

# CERTIFICATE

## of Product Conformity (QAL1)

Certificate No.: 0000040218\_02

**AMS designation:** Model 43i for SO<sub>2</sub>

**Manufacturer:** Thermo Fisher Scientific  
27, Forge Parkway  
Franklin, MA 02038  
USA

**Test Laboratory:** TÜV Rheinland Energy GmbH

**This is to certify that the AMS has been tested  
and found to comply with the standards:  
VDI 4202-1 (2002), VDI 4203-3 (2004), EN 14212 (2012),  
EN 15267-1 (2009) and EN 15267-2 (2009).**

Certification is awarded in respect of the conditions stated in this certificate  
(this certificate contains 15 pages).  
The present certificate replaces certificate 0000040218\_01 of 01 April 2019.



Suitability Tested  
Equivalent to  
2008/50/EC  
EN 15267  
Regular Surveillance  
[www.tuv.com](http://www.tuv.com)  
ID 0000040218

Publication in the German Federal Gazette  
(BAnz) of 01 April 2014

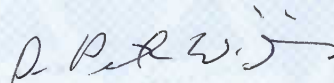
German Federal Environment Agency  
Dessau, 01 July 2020



Dr. Marcel Langner  
Head of Section II 4.1

This certificate will expire on:  
30 June 2025

TÜV Rheinland Energy GmbH  
Cologne, 30 June 2020



ppa. Dr. Peter Wilbring

[www.umwelt-tuv.eu](http://www.umwelt-tuv.eu)  
[tre@umwelt-tuv.eu](mailto:tre@umwelt-tuv.eu)  
Phone: + 49 221 806-5200

TÜV Rheinland Energy 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 certificate D-PL-11120-02-00.

|                               |  |
|-------------------------------|--|
| <b>Test Report:</b>           | 936/21203248/D1 dated 7 July 2006  |
| <b>Initial certification:</b> | 01 April 2014  |
| <b>Expiry date:</b>           | 30 June 2025   |
| <b>Certificate:</b>           | Renewal (of previous certificate 0000040218_01 dated 01 April 2019 valid until 30 June 2020) |
| <b>Publication:</b>           | BAnz AT 01.04.2014 B12, chapter VI notification 23   |

### **Approved application**

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

The suitability of the AMS for this application was assessed on the basis of a laboratory test and a three-months 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, in consultation with the manufacturer, that this AMS is suitable for monitoring the AMS readings 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 no. 936/21203248/D1 dated 7 July 2006 issued by TÜV Rheinland Immissionschutz 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, S. 6715,  
chapter IV number 2.2, UBA announcement dated 12 September 2006:

**AMS designation:**

SO<sub>2</sub> 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 performance testing**

SO<sub>2</sub> 0–700 µg/m<sup>3</sup> and

0–1 000 µg/m<sup>3</sup>

**Software version:**

V 01.03.00.083

**Test Laboratory:**

TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, Cologne,

TÜV Rheinland Group

Report no.: 936/21203248/D dated 7 July 2006

Publication in the German Federal Gazette: BAnz. 20 April 2007, no. 75, p. 4139, chapter IV  
notification 1, UBA announcement dated 12 April 2007:

**1 Notification issued by the Federal Environment Agency**

Thermo Electron Corp., Franklin, USA, now trade under the new name,  
Thermo Fisher Scientific, Franklin, USA.

Statement issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH,  
51101 Cologne, Dr Peter Wilbring, dated 20 December 2006

Publication in the German Federal Gazette: BAnz. 20 April 2007, no. 75, p. 4139, chapter IV notification 6, UBA announcement dated 12 April 2007:

**6 Notification as regards Federal Environment Agency (UBA) notices of 21 February 2006 (BAnz. p. 2653) and of 12 September 2006 (BAnz. p. 6715)**

The measuring systems model 42i for nitrogen oxide, model 43i for sulphur dioxide, model 48i for carbon monoxide and model 49i for ozone, manufactured by Thermo Fisher Scientific, MA 02038, USA, are also manufactured and sold identically and to the same standards by MLU-Monitoring für Leben und Umwelt Ges.m.b.H., Mödling, Austria.

Statement issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, 51101 Cologne, Dr Peter Wilbring, dated 14 December 2006

Publication in the German Federal Gazette: BAnz. 03 September 2008, no. 133, p. 3243, chapter IV notification 13, UBA announcement dated 12 August 2008:

**13 Notification as regards Federal Environment Agency notice of 12 September 2006 (BAnz. p. 6717)**

The current software version for the Model 43i air quality monitor manufactured by Thermo Fisher Scientific is:

V 01.05.06 (105721-00)

Statement issued 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, chapter III notification 17, UBA announcement dated 3 August 2009:

**17 Notification as regards Federal Environment Agency notice of 12 September 2006 (BAnz. p. 6717)**

The current software version for the Model 43i air quality monitor manufactured by Thermo Fisher Scientific is:

V 01.06.01 (108457-00)

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



Publication in the German Federal Gazette: BAnz. 28 July 2010, No. 111, p. 2597, chapter III notification 5, UBA announcement dated 12 July 2010:

**5 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6717) and of 3 August 2009 (BAnz. p. 2936)**

The Model 43i 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 issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 23 March 2010

Publication in the German Federal Gazette: BAnz. 29 July 2011, No. 113, p. 2725, chapter III notification 19, UBA announcement dated 15 July 2011:

**19 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 12 July 2010 (BAnz. p. 2597, chapter III 5<sup>th</sup> notification)**

The current software version for the Model 43i air quality monitor for SO<sub>2</sub> manufactured by Thermo Fisher Scientific is:

V 01.06.07 (110959-00)

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

Publication in the German Federal Gazette: BAnz AT 20.07.2012 B11, chapter IV notification 24, UBA announcement dated 06 July 2012:

**24 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6715, chapter IV number 2.2) and of 15 July 2011 (BAnz. p. 2725, chapter III 19<sup>th</sup> notification)**

The latest software version of the model 43i air quality monitor for SO<sub>2</sub> manufactured by Thermo Fisher Scientific is 01.06.08.

The Model 43i air quality monitor for SO<sub>2</sub> manufactured by Thermo Fisher Scientific will be equipped with the PU2737-N86 vacuum pump manufactured by KNF in the future.

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

Publication in the German Federal Gazette: BAnz AT 01.04.2014 B12, chapter VI notification 23, UBA announcement dated 27 February 2014:

**23 Notification as regards Federal Environment Agency (UBA) notices 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 24<sup>th</sup> notification)**

The Model 43i air quality monitor for SO<sub>2</sub> manufactured by Thermo Fisher Scientific complies with the requirements of EN 14212 (November 2012 version). Furthermore, the manufacturing process and the quality management for the Model 43i for SO<sub>2</sub> measuring system meet the requirements of EN 15267.

The test report on performance testing No. 936/21203248/D1 and the addendum no. 936/21221382/C as an integral part of this report are available online at [www.qal1.de](http://www.qal1.de).

The photomultiplier type has been discontinued and will be replaced by a new photomultiplier type Hamamatsu R11568-15.

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 02.00.00 (113419-00)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 2 October 2013

Publication in the German Federal Gazette: BAnz AT 05.08.2014 B11, chapter V notification 21 UBA announcement dated 17 July 2014:

**21 Notification as regards Federal Environment Agency (UBA) notices of 12 September 2006 (BAnz. p. 6717, chapter II number 2.2) and of 27 February 2014 (BAnz AT 01.04.2014 B12, chapter VI 23<sup>rd</sup> notification)**

The latest software version of the model 43i measuring system for SO<sub>2</sub> manufactured by Thermo Fisher Scientific is: V 02.00.03 (114181-00)

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



Publication in the German Federal Gazette: BAnz AT 02.04.2015 B5, chapter IV notification 17,  
UBA announcement 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 17 July 2014 (BAnz AT 05.08.2014 B11, chapter V 21<sup>st</sup> notification)**

The latest software version of the model 43i measuring system for SO<sub>2</sub> manufactured by Thermo Fisher Scientific is:  
V 02.02.00 (114619-00)

Statement issued by TÜV Rheinland Energie und Umwelt GmbH  
dated 22 September 2014

Publication in the German Federal Gazette: BAnz AT 14.03.2016 B7, chapter V notification 13  
UBA announcement dated 18 February 2016:

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

The latest software version of the model 43i measuring system for SO<sub>2</sub> manufactured by Thermo Fisher Scientific is:

V 02.02.07

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

Publication in the German Federal Gazette: BAnz AT 01.08.2016 B11, chapter V notification 37,  
UBA announcement dated 14 July 2016:

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

The latest software version of the model 43i measuring system for SO<sub>2</sub> manufactured by Thermo Fisher Scientific is:  
V 02.02.08

The optical lens used for the measuring system is provided by two different suppliers.

Statement issued by TÜV Rheinland Energy GmbH dated 27 May 2016

### Certified product

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

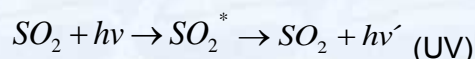
The ambient air sample is sucked through the bulkhead connection designated SAMPLE into the Model 43i measuring system. The sample flows through a hydrocarbon “kicker,” which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO<sub>2</sub> molecules pass through the hydrocarbon “kicker” unaffected.

The sample then flows into the fluorescence chamber, where pulsating UV light excites the SO<sub>2</sub> 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<sub>2</sub> molecules.

As the excited SO<sub>2</sub> molecules decay to lower energy states they emit UV light that is proportional to the SO<sub>2</sub> concentration. The band-pass filter allows only the wavelengths emitted by the excited SO<sub>2</sub> molecules to reach the photomultiplier tube (PMT). The PMT detects the UV light emission from the decaying SO<sub>2</sub> molecules. The photodetector, located at the back of the fluorescence 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<sub>2</sub> 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<sub>2</sub> 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:



First, UV light excites SO<sub>2</sub> molecules. Molecules then decay to their original state emitting energy hv'. The intensity of the fluorescent radiation is proportional to the number of SO<sub>2</sub> molecules present in the detection volume and thus proportional to the SO<sub>2</sub> concentration.

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



### General remarks

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 manufacturing process for 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 document as well as the certification mark remains property of TÜV Rheinland Energy GmbH. Upon revocation of the publication the certificate loses its validity. After the expiration of the certificate and on request of TÜV Rheinland Energy GmbH this document shall be returned and the certificate mark must no longer be used.

The relevant version of this certificate and its expiration date are also accessible on the internet at [qal1.de](http://qal1.de).

### Document history

Certification of the Model 43i measuring system is based on the documents listed below and the regular, continuous surveillance of the manufacturer's quality management system:

### Basic testing

Test Report: 936/21203248/D1 dated 7 July 2006  
TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, Cologne  
Publication: BAnz. 14 October 2006, No. 194, p. 6715, chapter IV number 2.2  
UBA announcement dated 12 September 2006

### Notifications

Statement issued 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 company name)

Statement issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 14 December 2006  
Publication: BAnz. 20 April 2007, no. 75, p. 4139, chapter IV notification 6  
UBA announcement dated 12 April 2007  
(Production and distribution by MLU)

Statement issued 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 updates)

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

Publication: 25 August 2009, no. 125, p. 2929, chapter III notification 17  
UBA announcement dated 3 August 2009  
(software updates)

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  
(Design 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 updates)

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  
(Design changes)

#### **Initial certification according to EN 15267**

Certificate no. 0000040218: 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: 936/21221382/C dated 20 September 2013

Publication: BAnz AT 01.04.2014 B12, chapter IV notification 23

UBA announcement dated 27 February 2014

#### **Notifications in accordance with EN 15267**

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 updates)

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 updates)

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 updates)

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 updates)



**Renewal of the certificate**

Certificate no. 0000040218\_01: 01 April 2019  
Expiry date of the certificate: 30 June 2020

**Renewal of the certificate**

Certificate no. 0000040218\_02: 01 July 2020  
Expiry date of the certificate: 30 June 2025

Expanded uncertainty from the results obtained in the laboratory tests for analyser 1

| Measuring device: Thermo Fisher Scientific Modell 43i |  | Serial-No.:                                  | Device 1       |                     |                               |
|---|--|--|----------------|---------------------|-------------------------------|
| Measured component: SO2                               |  | 1h-limit value:                              |                | 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          | $u_{r,z}$           | 0.0041                        |
| 2   | Repeatability standard deviation at 1h-limit value                   | ≤ 3.0 nmol/mol                               | 0.470          | $u_{r,1h}$          | 0.0173                        |
| 3   | "lack of fit" at 1h-limit value                                      | ≤ 4.0% of measured value                     | -0.400         | $u_{l,1h}$          | 0.0929                        |
| 4   | Sensitivity coefficient of sample gas pressure at 1h-limit value     | ≤ 2.0 nmol/mol/kPa                           | 0.040          | $u_{gp}$            | 0.0929                        |
| 5   | Sensitivity coefficient of sample gas temperature at 1h-limit value  | ≤ 1.0 nmol/mol/K                             | -0.080         | $u_{gt}$            | 0.5065                        |
| 6   | Sensitivity coefficient of surrounding temperature at 1h-limit value | ≤ 1.0 nmol/mol/K                             | 0.188          | $u_{st}$            | 2.7972                        |
| 7   | Sensitivity coefficient of electrical voltage at 1h-limit value      | ≤ 0.30 nmol/mol/V                            | -0.020         | $u_y$               | 0.0411                        |
| 8a  | Interferent H <sub>2</sub> O with 21 mmol/mol                        | ≤ 10 nmol/mol (Zero)<br>≤ 10 nmol/mol (Span) | 0.300<br>0.030 | $u_{H_2O}$          | 0.0005                        |
| 8b  | Interferent H <sub>2</sub> S with 200 nmol/mol                       | ≤ 5.0 nmol/mol (Zero)                        | 1.130          | $u_{int,pos}$       |                               |
| 8c  | Interferent NH <sub>3</sub> with 200 nmol/mol                        | ≤ 5.0 nmol/mol (Span)                        | 0.530          |                     |                               |
|   |  | ≤ 5.0 nmol/mol (Zero)                        | -0.600         |                     |                               |
|   |  | ≤ 5.0 nmol/mol (Span)                        | 0.770          |                     |                               |
|   |  | ≤ 5.0 nmol/mol (Zero)                        | 0.100          |                     |                               |
| 8d  | Interferent NO with 500 nmol/mol                                     | ≤ 5.0 nmol/mol (Span)                        | -0.230         | or                  | 38.8800                       |
|   |  | ≤ 5.0 nmol/mol (Zero)                        | 2.770          |                     |                               |
| 8e  | Interferent NO <sub>2</sub> with 200 nmol/mol                        | ≤ 5.0 nmol/mol (Span)                        | 2.030          |                     |                               |
|   |  | ≤ 5.0 nmol/mol (Zero)                        | 7.400          |                     |                               |
| 8f  | Interferent m-Xylene with 1 µmol/mol                                 | ≤ 10 nmol/mol (Span)                         | 7.470          | $u_{int,neg}$       |                               |
| 9   | Averaging effect   | ≤ 7.0% of measured value                     | -3.300         | $u_{av}$            | 6.3249                        |
| 18  | Difference sample/calibration port                                   | ≤ 1.0%                                       | 0.000          | $u_{dsc}$           | 0.0000                        |
| 21  | Uncertainty of test gas  | ≤ 3.0%                                       | 2.000          | $u_{og}$            | 1.7424                        |
|   |  |  |                | $u_c$               | 7.1063                        |
|   |  |  |                | U                   | 14.2127                       |
|   |  |  |                | W                   | 10.77                         |
|   |  |  |                | $W_{req}$           | 15                            |



Expanded uncertainty from the results obtained in the laboratory tests for analyser 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           | $u_{r,1h}$                           | 0.11                          | 0.0124           |
| 3                   | "lack of fit" at 1h-limit value                                      | ≤ 4.0% of measured value                     | -0.400          | $u_{l,1h}$                           | -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 <sub>2</sub> O with 21 mmol/mol                        | ≤ 10 nmol/mol (Zero)<br>≤ 10 nmol/mol (Span) | -0.470<br>0.030 | $u_{H_2O}$                           | 0.02                          | 0.0005           |
| 8b                  | Interferent H <sub>2</sub> S with 200 nmol/mol                       | ≤ 5.0 nmol/mol (Zero)                        | 0.530           | $u_{H_2S, pos}$                      |                               |                  |
| 8c                  | Interferent NH <sub>3</sub> with 200 nmol/mol                        | ≤ 5.0 nmol/mol (Span)                        | 1.230           |                                      |                               |                  |
|                     |  | ≤ 5.0 nmol/mol (Zero)                        | -1.270          |                                      |                               |                  |
| 8d                  | Interferent NO with 500 nmol/mol                                     | ≤ 5.0 nmol/mol (Span)                        | 0.200           |                                      |                               |                  |
|                     |  | ≤ 5.0 nmol/mol (Zero)                        | -0.230          |                                      |                               |                  |
| 8e                  | Interferent NO <sub>2</sub> with 200 nmol/mol                        | ≤ 5.0 nmol/mol (Span)                        | -0.400          |                                      |                               |                  |
|                     |  | ≤ 5.0 nmol/mol (Zero)                        | 2.130           |                                      |                               |                  |
| 8f                  | Interferent m-Xylene with 1 µmol/mol                                 | ≤ 5.0 nmol/mol (Span)                        | 2.670           |                                      |                               |                  |
|                     |  | ≤ 10 nmol/mol (Zero)                         | 7.570           |                                      |                               |                  |
| 9                   | Averaging effect   | ≤ 10 nmol/mol (Span)                         | 7.370           | $u_{int, neg}$                       |                               |                  |
| 18                  | Difference sample/calibration port                                   | ≤ 7.0% of measured value                     | -3.560          | $u_{av}$                             | -2.71                         | 7.3608           |
|                     |  | ≤ 1.0%                                       | 0.100           | $u_{dsc}$                            | 0.13                          | 0.0174           |
| 21                  | Uncertainty of test gas  | ≤ 3.0%                                       | 2.000           | $u_{sg}$                             | 1.32                          | 1.7424           |
|                     |  |  |                 | Combined standard uncertainty        |                               | $u_c$            |
|                     |  |  |                 | Expanded uncertainty                 |                               | U                |
|                     |  |  |                 | Relative expanded uncertainty        |                               | W                |
|                     |  |  |                 | Maximum allowed expanded uncertainty |                               | $W_{req}$        |
|                     |  |  |                 |                                      |                               | 7.8705 nmol/mol  |
|                     |  |  |                 |                                      |                               | 15.7410 nmol/mol |
|                     |  |  |                 |                                      |                               | 11.92 %          |
|                     |  |  |                 |                                      |                               | 15 %             |

Expanded uncertainty from the results obtained in the laboratory and field tests for analyser 1

| Measuring device: Thermo Fisher Scientific Modell 43i |  | Serial-No.:                           | Device 1         |                      |                               |
|---|--|---------------------------------------|------------------|----------------------|-------------------------------|
| Measured component: SO2                               |  | 1h-limit value:                       |                  | 132                  |                               |
| 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 <sub>r,z</sub>     | 0.0041                        |
| 2   | Repeatability standard deviation at 1h-limit value                   | ≤ 3.0 nmol/mol                        | 0.470            | u <sub>r,h</sub>     | -                             |
| 3   | "lack of fit" at 1h-limit value                                      | ≤ 4.0% of measured value              | -0.400           | u <sub>l,h</sub>     | 0.0929                        |
| 4   | Sensitivity coefficient of sample gas pressure at 1h-limit value     | ≤ 2.0 nmol/mol/kPa                    | 0.040            | u <sub>gp</sub>      | 0.0929                        |
| 5   | Sensitivity coefficient of sample gas temperature at 1h-limit value  | ≤ 1.0 nmol/mol/K                      | -0.080           | u <sub>gt</sub>      | 0.5065                        |
| 6   | Sensitivity coefficient of surrounding temperature at 1h-limit value | ≤ 1.0 nmol/mol/K                      | 0.188            | u <sub>st</sub>      | 2.7972                        |
| 7   | Sensitivity coefficient of electrical voltage at 1h-limit value      | ≤ 0.30 nmol/mol/V                     | -0.020           | u <sub>v</sub>       | 0.0411                        |
| 8a  | Interferent H <sub>2</sub> O with 21 nmol/mol                        | ≤ 10 nmol/mol (Zero)                  | 0.300            |                      |                               |
| 8b  | Interferent H <sub>2</sub> S with 200 nmol/mol                       | ≤ 10 nmol/mol (Span)                  | 0.030            | u <sub>H2O</sub>     | 0.0005                        |
| 8c  | Interferent NH <sub>3</sub> with 200 nmol/mol                        | ≤ 5.0 nmol/mol (Zero)                 | 1.130            |                      |                               |
| 8d  | Interferent NO with 500 nmol/mol                                     | ≤ 5.0 nmol/mol (Span)                 | 0.530            | u <sub>int,pos</sub> |                               |
| 8e  | Interferent NO <sub>2</sub> with 200 nmol/mol                        | ≤ 5.0 nmol/mol (Span)                 | -0.600           |                      |                               |
| 8f  | Interferent m-Xylene with 1 µmol/mol                                 | ≤ 5.0 nmol/mol (Zero)                 | 0.770            |                      |                               |
| 9   | Averaging effect   | ≤ 5.0 nmol/mol (Zero)                 | 0.100            |                      |                               |
| 10  | Reproducibility standard deviation under field conditions            | ≤ 5.0 nmol/mol (Span)                 | -0.230           | or                   | 38.8800                       |
| 11  | Long term drift at zero level  | ≤ 5.0 nmol/mol (Span)                 | 2.770            |                      |                               |
| 12  | Long term drift at span level  | ≤ 5.0 nmol/mol (Span)                 | 2.030            |                      |                               |
| 18  | Difference sample/calibration port                                   | ≤ 10 nmol/mol (Span)                  | 7.470            | u <sub>int,neg</sub> |                               |
| 21  | Uncertainty of test gas  | ≤ 7.0% of measured value              | -3.300           | u <sub>sv</sub>      | 6.3249                        |
|   |  | ≤ 5.0% of average over 3 months       | 3.900            | u <sub>r,f</sub>     | 26.5019                       |
|   |  | ≤ 4.0 nmol/mol                        | 0.340            | u <sub>g,l,z</sub>   | 0.0385                        |
|   |  | ≤ 5.0% of max. of certification range | 2.190            | u <sub>g,l,h</sub>   | 2.7856                        |
|   |  | ≤ 1.0%                                | 0.000            | u <sub>asc</sub>     | 0.0000                        |
|   |  | ≤ 3.0%                                | 2.000            | u <sub>og</sub>      | 1.7424                        |
| Combined standard uncertainty                         |  |                                       | u <sub>c</sub>   |                      | 8.9336                        |
| Expanded uncertainty                                  |  |                                       | U                |                      | 17.8671                       |
| Relative expanded uncertainty                         |  |                                       | W                |                      | 13.54                         |
| Maximum allowed expanded uncertainty                  |  |                                       | W <sub>req</sub> |                      | 15                            |



Expanded uncertainty from the results obtained in the laboratory and field tests for analyser 2

| Measuring device: Thermo Fisher Scientific Modell 431 |  | Serial-No.: Device 2                  |        | 132                  |   | nmol/mol                      |                               |
|---|--|---------------------------------------|--------|----------------------|---|-------------------------------|-------------------------------|
| Measured component: SO2                               |  | 1h-limit value:                       |        | Partial uncertainty  |   | Square of partial uncertainty |                               |
| No.   | Performance characteristic   | Performance criterion                 | Result | Partial uncertainty  | Result  | Partial uncertainty           | Square of partial uncertainty |
| 1   | Repeatability standard deviation at zero                             | ≤ 1.0 nmol/mol                        | 0.130  | U <sub>r,z</sub>     | 0.04  | 0.0014                        |                               |
| 2   | Repeatability standard deviation at 1h-limit value                   | ≤ 3.0 nmol/mol                        | 0.390  | U <sub>r,1h</sub>    | not considered, as U <sub>r,1h</sub> = 0, 11 < U <sub>r,f</sub> | -                             |                               |
| 3   | "lack of fit" at 1h-limit value                                      | ≤ 4.0% of measured value              | -0.400 | U <sub>l,1h</sub>    | -0.30   | 0.0929                        |                               |
| 4   | Sensitivity coefficient of sample gas pressure at 1h-limit value     | ≤ 2.0 nmol/mol/kPa                    | 0.050  | U <sub>sp</sub>      | 0.38  | 0.1452                        |                               |
| 5   | Sensitivity coefficient of sample gas temperature at 1h-limit value  | ≤ 1.0 nmol/mol/K                      | -0.210 | U <sub>t</sub>       | -1.87   | 3.4901                        |                               |
| 6   | Sensitivity coefficient of surrounding temperature at 1h-limit value | ≤ 1.0 nmol/mol/K                      | 0.256  | U <sub>s,t</sub>     | 2.28  | 5.1866                        |                               |
| 7   | Sensitivity coefficient of electrical voltage at 1h-limit value      | ≤ 0.30 nmol/mol/V                     | -0.020 | U <sub>v</sub>       | -0.20   | 0.0411                        |                               |
| 8a  | Interferent H <sub>2</sub> O with 21 nmol/mol                        | ≤ 10 nmol/mol (Zero)                  | -0.470 |                      |   |                               |                               |
|   |  | ≤ 10 nmol/mol (Span)                  | 0.030  |                      |   |                               |                               |
| 8b  | Interferent H <sub>2</sub> S with 200 nmol/mol                       | ≤ 5.0 nmol/mol (Zero)                 | 0.530  | U <sub>H2O</sub>     | 0.02  | 0.0005                        |                               |
|   |  | ≤ 5.0 nmol/mol (Span)                 | 1.230  | U <sub>int,pos</sub> |   |                               |                               |
| 8c  | Interferent NH <sub>3</sub> 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 |                      | 6.62  | 43.8536                       |                               |
| 8e  | Interferent NO <sub>2</sub> 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 <sub>int,neg</sub> |   |                               |                               |
| 9   | Averaging effect   | ≤ 7.0% of measured value              | -3.560 | U <sub>av</sub>      | -2.71   | 7.3608                        |                               |
| 10  | Reproducibility standard deviation under field conditions            | ≤ 5.0% of average over 3 months       | 3.900  | U <sub>r,f</sub>     | 5.15  | 26.5019                       |                               |
| 11  | Long term drift at zero level  | ≤ 4.0 nmol/mol                        | 0.340  | U <sub>d,z</sub>     | 0.20  | 0.0385                        |                               |
| 12  | Long term drift at span level  | ≤ 5.0% of max. of certification range | 2.700  | U <sub>d,1h</sub>    | 2.06  | 4.2340                        |                               |
| 18  | Difference sample/calibration port                                   | ≤ 1.0%                                | 0.100  | U <sub>Δsc</sub>     | 0.13  | 0.0174                        |                               |
| 21  | Uncertainty of test gas  | ≤ 3.0%                                | 2.000  | U <sub>tg</sub>      | 1.32  | 1.7424                        |                               |
| Combined standard uncertainty                         |  |                                       |        | U <sub>c</sub>       |   | 9.6284                        | nmol/mol                      |
| Expanded uncertainty                                  |  |                                       |        | U                    |   | 19.2569                       | nmol/mol                      |
| Relative expanded uncertainty                         |  |                                       |        | W                    |   | 14.59                         | %                             |
| Maximum allowed expanded uncertainty                  |  |                                       |        | W <sub>req</sub>     |   | 15                            | %                             |