CERTIFICATE

of Product Conformity (QAL1)

Certificate No.: 0000040218_03

Certified AMS:	Modell 43i for SO_2
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 14212 (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 16 pages).
The present certificate replaces certificate 0000040218_02 dated 1 July 2020.

TÜVRheinland® CERTIFIED
Suitability Tested
Complying with 2008/50/EC
EN 15267
Regular Surveillance
www.tuv.com
ID 0000040218

Publication in the German Federal Gazette (BAnz) of 14 October 2006

German Environment Agency

Dessau, 27 June 2025

This certificate will expire on: 30 June 2030

TÜV Rheinland Energy & Environment GmbH
Cologne, 26 June 2025

Dr. Marcel Langner
Head of Section II 4

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TÜV Rheinland Energy & Environment GmbH
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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.

Test report:	936/21203248/D1 dated 7 July 2006 and Addendum 936/21221382/C dated 20 September 2013 issued by TÜV Rheinland Energie und Umwelt GmbH
Initial certification:	1 April 2014
Expiry date:	30 June 2030
Certificate:	Renewal (of previous certificate 0000040218_02 of 1 July 2020 valid until 30 June 2025)
Publication:	BAnz. 14 October 2006, No. 194, p. 6715, chapter IV No. 2.2

Approved application

The tested AMS is suitable for continuous immission measurement of SO_2 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/D1 dated 7 July 2006 of TÜV Rheinland Immissionsschutz und Energiesysteme GmbH and Addendum 936/21221382/C dated 20 September 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. 14 October 2006, No. 194, p. 6715, chapter IV No. 2.2, Announcement by UBA dated 12 September 2006:

AMS designation:
SO_2 analyser model 43i

Manufacturer:
Thermo Electron Corporation Franklin, USA
Distribution:
Thermo Electron Corporation, Erlangen

Field of application:
For continuous ambient air monitoring of sulphur dioxide (stationary operation)

Measuring ranges during the performance test:

SO_2	0 – 700	µg/m³
	0 – 1,000	µg/m³

Software version:
V 01.03.00.083

Test institute:
TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, Cologne
TÜV Rheinland Group
Report No.: 936/21203248/D1 dated 7 July 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:

1 Notification of Federal Environment Agency (UBA)

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

Statement issued 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 13, Announcement by UBA dated 12 August 2008:

13 Notification of announcement by the Federal Environment Agency (UBA) of 12 September 2006 (BAnz. p. 6717)

The current software version of the ambient air measuring system 43i by Thermo Fisher Scientific is:
V 01.05.06 (105721-00)

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme of 10 March 2008

Publication in the German Federal Gazette: BAnz. 25 August 2009, No. 125, p. 2929, Chap. III notification 17, Announcement by UBA dated 3 August 2009:

17 Notification of announcement by the Federal Environment Agency (UBA) of 12 September 2006 (BAnz. p. 6717)

The current software version of the ambient air measuring system 43i by Thermo Fisher Scientific is:
V 01.06.01 (108457-00)

Statement by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH of 1 April 2009

Publication in the German Federal Gazette: BAnz. 28 Juli 2010, No. 111, p. 2597, Chap. III notification 5, Announcement by UBA dated 12 July 2010:

5 Notification of announcements by the Federal Environment Agency (UBA) of 12 September 2006 (BAnz. p. 6717) and of 3 August 2009 (BAnz. p. 2936)

The ambient air measuring system model 43i by Thermo Fisher Scientific can now also be operated with a sample gas pump type PU1959-N86-3.07 manufactured by KNF.

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

Publication in the German Federal Gazette: BAnz. 29 Juli 2011, No. 113, p. 2725, Chap. III notification 19, Announcement by UBA dated 15 July 2011:

19 Notification of announcements by the Federal Environment Agency (UBA) of 12 September 2006 (BAnz. p. 6715, Chapter IV Number 2.2) and of 12 July 2010 (BAnz. p. 2597, Chapter III notification 5)

The current software version of the ambient air measuring system model 43i for SO_2 by Thermo Fisher Scientific is:
V 01.06.07 (110959-00)

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

Publication in the German Federal Gazette: BAnz AT 20.07.2012 B11, Chap. IV notification 24, Announcement by UBA dated 6 July 2012:

24 Notification of announcements by the Federal Environment Agency (UBA) of 12 September 2006 (BAnz. p. 6715, Chapter IV Number 2.2) and of 15 July 2011 (BAnz. p. 2725, Chapter III notification 19)

The current software version of the ambient air measuring system model 43i for SO_2 by Thermo Fisher Scientific is 01.06.08.

The ambient air measuring system model 43i for SO_2 by Thermo Fisher Scientific will be fitted with the type PU2737-N86 vacuum pump manufactured by KNF.

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

Publication in the German Federal Gazette: BAnz AT 01.04.2014 B12, Chap. VI notification 23, Announcement by UBA dated 27 February 2014:

23 Notification of announcements by the Federal Environment Agency (UBA) of 12 September 2006 (BAnz. p. 6717, Chapter II Number 2.2) and of 6 July 2012 (BAnz. AT 20.07.2012 B11, Chapter IV notification 24)

The measuring system model 43i for SO_2 by Thermo Fisher Scientific fulfils the requirements of Standard EN 14212 (November 2012). Furthermore, the manufacturing process and quality management system of the measuring system model 43i for SO_2 fulfil the requirements of EN 15267.
The test report of the performance test with report number 936/21203248/D1 as well as an addendum as an integral part of the test report with report number 936/21221382/C can be viewed on the internet at www.qal1.de.

The Hamamatsu 1P28HA-5 photomultiplier was withdrawn and replaced by the new Hamamatsu R11568-15 photomultiplier.
The Arcturus Bd. 101491-xx processor board was withdrawn and replaced by the new Arcturus Bd. 110570-xx processor board.

The current software version of the measuring system is:
V 02.00.00 (113419-00)

Statement by TÜV Rheinland Energie und Umwelt GmbH of 2 October 2013

Publication in the German Federal Gazette: BAnz AT 05.08.2014 B11, Chap. V notification 21, Announcement by UBA dated 17 July 2014:

21 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 27 February 2014 (BAnz AT 01.04.2014 B12, chapter VI notification 23)

The current software version for the Model 43i measuring system for SO_2 manufactured by Thermo Fisher Scientific, is:
V 02.00.03 (114181-00)

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

Publication in the German Federal Gazette: BAnz AT 02.04.2015 B5, Chap. IV notification 17, Announcement by UBA dated 25 February 2015:

17 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 17July 2014 (BAnz AT 05.08.2014 B11, chapter V notification 21)

The current software version for the Model 43i measuring system for SO_2 manufactured by Thermo Fisher Scientific, is:
V 02.02.00 (114619-00)

Statement of 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 13, Announcement by UBA dated 18 February 2016:

13 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 25 February 2015 (BAnz AT 02.04.2015 B5, chapter IV notification 17)

The current software version of the measuring equipment Model 43i for SO_2 of Thermo Fisher Scientific is:
V 02.02.07

Statement of TÜV Rheinland Energie und Umwelt GmbH of 22 October 2015

Publication in the German Federal Gazette: BAnz AT 01.08.2016 B11, Chap. V notification 37, Announcement by UBA dated 14 July 2016:

37 Notification as regards Federal Environmental Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 18 February 2016 (BAnz AT 14.03.2016 B7, chapter V notification 13)

The current software version of the model 43i measuring system for SO_2 manufactured by Thermo Fisher Scientific is:
V 02.02.08

Supply of the optical lens used for this measuring system is ensured by two different suppliers.

Statement issued by TÜV Rheinland Energy GmbH of 27 May 2016

Publication in the German Federal Gazette: BAnz AT 05.08.2021 B5, Chap. IV notification 10, Announcement by UBA dated 29 June 2021:

10 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 14 July 2016 (BAnz AT 01.08.2016 B11, chapter V notification 37)

The latest software version of the Thermo Fisher Scientific measuring system Model 43i SO_2 analyser is:
V 03.00.01
In addition to this revision number, the following interim version is also valid:
V 03.00.00

Statement issued by TÜV Rheinland Energy GmbH dated 25 February 2021

Publication in the German Federal Gazette: BAnz AT 28.07.2022 B4, Chap. III notification 46, Announcement by UBA dated 28 June 2022:

46 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 29 June 2021 (BAnz AT 05.08.2021 B5, chapter IV notification 10)

The following hardware changes have been introduced for the Model 43i measuring device for SO_2 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 (Art. No. PMD2408PMB-A).

Statement issued by TÜV Rheinland Energy GmbH dated 18 May 2022

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

The ambient air sample is sucked through the bulkhead connection designated SAMPLE into the Model 43i measuring system. The sample flows through a hydrocarbon “kicker,” which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO_2 molecules pass through the hydrocarbon “kicker” unaffected.

The sample then flows into the fluorescence chamber, where pulsating UV light excites the SO_2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains four selective mirrors that reflect only the wavelengths which excite SO_2 molecules.

As the excited SO_2 molecules decay to lower energy states they emit UV light that is proportional to the SO_2 concentration. The band-pass filter allows only the wavelengths emitted by the excited SO_2 molecules to reach the photomultiplier tube (PMT). The PMT detects the UV light emission from the decaying SO_2 molecules. The photodetector, located at the back of the fluo-rescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light.

As the sample leaves the optical chamber, it passes through a flow sensor, a capillary, and the “shell” side of the hydrocarbon kicker. The Model 43i outputs the SO_2 concentration to the front panel display and the analog outputs. Furthermore, data is output via the analogue output and provided via a serial or Ethernet port.

The Model 43i operates on the principle that SO_2 molecules absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength.

Specifically:

$$\mathbf{SO_2 + h\,\upsilon \rightarrow SO_2^* \rightarrow SO_2 + h\,\upsilon'\ (UV)}$$

First, UV light excites SO_2 molecules. Molecules then decay to their original state emitting energy $h\,\upsilon'$. The intensity of the fluorescent radiation is proportional to the number of SO_2 molecules present in the detection volume and thus proportional to the SO_2 concentration.

This measuring principle corresponds to the standard reference method as described in EN 14212.

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 43i 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/D1 dated 7 July 2006
TÜV Rheinland Immissionsschutz und Energiesysteme GmbH
Publication: BAnz. 14 October 2006, No. 194, p. 6715, chapter IV number 2.2
UBA announcement dated 12 September 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 13
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 17
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 5
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 19
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 24
UBA announcement dated 6 July 2012
(Hardware changes)

Initial certification according to EN 15267
Certificate No. 0000040218_00: 29 April 2014
Expiry date of the certificate: 31 March 2019
Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 2 October 2013
Test report: 936/21203248/D1 dated 7 July 2006 TÜV Rheinland Immissionsschutz und Energiesysteme GmbH and Addendum 936/21221382/C dated 20 September 2013
Publication: BAnz AT 01.04.2014 B12, chapter VI notification 23
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 21
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 17
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 13
UBA announcement dated 18 February 2016
(Software changes)

Statement issued by TÜV Rheinland Energy GmbH dated 27 May 2016
Publication: BAnz AT 01.08.2016 B11, chapter V notification 37
UBA announcement dated 14 July 2016
(Software changes)

Renewal of certificates
Certificate No. 0000040218_01: 1 April 2019
Expiry date of the certificate: 30 June 2020

Renewal of certificates
Certificate No. 0000040218_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 10
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 46
UBA announcement dated 28 June 2022
(Hardware changes)

Renewal of certificates
Certificate No. 0000040218_03: 27 June 2025
Expiry date of the certificate: 30 June 2030

Expanded uncertainty laboratory, system 1

Measuring device:	Thermo Fisher Scientific Modell 43i				Serial-No.:	Device 1		
Measured component:	SO2				1h-limit value:	132		nmol/mol
No.	**Performance characteristic**		**Performance criterion**	**Result**	**Partial uncertainty**		**Square of partial uncertainty**	
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0.230	$u_{r,z}$	0.06	0.0041	
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0.470	$u_{r,lh}$	0.13	0.0173	
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	-0.400	$u_{l,lh}$	-0.30	0.0929	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	2.0 nmol/mol/kPa	0.040	u_{gp}	0.30	0.0929	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	1.0 nmol/mol/K	-0.080	u_{gt}	-0.71	0.5065	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	1.0 nmol/mol/K	0.188	u_{st}	1.67	2.7972	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	-0.020	u_V	-0.20	0.0411	
8a	Interferent H_2O with 21 mmol/mol	≤	10 nmol/mol (Zero)	0.300	u_{H2O}	0.02	0.0005	
		≤	10 nmol/mol (Span)	0.030				
8b	Interferent H_2S with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	1.130	$u_{int,pos}$			
		≤	5.0 nmol/mol (Span)	0.530				
8c	Interferent NH_3 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	-0.600				
		≤	5.0 nmol/mol (Span)	0.770				
8d	Interferent NO with 500 nmol/mol	≤	5.0 nmol/mol (Zero)	0.100		6.24	38.8800	
		≤	5.0 nmol/mol (Span)	-0.230	or			
8e	Interferent NO_2 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	2.770				
		≤	5.0 nmol/mol (Span)	2.030				
8f	Interferent m-Xylene with 1 µmol/mol	≤	10 nmol/mol (Zero)	7.400	$u_{int,neg}$			
		≤	10 nmol/mol (Span)	7.470				
9	Averaging effect	≤	7.0% of measured value	-3.300	u_{av}	-2.51	6.3249	
18	Difference sample/calibration port	≤	1.0%	0.000	u_{dsc}	0.00	0.0000	
21	Uncertainty of test gas	≤	3.0%	2.000	u_{cg}	1.32	1.7424	
					Combined standard uncertainty	u_c	7.1063	nmol/mol
					Expanded uncertainty	U	14.2127	nmol/mol
					Relative expanded uncertainty	W	10.77	%
					Maximum allowed expanded uncertainty	W_{req}	15	%

Expanded uncertainty laboratory, system 2

Measuring device:	Thermo Fisher Scientific Modell 43i				Serial-No.:	Device 2	
Measured component:	SO2				1h-limit value:	132	nmol/mol

No.	Performance characteristic		Performance criterion	Result	Partial uncertainty		Square of partial uncertainty	
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0.130	$u_{r,z}$	0.04	0.0014	
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0.390	$u_{r,lh}$	0.11	0.0124	
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	-0.400	$u_{l,lh}$	-0.30	0.0929	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	2.0 nmol/mol/kPa	0.050	u_{gp}	0.38	0.1452	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	1.0 nmol/mol/K	-0.210	u_{gt}	-1.87	3.4901	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	1.0 nmol/mol/K	0.256	u_{st}	2.28	5.1866	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	-0.020	u_v	-0.20	0.0411	
8a	Interferent H_2O with 21 mmol/mol	≤	10 nmol/mol (Zero)	-0.470	u_{H2O}	0.02	0.0005	
		≤	10 nmol/mol (Span)	0.030				
8b	Interferent H_2S with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	0.530	$u_{int,pos}$			
		≤	5.0 nmol/mol (Span)	1.230				
8c	Interferent NH_3 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	-1.270				
		≤	5.0 nmol/mol (Span)	0.200				
8d	Interferent NO with 500 nmol/mol	≤	5.0 nmol/mol (Zero)	-0.230		6.62	43.8536	
		≤	5.0 nmol/mol (Span)	-0.400	or			
8e	Interferent NO_2 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	2.130				
		≤	5.0 nmol/mol (Span)	2.670				
8f	Interferent m-Xylene with 1 µmol/mol	≤	10 nmol/mol (Zero)	7.570	$u_{int,neg}$			
		≤	10 nmol/mol (Span)	7.370				
9	Averaging effect	≤	7.0% of measured value	-3.560	u_{av}	-2.71	7.3608	
18	Difference sample/calibration port	≤	1.0%	0.100	u_{dsc}	0.13	0.0174	
21	Uncertainty of test gas	≤	3.0%	2.000	u_{cg}	1.32	1.7424	

Combined standard uncertainty	u_c	7.8705	nmol/mol
Expanded uncertainty	U	15.7410	nmol/mol
Relative expanded uncertainty	W	11.92	%
Maximum allowed expanded uncertainty	W_{req}	15	%

Combined uncertainty, laboratory and field, system 1

Measuring device:	Thermo Fisher Scientific Modell 43i				Serial-No.:	Device 1		
Measured component:	SO2			1h-limit value:	132		nmol/mol	
No.	Performance characteristic		Performance criterion	Result	Partial uncertainty		Square of partial uncertainty	
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0.230	$u_{r,z}$	0.06	0.0041	
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0.470	$u_{r,lh}$	not considered, as $u_{r,lh} = 0,13 < u_{r,f}$	-	
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	-0.400	$u_{l,lh}$	-0.30	0.0929	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	2.0 nmol/mol/kPa	0.040	u_{gp}	0.30	0.0929	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	1.0 nmol/mol/K	-0.080	u_{gt}	-0.71	0.5065	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	1.0 nmol/mol/K	0.188	u_{st}	1.67	2.7972	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	-0.020	u_V	-0.20	0.0411	
8a	Interferent H_20 with 21 mmol/mol	≤	10 nmol/mol (Zero)	0.300				
		≤	10 nmol/mol (Span)	0.030	u_{H2O}	0.02	0.0005	
8b	Interferent H_2S with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	1.130				
		≤	5.0 nmol/mol (Span)	0.530	$u_{int,pos}$			
8c	Interferent NH_3 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	-0.600				
		≤	5.0 nmol/mol (Span)	0.770				
8d	Interferent NO with 500 nmol/mol	≤	5.0 nmol/mol (Zero)	0.100				
		≤	5.0 nmol/mol (Span)	-0.230	or	6.24	38.8800	
8e	Interferent NO_2 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	2.770				
		≤	5.0 nmol/mol (Span)	2.030				
8f	Interferent m-Xylene with 1 µmol/mol	≤	10 nmol/mol (Zero)	7.400				
		≤	10 nmol/mol (Span)	7.470	$u_{int,neg}$			
9	Averaging effect	≤	7.0% of measured value	-3.300	$u_{a,v}$	-2.51	6.3249	
10	Reproducibility standard deviation under field conditions	≤	5.0% of average over 3 months	3.900	$u_{r,f}$	5.15	26.5019	
11	Long term drift at zero level	≤	4.0 nmol/mol	0.340	$u_{d,l,z}$	0.20	0.0385	
12	Long term drift at span level	≤	5.0% of max. of certification range	2.190	$u_{d,l,lh}$	1.67	2.7856	
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}	1.32	1.7424	

Combined standard uncertainty	u_c	8.9336	nmol/mol
Expanded uncertainty	U	17.8671	nmol/mol
Relative expanded uncertainty	W	13.54	%
Maximum allowed expanded uncertainty	W_{req}	15	%

Combined uncertainty, laboratory and field, system 2

Measuring device:	Thermo Fisher Scientific Model 43i			Serial-No.:	Device 2	
Measured component:	SO2			1h-limit value:	132	nmol/mol

No.	Performance characteristic		Performance criterion	Result	Partial uncertainty		Square of partial uncertainty	
1	Repeatability standard deviation at zero	≤	1.0 nmol/mol	0.130	$u_{r,z}$	0.04	0.0014	
2	Repeatability standard deviation at 1h-limit value	≤	3.0 nmol/mol	0.390	$u_{r,lh}$	not considered, as $u_{r,lh} = 0,11 < u_{r,f}$	-	
3	"lack of fit" at 1h-limit value	≤	4.0% of measured value	-0.400	$u_{l,lh}$	-0.30	0.0929	
4	Sensitivity coefficient of sample gas pressure at 1h-limit value	≤	2.0 nmol/mol/kPa	0.050	u_{gp}	0.38	0.1452	
5	Sensitivity coefficient of sample gas temperature at 1h-limit value	≤	1.0 nmol/mol/K	-0.210	u_{gt}	-1.87	3.4901	
6	Sensitivity coefficient of surrounding temperature at 1h-limit value	≤	1.0 nmol/mol/K	0.256	u_{st}	2.28	5.1866	
7	Sensitivity coefficient of electrical voltage at 1h-limit value	≤	0.30 nmol/mol/V	-0.020	u_V	-0.20	0.0411	
8a	Interferent H_2O with 21 mmol/mol	≤	10 nmol/mol (Zero)	-0.470				
		≤	10 nmol/mol (Span)	0.030	u_{H2O}	0.02	0.0005	
8b	Interferent H_2S with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	0.530				
		≤	5.0 nmol/mol (Span)	1.230	$u_{int,pos}$			
8c	Interferent NH_3 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	-1.270				
		≤	5.0 nmol/mol (Span)	0.200				
8d	Interferent NO with 500 nmol/mol	≤	5.0 nmol/mol (Zero)	-0.230				
		≤	5.0 nmol/mol (Span)	-0.400				
8e	Interferent NO_2 with 200 nmol/mol	≤	5.0 nmol/mol (Zero)	2.130				
		≤	5.0 nmol/mol (Span)	2.670				
8f	Interferent m-Xylene with 1 µmol/mol	≤	10 nmol/mol (Zero)	7.570				
		≤	10 nmol/mol (Span)	7.370	$u_{int,neg}$	or 6.62	43.8536	
9	Averaging effect	≤	7.0% of measured value	-3.560	$u_{a,v}$	-2.71	7.3608	
10	Reproducibility standard deviation under field conditions	≤	5.0% of average over 3 months	3.900	$u_{r,f}$	5.15	26.5019	
11	Long term drift at zero level	≤	4.0 nmol/mol	0.340	$u_{d,l,z}$	0.20	0.0385	
12	Long term drift at span level	≤	5.0% of max. of certification range	2.700	$u_{d,l,sh}$	2.06	4.2340	
18	Difference sample/calibration port	≤	1.0%	0.100	u_{ass}	0.13	0.0174	
21	Uncertainty of test gas	≤	3.0%	2.000	u_{cg}	1.32	1.7424	

Combined standard uncertainty	u_c	9.6284	nmol/mol
Expanded uncertainty	U	19.2569	nmol/mol
Relative expanded uncertainty	W	14.59	%
Maximum allowed expanded uncertainty	W_{req}	15	%