CERTIFICATE

of Product Conformity (QAL1)

Certificate No.: 0000040219_03

Certified AMS:	Modell 48i for CO
Manufacturer:	Thermo Fisher Scientific 27, Forge Parkway Franklin, MA 02038 USA
Test Institute:	TÜV Rheinland Energy & Environment GmbH

**This is to certify that the AMS has been tested
and found to comply with the standards
VDI 4202-1 (2018), EN 14626 (2012)
as well as EN 15267-1 (2009) and EN 15267-2 (2023).**

Certification is awarded in respect of the conditions stated in this certificate
(this certificate contains 17 pages).
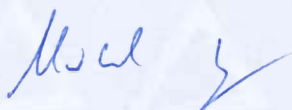The present certificate replaces certificate 0000040219_02 dated 1 July 2020.

TÜVRheinland®
CERTIFIED

Suitability Tested
Complying with
2008/50/EC
EN 15267
Regular
Surveillance
www.tuv.com
ID 0000040219

Publication in the German Federal Gazette
(BAnz) of 8 April 2006

This certificate will expire on:
30 June 2030
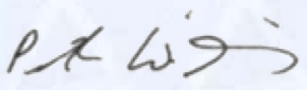
German Environment Agency

TÜV Rheinland Energy &
Environment GmbH

Dessau, 27 June 2025

Cologne, 26 June 2025

Dr. Marcel Langner
Head of Section II 4

ppa. Dr. Peter Wilbring

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TÜV Rheinland Energy & Environment GmbH
Am Grauen Stein
51105 Köln

Test institute accredited to EN ISO/IEC 17025 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.

qal1.de   qal1-info@qal.de   page 1 of 17

Test report:	936/21203248/A1 dated 5 January 2006 and Addendum 936/21221382/D dated 4 October 2013
Initial certification:	1 April 2014
Expiry date:	30 June 2030
Certificate:	Renewal (of previous certificate 0000040219_02 of 1 July 2020 valid until 30 June 2025)
Publication:	BAnz. 08 April 2006, No. 70, p. 2653, chapter IV No. 2.2 and Banz AT 01.04.2014 B12, chapter VI notification 24

Approved application

The tested AMS is suitable for continuous immission measurement of CO in stationary use.

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 an ambient 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 applicable at the time of testing. As changes in legal provisions are possible, any potential user should ensure that this AMS is suitable for monitoring the measured values relevant to the application.

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

Basis of the certification

This certification is based on:

- Test report 936/21203248/A1 dated 5 January 2006 of TÜV Immissionsschutz und Energiesysteme GmbH and Addendum 936/21221382/D dated 4 October 2013 issued by 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. 08 April 2006, No. 70, p. 2653, chapter IV No. 2.2, Announcement by UBA dated 21 February 2006:

AMS designation:

CO analyser model 48i

Manufacturer:

Thermo Electron Corp. Franklin, MA 02038 USA and D-91056 Erlangen

Field of application:

For continuous ambient air monitoring of CO (stationary operation)

Measuring ranges during the performance test:

CO	0 - 60	mg/m³
	0 - 100	mg/m³

Software version:

Version: V 01.02.14.097

Test institute:

TÜV Immissionsschutz und Energiesysteme GmbH, Cologne
TÜV Rheinland Group
Report No.: 936/21203248/A1 dated 5 January 2006

Publication in the German Federal Gazette: BAnz. 20 April 2007, No. 75, p. 4139, Chap. IV notification 1, Announcement by UBA dated 12 April 2007:

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1   Notification of Federal Environment Agency (UBA)

The new name of Thermo Electron Corp., Franklin, USA, is Thermo Fisher Scientific, Franklin, USA.

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme,
51101 Köln, Dr. Peter Wilbring, dated 20 December 2006

Publication in the German Federal Gazette: BAnz. 3 September 2008, No. 133, p. 3243, Chap. IV notification 14, Announcement by UBA dated 12 August 2008:

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14   Notification as regards Federal Environment Agency (UBA) notice of 21 February 2006 (BAnz. p. 2655)

The current software version for the Model 48i air quality monitor manufactured by Thermo Fisher Scientific is:

V 01.05.03 (106423-00)

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 10 March 2008

Publication in the German Federal Gazette: BAnz. 25 August 2009, No. 125, p. 2929, Chap. III notification 18, Announcement by UBA dated 3 August 2009:

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18   Notification as regards Federal Environment Agency (UBA) notice of 21 February 2006 (BAnz. p. 2655)

The current software version for the Model 48i air quality monitor manufactured by Thermo Fisher Scientific is:
V 01.06.01 (108458-00)

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 01 April 2009

Publication in the German Federal Gazette: BAnz. 28 Juli 2010, No. 111, p. 2597, Chap. III notification 6, Announcement by UBA dated 12 July 2010:

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6   Notification as regards Federal Environment Agency (UBA) notices of 21 February 2006 (BAnz. p. 2655) and of 3 August 2009 (BAnz. p. 2936)

The Model 48i air quality monitor manufactured by Thermo Fisher Scientific can also be used with the PU1959-N86-3.07 sample gas pump manufactured by KNF.

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 23 March 2010

Publication in the German Federal Gazette: BAnz. 29 Juli 2011, No. 113, p. 2725, Chap. III notification 20, Announcement by UBA dated 15 July 2011:

**20   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 12 July 2010 (BAnz. p. 2597, chapter III notification 6)**

The latest software version for the Model 48i air quality monitor for CO manufactured by Thermo Fisher Scientific is:
V 01.06.09 (110018-00)

Statement by TÜV Rheinland Energie und Umwelt GmbH dated 30 March 2011

Publication in the German Federal Gazette: BAnz AT 20.07.2012 B11, Chap. IV notification 25, Announcement by UBA dated 6 July 2012:

**25   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 15 July 2011 (BAnz. p. 2725, chapter III notification 20)**

The Model 48i air quality monitor for CO manufactured by Thermo Fisher Scientific will be equipped with the PU2737-N86 vacuum pump manufactured by KNF in the future.

Statement by TÜV Rheinland Energie und Umwelt GmbH dated 20 March 2012

Publication in the German Federal Gazette: BAnz AT 05.03.2013 B10, Chap. V notification 14, Announcement by UBA dated 12 February 2013:

**14   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 6 July 2012 (chapter IV notification 25)**

The latest software version of the model 48i air quality monitor for CO manufactured by Thermo Fisher Scientific is:
V 01.06.10 (112308-00)

Statement by TÜV Rheinland Energie und Umwelt GmbH dated 6 October 2012

Publication in the German Federal Gazette: BAnz AT 01.04.2014 B12, Chap. VI notification 24, Announcement by UBA dated 27 February 2014:

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24 **Notification as regards Federal Environment Agency (UBA) notices of 21 February 2006 (p. 2653, chapter IV number 2.2) and of 12 February 2013 (BAnz AT 05.03.2013 B10, chapter V notification 14)**

The Model 48i air quality monitor for CO manufactured by Thermo Fisher Scientific complies with the requirements of EN 14626 (December 2012 version). Furthermore, the manufacturing process and the quality management for the Model 48 measuring system for CO meets the requirements of EN 15267.

The test report on performance testing No. 936/21203248/A1 and the addendum no. 936/21221382/D as an integral part of this report are available online at www.qal1.de.

Production of the Arcturus Bd. 101491-xx processor board has been discontinued and will be replaced by the Arcturus Bd. 110570-xx processor board.

The current software version of the measuring system is:
V 02.00.01 (113420-00)

Statement by TÜV Rheinland Energie und Umwelt GmbH dated 1 October 2013

Publication in the German Federal Gazette: BAnz AT 05.08.2014 B11, Chap. V notification 22, Announcement by UBA dated 17 July 2014:

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22 **Notification as regards Federal Environment Agency (UBA) notices of 21 February 2006 (p. 2653, chapter IV number 2.2) and of 27 February 2014 (BAnz AT 01.04.2014 B12, chapter VI notification 24)**

The latest software version of the model 48i measuring system for CO manufactured by Thermo Fisher Scientific is:
V 02.00.03 (114182-00)

Statement by TÜV Rheinland Energie und Umwelt GmbH dated 28 March 2014

Publication in the German Federal Gazette: BAnz AT 02.04.2015 B5, Chap. IV
notification 18, Announcement by UBA dated 25 February 2015:

**18   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 17 July 2014 (BAnz AT 05.08.2014 B11, chapter V notification 22)**

The latest software version of the model 48i measuring system for CO
manufactured by Thermo Fisher Scientific is:
V 02.02.00 (114624-00)

Statement by TÜV Rheinland Energie und Umwelt GmbH of 22 September 2014

Publication in the German Federal Gazette: BAnz AT 14.03.2016 B7, Chap. V notification 14,
Announcement by UBA dated 18 February 2016:

**14   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (p. 2653, chapter IV number 2.2) and
of 25 February 2015 (BAnz AT 02.04.2015 B5, chapter IV notification 18)**

The latest software version of the model 48i measuring system for CO
manufactured by Thermo Fisher Scientific is:
V 02.02.03

Statement by TÜV Rheinland Energie und Umwelt GmbH dated 22 October 2015

Publication in the German Federal Gazette: BAnz AT 26.03.2019 B7, Chap. IV
notification 71, Announcement by UBA dated 27 February 2019:

**71   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (p. 2653, chapter IV number 2.2) and
of 25 February 2015 (BAnz AT 14.03.2016 B7, chapter V notification 14)**

The current software version of the model 48i for CO
manufactured by Thermo Fisher Scientific is: V 02.02.04

Moreover, the following design changes have been introduced:
– The measuring system may now also be equipped with the Measurement
  Interface Board 117999-00.
– The measuring system may now be equipped with the NSL-37V5C3 photocell.
– The model 48i ambient air quality measuring system for CO manufactured by
  Thermo Fisher Scientific may also use connectors manufactured by HAM-LET
  for its gas lines separately or in combination with those provided by Swagelok.

Statement by TÜV Rheinland Energy GmbH dated 10 January 2019

Publication in the German Federal Gazette: BAnz AT 05.08.2021 B5, Chap. IV notification 12, Announcement by UBA dated 29 June 2021:

**12   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 27 February 2019 (BAnz AT 26.03.2019 B7, chapter IV notification 71)**

The latest software version of the Thermo Fisher Scientific
measuring system Model 48i CO analyser is:
V 03.00.01
In addition to this revision number, the following interim version is also valid:
V 03.00.00

Statement by TÜV Rheinland Energy GmbH dated 25 February 2021

Publication in the German Federal Gazette: BAnz AT 28.07.2022 B4, Chap. III notification 47, Announcement by UBA dated 28 June 2022:

**47   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 29 June 2021 (BAnz AT 05.08.2021 B5, chapter IV notification 12)**

The following hardware changes have been introduced for the Model 48i measuring
device for CO from Thermo Fisher Scientific:
 - The measuring device can now also be equipped with
    the Arcturus CPU (53281) processor board.
 - The measuring device can now also be equipped with a SUNON housing fan
    (part No. PMD2408PMB-A).

Statement by TÜV Rheinland Energy GmbH dated 18 May 2022

Publication in the German Federal Gazette: BAnz AT 20.03.2023 B6, Chap. IV notification 85, Announcement by UBA dated 21 February 2023:

**85   Notification as regards Federal Environment Agency (UBA) notices
of 21 February 2006 (BAnz. p. 2653, chapter IV number 2.2) and
of 28 June 2022 (BAnz AT 28.07.2022 B4, chapter III notification 47)**

The Model 48i measuring system for CO from Thermo Fisher Scientific can also be
equipped with the alternative IR source of type 66785 15R from the manufacturer
Ohmite Dove Electronics.

Statement by TÜV Rheinland Energy GmbH dated 16 September 2022

Certified product

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

The Model 48i CO Analyzer measures CO concentration using Gas Filter Correlation (GFC). The Model 48i operates on the principle that carbon monoxide (CO) absorbs infrared radiation at a wavelength of 4.6 microns. The measuring system belongs to the group of photometric measuring systems. The measuring principle is based on determining the light absorption by the gas to be measured in the wavelength ranges characteristic of that gas. Analysis is performed by measuring the absorption on the basis of the dependence between the gas concentration and the amount of absorbed light according to the Beer-Lambert law:

$$I = I_o * \exp(-\alpha\, L\, c)$$

I   intensity with absorption
Io   light intensity without absorption
α absorption coefficient (provides information about degree of absorption)
L   absorption path or distance that the light travels during absorption
c   concentration of the absorbing gas, in this case CO
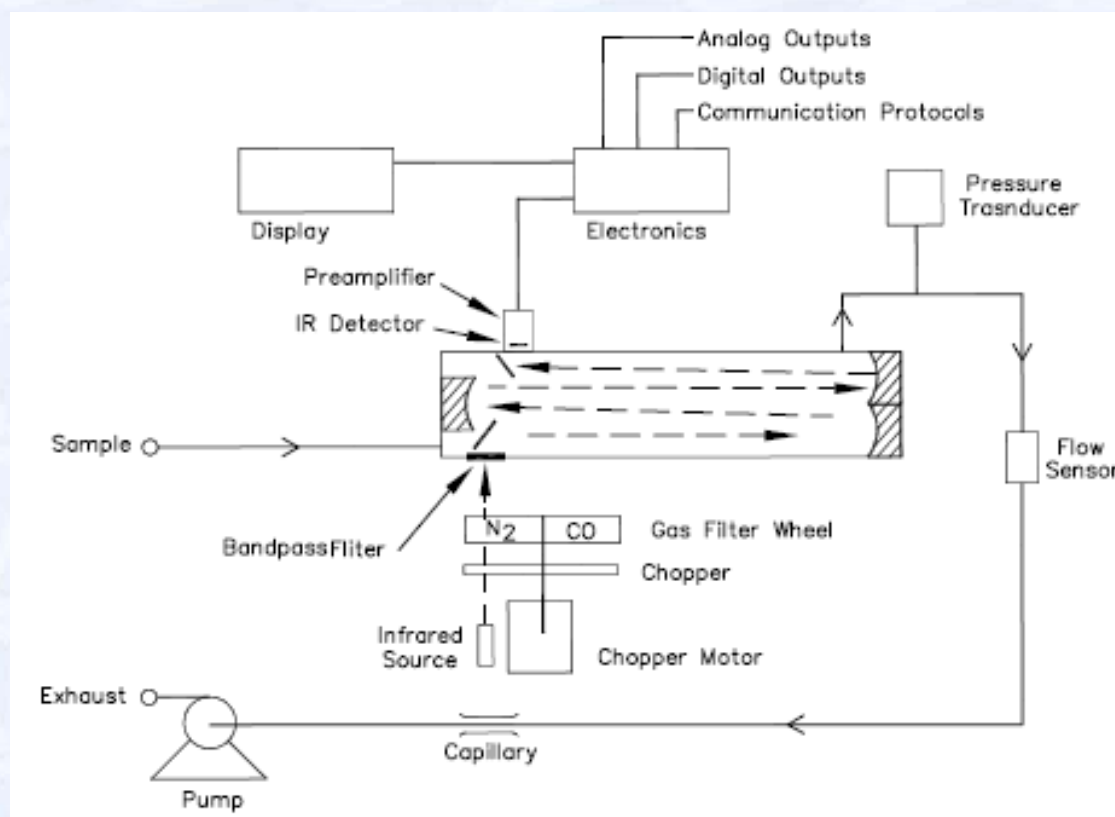
This measuring principle corresponds to the standard reference method as described in EN 14626.

The ambient air sample is sucked through the bulkhead connection designated SAMPLE into the Model 48i measuring system. The sample flows through the optical bench. Radiation from an infrared source is chopped and then passed through a gas filter alternating between CO and N_2. The radiation then passes through a narrow band-pass interference filter and enters the optical bench where absorption by the sample gas occurs. and falls on an infrared detector.

The CO gas filter acts to produce a reference beam, which cannot be further attenuated by CO in the sample cell. The N_2 side of the filter wheel is transparent to the infrared radiation and therefore produces a measure beam which can be absorbed in the cell. The chopped detector signal is modulated by the alternation between two gas filters with a amplitude related to the concentration of CO in the sample cell. The chopped detector signal is modulated by the alternation between two gas filters with a amplitude related to the concentration of CO in the sample cell. Other gases do not cause modulation of the detector signal since they absorb the reference and measure beams equally. Thus, the GFC system responds specifically to CO.

The Model 48i outputs the CO concentration to the front panel display, the analogue outputs, and also makes the data available over the serial or Ethernet connection.

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 & Environment 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 & Environment 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 & Environment 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 Modell 48i is based on the documents listed below and the regular, continuous monitoring of the Quality Management System of the manufacturer:

Basic test
Test report: 936/21203248/A1 dated 5 January 2006
TÜV Rheinland Immissionsschutz und Energiesysteme GmbH
Publication: BAnz. 08 April 2006, No. 70, p. 2653, chapter IV number 2.2
UBA announcement dated 21 February 2006

Notifications
Statement by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 20 December 2006
Publication: BAnz. 20 April 2007, No. 75, p. 4139, chapter IV notification 1
UBA announcement dated 12 April 2007
(New manufacturer name)

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 10 March 2008
Publication: BAnz. 03 September 2008, No. 133, p. 3243, chapter IV notification 14
UBA announcement dated 12 August 2008
(Software changes)

Statement issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 1 April 2009
Publication: BAnz. 25 August 2009, No. 125, p. 2929, chapter III notification 18
UBA announcement dated 3 August 2009
(Software changes)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 23 October 2010
Publication: BAnz. 28 July 2010, No. 111, p. 2597, chapter III notification 6
UBA announcement dated 12 July 2010
(Hardware changes)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 30 March 2011
Publication: BAnz. 29 July 2011, No. 113, p. 2725, chapter III notification 20
UBA announcement dated 15 July 2011
(Software changes)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 20 March 2012
Publication: BAnz AT 20.07.2012 B11, chapter IV notification 25
UBA announcement dated 6 July 2012
(Hardware changes)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 6 October 2012
Publication: BAnz AT 05.03.2013 B10, chapter V notification 14
UBA announcement dated 12 February 2013
(Software changes)

Initial certification according to EN 15267
Certificate No. 0000040219_00:   29 April 2014
Expiry date of the certificate: 31 March 2019
Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 1 October 2013
Test report: 936/21203248/A1 dated 5 January 2006 issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH and Addendum 936/21221382/D dated 4 October 2013
Publication: BAnz AT 01.04.2014 B12, chapter VI number 24
UBA announcement dated 27 February 2014

Notifications
Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 28 March 2014
Publication: BAnz AT 05.08.2014 B11, chapter V notification 22
UBA announcement dated 17 July 2014
(Software changes)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 22 September 2014
Publication: BAnz AT 02.04.2015 B5, chapter IV notification 18
UBA announcement dated 25 February 2015
(Software changes)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 22 October 2015
Publication: BAnz AT 14.03.2016 B7, chapter V notification 14
UBA announcement dated 18 February 2016
(Software changes)

Renewal of certificates
Certificate No. 0000040219_01:   1 April 2019
Expiry date of the certificate: 30 June 2020

Notifications
Statement issued by TÜV Rheinland Energy GmbH dated 10 January 2019
Publication: BAnz AT 26.03.2019 B7, chapter IV notification 71
UBA announcement dated 27 February 2019
(Hardware changes)

Renewal of certificates
Certificate No. 0000040219_02:   1 July 2020
Expiry date of the certificate: 30 June 2025

Notifications
Statement issued by TÜV Rheinland Energy GmbH dated 25 February 2021
Publication: BAnz AT 05.08.2021 B5, chapter IV notification 12
UBA announcement dated 29 June 2021
(Software changes)

Statement issued by TÜV Rheinland Energy GmbH dated 18 May 2022
Publication: BAnz AT 28.07.2022 B4, chapter III notification 47
UBA announcement dated 28 June 2022
(Hardware changes)

Statement issued by TÜV Rheinland Energy GmbH dated 16 September 2022
Publication: BAnz AT 20.03.2023 B6, chapter IV notification 85
UBA announcement dated 21 February 2023

Umwelt Bundesamt

TÜVRheinland®
Precisely Right.

(Soft- and hardware changes)

Renewal of certificates
Certificate No. 0000040219_03:   27 June 2025
Expiry date of the certificate: 30 June 2030

Expanded uncertainty laboratory, system 1

Measuring device: Thermo Fisher Scientific Modell 48i
Measured component: CO
Serial-No.: Device 1
8h-limit value: 8.62 µmol/mol

No.	Performance characteristic	Performance criterion	Result	Partial uncertainty		Square of partial uncertainty
1	Repeatability standard deviation at zero	≤ 0.3 µmol/mol	0.000	$u_{r,z}$	0.00	0.0000
2	Repeatability standard deviation at 8h-limit value	≤ 0.4 µmol/mol	0.020	u_r	0.00	0.0000
3	"lack of fit" at 8h-limit value	≤ 4.0% of measured value	0.800	u_l	0.04	0.0016
4	Sensitivity coefficient of sample gas pressure at 8h-limit value	≤ 0.7 µmol/mol/kPa	0.090	u_{gp}	0.22	0.0502
5	Sensitivity coefficient of sample gas temperature at 8h-limit value	≤ 0.3 µmol/mol/K	0.010	u_{gt}	0.02	0.0005
6	Sensitivity coefficient of surrounding temperature at 8h-limit value	≤ 0.3 µmol/mol/K	0.030	u_{st}	0.07	0.0047
7	Sensitivity coefficient of electrical voltage at 8h-limit value	≤ 0.3 µmol/mol/V	0.000	u_v	0.00	0.0000
8a	Interferent H_2O with 21 mmol/mol	≤ 1.0 µmol/mol (Zero)	0.040	u_{H2O}	0.03	0.0009
		≤ 1.0 µmol/mol (Span)	0.000			
8b	Interferent CO_2 with 500 µmol/mol	≤ 0.5 µmol/mol (Zero)	-0.060	$u_{Int,pos}$		
		≤ 0.5 µmol/mol (Span)	-0.010			
8c	Interferent NO with 1 µmol/mol	≤ 0.5 µmol/mol (Zero)	0.000	or	0.04	0.0014
		≤ 0.5 µmol/mol (Span)	-0.010			
8d	Interferent N_2O with 50 nmol/mol	≤ 0.5 µmol/mol (Zero)	0.170	$u_{Int,neg}$		
		≤ 0.5 µmol/mol (Span)	0.060			
9	Averaging effect	≤ 7.0% of measured value	-5.970	u_{av}	-0.30	0.0883
18	Difference sample/calibration port	≤ 1.0%	0.000	$u_{\Delta sc}$	0.00	0.0000
21	Uncertainty of test gas	≤ 3.0%	2.000	u_{og}	0.09	0.0074

Combined standard uncertainty	u_c	0.3937	µmol/mol
Expanded uncertainty	U	0.7875	µmol/mol
Relative expanded uncertainty	W	9.14	%
Maximum allowed expanded uncertainty	W_{req}	15	%

Umwelt Bundesamt

TÜVRheinland® Precisely Right.

Expanded uncertainty laboratory, system 2

Measuring device: Thermo Fisher Scientific Modell 48i
Measured component: CO
Serial-No.: Device 2
8h-limit value: 8.62 µmol/mol

No.	Performance characteristic	Performance criterion	Result	Partial uncertainty		Square of partial uncertainty
1	Repeatability standard deviation at zero	≤ 0.3 µmol/mol	0.000	$u_{r,z}$	0.00	0.0000
2	Repeatability standard deviation at 8h-limit value	≤ 0.4 µmol/mol	0.020	u_r	0.00	0.0000
3	"lack of fit" at 8h-limit value	≤ 4.0% of measured value	-0.300	u_l	-0.01	0.0002
4	Sensitivity coefficient of sample gas pressure at 8h-limit value	≤ 0.7 µmol/mol/kPa	0.090	u_{gp}	0.22	0.0502
5	Sensitivity coefficient of sample gas temperature at 8h-limit value	≤ 0.3 µmol/mol/K	0.040	u_{gt}	0.09	0.0084
6	Sensitivity coefficient of surrounding temperature at 8h-limit value	≤ 0.3 µmol/mol/K	0.030	u_{st}	0.07	0.0047
7	Sensitivity coefficient of electrical voltage at 8h-limit value	≤ 0.3 µmol/mol/V	0.000	u_v	0.00	0.0000
8a	Interferent H_2O with 21 mmol/mol (Zero)	≤ 1.0 µmol/mol	-0.020	u_{H2O}	-0.01	0.0002
	(Span)	≤ 1.0 µmol/mol	0.000			
8b	Interferent CO_2 with 500 µmol/mol (Zero)	≤ 0.5 µmol/mol	0.000	$u_{int,pos}$		
	(Span)	≤ 0.5 µmol/mol	-0.020			
8c	Interferent NO with 1 µmol/mol (Zero)	≤ 0.5 µmol/mol	0.000	or	0.07	0.0052
	(Span)	≤ 0.5 µmol/mol	-0.030			
8d	Interferent N_2O with 50 nmol/mol (Zero)	≤ 0.5 µmol/mol	0.000	$u_{int,neg}$		
	(Span)	≤ 0.5 µmol/mol	0.130			
9	Averaging effect	≤ 7.0% of measured value	-4.560	u_{av}	-0.23	0.0515
18	Difference sample/calibration port	≤ 1.0%	0.000	$u_{\Delta s.c}$	0.00	0.0000
21	Uncertainty of test gas	≤ 3.0%	2.000	u_{cg}	0.09	0.0074

Combined standard uncertainty	u_c	0.3577	µmol/mol
Expanded uncertainty	U	0.7153	µmol/mol
Relative expanded uncertainty	W	8.30	%
Maximum allowed expanded uncertainty	W_{req}	15	%

Combined uncertainty, laboratory and field, system 1

Measuring device: Thermo Fisher Scientific Modell 48i
Measured component: CO
Serial-No.: Device 1
8h-limit value: 8.62 µmol/mol

No.	Performance characteristic	Performance criterion	≤	Result	Partial uncertainty		Square of partial uncertainty (µmol/mol)
1	Repeatability standard deviation at zero	0.3 µmol/mol	≤	0.000	$u_{r,z}$	0.00	0.0000
2	Repeatability standard deviation at 8h-limit value	0.4 µmol/mol	≤	0.020	u_r	not considered, as $u_r = 0 < u_{r,f}$	-
3	"lack of fit" at 8h-limit value	4.0% of measured value	≤	0.800	u_l	0.04	0.0016
4	Sensitivity coefficient of sample gas pressure at 8h-limit value	0.7 µmol/mol/kPa	≤	0.090	u_{gp}	0.22	0.0502
5	Sensitivity coefficient of sample gas temperature at 8h-limit value	0.3 µmol/mol/K	≤	0.010	u_{gt}	0.02	0.0005
6	Sensitivity coefficient of surrounding temperature at 8h-limit value	0.3 µmol/mol/K	≤	0.030	u_{st}	0.07	0.0047
7	Sensitivity coefficient of electrical voltage at 8h-limit value	0.3 µmol/mol/V	≤	0.000	u_v	0.00	0.0000
8a	Interferent H_2O with 21 mmol/mol	1.0 µmol/mol (Zero)	≤	0.000	u_{H2O}	0.03	0.0009
		1.0 µmol/mol (Span)	≤	0.040			
8b	Interferent CO_2 with 500 µmol/mol	0.5 µmol/mol (Zero)	≤	-0.060	$u_{int,pos}$		
		0.5 µmol/mol (Span)	≤	-0.010			0.0014
8c	Interferent NO with 1 µmol/mol	0.5 µmol/mol (Zero)	≤	0.000	or	0.04	
		0.5 µmol/mol (Span)	≤	-0.010			
8d	Interferent N_2O with 50 nmol/mol	0.5 µmol/mol (Zero)	≤	0.170	$u_{int,neg}$		
		0.5 µmol/mol (Span)	≤	0.060			
9	Averaging effect	7.0% of measured value	≤	-5.970	u_{av}	-0.30	0.0883
10	Reproducibility standard deviation under field conditions	5.0% of average over 3 months	≤	3.530	$u_{r,f}$	0.30	0.0926
11	Long term drift at zero level	0.5 µmol/mol	≤	0.500	$u_{d,l,z}$	0.29	0.0833
12	Long term drift at span level	5.0% of max. of certification range	≤	-2.590	$u_{d,l,8h}$	-0.13	0.0166
18	Difference sample/calibration port	1.0%	≤	0.000	$u_{ls,o}$	0.00	0.0000
21	Uncertainty of test gas	3.0%	≤	2.000	u_{cg}	0.09	0.0074

Combined standard uncertainty	u_c	0.5895	µmol/mol
Expanded uncertainty	U	1.1791	µmol/mol
Relative expanded uncertainty	W	13.68	%
Maximum allowed expanded uncertainty	W_{req}	15	%

Combined uncertainty, laboratory and field, system 2

Measuring device:	Thermo Fisher Scientific Modell 48i					Serial-No.:		Device 2
Measured component:	CO					8h-limit value:	8.62	µmol/mol

No.	Performance characteristic	≤	Performance criterion	Result	Partial uncertainty		Square of partial uncertainty
1	Repeatability standard deviation at zero	≤	0.3 µmol/mol	0.000	$u_{r,z}$	0.00	0.0000
2	Repeatability standard deviation at 8h-limit value	≤	0.4 µmol/mol	0.020	u_r	not considered, as ur = 0 < ur,f	-
3	"lack of fit" at 8h-limit value	≤	4.0% of measured value	-0.300	u_l	-0.01	0.0002
4	Sensitivity coefficient of sample gas pressure at 8h-limit value	≤	0.7 µmol/mol/kPa	0.090	u_{gp}	0.22	0.0502
5	Sensitivity coefficient of sample gas temperature at 8h-limit value	≤	0.3 µmol/mol/K	0.040	u_{gt}	0.09	0.0084
6	Sensitivity coefficient of surrounding temperature at 8h-limit value	≤	0.3 µmol/mol/K	0.030	u_{st}	0.07	0.0047
7	Sensitivity coefficient of electrical voltage at 8h-limit value	≤	0.3 µmol/mol/V	0.000	u_v	0.00	0.0000
8a	Interferent H_2O with 21 mmol/mol	≤	1.0 µmol/mol (Zero)	0.000	u_{H2O}	-0.01	0.0002
		≤	1.0 µmol/mol (Span)	-0.020			
8b	Interferent CO_2 with 500 µmol/mol	≤	0.5 µmol/mol (Zero)	0.000	$u_{int,pos}$		
		≤	0.5 µmol/mol (Span)	-0.020			
8c	Interferent NO with 1 µmol/mol	≤	0.5 µmol/mol (Zero)	0.000	or	0.07	0.0052
		≤	0.5 µmol/mol (Span)	-0.030			
8d	Interferent N_2O with 50 nmol/mol	≤	0.5 µmol/mol (Zero)	0.000	$u_{int,neg}$		
		≤	0.5 µmol/mol (Span)	0.130			
9	Averaging effect	≤	7.0% of measured value	-4.560	u_{av}	-0.23	0.0515
10	Reproducibility standard deviation under field conditions	≤	5.0% of average over 3 months	3.530	$u_{r,f}$	0.30	0.0926
11	Long term drift at zero level	≤	0.5 µmol/mol	0.500	$u_{d,l,z}$	0.29	0.0833
12	Long term drift at span level	≤	5.0% of max. of certification range	1.840	$u_{d,l,8h}$	0.09	0.0084
18	Difference sample/calibration port	≤	1.0%	0.000	$u_{\Delta sc}$	0.00	0.0000
21	Uncertainty of test gas	≤	3.0%	2.000	u_{cg}	0.09	0.0074

Combined standard uncertainty	u_c	0.5587	µmol/mol
Expanded uncertainty	U	1.1175	µmol/mol
Relative expanded uncertainty	W	12.96	%
Maximum allowed expanded uncertainty	W_{req}	15	%