.	Performance characteristic		Criterion	Result	Uncertainty		Square of uncertainty
1	Repeatability at zero	≤	1,0 nmol/mol	0,100	$u_{r,Z}$	0,02	0,0003
2	Repeatability at concentration ct	≤	3,0 nmol/mol	0,900	$u_{r,th}$	0,02	0,0004
3	"lack of fit"	≤	4,0% of measured value	0,000	$u_{l,th}$	0,36	0,1313
4	Sensitivity coefficient of sample gas pressure	≤	8,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000
5	Sensitivity coefficient of sample gas temperature	≤	3,0 nmol/mol/K	0,000	u_{gt}	-0,05	0,0025
6	Sensitivity coefficient of surrounding temperature	≤	3,0 nmol/mol/K	0,000	u_{at}	0,00	0,0000
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	0,000	u_V	0,24	0,0553
8a	H20 with concentration 21 mmol/mol	≤	5,0 nmol/mol	0,000	u_{H2O}	0,00	0,0000
8b	CO2 with concentration 500 µmol/mol	≤	5,0 nmol/mol	0,000	$u_{int,pos}$ or $u_{int,neg}$	0,42	0,1764
8c	O3 with concentration 200 nmol/mol	≤	2,0 nmol/mol	0,000			
8d	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,000			
9	Averaging effect	≤	7,0% of measured value	0,000	u_{av}	-0,18	0,0328
18	Difference sample/calibration port	≤	1,0%	0,000	$u_{\Delta sc}$	0,00	0,0000
21	Converter efficiency	≥	98%	100,000	u_{CE}	0,00	0,0000
22	Increase of NO2 concentration due to residence time	≤	4,0 nmol/mol	0,000	u_{dtr}	0,00	0,0000
23	Uncertainty calibration gas	≤	3,0%	2,000	u_{cg}	1,05	1,0941
					combined standard uncertainty	u_c	1,2222 nmol/mol
					expanded uncertainty	U_c	2,4445 nmol/mol
					expanded uncertainty actual	$U_{c,rel}$	**2,34** %
					expanded uncertainty required	$U_{req,rel}$	15 %

Table 4: Total expanded uncertainty with the results of the laboratory test and field test according to EN 14211 (component NO_2) for system 1330

Device:	AR500			Serial No:	1330			
Component:	NO_2			1h-limit value:	104,6			nmol/mol
No.	**Performance characteristic**		**Criterion**	**Result**	**Uncertainty**		**Square of uncertainty**	
1	Repeatability at zero	≤	1,0 nmol/mol	0,100	$u_{r,z}$	0,02	0,0003	
2	Repeatability at concentration ct	≤	3,0 nmol/mol	0,900	$u_{r,lh}$	not respected because, ur,lh = 0,034 < ur,f	-	
3	"lack of fit"	≤	4,0% of measured value	0,600	$u_{l,lh}$	0,36	0,1313	
4	Sensitivity coefficient of sample gas pressure	≤	8,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000	
5	Sensitivity coefficient of sample gas temperature	≤	3,0 nmol/mol/K	-0,032	u_{gt}	-0,05	0,0025	
6	Sensitivity coefficient of surrounding temperature	≤	3,0 nmol/mol/K	0,000	u_{at}	0,00	0,0000	
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	0,073	u_V	0,24	0,0553	
8a	H20 with concentration 21 mmol/mol	≤	5,0 nmol/mol	0,000	u_{H2O}	0,00	0,0000	
8b	CO2 with concentration 500 µmol/mol	≤	5,0 nmol/mol	0,001	$u_{int,pos}$ or $u_{int,neg}$	0,42	0,1764	
8c	O3 with concentration 200 nmol/mol	≤	2,0 nmol/mol	0,002				
8d	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,000				
9	Averaging effect	≤	7,0% of measured value	-0,300	u_{av}	-0,18	0,0328	
10	Reproducibility under field conditions	≤	5,0% of the average of 3 Mon.	4,720	$u_{r,f}$	4,94	24,3752	
11	Long term drift at zero level	≤	5,0 nmol/mol	1,620	$u_{d,l,z}$	0,94	0,8748	
12	Long term drift at span level	≤	5,0% of max. of certification range	0,500	$u_{d,l,lh}$	0,30	0,0912	
18	Difference sample/calibration port	≤	1,0%	0,000	uDsc	0,00	0,0000	
21	Converter efficiency	≥	0,98	100,000	uCE	0,00	0,0000	
22	Increase of NO2 concentration due to residence time	≤	4,0 nmol/mol	0,000	uctr	0,00	0,0000	
23	Uncertainty calibration gas	≤	3,0%	2,000	ucg	1,05	1,0941	
					combined standard uncertainty	u_c	7,1561	nmol/mol
					expanded uncertainty	U_c	14,3121	nmol/mol
					expanded uncertainty actual	$U_{c,rel}$	**13,68**	%
					expanded uncertainty required	$U_{req,rel}$	15	%

Table 5: Total expanded uncertainty with the results of the laboratory test according to EN 14212 (component SO_2) for system 1329

Device:	AR500			Serial-No.:	Gerät 1 (1329)				
Component:	SO_2			1h-limit value:	132				nmol/mol
No.	Performance characteristic		Criterion	Result	Uncertainty			Square of uncertainty	
1	Repeatability at zero	≤	1,0 nmol/mol	0,100	$u_{r,Z}$	0,02		0,0003	
2	Repeatability at concentration ct	≤	3,0 nmol/mol	0,100	$u_{r,lv}$	0,02		0,0003	
3	"lack of fit"	≤	4,0% of measured value	1,600	u_{Llv}	1,22		1,4868	
4	Sensitivity coefficient of sample gas pressure	≤	3,0 nmol/mol/kPa	0,000	u_{gp}	0,00		0,0000	
5	Sensitivity coefficient of sample gas temperature	≤	1,0 nmol/mol/K	0,071	u_{gt}	0,54		0,2908	
6	Sensitivity coefficient of surrounding temperature	≤	1,0 nmol/mol/K	-0,030	u_{st}	-0,23		0,0523	
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	-0,010	u_V	-0,10		0,0103	
8a	H20 with concentration 21 mmol/mol	≤	10 nmol/mol	0,000	u_{H2O}	0,00		0,0000	
8b	H2S with concentration 200 nmol/mol	≤	5,0 nmol/mol	-0,409	$u_{int,pos}$				
8c	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,406					
8d	NO with concentration 500 nmol/mol	≤	5,0 nmol/mol	-0,604	or	0,40		0,1600	
8e	NO2 with concentration 200 nmol/mol	≤	5,0 nmol/mol	-0,404					
8f	m-Xylol with concentration 1 µmol/mol	≤	10 nmol/mol	1,421	$u_{int,neg}$				
9	Averaging effect	≤	7,0% of measured value	-0,100	u_{av}	-0,08		0,0058	
18	Difference sample/calibration port	≤	1,0%	0,000	u_{Dsc}	0,00		0,0000	
23	Uncertainty calibration gas	≤	3,0%	2,000	ucg	1,32		1,7424	
					combined standard uncertainty		u_c	1,9363	nmol/mol
					expanded uncertainty		U_c	3,8726	nmol/mol
					expanded uncertainty actual		$U_{c,rel}$	**2,93**	%
					expanded uncertainty required		$U_{req,rel}$	15	%

Table 6: Total expanded uncertainty with the results of the laboratory test and field test according to EN 14212 (component SO_2) for system 1329

Device:	AR500			Serial-No.:	Gerät 1 (1329)				
Component:	SO_2			1h-limit value:	132				nmol/mol
No.	Performance characteristic		Criterion	Result	Uncertainty			Square of uncertainty	
1	Repeatability at zero	≤	1,0 nmol/mol	0,100	$u_{r,z}$	0,02		0,0003	
2	Repeatability at concentration ct	≤	3,0 nmol/mol	0,100	$u_{r,lv}$	not respected because, ur,lv = 0,01 < ur,f		-	
3	"lack of fit"	≤	4,0% of measured value	1,600	$u_{l,lv}$	1,22		1,4868	
4	Sensitivity coefficient of sample gas pressure	≤	3,0 nmol/mol/kPa	0,000	u_{gp}	0,00		0,0000	
5	Sensitivity coefficient of sample gas temperature	≤	1,0 nmol/mol/K	0,071	u_{gt}	0,54		0,2908	
6	Sensitivity coefficient of surrounding temperature	≤	1,0 nmol/mol/K	-0,030	u_{st}	-0,23		0,0523	
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	-0,010	u_V	-0,10		0,0103	
8a	H20 with concentration 21 mmol/mol	≤	10 nmol/mol	0,000	u_{H2O}	0,00		0,0000	
8b	H2S with concentration 200 nmol/mol	≤	5,0 nmol/mol	-0,409	$u_{int,pos}$				
8c	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,406					
8d	NO with concentration 500 nmol/mol	≤	5,0 nmol/mol	-0,604	or	0,40		0,1600	
8e	NO2 with concentration 200 nmol/mol	≤	5,0 nmol/mol	-0,404					
8f	m-Xylol with concentration 1 µmol/mol	≤	10 nmol/mol	1,421	$u_{int,neg}$				
9	Averaging effect	≤	7,0% of measured value	-0,100	u_{av}	-0,08		0,0058	
10	Reproducibility under field conditions	≤	5,0% of the average of 3 Mon.	4,830	$u_{r,f}$	6,38		40,6483	
11	Long term drift at zero level	≤	5,0 nmol/mol	-0,920	$u_{d,l,z}$	-0,53		0,2821	
12	Long term drift at span level	≤	5,0% of max. of certification range	1,490	$u_{d,l,lv}$	1,14		1,2894	
18	Differenz Proben-/Kalibriergaseingang	≤	1,0%	0,000	u_{Disc}	0,00		0,0000	
23	Unsicherheit Prüfgas	≤	3,0%	2,000	ucg	1,32		1,7424	
					combined standard uncertainty		u_c	6,7800	nmol/mol
					expanded uncertainty		U_c	13,5600	nmol/mol
					expanded uncertainty actual		$U_{c,rel}$	**10,27**	%
					expanded uncertainty required		$U_{req,rel}$	15	%

Table 7: Total expanded uncertainty with the results of the laboratory test according to EN 14212 (component SO_2) for system 1330

Device: AR500 Serial-No.: Gerät 2 (1330)

Component: SO_2 1h-limit value: 132 nmol/mol

No.	Performance characteristic		Criterion	Result	Uncertainty		Square of uncertainty
1	Repeatability at zero	≤	1,0 nmol/mol	0,000	$u_{r,z}$	0,00	0,0000
2	Repeatability at concentration ct	≤	3,0 nmol/mol	0,100	$u_{r,hv}$	0,02	0,0003
3	"lack of fit"	≤	4,0% of measured value	1,400	$u_{l,hv}$	1,07	1,1384
4	Sensitivity coefficient of sample gas pressure	≤	3,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000
5	Sensitivity coefficient of sample gas temperature	≤	1,0 nmol/mol/K	0,011	u_{gt}	0,08	0,0070
6	Sensitivity coefficient of surrounding temperature	≤	1,0 nmol/mol/K	-0,060	u_{at}	-0,46	0,2091
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	0,010	u_V	0,10	0,0103
8a	H20 with concentration 21 mmol/mol	≤	10 nmol/mol	0,000	u_{H2O}	0,00	0,0000
8b	H2S with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,503	$u_{int,pos}$		
8c	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,203			
8d	NO with concentration 500 nmol/mol	≤	5,0 nmol/mol	0,202	or	1,23	1,5129
8e	NO2 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,401			
8f	m-Xylol with concentration 1 µmol/mol	≤	10 nmol/mol	0,809	$u_{int,neg}$		
9	Averaging effect	≤	7,0% of measured value	0,100	u_{av}	0,08	0,0058
18	Difference sample/calibration port	≤	1,0%	0,000	u_{Dsc}	0,00	0,0000
23	Uncertainty calibration gas	≤	3,0%	2,000	0	1,32	1,7424

combined standard uncertainty	u_c	2,1509	nmol/mol
expanded uncertainty	U_c	4,3017	nmol/mol
expanded uncertainty actual	$U_{c,rel}$	**3,26**	%
expanded uncertainty required	$U_{req,rel}$	15	%

Table 8: Total expanded uncertainty with the results of the laboratory test and field test according to EN 14212 (component SO_2) for system 1330

Device:	AR500			Serial-No.:	Gerät 2 (1330)			
Component:	SO_2			1h-limit value:	132			nmol/mol
No.	Performance characteristic		Criterion	Result	Uncertainty		Square of uncertainty	
1	Repeatability at zero	≤	1,0 nmol/mol	0,000	$u_{r,z}$	0,00	0,0000	
2	Repeatability at concentration ct	≤	3,0 nmol/mol	0,100	$u_{r,lv}$	not respected because, ur,lv = 0,01 < ur,f	-	
3	"lack of fit"	≤	4,0% of measured value	1,400	$u_{l,lv}$	1,07	1,1384	
4	Sensitivity coefficient of sample gas pressure	≤	3,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000	
5	Sensitivity coefficient of sample gas temperature	≤	1,0 nmol/mol/K	0,011	u_{gt}	0,08	0,0070	
6	Sensitivity coefficient of surrounding temperature	≤	1,0 nmol/mol/K	-0,060	u_{at}	-0,46	0,2091	
7	Sensitivity coefficient of electrical voltage	≤	0,30 nmol/mol/V	0,010	u_V	0,10	0,0103	
8a	H20 with concentration 21 mmol/mol	≤	10 nmol/mol	0,000	u_{H2O}	0,00	0,0000	
8b	H2S with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,503	$u_{int,pos}$			
8c	NH3 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,203				
8d	NO with concentration 500 nmol/mol	≤	5,0 nmol/mol	0,202	or	1,23	1,5129	
8e	NO2 with concentration 200 nmol/mol	≤	5,0 nmol/mol	0,401				
8f	m-Xylol with concentration 1 µmol/mol	≤	10 nmol/mol	0,809	$u_{int,neg}$			
9	Averaging effect	≤	7,0% of measured value	0,100	u_{lav}	0,08	0,0058	
10	Reproducibility under field conditions	≤	5,0% of the average of 3 Mon.	4,830	$u_{r,f}$	6,38	40,6483	
11	Long term drift at zero level	≤	5,0 nmol/mol	1,160	$u_{d,l,z}$	0,67	0,4485	
12	Long term drift at span level	≤	5,0% of max. of certification range	-2,070	$u_{d,l,lv}$	-1,58	2,4887	
18	Differenz Proben-/Kalibriergaseingang	≤	1,0%	0,000	u_{Dbc}	0,00	0,0000	
23	Unsicherheit Prüfgas	≤	3,0%	2,000	0	1,32	1,7424	
					combined standard uncertainty	u_c	6,9434	nmol/mol
					expanded uncertainty	U_c	13,8869	nmol/mol
					expanded uncertainty actual	$U_{c,rel}$	**10,52**	%
					expanded uncertainty required	$U_{req,rel}$	15	%

Table 9: Total expanded uncertainty with the results of the laboratory test according to EN 14625 (component O_3) for system 1329

Device:	AR500	Seriel No.	Gerät 1 (1329)				
Measured component:	O_3	hourly alert threshold	120	nmol/mol			

No.	Performance characteristic	Criterion	Result	Uncertainty		Square of uncertainty	
1	Repeatability standard deviation at zero	1,0 nmol/mol	0,200	$u_{r,Z}$	0,04	0,0013	
2	Repeatability standard deviation at ct	3,0 nmol/mol	0,600	$u_{r,Iv}$	0,11	0,0120	
3	"lack of fit" at the hourly alert threshold value	4,0% of measured value	0,400	$u_{l,Iv}$	0,28	0,0768	
4	Variations in sample gas pressure	2,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000	
5	Variations in sample gas temperature	1,0 nmol/mol/K	0,014	u_{gt}	0,15	0,0212	
6	Variations in surrounding temperature	1,0 nmol/mol/K	0,150	u_{st}	0,52	0,2700	
7	Variations in electrical voltage	0,30 nmol/mol/V	-0,010	u_V	-0,12	0,0147	
8a	Interference H20 with 21 mmol/mol	10 nmol/mol	0,000	u_{H2O}	0,00	0,0000	
8b	Interference Toluol with 0,5 µmol/mol	5,0 nmol/mol	2,147	$u_{int,pos}$ or $u_{int,\ neg}$	1,47	2,1573	
8c	Interference Xylol with 0,5 µmol/mol	5,0 nmol/mol	0,397				
9	Averaging effect	7,0% of measured value	0,200	u_{av}	0,14	0,0192	
18	Difference sample/calibration port	1,0%	0,000	u_{Dsc}	0,00	0,0000	
23	Uncertainty test gas	3,0%	2,000	ucg	1,20	1,4400	
				Combined standard uncertainty	u_c	2,0031	nmol/mol
				Expanded uncertainty	U_c	4,0062	nmol/mol
				Expanded uncertainty actual	$U_{c,rel}$	**3,34**	%
				Expanded uncertainty required	$U_{req,rel.}$	15	%

Table 10 Total expanded uncertainty with the results of the laboratory test and field test according to EN 14625 (component O_3) for system 1329

Device:	AR500	Seriel No.	Gerät 1 (1329)					
Measured component:	O_3	hourly alert threshold	120					nmol/mol
No.	**Performance characteristic**	**Criterion**	**Result**	**Uncertainty**			**Square of uncertainty**	
1	Repeatability standard deviation at zero	1,0 nmol/mol	0,200	$u_{r,z}$	0,04		0,0013	
2	Repeatability standard deviation at ct	3,0 nmol/mol	0,600	$u_{r,lv}$	not respected because, ur,lv = 0,1 < ur,f		-	
3	"lack of fit" at the hourly alert threshold value	4,0% of measured value	0,400	$u_{i,lv}$	0,28		0,0768	
4	Variations in sample gas pressure	2,0 nmol/mol/kPa	0,000	u_{gp}	0,00		0,0000	
5	Variations in sample gas temperature	1,0 nmol/mol/K	0,014	u_{gt}	0,15		0,0212	
6	Variations in surrounding temperature	1,0 nmol/mol/K	0,150	u_{at}	0,52		0,2700	
7	Variations in electrical voltage	0,30 nmol/mol/V	-0,010	u_V	-0,12		0,0147	
8a	Interference H20 with 21 mmol/mol	10 nmol/mol	0,000	u_{H2O}	0,00		0,0000	
8b	Interference Toluol with 0,5 µmol/mol	5,0 nmol/mol	2,147	$u_{int,pos}$ or $u_{int,\ neg}$	1,47		2,1573	
8c	Interference Xylol with 0,5 µmol/mol	5,0 nmol/mol	0,397					
9	Averaging effect	7,0% of measured value	0,200	u_{av}	0,14		0,0192	
10	Reproducibility standard deviation in field	5,0% of average of 3 month	2,410	$u_{r,f}$	2,89		8,3637	
11	Long term drift at zero	5,0 nmol/mol	1,460	$u_{d,l,z}$	0,84		0,7105	
12	Long term drift at span level	5,0% of range	-2,450	$u_{d,l,lv}$	-1,70		2,8812	
18	Difference sample/calibration port	1,0%	0,000	uDsc	0,00		0,0000	
23	Uncertainty test gas	3,0%	2,000	ucg	1,20		1,4400	
				Combined standard uncertainty		u_c	3,9945	nmol/mol
				Expanded uncertainty		U_c	7,9890	nmol/mol
				Expanded uncertainty actual		$U_{c,rel}$	**6,66**	%
				Expanded uncertainty required		$U_{req,rel.}$	15	%

Table 11: Total expanded uncertainty with the results of the laboratory test according to EN 14625 (component O_3) for system 1330

Device:	AR500	Seriel No.	Gerät 2 (1330)				
Measured component:	O_3	hourly alert threshold	120				nmol/mol
No.	**Performance characteristic**	**Criterion**	**Result**	**Uncertainty**		**Square of uncertainty**	
1	Repeatability standard deviation at zero	1,0 nmol/mol	0,200	$u_{r,Z}$	0,04	0,0013	
2	Repeatability standard deviation at ct	3,0 nmol/mol	0,400	$u_{r,lv}$	0,07	0,0053	
3	"lack of fit" at the hourly alert threshold value	4,0% of measured value	-0,300	$u_{l,lv}$	-0,21	0,0432	
4	Variations in sample gas pressure	2,0 nmol/mol/kPa	0,000	u_{gp}	0,00	0,0000	
5	Variations in sample gas temperature	1,0 nmol/mol/K	0,007	u_{gt}	0,07	0,0053	
6	Variations in surrounding temperature	1,0 nmol/mol/K	-0,120	u_{at}	-0,42	0,1728	
7	Variations in electrical voltage	0,30 nmol/mol/V	0,010	u_V	0,12	0,0147	
8a	Interference H20 with 21 mmol/mol	10 nmol/mol	0,000	u_{H2O}	0,00	0,0000	
8b	Interference Toluol with 0,5 µmol/mol	5,0 nmol/mol	0,396	$u_{int,pos}$ or $u_{int,neg}$	1,72	2,9416	
8c	Interference Xylol with 0,5 µmol/mol	5,0 nmol/mol	2,574				
9	Averaging effect	7,0% of measured value	-0,900	u_{av}	-0,62	0,3888	
18	Difference sample/calibration port	1,0%	0,000	u_{Dsc}	0,00	0,0000	
23	Uncertainty test gas	3,0%	2,000	0	1,20	1,4400	
				Combined standard uncertainty	u_c	2,2390	nmol/mol
				Expanded uncertainty	U_c	4,4780	nmol/mol
				Expanded uncertainty actual	$U_{c,rel}$	**3,73**	%
				Expanded uncertainty required	$U_{req,rel.}$	15	%

Table 12 Total expanded uncertainty with the results of the laboratory test and field test according to EN 14625 (component O_3) for system 1330

Device:	AR500	Seriel No.	Gerät 2 (1330)					
Measured component:	O_3	hourly alert threshold	120	nmol/mol				
No.	**Performance characteristic**	**Criterion**	**Result**	**Uncertainty**			**Square of uncertainty**	
1	Repeatability standard deviation at zero	1,0 nmol/mol	0,200	$u_{r,z}$	0,04		0,0013	
2	Repeatability standard deviation at ct	3,0 nmol/mol	0,400	$u_{r,lv}$	not respected, because ur,lv = 0,07 < ur,f		-	
3	"lack of fit" at the hourly alert threshold value	4,0% of measured value	-0,300	$u_{i,lv}$	-0,21		0,0432	
4	Variations in sample gas pressure	2,0 nmol/mol/kPa	0,000	u_{gp}	0,00		0,0000	
5	Variations in sample gas temperature	1,0 nmol/mol/K	0,007	u_{gt}	0,07		0,0053	
6	Variations in surrounding temperature	1,0 nmol/mol/K	-0,120	u_{at}	-0,42		0,1728	
7	Variations in electrical voltage	0,30 nmol/mol/V	0,010	u_V	0,12		0,0147	
8a	Interference H20 with 21 mmol/mol	10 nmol/mol	0,000	u_{H2O}	0,00		0,0000	
8b	Interference Toluol with 0,5 µmol/mol	5,0 nmol/mol	0,396	$u_{int,pos}$ or $u_{int,neg}$	1,72		2,9416	
8c	Interference Xylol with 0,5 µmol/mol	5,0 nmol/mol	2,574					
9	Averaging effect	7,0% of measured value	-0,900	u_{av}	-0,62		0,3888	
10	Reproducibility standard deviation in field	5,0% of average of 3 month	2,410	$u_{r,f}$	2,89		8,3637	
11	Long term drift at zero	5,0 nmol/mol	-1,840	$u_{d,l,z}$	-1,06		1,1285	
12	Long term drift at span level	5,0% of range	2,900	$u_{d,l,lv}$	2,01		4,0368	
18	Difference sample/calibration port	1,0%	0,000	uDsc	0,00		0,0000	
23	Uncertainty test gas	3,0%	2,000	0	1,20		1,4400	
				Combined standard uncertainty		u_c	4,3054	nmol/mol
				Expanded uncertainty		U_c	8,6109	nmol/mol
				Expanded uncertainty actual		$U_{c,rel}$	**7,18**	%
				Expanded uncertainty required		$U_{req,rel.}$	15	%