TÜV RHEINLAND ENERGY GMBH

Report on the performance test of the Fidas Smart 100 / Fidas Smart 100 E ambient air measuring system manufactured by Palas GmbH for particulate matter $PM_{2.5}$ and PM_{10}

TÜV Report: 936/21250983/B
Cologne, 15 September 2022

www.umwelt-tuv.de

tre-service@de.tuv.com

TÜV Rheinland Energy GmbH and its Ambient Air Quality department in particular
is accredited for the following activities:

- Determination of emissions and ambient air quality affected by air pollutants and odorous substances;
- Inspection of correct installation, function and calibration of continuously operating emission measuring instruments, including data evaluation and remote emission monitoring systems;
- Measurements in combustion chambers;
- Performance testing of measuring systems for continuous monitoring of emissions and ambient air, and of electronic data evaluation and remote emission monitoring systems;
- Determination of the stack height and air quality forecasts for hazardous and odorous substances;
- Determination of emissions and ambient air quality affected by noise and vibration, determination of sound power levels and noise measurements at wind turbines;

according to EN ISO/IEC 17025.

The accreditation has the DAkkS registration number: D-PL-11120-02-00
and covers the scope defined in the appendix to the certificate.

TÜV Rheinland Energy GmbH
D - 51105 Cologne, Am Grauen Stein,
Tel: + 49 (0) 221 806-5200, fax: 0221 806-1349

Blank page

Summary Overview

Palas GmbH, located in Karlsruhe, Germany, commissioned TÜV Rheinland Energy GmbH to carry out performance testing of the Fidas Smart 100 / Fidas Smart 100 E measuring system for particulate matter $PM_{2.5}$ and PM_{10} in accordance with the following standards:

- Standard EN 16450 Ambient air – Automated measuring systems for the measurement of the concentration of particulate matter (PM_{10}; $PM_{2.5}$, German version dated July 2017)
- VDI Standard 4202, part 3, Automated measuring systems for air quality monitoring - Performance test, declaration of suitability and certification of measuring systems for point-related measurement of mass concentration for particulate air pollutants, February 2019
- European standard EN 12341, Ambient air - Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2.5}$ mass concentration of suspended particulate matter; German version EN 12341:2014
- Guideline, Demonstration of Equivalence of Ambient Air Monitoring Methods, English version dated January 2010 version

The Fidas Smart 100 / Fidas Smart 100 E measuring systems determine dust concentrations using the measuring principle of scattered light measurement with a combination of a polychromatic LED and 90° scattered light detection. With the aid of a fan, ambient air is drawn in via a sampling head and passes through the sampling tube to the actual measuring instrument. The sampling tube includes a heater for the compact IADS (Intelligent Aerosol Drying System), which is designed to avoid condensation effects on the particles. The sample passes directly to the spectrometer after the sampling tube. There, the particle size is determined using the scattered light measurement technique and the mass concentration is calculated by means of an algorithm.

The Fidas Smart 100 measuring system is suitable for outdoor installation. The Fidas Smart 100 E measuring system has an extended sampling tube and is therefore intended for installation in measuring stations.

The tests were performed in the laboratory and in a twenty-month long field test.

The field test, which lasted several months, was carried out at the sites listed in Table 1.

Testing at the Niederzier 2 site was conducted exclusively for PM_{10}, as for PM_{10} insufficient value pairs above 28 mg/m³ had been determined. Therefore, this location was not evaluated for $PM_{2.5}$.

Table 1: Description of the test sites

	Cologne I	Niederzier I	Cologne II	Bornheim	Bonn	Niederzier II
Period	01/2021 – 03/2021	04/2021 – 06/2021	07/2021 – 11/2021	12/2021 – 03/2022	04/2022 – 05/2022	06/2022 – 08/2022
Number of measurement pairs: Test specimens	PM10: 53 $PM_{2.5}$: 44	PM_{10}: 59 $PM_{2.5}$: 57	PM_{10}: 117 $PM_{2.5}$: 115	PM_{10}: 83 $PM_{2.5}$: 93	PM_{10}: 54 $PM_{2.5}$: 54	PM_{10}: 67
Description	Urban back-ground	Industrial background	Urban back-ground	Affected by traffic	Urban back-ground	Industrial background
Classification of ambient air pollu-tion	Low to high	Average to high	Low	Average	Average	Average to high

The following table provides an overview of the equivalence tests performed.

Table 2: Results of equivalent testing (raw data)

Comparison campaigns		Slope	Axis inter-cept	All data sets W_{CM}<25 % raw data	Calibration yes/no	All data sets W_{CM}<25% cal. data
5	$PM_{2.5}$	0.963	0.263	no	yes	yes
6	PM_{10}	0.899	0.712	no	yes	yes

DAkkS Deutsche Akkreditierungsstelle D-PL-11120-02-00

Report on the performance test of the Fidas Smart 100 / Fidas Smart 100 E ambient air measuring system manufactured by Palas GmbH for particulate matter $PM_{2.5}$ and PM_{10}

AMS designation:	Fidas Smart 100 / Fidas Smart 100 E
Manufacturer:	Palas GmbH Greschbachstrasse 3b 76229 Karlsruhe
Test period:	10/2020 to 09/2022
Date of report:	15 September 2022
Report Number:	936/21250983/B
Editor:	Fritz Hausberg
Technical supervisor:	Guido Baum

Scope of report:

Report:		128	Pages
Appendix	pages	129	
Manual	pages	159	
Manual	with	112	Pages
Total		271	Pages

Blank page

Table of contents

List of tables

List of figures

Blank page

1. General

1.1 Certification proposal

Based on the positive results obtained, the following recommendation on the announcement of the AMS as a certified system is put forward:

AMS designation:

Fidas Smart 100 / Fidas Smart 100 E for particulate matter $PM_{2.5}$ und PM_{10}

Manufacturer:

Palas GmbH, Karlsruhe

Field of application:

For continuous ambient air measurement of fine dust, fractions $PM_{2.5}$ and PM_{10}, in stationary use

Measuring ranges during performance testing:

Component	Certification range	Unit
$PM_{2.5}$	0–20 000	µg/m³
PM_{10}	0–20 000	µg/m³

Software version:

1.0.11

Restrictions:
None

Notes:

1. The measuring system is available in a version for outdoor installation (Fidas Smart 100) as well as in a version for installation in a measuring station (Fidas Smart 100 E).
2. The PM_ENVIRO_0005-25 algorithm is used to determine the $PM_{2.5}$ component and the PM_ENVIRO_0005-10 algorithm is used to determine the PM_{10} component.
3. The test report on the performance test is available online at www.qal1.de.

Test Report:

TÜV Rheinland Energy GmbH, Cologne
Report no. 936/21250983/B dated 15 September 2022

Blank page

1.2 Summary report on test results

Summary of test results in accordance with standard EN 16450

Performance criterion	Requirement	Test result	Satis-fied	Page
1 Measurement ranges	0 µg/m³ to 1000 µg/m³ as a 24-hour average value 0 µg/m³ to 10,000 µg/m³ as a 1-hour average value, if applicable	The upper limit of the measuring range is at 20,000 µg/m³.	yes	51
2 Negative signals	Shall not be suppressed	While the AMS is able to display negative readings directly and via the various outputs, they should not be expected given the instrument design and the measurement principle applied.	yes	52
3 Zero level and detection limit (7.4.3)	Zero level: ≤ 2.0 µg/m³ Detection limit: ≤ 2.0 µg/m³	The zero level and the detection limit were determined to be 0.00 µg/m³ for both PM2.5 and PM10 for both systems.	yes	53
4 Flow rate accuracy (7.4.4)	≤ 2.0%	The relative difference determined for the mean of the measuring results at flow rates at -20°C and at 50°C did not exceed -1.7%.	yes	55
5 Constancy of sample flow rate (7.4.5)	≤ 2.0% sampling flow (averaged flow) ≤ 5% rated flow (instantaneous flow)	All determined instantaneous values deviate less than 3.9 %; all averaged values deviate less than -0.59 % from the nominal value.	yes	57
6 Leak tightness of the sampling system (7.4.6)	≤ 2.0% of sample flow rate	The leak test procedure specified by the system manufacturer proved to be suitable for monitoring the system tightness in the test.	yes	60
7 Dependence of measured value on surrounding temperature (7.4.7.)	≤ 2.0 µg/m³	The tested ambient temperature range is -20 °C to 50 °C. The maximum deviation from the mean measured value at TS,n was 0.0 µg/m³ for PM2.5 and for PM10.	yes	62
8 Dependence of measured value (span) on surrounding temperature (7.4.7)	≤ 5% from the value at the nominal test temperature	The tested ambient temperature range is -20 °C to 50 °C. The maximum deviation from the mean measured value at 20 °C was 3.1 % for PM2.5 and 0.5 % for PM10.	yes	64

Performance criterion	Requirement	Test result	Satis-fied	Page
9 Dependence of span on supply voltage (7.4.8)	≤ 5 % of the value at the nominal test voltage	No deviations of more than -0.8 % for PM2.5 and -0.1 % for PM10 at the extreme values related to the mean value at 230 V, could be detected by mains voltage changes.	yes	66
10 Effect of failure of mains voltage	Instrument parameters shall be secured against loss. On return of the mains voltage the instrument shall automatically resume functioning.	All instrument parameters are secured against loss. On return of mains voltage, the instrument returns to normal operating mode and automatically resumes measuring.	yes	68
11 Dependence of reading on water vapour concentration (7.4.9)	≤ 2.0 µg/m³ in zero air	The largest difference determined between the measured values at 40 % and at 90 % relative humidity was 0.0 µg/m³.	yes	69
12 Zero checks (7.5.3)	Absolute value ≤ 3.0 µg/m³	The absolute measured value determined at the zero point did not exceed 0.0 µg/m³.	yes	71
13 Recording of operational parameters (7.5.4)	Measuring systems shall be able to provide data of operational states for telemetric transmission of – at minimum – the following parameters: Flow rate Pressure drop over sample filter (if relevant) Sampling time Sampling volume (if relevant); Mass concentration of relevant PM fraction(s) Ambient temperature Exterior air pressure Air temperature in measuring section Temperature of sampling inlet if heated inlet is used	The AMS allows for comprehensive telemetric monitoring and control of the measuring system via various paths. The instrument provides operating statuses and all relevant parameters.	yes	73
14 Daily averages (7.5.5)	The AMS shall allow for the formation of daily averages or values.	It is possible to form valid daily averages.	yes	75
15 Availability (7.5.6)	At least 90%.	Availability was at 100% for both instruments.	yes	76
16 Between-AMS uncertainty (7.5.8.4)	≤ 2.5 µg/m³	At no more than 1.6 µg/m³ the uncertainty between the test specimen ubs remained well below the permissible maximum of 2.5 µg/m³.	yes	79

Performance criterion	**Requirement**	**Test result**	**Satis-fied**	**Page**
17 Expanded uncertainty (7.5.8.5 – 7.5.8.8)	≤ 25% at the level of the relevant limit value related to the 24-hour average results (after calibration where necessary, see 7.5.8.5)	The determined uncertainties WAMS are above the defined expanded relative uncertainty Wdqo of 25% for particulate matter for all considered data sets without applying correction factors. As for both PM2.5 and PM10 the axis intercept is significantly different from 0 and the slope is significantly different from 1, the application of correction factors according to "Item 6.1 17 Application of correction factors/terms" shall be made accordingly. After applying correction factors and terms, all considered data sets are below the specified expanded relative uncertainty Wdqo of 25%.		94
17 Use of correction factors/terms (7.5.8.5–7.5.8.8)	After the calibration: ≤ 25% at the level of the relevant limit value related to the 24-hour average results	After the use of correction factors, the candidate systems met the requirements for data quality of air quality monitors for all data sets.	yes	116
18 Maintenance interval (7.5.7)	At least 14 d	The maintenance interval is 1 year.	yes	123
6.1 19 Automatic diagnostic check (7.5.4)	Shall be possible for the AMS	The instrument provides all features described in the operation manual. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages. Data recording includes all monitored parameters.	yes	124
20 Checks of temperature sensors, pressure and/or humidity sensors	Shall be checked for the AMS to be within the following criteria ± 2 °C ± 1 kPa ± 5 % RH	It is possible to check and adjust the sensors for determining ambient temperature, ambient pressure and relative humidity on site. The sensors' deviations remained within the required ranges.	yes	125

Blank page

2. Task definition

2.1 Nature of the test

Palas GmbH commissioned TÜV Rheinland Energy GmbH with performance testing of the Fidas Smart 100 / Fidas Smart 100 E air quality monitor for the measurement of particulate matter in ambient air, fraction $PM_{2.5}$ and $PM_{10.}$

2.2 Objective

The air quality monitor is designed to determine suspended particulate matter $PM_{2.5}$ and PM_{10} in ambient air in the concentration range between 0 and 20,000 µg/m³.

The measuring system determines the suspended fine dust concentration by means of scattered light measurement.

The test was performed on the basis of the following standards:

- Standard EN 16450 Ambient air – Automated measuring systems for the measurement of the concentration of particulate matter (PM_{10}; $PM_{2.5}$), German version dated July 2017
- VDI Standard 4202, part 3, Automated measuring systems for air quality monitoring - Performance test, declaration of suitability and certification of measuring systems for point-related measurement of mass concentration for particulate air pollutants, February 2019
- European standard EN 12341, Ambient air - Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2,5}$ mass concentration of suspended particulate matter; German version EN 12341:2014
- Guideline “Demonstration of Equivalence of Ambient Air Monitoring Methods”, English version dated January 2010 version

3. Description of the AMS tested

3.1 Measuring principle

The Fidas Smart 100 / Fidas Smart 100 E measuring system is a measuring device for the determination of particulate matter in ambient air. The concentration of suspended particulate matter is determined with an optical aerosol spectrometer, which determines the particle size via scattered light analysis on the individual particle according to Lorenz-Mie. A fan sucks ambient air through the sample inlet through a heated sampling tube directly to the spectrometer.

The particles move separately through an optically differentiated measuring volume that is homogeneously illuminated by a polychromatic LED light source. Each particle generates a scattered light pulse that is detected at an angle of 85° to 90°. The number of particles is determined by the number of scattered light signals. The intensity of the measured scattered light signal is a measure of the particle diameter. The signal length is measured as well.

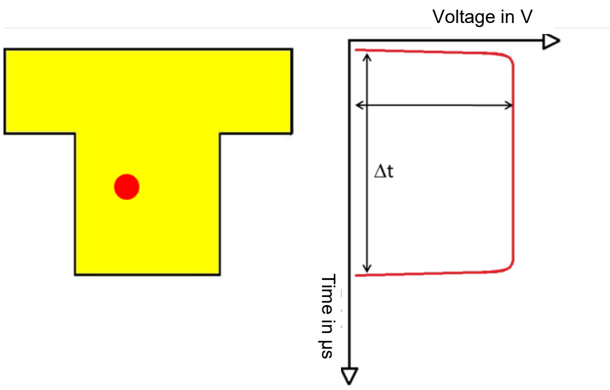

Figure 1: Measurement of scattered light signal at one single particle. Amplitude and signal length are being measured

Due to the specific T-aperture optics with simultaneous signal length measuring, border zone errors are eliminated. The term 'border zone error' refers to the merely partial illumination of particles at the end of the measuring range. This partial illumination results in the particles being classified as smaller in size than they actually are. Via the T-aperture, particles flying only through the arm of the T (shorter signal length) differ from those flying through the middle part of the T (longer signal length). The latter are completely illuminated in the upper section. Thus, border zone errors are eliminated.

3.2 Functioning of the measuring system

The particle sample passes through the sample inlet at a flow rate of 1.0 l/min (operation conditions) and is led into the sampling line which connects the sampling head to the aerosol sensor. The compact IADS (Intelligent Aerosol Drying System) moisture compensation module is used in order to avoid the possible effects of condensation, especially when ambient air humidity is high. The temperature of the IADS is controlled depending on the ambient temperature and humidity (measured by the system). The maximum heat capacity of the compact IADS is 40 W. After passing through the compact IADS module the particle sample is led to the aerosol sensor where the actual measuring is performed.

The measuring system Fidas Smart 100 is equipped with an integrated weather sensor for temperature, humidity and pressure. The sensor is supplied with outside air via the housing fan.

In addition, the measuring device was equipped with gas sensors for measuring CO_2 and VOC (volatile organic compounds). These sensors were not part of the test.

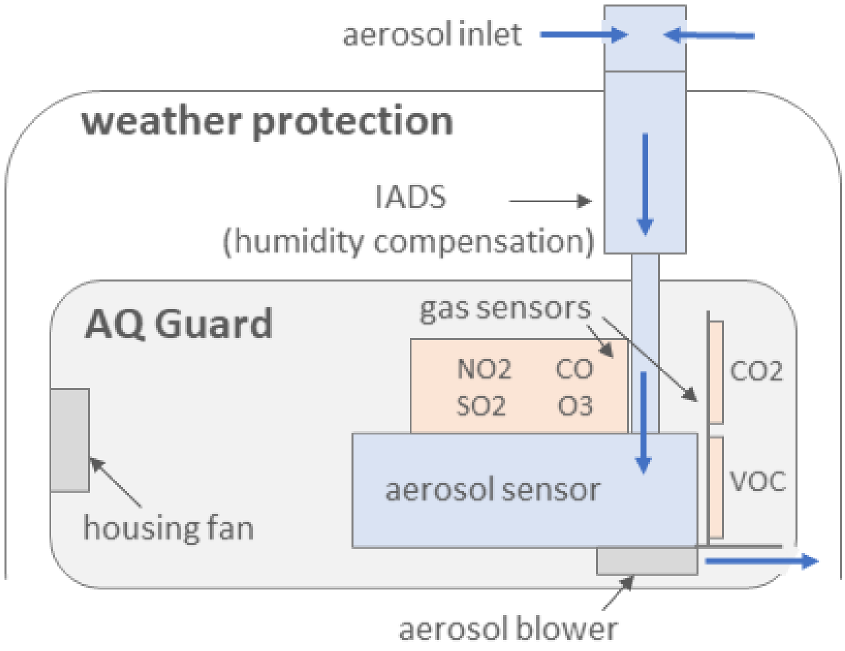

Figure 2: Functional diagram, Fidas Smart 100

3.3 AMS scope and set-up

The measuring system is designed to be installed outside without any additional weather protection. The tested AMS consists of the Fidas Smart 100 measuring system with weatherproof housing. The system requires only a 12-volt power supply to operate.

Figure 3: Fidas Smart 100 with weatherproof housing

Figure 4: Fidas Smart 100 without weatherproof housing

The measuring system can be operated either directly via the touchscreen on the front of the device (only accessible when the weatherproof housing is removed) or remotely via data interfaces via Ethernet, WiFi or mobile network (SIM card required). The user can retrieve measurement data and system information, change parameters and perform functionality tests of the measuring system.
A zero filter is mounted on the instrument inlet for the purpose of external zero checks. The use of this filter allows the provision of PM-free air. To test and if necessary adjust the sensitivity of the particle sensor, the instrument shall be supplied with particles of a defined size (MonoDust 1500). The particle size distribution of this dust is monodisperse and the peak in the distribution of the raw data, which has been generated in the instrument, shall lie at the target channel given on the Monodust calibration certificate (typically 140.1). If the peak deviates from this value, the value can be adjusted. Due to this adjustment at one particle size, the sensitivity of the measuring system for all particle sizes is adjusted automatically as the instrument operates with only one A/D converter.

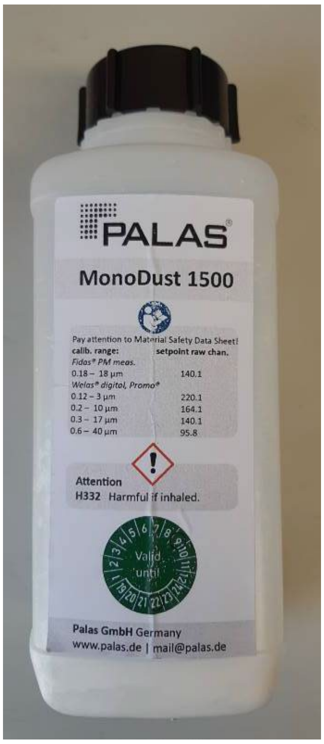

Figure 5: MonoDust 1500

Fidas Smart 100 E:
Optionally, the measuring system is also available with an extended sampling tube for indoor installation (e.g. measuring station with roof duct). Here, the extended sampling tube is mounted between the sampling head and the heated moisture compensation module, IADS. The weather sensor for determining air temperature and humidity is mounted on the sampling tube to determine the operating conditions outside the measuring station. Here, the same sensor was used that is otherwise used for the measuring system.

The extensions are 1.2 m in length and consist of an outer protective tube (diameter 60 mm) and the actual aerosol tube (diameter 26 mm). To ensure that the extended sampling tube did not have a negative effect on the performance of the measuring equipment, tests were carried out in the laboratory in the climatic chamber. For this purpose, the measuring instrument was installed in a climatic cabinet with a roof duct. This climatic cabinet (tempered to approx. 20 °C) was positioned in the climatic chamber. The climatic chamber was set to 38°C and 90 % relative humidity. This simulated operation in an air-conditioned measuring container in hot and humid ambient conditions.

Here, no negative influence could be determined through the use of the extended sampling tube.

Table 3: Fidas Smart 100 E at zero point tests

	SN 13418		SN 13419	
	Measured value $PM_{2.5}$	Measured value PM_{10}	Measured value $PM_{2.5}$	Measured value PM_{10}
	µg/m³	µg/m³	µg/m³	µg/m³
20°C, 50 % rel. Humidity	0.0	0.0	0.0	0.0
38°C, 80 % rel. Humidity	0.0	0.0	0.0	0.0

Table 4: Fidas Smart 100 E with MonoDust 1500 tests

	SN 13418		SN 13419	
	Measured value $PM_{2.5}$	Measured value PM_{10}	Measured value $PM_{2.5}$	Measured value PM_{10}
	µg/m³	µg/m³	µg/m³	µg/m³
20°C, 50 % rel. Humidity	25.14	39.98	25.14	39.98
38°C, 80 % rel. Humidity	25.07	39.99	25.21	39.97

Figure 6: Fidas 100 E

Figure 7: Weather sensor on the sampling tube

Software versions:

Software version 1.0.4 was installed on the systems during the test. In the meantime, the manufacturer has further developed the software version. Bugs have been fixed and functional enhancements, e.g. in the network settings, have been implemented. Further functional enhancements are not relevant for the variant to be certified.
The current software version of the AMS is therefore: 1.0.11. The intermediate versions 1.0.5. 1.0.6, 1.0.7, 1.0.8, 1.0.9 and 1.0.10 can also be used. The software changes were classified as type 0 changes.

Note on visual material used in the test report

At the beginning of the test, the manufacturer intended to market the measuring system under the name "AQGuard". In the course of testing, the manufacturer decided to market the measuring system under the name "Fidas Smart System" with the system variants "Fidas Smart 100" and "Fidas Smart 100 E". Therefore, corresponding "AQGuard" markings are still visible on the test instruments.

4. Test programme

4.1. General

Performance testing was carried out using two identical instruments with the following serial numbers:

System 1: 12248

System 2: 12250

Testing was performed with software version 1.0.4.

4.2 Laboratory testing

Performance testing was carried out using two identical instruments with the following serial numbers:

System 1: 12248

System 2: 12250

The tests with the extended sampling tube were performed on two identical instruments with the serial numbers (see pg. 23 and 24):

System 1: 13418

System 2: 13419

Standard [9] specifies the following test programme for the laboratory test:

- Readings
- Negative signals
- Zero level and detection limit
- Flow rate accuracy
- Water tightness of the sampling system
- Dependence of the zero point on the ambient temperature
- Dependence of the reading on the ambient temperature
- Effect of mains voltage on the reading
- Effect of failure of mains voltage
- Effect of humidity on the reading

The following devices were used to determine the performance characteristics during the laboratory tests.

- Climatic chamber (temperature range –20°C to +50°C, accuracy better than 1°C).
- Isolating transformer
- 1 mass flow meter Model 4043 (manufacturer: TSI)
- 1 reference flow meter, type BIOS Met Lab 500 (manufacturer: Mesa Lab)
- Zero filter for external zero checks
- MonoDust 1500 for checking the sensitivity

The measured values were recorded internally. The set of raw data was downloaded and evaluated in Excel.

Sensitivity testing was performed with monodisperse dust (MonoDust 1500). When this test dust is applied, a peak in the size distribution is to be expected in channel 140.1. To allow for quantification of deviations from the classification, data sets from the field test served as a basis for calculating the potential effect of peak shifts of up to ±3 channels on measured values for PM.

In the event of a peak shift in the 140.1 channel, there will be a shift in all other channels by the same number of raw data channels. This is linked to the use of an A/D converter which possesses a logarithmic characteristic. If the entire raw data distribution is now hypothetically shifted by +- 3 channels and the PM values are thus recalculated, the effect on the PM measured values can thus be determined. To this effect, the actual measured PM values were plotted against those recalculated from the hypothetically shifted raw data distribution in an XY plot, and a linear regression line was calculated between these values. The following matrix presents the results of this calculation.

Table 5: Matrix showing the effect of peak shifts on mass concentrations (PM_ENVIRO_0005-25) for $PM_{2.5}$

Channel shift	Slope	Axis intercept
-3	1.086	0.03889
-2	1.056	0.025
-1	1.029	0.0122
0	1	0
1	0.973	-0.00785
2	0.945	-0.0197
3	0.918	-0.031

Table 6: Matrix showing the effect of peak shifts on mass concentrations (PM_ENVIRO_0005-10) for PM_{10}

Channel shift	Slope	Axis intercept
-3	1.023	0.28767374
-2	1.012	0.21356596
-1	0.996	0.1441563
0	1	0
1	1.001	-0.16967074
2	0.994	-0.31094192
3	0.973	-0.18567619

If, for example, there is a shift of -3 channels when using the PM_ENVIRO_0005_25 method, the actual PM values are related to the hypothetically determined PM values as follows:

$PM_{2.5}$_actual=1.086*$PM_{2.5}$_hypothetical+0.03889
PM_{10}_actual=1.023*PM_{10}_hypothetical+0.28107.

A shift of -3 channels means, e.g. for $PM_{2.5}$, that the particle size is determined too small, which leads to the $PM_{2.5}$ value being measured too low by a factor of 1.086.

For the purpose of evaluation, a hypothetical measured value for $PM_{2.5}$ of 25 µg/m³ and for PM_{10} of 40 µg/m³ was then used for the ideal case (peak exactly in channel 140.1) and then, depending on the peak shift, the corresponding concentration value to be expected was determined according to the matrix above.

Chapter 6 summarizes the results of the laboratory tests.

4.3 Field test

Performance testing was carried out using two identical instruments with the following serial numbers:

System 1: 12248

System 2: 12250

Standard [9] specifies the following test programme for the field test:

- Constancy of sample volumetric flow
- Zero checks
- Recording of operational parameters
- Daily values/daily averages
- Availability
- Between-AMS uncertainty
- Expanded uncertainty
- Maintenance interval/period of unattended operation
- Automatic diagnostic check
- Checks of temperature sensors, pressure and/or humidity sensors

The following instruments were used during the field test.

- Measurement container provided by TÜV Rheinland, air-conditioned to about 20 °C
- Weather station for recording meteorological parameters such as air temperature, air pressure, air humidity, wind speed, wind direction as well as rainfall
- 4 reference measuring systems SEQ47/50-RV for $PM_{2.5}$ and PM_{10} according to point 5; 2 LVS3 for $PM_{2.5}$ (only field test Cologne 1, here two LVS3 were used for $PM_{2.5}$ and 2 SEQ47/50-RV for PM_{10})
- 1 mass flow meter Model 4043 (manufacturer: TSI)
- Zero filter for external zero checks
- MonoDust 1500 for checking the sensitivity

In the field test, two Fidas Smart 100 systems and four reference instruments (2 for $PM_{2.5}$ and 2 for PM_{10}) were running simultaneously. The SEQ47/50-RV reference instruments automatically change filters every 24 h. For the LVS3 reference instruments, the filters must be changed manually every 24 hours. The results can be fully transferred to the Fidas Smart 100 E measuring systems.

Impaction plates on the sampling head were cleaned approximately every two weeks during the test period and greased with silicone grease in order to ensure reliable separation of the particles.

The flow rates of the tested and the reference instruments were checked before and after each relocation using a dry gas meter or a mass flow controller in each case connected to the instrument's air inlet via a hose line.

Sites of measurement and instrument installation

At the field test sites in Cologne, Bornheim and Bonn, an air pollution measurement station was used on whose roof the test specimens were installed. Except for at the Cologne I site, the reference instruments were installed directly in front of it. At the Cologne I site, the SEQ47/50-RV reference devices were in the measurement station and the LVS3 reference instruments were installed on the roof. Testing at the site in Niederzier was carried out without an air pollution measurement station. Here, the measuring systems and reference instruments were installed on the ground in close proximity to each other.

The field test was performed at the following measurement sites:

Table 7: Field test sites

No.	Measurement site	Period	Description
1	Cologne I	01/2021 – 03/2021	Urban background
2	Niederzier I	04/2021 – 06/2021	Industrial background
3	Cologne II	07/2021 – 11/2021	Urban background
4	Bornheim	12/2021 – 03/2021	Affected by traffic
5	Bonn	04/2022 – 05/2022	Urban background
6	Niederzier 2	06/2022 – 08/2022	Industrial background

Testing at the Niederzier 2 site was conducted exclusively for PM_{10}, as for PM_{10} insufficient value pairs above 28 mg/m³ had been determined. Therefore, this location was not evaluated for $PM_{2.5}$.

Figure 8 to Figure 18 show the PM concentrations measured with the reference systems at the field test sites.

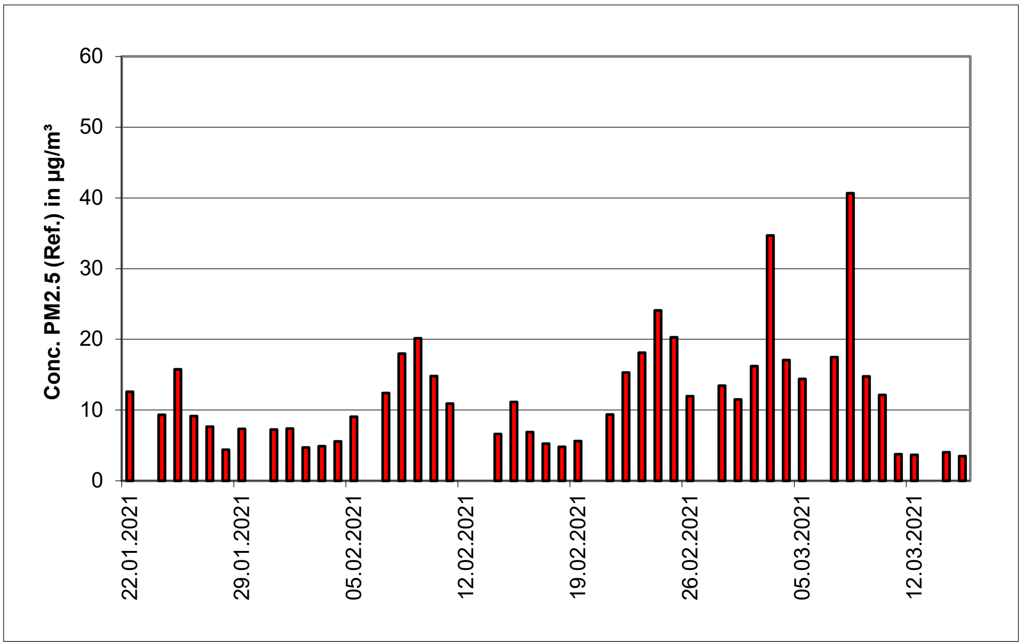

Figure 8: $PM_{2.5}$ concentrations (reference) at the Cologne I location

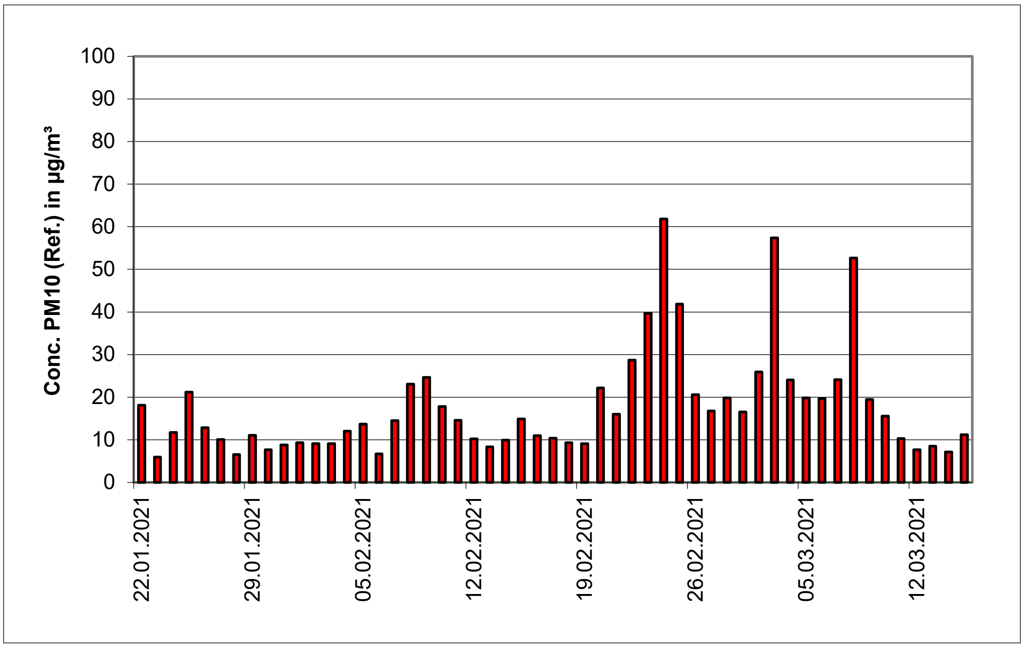

Figure 9: PM_{10} concentrations (reference) at the Cologne I location

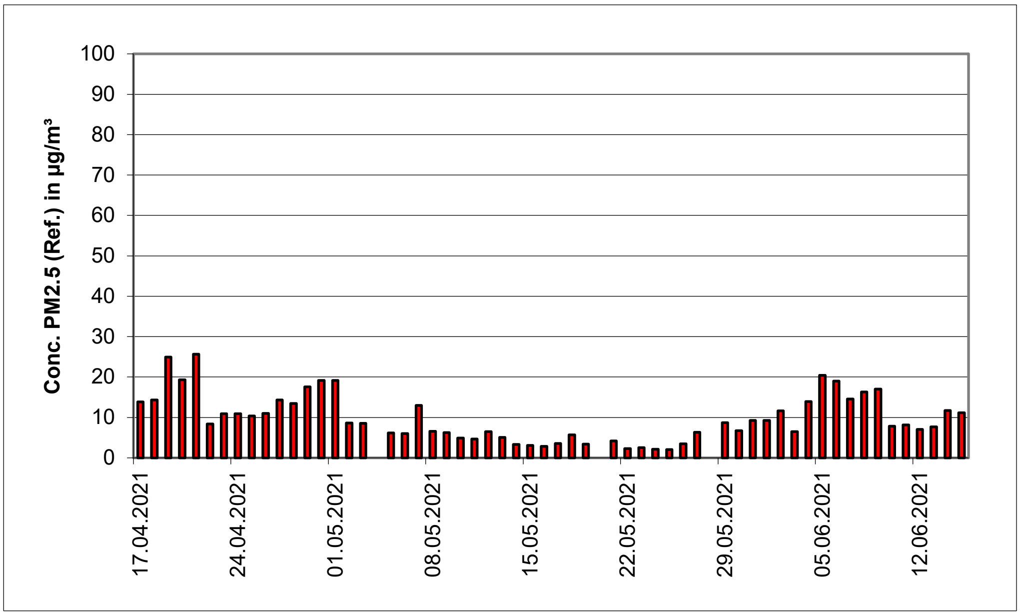

Figure 10: $PM_{2.5}$ concentrations (reference) at the Niederzier I location

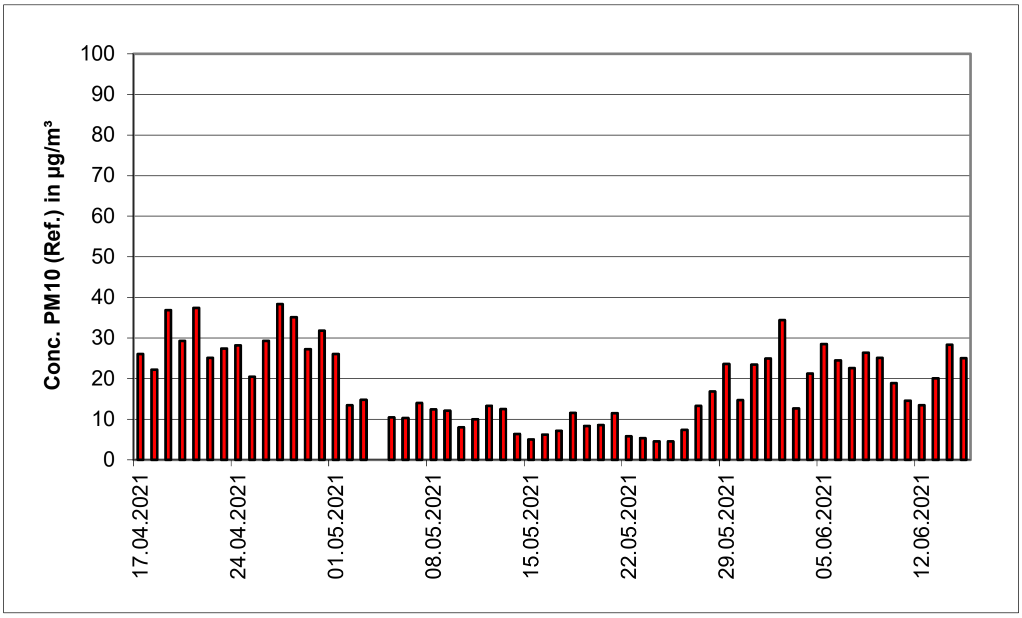

Figure 11: PM_{10} concentrations (reference) at the Niederzier I location

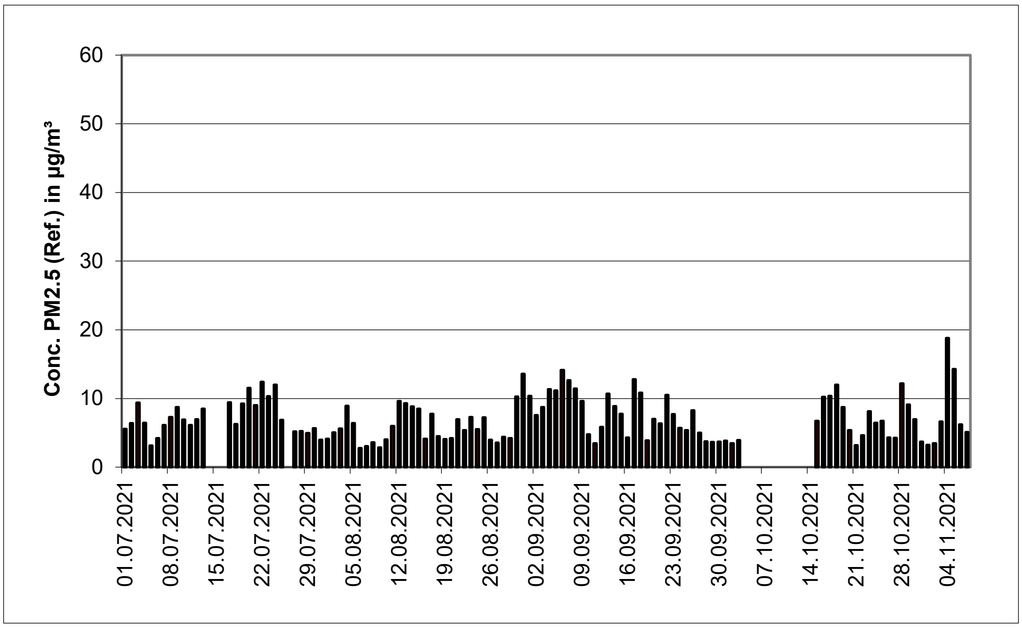

Figure 12: $PM_{2.5}$ concentrations (reference) at the Cologne II location

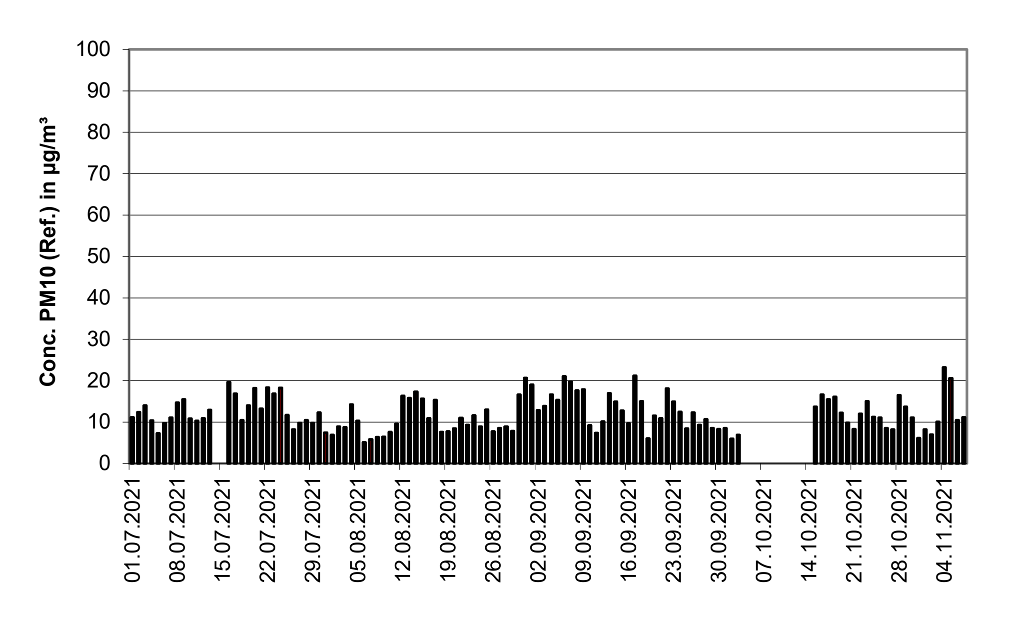

Figure 13: PM_{10} concentrations (reference) at the Cologne II location

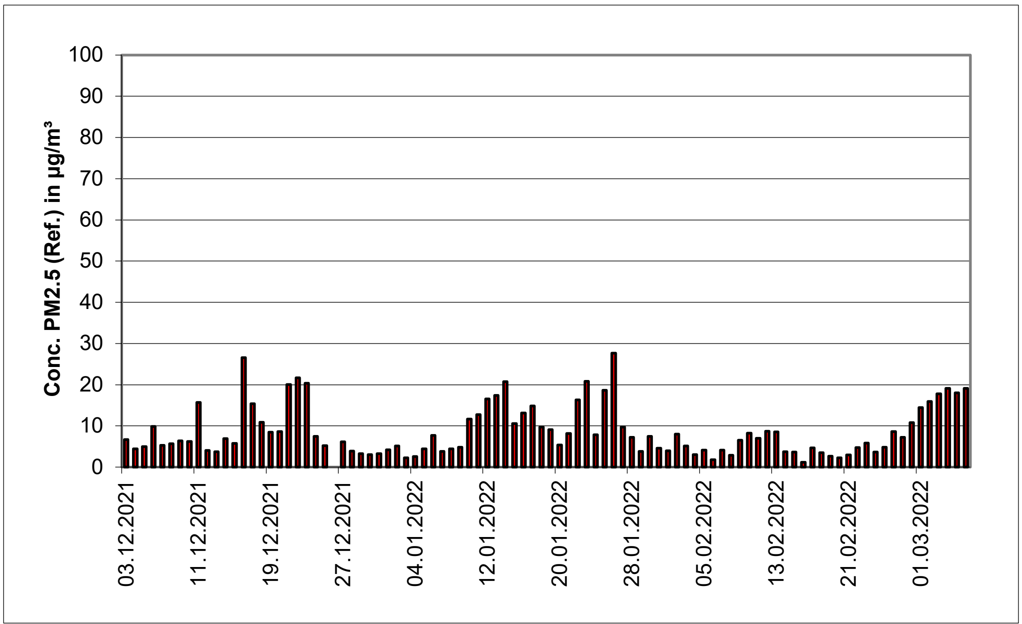

Figure 14: $PM_{2.5}$ concentrations (reference) at the Bornheim location

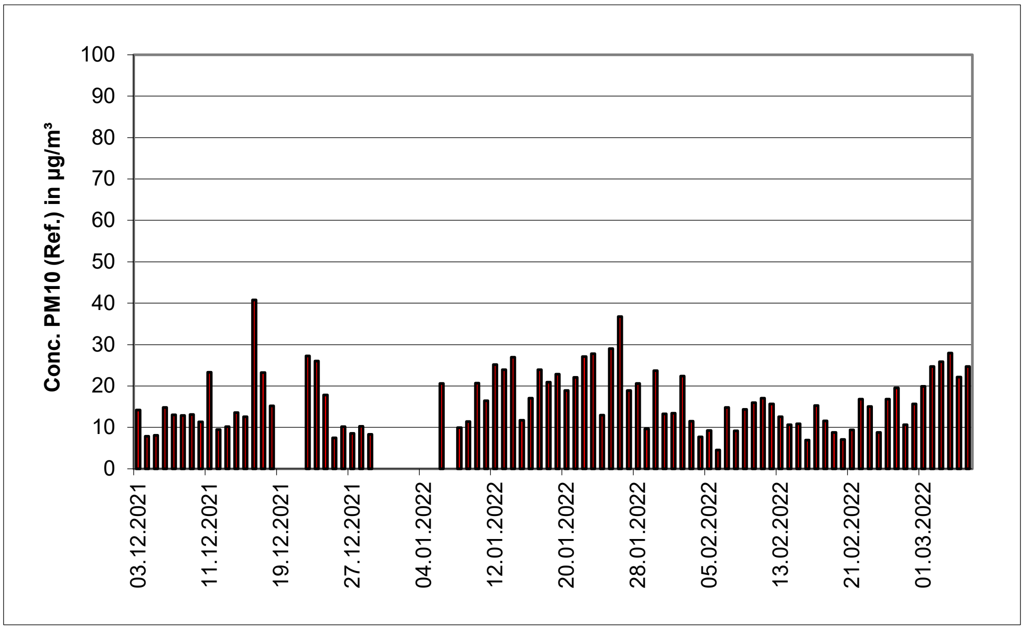

Figure 15: PM_{10} concentrations (reference) at the Bornheim location

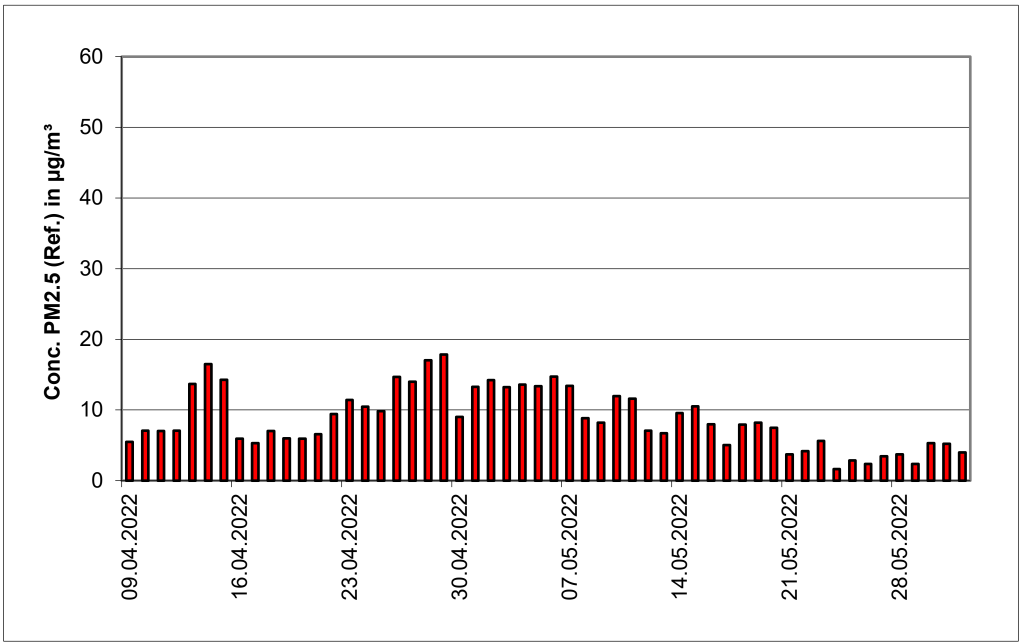

Figure 16: $PM_{2.5}$ concentrations (reference) at the Bonn location

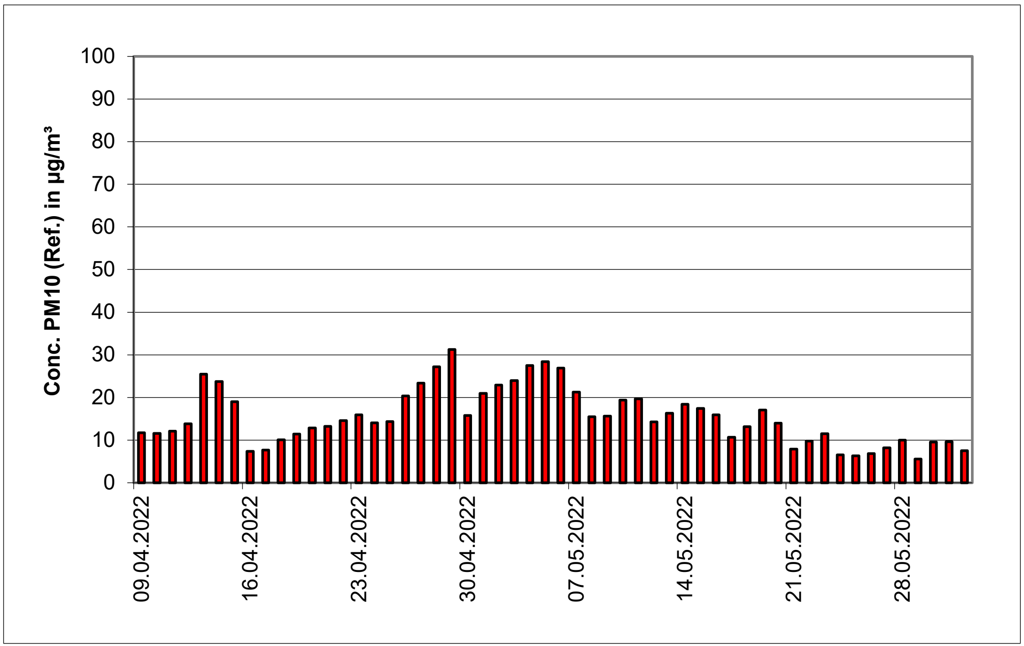

Figure 17: PM_{10} concentrations (reference) at the Bonn location

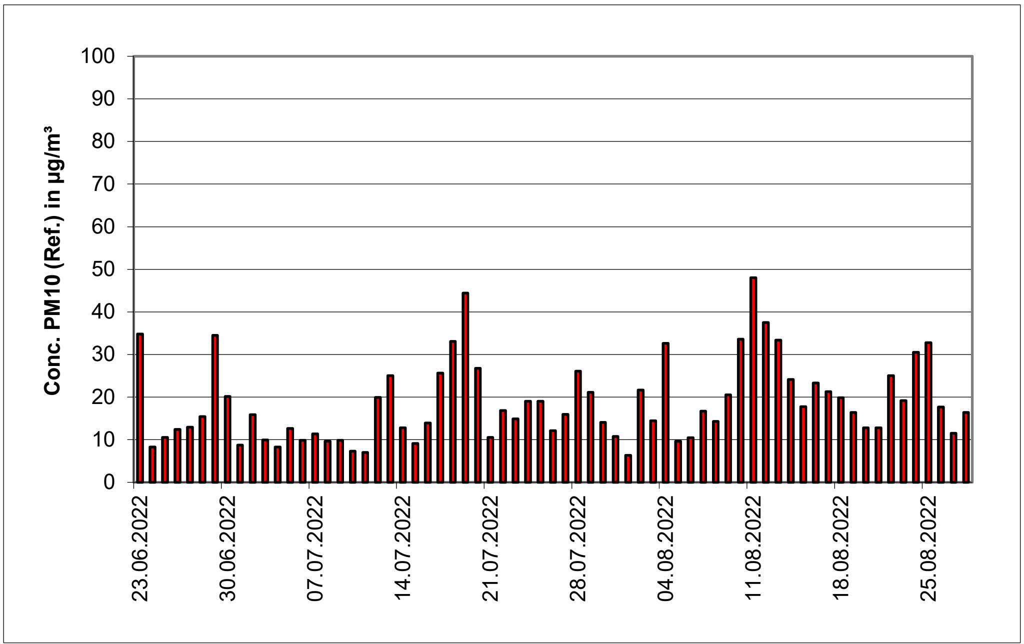

Figure 18: PM_{10} concentrations (reference) at the Niederzier II location

The following figures show the various field test locations (the AMS are marked in red):

Figure 19: Field test site Cologne

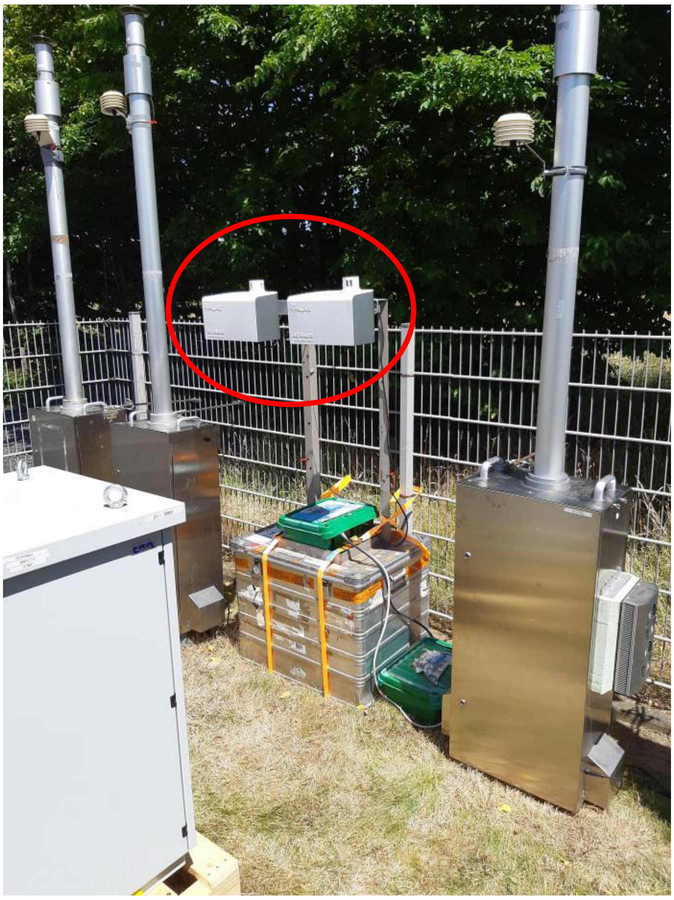

Figure 20: Field test site Niederzier (AMS in the middle)

Figure 21: Field test site Bornheim

Figure 22: Field test site Bonn

In addition to the air quality measuring systems for monitoring suspended particulate matter, a data logger for meteorological data was installed at the measuring station/measurement site. Data on air temperature, pressure, humidity, wind speed, wind direction and precipitation were continually measured. 1 minute mean values were recorded.

The following dimensions describe the design of the measurement cabinet as well as the position of the sampling probes.

Germany

- Height of cabinet roof: 2.50 m
- Height of sampling for test equipment: 3.70 m above ground/ 1.20 m above container roof
- Reference system: 3.47m above ground/0.97 m above container roof
- Height of the wind vane: 4.5 m above ground level

In addition to an overview of the meteorological conditions determined during measurements at the 6 field test sites, the following Table 8 provides information on the concentrations of suspended particulate matter.

Table 8: Ambient conditions at the field test sites as daily averages

	Cologne I	Niederzier I	Cologne II	Bornheim	Bonn	Niederzier II
Number of value pairs Reference	PM_{10}: 53 $PM_{2.5}$: 44	PM_{10}: 59 $PM_{2.5}$: 57	PM_{10}: 117 $PM_{2.5}$: 115	PM_{10}: 83 $PM_{2.5}$: 93	PM_{10}: 54 $PM_{2.5}$: 54	PM_{10}: 67
Ratio of $PM_{2.5}$ to PM_{10} [%] Range Average	31.1 – 85.4 64.5	33.4 – 92.6 52.0	35.3 – 80.9 57.2	16.4 – 90.0 51.3	24.8 – 80.4 55.4	Not determined
Air temperature [°C] Range Average	-5.8 – 15.4 5.7	4.9 – 26.9 13.6	6.7 – 22.5 6.7	-1.5 – 14.0 5.6	6.7 – 24.3 15.0	16.5 – 28.1 20.7
Air pressure [hPa] Range Average	985 – 1030 1007	990 – 1016 1004	996 – 1025 1012	989 – 1034 1013	995 – 1023 1011	994 – 1019 1007
Rel. Humidity [%] Range Average	42 – 90 71	48 – 94 72	60 – 93 75	54 – 99 83	37 – 85 58	36 – 86 61
Wind speed* [m/s] Range Average	Not determined	1.3 – 9.1 3.4	0.01 – 1.7 0.3	0.3 – 3.7 1.3	0.3 – 1.5 0.6	Not determined

*These data are only indicative measurements

Sampling duration

Standard EN 12341 [3] fixes the sampling time at 24 h ± 1 h.

During the field test, a sampling time of 24 h was always set for all instruments (from 10:00 - 10:00 h at the Cologne I site; from 00:00 - 00:00 h at all other sites).

Data handling

Prior to their assessment for each field test site, measured value pairs determined from reference values during the field test were submitted to a statistical Grubbs's test for outliers (99%) in order to prevent distortions of the measured results from data, which evidently is implausible. Measured values pairs detected as significant outliers may be expunged from the pool of values as long as the test statistic remains above the critical value. In accordance with standard EN 16450 [4], it is permitted to remove up to 2.5% of data pairs that qualify as outliers as long as at least 40 valid data pairs per site remain. One outlier was identified for $PM_{2.5}$.

The following value pair has been expunged:

Table 9: Removed value pair in line with Gubbs, reference $PM_{2.5}$

Location	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]
Bornheim	26.12.2021	13.3	8.83

The measured values on 04.05.2021 had to be discarded because bad weather had severely impaired the reference measurements.

Filter handling – Mass measurement

The following filters were used during performance testing:

Table 10: Filter materials used

Filter material, type	Manufacturer
Emfab™, ∅ 47 mm	Pall

Filter handling was performed in compliance with EN 12341.

The filter handling and weighing procedures are described in detail in Appendix 2 to this report.

5. Reference Measurement Method

The following instruments were used for the field test.

1. As reference instrument $PM_{2.5}$: Standard reference sampling devices Low Volume Sampler LVS3
   Manufacturer: Sven Leckel Ingenieurbüro GmbH, Berlin
   $PM_{2.5}$ sample inlet
2. As reference instrument $PM_{2.5}$ and PM_{10}:
   Standard reference samplers with automatic filter change SEQ47/50-RV
   Manufacturer: Sven Leckel Ingenieurbüro GmbH, Berlin
   $PM_{2.5}$ und PM_{10} sampling head

In the Cologne I field test, two LVS3 reference instruments were used for $PM_{2.5}$ and two SEQ47/50-RV for PM_{10}. At all other field test sites, only SEQ47/50-RV were used.

During the test, two reference instruments for $PM_{2.5}$ and two for PM_{10} were operated in parallel with a controlled flow rate of 2.3 m³/h. Under normal conditions the accuracy of flow control is < 1% of the nominal flow rate.

On the reference instruments, the rotary vane vacuum pump takes in sample air via the sampling head. The volumetric flow is measured between the filter and the vacuum pump with the help of a measuring orifice. The air taken in flows from the pump via a separator for the abrasion of the rotary vane to the air outlet.

In the LVS3, the measuring electronics display the aspirated sample air volume in standard and operating m³ after sampling has been completed.

With the SEQ47/50-RV, a new filter is automatically inserted after 24 hours of sampling and the sampled filter is placed in the filter magazine. The relevant sampling parameters are stored on a storage medium.

The concentration of suspended dust was determined by dividing the amount of suspended dust on the respective filter determined gravimetrically in the laboratory by the associated sample air volume in operating m³.

6. Test results

6.1 6.3 General requirements (VDI 4202 Part 3 February 2019)

6.1 6.3.1 Measured value display

The measuring system shall have an operative measured value display as part of the instrument.

6.2 Equipment

No additional equipment is required.

6.3 Testing

It was checked whether the measuring system has a measured value display.

6.4 Evaluation

The measuring system has an operative measured value display at the front of the instrument. This is only visible when the weatherproof housing is dismantled.

6.5 Assessment

The measuring system has an operative measured value display at the front of the instrument.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Figure 23 shows the measuring system with integrated display of measured values.

Figure 23: Fidas Smart 100 with measured value display

6.1 6.3.2 Easy maintenance

Necessary maintenance of the measuring systems should be possible without large effort, if possible from outside.

6.2 Equipment

No additional equipment is required.

6.3 Testing

The necessary regular maintenance was performed in accordance with the instruction manual.

6.4 Evaluation

The manufacturer has prepared a maintenance plan for this measuring system. The shortest maintenance interval is 1 year (check with Monodust 1500 and check volume flow).

Please note: The European standard EN 16450 [4] contains more extensive requirements for the necessary frequency of calibrations, tests and maintenance work. This may make it necessary to check the measuring equipment more frequently.

6.5 Assessment

Maintenance work can be carried out externally with standard tools and reasonable effort.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Maintenance was performed during the test in accordance with the activities and procedures described in the operating manual. Complying with the procedures described in the manual, no difficulties were identified. All maintenance work was carried out without any problems.

6.1 6.3.3 Functional check

If the operation or the functional check of the measuring system require particular instruments, they shall be considered as part of the measuring system and be applied in the corresponding sub-tests and included in the assessment.
The test laboratory shall assess the suitability of the automatic function control of the AMS.

6.2 Equipment

Operating manual

6.3 Testing

The tested system does not have an automatic function control. The current operating status of the measuring system is continuously monitored and any issues will be flagged via a series of different error messages.

6.4 Evaluation

The tested measuring system does not have internal devices for operating the functional check. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages.

A zero filter is mounted to the instrument inlet for the purpose of external zero checks. The use of this filter allows the provision of PM-free air. To check the sensitivity, the instrument is exposed to particles of a defined size (MonoDust 1500). The particle size distribution of this dust is monodisperse and the peak in the distribution of the raw data, which has been generated in the instrument, shall lie at the target channel given on the Monodust calibration certificate (typically 140.1). If the peak deviates from this value, the value can be adjusted. Due to this adjustment at one particle size, the sensitivity of the measuring system for all particle sizes is adjusted automatically as the instrument operates with only one A/D converter.

6.5 Assessment

The tested system does not have an automatic function check.

Criterion satisfied? not applicable

6.6 Detailed presentation of test results

Not applicable.

6.1 6.3.4 Set-up times and warm-up times

The operating instructions have to contain the manufacturer's data relating to the setting-up time and running-in time of the AMS.

6.2 Equipment

User manual.

6.3 Testing

The measuring systems were set up following the manufacturer's instructions. Set-up times and warm-up times were recorded separately.

Necessary structural measures in advance of installation, such as the installation of roof ducts, are not evaluated here.

6.4 Evaluation

The set-up time is primarily determined by the conditions at the installation site. Installation consists essentially of mounting the measuring instrument on a suitable fixture and establishing the power supply. The start-up procedure is described in detail in chapter 4 of the user manual. Afterwards, various tests must be carried out, such as checking the tightness.

In the case of the Fidas Smart 100 E measuring system, the roof outlet must also be set up and sealed.

For the initial installation and various changes in the position of the field measuring point, a set-up time of approx. 0.5 h was determined.

The measuring system is then ready for use.

6.5 Assessment

Set-up time during the performance testing was approx. 0.5 h. The work required for this is described in the user manual.

The warm-up time until valid measured values are available after switching on is approx. 15 minutes.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not applicable.

6.1 6.3.5 Instrument design

The instruction manual shall include specifications from the manufacturer regarding the design of the measuring system. The main elements are:

- *Instrument shape (e.g. bench mounting, rack mounting, free mounting)*
- *Mounting position (e.g. horizontal or vertical mounting)*
- *Safety requirements*
- *Dimensions*
- *Weight*
- *Power consumption*
- *Preventing condensation within the analyser.*

6.2 Equipment

Operating manual as well as a measuring instrument for recording energy consumption (Voltcraft Energylogger) and scales.

6.3 Testing

The instrument design of the measuring systems handed over for testing was compared to the description provided in the manual. The energy consumption specified was verified over 24 h during normal operation.

6.4 Evaluation

The Fidas Smart 100 measuring system must be mounted in a horizontal installation position with the wall bracket. The under side of the measuring system must be kept clear. The Fidas Smart 100 E measuring system can also be installed standing on a surface. The temperature at the installation site must be in the range -20 °C to 50 °C; weather protection is not necessary (if the outdoor cover is used).

The dimensions and weight of the measuring system correspond to the information provided in the operating manual. The measuring system weighs approx. 2.4 kg and the cover weighs approx. 1.5 kg. The extended sampling tube for the Fidas Smart 100 E measuring system weighs 2.2 kg.

The energy requirement of the measuring system is specified by the manufacturer as a maximum of 60 watts. A significant proportion of this is accounted for by the compact IADS humidity compensation module, which has a power consumption of up to 40 watts. Over 24 hours, the average power consumption was approx. 32 watts.

To avoid condensation effects, the IADS humidity compensation module is installed upstream of the aerosol sensor. The maximum power of the IADS heater is specified by the manufacturer as 40 watts. Since excessive temperatures in the sampling tube can lead to reduced results due to volatilization, the sampling tube is only heated as much as absolutely necessary. The heating power is essentially controlled as a function of the air humidity and is thus strongly dependent on the ambient conditions.

6.5 Assessment

Specifications made in the instruction manual concerning instrument design are complete and correct.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 6.3.6 Unintended adjustment

It shall be possible to secure the adjustment of the measuring system against illicit or unintended adjustment during operation. Alternatively, the operating manual shall specifically note that the measuring system may only be installed in a secured area.

6.2 Equipment

The test of this criterion did not require any further equipment.

6.3 Testing

The measuring system is operated via a front display or via an external computer connected directly or via network.

6.4 Evaluation

The system has password protection. Changing parameters is only possible after entering the password.

6.5 Assessment

The measuring system is secured against unintended and unauthorised adjustment of instrument parameters by way of a password.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 6.3.7 Data output

The output signal shall be provided digitally and/or as analogue signals (e.g. 4 mA to 20 mA).

6.2 Equipment

PC

6.3 Testing

The various outputs are checked and evaluated.

6.4 Evaluation

The measured values are only output digitally. The measuring system has USB, Ethernet, WLAN and mobile network (SIM card required).

6.5 Assessment

The measured signals are provided digitally.

It is possible to connect additional measuring and peripheral devices.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 6.3.8 Digital interface

The digital interface shall allow the transmission of output signals, status signals, and information like instrument type, measurement range, and measured component and unit. The digital interface shall be described fully in respective standards and guidelines.
Access to the measuring system via digital interfaces, e.g. for data transmission, shall be secured against unauthorised access, e.g. by a password.

6.2 Equipment

PC for data transmission.

6.3 Testing

The measuring system provides the following transmission routes: TCP/IP network, USB, WLAN and mobile network.

6.4 Evaluation

Digital measured signals are provided as follows: TCP/IP network, USB, WLAN and mobile network.

The digital output signals were checked using a PC connected to the measuring systems. All relevant pieces of information such as measured signals, status signals, measured component, measurement range, unit and further instrument information can be transmitted digitally. The digital transmission protocols UDP ASCII and TCP ASCII are supported.

Digital data retrieval always requires entry of the correct password.

6.5 Assessment

Digital transmission of measured values operates correctly.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 6.3.9 Data transmission protocol

The measuring system shall contain at minimum one data transmission protocol for the digital transmission of the output signal.

Every data transmission protocol provided by the manufacturer for the measuring system shall allow the correct transmission of the data and detect errors in the transmission. The data transmission protocol including the used commands is to be documented in the instruction manual. The data transmission protocol shall allow to transmit at minimum the following data:

- *Identification of the measuring system*
- *Identification of measured components*
- *Unit*
- *Output signal with time signature (date and time)*
- *Operation and error status*
- *Operating commands for remote control of the measuring systems*

All data are to be transmitted as clear text (ASCII characters).

The AMS has to transmit telemetrically the data of operating states of at least the following parameters:

- *Volumetric flow rate*
- *Pressure drop across the sampling filter (where relevant)*
- *Sampling duration*
- *Sample volume (where relevant)*
- *Mass concentration of the relevant particulate matter fraction(s)*
- *Ambient air temperature*
- *Ambient air pressure*
- *Air temperature in the measuring unit*
- *Temperature of the sample inlet if a heated sample inlet is used*

The results of automated/functional checks have to be recorded, where available.

6.2 Equipment

PC for data transmission.

6.3 Testing

2 different protocols can be transmitted via the interfaces: UDP ASCII and TCP ASCII.

6.4 Evaluation

2 different protocols can be transmitted via the interfaces: UDP ASCII and TCP ASCII. Chapter 12 of the manual describes the protocols.

6.5 Assessment

The measuring system has 4 different transmission protocols as standard. Measured and status signals are transmitted correctly.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 7.1 Performance requirements (EN 16450, June 2017)

6.1 1 Measurement ranges

The measurement range of the AMS has to comprise at least the following values:
0 µg/m³ to 1000 µg/m³ as a 24-hour average value
0 µg/m³ to 10,000 µg/m³ as a 1-hour average value, if applicable

6.2 Equipment

The test of this criterion did not require any further equipment.

6.3 Testing

It was tested whether the measuring system's upper limit of measurement meets the requirements.

6.4 Evaluation

A maximum measuring range of 0 - 20,000 µg/m³ is possible with the measuring system.

6.5 Assessment

The upper limit of the measuring range is at 20,000 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 2 Negative signals

Negative signals shall not be suppressed.

6.2 Equipment

The test of this criterion did not require any further equipment.

6.3 Testing

It was tested in the laboratory as well as in the field whether the measuring system can also output negative measured values.

6.4 Evaluation

The measuring system is able to output negative signals both via its display and its data outputs, however, negative measured values did not occur during the test. Given the measuring principle and design of the instrument, negative values are not to be expected.

6.5 Assessment

While the AMS is able to display negative readings directly and via the various outputs, they should not be expected given the instrument design and the measurement principle applied.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

6.1 3 Zero level and detection limit (7.4.3)

Zero level: ≤ 2.0 µg/m³
Detection limit: ≤ 2.0 µg/m³

6.2 Equipment

Zero filter for zero checks

6.3 Testing

The zero level and detection limit of the AMS shall be determined by measurement of 15 24 hour average readings obtained by sampling from zero air (no rolling or overlapped averages are permitted). The mean of these 15 24 h averages is used as the zero level. The detection limit is calculated as 3.3 times the standard deviation of the 15 24 h averages.

The zero level and the detection limit were determined with zero filters installed at the AMS inlets of the instruments during normal operation. Air free of suspended particulate matter was applied over a period of 15 days for a duration of 24 h each.

6.4 Evaluation

The detection limit X is calculated from the standard deviation s_{x0} of the measured values sucking air free from suspended particulate matter through both test specimen. It is equal to the standard deviation of the average x_0 of the measured values x_{0i} multiplied by 3.3 for each test specimen.

$$X = 3.3 \cdot s_{x0} \qquad \text{where } s_{x0} = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1,n} (x_{0i} - \overline{x_0})^2}$$

6.5 Assessment

The zero level and the detection limit were determined to be 0.00 µg/m³ for both $PM_{2.5}$ and PM_{10} for both systems.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 11: Zero level and detection limit $PM_{2.5}$

		Device	Device
Number of values n		15	15
Average of the zero values $\overline{x_0}$	µg/m³	0.00	0.00
Standard deviation of the values $s_{\overline{x0}}$	µg/m³	0.00	0.00
Student-Factor $t_{n-1;0,95}$		2.14	2.14
Detection limit x	µg/m³	**0.00**	**0.00**

Table 12: Zero level and detection limit PM_{10}

		Device 12248	Device 12250
Number of values n		15	15
Average of the zero values $\overline{x_0}$	µg/m³	0.00	0.00
Standard deviation of the values $s_{\overline{x0}}$	µg/m³	0.00	0.00
Student-Factor $t_{n-1;0,95}$		2.14	2.14
Detection limit x	µg/m³	**0.00**	**0.00**

Annex 1 in the appendices contains the individual measured values for the determination of the zero level and detection limit.

6.1 4 Flow rate accuracy (7.4.4)

The relative difference between the two values determined for the flow rate shall be ≤ 2.0%.
The relative difference between the two values determined for the flow rate shall fulfil the following performance requirements:

≤ 2.0%

- *at 5°C and 40°C for installations in an air-conditioned environment by default*
- *at minimum and maximum temperatures specified by the manufacturer if these deviate from the default temperatures.*

6.2 Equipment

Climatic chamber for the temperature range between -20 °C and 50 °C, a reference flow meter in accordance with item 4.

6.3 Testing

At each temperature, at least ten independent measurements shall be performed over a minimum period of one hour at the operating flow rate specified by the manufacturer. The measurements shall be performed at equal intervals over the measurement period. For each temperature, the mean of the measurement results shall be compared with the operational flow rate.

The Fidas Smart 100 measuring system operates at a flow rate of 1 l/min. The manufacturer has set the minimum temperature at -20 °C and the maximum temperature at 50 °C, as the measuring system is intended for outdoor installations.

With the help of a reference flow meter, the volume flow was measured at -20 °C and 50 °C by means of 10 measurements over 1 hour at the operational volume flow specified by the manufacturer. The measurements were performed at equal intervals throughout the measurement period.

6.4 Evaluation

Averages were calculated from the 10 measured values per temperature level and the deviations from the operating volume flow rate specified by the manufacturer were determined.

6.5 Assessment

The relative difference determined for the mean of the measuring results at flow rates at -20°C and at 50°C did not exceed -1.7%.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Results of the flow measurements at the permissible ambient temperatures are shown in the following table.

Table 13: Flow rate accuracy at -20 °C and +50 °C

		Device 12248	Device 12250
Nominal value flow rate	l/min	1.00	1.00
Mean value at -20°C	l/min	1.003	0.983
Dev. from nominal value	%	0.3	-1.7
Mean value at 50°C	l/min	1.011	1.001
Dev. from nominal value	%	1.1	0.1

6.1 5 Constancy of sample flow rate (7.4.5)

The instantaneous flow rate and the flow rate averaged over the sampling period shall fulfil the performance requirements below.
≤ 2.0 % of the nominal value of the volume flow (averaged sample flow)
≤ 5 % of the nominal value of the volume flow (instantaneous value of the sample flow)

6.2 Equipment

For this test, an additional reference flow meter in accordance with item 4 was provided.

6.3 Testing

The Fidas Smart 100 measuring system operates with a flow rate of 1 l/min.

The sample flow rate was calibrated prior to the first field test and then checked with the help of a mass flow controller at every new field test site and re-adjusted when necessary.

To determine the constancy of the sample flow rate, the flow rate was recorded and evaluated with the help of a mass flow meter once over a period of 24h.

6.4 Evaluation

The average, standard deviation as well as the maximum and minimum values were determined from the measured values for the flow rate (24-hour average).

6.5 Assessment

The charts illustrating the constancy of the sample flow rate (24h average) demonstrate that all measured values determined during sampling deviate from their respective nominal values by less than 3.9%. The deviation of the daily averages for the overall flow rate of 1 l/min did not exceed -0.59% of the nominal value.

All determined instantaneous values deviate less than 3.9 %; all averaged values deviate less than -0.59 % from the nominal value.

Criterion satisfied? yes

6.6 Detailed presentation of test results for the nominal flow

Table Table 14 lists the characteristics determined for the flow rate. Figure 24 to Figure 25 provide a chart of the flow rate measurement for both instruments.

Table 14: Performance characteristics for the overall flow rate measurement (daily average)

		Device 12248	Device 12250
Mean value	l/min	1.01	0.99
Dev. from nominal value	%	0.52	-0.59
Standard deviation	l/min	0.01	0.01
Minimum value	l/min	0.986	0.961
Maximum value	l/min	1.039	1.033

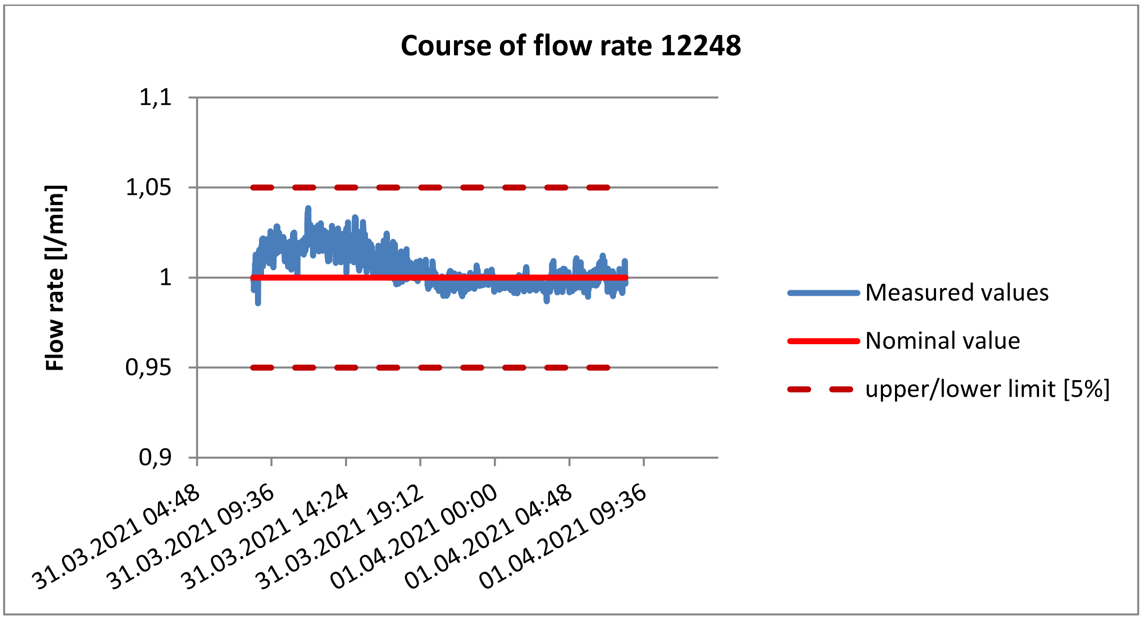

Figure 24: Flow rate of tested instrument SN 12248

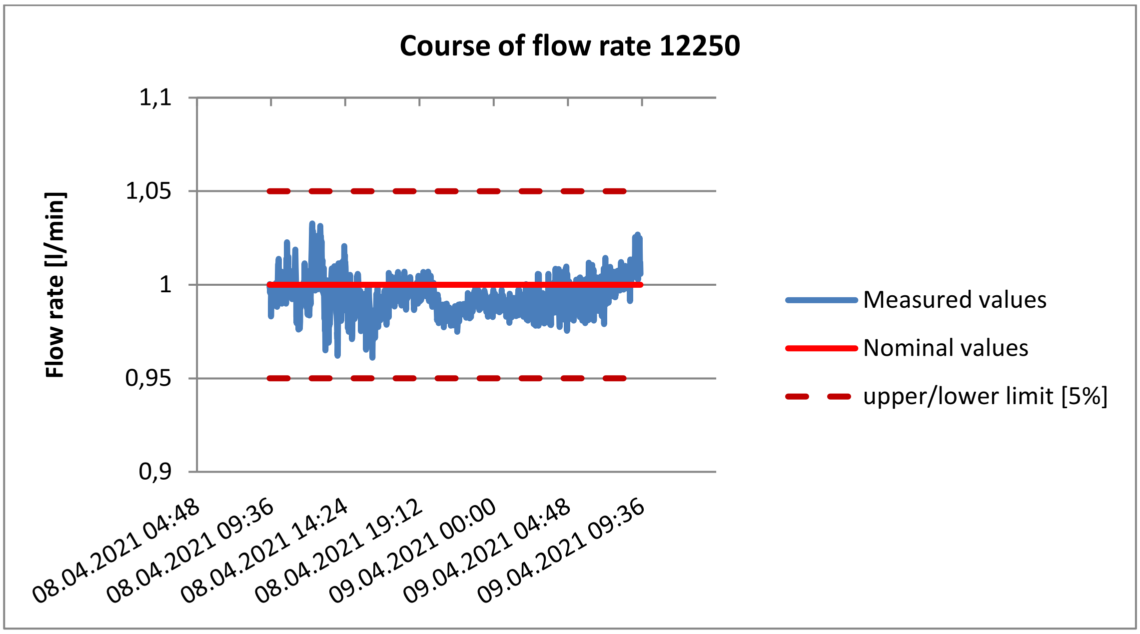

Figure 25: Flow rate of tested instrument SN 12250

6.1 6 Leak tightness of the sampling system (7.4.6)

Leakage shall not exceed 2.0% of the sample flow rate or else meet the AMS manufacturer's specifications in complying with the required data quality objectives (DQO).

6.2 Equipment

Means to block the sample inlet.

6.3 Testing

The tightness (leakage rate) of the entire flow route of the AMS (sample inlet, sampling line, measuring system) shall be tested as specified by the manufacturer. A leak test integrated in an AMS can be used, provided that the stringency of such a test is suitable for a proper assessment of the instrument's leak tightness.

If the complete system cannot be tested for technical reasons, the leak rate can be determined separately for each element of the flow path. If proper sealing of the sample inlet is not possible, it may be excluded from the test.

There is a defined procedure to check the tightness of the Fidas Smart 100 measuring systems. For this purpose, the instrument is switched to the “air tightness” test mode according to chapter 4.5 of the manual and a zero filter is mounted on the sample inlet. The measuring system waits automatically until the particle concentration is constant at 0.00 1/cm³. Then the fan speed is set to the highest level. In the event of a leak, particles would then enter the measuring chamber due to the higher negative pressure. If the particle concentration remains at 0.00 1/cm³, the leak test is deemed to have been passed. This is displayed in the software / on the screen. This procedure is performed analogously for the Fidas Smart 100 E measuring system. The aerosol tube extension is then part of the leak test.

This procedure was carried out at the beginning and at the end of the field test at every location.

6.4 Evaluation

The leak test was carried out at the beginning and at the end of the field test at every location.

The leak test procedure specified by the manufacturer proved to be a suitable method for monitoring the leak tightness of the system in the test.

6.5 Assessment

The leak test procedure specified by the system manufacturer proved to be suitable for monitoring the system tightness in the test.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not applicable in this instance.

6.1 7 Dependence of measured value on surrounding temperature (7.4.7.)

The differences found shall comply with the performance criteria given below.
Zero point ≤ 2.0 µg/m³

- *between 5°C and 40°C by default, for installations in an air-conditioned environment.*
- *at minimum and maximum temperatures specified by the manufacturer if these deviate from the default temperatures.*

6.2 Equipment

Climatic chamber for the temperature range -20 °C to 50 °C, zero filter for zero point check.

6.3 Testing

The dependence of the zero reading on the ambient temperature must be determined at the following temperatures:

a) at a nominal temperature $T_{S,n}$ = 20 °C;

b) at a minimum temperature $T_{S,1}$ = -20 °C

c) at a maximum temperature $T_{S,2}$ = 50 °C.

To test the dependence of the zero point on the surrounding temperature, the complete measuring system was operated in a climatic chamber. Sample air, free of suspended particles, was supplied to the two candidate systems after fitting two zero filters at the AMS inlet in order to perform zero point checks.

At each temperature setting, three separate measurement results shall be recorded at the zero point.

For each temperature setting, the criteria for the warm-up or stabilisation time according to 7.4.2.1 must be fulfilled.

The tests were performed in the temperature sequence $T_{S,n}$ — $T_{S,1}$ — $T_{S,n}$ — $T_{S,2}$ — $T_{S,n}$. The manufacturer has set the minimum temperature at -20 °C and the maximum temperature at 50 °C, as the measuring system is intended for outdoor installations.

Readings were recorded at zero point after an equilibration period of at least 6h for every temperature step (3 readings each).

6.4 Evaluation

The measured values for the concentration of the respective individual measurements were taken, averaged for each temperature increment and evaluated as described below.

In order to exclude any possible drift due to factors other than temperature, the measurements at $T_{S,n}$ were averaged.

The differences between readings at both extreme temperatures and $T_{S,n}$ were determined.

6.5 Assessment

The tested ambient temperature range is -20 °C to 50 °C. The maximum deviation from the mean measured value at $T_{S,n}$ was 0.0 µg/m³ for $PM_{2.5}$ and for PM_{10}.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 15: Dependence of zero point on surrounding temperature, deviation in µg/m³, average of three measurements, $PM_{2.5}$

Temperature	SN 12248		SN 12250	
	Measured value	Deviation to mean value at 20°C	Measured value	Deviation to mean value at 20°C
°C	µg/m³	µg/m³	µg/m³	µg/m³
20	0.0	0.0	0.0	0.0
-20	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
Mean value at 20°C	0.0	-	0.0	-

Table 16: Dependence of zero point on surrounding temperature, deviation in µg/m³, average of three measurements, PM_{10}

Temperature	SN 12248		SN 12250	
	Measured value	Deviation to mean value at 20°C	Measured value	Deviation to mean value at 20°C
°C	µg/m³	µg/m³	µg/m³	µg/m³
20	0.0	0.0	0.0	0.0
-20	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
Mean value at 20°C	0.0	-	0.0	-

Annex 3 in the appendices contains the individual measured results.

6.1 8 Dependence of measured value (span) on surrounding temperature (7.4.7)

The differences found shall comply with the performance criteria given below.
Sensitivity of the measuring system (span):
≤ 5 % from the value at the nominal test temperature

- *between 5°C and 40°C by default, for installations in an air-conditioned environment.*
- *at minimum and maximum temperatures specified by the manufacturer if these deviate from the default temperatures.*

6.2 Equipment

Climatic chamber for the temperature range -20 °C to 50 °C, MonoDust 1500 for sensitivity testing.

6.3 Testing

The dependence of the span value, measured by applying a calibration artefact on the surrounding temperature, shall be determined at the following temperatures:

a) at a nominal temperature $T_{S,n}$ = 20 °C;

b) at a minimum temperature $T_{S,1}$ = -20 °C

c) at a maximum temperature $T_{S,2}$ = 50 °C.

To test the dependence of the sensitivity of the measuring system (span) on the ambient temperature, the complete measuring equipment was operated in the climatic chamber. For the span point tests, MonoDust 1500 was applied to the test systems. The channel shift was assessed here and no direct concentration measurement was performed (see pg. 29).

For each temperature setting, three independent measurement results of the sensitivity are to be recorded.

For each temperature setting, the criteria for the warm-up or stabilisation time according to 7.4.2.1 must be fulfilled.

The tests were performed in the temperature sequence $T_{S,n}$ — $T_{S,1}$ — $T_{S,n}$ — $T_{S,2}$ — $T_{S,n}$. The manufacturer has set the minimum temperature at -20 °C and the maximum temperature at 50 °C, as the measuring system is intended for outdoor installations.

Readings were recorded at span point after an equilibration period of at least 6h for every temperature step (3 readings each).

6.4 Evaluation

The measured values for the concentration of the respective individual measurements were taken, averaged for each temperature increment and evaluated as described below.

In order to exclude any possible drift due to factors other than temperature, the measurements at $T_{S,n}$ were averaged.

The differences between readings at both extreme temperatures and $T_{S,n}$ were determined.

6.5 Assessment

The tested ambient temperature range is -20 °C to 50 °C. The maximum deviation from the mean measured value at 20 °C was 3.1 % for $PM_{2.5}$ and 0.5 % for PM_{10}.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 17: Dependence of measured value on surrounding temperature, deviation in %, average from three measurements for $PM_{2.5}$

Temperature	SN 12248		SN 12250	
	Measured value	Deviation to mean value at 20°C	Measured value	Deviation to mean value at 20°C
°C	0	%	0	%
20	24.9	-0.3	24.5	0.0
-20	24.9	-0.4	24.0	-1.8
20	25.0	0.0	24.4	-0.3
50	25.5	2.3	25.2	3.1
20	25.0	0.3	24.5	0.3
Mean value at 20°C	25.0	-	24.5	-

Table 18: Dependence of measured value on surrounding temperature, deviation in %, average from three measurements for PM_{10}

Temperature	SN 12248		SN 12250	
	Measured value	Deviation to mean value at 20°C	Measured value	Deviation to mean value at 20°C
°C	0	%	0	%
20	40.0	0.0	40.0	0.0
-20	40.0	0.0	40.2	0.5
20	40.0	0.0	40.0	0.0
50	39.9	-0.2	40.0	-0.1
20	40.0	0.0	40.0	0.0
Mean value at 20°C	40.0	-	40.0	-

The respective results of the 3 individual measurements are shown in Annex 3.

6.1 9 Dependence of span on supply voltage (7.4.8)

The differences found shall comply with the performance criteria given below.
Sensitivity of the measuring system (span):
≤ 5% from the value at the nominal test voltage

6.2 Equipment

Isolating transformer, MonoDust 1500 for sensitivity check.

6.3 Testing

The dependence of the measured value corrected by a calibration factor on the supply voltage must be determined at the following voltages (cf. EN 50160 [10] taking into consideration the manufacturer's specifications:

- at the nominal voltage $Vs,_n$ = 230 V;
- at a minimum voltage $V_{s,1}$ = 195 V;
- at a maximum voltage $V_{s,2}$ = 253 V.

This test item requires the use of calibration equipment for span.

Three individual readings shall be recorded for span at each voltage setting.

At each voltage setting the criteria for warm-up or stabilization time are to be met according to 7.4.2.1.

The tests are performed in the voltage sequence $V_{S,n}$ - $V_{S,1}$ - $V_{S,n}$ - $V_{S,2}$ - $V_{S,n}$.

For the span point tests, MonoDust 1500 was applied to the test systems. The channel shift was assessed here and no direct concentration measurement was performed (see pg. 29).

6.4 Evaluation

In order to rule out a possible drift caused by factors other than voltage, the measured values were averaged at $V_{S,n}$.

The differences between readings at both extreme voltages and $V_{S,n}$ were determined.

6.5 Assessment

No deviations of more than -0.8 % for $PM_{2.5}$ and -0.1 % for PM_{10} at the extreme values related to the mean value at 230 V, could be detected by mains voltage changes.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 19: Influence of mains voltage on measured value, deviation in % for $PM_{2.5}$

Supply voltage	SN 12248		SN 12250	
	Measured value	Deviation to mean value at 230 V	Measured value	Deviation to mean value at 230 V
V	µg/m³	%	µg/m³	%
230	25.0	0.0	24.5	0.3
195	25.0	0.0	24.5	0.3
230	25.1	0.2	24.6	0.5
253	25.0	-0.3	24.5	0.1
230	25.0	-0.1	24.3	-0.8

Table 20: Influence of mains voltage on measured value, deviation in % for PM_{10}

Supply voltage	SN 12248		SN 12250	
	Measured value	Deviation to mean value at 230 V	Measured value	Deviation to mean value at 230 V
V	µg/m³	%	µg/m³	%
230	40.0	0.0	40.0	-0.1
195	40.0	0.0	40.0	-0.1
230	40.0	0.0	40.0	-0.1
253	40.0	0.0	40.0	-0.1
230	40.0	0.0	40.1	0.1

Annex 4 in the appendices contains the individual results.

6.1 10 Effect of failure of mains voltage

Instrument parameters shall be secured against loss.
On return of main voltage the instrument shall automatically resume functioning.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

A simulated failure in the mains voltage served to test whether the instrument remained fully functional, reached operation mode on return of the mains voltage and retained all instrument parameters completely.

6.4 Evaluation

The measuring system resumes operation after a power failure and the start of the operating system. It is operational after a couple of minutes. All instrument parameters are preserved.

6.5 Assessment

All instrument parameters are secured against loss. On return of mains voltage, the instrument returns to normal operating mode and automatically resumes measuring.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not applicable.

6.1 11 Dependence of reading on water vapour concentration (7.4.9)

The largest difference in readings between 40% and 90%
relative humidity shall fulfil the performance criterion stated below:
≤ 2.0 µg/m³ in zero air when cycling relative humidity from 40% to 90% and back.

6.2 Equipment

Climatic chamber with humidity control for the range 40 % to 90 % relative humidity, zero filter for zero point verification.

6.3 Testing

The dependence of the reading on the water vapour concentration in the sample air was determined by supplying humidified zero air in the range of 40 % to 90 % relative humidity. To this effect, the measuring system was operated in the climatic chamber and the relative humidity of the entire surrounding atmosphere was controlled. Sample air, free of suspended particles was supplied to the instruments after fitting two zero filters at either AMS inlet in order to perform zero point checks.

After stabilisation of the relative humidity and concentration readings of the AMS, a reading was taken over the smallest averaging period of the AMS at 40 % relative humidity. The relative humidity was then increased to 90 % at a rate of 25 % per hour. The time taken to reach equilibrium and the average concentration reading were recorded. The relative humidity was then reduced to 40 % at a rate of 25 % per hour. The time taken to reach equilibrium and the average concentration reading were recorded again.

6.4 Evaluation

The measured values for the zero concentrations of the individual measurements at stable humidities were read out and evaluated. The largest difference in µg/m³ between the values in the range of 40 % to 90 % relative humidity is considered.

6.5 Assessment

The largest difference determined between the measured values at 40 % and at 90 % relative humidity was 0.0 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 21: Dependence of reading on water vapour concentration, deviation in µg/m³, $PM_{2.5}$

rel. Humidity	SN 12248		SN 12250	
	Measured value	Deviation to previous value	Measured value	Deviation to previous value
%	µg/m³	µg/m³	µg/m³	µg/m³
40	0.0	-	0.0	-
90	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0
Maximum deviation	0.0		0.0	

Table 22: Dependence of reading on water vapour concentration, deviation in µg/m³, PM_{10}

rel. Humidity	SN 12248		SN 12250	
	Measured value	Deviation to previous value	Measured value	Deviation to previous value
%	µg/m³	µg/m³	µg/m³	µg/m³
40	0.0	-	0.0	-
90	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0
Maximum deviation	0.0		0.0	

6.1 12 Zero checks (7.5.3)

During the tests, the absolute measured value of the AMS shall not exceed the following criterion:
Absolute value ≤ 3.0 µg/m³

6.2 Equipment

Zero filter for zero checks

6.3 Testing

Regular checks of the AMS reading at zero point shall be performed in the field during normal operation over a sufficient time period by using an appropriate method to provide zero air to the AMS. The manufacturer's instructions shall be observed. An appropriate method to generate zero air is the sampling of ambient air through a zero filter (HEPA) installed at the inlet of the AMS instead of the regular sampling inlet. The zero check shall be performed for at least 24 h.

The checks shall be done at least at the beginning and at the end of each of the 6 comparisons.

6.4 Evaluation

During the tests, the absolute measured value of the AMS at zero point defined at 3.0 µg/m³ shall not be exceeded.

6.5 Assessment

The absolute measured value determined at the zero point did not exceed 0.0 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 23: Zero checks, $PM_{2.5}$

Date	SN 12248		Date	SN 12250	
	Measured Value µg/m³	Measured value (absolute) < 3.0 µg/m³		Measured Value µg/m³	Measured value (absolute) < 3.0 µg/m³
1/21/2021	0.0	ok	1/21/2021	0.0	ok
3/17/2021	0.0	ok	3/17/2021	0.0	ok
4/16/2021	0.0	ok	4/16/2021	0.0	ok
6/18/2021	0.0	ok	6/18/2021	0.0	ok
6/30/2021	0.0	ok	6/30/2021	0.0	ok
11/8/2021	0.0	ok	11/8/2021	0.0	ok
12/1/2021	0.0	ok	12/1/2021	0.0	ok
3/8/2022	0.0	ok	3/8/2022	0.0	ok
4/5/2022	0.0	ok	4/5/2022	0.0	ok
6/3/2022	0.0	ok	6/3/2022	0.0	ok

Table 24: Zero checks, PM_{10}

Date	SN 12248		Date	SN 12250	
	Measured Value µg/m³	Measured value (absolute) < 3.0 µg/m³		Measured Value µg/m³	Measured value (absolute) < 3.0 µg/m³
1/21/2021	0.0	ok	1/21/2021	0.0	ok
3/17/2021	0.0	ok	3/17/2021	0.0	ok
4/16/2021	0.0	ok	4/16/2021	0.0	ok
6/18/2021	0.0	ok	6/18/2021	0.0	ok
6/30/2021	0.0	ok	6/30/2021	0.0	ok
11/8/2021	0.0	ok	11/8/2021	0.0	ok
12/1/2021	0.0	ok	12/1/2021	0.0	ok
3/8/2022	0.0	ok	3/8/2022	0.0	ok
4/5/2022	0.0	ok	4/5/2022	0.0	ok
6/3/2022	0.0	ok	6/3/2022	0.0	ok
6/21/2022	0.0	ok	6/21/2022	0.0	ok
9/6/2022	0.0	ok	9/6/2022	0.0	ok

6.1 13 Recording of operational parameters (7.5.4)

During the tests the AMS shall be able to telemetrically transmit operational states of – at minimum – the following parameters:

- *Flow rate;*
- *Pressure drop over sample filter (if relevant);*
- *Sampling time;*
- *Sampling volume (if relevant);*
- *Mass concentration of relevant PM fraction(s);*
- *Ambient temperature;*
- *Exterior air pressure;*
- *Air temperature in measuring section;*
- *Temperature of the sampling inlet if a heated inlet is used.*

The results of automated/functional checks have to be recorded, where available.

6.2 Equipment

Computer for data acquisition.

6.3 Testing

The measuring system enables comprehensive telemetric monitoring and control of the AMS via various paths and can also output measured values or status information via various protocols (UDP ASCII and TCP ASCII) according to the manufacturer's specifications.

It is possible to communicate the operating statuses and relevant parameters including:

- Aerosol pump performance
- Temperature of the IADS
- Temperature of the LED
- Flow rate
- Ambient temperature, pressure, humidity

All values are stored.

6.4 Evaluation

The AMS allows for comprehensive telemetric monitoring and control of the measuring system via various paths. The instrument provides operating statuses and all relevant parameters.

6.5 Assessment

The AMS allows for comprehensive telemetric monitoring and control of the measuring system via various paths. The instrument provides operating statuses and all relevant parameters.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not applicable.

6.1 14 Daily averages (7.5.5)

The AMS shall allow for the formation of daily averages or values.

6.2 Equipment

For this test, a clock was additionally provided.

6.3 Testing

It was checked whether the measuring system allows the formation of a daily average.

6.4 Evaluation

The measuring system continuously determines the suspended particulate matter mass concentration for $PM_{2.5}$ and PM_{10}. The data is stored internally as 2-minute averages. From this, 24 h averages can be determined.

6.5 Assessment

It is possible to form valid daily averages.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not applicable.

6.1 15 Availability (7.5.6)

The availability of the measuring system shall be at least 90%.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

The start and end times of the availability tests are determined by the start and end times, respectively, at each of the six field test sites. Proper operation of the measuring system was verified during every on-site visit (usually every working day). This daily check consisted of plausibility checks on the measured values, status signals and other relevant parameters (see 7.5.4). Time, duration and nature of any error in functioning are recorded.

The total time during the field test in which valid measurement data of ambient air concentrations were obtained was used for calculating availability. Time needed for scheduled calibrations and maintenance (cleaning; change of consumables) should not be included.

Availability is calculated as

$$A = \frac{t_{valid} + t_{cal,maint}}{t_{field}}$$

Where:

t_{valid} is the time during which valid data have been collected;

$t_{cal,maint}$ is the time spent for scheduled calibrations and maintenance;

t_{field} is the total duration of the field test.

6.4 Evaluation

Table 25 shows a list of operating, maintenance and malfunction times. During the field test, the measuring systems were operated for a total of 470 measuring days. This period includes 12 days with zero filter operation.

Outages caused by external events not ascribed to the measuring system amounted to 2 days (power outage). The externally-caused outages reduced the total time of operation to 468 measuring days.

No instrument malfunctions were observed.

6.5 Assessment

Availability was at 100% for both instruments.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 25: Determination of the availability

		System 1 (SN 12248)	System 2 (SN 12250)
Operation time (t_{field})	d	468	468
Outage time	d	0	0
Maintenance time incl. zero filter ($t_{cal,maint}$)	d	12	12
Actual operating time (t_{valid})	d	456	456
Availability	%	100	100

6.1 Method used for equivalence testing (7.5.8.4 & 7.5.8.8)

Standard EN 16450 [4] requires compliance with the following five criteria:

1. Of the full data set, at least 20% of the concentration values (determined with the reference method) shall be greater than 28 µg/m³ for PM_{10} and 17 µg/m³ for $PM_{2.5}$. When, due to low concentration levels, the criteria for 20 % of results to be greater than 28 µg/m3 for PM_{10}, or to be greater than 17 µg/m3 for $PM_{2.5}$ cannot be obtained, a minimum of 32 data points higher than these thresholds is considered sufficient.
2. Between-AMS uncertainty shall remain below 2.5 µg/m³ for the overall data and for data sets with data larger than/equal to 30 µg/m³ for PM_{10} and 18 µg/m³ for $PM_{2.5}$.
3. The uncertainty between reference systems shall not exceed 2.0 µg/m³.
4. The expanded uncertainty (W_{CM}) is calculated at 50 µg/m³ for PM_{10} and at 30 µg/m³ for $PM_{2.5}$ for every individual test specimen and checked against the average of the reference method. For each of the following cases, the expanded uncertainty shall not exceed 25%:
   - Full data set:
   - Data sets representing PM concentrations greater than/equal to 30 µg/m³ for PM_{10}, or concentrations greater than/equal to 18 µg/m³ for $PM_{2.5}$, provided that the set contains 40 or more valid data pairs
   - Data sets for each individual site
5. Preconditions for acceptance of the full data set are that the slope b is insignificantly different from 1: $|b-1| \leq 2 \cdot u(b)$ and the intercept a is insignificantly different from 0: $|a| \leq 2 \cdot u(a)$. If these requirements are not met, then the test specimens can be calibrated with the values of the total data set for the slope and/or for the axis section.

The following chapters address the issue of verifying compliance with the five criteria.

Chapter 6.1 16 Between-AMS uncertainty (7.5.8.4) addresses verification of criteria 1 and 2.

Chapter 6.1 17 Expanded uncertainty (7.5.8.5 – 7.5.8.8) addresses verification of criteria 3, 4 and 5.

Chapter 6.1 17 Use of correction factors/terms (7.5.8.5–7.5.8.8) contains an assessment for the case that criterion 5 is not complied with without applying correction factors.

6.1 16 Between-AMS uncertainty (7.5.8.4)

The between-AMS uncertainty u_{bs} shall be ≤ 2.5 µg/m³.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

The test was performed as part of the field test with four separate comparison campaigns. Different seasons as well as different levels of PM concentrations were considered.

Of the total data set, at least 20% of the concentration values determined by the reference method must be greater than 17 µg/m³ for $PM_{2.5}$ or greater than 28 µg/m³ for PM_{10}. Should this not be assured because of low concentration levels, a minimum of 32 value pairs is considered sufficient.

For each comparison campaign, at least 40 valid value pairs were determined. Of the entire data set, a total of 34 measured values were above 17 µg/m³ for $PM_{2.5}$ and 33 measured values were above 28 µg/m³ for PM_{10}. The concentrations measured were related to the ambient conditions.

6.4 Evaluation

Chapter 7.5.8.4 of standard EN 16450 specifies that:

The between-AMS uncertainty u_{bs} shall be ≤ 2.5 µg/m³. A between-AMS uncertainty > 2.5 µg/m³ is an indication of unsuitable performance of one or both instruments, and equivalence should not be stated.

Uncertainty is determined for:

- All results combined (complete data set)
- 1 data set with measured values ≥ 18 µg/m³ for $PM_{2.5}$ (basis: averages reference measurement)
- 1 data set with measured values ≥ 30 µg/m³ for PM_{10} (basis: averages reference measurement)

The between-AMS uncertainty u_{bs} is calculated from the differences of all daily averages (24h-values) of the AMS which are operated simultaneously as:

$$u_{bs,AMS}^2 = \frac{\sum_{i=1}^{n}(y_{i,1} - y_{i,2})^2}{2n}$$

Where: $y_{i,1}$ and $y_{i,2}$ = Results of the parallel measurements of individual 24h-values i

n = Number of 24h-values

6.5 Assessment

At no more than 1.6 µg/m³ the uncertainty between the test specimen u_{bs} remained well below the permissible maximum of 2.5 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 26: Between-AMS uncertainty $u_{bs,AMS}$

Location	**Number of measurements**	**Uncertainty $u_{bs,AMS}$ µg/m³**	
		$PM_{2.5}$	**PM_{10}**
All locations	**363 ($PM_{2.5}$) 433 (PM_{10})**	**0.415**	**0.639**
Classification via reference values			
Values ≥ 18 µg/m³ ($PM_{2.5}$) Values ≥ 30 µg/m³ (PM_{10})	**25 ($PM_{2.5}$) 25 (PM_{10})**	**0.992**	**1.6**

Please note: In the following charts CM1 corresponds to SN 12248 and CM2 corresponds to SN 12250.

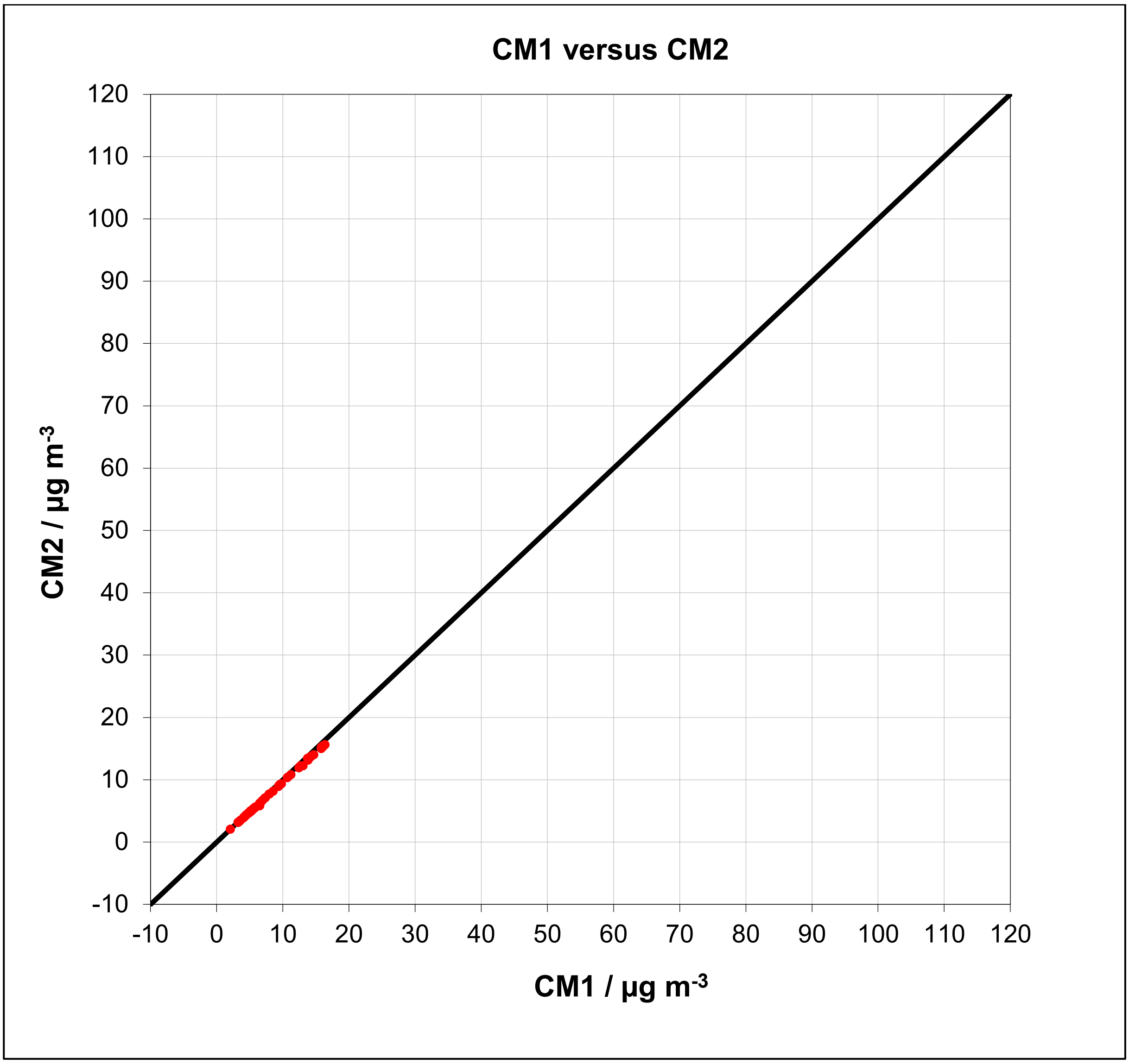

Figure 26: Results of parallel measurements, all sites, $PM_{2.5}$

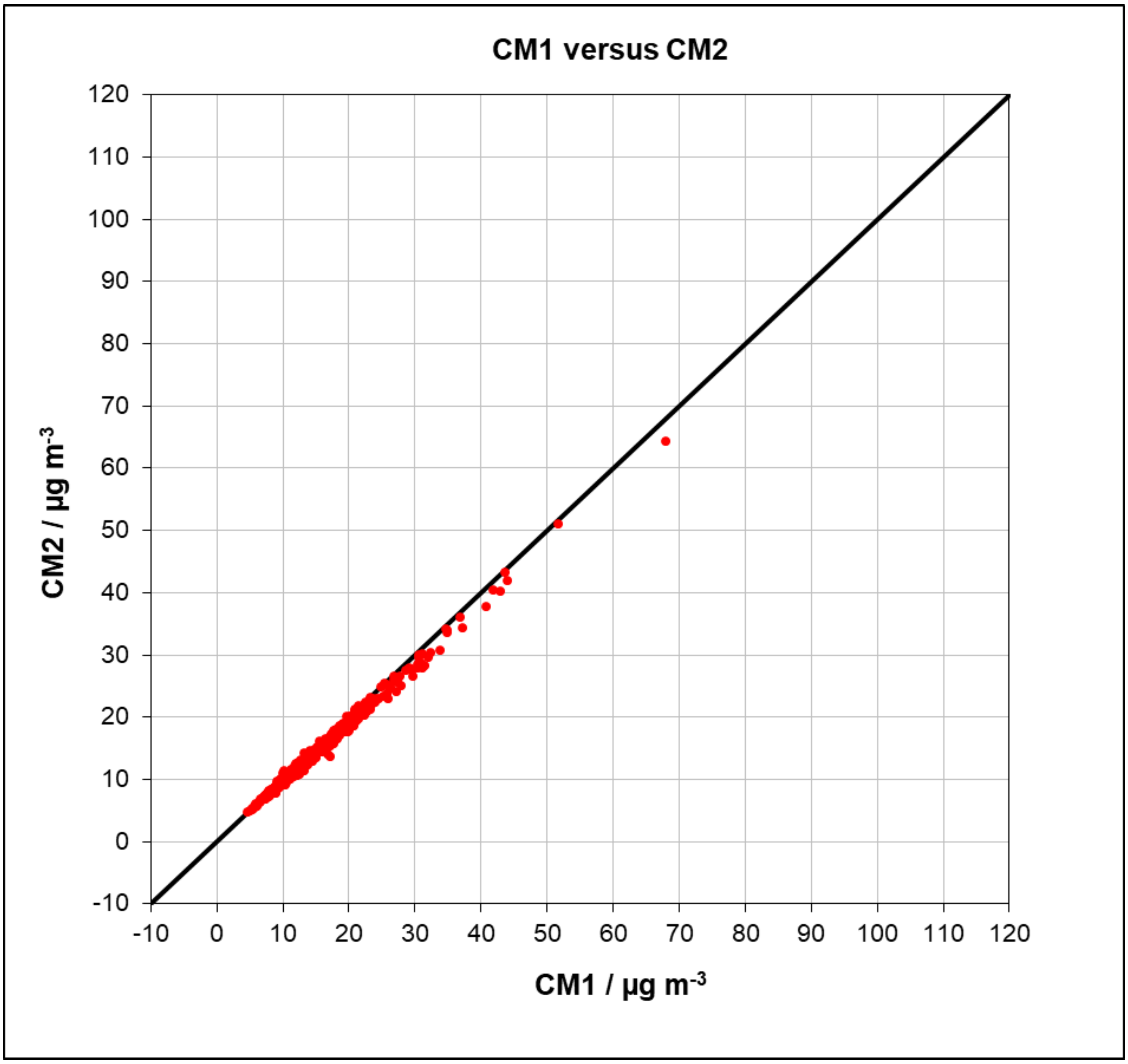

Figure 27: Results of parallel measurements, all sites, PM_{10}

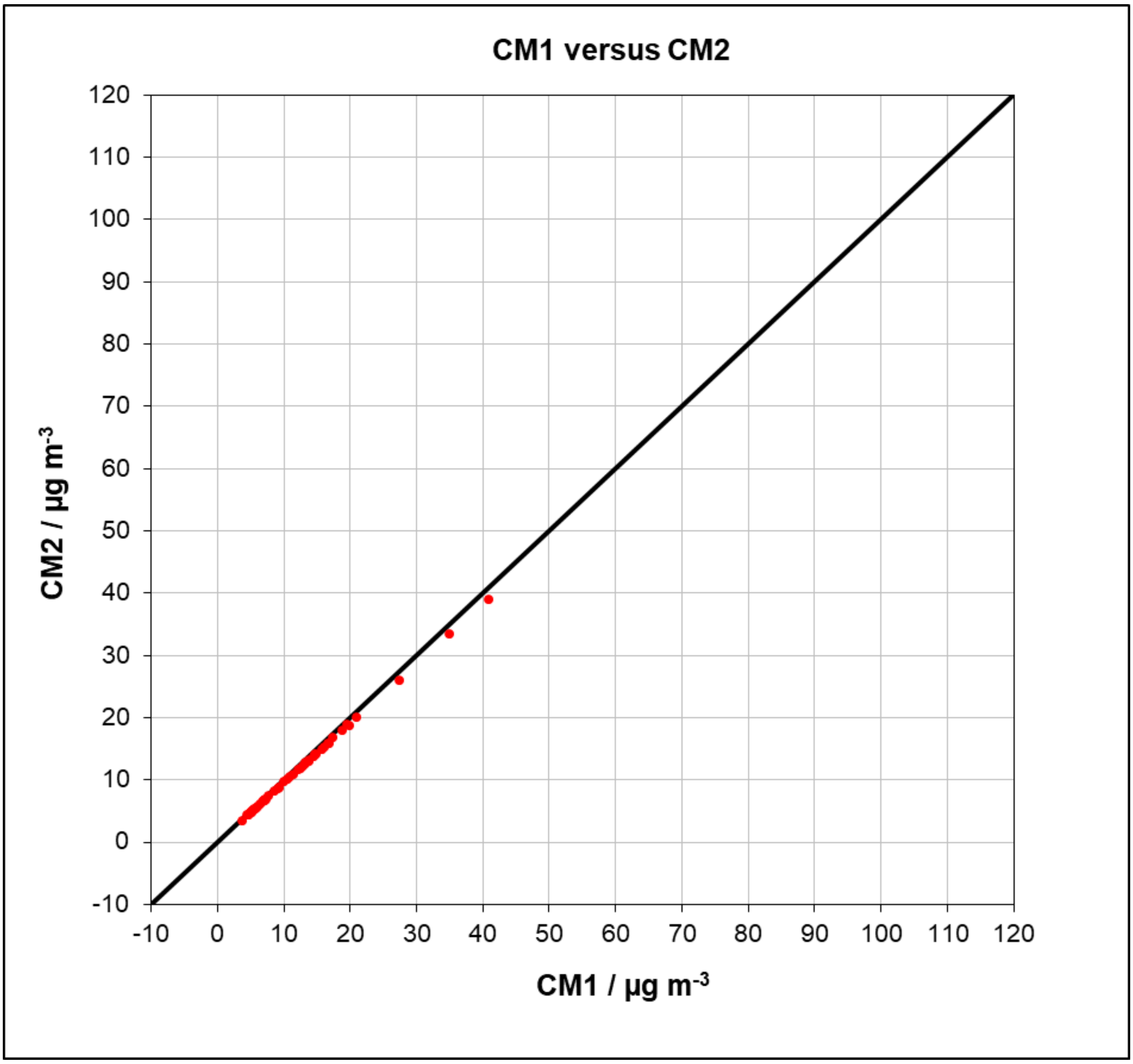

Figure 28: Results of parallel measurements, Cologne I, $PM_{2.5}$

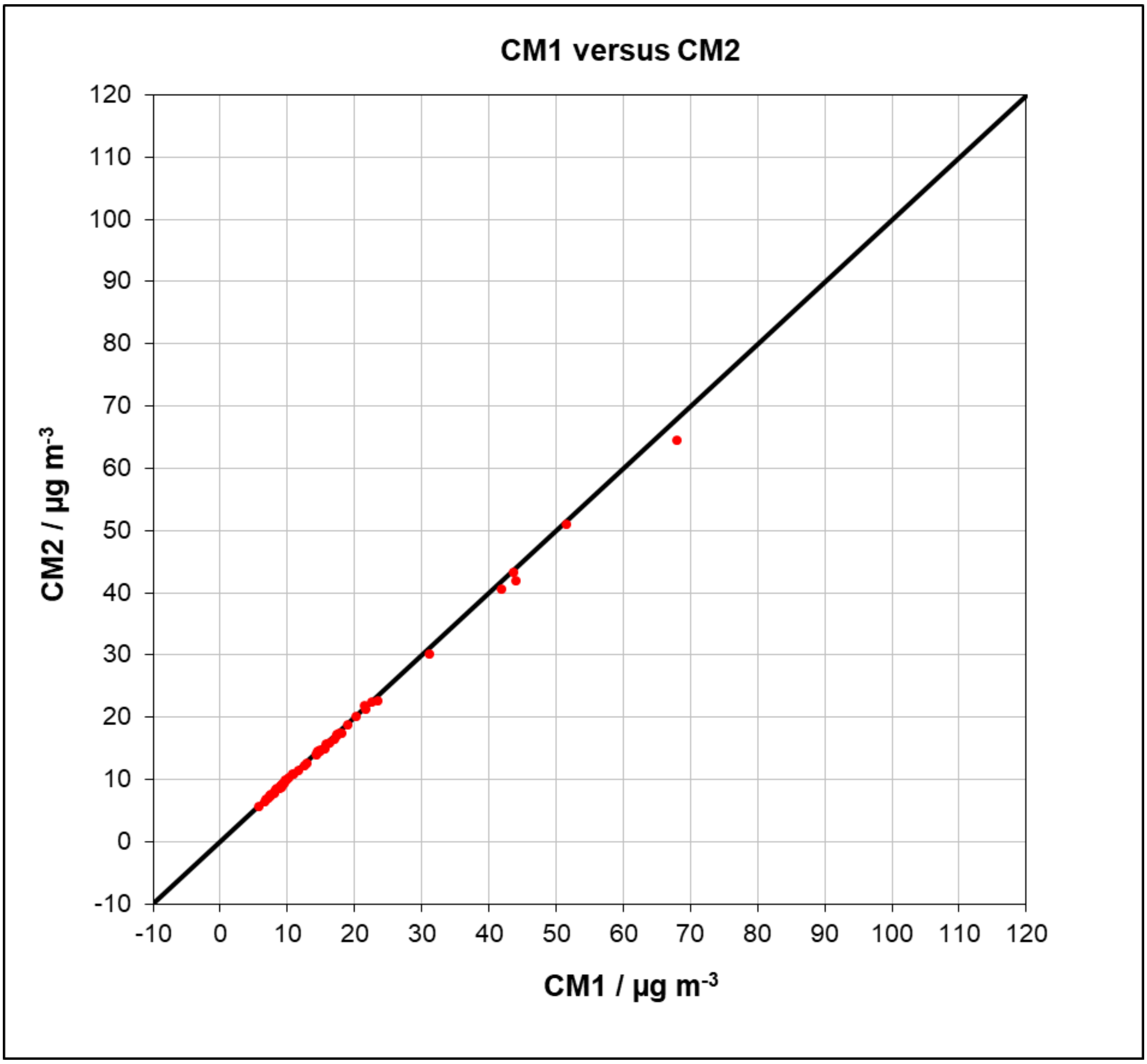

Figure 29: Results of parallel measurements, Cologne I, PM_{10}

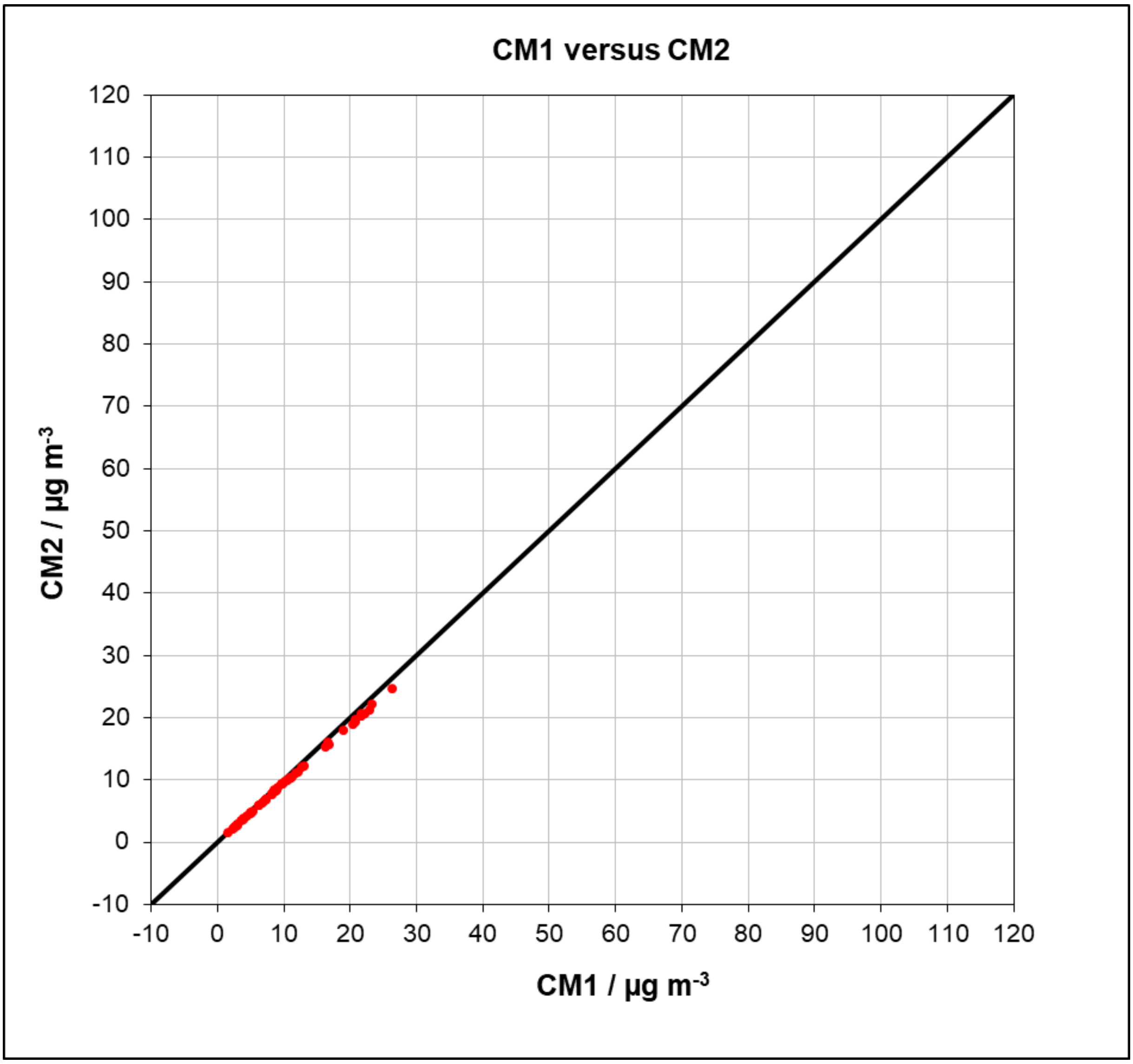

Figure 30: Results of parallel measurements, Niederzier I, $PM_{2.5}$

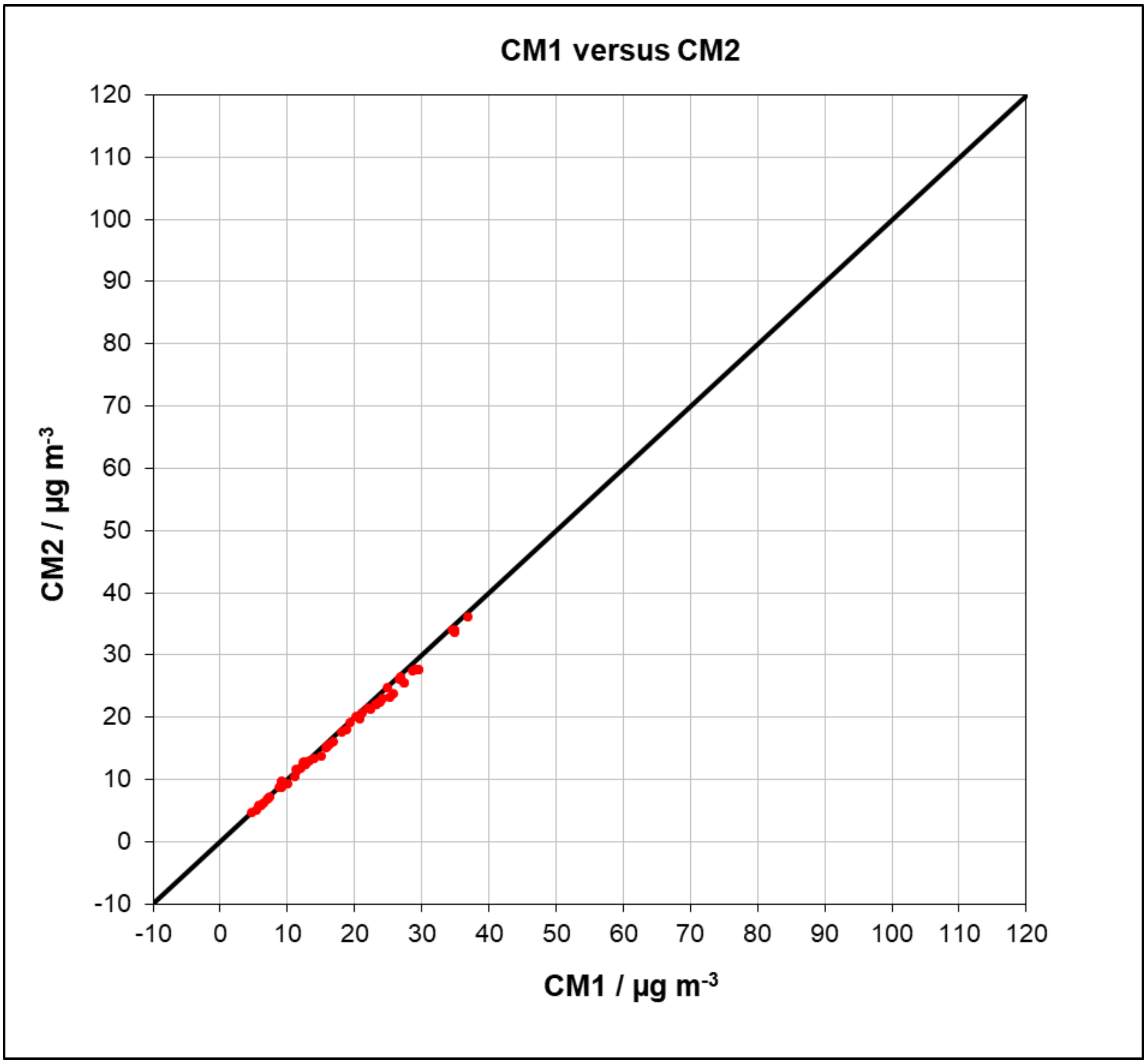

Figure 31: Results of parallel measurements, Niederzier I, PM_{10}

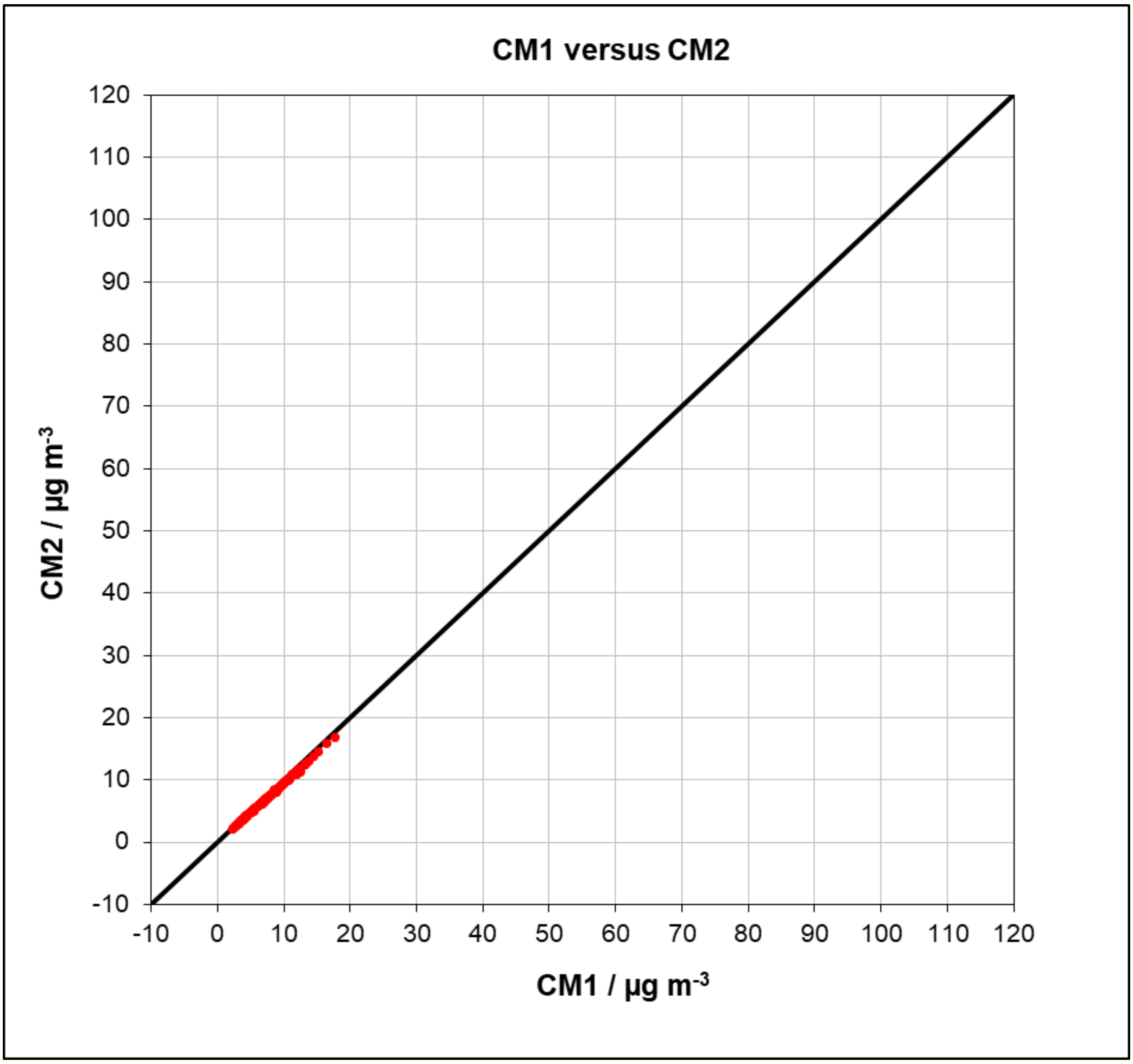

Figure 32: Results of parallel measurements, Cologne II, $PM_{2.5}$

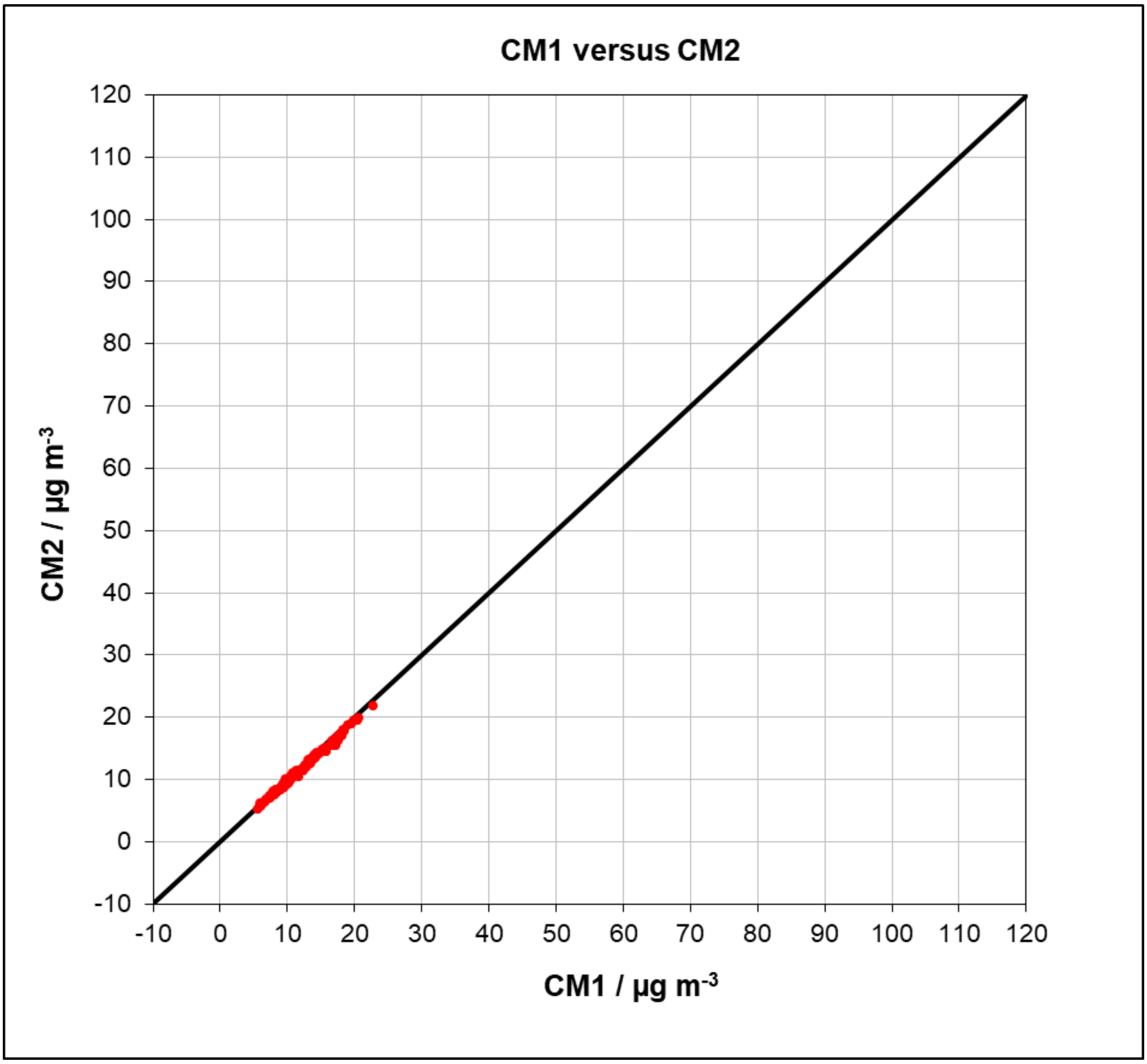

Figure 33: Results of parallel measurements, Cologne II, PM_{10}

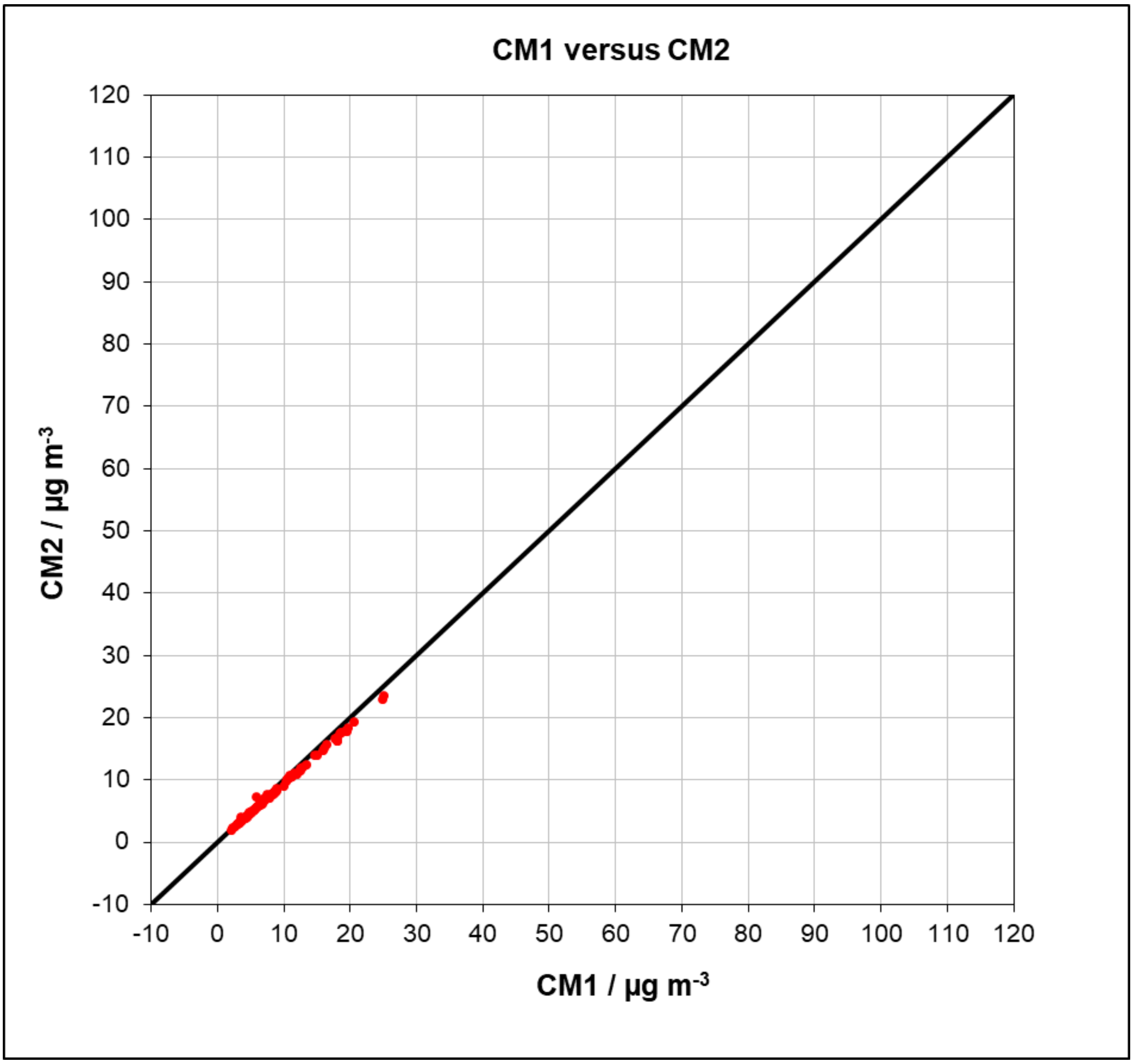

Figure 34: Results of parallel measurements, Bornheim, $PM_{2.5}$

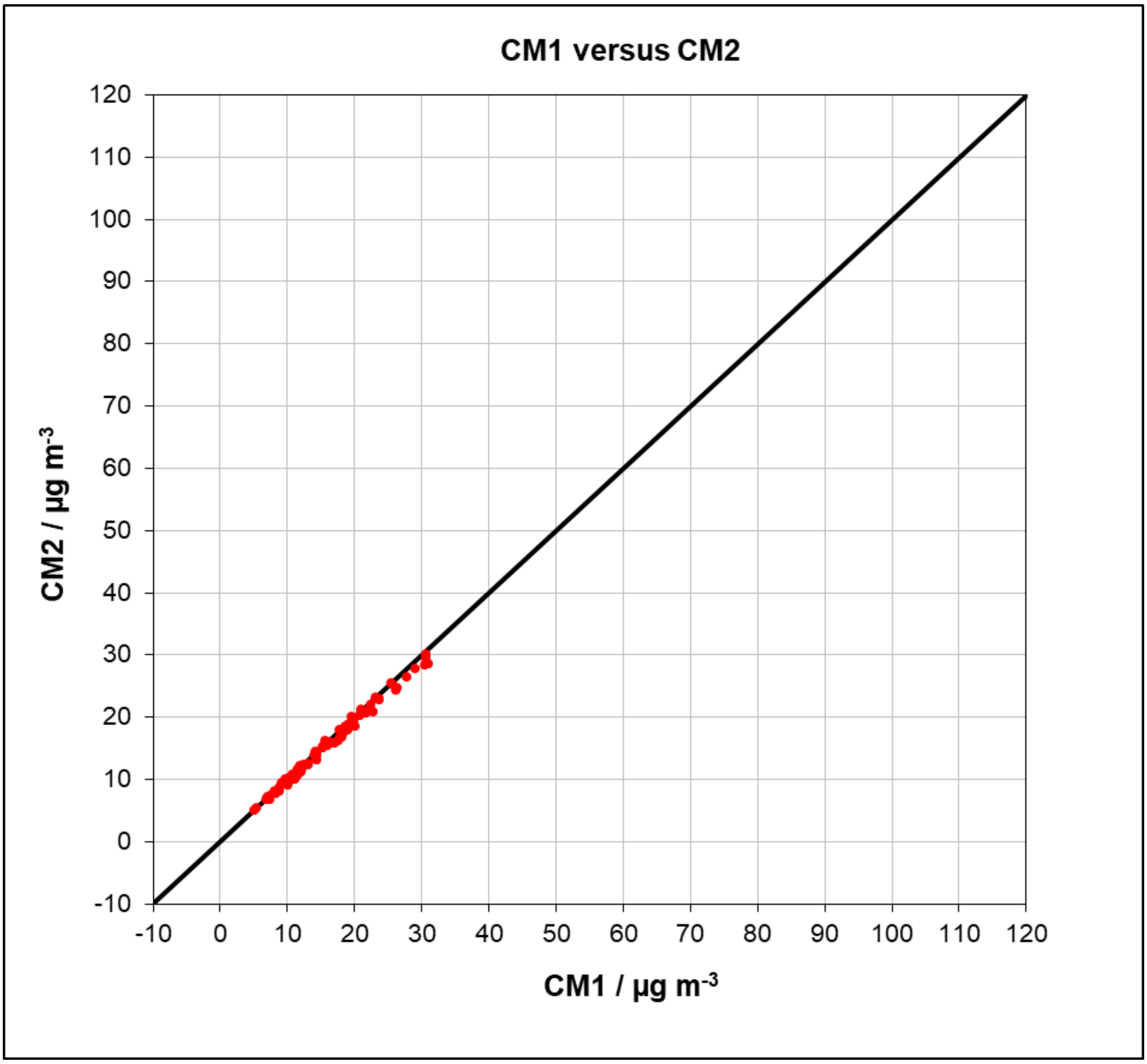

Figure 35: Results of parallel measurements, Bornheim, PM_{10}

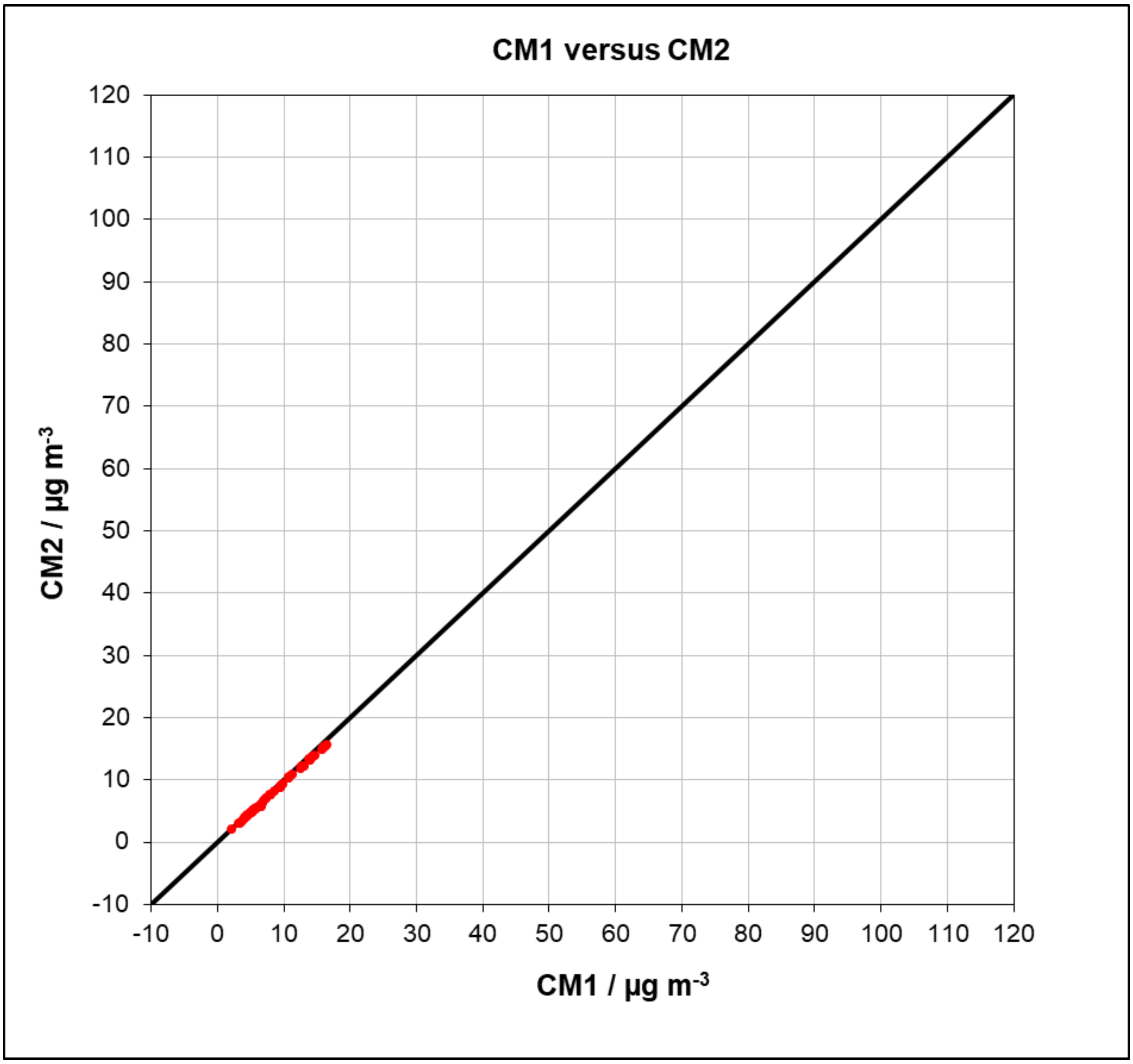

Figure 36: Results of parallel measurements, Bonn, $PM_{2.5}$

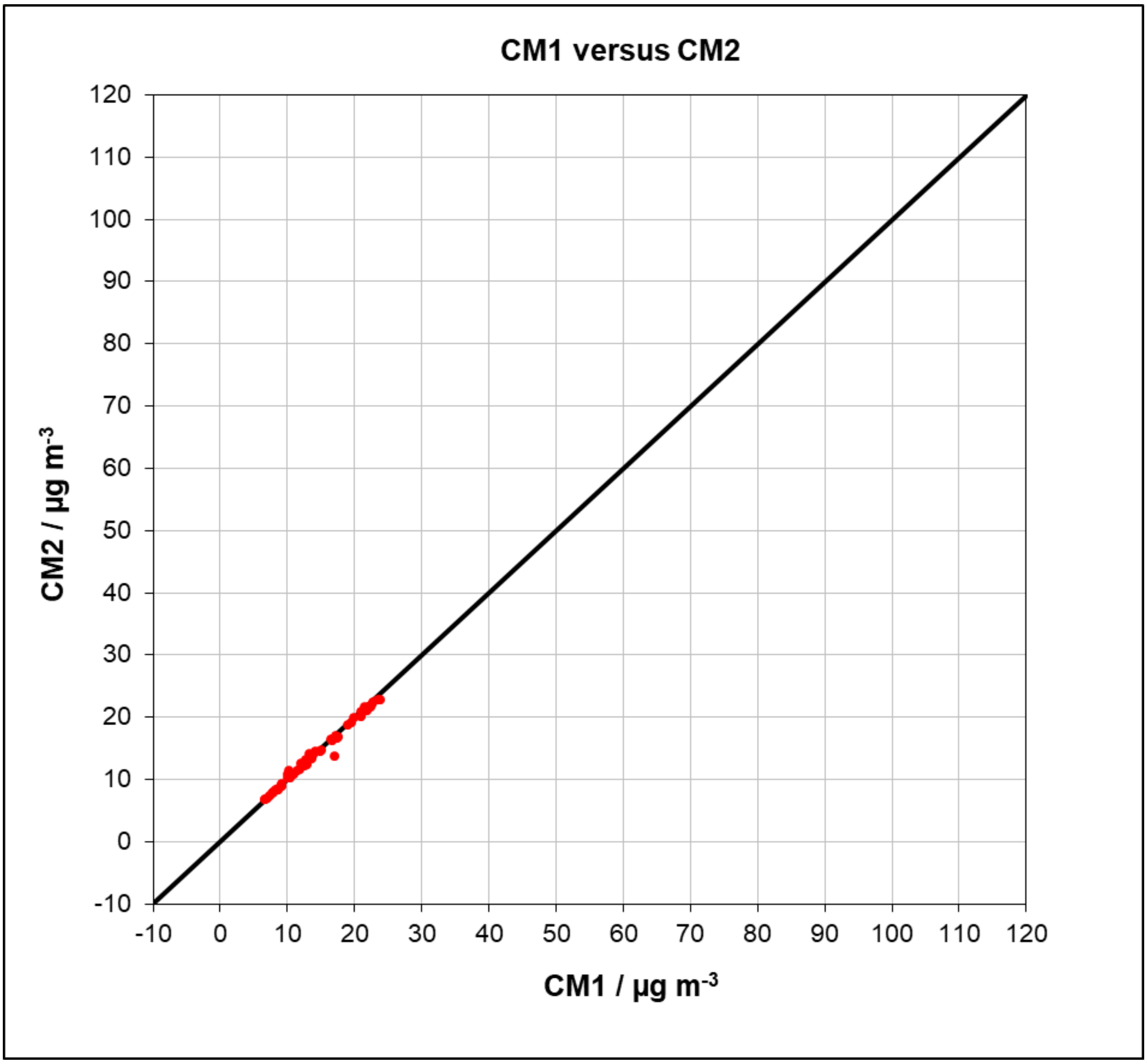

Figure 37: Results of parallel measurements, Bonn, PM_{10}

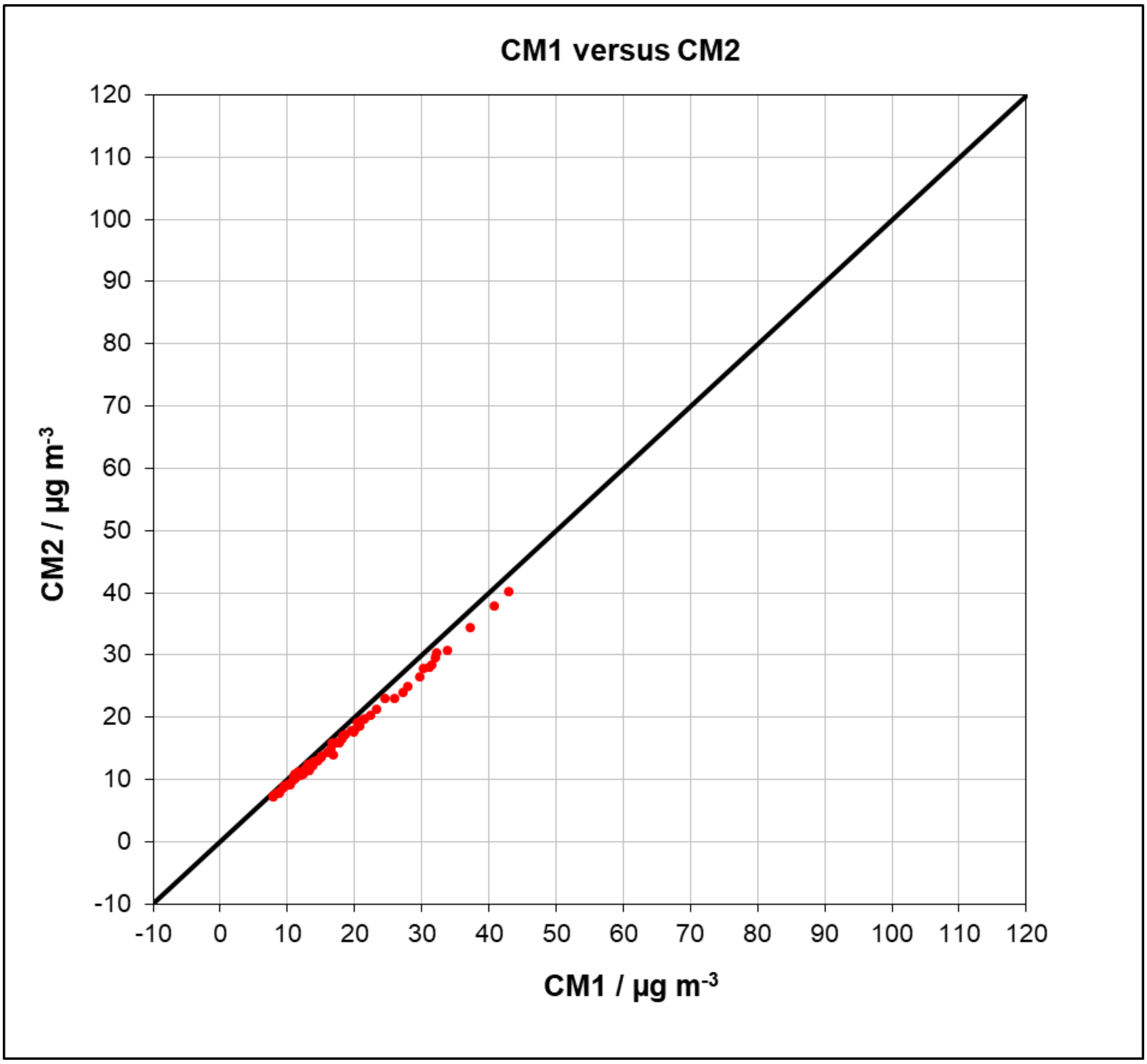

Figure 38: Results of parallel measurements, Niederzier II, PM_{10}

6.1 17 Expanded uncertainty (7.5.8.5 – 7.5.8.8)

The expanded uncertainty shall be ≤ 25% at the level of the relevant limit value related to the 24-hour average results – after a calibration where necessary.

6.2 Equipment

Additional reference measurement systems as described in chapter 5 of this report were used for this test.

6.3 Testing

The test was performed as part of the field test with four separate comparison campaigns. Different seasons and different levels of $PM_{2.5}$ and PM_{10} concentrations were considered.

Of the total data set, at least 20% of the concentration values determined by the reference method must be greater than 17 µg/m³ for $PM_{2.5}$ or 28 µg/m³ for PM_{10}. Should this not be assured because of low concentration levels, a minimum of 32 value pairs is considered sufficient.

For each comparison campaign, at least 40 valid value pairs were determined. For all comparison campaigns there were 34 value pairs above 17 µg/m³ for $PM_{2.5}$ and 33 value pairs above 28 µg/m³ for PM_{10}. The concentrations measured were related to the ambient conditions.

6.4 Evaluation

[EN 16450, 7.5.8.3]

Before calculating the expanded uncertainty of the test specimens, uncertainties were established between the simultaneously operated reference measuring systems (u_{ref})

Uncertainties between the simultaneously operated reference measuring systems $u_{bs,RM}$ were established similar to the between-AMS uncertainties and shall be ≤ 2.0 µg/m³.

Results of the evaluation are summarised in section 6.6.

[EN 16450, 7.5.8.5 & 7.5.8.6]

In order to assess comparability of the tested instruments y with the reference method x, a linear relationship $y_i = a + bx_i$ between the measured values of both methods is assumed. The association between the averages of the reference systems and each individual test specimen to be assessed is established by means of orthogonal regression.

The regression is calculated for:

- All sites or comparisons respectively together
- Every location or comparison separately
- For a reduced data set that considers only dust concentrations greater than or equal to 18 µg/m3 for $PM_{2.5}$ or 30 µg/m³ for PM_{10}, provided the subset contains at least 40 valid data pairs. Since partial data sets with at least 40 valid data pairs were not obtained for both $PM_{2.5}$ and PM_{10}, no evaluation was performed for data pairs greater than or equal to 18 µg/m³ for $PM_{2.5}$ or 30 µg/m³ for PM_{10}.

For further assessment, the uncertainty u_{c_s} resulting from a comparison of the test specimens with the reference method is described in the following equation which defines u_{CR} as a function of the fine dust concentration x_i.

$$u_{yi}^2 = \frac{RSS}{(n-2)} - u_{RM}{}^2 + \left[a + (b-1)L\right]^2$$

Where RSS = the sum of the (relative) residuals from orthogonal regression

u_{RM} = random uncertainty of the reference method; u_{RM} is calculated as $u_{bs,RM}/\sqrt{2}$, where $u_{bs,RM}$ is the uncertainty between the two reference instruments operated in parallel.

L = Replacement daily limit value for $PM_{2.5}$ (30 µg/m³)

The algorithms for calculating axis intercept a and slope b as well as their variance by means of orthogonal regression are described in detail in annex B to [4].

The sum of (relative) residuals RSS is calculated according to the following equation:

$$RSS = \sum_{i=1}^{n} (y_i - a - bx_i)^2$$

Uncertainty u_{CR} is calculated for:

- All sites or comparisons respectively together
- Every location or comparison separately
- For a reduced data set only taking into account concentrations greater than or equal to 18 µg/m³ for $PM_{2.5}$, provided that the subset contains 40 or more valid data pairs.

The Guideline states the following prerequisite for accepting the full data set:

- The slope be is insignificantly different from 1: $|b-1| \le 2 \cdot u(b)$

and

- The axis intercept a is insignificantly different from 0: $|a| \le 2 \cdot u(a)$, where u(a) and u(b) describe the standard uncertainty of the slope and the axis intercept calculated as the square root of the variance. If the prerequisites are not met, it is possible to calibrate the measuring systems in accordance with section 4 of the standard 7.5.8.6 [4] (also see 6.1 17 Use of correction factors/terms). The calibration may only be performed for the full data set.

[EN 16450 section 7.5.8.7] The combined uncertainty of the tested instruments for all data sets w^2_{AMS} is calculated as follows:

$$w_{AMS}^2 = \frac{u_{yi=L}^2}{L^2}$$

For each data set the uncertainty w_{AMS} is calculated at a level of L = 30 µg/m³ for $PM_{2.5}$ and L = 50 µg/m³ for PM_{10}.

[EN 16450 7.5.8.8] For each data set the expanded relative uncertainty of the results measured with the test specimen is calculated by multiplying w_{AMS} by a coverage factor k according to the following equation:

$$W_{AMS} = k \cdot w_{AMS}$$

Considering the large number of available test results, an expansion factor k=2 must be used.

7.5 Assessment

The determined uncertainties W_{AMS} are above the defined expanded relative uncertainty W_{dqo} of 25% for particulate matter for all considered data sets without applying correction factors. As for both $PM_{2.5}$ and PM_{10} the axis intercept is significantly different from 0 and the slope is significantly different from 1, the application of correction factors according to "Item 6.1 17 Application of correction factors/terms" shall be made accordingly. After applying correction factors and terms, all considered data sets are below the specified expanded relative uncertainty W_{dqo} of 25%.

Criterion satisfied? yes

Table 27 and Table 28 below summarise all results for the equivalence tests. Where a criterion was not satisfied, the corresponding line is marked in red.

Table 27: Overview of equivalence testing, $PM_{2.5}$

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	Fidas Smart System		SN	12248 & 12250	
			Limit value	30	µg/m³
Status of measured values	Raw data		Allowed uncertainty	25	%
All comparisons					
Uncertainty between Reference	**0.51**	**µg/m³**			
Uncertainty between Candidates	**0.41**	**µg/m³**			
	12248 & 12250				
Number of data pairs	**363**				
Slope b	**0.963**	significant			
Uncertainty of b	**0.012**				
Ordinate intercept a	**0.263**	significant			
Uncertainty of a	**0.127**				
Expanded meas. uncertainty W_{CM}	**10.03**	**%**			

Comparison candidate with reference according to Standard EN 16450:2017				
Candidate	Fidas Smart System	SN	12248 & 12250	
		Limit value	30	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Cologne I				
Uncertainty between Reference	**0.33**	**µg/m³**		
Uncertainty between Candidates	**0.43**	**µg/m³**		
	12248		**12250**	
Number of data pairs	**44**		**44**	
Slope b	**1.021**		**0.975**	
Uncertainty of b	**0.019**		**0.019**	
Ordinate intercept a	**-0.087**		**-0.053**	
Uncertainty of a	**0.278**		**0.264**	
Expanded meas. uncertainty W_{CM}	**7.39**	**%**	**8.19**	**%**
Niederzier I				
Uncertainty between Reference	**0.38**	**µg/m³**		
Uncertainty between Candidates	**0.49**	**µg/m³**		
	12248		**12250**	
Number of data pairs	**57**		**57**	
Slope b	**1.060**		**0.990**	
Uncertainty of b	**0.034**		**0.032**	
Ordinate intercept a	**-0.421**		**-0.289**	
Uncertainty of a	**0.386**		**0.371**	
Expanded meas. uncertainty W_{CM}	**13.44**	**%**	**10.21**	**%**
Cologne II				
Uncertainty between Reference	**0.45**	**µg/m³**		
Uncertainty between Candidates	**0.31**	**µg/m³**		
	12248		**12250**	
Number of data pairs	**115**		**115**	
Slope b	**1.056**		**0.990**	
Uncertainty of b	**0.031**		**0.029**	
Ordinate intercept a	**-0.220**		**-0.138**	
Uncertainty of a	**0.235**		**0.222**	
Expanded meas. uncertainty W_{CM}	**11.66**	**%**	**6.71**	**%**
Bornheim				
Uncertainty between Reference	**0.47**	**µg/m³**		
Uncertainty between Candidates	**0.52**	**µg/m³**		
	12248		**12250**	
Number of data pairs	**93**		**93**	
Slope b	**0.901**		**0.830**	
Uncertainty of b	**0.023**		**0.024**	
Ordinate intercept a	**1.294**		**1.385**	
Uncertainty of a	**0.246**		**0.251**	
Expanded meas. uncertainty W_{CM}	**14.15**	**%**	**26.40**	**%**
Bonn				
Uncertainty between Reference	**0.80**	**µg/m³**		
Uncertainty between Candidates	**0.31**	**µg/m³**		
	12248		**12250**	
Number of data pairs	**54**		**54**	
Slope b	**0.993**		**0.948**	
Uncertainty of b	**0.045**		**0.043**	
Ordinate intercept a	**-0.234**		**-0.216**	
Uncertainty of a	**0.441**		**0.421**	
Expanded meas. uncertainty W_{CM}	**9.10**	**%**	**14.39**	**%**
All comparisons				
Uncertainty between Reference	**0.51**	**µg/m³**		
Uncertainty between Candidates	**0.41**	**µg/m³**		
	12248		**12250**	
Number of data pairs	**363**		**363**	
Slope b	**0.993**	**not significant**	**0.933**	**significant**
Uncertainty of b	**0.012**		**0.012**	
Ordinate intercept a	**0.235**	**not significant**	**0.289**	**significant**
Uncertainty of a	**0.129**		**0.126**	
Expanded meas. uncertainty W_{CM}	**8.39**	**%**	**14.03**	**%**

Table 28: Overview of equivalence testing, PM_{10}

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	Fidas Smart System		SN	12248 & 12250	
			Limit value	50	µg/m³
Status of measured values	Raw data		Allowed uncertainty	25	%
All comparisons					
Uncertainty between Reference	**0.63**	**µg/m³**			
Uncertainty between Candidates	**0.64**	**µg/m³**			
	12248 & 12250				
Number of data pairs	**433**				
Slope b	**0.899**	significant			
Uncertainty of b	**0.012**				
Ordinate intercept a	**0.712**	significant			
Uncertainty of a	**0.218**				
Expanded measured uncertainty WCM	**19.17**	**%**			

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	Fidas Smart System		SN	12248 & 12250	
			Limit value	50	µg/m³
Status of measured values	Raw data		Allowed uncertainty	25	%
Cologne I					
Uncertainty between Reference	**0.26**	**µg/m³**			
Uncertainty between Candidates	**0.47**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**53**			**53**	
Slope b	**0.996**			**0.957**	
Uncertainty of b	**0.027**			**0.023**	
Ordinate intercept a	**-1.144**			**-0.735**	
Uncertainty of a	**0.576**			**0.498**	
Expanded measured uncertainty W_{CM}	**11.01**	%		**14.23**	%
Niederzier I					
Uncertainty between Reference	**0.65**	**µg/m³**			
Uncertainty between Candidates	**0.62**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**59**			**59**	
Slope b	**0.922**			**0.874**	
Uncertainty of b	**0.025**			**0.024**	
Ordinate intercept a	**0.976**			**1.266**	
Uncertainty of a	**0.518**			**0.500**	
Expanded measured uncertainty W_{CM}	**13.62**	%		**21.20**	%
Cologne II					
Uncertainty between Reference	**0.50**	**µg/m³**			
Uncertainty between Candidates	**0.38**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**117**			**117**	
Slope b	**0.927**			**0.870**	
Uncertainty of b	**0.028**			**0.025**	
Ordinate intercept a	**0.769**			**1.061**	
Uncertainty of a	**0.357**			**0.315**	
Expanded measured uncertainty W_{CM}	**12.51**	%		**22.06**	%
Bornheim					
Uncertainty between Reference	**0.69**	**µg/m³**			
Uncertainty between Candidates	**0.47**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**83**			**83**	
Slope b	**0.912**			**0.870**	
Uncertainty of b	**0.047**			**0.048**	
Ordinate intercept a	**0.721**			**1.007**	
Uncertainty of a	**0.853**			**0.858**	
Expanded measured uncertainty W_{CM}	**19.37**	%		**25.35**	%
Bonn					
Uncertainty between Reference	**0.50**	**µg/m³**			
Uncertainty between Candidates	**0.45**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**54**			**54**	
Slope b	**0.797**			**0.759**	
Uncertainty of b	**0.039**			**0.034**	
Ordinate intercept a	**1.934**			**2.404**	
Uncertainty of a	**0.651**			**0.562**	
Expanded measured uncertainty W_{CM}	**33.68**	%		**39.18**	%
Niederzier II					
Uncertainty between Reference	**0.94**	**µg/m³**			
Uncertainty between Candidates	**1.23**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**67**			**67**	
Slope b	**0.885**			**0.811**	
Uncertainty of b	**0.026**			**0.025**	
Ordinate intercept a	**1.638**			**1.469**	
Uncertainty of a	**0.547**			**0.532**	
Expanded measured uncertainty W_{CM}	**18.16**	%		**32.76**	%
All comparisons					
Uncertainty between Reference	**0.63**	**µg/m³**			
Uncertainty between Candidates	**0.64**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**433**			**433**	
Slope b	**0.927**	**significant**		**0.874**	**significant**
Uncertainty of b	**0.012**			**0.012**	
Ordinate intercept a	**0.556**	**significant**		**0.847**	**significant**
Uncertainty of a	**0.225**			**0.215**	
Expanded measured uncertainty W_{CM}	**15.15**	%		**23.39**	%

Results for testing the five criteria from chapter 6.1 Method used for equivalence testing were as follows:

Criterion 1: More than 32 value pairs were greater than 17 µg/m³ ($PM_{2.5}$) or 28 µg/m³ (PM_{10}).

Criterion 2: Between-AMS uncertainty of the AMS tested did not exceed 2.5 µg/m³.

Criterion 3: Uncertainty between reference instruments did not exceed 2.0 µg/m³.

Criterion 4: Not all expanded uncertainties were below 25%.

Criterion 5: In a test candidate, the slope and the intercept were significantly larger than allowed when evaluating the total data set.

Further: There is a slope of 0.963 ($PM_{2.5}$) or 0.899 (PM_{10}) and an intercept of 0.263 ($PM_{2.5}$) or 0.712 (PM_{10}) for the total data set for both test candidates together at an expanded total uncertainty of 10.03% ($PM_{2.5}$) and 19.17% (PM_{10}).

The result was that for both $PM_{2.5}$ and PM_{10} the intercept was significantly different from 0 and the slope was significantly different from 1. Therefore, an additional assessment was carried out as in chapter "6.1 17 Application of correction factors/terms" by applying the corresponding calibration factor to the data sets.

6.6 Detailed presentation of test results

Table 29 provides an overview of the between-RM uncertainties $u_{bs,RM}$ determined during the field tests.

Table 29: Between RM uncertainty $u_{bs,RM}$, $PM_{2.5}$

Reference instruments	**Location**	**Number of measurements**	**Uncertainty $u_{bs,RM}$**
No.			µg/m³
1 / 2	Cologne I	44	0.33
1 / 2	Niederzier I	57	0.38
1 / 2	Cologne II	115	0.45
1 / 2	Bornheim	93	0.47
1 / 2	Bonn	54	0.80
1 / 2	All locations	363	0.51

Table 30: Between RM uncertainty $u_{bs,RM}$, PM_{10}

Reference instruments	**Location**	**Number of measurements**	**Uncertainty $u_{bs,RM}$**
No.			µg/m³
1 / 2	Cologne I	53	0.26
1 / 2	Niederzier I	59	0.65
1 / 2	Cologne II	117	0.50
1 / 2	Bornheim	83	0.69
1 / 2	Bonn	54	0.50
1 / 2	Niederzier II	67	0.94
1 / 2	All locations	433	0.63

At all sites, between-RM uncertainty $u_{bs,RM}$ was < 2.0 µg/m³.

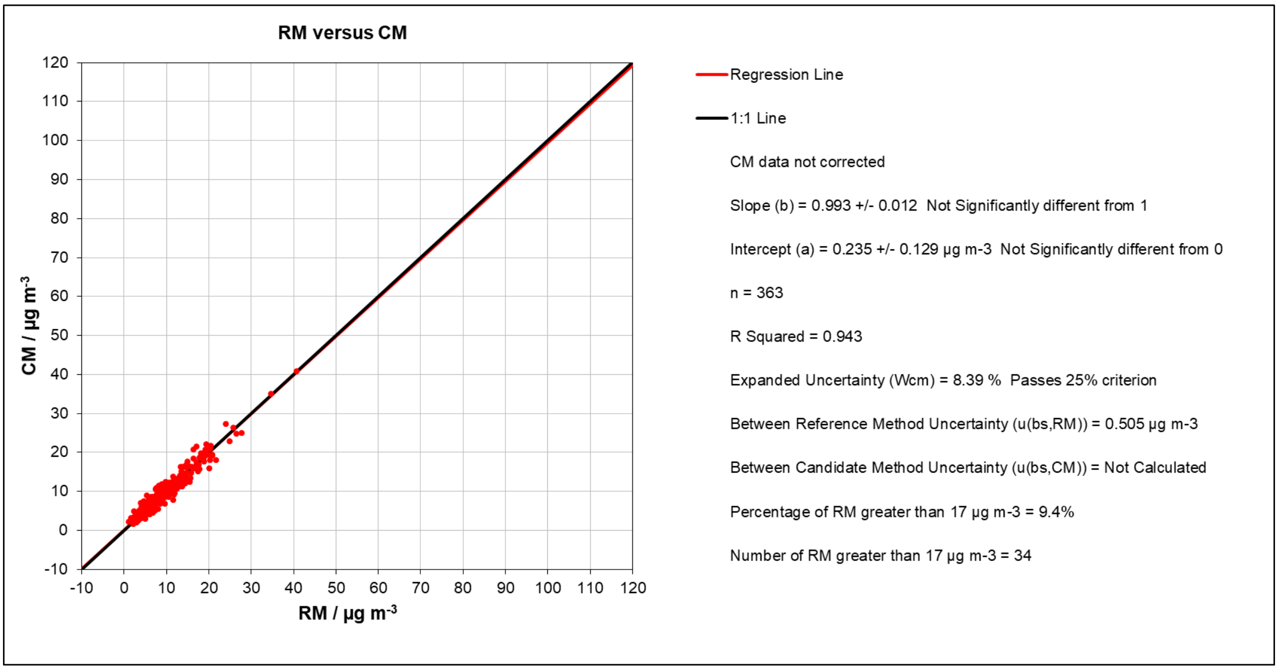

Figure 39: Reference vs. tested instrument, SN 12248, all sites, $PM_{2.5}$

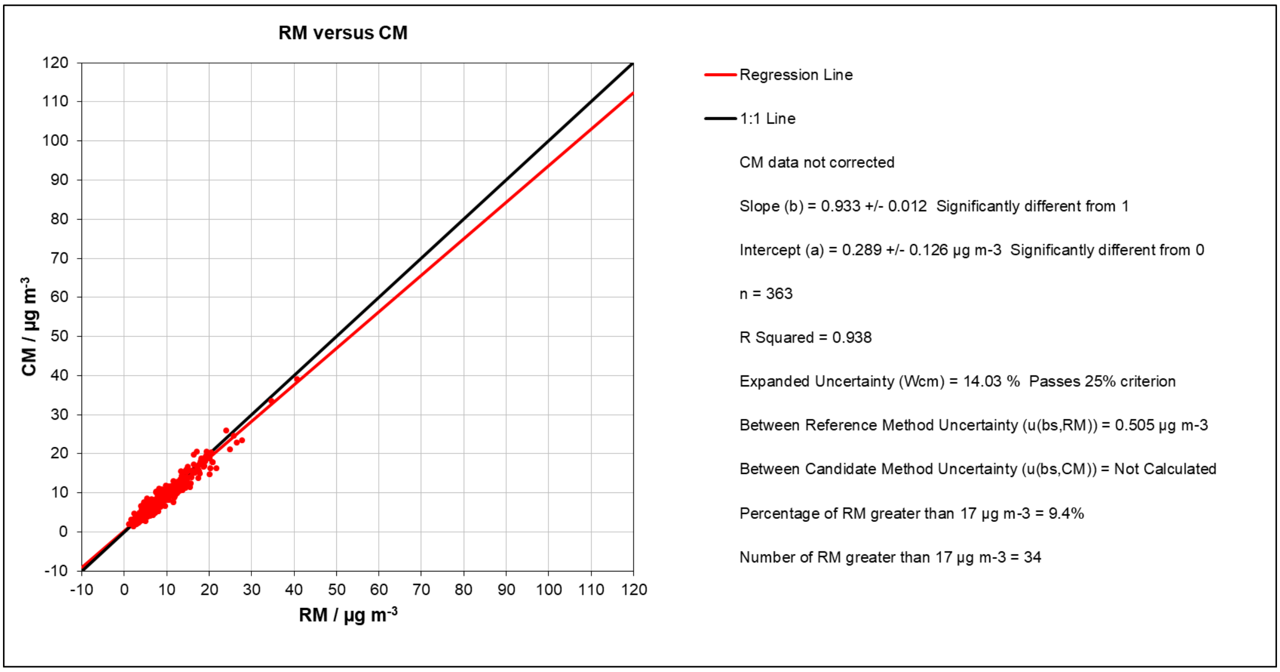

Figure 40: Reference vs. tested instrument, SN 12250, all sites, $PM_{2.5}$

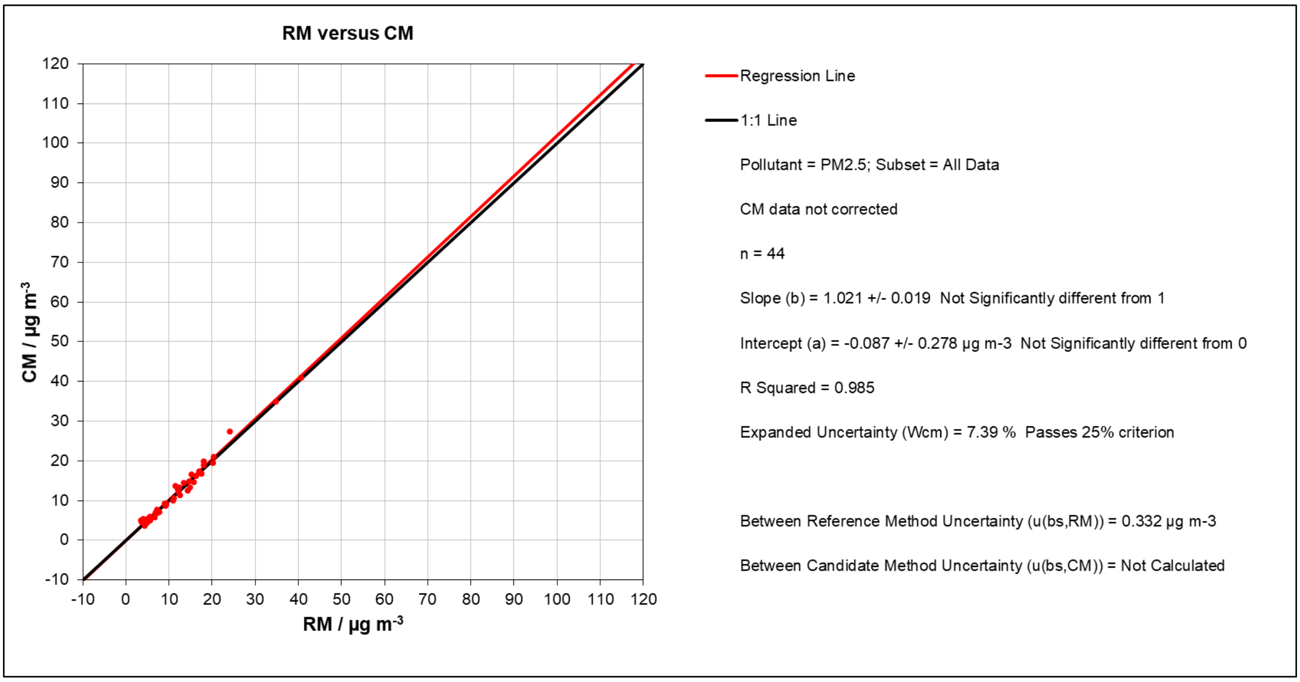

Figure 41: Reference vs. tested instrument, SN 12248, Cologne I, $PM_{2.5}$

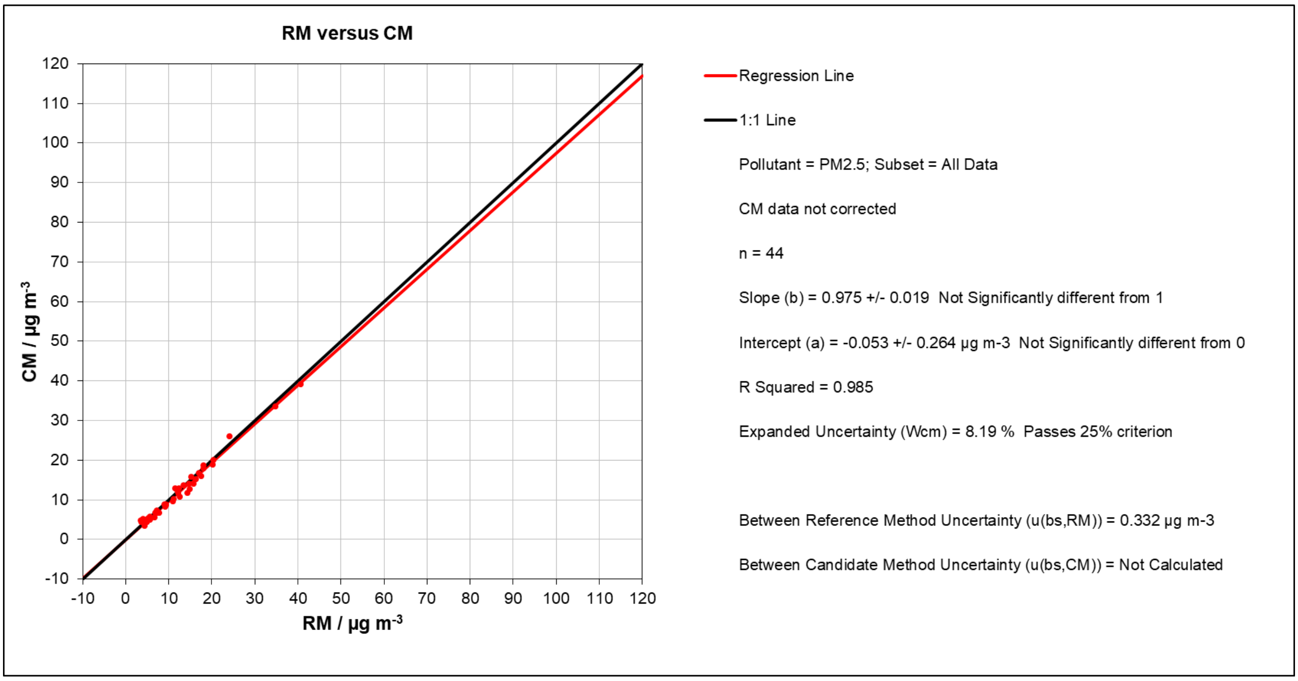

Figure 42: Reference vs. tested instrument, SN 12250, Cologne I, $PM_{2.5}$

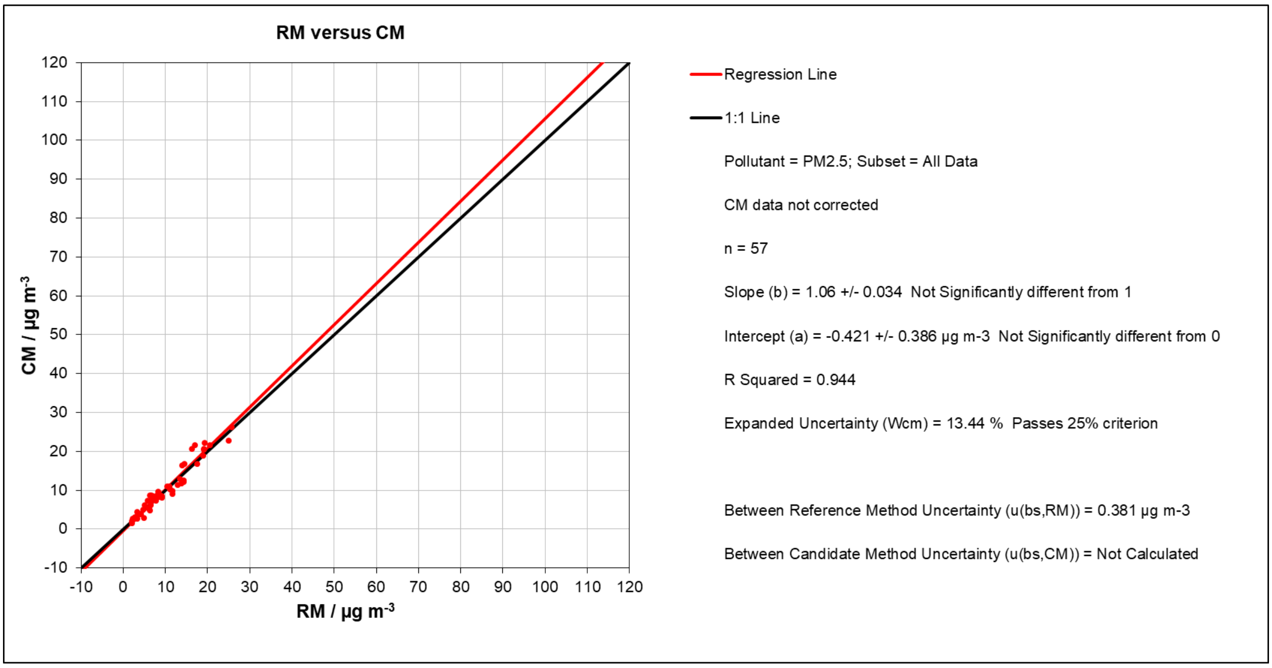

Figure 43: Reference vs. tested instrument, SN 12248, Niederzier I, $PM_{2.5}$

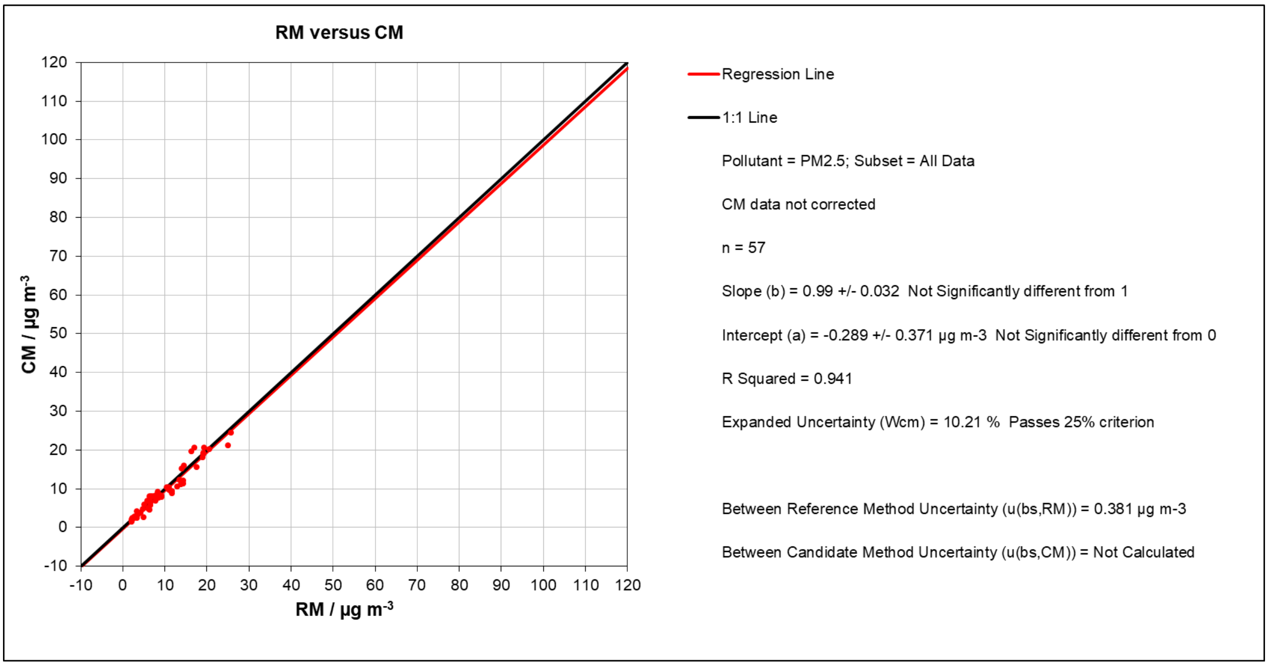

Figure 44: Reference vs. tested instrument, SN 12250, Niederzier I, $PM_{2.5}$

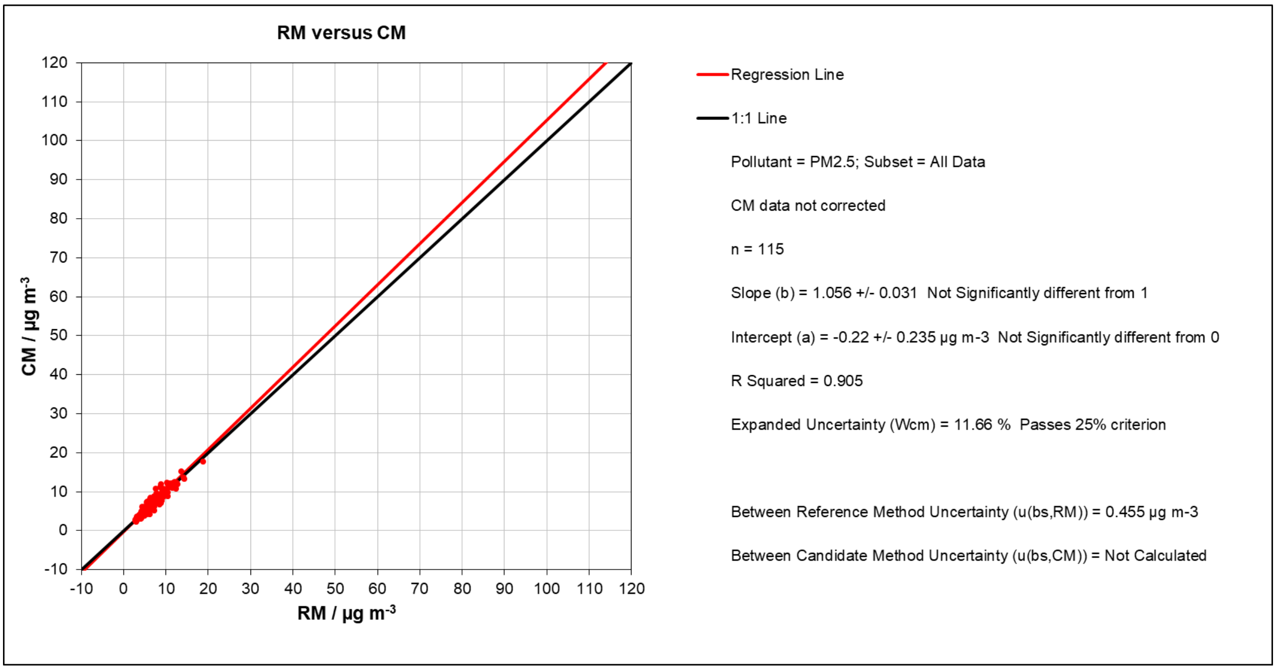

Figure 45: Reference vs. tested instrument, SN 12248, Cologne II, $PM_{2.5}$

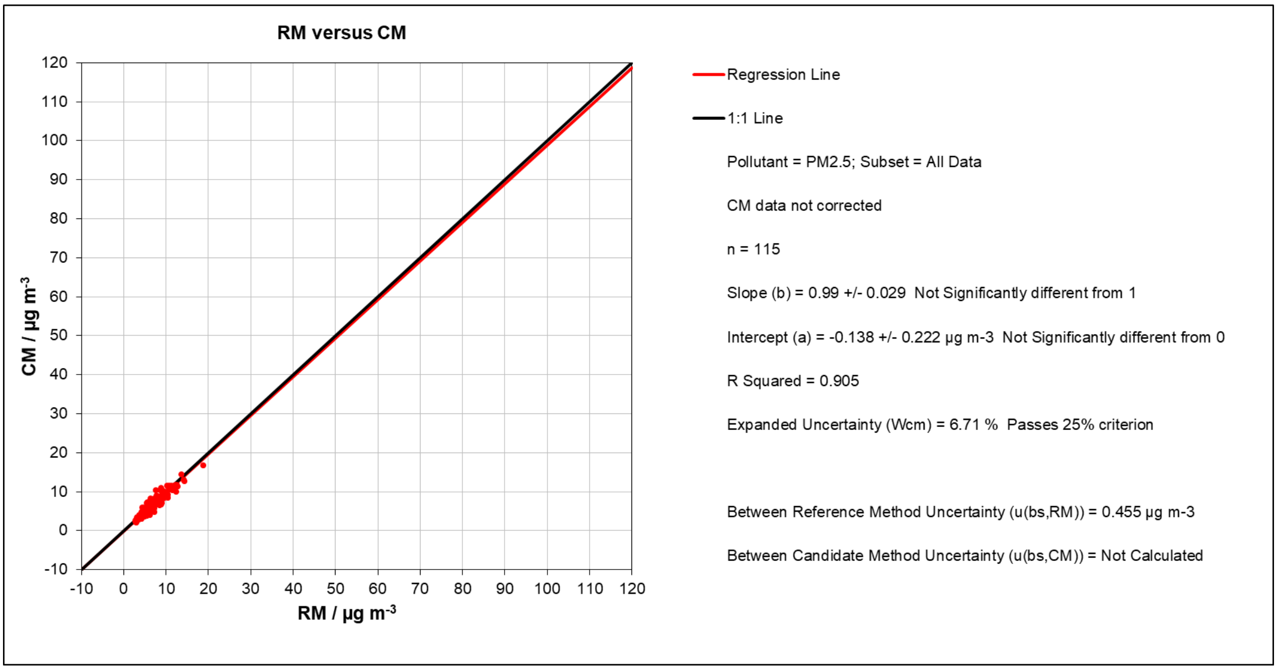

Figure 46: Reference vs. tested instrument, SN 12250, Cologne II, $PM_{2.5}$

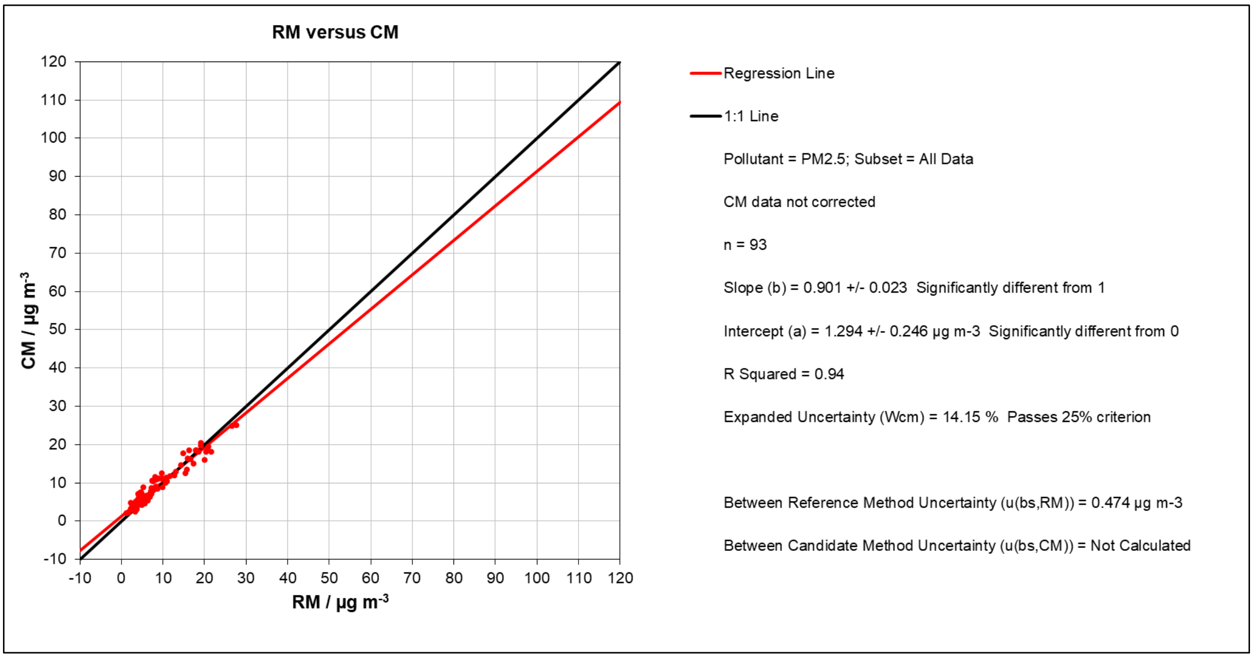

Figure 47: Reference vs. tested instrument, SN 12248, Bornheim, $PM_{2.5}$

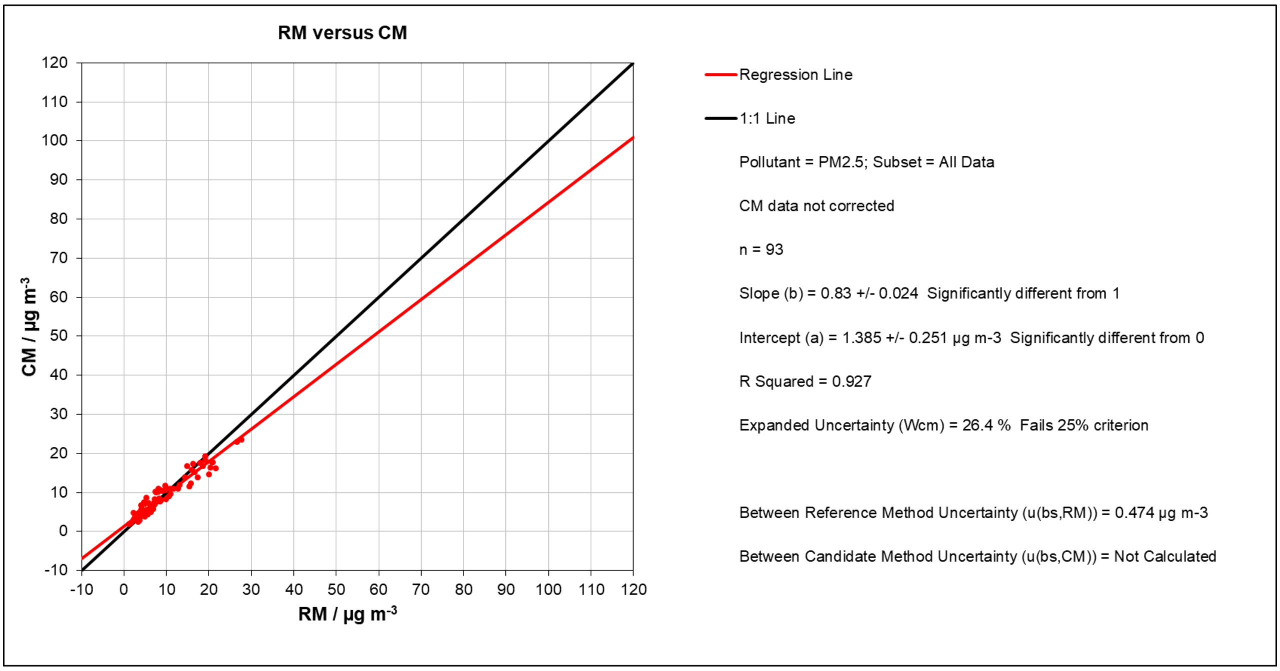

Figure 48: Reference vs. tested instrument, SN 12250, Bornheim, $PM_{2.5}$

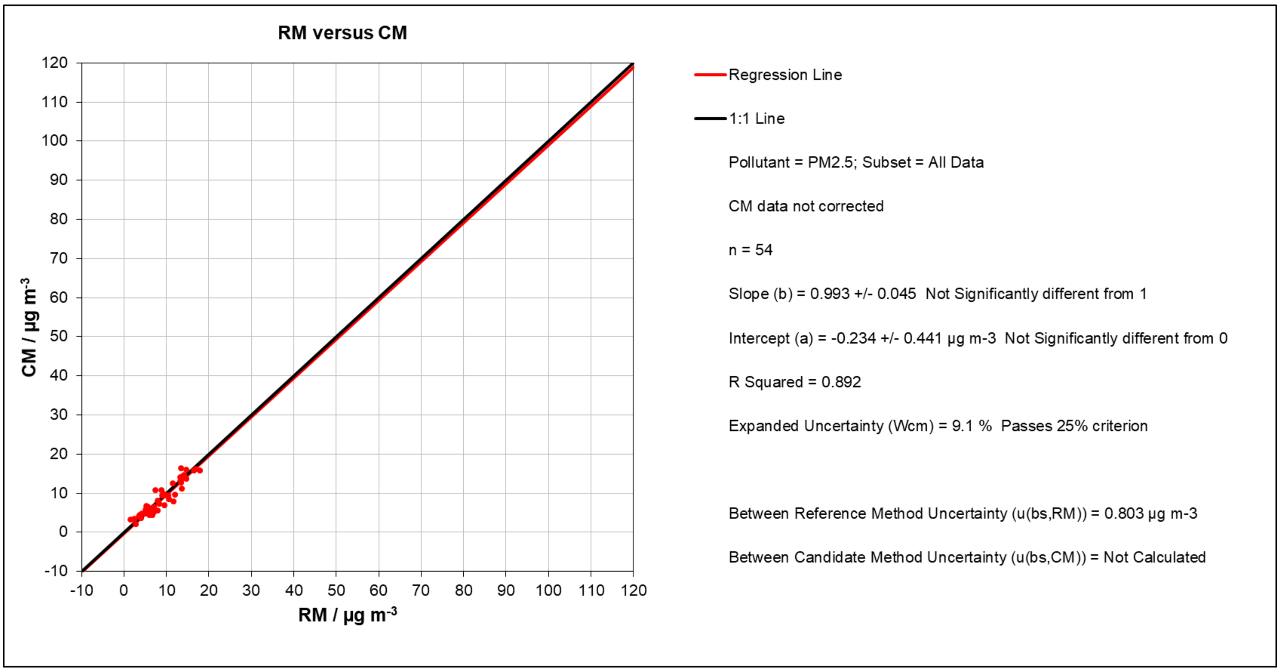

Figure 49: Reference vs. tested instrument, SN 12248, Bonn, $PM_{2.5}$

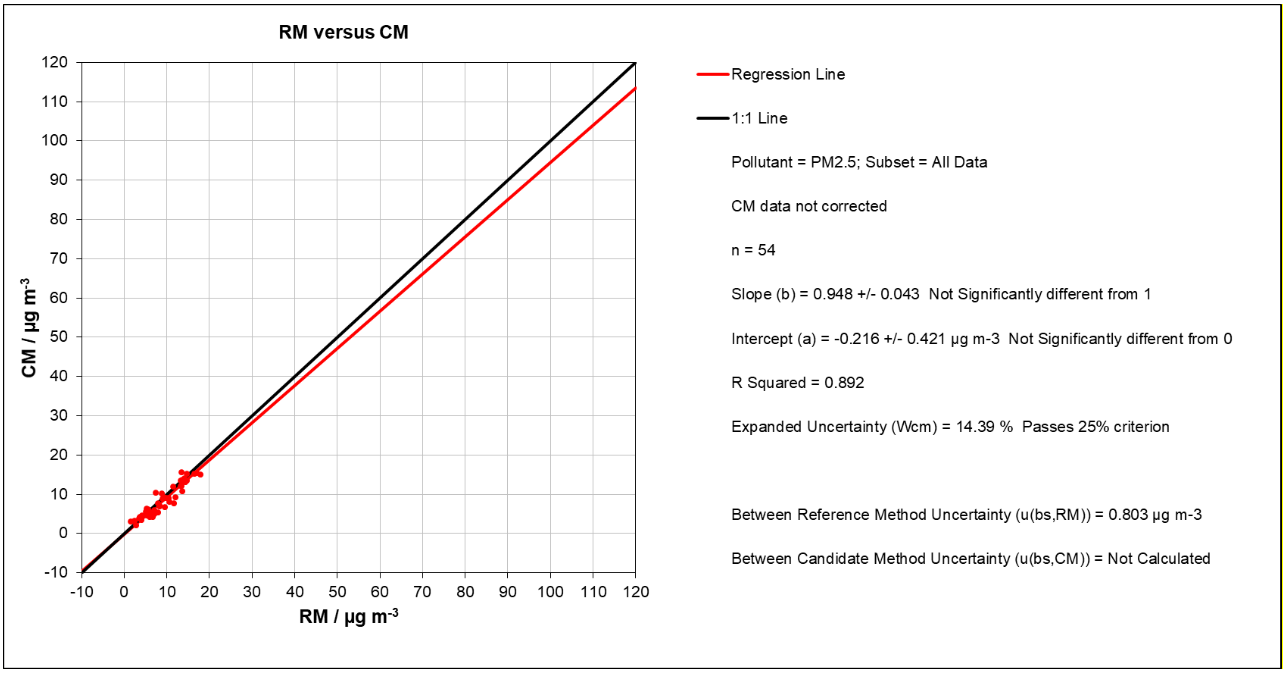

Figure 50: Reference vs. tested instrument, SN 12250, Bonn, $PM_{2.5}$

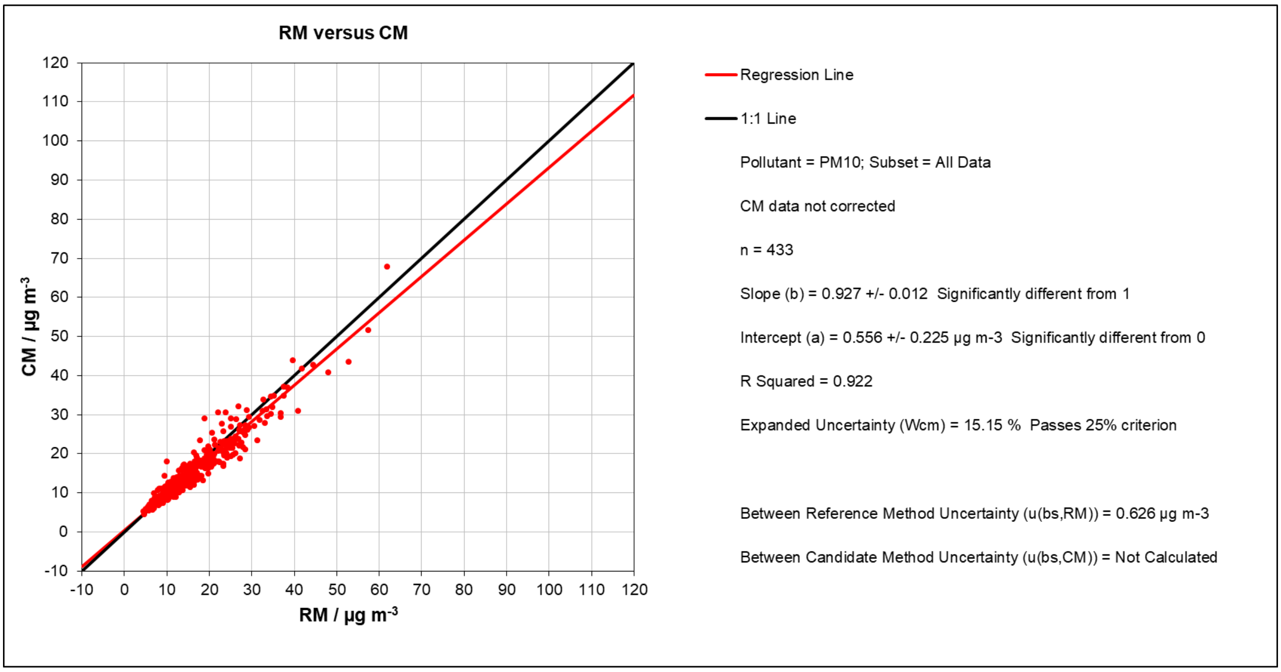

Figure 51: Reference vs. tested instrument, SN 12248, all sites, PM_{10}

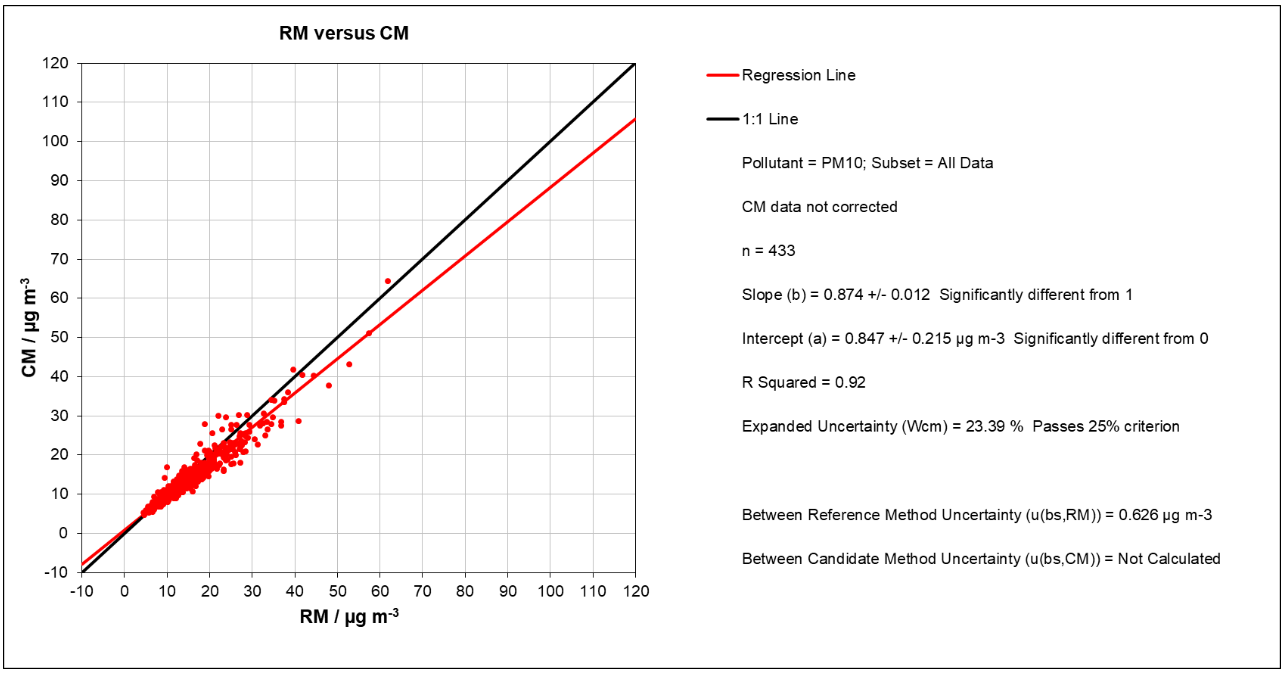

Figure 52: Reference vs. tested instrument, SN 12250, all sites, PM_{10}

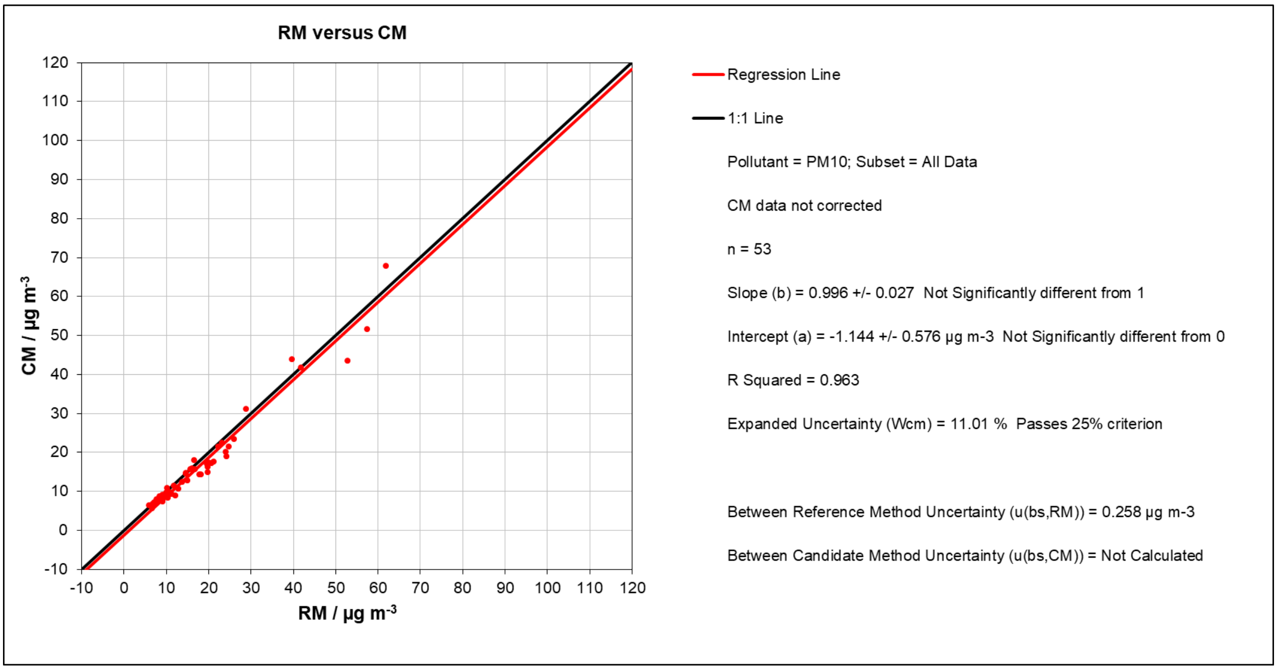

Figure 53: Reference vs. tested instrument, SN 12248, Cologne I, PM_{10}

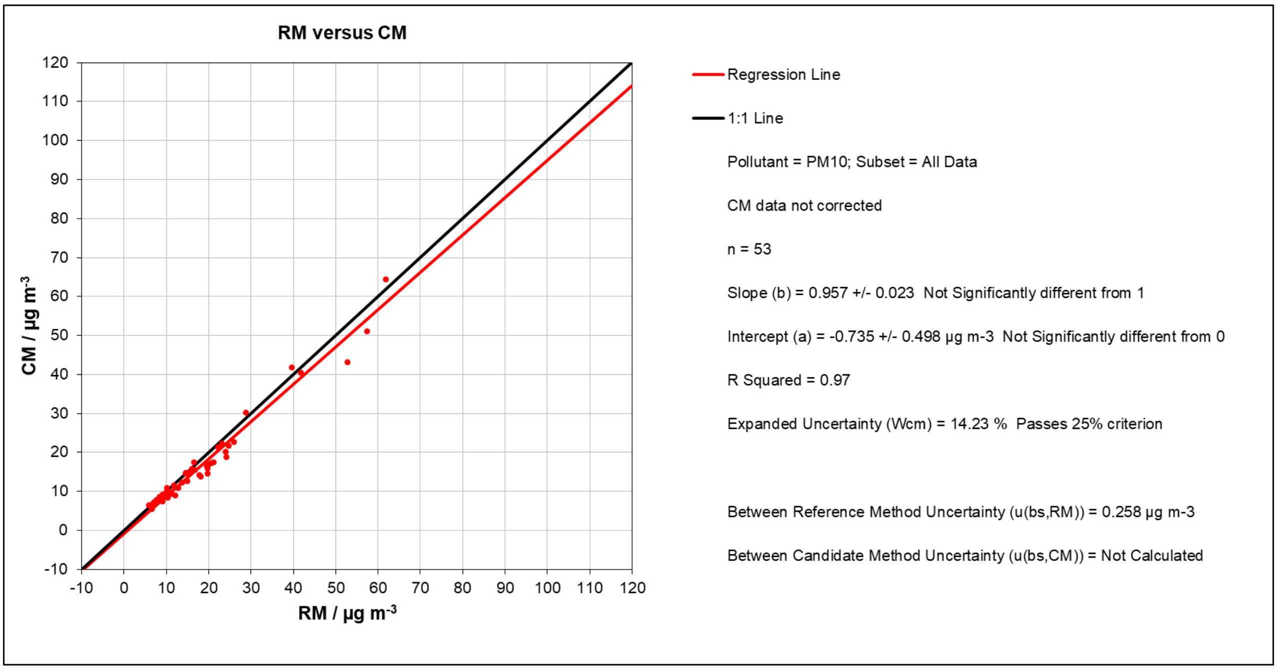

Figure 54: Reference vs. tested instrument, SN 12250, Cologne I, PM_{10}

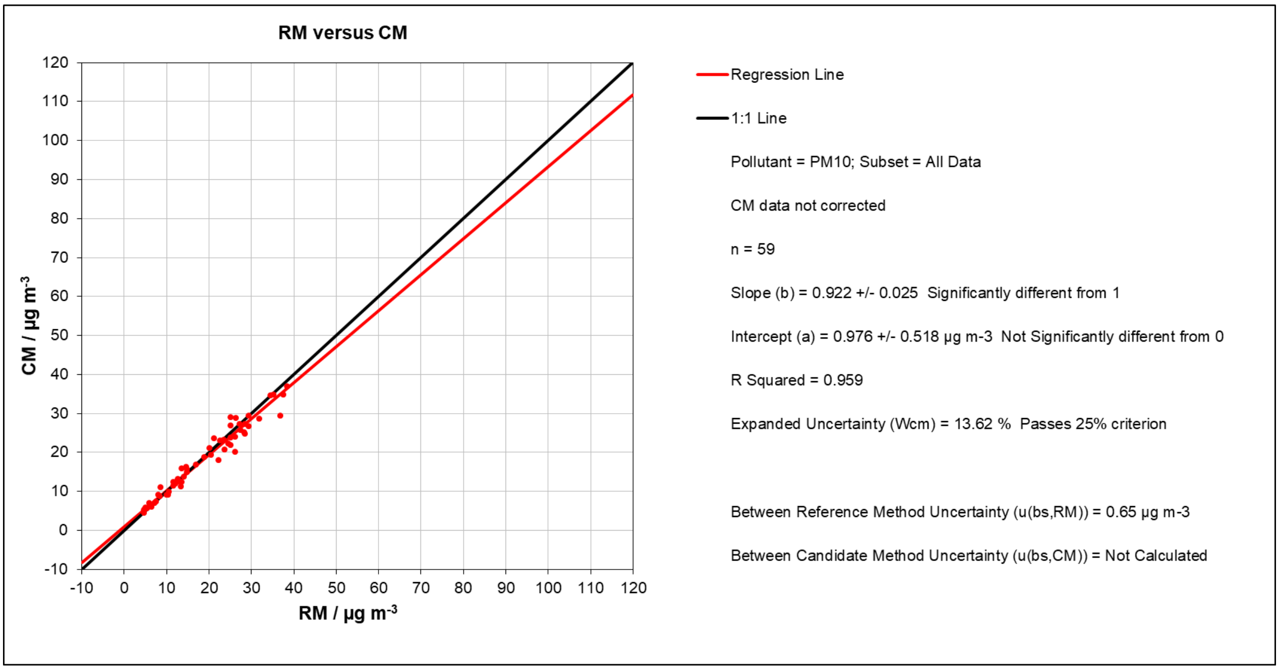

Figure 55: Reference vs. tested instrument, SN 12248, Niederzier I, PM_{10}

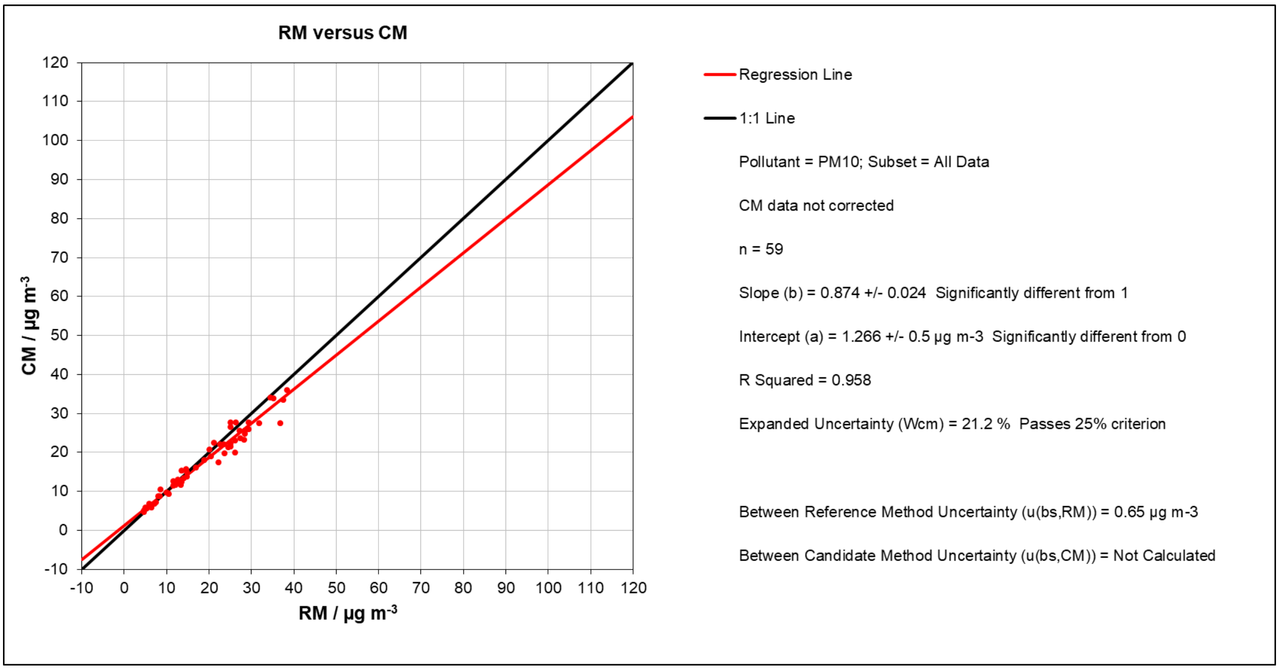

Figure 56: Reference vs. tested instrument, SN 12250, Niederzier I, PM_{10}

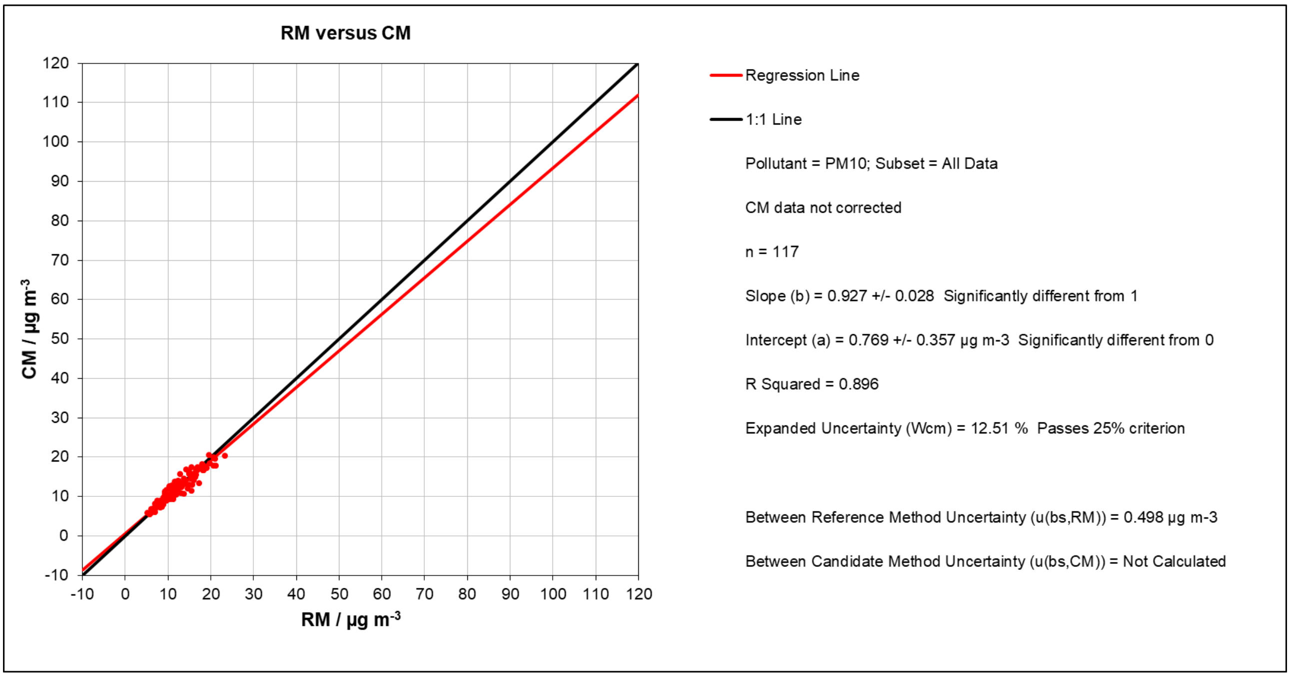

Figure 57: Reference vs. tested instrument, SN 12248, Cologne II, PM_{10}

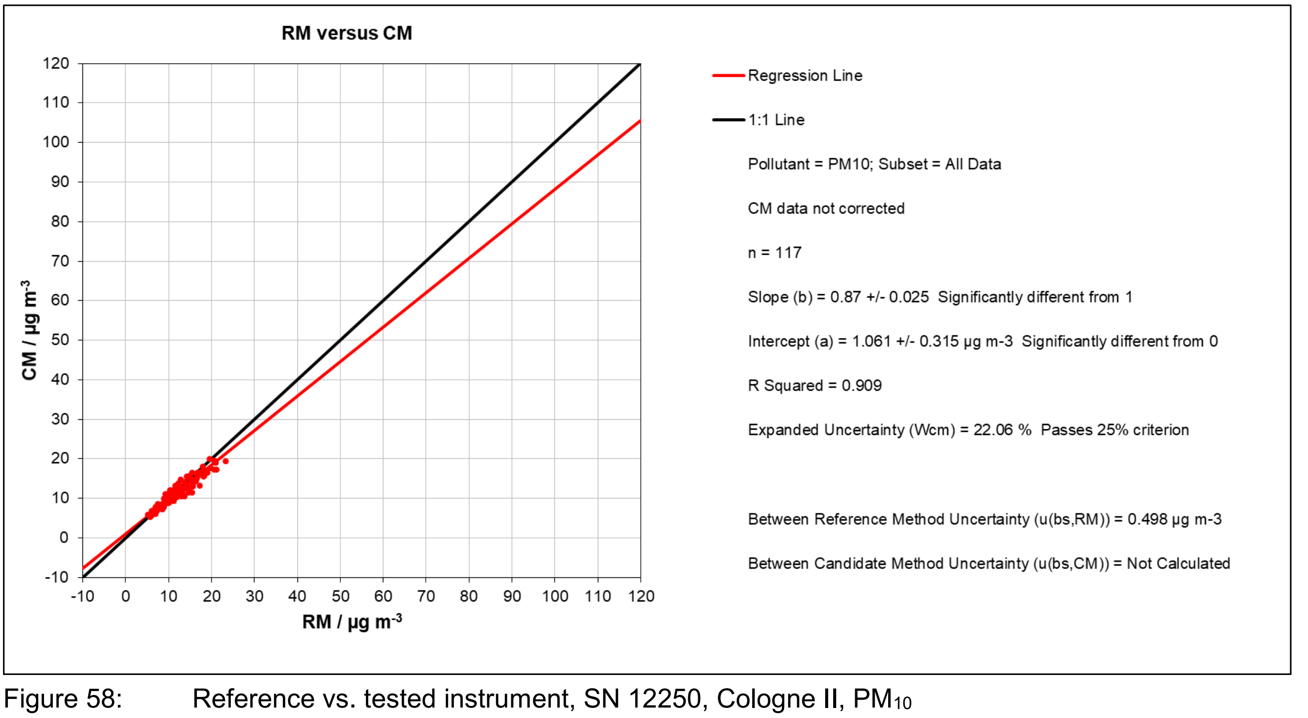

Figure 58: Reference vs. tested instrument, SN 12250, Cologne II, PM_{10}

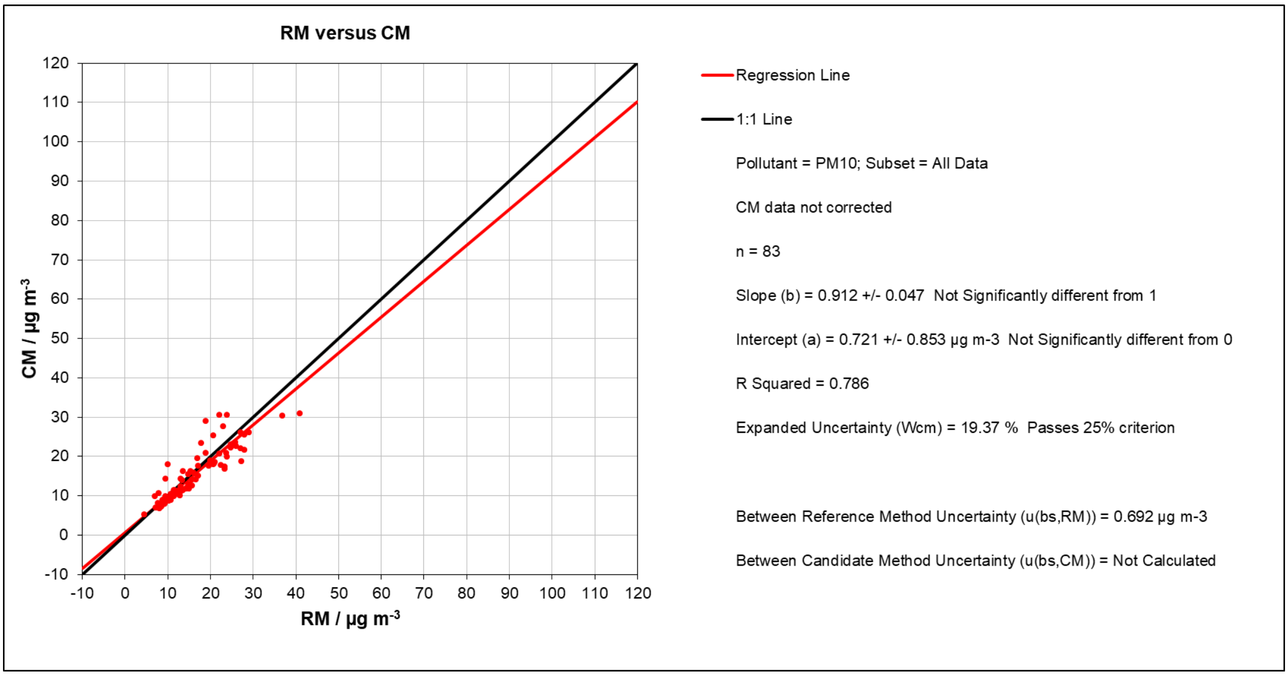

Figure 59: Reference vs. tested instrument, SN 12248, Bornheim, PM_{10}

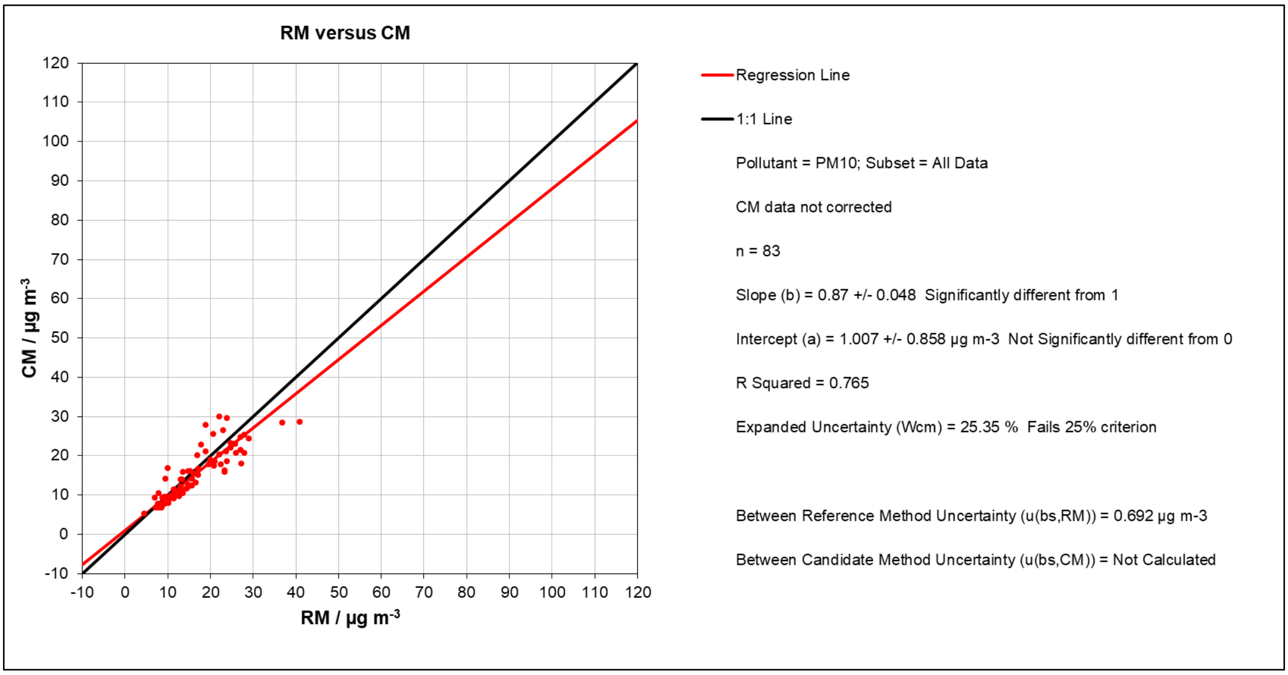

Figure 60: Reference vs. tested instrument, SN 12250, Bornheim, PM_{10}

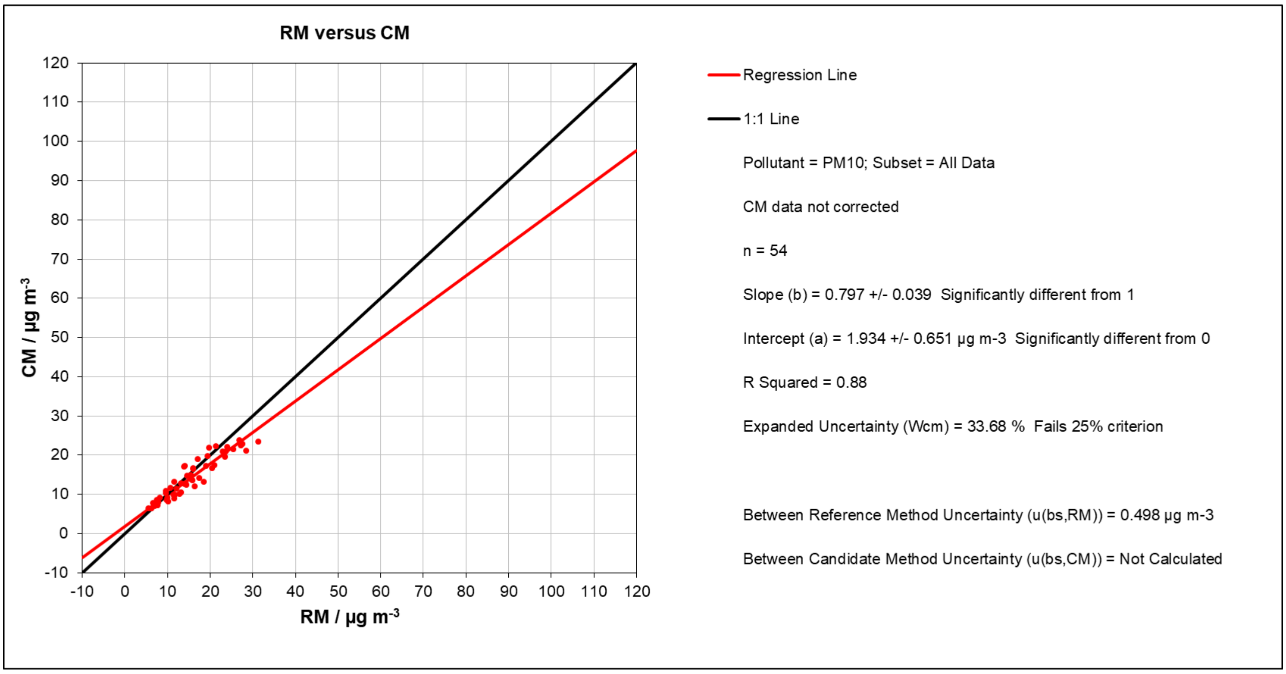

Figure 61: Reference vs. tested instrument, SN 12248, Bonn, PM_{10}

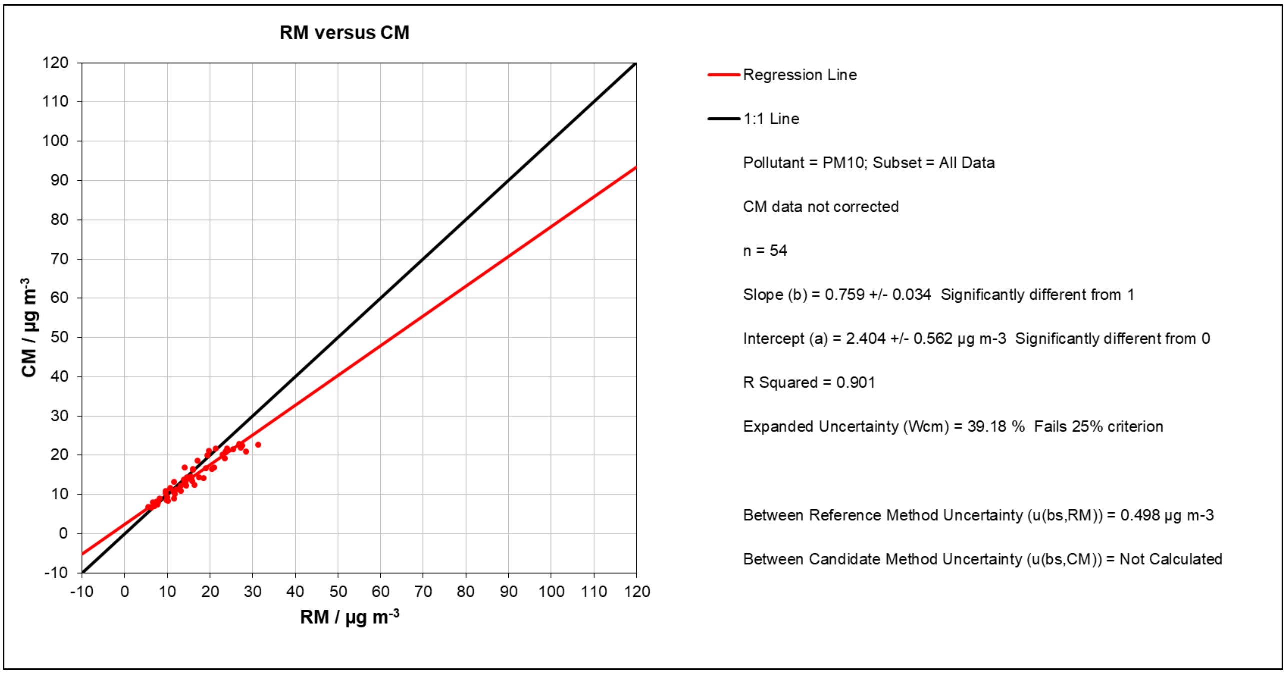

Figure 62: Reference vs. tested instrument, SN 12250, Bonn, PM_{10}

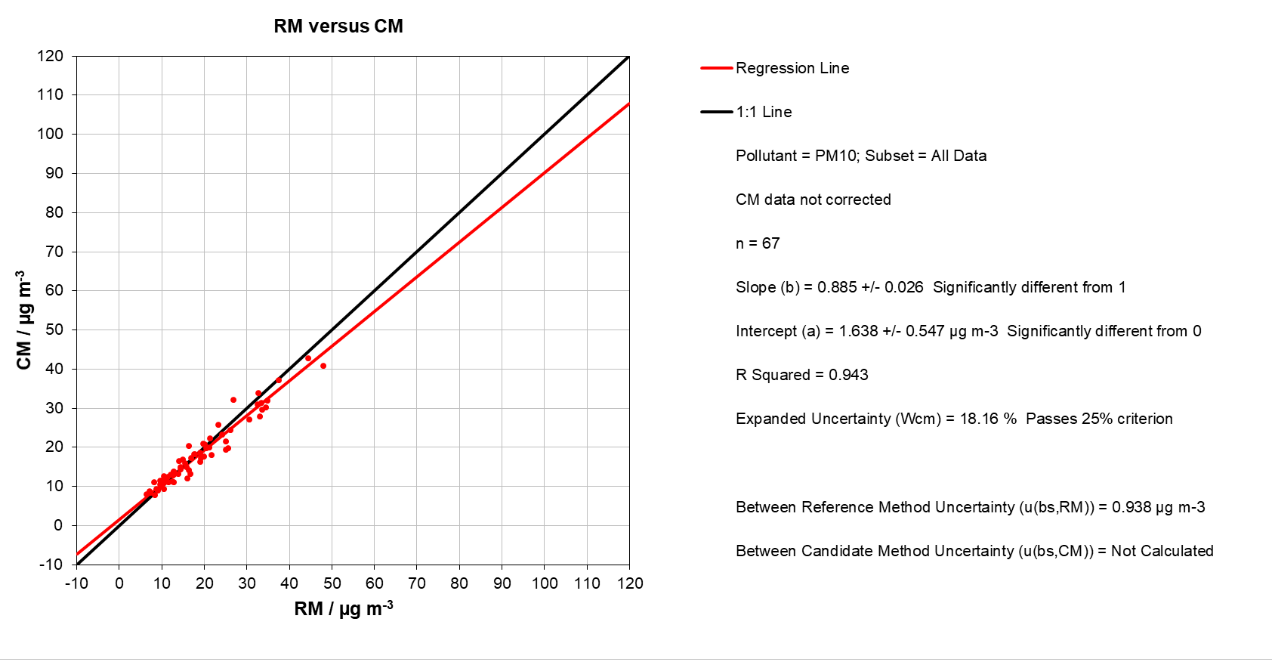

Figure 63: Reference vs. tested instrument, SN 12248, Niederzier II, PM_{10}

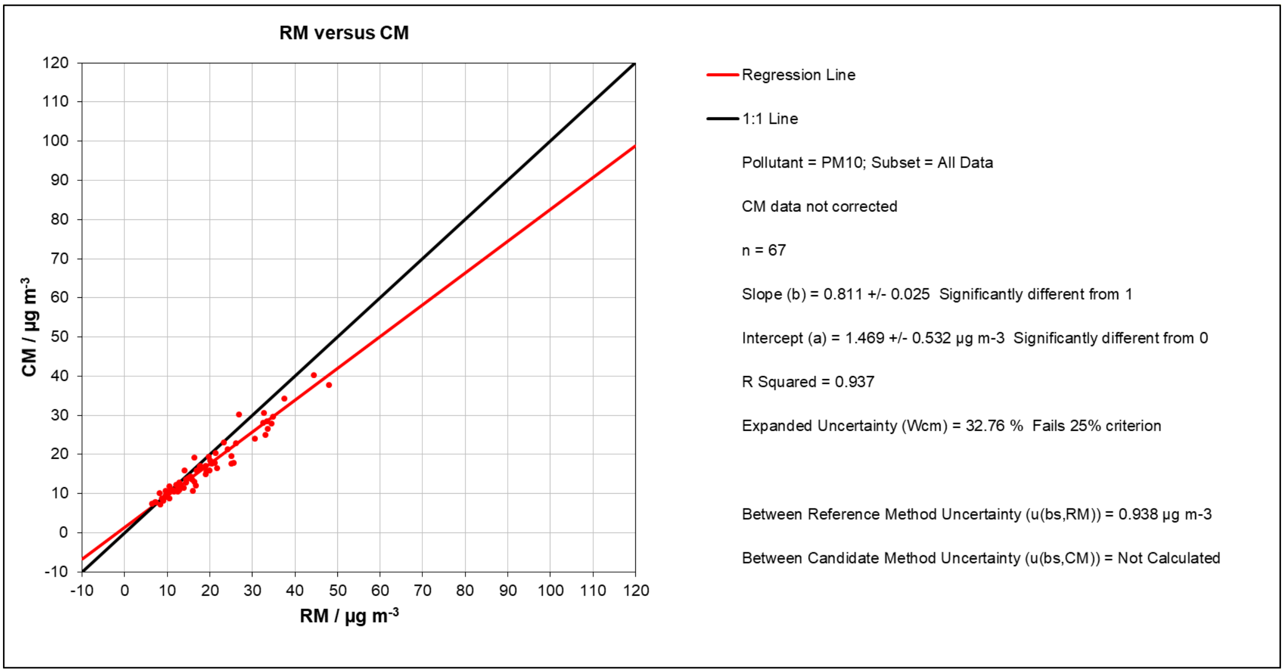

Figure 64: Reference vs. tested instrument, SN 12250, Niederzier II, PM_{10}

6.1 17 Use of correction factors/terms (7.5.8.5–7.5.8.8)

Correction factors/terms (=calibration) shall be applied if the highest expanded uncertainty calculated for the tested instruments exceeds the relative expanded uncertainty specified under the requirements for data quality or the test demonstrates that the slope is significantly different from 1 and/or the ordinate intercept is significantly different from 0.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

See section
6.1 17 Expanded uncertainty (7.5.8.5 – 7.5.8.8)

6.4 Evaluation

If it emerges from the evaluation of raw data in accordance with 6.1. 17 Expanded uncertainty of AMS results (7.5.8.5–7.5.8.8) that $W_{AMS} > W_{dqo}$, (i.e. AMS uncertainty > 25%) i.e. the tested instrument is not found to be equivalent with the reference method, then it is permissible to use a correction factor or term which results from the regression equation for <u>the full data set</u>. The corrected values have to meet the requirements for all data sets or sub data sets. Moreover, a correction may also be used for the case that $W_{AMS} \le W_{dqo}$ in order to improve the accuracy of the tested instruments.

Three different situations may occur:

a) Slope b is not significantly different from 1: $|b-1| \le 2u(b)$
Axis intercept a is significantly different from 0: $|a| > 2u(a)$

b) Slope b is significantly different from 1: $|b-1| > 2u(b)$
Axis intercept a is not significantly different from 0: $|a| \le 2u(a)$

b) Slope b is significantly different from 1: $|b-1| > 2u(b)$
Axis intercept a is significantly different from 0: $|a| > 2u(a)$

concerning a)

The value of the axis intercept a may be used as a correction term to correct all input values y_i according to the following equation:

$$y_{i,corr} = y_i - a$$

The corrected values $y_{i,corr}$ may then serve to calculate the following new terms using linear regression:

$$y_{i,corr} = c + dx_i$$

and

$$u_{yi,corr}^2 = \frac{RSS}{(n-2)} - u_{RM}{}^2 + \left[c + (d-1)L\right]^2 + u^2(a)$$

where u(a) = uncertainty of the axis intercept a, whose value was used to determine $y_{i,corr}$.

The algorithms for calculating axis intercepts and slopes as well as their variance by means of orthogonal regression are described in detail in annex B to [4].

concerning b)

The value of the slope b may be used as a correction term to correct all input values y_i according to the following equation:

$$y_{i,corr} = \frac{y_i}{b}$$

The corrected values $y_{i,corr}$ may then serve to calculate the following new terms using a new linear regression:

$$y_{i,corr} = c + dx_i$$

and

$$u^2_{yi,corr} = \frac{RSS}{(n-2)} - u_{RM}{}^2 + [c + (d-1)L]^2 + L^2 u^2(b)$$

where u(b) = uncertainty of the original slope b, whose value was used to determine $y_{i,corr}$.

The algorithms for calculating axis intercepts and slopes as well as their variance by means of orthogonal regression are described in detail in annex B to [9].

concerning c)

The values of the slope b and the axis intercept a may be used as correction terms to correct all input values y_i according to the following equation:

$$y_{i,corr} = \frac{y_i - a}{b}$$

The corrected values $y_{i,corr}$ may then serve to calculate the following new terms using a new linear regression:

$$y_{i,corr} = c + dx_i$$

and

$$u^2_{yi,corr} = \frac{RSS}{(n-2)} - u_{RM}{}^2 + [c + (d-1)L]^2 + L^2 u^2(b) + u^2(a)$$

where u(b) = uncertainty of the original slope b, whose value was used to determine $y_{i,corr}$ and u(a) = uncertainty of the original axis intercept a, whose value was used to determine $y_{i,corr}$.

The algorithms for calculating axis intercepts and slopes as well as their variance by means of orthogonal regression are described in detail in annex B to [4].

The values for $u_{c\_s,corr}$ are then used to calculate the combined relative uncertainty of the AMS after correction in accordance with the following equation:

$$w^2_{AMS,corr} = \frac{u^2_{corr,yi=L}}{L^2}$$

The uncertainty $w_{AMS,corr}$ for the corrected data set is calculated at the 24h limit value using y_i as concentration at the limit value.

The relative expanded uncertainty $W_{AMS,corr}$ is calculated using the following equation:

$$W_{AMS',corr} = k \cdot w_{AMS,corr}$$

Considering the large number of available test results, an expansion factor k=2 must be used.

The largest resulting uncertainty $W_{AMS,corr}$ is compared and assessed against the criteria for data quality of air quality measurements in accordance with EU Directive [8]. Two situations are conceivable:

1. $W_{AMS,corr} \leq W_{dqo}$ → The tested instrument is deemed equivalent to the reference method.
2. $W_{AMS,corr} > W_{dqo}$ → The tested instrument is not deemed equivalent to the reference method.

The expanded relative uncertainty W_{dqo} specified is 25%.

6.5 Assessment

After the use of correction factors, the candidate systems met the requirements for data quality of air quality monitors for all data sets.

Criterion satisfied? yes

The analysis of the total data set shows that for both $PM_{2.5}$ and PM_{10} the intercept is significantly different from 0 and the slope is significantly different from 1.

An axis intercept and slope correction of the entire data set (for each of $PM_{2.5}$ and PM_{10}) was performed and all data sets were re-evaluated using the corrected values.

All data sets meet the data quality requirements after correction.

When a measuring system is operated in the context of a measurement grid, the January 2010 version of the Guideline and standard EN 16450 require that the instruments are tested annually at a number of sites which in turn depends on the highest expanded uncertainty determined during equivalence testing. The criterion used for specifying the number of sites for annual testing is grouped into 5% steps (Guideline [9], Chapter 9.9.2, Table 6 and/or EN 16450 [4], Chapter 8.6.2, Table 5). It should be noted that the highest expanded uncertainty determined after applying the correction was in the range 20% to 25%.

The monitoring network operator or the competent authority of a member state is responsible for compliant implementation of the requirements for regular tests as described above. However, TÜV Rheinland recommends that the expanded uncertainty of the total data set (of all data) be used for this purpose, in this case 10.03 % ($PM_{2.5}$) and 19.17 % (PM_{10}) (uncorrected data set) and 9.01 % ($PM_{2.5}$) and % 9.71 (PM_{10}) (data set after axis intercept correction), respectively, which would require annual verification at 2 measurement locations.

6.6 Detailed presentation of test results

Table 31 and Table 32 show the evaluation results of the equivalence test after applying the correction factor to the full data set.

Table 31: Summary of equivalence test results after intercept and slope correction, $PM_{2.5}$

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	Fidas Smart System		SN	12248 & 12250	
			Limit value	30	µg/m³
Status of measured values	Data corrected		Allowed uncertainty	25	%
All comparisons					
Uncertainty between Reference	**0.51**	**µg/m³**			
Uncertainty between Candidates	**0.43**	**µg/m³**			
	12248 & 12250				
Number of data pairs	**363**				
Slope b	**1.001**	**not significant**			
Uncertainty of b	**0.013**				
Ordinate intercept a	**-0.010**	**not significant**			
Uncertainty of a	**0.132**				
Expanded meas. uncertainty W_{CM}	**9.01**	**%**			

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	Fidas Smart System		SN	12248 & 12250	
			Limit value	30	µg/m³
Status of measured values	Data corrected		Allowed uncertainty	25	%
Cologne I					
Uncertainty between Reference	**0.33**	**µg/m³**			
Uncertainty between Candidates	**0.45**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**44**			**44**	
Slope b	**1.061**			**1.012**	
Uncertainty of b	**0.020**			**0.019**	
Ordinate intercept a	**-0.367**			**-0.332**	
Uncertainty of a	**0.288**			**0.275**	
Expanded meas. uncertainty W_{CM}	**12.06**	**%**		**6.89**	**%**
Niederzier I					
Uncertainty between Reference	**0.38**	**µg/m³**			
Uncertainty between Candidates	**0.51**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**57**			**57**	
Slope b	**1.102**			**1.030**	
Uncertainty of b	**0.035**			**0.034**	
Ordinate intercept a	**-0.722**			**-0.584**	
Uncertainty of a	**0.401**			**0.385**	
Expanded meas. uncertainty W_{CM}	**18.79**	**%**		**10.36**	**%**
Cologne II					
Uncertainty between Reference	**0.45**	**µg/m³**			
Uncertainty between Candidates	**0.32**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**115**			**115**	
Slope b	**1.099**			**1.030**	
Uncertainty of b	**0.032**			**0.030**	
Ordinate intercept a	**-0.517**			**-0.431**	
Uncertainty of a	**0.244**			**0.230**	
Expanded meas. uncertainty W_{CM}	**17.82**	**%**		**7.55**	**%**
Bornheim					
Uncertainty between Reference	**0.47**	**µg/m³**			
Uncertainty between Candidates	**0.54**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**93**			**93**	
Slope b	**0.937**			**0.863**	
Uncertainty of b	**0.024**			**0.025**	
Ordinate intercept a	**1.061**			**1.155**	
Uncertainty of a	**0.256**			**0.261**	
Expanded meas. uncertainty W_{CM}	**10.99**	**%**		**21.98**	**%**
Bonn					
Uncertainty between Reference	**0.80**	**µg/m³**			
Uncertainty between Candidates	**0.32**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**54**			**54**	
Slope b	**1.034**			**0.987**	
Uncertainty of b	**0.047**			**0.045**	
Ordinate intercept a	**-0.536**			**-0.516**	
Uncertainty of a	**0.458**			**0.437**	
Expanded meas. uncertainty W_{CM}	**9.95**	**%**		**10.84**	**%**
All comparisons					
Uncertainty between Reference	**0.51**	**µg/m³**			
Uncertainty between Candidates	**0.43**	**µg/m³**			
	12248			**12250**	
Number of data pairs	**363**			**363**	
Slope b	**1.032**	significant		**0.971**	significant
Uncertainty of b	**0.013**			**0.013**	
Ordinate intercept a	**-0.039**	**not significant**		**0.017**	**not significant**
Uncertainty of a	**0.134**			**0.131**	
Expanded meas. uncertainty W_{CM}	**10.99**	**%**		**10.64**	**%**

Table 32: Summary of equivalence test results after intercept and slope correction, PM_{10}

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	Fidas Smart System		SN	12248 & 12250	
			Limit value	50	µg/m³
Status of measured values	Corrected data		Allowed uncertainty	25	%
All comparisons					
Uncertainty between Reference	**0.63**	**µg/m³**			
Uncertainty between Candidates	**0.71**	**µg/m³**			
	12248 & 12250				
Number of data pairs	**433**				
Slope b	**1.004**	**not significant**			
Uncertainty of b	**0.013**				
Ordinate intercept a	**-0.069**	**not significant**			
Uncertainty of a	**0.242**				
Expanded measured uncertainty WCM	**9.71**	**%**			

Comparison candidate with reference according to Standard EN 16450:2017				
Candidate	Fidas Smart System	SN	12248 & 12250	
		Limit value	50	µg/m^3
Status of measured values	Corrected data	Allowed uncertainty	25	%
Cologne I				
Uncertainty between Reference	**0.26**	**µg/m^3**		
Uncertainty between Candidates	**0.52**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**53**		**53**	
Slope b	**1.109**		**1.066**	
Uncertainty of b	**0.030**		**0.026**	
Ordinate intercept a	**-2.102**		**-1.639**	
Uncertainty of a	**0.640**		**0.554**	
Expanded measured uncertainty W_{CM}	**17.41**	**%**	**11.61**	**%**
Niederzier I				
Uncertainty between Reference	**0.65**	**µg/m^3**		
Uncertainty between Candidates	**0.69**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**59**		**59**	
Slope b	**1.028**		**0.974**	
Uncertainty of b	**0.028**		**0.027**	
Ordinate intercept a	**0.251**		**0.574**	
Uncertainty of a	**0.575**		**0.555**	
Expanded measured uncertainty W_{CM}	**10.55**	**%**	**8.52**	**%**
Cologne II				
Uncertainty between Reference	**0.50**	**µg/m^3**		
Uncertainty between Candidates	**0.42**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**117**		**117**	
Slope b	**1.037**		**0.973**	
Uncertainty of b	**0.031**		**0.027**	
Ordinate intercept a	**-0.011**		**0.327**	
Uncertainty of a	**0.397**		**0.350**	
Expanded measured uncertainty W_{CM}	**9.43**	**%**	**6.77**	**%**
Bornheim				
Uncertainty between Reference	**0.69**	**µg/m^3**		
Uncertainty between Candidates	**0.52**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**83**		**83**	
Slope b	**1.028**		**0.982**	
Uncertainty of b	**0.053**		**0.053**	
Ordinate intercept a	**-0.218**		**0.086**	
Uncertainty of a	**0.948**		**0.954**	
Expanded measured uncertainty W_{CM}	**15.07**	**%**	**14.80**	**%**
Bonn				
Uncertainty between Reference	**0.50**	**µg/m^3**		
Uncertainty between Candidates	**0.50**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**54**		**54**	
Slope b	**0.892**		**0.848**	
Uncertainty of b	**0.043**		**0.037**	
Ordinate intercept a	**1.265**		**1.810**	
Uncertainty of a	**0.723**		**0.625**	
Expanded measured uncertainty W_{CM}	**18.62**	**%**	**24.36**	**%**
Niederzier II				
Uncertainty between Reference	**0.94**	**µg/m^3**		
Uncertainty between Candidates	**1.37**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**67**		**67**	
Slope b	**0.987**		**0.905**	
Uncertainty of b	**0.029**		**0.028**	
Ordinate intercept a	**0.972**		**0.784**	
Uncertainty of a	**0.608**		**0.592**	
Expanded measured uncertainty W_{CM}	**9.06**	**%**	**18.14**	**%**
All comparisons				
Uncertainty between Reference	**0.63**	**µg/m^3**		
Uncertainty between Candidates	**0.71**	**µg/m^3**		
	12248		**12250**	
Number of data pairs	**433**		**433**	
Slope b	**1.035**	**significant**	**0.976**	**not significant**
Uncertainty of b	**0.014**		**0.013**	
Ordinate intercept a	**-0.246**	**not significant**	**0.081**	**not significant**
Uncertainty of a	**0.250**		**0.239**	
Expanded measured uncertainty W_{CM}	**11.64**	**%**	**10.60**	**%**

6.1 18 Maintenance interval (7.5.7)

The maintenance interval of the AMS shall be at least 14 days.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

The maintenance interval is the longest time period without intervention as recommended by the manufacturer. The relevant body shall ensure that during this period the AMS does not need any maintenance or adjustment.

6.4 Evaluation

The manufacturer has prepared a maintenance plan for this measuring system. The shortest maintenance interval is 1 year (check with Monodust 1500 and check volume flow).

Please note: The European standard EN 16450 [4] contains more extensive requirements for the necessary frequency of calibrations, tests and maintenance work. This may make it necessary to check the AMS more frequently.

6.5 Assessment

The maintenance interval is 1 year.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Chapter 6.1 of the manual lists the necessary maintenance work.

6.1 19 Automatic diagnostic check (7.5.4)

Automatic checks must be possible.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

The current operating status of the measuring system is continuously monitored and any issues will be flagged via a series of different error messages. The current state of monitored parameters can be displayed on the instrument itself and is recorded as part of data logging. An error message is flagged if performance characteristics are outside the permissible range of tolerance.

6.4 Evaluation

The instrument provides all features described in the operation manual. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages. Data recording includes all monitored parameters.

6.5 Assessment

The instrument provides all features described in the operation manual. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages. Data recording includes all monitored parameters.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Chapter 5 of the manual describes all possible alarms and status codes.

6.1 20 Checks of temperature sensors, pressure and/or humidity sensors

The verifiability of temperature sensors, pressure and/or humidity sensors shall be checked for the AMS. Deviations determined shall be within the following criteria:
T ±2 °C
p ±1 kPa
rF ± 5 %

6.2 Equipment

Barometer, thermometer and hygrometer.

6.3 Testing

This minimum requirement serves to verify whether AMS sensors for temperature, pressure and humidity, which are necessary for correct AMS performance, are accessible and can be checked at the field test site location. In the event, checks cannot be performed on site, this has to be documented. AMS sensors were checked at the beginning and at the end of each field test.

6.4 Evaluation

The AMS uses a combined weather sensor to record the outside temperature and the relative humidity. In the Fidas Smart 100 variant, this is mounted directly on the inlet of the housing ventilation. Since the housing is continuously ventilated, the sensor is permanently supplied with fresh air. In the Fidas Smart 100 E variant, this sensor is mounted on the sampling tube below the sampling head.

The air pressure is measured in the unit for both variants.

Relying on transfer standards, it is easily possible to perform comparison measurements on site at any time and to adjust the sensors. The sensors' deviations remained within the required ranges.

6.5 Assessment

It is possible to check and adjust the sensors for determining ambient temperature, ambient pressure and relative humidity on site. The sensors' deviations remained within the required ranges.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

7. Recommendations for use in practice

7.1 Work in the maintenance interval

The tested measuring systems require regular performance of the following tasks:

Every year:

- Clean the sample inlet
- Test the power supply
- Check sensors for temperature, pressure and moisture
- Check the volume flow
- Calibrate sensors for temperature, pressure and moisture
- Calibrate the throughput
- Leak test
- Check zero measurements

Further details can be found in chapter 6 of the user manual.

Please note: The European standard EN 16450 [4] contains more extensive requirements for the necessary frequency of calibrations, tests and maintenance work. EN 16450 [4] , section 8.2.4 requires the status readings of operational parameters to be checked daily (on working days). The volume flow and the sensors for temperature, pressure and humidity must be checked every 3 months.

Environmental Protection/Air Pollution Control

Dipl.-Ing. Guido Baum	Dipl.-Ing. Fritz Hausberg

Cologne, 15 September 2022
936/21250983/B

8. Bibliography

[1] VDI Standard 4202, part 3, “Automated measuring systems for air quality monitoring - Performance test, declaration of suitability and certification of measuring systems for point-related measurement of mass concentration for particulate air pollutants”, February 2019

[2] VDI standard 4203, part 1, “Automated measuring systems and data evaluation systems for emission monitoring – Performance test, declaration of suitability and certification of stationary automated measuring systems and check of the quality management system of the manufacturer”, July 2017

[3] European standard EN 12341, “Ambient air - Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2,5}$ mass concentration of suspended particulate matter”; German version EN 12341:2014

[4] European standard EN 16450 “Ambient air – Automated measuring systems for the measurement of the concentration of particulate matter” (PM10; PM2.5, German version dated July 2017)

[5] Guideline “Demonstration of Equivalence of Ambient Air Monitoring Methods”, English version dated January 2010

[6] Operating manual - Fidas Smart System, V1.0_09/22

[7] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

9. Appendices

Appendix 1 Measured and calculated values

- Annex 1: Zero level and detection limit
- Annex 2: Flow rate accuracy
- Annex 3: Temperature dependence of the zero point and sensitivity
- Annex 4: Independence of supply voltage
- Annex 5: Measured values from the field test sites

Appendix 2: Methods used for filter weighing

Appendix 3 CE Certificate and Certificate of Accreditation

Appendix 4: Operation manual

Annex 1 **Detection limit** **Page 1 of 2**

Manufacturer Palas GmbH

Type Fidas Smart 100

Standards ZP Zero filter

Serial-No. 12248 / 12250

No.	Date	Measured values [µg/m³] 12248	Date	Measured values [µg/m³] 12250
1	10/27/2020	0.0	10/27/2020	0.0
2	10/28/2020	0.0	10/28/2020	0.0
3	10/29/2020	0.0	10/29/2020	0.0
4	10/30/2020	0.0	10/30/2020	0.0
5	10/31/2020	0.0	10/31/2020	0.0
6	11/1/2020	0.0	11/1/2020	0.0
7	11/2/2020	0.0	11/2/2020	0.0
8	11/3/2020	0.0	11/3/2020	0.0
9	11/4/2020	0.0	11/4/2020	0.0
10	11/5/2020	0.0	11/5/2020	0.0
11	11/6/2020	0.0	11/6/2020	0.0
12	11/7/2020	0.0	11/7/2020	0.0
13	11/8/2020	0.0	11/8/2020	0.0
14	11/9/2020	0.0	11/9/2020	0.0
15	11/10/2020	0.0	11/10/2020	0.0
	No. of values	15	No. of values	15
	Mean	0.00	Mean	0.00
	Standard deviation s_{x0}	0.00	Standard deviation s_{x0}	0.00
	Detection limit x	0.00	Detection limit x	0.00

$$s_{xo} = \sqrt{\left(\frac{1}{n-1}\right) \cdot \sum_{i=1,n} (x_{0i} - \overline{x}_0)^2}$$

Annex 1 **Detection limit** **Page 2 of 2**

Manufacturer Palas GmbH

Type Fidas Smart 100

Standards ZP Zero filter

Serial-No. 12248 / 12250

No.	Date	Measured values [µg/m³] 12248	Date	Measured values [µg/m³] 12250
1	10/27/2020	0.0	10/27/2020	0.0
2	10/28/2020	0.0	10/28/2020	0.0
3	10/29/2020	0.0	10/29/2020	0.0
4	10/30/2020	0.0	10/30/2020	0.0
5	10/31/2020	0.0	10/31/2020	0.0
6	11/1/2020	0.0	11/1/2020	0.0
7	11/2/2020	0.0	11/2/2020	0.0
8	11/3/2020	0.0	11/3/2020	0.0
9	11/4/2020	0.0	11/4/2020	0.0
10	11/5/2020	0.0	11/5/2020	0.0
11	11/6/2020	0.0	11/6/2020	0.0
12	11/7/2020	0.0	11/7/2020	0.0
13	11/8/2020	0.0	11/8/2020	0.0
14	11/9/2020	0.0	11/9/2020	0.0
15	11/10/2020	0.0	11/10/2020	0.0
	No. of values	15	No. of values	15
	Mean	0.00	Mean	0.00
	Standard deviation s_{x0}	0.00	Standard deviation s_{x0}	0.00
	Detection limit x	0.00	Detection limit x	0.00

$$s_{xo} = \sqrt{\left(\frac{1}{n-1}\right) \cdot \sum_{i=1,n} (x_{0i} - \overline{x_0})^2}$$

Annex 2 **Flow rate accuracy** **Page 1 of 1**

Manufacturer: Palas GmbH

Type: Fidas Smart 100

Serial-No.: 12248 / 12250

Nominal flow rate [l/min]: 1

		12248			12250		
Temperature 1	-20°C	No.	Date/Time	Measured value [l/min]	No.	Date/Time	Measured value [l/min]
		1	12/17/2020 8:10	1.00	1	12/17/2020 8:15	16.35
		2	12/17/2020 8:20	1.02	2	12/17/2020 8:25	16.41
		3	12/17/2020 8:30	1.02	3	12/17/2020 8:35	16.44
		4	12/17/2020 8:40	1.00	4	12/17/2020 8:45	16.39
		5	12/17/2020 8:50	1.01	5	12/17/2020 8:55	16.42
		6	12/17/2020 9:00	1.03	6	12/17/2020 9:05	16.36
		7	12/17/2020 9:10	1.05	7	12/17/2020 9:15	16.33
		8	12/17/2020 9:20	1.06	8	12/17/2020 9:25	16.44
		9	12/17/2020 9:30	1.07	9	12/17/2020 9:35	16.38
		10	12/17/2020 9:40	1.07	10	12/17/2020 9:45	16.41
			Mean	**1.03**		**Mean**	**16.39**

		12248			12250		
Temperature 2	50°C	No.	Date/Time	Measured value [l/min]	No.	Date/Time	Measured value [l/min]
		1	12/17/2020 15:30	1.04	1	12/17/2020 15:35	16.58
		2	12/17/2020 15:40	1.04	2	12/17/2020 15:45	16.52
		3	12/17/2020 15:50	1.04	3	12/17/2020 15:55	16.60
		4	12/17/2020 16:00	1.04	4	12/17/2020 16:05	16.61
		5	12/17/2020 16:10	1.04	5	12/17/2020 16:15	16.78
		6	12/17/2020 16:20	1.04	6	12/17/2020 16:25	16.82
		7	12/17/2020 16:30	1.04	7	12/17/2020 16:35	16.95
		8	12/17/2020 16:40	1.04	8	12/17/2020 16:45	16.87
		9	12/17/2020 16:50	1.04	9	12/17/2020 16:55	16.61
		10	12/17/2020 17:00	1.05	10	12/17/2020 17:05	16.60
			Mean	**1.04**		**Mean**	**16.69**

Annex 3 — Dependence of zero point on surrounding temperature for $PM_{2.5}$ — Page 1 of 4

Manufacturer: Palas GmbH

Type: Fidas Smart 100

Serial-No.: SN 12248 / SN 12250

SN 12248	No.	Temperature [°C]	Measurement 1 Measured value [µg/m³]	Measurement 2 Measured value [µg/m³]	Measurement 3 Measured value [µg/m³]	Mean value of 3 measurements [µg/m³]	Mean value at 20°C [µg/m³]
Zero	1	20	0.0	0.0	0.0	0.0	0.0
	2	-20	0.0	0.0	0.0	0.0	
	3	20	0.0	0.0	0.0	0.0	
	4	50	0.0	0.0	0.0	0.0	
	5	20	0.0	0.0	0.0	0.0	

SN 12250	No.	Temperature [°C]	Measured value [µg/m³]	Measured value [µg/m³]	Measured value [µg/m³]	Mean value of 3 measurements [µg/m³]	Mean value at 20°C [µg/m³]
Zero	1	20	0.0	0.0	0.0	0.0	0.0
	2	-20	0.0	0.0	0.0	0.0	
	3	20	0.0	0.0	0.0	0.0	
	4	50	0.0	0.0	0.0	0.0	
	5	20	0.0	0.0	0.0	0.0	

Annex 3 Dependence of zero point on surrounding temperature for PM_{10} Page 2 of 4

Manufacturer Palas GmbH

Type Fidas Smart 100

Serial-No. SN 12248 / SN 12250

			Measurement 1	Measurement 2	Measurement 3		
SN 12248	No.	Temperature [°C]	Measured value [µg/m³]	Measured value [µg/m³]	Measured value [µg/m³]	Mean value of 3 measurements [µg/m³]	Mean value at 20°C [µg/m³]
Zero	1	20	0.0	0.0	0.0	0.0	0.0
	2	-20	0.0	0.0	0.0	0.0	
	3	20	0.0	0.0	0.0	0.0	
	4	50	0.0	0.0	0.0	0.0	
	5	20	0.0	0.0	0.0	0.0	
SN 12250	No.	Temperature [°C]	Measured value [µg/m³]	Measured value [µg/m³]	Measured value [µg/m³]	Mean value of 3 measurements [µg/m³]	Mean value at 20°C [µg/m³]
Zero	1	20	0.0	0.0	0.0	0.0	0.0
	2	-20	0.0	0.0	0.0	0.0	
	3	20	0.0	0.0	0.0	0.0	
	4	50	0.0	0.0	0.0	0.0	
	5	20	0.0	0.0	0.0	0.0	

Annex 3 **Dependence of span on surrounding temperature for $PM_{2.5}$** **Page 3 of 4**

Manufacturer Palas GmbH

Type Fidas Smart 100

Serial-No. SN 12248 / SN 12250

Used test standard MonoDust 1500

			Measurement 1	Measurement 2	Meaurement 3		
SN 12248	No.	Temperature [°C]	Measured value µg/m³	Measured value µg/m³	Measured value µg/m³	Mean value of 3 measurements µg/m³	Mean value at 20°C µg/m³
Span	1	20	25.0	24.9	24.8	24.9	25.0
	2	-20	24.9	24.9	24.8	24.9	
	3	20	24.9	25.0	24.9	25.0	
	4	50	25.6	25.5	25.5	25.5	
	5	20	25.0	25.0	25.1	25.0	
SN 12250	No.	Temperature [°C]	Measured value µg/m³	Measured value µg/m³	Measured value µg/m³	Mean value of 3 measurements µg/m³	Mean value at 20°C µg/m³
Span	1	20	24.4	24.5	24.5	24.5	24.5
	2	-20	24.2	24.3	23.7	24.0	
	3	20	24.5	24.4	24.4	24.4	
	4	50	25.1	25.2	25.4	25.2	
	5	20	24.6	24.6	24.5	24.5	

Annex 3 — Dependence of span on surrounding temperature for PM_{10} — Page 4 of 4

Manufacturer Palas GmbH

Type Fidas Smart 100

Serial-No. SN 12248 / SN 12250

Used test standard MonoDust 1500

			Measurement 1	Measurement 2	Meaurement 3		
SN 12248	No.	Temperature [°C]	Measured value µg/m³	Measured value µg/m³	Measured value µg/m³	Mean value of 3 measurements µg/m³	Mean value at 20°C µg/m³
Span	1	20	40.0	40.0	40.0	40.0	40.0
	2	-20	40.0	40.0	40.0	40.0	
	3	20	40.0	40.0	40.0	40.0	
	4	50	39.9	39.9	39.9	39.9	
	5	20	40.0	40.0	40.0	40.0	
SN 12250	No.	Temperature [°C]	Measured value µg/m³	Measured value µg/m³	Measured value µg/m³	Mean value of 3 measurements µg/m³	Mean value at 20°C µg/m³
Span	1	20	40.0	40.0	40.0	40.0	40.0
	2	-20	40.1	40.0	40.5	40.2	
	3	20	40.0	40.0	40.0	40.0	
	4	50	40.0	40.0	39.9	40.0	
	5	20	40.0	40.0	40.0	40.0	

Annex 4 — Dependence of span on supply voltage for $PM_{2.5}$ — Page 1 of 2

Manufacturer	Palas GmbH
Type	Fidas Smart 100
Serial-No.	SN 12248 / SN 12250
Used test standard	MonoDust 1500

SN 12248	No.	Mains voltage [V]	Measurement 1 Measured value µg/m³	Measurement 2 Measured value µg/m³	Measurement 3 Measured value µg/m³	Mean value of 3 measurements µg/m³
Span	1	230	25.1	25.0	25.0	25.0
	2	195	25.1	25.0	25.0	25.0
	3	230	25.1	25.1	25.1	25.1
	4	253	25.1	24.9	24.9	25.0
	5	230	25.1	25.0	24.9	25.0

SN 12250	No.	Mains voltage [V]	Measured value µg/m³	Measured value µg/m³	Measured value µg/m³	Mean value of 3 measurements µg/m³
Span	1	230	24.6	24.5	24.5	24.5
	2	195	24.7	24.4	24.4	24.5
	3	230	24.6	24.6	24.6	24.6
	4	253	24.5	24.4	24.5	24.5
	5	230	24.4	24.2	24.2	24.3

Annex 4 Dependence of span on supply voltage for PM_{10} Page 2 of 2

Manufacturer	Palas GmbH
Type	Fidas Smart 100
Serial-No.	SN 12248 / SN 12250
Used test standard	MonoDust 1500

SN 12248	No.	Mains voltage [V]	Measurement 1 Measured value µg/m³	Measurement 2 Measured value µg/m³	Measurement 3 Measured value µg/m³	Mean value of 3 measurements µg/m³
Span	1	230	40.0	40.0	40.0	40.0
	2	195	40.0	40.0	40.0	40.0
	3	230	40.0	40.0	40.0	40.0
	4	253	40.0	40.0	40.0	40.0
	5	230	40.0	40.0	40.0	40.0

SN 12250	No.	Mains voltage [V]	Measurement 1 Measured value µg/m³	Measurement 2 Measured value µg/m³	Measurement 3 Measured value µg/m³	Mean value of 3 measurements µg/m³
Span	1	230	40.0	40.0	40.0	40.0
	2	195	40.0	40.0	40.0	40.0
	3	230	40.0	40.0	40.0	40.0
	4	253	40.0	40.0	40.0	40.0
	5	230	40.0	40.1	40.1	40.1

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 1 of 16**

Manufacturer: Palas GmbH
Type of instrument: Fidas Smart 100
Serial-No.: SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
1	1/22/2021	12.6	12.6	18.1	18.0	69.7	11.4	10.9	14.3	13.9		Cologne I
2	1/23/2021			5.8	6.1		5.1	4.8	6.6	6.4		Cologne I
3	1/24/2021	9.3	9.3	11.7	11.7	79.7	9.3	8.9	11.6	11.5		Cologne I
4	1/25/2021	15.9	15.6	21.1	21.3	74.3	14.7	14.1	17.8	17.5		Cologne I
5	1/26/2021	9.1	9.1	12.6	13.0	71.3	8.6	8.3	10.8	10.9		Cologne I
6	1/27/2021	7.6	7.8	10.2	10.1	76.0	7.1	6.8	9.1	9.1		Cologne I
7	1/28/2021	4.6	4.2	6.4	6.7	66.7	3.7	3.5	5.6	5.6		Cologne I
8	1/29/2021	7.5	7.2	11.4	10.7	66.4	7.0	6.7	9.4	9.4		Cologne I
9	1/30/2021			8.0	7.3		6.8	6.4	8.0	7.8		Cologne I
10	1/31/2021	7.7	6.8	9.0	8.6	82.6	7.7	7.4	8.7	8.6		Cologne I
11	2/1/2021	7.8	6.9	9.3	9.2	79.5	7.3	6.9	9.0	8.7		Cologne I
12	2/2/2021	4.9	4.6	9.2	9.1	51.9	4.8	4.6	7.6	7.5		Cologne I
13	2/3/2021	5.3	4.5	9.3	8.8	53.9	4.5	4.3	7.5	7.6		Cologne I
14	2/4/2021	5.7	5.4	11.9	12.1	46.2	5.1	4.9	8.9	8.9		Cologne I
15	2/5/2021	9.0	9.2	13.6	13.8	66.2	9.3	8.8	12.5	12.3		Cologne I
16	2/6/2021			6.4	7.0		5.7	5.4	6.8	6.8		Cologne I
17	2/7/2021	12.7	12.1	14.4	14.6	85.4	13.3	12.9	14.6	14.5		Cologne I
18	2/8/2021	18.1	17.9	22.9	23.2	78.0	18.8	18.0	22.6	22.4		Cologne I
19	2/9/2021	20.1	20.1	24.6	24.7	81.8	19.5	18.9	21.5	21.8		Cologne I
20	2/10/2021	14.8	14.8	17.8	17.8	83.4	13.3	12.7	14.4	14.2		Cologne I
21	2/11/2021	10.8	11.0	14.6	14.6	74.6	10.0	9.7	14.8	14.7		Cologne I
22	2/12/2021			10.4	10.0		7.2	7.0	10.9	10.9		Cologne I
23	2/13/2021			8.4	8.4		6.3	6.1	8.7	8.6		Cologne I
24	2/14/2021	6.7	6.6	9.9	9.9	66.8	5.9	5.6	9.8	9.8		Cologne I
25	2/15/2021	11.1	11.2	15.1	14.6	75.0	10.6	10.2	12.8	12.7		Cologne I
26	2/16/2021	6.6	7.1	11.0	10.9	62.6	6.9	6.8	9.8	9.8		Cologne I
27	2/17/2021	5.0	5.5	10.5	10.2	50.9	5.6	5.4	8.5	8.5		Cologne I
28	2/18/2021	4.6	5.0	9.6	9.0	51.5	5.1	5.0	8.3	8.5		Cologne I
29	2/19/2021	5.2	6.1	9.1	9.0	61.9	6.0	5.8	9.2	9.1		Cologne I
30	2/20/2021			22.1	22.1		10.9	10.5	21.6	21.4		Cologne I

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 2 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
31	2/21/2021	9.3	9.4	16.0	16.1	58.5	9.0	8.6	15.9	15.8		Cologne I
32	2/22/2021	15.2	15.4	28.5	28.9	53.3	16.5	15.8	31.1	30.2		Cologne I
33	2/23/2021	17.9	18.4	39.5	39.9	45.6	19.8	18.8	44.0	41.9		Cologne I
34	2/24/2021	23.5	24.6	61.3	62.3	38.9	27.4	26.1	68.0	64.4		Cologne I
35	2/25/2021	19.8	20.8	41.7	41.9	48.5	21.0	20.1	41.8	40.5		Cologne I
36	2/26/2021	11.5	12.4	20.5	20.6	58.1	12.8	12.3	17.3	17.2		Cologne I
37	2/27/2021			16.7	16.8		13.8	13.2	15.8	15.6		Cologne I
38	2/28/2021	13.3	13.6	19.7	20.0	67.7	14.4	13.7	17.4	17.0		Cologne I
39	3/1/2021	11.3	11.7	16.3	16.8	69.5	13.7	13.0	18.1	17.4		Cologne I
40	3/2/2021	16.0	16.4	26.0	25.8	62.5	16.2	15.3	23.5	22.7		Cologne I
41	3/3/2021	34.6	34.8	57.3	57.5	60.4	35.0	33.5	51.6	51.1		Cologne I
42	3/4/2021	17.2	16.9	24.1	24.0	70.9	17.4	16.8	20.2	20.2		Cologne I
43	3/5/2021	14.5	14.3	19.4	20.2	72.7	12.5	11.8	14.9	14.5		Cologne I
44	3/6/2021			19.9	19.6		15.8	14.8	16.2	15.9		Cologne I
45	3/7/2021	17.3	17.7	24.1	24.2	72.5	16.8	16.0	19.0	18.8		Cologne I
46	3/8/2021	40.7	40.6	53.1	52.2	77.2	40.9	39.1	43.6	43.2		Cologne I
47	3/9/2021	14.7	14.8	19.5	19.5	75.7	14.8	14.1	17.0	16.5		Cologne I
48	3/10/2021	12.0	12.3	15.5	15.6	77.8	12.1	11.7	15.7	15.0		Cologne I
49	3/11/2021	3.7	3.8	10.5	10.2	36.3	4.6	4.4	10.1	10.3		Cologne I
50	3/12/2021	3.4	3.9	7.4	8.0	47.8	4.6	4.4	7.1	7.0		Cologne I
51	3/13/2021			8.5	8.5		4.5	4.3	8.0	8.1		Cologne I
52	3/14/2021	4.3	3.7	7.0	7.3	56.3	5.4	5.2	7.3	7.3		Cologne I
53	3/15/2021	3.5	3.4	11.0	11.3	31.1	4.9	4.7	9.3	9.4		Cologne I
54	4/17/2021	14.3	13.4	25.4	26.7	53.2	11.8	11.1	20.2	20.1		Niederzier I
55	4/18/2021	14.6	14.1	21.7	22.6	64.8	12.1	11.4	18.1	17.6		Niederzier I
56	4/19/2021	25.3	24.6	36.4	37.3	67.8	22.9	21.2	29.5	27.6		Niederzier I
57	4/20/2021	19.4	19.3	29.1	29.5	66.0	22.1	20.7	29.6	27.7		Niederzier I
58	4/21/2021	25.8	25.6	37.3	37.6	68.6	26.3	24.6	34.8	33.6		Niederzier I
59	4/22/2021	8.7	8.0	25.0	25.2	33.4	9.7	9.3	22.0	21.5		Niederzier I
60	4/23/2021	10.8	11.0	27.1	27.7	39.8	11.1	10.4	25.8	23.7		Niederzier I

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 3 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
61	4/24/2021	11.2	10.7	28.1	28.3	38.8	10.5	9.9	25.2	23.3		Niederzier I
62	4/25/2021	10.3	10.4	20.3	20.5	50.8	10.9	10.3	19.3	19.1		Niederzier I
63	4/26/2021	11.0	11.0	29.0	29.7	37.4	10.6	10.1	26.7	26.1		Niederzier I
64	4/27/2021	14.2	14.4	38.0	38.8	37.3	12.6	12.1	36.9	36.1		Niederzier I
65	4/28/2021	13.3	13.6	34.9	35.3	38.3	13.0	12.3	34.9	34.0		Niederzier I
66	4/29/2021	17.3	17.9	27.2	27.3	64.7	16.9	15.6	27.4	25.6		Niederzier I
67	4/30/2021	19.0	19.4	31.5	32.1	60.3	20.7	19.4	28.6	27.5		Niederzier I
68	5/1/2021	19.0	19.3	25.7	26.4	73.6	20.4	19.0	24.1	23.1		Niederzier I
69	5/2/2021	8.6	8.7	13.3	13.6	64.4	8.7	8.2	12.4	12.4		Niederzier I
70	5/3/2021	8.5	8.5	14.9	14.6	57.7	8.2	7.6	15.1	13.8		Niederzier I
71	5/4/2021										Storm	Niederzier I
72	5/5/2021	6.3	6.1	10.5	10.5	59.4	5.1	4.8	9.9	9.4		Niederzier I
73	5/6/2021	6.2	5.9	10.2	10.4	58.6	5.4	5.0	9.2	9.7		Niederzier I
74	5/7/2021	13.5	12.4	13.7	14.3	92.6	11.3	10.6	13.9	13.4		Niederzier I
75	5/8/2021	6.1	7.0	12.2	12.7	53.0	6.8	6.4	12.8	12.6		Niederzier I
76	5/9/2021	6.0	6.6	11.6	12.6	51.8	4.9	4.6	12.1	11.8		Niederzier I
77	5/10/2021	4.9	5.0	8.1	8.0	61.1	2.9	2.8	9.2	8.8		Niederzier I
78	5/11/2021	4.2	5.1	9.7	10.3	46.9	5.0	4.9	9.2	9.7		Niederzier I
79	5/12/2021	6.1	6.8	12.9	13.7	48.5	6.2	5.9	11.2	11.7		Niederzier I
80	5/13/2021	4.7	5.5	12.4	12.6	40.7	6.2	5.9	12.7	12.3		Niederzier I
81	5/14/2021	3.3	3.4	6.2	6.5	52.4	2.6	2.5	6.0	5.9		Niederzier I
82	5/15/2021	2.8	3.4	5.0	5.0	61.8	3.0	2.8	5.8	5.8		Niederzier I
83	5/16/2021	3.0	2.6	6.1	6.3	45.5	3.0	2.9	6.4	6.3		Niederzier I
84	5/17/2021	3.5	3.7	7.1	7.3	50.1	3.9	3.6	7.1	7.0		Niederzier I
85	5/18/2021	5.9	5.5	11.2	11.9	49.6	7.3	7.0	11.4	11.5		Niederzier I
86	5/19/2021	3.3	3.5	8.5	8.1	40.8	4.4	4.3	8.8	8.9		Niederzier I
87	5/20/2021	0.0	0.0	8.4	8.7		7.2	6.7	11.2	10.5		Niederzier I
88	5/21/2021	4.5	3.9	11.5	11.5	36.7	3.9	3.8	12.4	12.7		Niederzier I
89	5/22/2021	2.5	2.0	6.0	5.7	38.8	2.7	2.6	7.1	6.9		Niederzier I
90	5/23/2021	2.6	2.5	5.6	5.0	47.4	2.5	2.4	5.7	5.8		Niederzier I

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 4 of 16**

Manufacturer: Palas GmbH

Type of instrument: Fidas Smart 100

Serial-No.: SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
91	5/24/2021	2.0	2.2	4.7	4.5	46.1	1.6	1.5	4.6	4.7		Niederzier I
92	5/25/2021	1.9	2.1	4.8	4.3	44.5	2.2	2.1	5.4	5.1		Niederzier I
93	5/26/2021	3.3	3.6	7.5	7.3	46.6	3.6	3.4	7.4	7.2		Niederzier I
94	5/27/2021	6.5	6.2	13.4	13.2	47.7	8.6	8.1	12.5	12.8		Niederzier I
95	5/28/2021			16.7	17.1		9.0	8.5	16.8	16.2		Niederzier I
96	5/29/2021	8.7	8.7	23.2	24.0	36.9	8.9	8.5	20.7	19.8		Niederzier I
97	5/30/2021	6.6	6.8	14.4	15.0	45.8	8.6	8.2	15.7	15.0		Niederzier I
98	5/31/2021	9.3	9.2	22.5	24.4	39.4	8.6	8.3	23.3	22.1		Niederzier I
99	6/1/2021	9.8	8.7	23.6	26.3	37.1	8.2	7.8	26.9	26.6		Niederzier I
100	6/2/2021	12.0	11.3	32.5	36.3	33.8	9.8	9.4	34.6	34.1		Niederzier I
101	6/3/2021	6.7	6.3	11.9	13.4	51.2	7.3	7.0	13.3	13.0		Niederzier I
102	6/4/2021	14.1	13.8	21.0	21.4	65.6	16.3	15.3	23.7	22.4		Niederzier I
103	6/5/2021	20.9	20.1	27.9	29.1	71.8	21.7	20.3	27.4	25.6		Niederzier I
104	6/6/2021	19.5	18.5	24.3	24.7	77.5	19.0	18.1	22.4	21.3		Niederzier I
105	6/7/2021	14.8	14.3	22.3	22.9	64.5	16.7	16.0	23.0	22.1		Niederzier I
106	6/8/2021	16.5	16.2	25.9	26.8	62.1	20.7	19.7	29.0	27.7		Niederzier I
107	6/9/2021	17.2	16.8	24.8	25.5	67.8	21.6	20.6	29.1	27.8		Niederzier I
108	6/10/2021	8.3	7.4	18.2	19.6	41.5	7.3	7.0	18.9	18.0		Niederzier I
109	6/11/2021	8.5	7.8	14.3	14.7	56.0	8.7	8.2	16.3	15.7		Niederzier I
110	6/12/2021	7.3	6.9	13.3	13.7	52.5	8.5	8.2	15.9	15.4		Niederzier I
111	6/13/2021	7.8	7.6	19.5	20.7	38.3	8.5	8.3	21.1	20.8		Niederzier I
112	6/14/2021	12.2	11.2	27.6	29.1	41.2	9.1	8.8	24.9	24.8		Niederzier I
113	6/15/2021	11.7	10.7	24.5	25.6	44.7	10.2	9.7	23.9	22.4		Niederzier I
114	7/1/2021	6.1	5.0	11.1	11.2	49.6	7.4	7.1	11.3	11.5		Cologne II
115	7/2/2021	7.0	5.8	11.8	12.9	51.9	8.5	8.3	14.1	13.9		Cologne II
116	7/3/2021	9.9	8.9	13.8	14.2	67.0	8.6	8.2	13.3	12.7		Cologne II
117	7/4/2021	6.8	6.1	10.1	10.6	62.3	6.8	6.4	12.1	11.6		Cologne II
118	7/5/2021	3.4	2.8	7.1	7.5	42.9	2.6	2.5	7.4	7.3		Cologne II
119	7/6/2021	4.9	3.5	9.3	10.0	43.7	3.2	3.1	10.0	9.4		Cologne II
120	7/7/2021	5.0	7.2	10.8	11.3	55.4	4.2	4.1	10.2	10.0		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions**

Manufacturer: Palas GmbH

Type of instrument: Fidas Smart 100

Serial-No.: SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
121	7/8/2021	7.6	7.0	14.3	15.0	49.6	6.1	5.8	12.2	11.5		Cologne II
122	7/9/2021	9.2	8.2	15.2	15.7	56.4	11.1	10.5	17.5	16.5		Cologne II
123	7/10/2021	7.2	6.6	10.7	11.0	63.7	7.7	7.3	12.8	12.0		Cologne II
124	7/11/2021	6.1	6.0	10.1	10.5	59.1	7.9	7.4	12.7	12.1		Cologne II
125	7/12/2021	7.0	6.9	10.8	11.1	63.6	7.3	6.9	12.3	11.7		Cologne II
126	7/13/2021	8.1	8.9	12.8	13.0	65.7	8.9	8.1	13.4	12.6		Cologne II
127	7/16/2021			19.7	19.5		13.2	12.4	20.5	20.0	Power cut storm 07/14/2021	Cologne II
128	7/17/2021	9.5	9.3	16.2	17.4	56.0	10.9	10.2	16.9	16.4		Cologne II
129	7/18/2021	6.2	6.3	9.7	11.2	59.7	5.2	4.9	10.2	9.5		Cologne II
130	7/19/2021	9.2	9.3	13.6	14.3	66.2	10.2	9.5	14.2	13.6		Cologne II
131	7/20/2021	11.6	11.4	17.9	18.5	63.3	12.2	11.4	17.5	17.0		Cologne II
132	7/21/2021	8.9	9.1	12.9	13.6	67.8	7.7	7.1	12.4	11.7		Cologne II
133	7/22/2021	12.2	12.6	17.6	19.0	67.6	10.7	9.9	16.7	15.8		Cologne II
134	7/23/2021	10.1	10.5	16.4	17.2	61.2	10.7	9.9	17.5	16.3		Cologne II
135	7/24/2021	11.9	12.1	17.9	18.5	65.9	12.5	11.4	18.0	17.0		Cologne II
136	7/25/2021	6.6	7.1	11.6	11.7	59.1	7.1	6.6	12.5	12.1		Cologne II
137	7/26/2021			8.0	8.4		4.0	3.7	9.0	8.4		Cologne II
138	7/27/2021	5.2	5.1	9.7	9.8	53.4	5.4	5.0	10.4	9.9		Cologne II
139	7/28/2021	5.4	5.1	10.3	10.5	50.4	5.0	4.7	10.5	10.1		Cologne II
140	7/29/2021	5.1	4.8	9.7	9.9	50.8	3.9	3.7	9.2	8.8		Cologne II
141	7/30/2021	6.3	5.0	12.3	12.2	46.0	5.1	4.9	11.9	11.6		Cologne II
142	7/31/2021	4.2	3.7	7.3	7.6	53.2	3.2	3.0	7.9	7.6		Cologne II
143	8/1/2021	4.8	3.4	6.7	7.0	59.7	3.8	3.6	7.5	7.1		Cologne II
144	8/2/2021	5.7	4.4	8.4	9.4	56.7	5.3	5.0	9.4	8.8		Cologne II
145	8/3/2021	6.2	5.0	8.2	9.2	64.2	5.4	4.9	8.7	8.4		Cologne II
146	8/4/2021	9.4	8.4	13.8	14.7	62.7	11.9	10.9	16.9	15.5		Cologne II
147	8/5/2021	6.8	6.0	10.2	10.2	62.4	8.3	7.7	12.4	11.5		Cologne II
148	8/6/2021	3.1	2.4	5.1	5.2	54.0	2.5	2.3	6.0	5.9		Cologne II
149	8/7/2021	2.7	3.3	5.6	5.9	52.5	2.3	2.2	5.5	5.3		Cologne II
150	8/8/2021	3.0	4.2	6.4	6.3	56.4	3.1	3.0	6.9	6.9		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 6 of 16**

Manufacturer: Palas GmbH
Type of instrument: Fidas Smart 100
Serial-No.: SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
151	8/9/2021	2.9	2.8	6.3	6.5	44.4	2.8	2.7	6.7	6.5		Cologne II
152	8/10/2021	4.1	3.9	7.3	7.9	52.7	4.0	3.7	8.5	8.0		Cologne II
153	8/11/2021	6.3	5.7	9.4	9.6	62.9	6.8	6.2	11.6	10.4		Cologne II
154	8/12/2021	9.7	9.5	16.1	16.4	59.1	9.1	8.5	15.0	14.5		Cologne II
155	8/13/2021	8.9	9.7	15.8	15.8	58.9	9.2	8.6	15.7	14.6		Cologne II
156	8/14/2021	9.3	8.3	17.4	17.1	50.9	7.1	6.8	13.4	13.3		Cologne II
157	8/15/2021	9.0	8.0	15.7	15.6	54.2	6.8	6.5	13.1	13.1		Cologne II
158	8/16/2021	4.2	4.1	10.3	11.5	37.9	4.5	4.3	10.4	10.5		Cologne II
159	8/17/2021	7.9	7.6	15.4	15.1	50.7	9.6	9.1	14.6	14.3		Cologne II
160	8/18/2021	4.2	4.7	8.4	6.7	59.2	5.2	4.9	9.0	8.7		Cologne II
161	8/19/2021	3.8	4.3	7.5	8.0	52.6	4.3	4.1	8.2	8.0		Cologne II
162	8/20/2021	4.0	4.4	7.6	9.3	49.9	4.3	4.0	8.1	7.7		Cologne II
163	8/21/2021	6.9	7.0	10.8	11.1	63.6	5.5	5.2	9.9	9.7		Cologne II
164	8/22/2021	5.7	5.1	8.8	9.7	58.0	6.1	5.7	10.7	10.4		Cologne II
165	8/23/2021	7.1	7.5	11.5	11.7	62.9	8.8	8.2	12.7	12.0		Cologne II
166	8/24/2021	5.6	5.5	8.6	9.2	62.2	4.1	3.9	8.0	7.9		Cologne II
167	8/25/2021	7.7	6.7	12.9	13.1	55.7	5.1	4.9	10.9	10.6		Cologne II
168	8/26/2021	3.9	4.0	7.4	8.1	51.3	4.4	4.2	8.4	8.3		Cologne II
169	8/27/2021	3.6	3.4	8.4	8.6	41.5	3.5	3.4	9.0	8.6		Cologne II
170	8/28/2021	4.5	4.3	9.3	8.4	49.5	6.3	6.0	9.8	9.9		Cologne II
171	8/29/2021	4.5	3.9	8.1	7.6	53.8	5.0	4.8	8.3	8.4		Cologne II
172	8/30/2021	10.5	10.0	16.7	16.6	61.6	12.3	11.6	17.1	16.6		Cologne II
173	8/31/2021	14.0	13.2	21.0	20.3	65.7	15.2	14.5	19.9	19.5		Cologne II
174	9/1/2021	10.5	10.2	19.4	18.7	54.3	12.0	11.4	17.4	16.6		Cologne II
175	9/2/2021	7.6	7.5	12.6	13.1	59.0	10.9	10.4	15.7	14.9		Cologne II
176	9/3/2021	9.1	8.3	13.7	14.0	62.9	9.4	9.0	14.0	13.8		Cologne II
177	9/4/2021	11.5	11.2	16.6	16.6	68.3	12.2	11.5	16.7	16.3		Cologne II
178	9/5/2021	11.3	11.0	15.3	15.2	73.0	11.7	11.0	15.2	15.0		Cologne II
179	9/6/2021	14.3	13.9	21.0	21.0	67.0	13.7	13.0	19.6	19.0		Cologne II
180	9/7/2021	12.5	12.7	19.4	20.0	64.1	12.4	11.7	18.4	17.7		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
181	9/8/2021	11.5	11.3	17.6	17.7	64.8	10.9	10.4	17.3	16.8		Cologne II
182	9/9/2021	9.4	9.8	17.5	18.2	53.8	10.2	9.8	18.3	18.1		Cologne II
183	9/10/2021	4.8	4.7	9.3	9.0	52.0	4.8	4.6	9.7	9.3		Cologne II
184	9/11/2021	3.2	3.7	7.4	7.3	47.1	3.7	3.5	7.3	7.0		Cologne II
185	9/12/2021	5.8	5.8	10.1	10.2	57.5	5.6	5.3	9.3	8.9		Cologne II
186	9/13/2021	11.1	10.3	16.6	17.2	63.2	11.6	11.0	16.9	16.0		Cologne II
187	9/14/2021	9.0	8.7	14.8	15.0	59.4	9.1	8.6	15.9	15.3		Cologne II
188	9/15/2021	8.0	7.5	12.4	13.1	60.8	8.0	7.5	12.9	12.3		Cologne II
189	9/16/2021	4.3	4.3	9.4	9.8	44.7	4.1	4.0	8.9	8.8		Cologne II
190	9/17/2021	12.9	12.6	20.6	21.7	60.4	12.0	11.4	17.9	17.3		Cologne II
191	9/18/2021	11.3	10.4	14.7	15.2	72.2	12.2	11.6	16.4	15.7		Cologne II
192	9/19/2021	4.3	3.5	6.2	5.8	64.6	3.4	3.2	6.0	5.8		Cologne II
193	9/20/2021	7.3	6.7	11.4	11.7	60.8	7.8	7.5	13.7	13.3		Cologne II
194	9/21/2021	6.7	5.9	10.9	10.9	58.1	6.5	6.2	11.1	11.0		Cologne II
195	9/22/2021	10.7	10.3	17.8	18.4	58.0	9.8	9.3	16.8	15.6		Cologne II
196	9/23/2021	8.0	7.4	14.8	15.1	51.5	7.1	6.8	15.7	15.1		Cologne II
197	9/24/2021	5.8	5.6	12.0	12.9	45.8	7.6	7.3	14.0	13.5		Cologne II
198	9/25/2021	5.8	5.0	8.5	8.4	64.0	4.7	4.5	8.2	8.0		Cologne II
199	9/26/2021	8.7	7.8	12.1	12.5	66.9	8.0	7.6	12.9	12.2		Cologne II
200	9/27/2021	4.9	5.0	9.2	9.4	53.6	6.2	6.0	11.2	11.0		Cologne II
201	9/28/2021	3.8	3.8	10.5	10.7	35.3	4.1	4.1	9.7	10.1		Cologne II
202	9/29/2021	3.6	3.6	8.2	8.9	42.7	3.6	3.4	7.4	7.3		Cologne II
203	9/30/2021	4.1	3.3	8.6	7.9	44.6	3.8	3.7	7.9	7.9		Cologne II
204	10/1/2021	4.3	3.4	8.8	8.2	44.8	3.4	3.4	7.8	8.1		Cologne II
205	10/2/2021	3.4	3.5	5.2	6.7	58.1	3.0	2.9	5.9	6.2		Cologne II
206	10/3/2021	4.2	3.6	6.9	6.9	56.7	3.5	3.4	8.2	7.9		Cologne II
207	10/4/2021						2.6	2.5	5.9	5.9		Cologne II
208	10/5/2021						3.0	2.9	6.3	6.3		Cologne II
209	10/6/2021						2.9	2.7	6.0	5.8		Cologne II
210	10/7/2021						10.0	9.6	14.1	13.6		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 8 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
211	10/8/2021						8.3	7.8	12.6	12.4		Cologne II
212	10/9/2021						16.5	15.8	22.7	21.8		Cologne II
213	10/10/2021						14.4	13.7	18.9	18.7		Cologne II
214	10/11/2021						11.7	11.2	18.2	17.5		Cologne II
215	10/12/2021						6.3	6.0	10.2	10.0		Cologne II
216	10/13/2021						7.1	6.8	13.1	12.5		Cologne II
217	10/14/2021						8.7	8.3	13.9	13.6		Cologne II
218	10/15/2021	6.9	6.6	13.2	14.2	49.3	6.8	6.4	10.8	10.6		Cologne II
219	10/16/2021	10.3	10.1	16.5	16.7	61.3	10.6	9.9	17.2	15.5		Cologne II
220	10/17/2021	10.4	10.4	15.1	15.9	66.9	8.9	8.4	11.5	11.4		Cologne II
221	10/18/2021	12.3	11.6	16.0	16.2	74.3	11.3	10.9	14.3	14.3		Cologne II
222	10/19/2021	9.2	8.3	12.0	12.4	71.7	8.7	8.3	11.9	11.5		Cologne II
223	10/20/2021	5.4	5.4	10.2	9.3	54.6	5.7	5.5	9.4	9.4		Cologne II
224	10/21/2021	3.3	3.1	8.8	7.7	38.5	3.4	3.4	8.3	8.4		Cologne II
225	10/22/2021	4.5	4.7	12.6	11.3	38.6	5.0	4.9	10.5	10.3		Cologne II
226	10/23/2021	8.4	7.8	15.3	14.7	54.1	9.0	8.4	13.1	12.8		Cologne II
227	10/24/2021	6.1	6.8	11.6	10.9	57.3	7.1	6.7	9.4	9.3		Cologne II
228	10/25/2021	6.7	6.7	11.3	10.7	60.9	6.9	6.5	10.0	9.9		Cologne II
229	10/26/2021	4.4	4.3	8.6	8.4	50.5	4.5	4.3	7.4	7.4		Cologne II
230	10/27/2021	4.0	4.5	8.7	7.6	52.2	4.4	4.2	7.7	7.8		Cologne II
231	10/28/2021	11.9	12.4	16.9	16.1	73.8	12.4	11.9	15.6	15.0		Cologne II
232	10/29/2021	9.2	9.1	14.3	13.1	66.6	10.2	9.7	14.6	14.2		Cologne II
233	10/30/2021	6.9	7.0	11.9	10.3	62.7	7.2	6.9	10.7	11.0		Cologne II
234	10/31/2021	3.4	3.9	6.8	5.4	60.4	3.8	3.7	6.8	6.9		Cologne II
235	11/1/2021	3.4	3.1	8.9	7.5	39.2	3.6	3.5	7.3	7.5		Cologne II
236	11/2/2021	3.9	3.0	7.4	6.4	49.7	3.3	3.2	6.1	6.0		Cologne II
237	11/3/2021	6.6	6.6	10.4	9.7	65.8	6.4	6.1	9.3	9.1		Cologne II
238	11/4/2021	18.2	19.4	23.8	22.6	80.9	17.7	16.8	20.3	19.5		Cologne II
239	11/5/2021	13.8	14.7	21.0	20.1	69.5	13.2	12.7	17.8	17.2		Cologne II
240	11/6/2021	5.9	6.5	10.6	10.3	59.3	6.9	6.5	9.4	9.4		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 9 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
241	11/7/2021	5.0	5.2	10.9	11.4	45.9	5.6	5.4	9.7	9.7		Cologne II
242	12/3/2021	6.5	6.8	14.7	13.8	46.8	6.4	6.0	11.8	11.7		Bornheim
243	12/4/2021	4.0	4.8	8.3	7.3	56.1	4.6	4.3	10.6	10.5		Bornheim
244	12/5/2021	5.2	4.7	8.5	7.6	61.2	4.2	3.9	6.9	6.9		Bornheim
245	12/6/2021	9.9	9.9	15.1	14.5	66.7	9.0	8.3	13.1	12.7		Bornheim
246	12/7/2021	5.4	5.1	13.9	12.2	40.3	6.0	5.7	14.4	14.0		Bornheim
247	12/8/2021	5.5	5.8	13.2	12.5	44.0	4.6	4.4	10.1	10.3		Bornheim
248	12/9/2021	5.9	6.9	13.6	12.6	48.8	5.5	5.1	11.4	11.0		Bornheim
249	12/10/2021	6.3	6.1	11.9	10.8	54.5	6.7	6.1	10.0	9.2		Bornheim
250	12/11/2021	15.9	15.5	23.5	23.1	67.3	13.5	12.4	17.5	16.3		Bornheim
251	12/12/2021	4.3	3.7	9.5	9.5	42.5	5.8	5.6	14.4	14.3		Bornheim
252	12/13/2021	3.9	3.5	10.5	9.8	36.5	3.0	2.9	8.7	8.7		Bornheim
253	12/14/2021	7.2	6.7	13.7	13.4	51.1	6.4	5.9	11.5	10.6		Bornheim
254	12/15/2021	6.5	5.1	12.4	12.8	46.0	5.4	5.1	10.3	9.8		Bornheim
255	12/16/2021	26.7	26.4	41.1	40.5	65.1	24.8	22.9	31.0	28.7		Bornheim
256	12/17/2021	15.8	15.0	23.8	22.6	66.4	12.5	11.6	16.9	16.0		Bornheim
257	12/18/2021	11.5	10.4	15.6	14.7	71.9	10.4	9.7	13.0	12.4		Bornheim
258	12/19/2021	9.4	7.6				8.4	7.7	12.0	11.2	tech. issue ref.	Bornheim
259	12/20/2021	9.9	7.4				8.6	8.1	14.1	14.6		Bornheim
260	12/21/2021	19.3	20.8				16.0	14.7	19.8	19.5		Bornheim
261	12/22/2021	21.5	21.9	28.0	26.6	79.6	18.1	16.3	18.9	18.1		Bornheim
262	12/23/2021	20.4	20.3	26.2	25.8	78.2	18.0	16.3	22.7	20.8		Bornheim
263	12/24/2021	7.3	7.7	18.6	17.1	41.9	8.0	7.7	23.5	22.8		Bornheim
264	12/25/2021	5.4	5.0	7.4	7.6	69.7	5.0	4.6	7.0	6.8		Bornheim
265	12/26/2021			10.4	9.9		7.9	7.1	8.9	8.1		Bornheim
266	12/27/2021	6.0	6.2	8.5	8.7	71.0	5.4	4.9	7.4	6.8		Bornheim
267	12/28/2021	3.5	4.3	10.2	10.3	38.0	4.5	4.4	9.3	9.3		Bornheim
268	12/29/2021	3.2	3.3	8.3	8.4	39.1	3.7	3.5	7.3	7.4		Bornheim
269	12/30/2021	3.1	2.9				2.9	2.8	6.9	7.1	tech. issue ref.	Bornheim
270	12/31/2021	3.6	2.9				2.6	2.4	5.0	5.1		Bornheim

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 10 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
271	1/1/2022	4.1	4.3				4.5	4.3	7.1	7.1		Bornheim
272	1/2/2022	5.5	4.8				5.1	4.8	9.8	9.5		Bornheim
273	1/3/2022	2.6	1.9				4.9	4.8	10.8	10.8		Bornheim
274	1/4/2022	2.7	2.5				3.2	3.1	7.2	7.3		Bornheim
275	1/5/2022	4.6	4.2				5.4	5.2	9.6	10.1		Bornheim
276	1/6/2022	7.6	7.7	20.7	20.6	37.2	10.5	10.1	25.4	25.5		Bornheim
277	1/7/2022	4.2	3.4				4.4	4.1	11.5	11.6	tech. issue ref.	Bornheim
278	1/8/2022	4.5	4.4	9.8	10.1	44.8	5.9	5.5	18.0	16.9		Bornheim
279	1/9/2022	4.9	4.8	11.2	11.5	42.7	5.7	5.4	11.6	11.5		Bornheim
280	1/10/2022	12.1	11.3	20.7	20.8	56.3	11.7	11.0	18.2	17.5		Bornheim
281	1/11/2022	13.1	12.4	16.3	16.6	77.4	12.0	10.9	14.3	13.3		Bornheim
282	1/12/2022	17.0	16.2	25.3	25.0	65.8	16.2	15.2	23.3	23.1		Bornheim
283	1/13/2022	17.9	16.9	24.5	23.3	72.7	15.1	13.9	20.1	18.7		Bornheim
284	1/14/2022	21.0	20.5	27.8	26.2	76.8	19.2	17.8	22.2	21.5		Bornheim
285	1/15/2022	10.7	10.4	11.7	11.7	90.0	10.0	9.0	11.1	10.1		Bornheim
286	1/16/2022	13.3	13.1	17.4	16.7	77.2	12.9	12.0	17.7	16.8		Bornheim
287	1/17/2022	15.1	14.6	25.2	22.6	62.1	17.7	16.7	30.6	29.6		Bornheim
288	1/18/2022	9.7	9.7	21.9	20.0	46.4	11.1	10.5	18.6	18.6		Bornheim
289	1/19/2022	8.9	9.3	23.9	21.8	39.7	11.2	10.5	27.8	26.6		Bornheim
290	1/20/2022	5.3	5.4	19.8	17.9	28.3	8.9	8.6	20.9	21.2		Bornheim
291	1/21/2022	8.2	8.1	23.2	21.0	36.9	11.6	11.0	30.6	30.1		Bornheim
292	1/22/2022	16.5	16.1	27.8	26.4	60.2	18.5	17.3	26.3	24.9		Bornheim
293	1/23/2022	19.8	21.8	26.5	29.2	74.9	19.5	17.8	21.7	20.8		Bornheim
294	1/24/2022	7.9	7.9	12.8	13.0	60.7	8.6	7.8	12.4	12.4		Bornheim
295	1/25/2022	18.8	18.5	29.3	28.8	64.2	18.1	16.8	26.2	24.5		Bornheim
296	1/26/2022	27.7	27.6	37.3	36.2	75.1	25.1	23.5	30.4	28.5		Bornheim
297	1/27/2022	9.9	9.5	19.2	18.6	51.3	12.6	11.8	29.1	27.9		Bornheim
298	1/28/2022	7.6	6.8	21.1	20.1	35.1	8.7	8.3	18.1	18.1		Bornheim
299	1/29/2022	4.4	3.3	9.4	9.9	39.6	4.8	4.6	9.5	9.5		Bornheim
300	1/30/2022	7.9	7.0	23.8	23.7	31.4	10.5	10.1	20.9	21.1		Bornheim

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 11 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
301	1/31/2022	4.7	4.5	12.8	13.8	34.5	7.5	7.2	13.9	14.1		Bornheim
302	2/1/2022	3.9	4.0	13.6	13.3	29.3	7.0	6.8	16.3	16.0		Bornheim
303	2/2/2022	8.3	7.7	22.4	22.3	35.9	10.8	10.3	17.8	17.9		Bornheim
304	2/3/2022	4.9	5.4	12.0	11.0	44.7	5.5	5.2	10.6	10.2		Bornheim
305	2/4/2022	3.0	3.0	7.0	8.4	38.9	3.3	3.1	8.2	7.8		Bornheim
306	2/5/2022	4.0	4.2	9.1	9.4	44.3	4.3	4.1	8.0	7.9		Bornheim
307	2/6/2022	1.6	1.9	4.2	4.9	38.9	2.4	2.2	5.3	5.4		Bornheim
308	2/7/2022	4.3	4.0	15.3	14.4	28.1	6.1	5.8	15.5	16.2		Bornheim
309	2/8/2022	3.0	2.8	9.6	8.6	31.6	3.0	3.0	9.2	9.6		Bornheim
310	2/9/2022	6.6	6.4	14.5	14.1	45.6	6.3	5.8	12.2	11.8		Bornheim
311	2/10/2022	8.2	8.3	15.9	16.0	51.4	9.0	8.5	16.0	15.6		Bornheim
312	2/11/2022	7.0	7.1	17.0	17.1	41.2	7.7	7.3	15.2	15.1		Bornheim
313	2/12/2022	9.0	8.4	15.2	16.1	55.6	8.5	7.9	12.7	12.4		Bornheim
314	2/13/2022	8.3	8.8	12.6	12.6	67.6	8.7	8.0	11.6	11.3		Bornheim
315	2/14/2022	3.5	4.0	10.6	10.7	35.3	4.1	3.8	10.5	10.1		Bornheim
316	2/15/2022	3.1	4.2	10.9	10.8	33.4	4.5	4.2	10.1	9.8		Bornheim
317	2/16/2022	1.2	1.1	7.1	6.8	16.4	2.1	2.0	10.0	9.3		Bornheim
318	2/17/2022	4.7	4.6	16.1	14.4	30.6	7.5	7.1	16.2	16.1		Bornheim
319	2/18/2022	3.9	3.1	12.0	11.1	30.5	5.2	4.9	11.5	11.1		Bornheim
320	2/19/2022	2.2	3.1	9.2	8.4	30.3	4.0	3.9	9.1	9.3		Bornheim
321	2/20/2022	2.5	2.1	7.3	7.0	31.8	3.4	3.2	7.0	6.9		Bornheim
322	2/21/2022	2.8	3.1	9.4	9.4	31.2	4.6	4.4	9.9	9.6		Bornheim
323	2/22/2022	4.9	4.5	17.0	16.7	28.0	7.5	7.6	15.2	15.3		Bornheim
324	2/23/2022	5.8	5.9	14.7	15.3	38.9	5.9	7.4	11.8	12.2		Bornheim
325	2/24/2022	3.6	3.7	8.6	8.9	41.9	3.6	4.0	8.1	8.1		Bornheim
326	2/25/2022	5.2	4.5	17.2	16.4	28.8	7.2	7.2	19.6	20.1		Bornheim
327	2/26/2022	9.3	8.1	20.0	19.0	44.4	10.9	10.6	17.7	17.9		Bornheim
328	2/27/2022	7.7	6.7	11.2	10.0	67.9	7.1	7.0	9.1	9.3		Bornheim
329	2/28/2022	10.8	10.8	16.3	15.1	68.8	11.4	10.9	14.2	14.2		Bornheim
330	3/1/2022	14.9	14.0	20.2	19.7	72.3	14.6	14.0	19.1	19.0		Bornheim

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 12 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
331	3/2/2022	15.8	16.1	25.1	24.3	64.6	16.4	15.7	23.2	23.2		Bornheim
332	3/3/2022	17.9	17.8	26.2	25.5	69.0	18.6	17.5	23.6	23.0		Bornheim
333	3/4/2022	19.2	19.0	28.2	27.7	68.5	20.5	19.3	25.7	25.4		Bornheim
334	3/5/2022	18.0	18.1	22.7	21.6	81.4	18.6	17.5	20.8	20.4		Bornheim
335	3/6/2022	19.0	19.2	25.2	24.2	77.2	19.7	18.3	22.3	22.1		Bornheim
336	4/9/2022	5.6	5.4	12.2	11.2	46.8	5.4	5.1	10.0	10.2		Bonn
337	4/10/2022	7.4	6.8	11.7	11.4	61.2	5.9	5.6	9.1	9.0		Bonn
338	4/11/2022	7.6	6.4	12.2	12.0	58.1	6.4	6.0	11.5	11.4		Bonn
339	4/12/2022	7.3	6.9	13.7	14.0	51.2	6.5	5.8	17.1	13.7		Bonn
340	4/13/2022	13.7	13.7	24.9	26.1	53.8	11.3	10.8	21.5	21.6		Bonn
341	4/14/2022	16.6	16.4	23.8	23.7	69.6	15.9	15.2	20.9	21.0		Bonn
342	4/15/2022	14.8	13.8	18.9	19.0	75.3	13.9	13.1	17.3	16.7		Bonn
343	4/16/2022	6.9	5.0	7.3	7.5	80.4	5.7	5.4	8.6	8.3		Bonn
344	4/17/2022	5.5	5.1	7.6	7.7	69.3	4.9	4.6	7.3	7.5		Bonn
345	4/18/2022	6.4	7.6	10.3	9.8	69.8	5.3	5.0	8.3	8.3		Bonn
346	4/19/2022	5.3	6.7	11.6	11.2	52.6	5.0	4.8	10.0	11.0		Bonn
347	4/20/2022	5.7	6.2	12.6	13.1	46.3	4.4	4.3	10.2	11.5		Bonn
348	4/21/2022	6.2	7.0	13.1	13.3	49.8	5.2	4.9	10.6	10.9		Bonn
349	4/22/2022	9.0	9.9	14.8	14.4	64.6	9.8	9.3	14.9	14.5		Bonn
350	4/23/2022	11.1	11.8	15.9	16.0	71.8	12.5	11.9	16.6	16.4		Bonn
351	4/24/2022	9.4	11.6	13.5	14.5	74.8	9.4	9.0	12.7	13.1		Bonn
352	4/25/2022	8.8	10.9	13.8	15.0	68.5	9.5	9.1	12.6	12.2		Bonn
353	4/26/2022	13.3	16.1	20.5	20.2	72.2	13.8	13.4	16.7	16.5		Bonn
354	4/27/2022	12.8	15.2	23.2	23.6	59.9	14.3	13.7	19.6	19.3		Bonn
355	4/28/2022	15.8	18.3	27.3	27.1	62.6	16.2	15.5	22.6	22.0		Bonn
356	4/29/2022	16.6	19.1	31.9	30.7	57.1	15.8	15.0	23.4	22.8		Bonn
357	4/30/2022	8.9	9.1	15.7	15.8	57.1	9.4	8.9	13.6	13.4		Bonn
358	5/1/2022	12.6	13.9	21.5	20.4	63.2	13.1	12.2	17.5	16.9		Bonn
359	5/2/2022	13.9	14.5	23.5	22.3	62.1	14.7	14.0	20.9	20.1		Bonn
360	5/3/2022	13.1	13.4	24.6	23.3	55.1	14.1	13.5	22.0	21.7		Bonn

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 13 of 16**

Manufacturer: Palas GmbH

Type of instrument: Fidas Smart 100

Serial-No.: SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
361	5/4/2022	13.7	13.4	27.8	27.2	49.5	14.3	13.7	22.8	22.5		Bonn
362	5/5/2022	13.8	12.9	28.3	28.4	47.1	12.7	12.2	21.3	20.9		Bonn
363	5/6/2022	15.4	14.0	27.5	26.2	54.8	16.1	15.3	23.8	22.9		Bonn
364	5/7/2022	13.9	12.9	21.7	20.9	62.9	16.4	15.6	22.3	21.7		Bonn
365	5/8/2022	8.9	8.8	15.7	15.3	57.0	10.7	10.3	15.0	14.7		Bonn
366	5/9/2022	8.0	8.4	15.8	15.4	52.6	7.4	7.1	13.8	14.0		Bonn
367	5/10/2022	12.2	11.8	19.4	19.3	61.8	9.6	9.2	19.8	20.0		Bonn
368	5/11/2022	11.1	12.2	19.7	19.7	59.0	7.9	7.7	21.9	21.1		Bonn
369	5/12/2022	7.3	6.9	14.1	14.4	49.5	5.1	5.0	12.8	12.8		Bonn
370	5/13/2022	6.3	7.2	16.8	15.8	41.2	4.5	4.3	12.0	12.5		Bonn
371	5/14/2022	9.2	10.0	19.0	17.8	52.0	6.9	6.7	13.2	14.2		Bonn
372	5/15/2022	10.2	10.8	18.1	16.8	60.3	8.5	8.1	14.1	14.5		Bonn
373	5/16/2022	7.9	8.1	15.7	16.2	50.0	8.0	7.7	16.5	16.5		Bonn
374	5/17/2022	4.8	5.3	10.5	10.9	47.1	5.8	5.6	11.8	11.6		Bonn
375	5/18/2022	7.5	8.3	12.8	13.5	60.4	5.5	5.3	12.8	12.4		Bonn
376	5/19/2022	7.7	8.7	16.5	17.6	48.1	7.3	7.0	19.1	18.7		Bonn
377	5/20/2022	6.8	8.2	13.9	14.1	53.4	10.8	10.4	17.2	17.0		Bonn
378	5/21/2022	3.7	3.7	8.0	7.8	47.1	4.1	3.9	7.9	8.0		Bonn
379	5/22/2022	3.6	4.7	9.5	10.0	42.7	4.8	4.6	8.5	8.6		Bonn
380	5/23/2022	5.1	6.2	11.4	11.5	48.9	6.5	6.2	13.2	13.2		Bonn
381	5/24/2022	0.6	2.6	6.0	7.2	24.8	3.2	3.1	7.9	8.0		Bonn
382	5/25/2022	2.6	3.1	6.3	6.3	45.4	2.1	2.0	6.6	6.8		Bonn
383	5/26/2022	2.0	2.7	6.4	7.3	34.5	3.3	3.1	7.0	7.0		Bonn
384	5/27/2022	3.5	3.4	7.9	8.6	42.1	4.1	3.9	9.2	9.1		Bonn
385	5/28/2022	3.9	3.6	9.8	10.2	37.4	4.4	4.2	9.2	9.4		Bonn
386	5/29/2022	3.0	1.8	5.5	5.6	42.9	3.5	3.3	6.6	6.9		Bonn
387	5/30/2022	5.4	5.2	9.1	10.0	55.7	6.7	6.4	10.9	11.0		Bonn
388	5/31/2022	5.1	5.4	9.1	10.0	54.5	5.7	5.4	10.4	10.3		Bonn
389	6/1/2022	4.2	3.8	7.4	7.6	53.4	3.6	3.5	7.8	7.8		Bonn
390	6/23/2022			35.1	34.5				32.0	29.7		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 14 of 16**

Manufacturer Palas GmbH
Type of instrument Fidas Smart 100
Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
391	6/24/2022			8.4	8.2				11.0	10.1		Cologne II
392	6/25/2022			10.7	10.3				10.9	10.4		Cologne II
393	6/26/2022			12.1	12.7				11.3	10.6		Cologne II
394	6/27/2022			13.6	12.2				13.2	12.1		Cologne II
395	6/28/2022			15.3	15.5				15.9	14.4		Cologne II
396	6/29/2022			35.6	33.4				30.3	27.9		Cologne II
397	6/30/2022			20.6	19.6				20.8	18.6		Cologne II
398	7/1/2022			9.1	8.4				9.4	8.9		Cologne II
399	7/2/2022			16.5	15.3				15.0	13.6		Cologne II
400	7/3/2022			10.6	9.4				9.9	9.1		Cologne II
401	7/4/2022			8.7	7.8				7.9	7.2		Cologne II
402	7/5/2022			12.1	13.2				12.8	11.4		Cologne II
403	7/6/2022			10.0	9.7				10.3	9.1		Cologne II
404	7/7/2022			10.9	11.9				12.4	10.9		Cologne II
405	7/8/2022			9.0	10.3				10.5	9.6		Cologne II
406	7/9/2022			9.2	10.6				11.5	10.4		Cologne II
407	7/10/2022			6.5	8.0				8.4	7.9		Cologne II
408	7/11/2022			5.6	8.5				8.8	7.8		Cologne II
409	7/12/2022			18.8	21.1				17.7	15.9		Cologne II
410	7/13/2022			24.5	25.5				21.5	19.7		Cologne II
411	7/14/2022			12.8	12.8				13.8	12.3		Cologne II
412	7/15/2022			9.0	9.2				8.9	8.2		Cologne II
413	7/16/2022			13.8	14.1				13.2	11.5		Cologne II
414	7/17/2022			25.8	25.5				19.7	17.9		Cologne II
415	7/18/2022			33.6	32.5				27.9	25.0		Cologne II
416	7/19/2022			44.6	44.3				42.9	40.2		Cologne II
417	7/20/2022			26.5	27.1				32.3	30.3		Cologne II
418	7/21/2022			10.0	11.1				12.7	11.9		Cologne II
419	7/22/2022			17.4	16.3				17.2	16.0		Cologne II
420	7/23/2022			15.4	14.3				16.9	14.0		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 15 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
421	7/24/2022			19.7	18.3				16.4	15.0		Cologne II
422	7/25/2022			19.8	18.2				18.6	17.2		Cologne II
423	7/26/2022			12.1	12.1				13.0	12.3		Cologne II
424	7/27/2022			16.2	15.7				12.1	10.7		Cologne II
425	7/28/2022			26.7	25.4				24.5	23.0		Cologne II
426	7/29/2022			21.4	20.8				20.1	17.9		Cologne II
427	7/30/2022			14.7	13.4				16.6	15.9		Cologne II
428	7/31/2022			11.2	10.3				11.7	11.2		Cologne II
429	8/1/2022			6.3	6.3				8.0	7.4		Cologne II
430	8/2/2022			22.2	21.1				18.2	16.5		Cologne II
431	8/3/2022			15.0	13.8				15.0	13.7		Cologne II
432	8/4/2022			34.0	31.2				31.1	28.0		Cologne II
433	8/5/2022			10.3	9.0				11.4	10.8		Cologne II
434	8/6/2022			11.2	9.7				9.5	8.8		Cologne II
435	8/7/2022			17.4	16.1				13.2	12.1		Cologne II
436	8/8/2022			15.1	13.5				14.5	12.9		Cologne II
437	8/9/2022			21.1	20.0				19.9	17.6		Cologne II
438	8/10/2022			34.2	33.0				29.7	26.5		Cologne II
439	8/11/2022			48.5	47.5				40.8	37.8		Cologne II
440	8/12/2022			37.8	37.2				37.1	34.4		Cologne II
441	8/13/2022			33.9	33.0				31.4	28.4		Cologne II
442	8/14/2022			24.4	23.8				23.3	21.3		Cologne II
443	8/15/2022			18.0	17.5				18.3	17.1		Cologne II
444	8/16/2022			23.5	23.1				25.9	23.0		Cologne II
445	8/17/2022			21.5	21.0				22.3	20.4		Cologne II
446	8/18/2022			20.0	19.6				21.1	19.5		Cologne II
447	8/19/2022			16.6	16.3				20.5	19.2		Cologne II
448	8/20/2022			13.2	12.4				13.8	12.8		Cologne II
449	8/21/2022			12.9	12.6				11.1	10.9		Cologne II
450	8/22/2022			26.3	23.7				19.4	17.7		Cologne II

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 16 of 16**

Manufacturer Palas GmbH

Type of instrument Fidas Smart 100

Serial-No. SN 12248 / SN 12250

PM10 + PM2.5
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM2,5 [µg/m³]	Ref. 2 PM2,5 [µg/m³]	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Ratio PM2,5/PM10 [%]	SN 12248 PM2,5 [µg/m³]	SN 12250 PM2,5 [µg/m³]	SN 12248 PM10 [µg/m³]	SN 12250 PM10 [µg/m³]	Remark	Test site
451	8/23/2022			20.4	18.0				17.3	15.8		Cologne II
452	8/24/2022			32.2	28.9				27.1	24.1		Cologne II
453	8/25/2022			34.0	31.5				33.9	30.7		Cologne II
454	8/26/2022			19.3	16.0				18.2	16.9		Cologne II
455	8/27/2022			11.9	11.1				11.2	10.5		Cologne II
456	8/28/2022			16.9	15.9				14.1	13.1		Cologne II

Appendix 2:

Methods used for filter weighing

Performance of weighing and handling of the filters

Weighing takes place in an air-conditioned weighing chamber. Conditions are as follows: 20 °C ±1 °C and 45% ± 50% rel. humidity and thus meet the requirements of EN 12341.

Filters for the field test are weighed manually. For further processing, filters incl. the control filters are placed on sieves to avoid cross-loading.
Conditions for initial and back weighing had previously been defined and are in line with the specifications of standard EN 12341.

Before sampling = pre-weighing	After sampling = post-weighing
Conditioning > 48 hours	Conditioning > 48 hours
Filter weighing	Filter weighing
Repeated conditioning > 12 hours	Repeated conditioning 24 to 72 hours
Filter weighing and immediate packing	Filter weighing

Blank value samples both from the weighing chamber and the field are used for the purpose of quality assurance. In doing so, the requirements of standard EN 12341 are taken into account.

Weighed filters are kept separately in polystyrene boxes for transports to and from the measurement site and for storage. The box is not opened until the filter is inserted in the filter cartridge. Unloaded filters shall be stored no longer than 2 months before sampling. Should this period be exceeded, initial weighing will be repeated.

Loaded filters must be brought to the weighing chamber within a month. They are then weighed within a month.

Appendix 3 CE Certificate and Certificate of Accreditation

EU-Konformitätserklärung

PALAS®

Der Hersteller

Palas GmbH
Greschbachstraße 3 b
76229 Karlsruhe
Deutschland

erklärt hiermit in alleiniger Verantwortung, dass die Produkte

Aerosolspektrometer:
AQ Guard, AQ Guard Smart 1000 / 1100 / 1200 / 2000

Feinstaubmessgeräte:
Fidas Smart 100 / 100 E

mit den Bestimmungen folgender Richtlinie übereinstimmen:

2014/53/EU	Funkanlagen-Richtlinie (RED)
2011/65/EU	RoHS

Die Schutzziele folgender Richtlinien werden eingehalten:

2014/35/EU	Niederspannungsrichtlinie
2014/30/EU	EMV-Richtlinie

Folgende harmonisierte Normen wurden angewendet:

DIN EN 61010-1:2020-03	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + COR:2011 + A1:2016, modifiziert + A1:2016/COR1:2019)
DIN EN 61326-1:2013-07	Elektrische Mess-, Steuer-, Regel- und Laborgeräte; EMV-Anforderungen – Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012)
DIN EN IEC 63000:2019-05	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe

Karlsruhe, 05.09.2022

Dr.-Ing. Maximilian Weiß
Geschäftsführer

www.palas.de

PALASCOUNTS

Figure 65: CE Certificate

DAkkS
Deutsche
Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Beliehene gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV
Unterzeichnerin der Multilateralen Abkommen
von EA, ILAC und IAF zur gegenseitigen Anerkennung

Akkreditierung

Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium

TÜV Rheinland Energy GmbH
mit seinen in der Urkundenanlage aufgeführten Messstellen und Standorten

die Kompetenz nach DIN EN ISO/IEC 17025:2018 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

Bestimmung (Probenahme und Analytik) von anorganischen und organischen gas- oder partikel-förmigen Luftinhaltsstoffen im Rahmen von Emissions- und Immissionsmessungen; Probenahme von luftgetragenen polyhalogenierten Dibenzo-p-Dioxinen und Dibenzofuranen bei Emissionen und Immissionen; Probenahme von faserförmigen Partikeln bei Emissionen und Immissionen; Ermittlung von gas- oder partikelförmigen Luftinhaltsstoffen mit kontinuierlich arbeitenden Messgeräten; Bestimmung von Geruchsstoffen in Luft; Kalibrierungen und Funktionsprüfungen kontinuierlich arbeitender Messgeräte für Luftinhaltsstoffe einschließlich Systemen zur Datenauswertung und Emissionsfernüberwachung; Feuerraummessungen; Eignungsprüfungen von automatisch arbeitenden Emissions- und Immissionsmesseinrichtungen einschließlich Systemen zur Datenauswertung und Emissionsfernüberwachung; Ermittlung der Emissionen und Immissionen von Geräuschen; Bestimmung von Geräuschen in der Nachbarschaft; Ermittlung von Geräuschen und Vibrationen am Arbeitsplatz; akustische und schwingungstechnische Messungen im Eisenbahnwesen; Bestimmung von Schallleistungspegeln von zur Verwendung im Freien vorgesehenen Geräten und Maschinen nach Richtlinie 2000/14/EG und Konformitätsbewertungsverfahren; Schornsteinhöhenberechnung und Immissionsprognose auf der Grundlage der Technischen Anleitung zur Reinhaltung der Luft und der Geruchsimmissions-Richtlinie und der VDI 3783 Blatt 13; Windenergieanlagen: Bestimmung von Windpotential, Energieerträgen, Standorterträgen und Standortgüte nach EEG, standortbezogenen Turbulenzcharakteristika und Extremwinde; Schallimmissionsprognosen, Schattenwurfimmissionsberechnung und Sichtbarkeitsbestimmung; Probenahme und mikrobiologische Untersuchungen von Nutzwasser gemäß §3 Absatz 8 42. BImSchV; physikalische, physikalisch-chemische und mikrobiologische Untersuchungen von Wasser (Abwasser, Wasser aus Rückkühlwerken sowie raumlufttechnischen Anlagen); Probenahme von Abwasser; mikrobiologische und ausgewählte chemische Untersuchungen gemäß Trinkwasserverordnung; Probenahme von Roh- und Trinkwasser; ausgewählte mikrobiologische Untersuchungen von Bedarfsgegenständen und kosmetischen Mitteln; Probenahme anorganischer faserförmiger Partikel sowie von partikel- und gasförmigen luftverunreinigenden Stoffen in der Innenraumluft; ausgewählte mikrobiologische Untersuchungen in Innenräumen; Ermittlung von Aerosolen und Faserstäuben, anorganischen und organischen Gasen und Dämpfen sowie ausgewählten Parametern und/oder in ausgewählten Gebieten bei Arbeitsplatzmessungen gemäß Gefahrstoffverordnung §7, Abs. 10; Modul Immissionsschutz

Die Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 17.06.2020 mit der Akkreditierungsnummer D-PL-11120-02. Sie besteht aus diesem Deckblatt, der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 48 Seiten.

Registrierungsnummer der Urkunde: **D-PL-11120-02-00**

Berlin, 17.06.2020

i.V. Im Auftrag Dipl.-Ing. Andrea Valbuena
Abteilungsleiterin

Die Urkunde samt Urkundenanlage gibt den Stand zum Zeitpunkt des Ausstellungsdatums wieder. Der jeweils aktuelle Stand des Geltungsbereiches der Akkreditierung ist der Datenbank akkreditierter Stellen der Deutschen Akkreditierungsstelle GmbH (DAkkS) zu entnehmen. https://www.dakks.de/content/datenbank-akkreditierter-stellen

Siehe Hinweise auf der Rückseite

Figure 66: Certificate of accreditation according to EN ISO/IEC 17025:2005

Deutsche Akkreditierungsstelle GmbH

Standort Berlin
Spittelmarkt 10
10117 Berlin

Standort Frankfurt am Main
Europa-Allee 52
60327 Frankfurt am Main

Standort Braunschweig
Bundesallee 100
38116 Braunschweig

Die auszugsweise Veröffentlichung der Akkreditierungsurkunde bedarf der vorherigen schriftlichen Zustimmung der Deutsche Akkreditierungsstelle GmbH (DAkkS). Ausgenommen davon ist die separate Weiterverbreitung des Deckblattes durch die umseitig genannte Konformitätsbewertungsstelle in unveränderter Form.

Es darf nicht der Anschein erweckt werden, dass sich die Akkreditierung auch auf Bereiche erstreckt, die über den durch die DAkkS bestätigten Akkreditierungsbereich hinausgehen.

Die Akkreditierung erfolgte gemäß des Gesetzes über die Akkreditierungsstelle (AkkStelleG) vom 31. Juli 2009 (BGBl. I S. 2625) sowie der Verordnung (EG) Nr. 765/2008 des Europäischen Parlaments und des Rates vom 9. Juli 2008 über die Vorschriften für die Akkreditierung und Marktüberwachung im Zusammenhang mit der Vermarktung von Produkten (Abl. L 218 vom 9. Juli 2008, S. 30).
Die DAkkS ist Unterzeichnerin der Multilateralen Abkommen zur gegenseitigen Anerkennung der European co-operation for Accreditation (EA), des International Accreditation Forum (IAF) und der International Laboratory Accreditation Cooperation (ILAC). Die Unterzeichner dieser Abkommen erkennen ihre Akkreditierungen gegenseitig an.

Der aktuelle Stand der Mitgliedschaft kann folgenden Webseiten entnommen werden:
EA: www.european-accreditation.org
ILAC: www.ilac.org
IAF: www.iaf.nu

Figure 67: Certificate of accreditation according to EN ISO/IEC 17025:2005 - page 2

Appendix 4: Operation manual