

CERTIFICATE

of Product Conformity (QAL1)

Certificate No.: 0000043527_01

Certified AMS: T500U for NO₂

Manufacturer: Teledyne API
9480 Carroll Park Drive
San Diego, CA 92103
USA

Test Institute: TÜV Rheinland Energie und Umwelt GmbH

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

**VDI 4202-1: 2010, VDI 4203-3: 2010, EN 14211: 2012,
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).

The present certificate replaces certificate no. 0000043527 of 30 April 2015



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

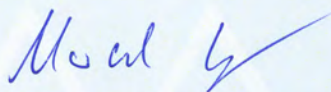
www.tuv.com
ID 0000043527

Publication in the German Federal Gazette
(BAnz.) of 26 August 2015

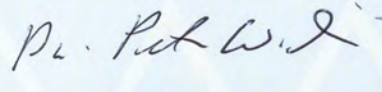
This certificate will expire on:
01 April 2020

German Federal Environment Agency
Dessau, 30 September 2015

TÜV Rheinland Energie und Umwelt GmbH
Cologne, 29 September 2015



i. A. Dr. Marcel Langner



ppa. Dr. Peter Wilbring

www.umwelt-tuv.de / www.eco-tuv.com
teu@umwelt-tuv.de
Tel. +49 221 806-5200

TÜV Rheinland Energie und Umwelt GmbH
Am Grauen Stein
51105 Cologne

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

Certificate:
0000043527_01 / 30 September 2015

Test report: 936/21224798/B of 3 March 2015
Initial certification: 02 April 2015
Date of expiry: 01 April 2020
Publication: BAnz AT 26 August 2015 B4, chapter III number 1.1

Approved application

The certified AMS is suitable for continuous ambient air monitoring (stationary operation).

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

The AMS is approved for the temperature range of 0 °C to +30 °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 936/21224798/B of 3 March 2015 of TÜV Rheinland Energie und Umwelt GmbH
- suitability announced by the German Federal Environment Agency (UBA) as the relevant body
- the on-going surveillance of the product and the manufacturing process
- publication in the German Federal Gazette (BAnz AT 26 August 2015 B4, chapter III number 1.1: Announcement by UBA from 22 July 2015)

Measuring system:

T500U for NO₂

Manufacturer:

Teledyne API, San Diego, USA

Field of application:

For the continuous determination of nitrogen dioxide concentrations in ambient air in stationary application

Measuring range during performance testing:

Component	Certification range	Unit
Nitrogen dioxide	0 – 500	µg/m ³

Software version:

Rev. 1.0.2 bld 22

Restrictions:

None

Notes:

1. The performance test report is available online at www.qal1.de.
2. Equivalence to the reference method was demonstrated for component NO₂ in accordance with the requirements of the guideline "Demonstration of Equivalence of Ambient Air Monitoring Methods".
3. Supplementary testing (demonstration of equivalence to the reference measurement method) to Federal Environment Agency notice of 25 February 2015 (BANz AT 2 April 2015 B5, chapter III number 2.1).

Test report:

TÜV Rheinland Energie und Umwelt GmbH, Cologne
Report no.: 936/21224798/B of 3 March 2015

Certified product

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

The T500U is an optical absorption spectrometer, which can measure NO₂ directly by means of the "Cavity Attenuated Phase Shift (CAPS)" method. The CAPS method uses light from a blue Ultraviolet (UV) light emitting diode (LED) centred at 450 nm, a measurement cell with high reflectivity mirrors located at either end to provide an extensive optical path length, and a vacuum photodiode detector. These components are assembled into the optical cell which resides in a temperature-controlled oven. The oven raises the ambient temperature of the sample gas to 45 °C. This mitigates the formation of moisture on the surfaces of the mirrors while also minimizing changes in the absorption coefficient due to temperature fluctuations.

NO₂ is measured directly by means of optical absorption. This phenomenon is well-defined and is described by the Beer-Lambert law, where the absorbance (lost light) is directly proportional to both the path-length and concentration of the absorbing gas.

$$A = \epsilon lc$$

(A = Absorbance, ϵ = molar absorptivity, l = mean light path length, c = concentration)

The T500U uses few components: an optical cell, a pair of highly reflective spherical mirrors centred at 450 nm, a light emitting diode (LED), and a vacuum photodiode detector.

The LED is located behind a mirror at one end of the cell, and the detector behind the other mirror, at the opposite end of the cell. The LED emits ultraviolet (UV) light into the cell; the light reflects back and forth between the two mirrors, building intensity and running a very long path length. The long path extends the "time" or "life" of the photon through the use of precisely timed data acquisition. Coupled with a proprietary algorithm, the measured absorption is translated into a phase shift, from which the NO₂ concentration is calculated.

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.

Certificate:
0000043527_01 / 30 September 2015

Certification of T500U for NO₂ 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. 0000043527: 30 April 2015

Expiry date of the certificate: 01 April 2020

Test report: 936/21224798/A of 02 October 2014
TÜV Rheinland Energie und Umwelt GmbH, Cologne

Publication: BAnz AT 02 April 2015 BA, chapter III Number 2.1
Announcement by UBA from 25 February 2015

Supplementary testing according to EN 15267

Certificate No. 0000043527_01: 30 September 2015

Expiry date of the certificate: 01 April 2020

Test report: 936/21224798/B of 3 March 2015
TÜV Rheinland Energie und Umwelt GmbH, Cologne

Publication: BAnz AT 26 August 2015 B4, chapter III number 1.1
Announcement by UBA from 22 July 2015

Expanded uncertainty based on the results of the laboratory testing of system 1

Measuring device: Teledyne 1500U		Serial-No.: SN 63 (Gerät 1)		nmol/mol	
Measured component: NO ₂		1h-limit value:		104.6	
No.	Performance characteristic	Performance criterion	Result	Partial uncertainty	Square of partial uncertainty
1	Repeatability standard deviation at zero	≤ 1.0 nmol/mol	0.070	U _{r,z}	0.0001
2	Repeatability standard deviation at 1h-limit value	≤ 3.0 nmol/mol	0.250	U _{r,h}	0.0015
3	"lack of fit" at 1h-limit value	≤ 4.0% of measured value	0.770	U _{l,h}	0.2162
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤ 8.0 nmol/mol/kPa	0.080	U _{gp}	0.5944
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.010	U _{gt}	0.0093
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.097	U _{st}	0.8646
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤ 0.30 nmol/mol/V	0.003	U _v	0.0012
8a	Interferent H ₂ O with 21 mmol/mol	≤ 10 nmol/mol (Zero) ≤ 10 nmol/mol (Span)	0.120 -1.830	U _{H2O}	1.8876
8b	Interferent CO ₂ with 500 µmol/mol	≤ 5.0 nmol/mol (Zero) ≤ 5.0 nmol/mol (Span)	0.440 1.330	U _{int,pos} or	0.8824
8c	Interferent NH ₃ mit 200 nmol/mol	≤ 5.0 nmol/mol (Zero) ≤ 5.0 nmol/mol (Span)	-0.030 0.290	U _{int,neg}	
9	Averaging effect	≤ 7.0% of measured value	-2.310	U _{av}	1.9461
18	Difference sample/calibration port	≤ 1.0%	-0.140	U _{ssc}	0.0214
21	Converter efficiency	≥ 98	100.00	U _{cc}	0.0000
23	Uncertainty of test gas	≤ 3.0%	2.000	U _{cg}	1.0941
Combined standard uncertainty				U _c	2.7424
Expanded uncertainty				U	5.4847
Relative expanded uncertainty				W	5.24
Maximum allowed expanded uncertainty				W _{req}	15

Expanded uncertainty based on the results of the laboratory testing of system 2

Measuring device:		Serial-No.:		1h-limit value:		Square of partial uncertainty	
Teledyne T500U		SN 65 (Gerät 2)		104.6		nmol/mol	
Measured component:		Performance criterion		Result		Partial uncertainty	
NO ₂		≤ 1.0 nmol/mol		0.050		U _{r,z} 0.01	
Repeatability standard deviation at zero		≤ 3.0 nmol/mol		0.150		U _{r,ih} 0.02	
Repeatability standard deviation at 1h-limit value		≤ 4.0% of measured value		0.690		U _{l,ih} 0.42	
"lack of fit" at 1h-limit value		≤ 8.0 nmol/mol/kPa		0.160		U _{gp} 1.55	
Sensitivity coefficient of sample gas pressure at 1h-limit value		≤ 3.0 nmol/mol/K		0.010		U _{gt} 0.10	
Sensitivity coefficient of sample gas temperature at 1h-limit value		≤ 3.0 nmol/mol/K		0.143		U _{st} 1.39	
Sensitivity coefficient of surrounding temperature at 1h-limit value		≤ 0.30 nmol/mol/V		0.004		U _v 0.05	
Sensitivity coefficient of electrical voltage at 1h-limit value		≤ 10 nmol/mol (Zero)		0.000		U _{H2O} -1.25	
Interferent H ₂ O with 21 nmol/mol		≤ 10 nmol/mol (Span)		0.000		U _{H2O} -1.25	
Interferent CO ₂ with 500 µmol/mol		≤ 5.0 nmol/mol (Zero)		0.470		U _{int,pos}	
Interferent NH ₃ mit 200 nmol/mol		≤ 5.0 nmol/mol (Span)		1.090		or 0.73	
Averaging effect		≤ 5.0 nmol/mol (Zero)		0.030		U _{int,neg}	
Difference sample/calibration port		≤ 7.0% of measured value		-2.080		U _{av} -1.26	
Converter efficiency		≤ 1.0%		-0.170		U _{sc} -0.18	
Uncertainty of test gas		≥ 98		100.00		U _{EC} 0.00	
		≤ 3.0%		2.000		U _{cg} 1.05	
		Combined standard uncertainty		U _c		3.0525	
		Expanded uncertainty		U		6.1051	
		Relative expanded uncertainty		W		5.84	
		Maximum allowed expanded uncertainty		W _{req}		15	

Expanded uncertainty based on the results of the laboratory and field testing of system 1

Measuring device: Teledyne T500U		Serial-No.: SN 63 (Gerät 1)		nmol/mol	
Measured component: NO ₂		1h-limit value:		104.6	
No.	Performance characteristic	Performance criterion	Result	Partial uncertainty	Square of partial uncertainty
1	Repeatability standard deviation at zero	≤ 1.0 nmol/mol	0.070	U _{r,z}	0.0001
2	Repeatability standard deviation at 1h-limit value	≤ 3.0 nmol/mol	0.250	U _{r,h}	not considered, as $\sqrt{2} \cdot u_{r,h} = 0.05 < u_{r,f}$
3	"lack of fit" at 1h-limit value	≤ 4.0% of measured value	0.770	U _{l,h}	0.2162
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤ 8.0 nmol/mol/kPa	0.080	U _{gp}	0.5944
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.010	U _{gt}	0.0093
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.097	U _{st}	0.8646
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤ 0.30 nmol/mol/V	0.003	U _v	0.0012
8a	Interferent H ₂ O with 21 nmol/mol	≤ 10 nmol/mol (Zero)	0.120	U _{H2O}	1.8876
		≤ 10 nmol/mol (Span)	-1.830		
8b	Interferent CO ₂ with 500 µmol/mol	≤ 5.0 nmol/mol (Zero)	0.440	U _{int,pos}	
		≤ 5.0 nmol/mol (Span)	1.330	or	
8c	Interferent NH ₃ mit 200 nmol/mol	≤ 5.0 nmol/mol (Zero)	-0.030	U _{int,neg}	0.8824
		≤ 5.0 nmol/mol (Span)	0.290		
9	Averaging effect	≤ 7.0% of measured value	-2.310	U _{av}	1.9461
10	Reproducibility standard deviation under field conditions	≤ 5.0% of average over 3 months	1.210	U _{r,f}	1.6019
11	Long term drift at zero level	≤ 5.0 nmol/mol	0.300	U _{l,z}	0.0300
12	Long term drift at span level	≤ 5.0% of max. of certification range	-1.580	U _{l,h}	0.9105
18	Difference sample/calibration port	≤ 1.0%	-0.140	U _{sc}	0.0214
21	Converter efficiency	≥ 98	100.000	U _{EC}	0.0000
23	Uncertainty of test gas	≤ 3.0%	2.000	U _{cg}	1.0941
Combined standard uncertainty				U _c	3.1717
Expanded uncertainty				U	6.3435
Relative expanded uncertainty				W	6.06
Maximum allowed expanded uncertainty				W _{req}	15

Expanded uncertainty based on the results of the laboratory and field testing of system 2

Measuring device:		Serial-No.:		SN 65 (Gerät 2)		nmol/mol	
Measured component:		1h-limit value:		104.6			
No.	Performance characteristic	Performance criterion	Result	Partial uncertainty	Square of partial uncertainty		
1	Repeatability standard deviation at zero	≤ 1.0 nmol/mol	0.050	u _{r,z}	0.01	0.0001	
2	Repeatability standard deviation at 1h-limit value	≤ 3.0 nmol/mol	0.150	u _{r,h}	not considered, as $\sqrt{2} \cdot u_{r,h} = 0.03 < u_{r,f}$	-	
3	"lack of fit" at 1h-limit value	≤ 4.0% of measured value	0.690	u _{l,h}	0.42	0.1736	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤ 8.0 nmol/mol/kPa	0.160	u _{sp}	1.55	2.4029	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.010	u _{gt}	0.10	0.0091	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.143	u _{st}	1.39	1.9194	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤ 0.30 nmol/mol/V	0.004	u _v	0.05	0.0021	
8a	interferent H ₂ O with 21 mmol/mol	≤ 10 nmol/mol (Zero)	0.220	u _{H2O}	-1.25	1.5732	
		≤ 10 nmol/mol (Span)	-1.670				
8b	interferent CO ₂ with 500 μmol/mol	≤ 5.0 nmol/mol (Zero)	0.470	u _{int,pos}			
		≤ 5.0 nmol/mol (Span)	1.090	or	0.73	0.5329	
8c	interferent NH ₃ mit 200 nmol/mol	≤ 5.0 nmol/mol (Zero)	0.030				
		≤ 5.0 nmol/mol (Span)	0.170	u _{int,neg}			
9	Averaging effect	≤ 7.0% of measured value	-2.080	u _{av}	-1.26	1.5779	
10	Reproducibility standard deviation under field conditions	≤ 5.0% of average over 3 months	1.210	u _{r,f}	1.27	1.6019	
11	Long term drift at zero level	≤ 5.0 nmol/mol	0.280	u _{r,z}	0.16	0.0261	
12	Long term drift at span level	≤ 5.0% of max. of certification range	-1.820	u _{d,l,h}	-1.10	1.2080	
18	Difference sample/calibration port	≤ 1.0%	-0.170	u _{asc}	-0.18	0.0316	
21	Converter efficiency	≥ 98	100.000	u _{ec}	0.00	0.0000	
23	Uncertainty of test gas	≤ 3.0%	2.000	u _{cg}	1.05	1.0941	
Combined standard uncertainty						u _c	3.4861
Expanded uncertainty						U	6.9722
Relative expanded uncertainty						W	6.67
Maximum allowed expanded uncertainty						W _{req}	15