

CERTIFICATE

of Product Conformity (QAL1)

Certificate No.: 0000043527_02

Certified AMS: T500U for NO₂

Manufacturer: Teledyne API
9970 Carroll Canyon Road
San Diego, CA, 92131
USA

Test Institute: TÜV Rheinland Energy GmbH

**This is to certify that the AMS has been tested
and found to comply with the standards
VDI 4202-1 (2010), VDI 4203-3 (2010), EN 14211 (2012)
and EN 15267-1 (2009), EN 15267-2 (2009).**

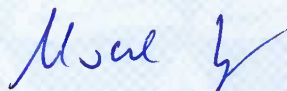
Certification is awarded in respect of the conditions stated in this certificate
(this certificate contains 11 pages).
The present certificate replaces certificate 0000043527_01 of 30 September 2015.



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

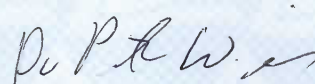
German Federal Environment Agency
Dessau, 02 April 2020



Dr. Marcel Langner
Head of Section II 4.1

This certificate will expire on:
01 April 2025

TÜV Rheinland Energy GmbH
Cologne, 01 April 2020



ppa. Dr. Peter Wilbring

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Test institute accredited to EN ISO/IEC 17025:2005 by DAkkS (German Accreditation Body). This accreditation is limited to the accreditation scope defined in the enclosure to the certificate D-PL-11120-02-00

Certificate:
0000043527_02 / 02 April 2020

Test report: 936/21224798/B dated 03 March 2015
Initial certification: 30 April 2015
Expiry date: 01 April 2025
Certificate: renewal (previous certificate 0000043527_01 dated 30 September 2015 valid until 01 April 2020)
Publication: BAnz AT 26.08.2015 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 three-month field test.

The AMS is approved for the temperature range of 0 °C to +30 °C.

The notification of suitability of the AMS, performance testing, and the uncertainty calculation have been effected on the basis of the regulations valid at the time of performance testing. As changes in legal regulations are possible, any potential user should ensure in consultation with the manufacturer that this AMS is suitable for monitoring the limit value relevant to the application.

Any potential user should ensure, in consultation with the manufacturer, that this AMS is suitable for the intended purpose.

Basis of the certification

This certification is based on:

- Test report 936/21224798/B dated 03 March 2015 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 AT 26.08.2015 B4, chapter III number 1.1,
UBA announcement dated 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 the 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) as regards Federal Environment Agency notice of 25 February 2015 (BAnz AT 02.04.2015 B5, chapter III number 2.1).

Test report:

TÜV Rheinland Energie und Umwelt GmbH, Cologne
Report No.: 936/21224798/B dated 03 March 2015

Publication in the German Federal Gazette: BAnz AT 14.03.2016 B7,
chapter V notification 11, UBA announcement dated 18 February 2016:

11 Notification as regards Federal Environment Agency (UBA) notices of 22 July 2015 (BAnz AT 26.08.2015 B4, chapter III number 1.1)

The current software versions for the measuring equipment T500U for NO₂ of Teledyne Advanced Pollution Instrumentation are:

package version: 1.0.0
driver version: 1.0.2

Statement of TÜV Rheinland Energie und Umwelt GmbH of 19 October 2015

Publication in the German Federal Gazette: BAnz AT 26.03.2018 B7,
chapter V notification 15, UBA announcement dated 21 February 2018:

15 Notification as regards Federal Environment Agency notices of 22 July 2015 (BAnz AT 26.08.2015 B4, chapter III number 1.1) and of 18 February 2016 (BAnz AT 14.03.2016 B7, chapter V 11th notification)

The production site of the T500U air quality monitor for NO₂ manufactured by Teledyne Advanced Pollution Instrumentation has moved to:

9970 Carroll Canyon Road
San Diego, CA 92131
USA

Statement issued by TÜV Rheinland Energy GmbH dated 17 August 2017

Publication in the German Federal Gazette: BAnz AT 26.03.2019 B7,
chapter IV notification 69, UBA announcement dated 27 February 2019:

69 Notification as regards Federal Environment Agency notices of 22 July 2015 (BAnz AT 26.08.2015 B4, chapter III number 1.1) and of 21 February 2018 (BAnz AT 26.03.2018 B8, chapter V 15th Notification)

The current software version of the T500U measuring system for NO₂ manufactured by Teledyne Advanced Pollution Instrumentation is:

Package version: 1.2.3
Driver version: 1.0.2

Statement issued by TÜV Rheinland Energy GmbH dated 5 September 2018

Publication in the German Federal Gazette: BAnz AT 24.03.2020 B7,
chapter IV notification 69, UBA announcement dated 24 February 2020:

**69 Notification as regards Federal Environment Agency (UBA) notices
of 22 July 2015 (BAnz AT 26.08.2015 B4, chapter III number 1.1) and
of 27 February 2019 (BAnz AT 26.03.2019 B7, chapter IV 69th notification)**

The company name has changed from Teledyne Advanced Pollution Instruments to
Teledyne API.

The latest software version of the T500U measuring system for NO₂ manufactured
by Teledyne API is:

Package version: 1.3.19
Driver version: 1.0.6

This includes the following versions:

Package version	Driver version
1.3.17	1.0.6
1.3.12, build 149	1.0.5
1.3.11	1.0.4
1.3.5	1.0.3
1.3.4	1.0.3
1.3.0	1.0.2

Statement issued by TÜV Rheinland Energy GmbH dated 2 September 2019

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 Energy 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 certification mark may be applied to the product or used in advertising materials for the certified product.

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

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

History of documents

Certification of T500U 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_00: 30 April 2015
Expiry date of the certificate: 01 April 2020
Test report 936/21224798/A dated 02 October 2014
TÜV Rheinland Energie und Umwelt GmbH, Cologne
Publication: BAnz AT 02.04.2015 B5, chapter III no. 2.1
UBA announcement dated 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 dated 03 March 2015
TÜV Rheinland Energie und Umwelt GmbH, Cologne
Publication: BAnz AT 26.08.2015 B4, chapter III no. 1.1
UBA announcement dated 22 July 2015
(Demonstration of equivalence with reference method)

Notifications

Statement of TÜV Rheinland Energy GmbH dated 19 October 2015
Publication: BAnz AT 14.03.2016 B7, chapter V notification 11
UBA announcement dated 18 February 2016
(software changes)

Statement of TÜV Rheinland Energy GmbH dated 17 August 2017
Publication: BAnz AT 26.03.2018 B8, chapter V notification 15
UBA announcement dated 21 February 2018
(change of production address)

Statement of TÜV Rheinland Energy GmbH dated 05 September 2018
Publication: BAnz AT 26.03.2019 B7, chapter IV notification 69
UBA announcement dated 27 February 2019
(software changes)

Statement of TÜV Rheinland Energy GmbH dated 2 September 2019
Publication: BAnz AT 24.03.2020 B7, chapter IV notification 69
UBA announcement dated 24 February 2020
(software changes)

Renewal of the certificate

Certificate No. 0000043527_02: 02 April 2020
Expiry date of the certificate: 01 April 2025

Expanded uncertainty, System 1

Measuring device:		Serial-No.:		1h-limit value:		nmol/mol	
Teledyne T5000		SN 63 (Gerät 1)		104.6			
Measured component:		Performance criterion		Result		Square of partial uncertainty	
NO ₂		≤ 1.0 nmol/mol		0.070		0.01	
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 _{sp}	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}	0.8824		
		≤ 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}			
		≤ 5.0 nmol/mol (Span)	0.290				
9	Averaging effect	≤ 7.0% of measured value	-2.310	u _{av}	1.9461		
18	Difference sample/calibration port	≤ 1.0%	-0.140	u _{sc}	0.0214		
21	Converter efficiency	≥ 98	100.00	u _{ec}	0.0000		
23	Uncertainty of test gas	≤ 3.0%	2.000	u _{cg}	1.0941		
Combined standard uncertainty				u _c	2.7424	nmol/mol	
Expanded standard uncertainty				U	5.4847	nmol/mol	
Relative expanded uncertainty				W	5.24	%	
Maximum allowed expanded uncertainty				W _{req}	15	%	

Expanded uncertainty, System 2

Measuring device:		Serial-No.:		1h-limit value:		nmol/mol	
Teledyne T5000		SN 65 (Gerät 2)		104.6			
Measured component:		Performance criterion		Result		Square of 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,1h} 0.02	
Repeatability standard deviation at 1h-limit value		≤ 4.0% of measured value		0.690		U _{1h} 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		1.5732	
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	
Interferent NH ₃ mit 200 nmol/mol		≤ 5.0 nmol/mol (Zero)		0.030		0.5329	
		≤ 5.0 nmol/mol (Span)		0.170		U _{int,neg}	
Averaging effect		≤ 7.0% of measured value		-2.080		U _{av} -1.26	
Difference sample/calibration port		≤ 1.0%		-0.170		U _{sc} -0.18	
Converter efficiency		≥ 98		100.00		U _{EC} 0.00	
Uncertainty of test gas		≤ 3.0%		2.000		U _{cg} 1.05	
		Combined standard uncertainty		2.000		1.0941	
		Expanded uncertainty		3.0525		u _c 3.0525	
		Relative expanded uncertainty		6.1051		U 6.1051	
		Maximum allowed expanded uncertainty		5.84		W 5.84	
				15		W _{req} 15	

Combined standard uncertainty, System 1

Measuring device:		Teledyne T500U		Serial-No.:		SN 63 (Gerat 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}	0.01	0.0001				
2	Repeatability standard deviation at 1h-limit value	≤ 3.0 nmol/mol	0.250	U _{r,1h}	not considered, as $\sqrt{2} \cdot u_{r,1h} = 0.05 < u_{r,f}$	-				
3	"lack of fit" at 1h-limit value	≤ 4.0% of measured value	0.770	U _{l,1h}	0.47	0.2162				
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤ 8.0 nmol/mol/kPa	0.080	U _{gp}	0.77	0.5944				
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.010	U _{gt}	0.10	0.0093				
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤ 3.0 nmol/mol/K	0.097	U _{st}	0.93	0.8646				
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤ 0.30 nmol/mol/V	0.003	U _v	0.03	0.0012				
8a	Interferent H ₂ O with 21 nmol/mol	≤ 10 nmol/mol (Zero)	0.120	U _{H2O}	-1.37	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		0.94	0.8824				
8c	Interferent NH ₃ mit 200 nmol/mol	≤ 5.0 nmol/mol (Zero)	-0.030	or						
		≤ 5.0 nmol/mol (Span)	0.290	U _{int,neg}						
9	Averaging effect	≤ 7.0% of measured value	-2.310	U _{av}	-1.40	1.9461				
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	0.300	U _{d,l,z}	0.17	0.0300				
12	Long term drift at span level	≤ 5.0% of max. of certification range	-1.560	U _{d,l,1h}	-0.95	0.9105				
18	Difference sample/calibration port	≤ 1.0%	-0.140	U _{ssc}	-0.15	0.0214				
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	3.1717	nmol/mol		
				Expanded uncertainty		U	6.3435	nmol/mol		
				Relative expanded uncertainty		W	6.06	%		
				Maximum allowed expanded uncertainty		W _{req}	15	%		

Combined standard uncertainty, System 2

Measuring device:		Serial-No.:		1h-limit value:		Square of partial uncertainty		nmol/mol			
Teledyne T5000		SN 65 (Gerät 2)		104.6							
Measured component:		Performance characteristic		Performance criterion		Result		Partial uncertainty		nmol/mol	
NO ₂		Repeatability standard deviation at zero		≤ 1.0 nmol/mol		0.050		u _{r,z}		0.0001	
		Repeatability standard deviation at 1h-limit value		≤ 3.0 nmol/mol		0.150		u _{r,1h} not considered, as $\sqrt{2} \cdot u_{r,1h} = 0.03 < u_{r,f}$			
		"lack of fit" at 1h-limit value		≤ 4.0% of measured value		0.690		u _{1,1h}		0.1736	
		Sensitivity coefficient of sample gas pressure at 1h-limit value		≤ 8.0 nmol/mol/kPa		0.160		u _{pp}		2.4029	
		Sensitivity coefficient of sample gas temperature at 1h-limit value		≤ 3.0 nmol/mol/K		0.010		u _{gt}		0.0091	
		Sensitivity coefficient of surrounding temperature at 1h-limit value		≤ 3.0 nmol/mol/K		0.143		u _{st}		1.9194	
		Sensitivity coefficient of electrical voltage at 1h-limit value		≤ 0.30 nmol/mol/V		0.004		u _v		0.0021	
8a		interferent H ₂ O with 21 nmol/mol		≤ 10 nmol/mol (Zero)		0.220		u _{H2O}		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		0.5329	
8c		interferent NH ₃ mit 200 nmol/mol		≤ 5.0 nmol/mol (Zero)		0.030		u _{int,neg}			
				≤ 5.0 nmol/mol (Span)		0.170					
9		Averaging effect		≤ 7.0% of measured value		-2.080		u _{av}		1.5779	
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		0.280		u _{d,z}		0.0261	
12		Long term drift at span level		≤ 5.0% of max. of certification range		-1.820		u _{d,1h}		1.2080	
18		Difference sample/calibration port		≤ 1.0%		-0.170		u _{asc}		0.0316	
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				3.4861	
				Expanded uncertainty		U				6.9722	
				Relative expanded uncertainty		W				6.67	
				Maximum allowed expanded uncertainty		W _{req}				15	