TÜV RHEINLAND IMMISSIONSSCHUTZ
UND ENERGIESYSTEME GMBH

Report on the suitability test of the ambient air quality measuring system BAM-1020 with PM10 pre-separator of the company Met One Instruments, Inc. for the measured component suspended particulate matter PM10

TÜV-Report: 936/21205333/A
Cologne, December 06, 2006

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- Determination of emissions and ambient air quality of air pollutants and odorants;
- Verification of the correct installation and the function as well as the calibration of continuous operating emission measuring systems including systems for data evaluation and remote monitoring of emissions;
- Suitability testing of measuring systems for continuous monitoring of emissions and ambient air quality as well as for electronic systems for data evaluation and remote monitoring of emissions

The accreditation is valid up to 04-12-2010.
DAR-Registration number: DAP-PL-3856.99.

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DAP-PL-3856.99

Report on the suitability test of the ambient air quality measuring system BAM-1020 with PM10 pre-separator of the company Met One Instruments, Inc. for the measured component suspended particulate matter PM10

Tested measuring system:	BAM-1020 with PM10 pre-separator
Manufacturer of the instrument:	Met One Instruments, Inc. 1600 NW Washington Blvd. Grants Pass, Oregon 97526 USA
Time period of testing:	from: February 2006 until: December 2006
Date of report:	December 06, 2006
Number of report:	936/21205333/A
Scope of report:	altogether 320 pages appendix from page 148 manual from page 169 with 151 pages

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1 Summary and proposal for declaration of suitability

1.1 Summary

According to the 1st Daughter Directive 1999/30/EC of 22 April 1999 „relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air" of the Ambient Air Quality Framework Directive 96/62/EC of 27 September 1996 „on ambient air quality assessment and management", the methods described in DIN EN 12341 „Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement methods" have to be used as reference method for the measurement of the PM10 concentration. Nevertheless, the Member States may also use a different method, if it is demonstrated, that „it displays a consistent relationship to the reference method. In that event the results achieved by that method must be corrected by a relevant factor to produce results equivalent to those that would have been achieved by using the reference method. "(1999/30/EC, Annex IX, Art. IV, Para.2).

The Guideline VDI 4202, Sheet 1 of June 2002 describes the „Minimum requirements for suitability tests of automated ambient air quality measuring systems". The general framework for the related test work is described in Guideline VDI 4203, Sheet 1 „Testing of automated measuring systems – General concepts "of October 2001. VDI 4203, Sheet 3, „Testing of automated measuring systems – Test procedures for point-related ambient air quality measuring systems of gaseous and particulate pollutants" of August 2004 specifies this framework.

Furthermore, the Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods" of the ad-hoc-EC-working group of November 2005 describes another method for the test of equivalency of non-reference methods. Though the mentioned Guidance is not normative, the application is recommended by the so-called CAFE-committee for the present.

On behalf of Met One Instruments, Inc., TÜV Rheinland Immissionsschutz und Energiesysteme GmbH has performed the suitability test of the measuring system BAM-1020 for the component PM10.

The suitability test was carried out in compliance with the following guidelines and requirements:

- VDI-Guideline 4202, Sheet 1, „Minimum requirements for suitability tests of automated ambient air quality measuring systems – Point-related measurement methods of gaseous and particulate pollutants “, June 2002 [1]
- VDI-Guideline 4203, Sheet 3, „Testing of automated measuring systems – Test procedures for point-related ambient air quality measuring systems of gaseous and particulate pollutants“, August 2004 [2]
- European Standard EN 12341, „Air quality - Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement methods“, German version DIN EN 12341: 1998 [3]
- Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods”, English version of November 2005 [9]

The investigations according to the Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods” have been carried out exemplarily on the basis of the measured data according to [1], [2] and [3], obtained during the field test. Hereby the investigations have been performed deviant to the requirement of the Guidance only at three instead of four field test sites and with less than respectively 40 valid paired measurements per field test site.

The measuring system BAM-1020 determines the particulate concentration by a radiometer measuring principle. With the aid of a pump, ambient air is sucked through a PM10 sampling head. The dust-loaded sampling air is afterwards sucked on a filter tape. The determination of the separated mass of dust on the filter tape is performed after the respective sampling by the radiometric measuring principle of beta-attenuation.

The investigations have been carried out in the laboratory and during a field test, lasting several months.

The field test, lasting several months, was performed at the test sites according to Table 1:

Table 1: Description of the test sites

	Cologne, parking lot	Titz-Roedingen	Cologne, Frankfurter Str.	additional Cologne, Frankfurter Str.
Time period	02/2006 – 04/2006	07/2006 – 09/2006	09/2006 – 10/2006	10/2006 – 11/2006
Used PM10-sampling inlet	BX-802 US	BX-802 US	BX-802 US	BX-809 EU
No. of pairs of measured values: Candidate	52	37	28	26
Characterization:	Urban background	Rural situation	Traffic	Traffic
Rank of pollution	average to high	low	average to high	average to high

The minimum requirements have been fulfilled in the suitability test.

Therefore the TÜV Rheinland Immissionsschutz und Energiesysteme GmbH proposes the publication as a suitability-tested measuring system for continuous monitoring of ambient air quality of suspended particulate matter PM10.

1.2 Proposal for declaration of suitability

Due to the positive achieved results, the following recommendation for declaration of suitability as suitability-tested measuring system is:

1.2.1	**Measurement task**	:	Continuous monitoring of ambient air quality of suspended particulate matter PM10
1.2.2	**Name of device**	:	BAM-1020 with PM10 pre-separator
1.2.3	**Measured components**	:	PM10
1.2.4	**Manufacturer**	:	Met One Instruments, Inc. 1600 NW Washington Blvd., Grants Pass, OR 97526, USA
1.2.5	**Suitability**	:	For continuous monitoring of ambient air quality of the PM10-fraction in suspended particulate matter in stationary applications.
1.2.6	**Measuring ranges in the suitability test**	:	0 to 1.000 mg/m³ = 0 to 1000 µg/m³
1.2.7	**Software version**	:	Version 3236-02 3.2.1b
1.2.8	**Restrictions**	:	None
1.2.9	**Remarks**	:	1. For recordation of PM10, the system has to be equipped with the following options: Sample heater (BX-830), sampling inlet (BX-802), ambient temperature sensor (BX-592) and air pressure sensor (BX-594). 2. The heater may only be used in the operational mode, which has been applied during the suitability test. 3. The volume flow regulation has to be carried out at actual volume with reference to the ambient conditions (operational mode ACTUAL). 4. The measuring system has been operated with the sample heater BX-830 during the complete suitability test. 5. The cycle time during the suitability test was 1 h, i.e. an automatic filter change has been performed every hour. Each filter spot has been used one time. 6. The measuring system has to be operated in a lockable measuring cabinet. 7. The measuring system has to be calibrated with the gravimetric PM10-reference method according to DIN EN 12341 on the site at regular intervals.

1.2.10 Test house	**:**	TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, Cologne, Germany TÜV Rheinland Group Responsible investigator: Mr. Dipl.-Ing. Karsten Pletscher
1.2.11 Test report	**:**	936/21205333/A of December 06, 2006

1.3 Summary of test results

Minimum requirement		Requirement	Test results	ful-filled	Page
4	Requirements on the instruments design				
4.1	General requirements				
4.1.1	Measured value display	Shall be available	The measuring system has got a measured value display.	yes	49
4.1.2	Easy maintenance	Maintenance work should be possible without larger time and effort, if possible performed from outside.	Maintenance work can be done from outside with common tools and justifiable operating expense.	yes	51
4.1.3	Functional check	Particular instruments for this shall be considered as part of the device, be applied in the corresponding sub-tests and be assessed. Test gas units shall indicate their operational readiness to the measuring system by status signals and shall provide direct or remote control via the measuring system. Uncertainty of the test gas unit shall not exceed 1 % of B2 within three months.	All instrument functions, listed in the manual, are available, can be activated and are functioning. The current status of the system is monitored continuously and is indicated by a series of different status messages (operational, alarm and error status.	yes	53
4.1.4	Set-up times and warm-up times	The manual shall contain specifications for this.	The set-up times and the warm-up times have been determined.	yes	55
4.1.5	Instrument design	The manual shall contain specifications for this.	The specifications for the instrument design, mentioned in the manual, are complete and correct.	yes	56
4.1.6	Unintended adjustment	Shall have protection against it.	The measurement system is protected against unintended and unauthorized adjustment of instrument parameters. Moreover the measuring system has to be locked in a measurement cabinet.	yes	57
4.1.7	Data output	Shall be offered digital and/or analogue.	The measured signals are offered analogue (0-1 resp. 10 V resp. 0–16 mA / 4-20 mA) and digital (via RS 232).	yes	58
4.2	Requirements for measuring systems for mobile application	Permanent operational standby shall be secured; requirements for stationary application shall also be fulfilled for mobile application.	In the context of the field test, the measuring system was operated at several different sites. A mobile application of the measuring system was not tested within the scope of the test.	no	60

Minimum requirement	Requirement	Test results	ful-filled	Page
5. Performance requirements				
5.1 General	Manufacturer's specifications in the manual shall not be contradictory to the results of the suitability test.	Differences between instrument layout and manuals have not been observed.	yes	61
5.2 General requirements				
5.2.1 Measuring range	Upper limit of measuring range larger than B_2.	A measuring range of 0 -1,000 µg/m³ is set by default. Other measuring ranges in the range between at minimum 0-100 µg/m³ and at maximum 0-10,000 µg/m³ are possible.	yes	62
5.2.2 Negative output signals	Shall not be suppressed (life zero).	Negative measuring signals are displayed directly and are output correctly via the respective measured value outputs by the measuring system.	yes	63
5.2.3 Analytical function	Relationship between output signal and measured quantity shall be represented by analytical function and determined by regression analysis.	A statistically secured relationship between the reference method and the instrument reading could be proved.	yes	65
5.2.4 Linearity	Deviation of group averages of measured values from the calibration function in the range from zero to B_1 maximum 5 % of B_1 and in the range from zero to B_2 maximum 1 % of B_2.	For particulate measuring systems, this test has to be performed according to the minimum requirement 5.3.1 „Equivalency of the sampling system".	yes	66
5.2.5 Detection limit	Maximum B_0.	The detection limit has been determined from the investigations to 1.7 µg/m³ for device 1 (SN 4924) and to 1.9 µg/m³ for device 2 (SN 4925).	yes	67
5.2.6 Response time	Maximum 5 % of averaging time (equal to 180 seconds).	Not applicable.	-	69
5.2.7 Dependence of the zero point on ambient temperature	Measured value at zero point shall not exceed B_0 at ΔT_u of 15 K between +5 °C and +20 °C respectively of 20 K between +20 °C and +40 °C.	Considering the values offered from the device, a maximum influence of the ambient temperature on the zero point of 0.7 µg/m³ could be detected.	yes	70

Minimum requirement	Requirement	Test results	ful-filled	Page
5.2.8 Dependence of the measured value on ambient temperature	The deviation of the measured value in the range of B1 shall not be exceed ± 5 % at ΔT_u of 15 K between +5 °C and +20 °C respectively of 20 K between +20 °C and +40 °C.	There have been no deviations > 0.1 % for device 1 (SN 4924), and no deviations > 0.2 % for device 2 (SN 4925), related to the start value at 20 °C.	yes	72
5.2.9 Drift of zero point	In 24 hours and in the maintenance interval maximum B_0.	The measuring system carries out a regular device-internal check of the zero point of the radiometric measurement during each measurement cycle. This test leads to no interruption of the ongoing measuring operation at all. The obtained values, determined within the scope of the drift investigations, are within the allowed limits in the maintenance interval.	yes	75
5.2.10 Drift of measured value	In 24 hours and in the maintenance interval maximum 5% of B_1.	The measuring system carries out a regular device-internal check of the sensitivity of the radiometric measurement during each measurement cycle. This test leads to no interruption of the ongoing measuring operation at all. The values for the drift of the sensitivity, determined within the scope of the test, were at maximum 0.44 % (SN 4924) respectively -0.02 % (SN 4925) in the maintenance interval.	yes	81
5.2.11 Cross-sensitivity	In the range of zero point maximum B_0 and in the range B_2 maximum 3 % of B_2.	Not applicable.	-	86
5.2.12 Reproducibility RD	$R_D \geq 10$, related to B_1.	The reproducibility RD was at minimum 16 during the field test.	yes	87
5.2.13 Hourly averages	Formation shall be possible.	The formation of hourly averages for the component SPM PM10 is not necessary for the monitoring of the relevant limit values, but possible.	yes	89
5.2.14 Mains voltage and frequency	Change in measured value at B_1 maximum B_0 in the mains voltage interval (230 +15/-20) V and change in measured value for mobile applications maximum B_0 in the power frequency interval (50 ± 2) Hz.	Through changes in the mains voltage, maximum deviations of -1.6 µg/m³ at the zero point and maximum 0.2 % at the tested reference points could be detected.	yes	92
5.2.15 Failure in mains voltage	Uncontrolled emission of operation or calibration gas shall be avoided; instrument parameters shall be secured by buffering against loss; operation mode shall be secured after return of mains voltage and measurement shall be resumed.	All instrument parameters are protected against loss by buffering. The measuring system is in normal operating condition after return of power supply and continues independently the measurements with reaching the next hour.	yes	93

Minimum requirement	Requirement	Test results	ful-filled	Page
5.2.16 Operating states	Shall be able to be controlled by telemetrically transmitted status signals.	The measuring systems can be controlled and monitored extensively from an external PC via a modem.	yes	94
5.2.17 Switch-over	Measurement/functional check and/or calibration shall be able to be activated telemetrically and manually.	Generally all necessary operations for functional check and calibration can be monitored directly at the device or via telemetric remote control.	yes	95
5.2.18 Availability	At least 90 %.	The availability was 99.7 % for both devices without outages, caused by testing, respectively 99.0 % incl. outages, caused by testing.	yes	96
5.2.19 Efficiency of the converter	At least 95 %.	Not applicable.	not applicable	98
5.2.20 Maintenance interval	Preferably 28 days, at least 14 days.	The maintenance interval is defined by the accruing maintenance work and it is 4 weeks.	yes	99
5.2.21 Overall uncertainty	Fulfillment of the requirements on the data quality [G10 to G12].	The overall uncertainties have been 7.23 % respectively 7.89 % for U(c) and 7.44 % respectively 8.28 % for $U(\bar{c})$.	yes	100
5.3.1 Equivalency of the sampling system	To the reference method according to EN 12 341 [T2] shall be demonstrated.	The reference-equivalence functions are bounded within the limits of the acceptance envelope. Furthermore the variance coefficient R^2 of the determined reference-equivalence functions is ≥ 0.95 for the respective concentration range.	yes	104

Minimum requirement		Requirement	Test results	ful-filled	Page
5.3.2	Reproducibility of the sampling systems	Shall be demonstrated in the field test according to DIN EN 12341 [T2] for two identical sampling systems.	The two-sided confidence interval CI95 is, with maximum 2.54 µg/m³, below the specified level of 5 µg/m³.	yes	112
5.3.3	Calibration	By comparison measurement in the field test with reference method according to DIN EN 12341 [T2]; relationship between measured signal and gravimetrically determined reference concentration to be determined as a steady function.	Refer to module 5.2.3.	-	116
5.3.4	Cross-sensitivity	Maximum 10 % of B_1.	No interfering influence > 1.46 µg/m³ deviation from the nominal value on the measured signal through the air humidity, which is contained in the medium being measured could be detected. During the field test, it could be observed no negative influence on the measured values during varying relative air humidity and activated heating system.	yes	118
5.3.5	Daily averages	24 h-mean values shall be possible; time needed for the filter change maximum 1 % of averaging time.	With the described system configuration and with a measurement cycle of 60 min, the formation of valid daily averages on the basis of 24 single measurements is possible.	yes	120
5.3.6	Constancy of sample volumetric flow	± 3 % of nominal value during sampling time; Instantaneous values ± 5 % of nominal value during sampling time.	All determined averages over the measurement cycle deviate less than ± 3 %, all instantaneous values deviate less than ± 5 % from the nominal value.	yes	122
5.3.7	Tightness of the sampling system	Leakage maximum 1 % of sample volume.	The maximum determined leakages have been 0.6 % for device 1 (SN 4924) as well as 0.6 % for device 2 (SN 4925).	yes	124
5.4	Requirements for multiple-component measuring systems	Shall be fulfilled for each single component in the simultaneous operation of all measuring channels; the formation of hourly averages shall be secured in case of sequential operation.	Not applicable.	-	125

Minimum requirement	Requirement	Test results	ful-filled	Page
Additional test criteria according to Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods“				
Determination of the between-instrument uncertainty ubs [9.5.2.1]	Shall be determined in the field test according to point 9.5.2.1 of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods“ for two identical systems.	The between-instrument uncertainty ubs is with at maximum 1.22 µg/m³ below the required value of 3 µg/m³.	yes	127
Calculation of the expanded uncertainty of the instruments [9.5.2.2-9.5.6]	Determination of expanded uncertainty of candidates according to the points 9.5.2.2et seq. of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods“.	The determined uncertainties WCM are below the set expanded relative uncertainty Wdqo of 25 % for PM for all regarded datasets without the application of correction factors.	yes	134
Application of correction factors or terms [9.7]	If the highest calculated expanded uncertainty of candidates is larger then the expanded relative uncertainty, specified in the requirements on the data quality of ambient air quality measurements according to EU-Guideline [7], an application of correction factors is allowed. The corrected values shall meet the requirements according to the points 9.5.2.2et seq. of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods“.	The candidate systems fulfill the requirements on the data quality of ambient air quality measurements during the test without the application of correction factors.	yes	143

2 Terms of reference

2.1 Kind of testing

On behalf of Met One Instruments, Inc., TÜV Rheinland Immissionsschutz und Energiesysteme GmbH has performed the suitability test of the measuring system BAM-1020 with PM10 pre-separator. The test was performed as a complete suitability test.

2.2 Objective

The measuring systems shall determine the content of PM10 suspended particulate matter in ambient air in the concentration range 0 to 1.000 mg/m³ = 0 to 1000 µg/m³.

The suitability test was performed on the basis of the current guidelines for suitability tests.

The test was carried out considering the following guidelines:

- Guideline VDI 4202, Sheet 1, „Minimum requirements for suitability tests of automated ambient air quality measuring systems – Point-related measurement methods of gaseous and particulate pollutants “, June 2002, [1]
- Guideline VDI 4203, Sheet 3, „Testing of automated measuring systems – Test procedures for point-related ambient air quality measuring systems of gaseous and particulate pollutants “, August 2004, [2]
- European Standard DIN EN 12341, „Air quality – Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement methods“, German version DIN EN 12341: 1998, [3]

Furthermore an additional evaluation of the field test data according to the criteria of the Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods” from the EU working group was performed within the scope of the suitability test at hand.

- Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods”, English version from November 2005, [9]

The investigations according to the Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods” have been carried out exemplarily on the basis of the measured data according to [1], [2] and [3], obtained during the field test. Hereby the investigations have been performed deviant to the requirement of the Guidance only at three instead of four field test sites and with less than respectively 40 valid paired measurements per field test site.

3 Description of the tested system

3.1 Measuring principle

The ambient air measuring system BAM-1020 is based on the measuring principle of beta-attenuation.

The principle of the radiometric determination of mass is based on the physical law of attenuation of beta-rays when passing a thin layer of material. There is the following relationship:

$$c\left(\frac{\mu g}{m^3}\right) = \frac{10^6 A(cm^2)}{Q\left(\frac{l}{min}\right)\Delta t(min)\mu\left(\frac{cm^2}{g}\right)} ln\left(\frac{I_0}{i}\right)$$

with:

C	particle-mass concentration	A	sampling area for particles (filter spot)
Q	sampling flow rate	Δt	sampling time
µ	mass absorption coefficient	I_0	beta count rate at the beginning (clean)
I	beta count at the end (collect)		

The radiometric determination of mass is calibrated in the factory and is checked within the scope of internal quality assurance hourly at the zero point (clean filter spot) and at the reference point (built-in reference foil) during operation. With the help of the generated data, measured values at zero and reference point can be easily affiliated. They can be compared with any stability requirements (drift effects) respectively with the nominal value for the reference foil (factory setting, please refer to appendix B in the manual).

3.2 Functionality of the measuring system

The particle sample passes the PM10-sampling inlet with a flow rate of 1 m³/h and arrives via the sampling tube at the measuring instrument BAM-1020.

Within the scope of the test work, the measuring system was operated with the sample heater BX-830. The heater can be controlled with the help of two control process variables respectively with their combination:

1. The relative humidity RH at the filter tape (factory setting: 45 %)
2. The temperature difference Delta-T between ambient temperature and temperature at the filter tape (factory setting: 5 °C)

As soon as the relative humidity RH is 1% below the nominal value or the critical value for Delta-T is reached respectively is exceeded, the heater is switched off. Thereby the criterion for Delta-T is the striking one, which means, that in case the relative humidity RH is above the nominal value, but the value for Delta-T is above or equal the critical value, the heater is switched off.

During the test work, the candidates were installed in an air-conditioned measuring cabinet. For this configuration, the controlling of the heater with the help of the Delta-T criterion is not reasonable. For this reason, the heater was only controlled with the help of the parameter relative humidity RH during the complete test work.

The particles arrive at the measuring instrument and will be separated at the glass fiber filter tape for the radiometric measurement.

One measurement cycle (incl. automatic check of the radiometric measurement) consists of the following steps (setting: measuring time for radiometry 4 min):

1. The initial count of the clean filter tape I_0 is performed at the beginning of the cycle for a period of four minutes.
2. The filter tape is advanced four windows and the sampling (vacuum pumping) begins on the spot in which I_0 was just measured. Air is drawn through this spot on the filter tape for approximately 50 minutes.
3. At the same time the second count I_1 occurs (at a point on the tape 4 windows back) for a period of four minutes. The purpose of the measurement is to perform the verification for instrument drift caused by varying external parameters such as temperature and relative humidity. A third count I_2 occurs with the reference membrane extended over the same place on the tape. The sample time should be chosen greater than or equal to 13 minutes, so as to allow for the overlapping auto calibration time.
   If there is enough time left, another count I_{1x} occurs four minutes before the end of sampling time on the same point of the tape. With the help of I_1 and I_{1x}, the stability at the zero point can be monitored.
4. After sampling, the filter tape is moved back four windows to measure the beta ray absorption through the section that has collected dust (I_3). Finally the concentration calculation is performed to complete the cycle.

5. The next cycle begins with step 1

Figure 1 shows schematically the course of a measurement cycle.

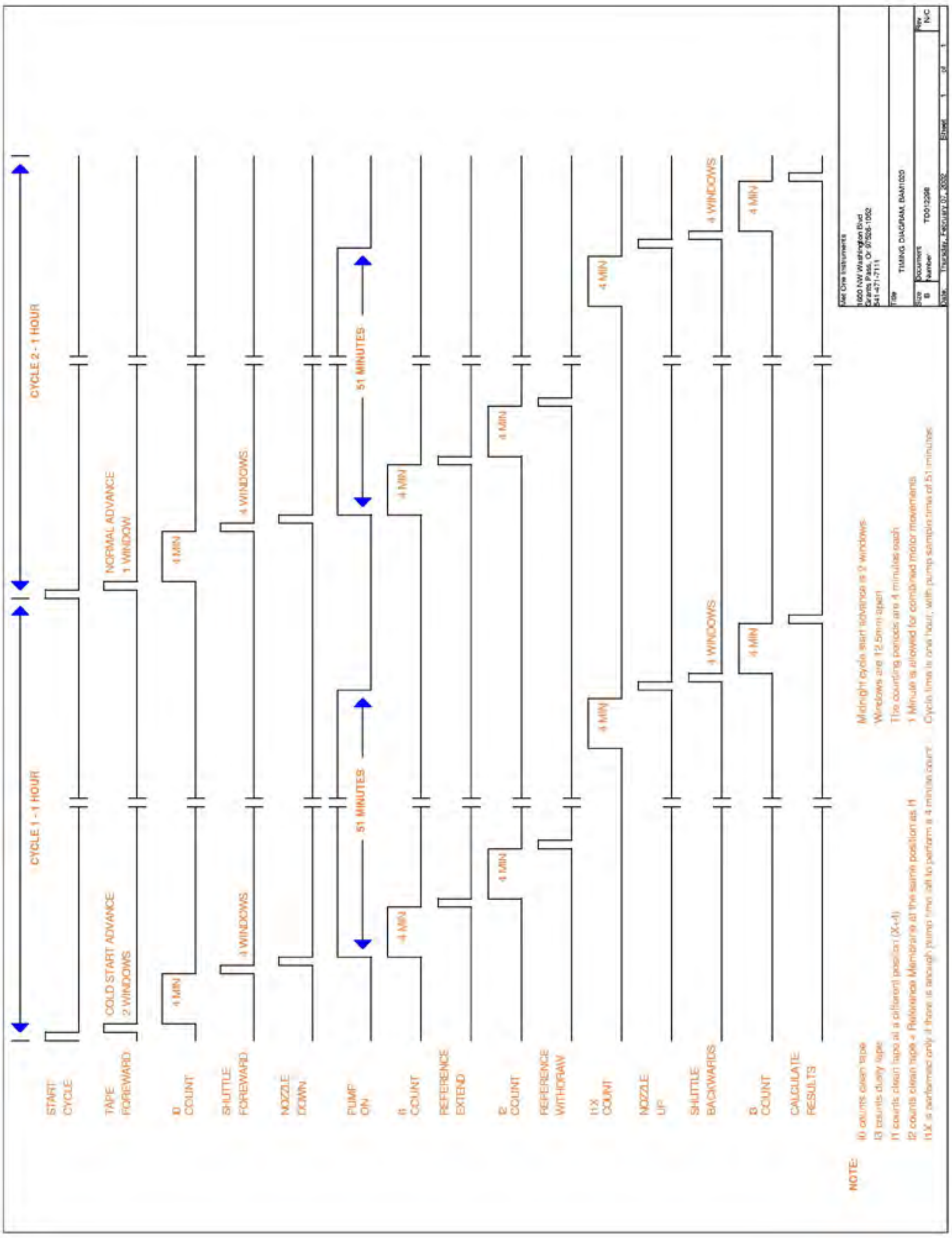

Figure 1: Timing diagram of the measurement cycle BAM-1020

During the suitability test work, a cycle time of 60 min with a time need of 4 min for the radiometric measurement was set.

Therefore the cycle time consists of 2 x 4 min for the radiometric measurement (I_0 & I_3) as well as approximately 1-2 min for filter tape movements. Thus the effective sampling time is around 50 min.

Furthermore, the measuring system allows an extension of the measuring time to 6 or 8 min in order to increase the precision of the radiometric measurement. The effective sampling time is then decreased to 46 respectively 42 min.

3.3 Extent and set-up of the measuring system

The ambient air measuring system BAM-1020 is based on the measuring principle of beta-attenuation.

The tested measuring system consists of the PM10-sampling inlet (US (BX-802), EU (BX-809)), the sampling tube, the sample heater BX-830, the ambient temperature sensor BX-592 (incl. radiation protection shield), the air pressure sensor BX-594, the vacuum pump BX-127, the measuring instrument BAM-1020 (incl. glass fiber filter tape), the respective connecting tubes and lines as well as adapters, the roof flange as well as the manual in English language.

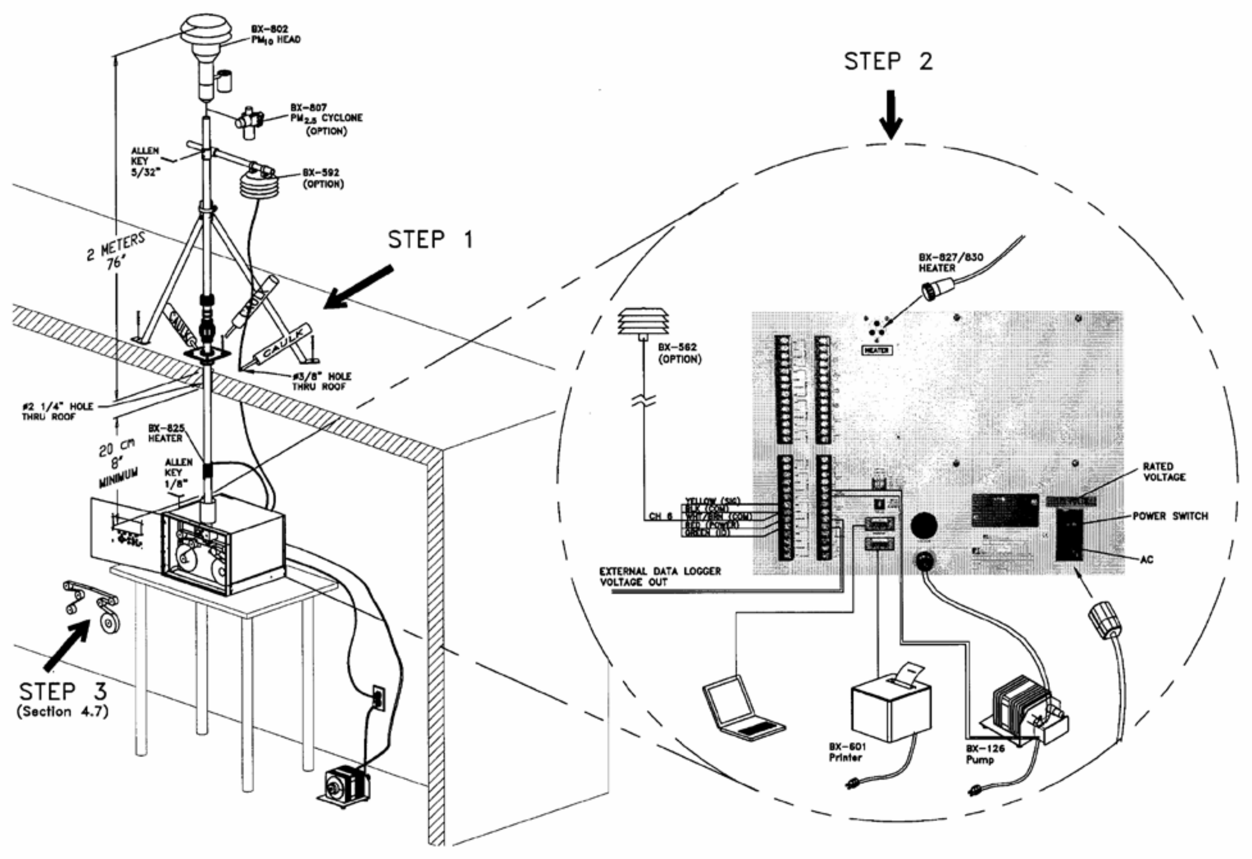

Figure 2: Overview measuring system BAM-1020

The measuring instrument BAM-1020 offers the possibility to connect up to 6 different sensors at the available analogue inputs. For example, besides the ambient temperature sensor BX-592 and the air pressure sensor BX-594, the connection of sensors for the wind direction (BX-590), for the wind velocity (BX.591), for the air humidity (BX-593) as well as for solar radiation (BX-595) is imaginable.

Concerning the sampling inlets, either an US-PM10 sampling inlet (type: BX-802, manufacture and design according to Guideline EPA 40 CFR Part 50) or an EU-PM10 sampling inlet (type: BX-809) is available. The sampling inlet serves as a pre-separator for the suspended particulate matter, which is drawn from the ambient air. The instruments are operated with a constant, regulated volume flow of 16.67 l/min = 1.0 m³/h. As an alternative option, it is possible to use TSP-sampling inlets as well as PM2.5-cyclones, installed behind the PM10-sampling inlet.

Figure 3: US- PM10-sampling inlet BX-802 for BAM-1020

Figure 4: European PM10-sampling inlet BX-809 for BAM-1020

The sampling tube connects the sampling inlet and the measuring instrument. The length of the sampling tube was 2.4 m during the test, differing lengths can be manufactured with respect to the local conditions.

The sample heater BX-830 is installed at the lower end of the sampling tube (approximately 50 mm above the instrument inlet of BAM-1020). The operation of the heating systems is performed as described in point 3.2 Functionality of the measuring system.

Figure 5: Sample heater BX-830

The vacuum pump BX-127 is connected to the measuring instrument at the end of the sampling path with a hose. The pump is controlled via the measuring system. The measuring system BAM-1020 contains, besides the radiometric measurement part, the glass fiber filter tape incl. transport system, large parts of the pneumatic system (flow measurement by mass flow sensor), the control unit of the sample heater and all necessary electronic parts and microprocessors for the control and operation of the measuring system as well as for the communication with the system.

Figure 6: Measuring instrument BAM-1020

Figure 7: Measuring systems BAM-1020, installed in measurement cabinet

Figure 8: Vacuum pump

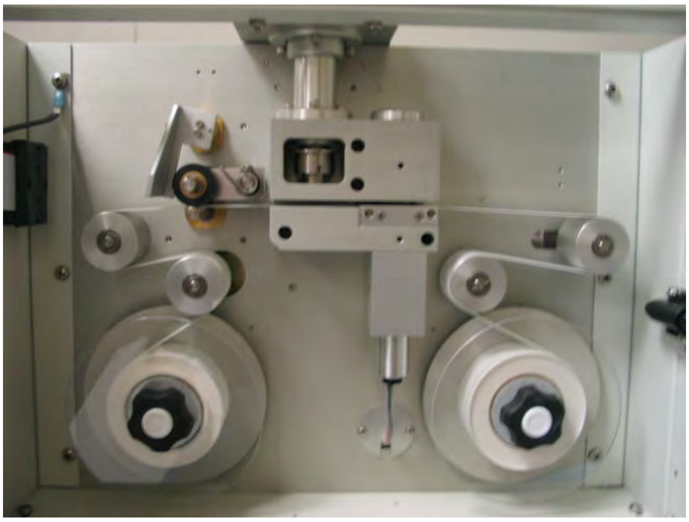

Figure 9: Front view BAM-1020, front cover opened

The handling of the measuring systems is done via a soft keypad in combination with a display at the front of the instrument. The user is able to get stored data, to change parameters and to perform several tests to control the functional capability of the measuring system.

The main screen of the user display can be found on the top level – here the actual time and date, the software version, the last concentration value as well as the status of the instrument are displayed.

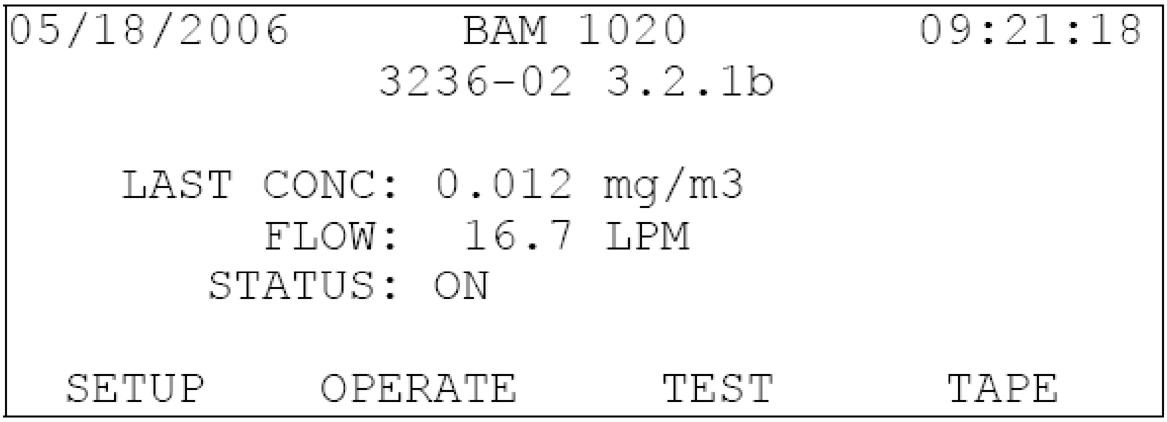

Figure 10: Main screen of the user display

Via the function keys F1 to F6, different functions can be easily called from the top level. For example it is possible, to access actual information on the last concentration values as well as measured values from other sensors (ambient temperature..), error messages and on stored data for the measurements of the last ten days.

Starting from the top level, one can furthermore access on the following sub-menus via soft key:

1. Menu „SETUP“ (Press soft key „SETUP“):
   The configuration and setting of parameters of the measuring system is done in the menu „SETUP“. The user can do settings for parameters like for instance date/time, sampling time, measuring range, flow rate, output of measured values (actual or standard conditions), change of pass word, interfaces, external sensors and sample heater.

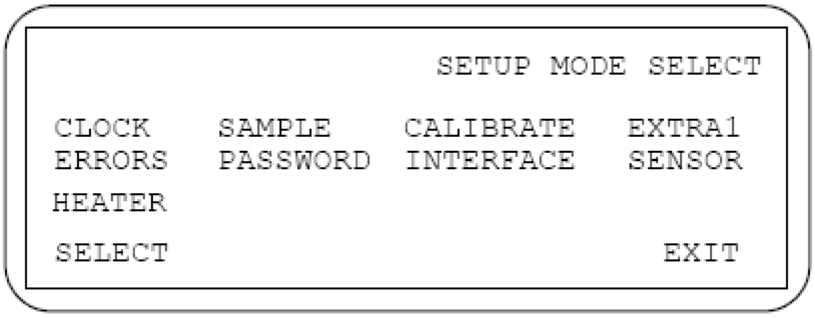

Figure 11: Menu „SETUP“

2. Menu „OPERATION“ (Press soft key „OPERATION“):
   In the menu „OPERATION“, it is possible to call up information during the operation of the measuring system. As long as the operating mode is switched on „ON“, the measuring system will be in operation according the settings. An interruption of the ongoing measurement can be done either by switching the operating mode to „OFF“, by calling up the menus „SETUP“, „TEST“ or „TAPE“ during the ongoing operation or in case of a severe malfunction (e.g. crack of filter tape).

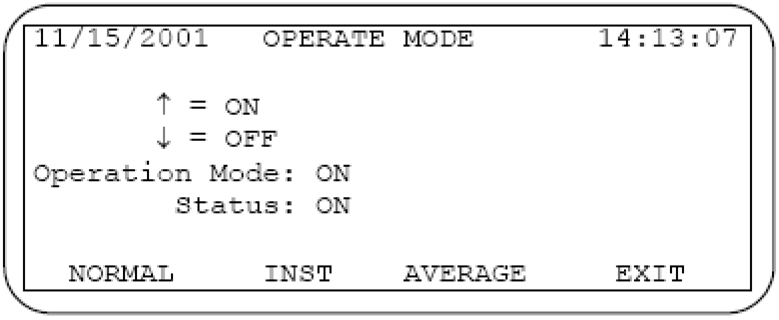

Figure 12: Menu „OPERATION“

3. Menu „TEST“ (Press soft key „TEST“):
   In the menu „TEST“, the user can perform several tests for checking the hardware and components, e.g. a check of the radiometric measurement (reference foil test), a check of the flow rate or a calibration of temperature and pressure sensors as well as of the flow rate is possible.

```
TEST MENU

COUNT      PUMP       TAPE       DAC
CALIBRATE  INTERFACE  FLOW       ALIGN
HEATER     FILTER-T   RH


 SELECT                            EXIT
```

Figure 13: Menu „TEST“

4. Menu „TAPE“ (Press soft key „TAPE“):
   In the menu „TAPE“, it is possible to start at any time (= aborting the ongoing measurement) an extensive self test of the measuring system. In this self test, which takes around 4 min, several mechanic parts (e.g. the filter transport system) are tested on functional capability and the flow rate and the condition of the filter tape (tension, crack of tape) are checked. In case of irregularities or unallowable deviations, an error message „FAIL“ is displayed and a specific search for the problem can start. If the self test can be performed without problems, the status „SELFTEST PASSED“ is displayed and the operation can start. The performance of this test is generally recommended after each restart of the measurement after abort, in each case after a change of the filter tape.

```
02/08/1999           15:29:30
LATCH: OFF           TAPE BREAK: OK
CAPSTAN: OK          TAPE TENSION: OK
NOZZLE DN: OK        SHUTTLE: OK
NOZZLE UP: OK        REF EXTEND: OK
FLOW: OK             REF WITHDRAW: OK
Status:   SELF TEST PASSED
TENSION   SELF TEST             EXIT
```

Figure 14: Menu „TAPE/SELF TEST“

Besides the direct communication via keys/display, there are numerous possibilities to communicate via different analogue outputs, relais (status and alarm messages) as well via RS-232 interfaces. The RS232-interfaces allow the connection of printer, PC and modem. The communication with the instrument can be done for instance with the software HyperTerminal.

The serial interface #1 serves form data transfer and transmission of the instrument status. This interface together with a modem is often used for remote control.

The following system menu is available:

```
---------------------------------------
|  > BAM-1020 <     System Menu      |
---------------------------------------

Select One of the Following:

0 - None
1 - Display Current Day Data
2 - Display All Data
3 - Display New Data
4 - Display System Configuration
5 - Display Date / Time
6 - CSV Type Report
7 - Display last 100 errors
8 - Display > BAM-1020 < Utility Commands
9 - Display Pointers

Press <Enter> to Exit a Selection
```

Figure 15: Communication via serial interface #1 – system menu

During the test work, the measured data have been readout and recorded once a week. They are suitable for further data integration to daily mean values in an external spreadsheet. The following picture shows an example for data, which have been recorded that way.

Station	1							
Time	Conc(mg)	Qtot(m3)	BP(mm)	WS(MPS)	no(V)	RH(%)	Delta(C)	AT(C)
9/28/2006 14:00	0.029	0.834	755.1	2.3	0.015	35	58.3	20.7
9/28/2006 15:00	0.031	0.834	754.9	2.1	0.012	33	58.4	21.7
9/28/2006 16:00	0.024	0.834	754.7	2.1	0.012	32	58.5	22
9/28/2006 17:00	0.03	0.834	754.5	2	0.011	32	58.5	22.3
9/28/2006 18:00	0.025	0.834	754.4	2	0.01	32	58.5	22.3
9/28/2006 19:00	0.029	0.834	754.3	2	0.01	33	58.5	21.5
9/28/2006 20:00	0.034	0.834	754.4	2	0.01	35	58.5	20.4
9/28/2006 21:00	0.048	0.834	754.5	2	0.01	36	58.5	19.1
9/28/2006 22:00	0.047	0.834	754.6	2	0.01	37	58.5	18.1
9/28/2006 23:00	0.051	0.834	754.8	2	0.01	37	58.5	17.1
9/29/2006 0:00	0.036	0.834	754.8	2	0.01	37	58.5	16.6
9/29/2006 1:00	0.035	0.834	754.7	2	0.01	37	58.5	16
9/29/2006 2:00	0.029	0.834	754.6	2	0.01	38	58.5	15.8
9/29/2006 3:00	0.03	0.834	754.6	2	0.01	38	58.5	15.3

Conc(mg):	concentration value in mg/m³, ambient conditions
Qtot(m³):	total sample volume in m³ (here at 50 min sampling time)
BP(mm-Hg):	ambient pressure in mm-Hg
WS:	wind velocity, not active in this case
no(V):	not active in this case
RH(%):	relative humidity below the filter tape in % - used for control of the sample heater
Delta(C):	difference ambient temperature – temperature at filter tape – used for control of the sample heater, not active in this case
AT(C):	ambient temperature in °C

The serial interface #2 serves only as a printer output and can be connected to a printer or a PC. It offers the possibility of continuous recording of actual information on the measurements.

Table 2 contains an overview of important technical specifications of the ambient air measuring system BAM-1020.

Table 2: Technical data BAM-1020 (specifications of manufacturer)

Dimensions / Weight		BAM-1020
	Measuring instrument	365 x 483 x 457 mm / 21 kg (without pump)
	Sampling tube	2.4 m
	Sampling inlet	BX-802 (US) BX-809 (EU)
Power supply		100/115/230 V, 50/60 Hz
Power consumption		75 W, Detector Control Unit
Ambient conditions		
	Temperature	-30 - +60 °C (specification of manufacturer) +5 - +40 °C in suitability test
	Humidity	not condensing
Sample flow rate		16,67 l/min = 1 m³/h
Radiometry	**Source**	^{14}C, <2,2 MBq (< 60 µCi)
	Detector	Scintillation probe
	Check procedure	Hourly, internal zero and reference point checks (reference foil), deviations from the nominal value are recorded
Parameter of filter change		
	Measurement cycle (cycle time)	1 min – 200 min Default: 60 min
	Measuring time radiometry	selectable 4,6 or 8 min Default: 4 min
	Sampling time	depending on measuring time radiometry 50, 46 or 42 min Default: 50 min
Parameter sample heater BX-830 (optional)		
	maximum temperature difference filter tape – ambient temperature	Default: 5°C
	Nominal value for relative humidity at filter tape	Default: 45 %
Buffer capacity (internal)		30 – 200 days, depending on cycle time
Analogue output		0 – 1 (10) V or 0 – 16 mA / 4 – 20 mA – can be set to 0-0.100, 0.200, 0.250, 0.500, 1.000, 2.000, 5.000 or 10.000 mg/m³
Digital output		2 x RS 232 – interface for data transmission and remote control
Status signals / error messages		available, for an overview refer to chapter 8 in the manual

4 Test program

4.1 General

The suitability test was carried out with two identical devices with the serial numbers SN 4924 and SN 4925.

At the beginning of the suitability test (February 2006), the software version 3236-02 2.65 was installed at the candidates. During the test work, the software was continuously enhanced and optimized up to the version 3236-02 3.2.1b. The changes have been checked and parts of the test work have been repeated, if necessary. There is no influence to expect on the instruments performance due to the performed alterations up to the version 3236-02 3.2.1b.

A field test at different field test sites over several months followed the laboratory test, during which the performance characteristics were assessed.

All determined concentrations are expressed in µg/m³, referred to standard conditions (273 K, 101.3 kPa). The additional evaluations according to Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods” were done with concentrations, converted to ambient conditions.

During the test work, there have been no changes on the instruments in manufacture and shape.

In the following report, the minimum requirements according to the considered guidelines [1,2,3] for each test point are stated with number and wording in the respective headlines.

4.2 Laboratory test

The laboratory test was performed with two identical devices of the type BAM-1020 with the serial numbers SN 4924 and SN 4925. According to the guidelines [1,2,3], the following test program in the laboratory was carried out:

- Description of the instrument functions
- Determination of the detection limit
- Determination of the dependence of zero point / sensitivity on the ambient temperature
- Determination of the dependence of zero point / sensitivity on the mains voltage

The following instruments have been used for the laboratory test for the determination of the performance characteristics:

- Climate chamber (temperature range from –20 °C to +50 °C, accuracy better than 1 °C)
- Adjustable isolating transformer
- Reference foil (built-in firmly in the devices)

The recording of the measured values was carried out via HyperTerminal with the aid of a desktop PC.

The results of the laboratory tests are compiled in point 6.

4.3 Field test

The field test was performed with two identical measuring systems.

Device 1: No. SN 4924

Device 2: No. SN 4925

The field investigations at the three different test sites were performed with an US-PM10-sampling inlet (BX-802). After having finished these investigations on Oct. 26, 2006, the candidates have been additionally equipped with the EU-PM10-sampling inlet (BX-809) at the field test site Cologne, Frankfurter Str. Target of these additional investigations has been the proof that the results, obtained with both different types of sampling inlets, do not differ significantly from each other and thus the operation of the system is basically possible with both types of sampling inlets.

For the field test, the following test program was established:

- Investigation of the comparability of the candidate systems according to DIN EN 12341 and (additionally) according to Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods”)
- Investigation of the comparability of the candidate system with the reference method (according to DIN EN 12341 and (additionally) according to Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods”)
- Additional investigations of the comparability of the two candidate systems according to DIN EN 12341 and (additionally) according to Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods” at field test site Cologne, Frankfurter Str. with EU-PM10-sampling inlet,
- Additionally investigation of the comparability of the candidate systems with the reference method (according to DIN EN 12341 and (additionally) according to Guidance “Demonstration of Equivalence of Ambient Air Monitoring Methods”) at field test site Cologne, Frankfurter Str. with EU-PM10-sampling inlet.
- Investigation of the constancy of the sampling flow rate
- Determination of the ability for calibration, erection of the analytical function
- Determination of the reproducibility R

- Determination of the drift behavior at zero and reference point
- Investigation of the tightness of the sampling system
- Examination of the dependence of the measured values on the air humidity, which is contained in the medium being measured
- Determination of the maintenance interval
- Determination of the availability
- Determination of the overall uncertainty of the candidate systems.

The following instruments have been used for the field test:

- Measurement cabinet of the TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, climate-controlled on approximately 20 °C
- Weather station (WS 500 of the company ELV Elektronik AG) for the recording of meteorological data, e.g. ambient temperature, ambient pressure, relative humidity, wind velocity, wind direction and amount of precipitation
- 2 reference samplers according to point 5
- 1 classifying sampler according to point 5
- Flow meter DK 37 E (manufacturer: Krohne)
- Dry gas meter (manufacturer: Elster-Instromet)
- Measuring device for the registration of the power consumption Metratester 5 (manufacturer: Gossen Metrawatt)
- Reference foil (built-in firmly in the devices)

Two BAM-1020 – systems, two reference samplers and one classifying sampler have been used simultaneously for in each case 24 h during the field test. The classifying sampler as well as the reference samplers at the first field test site (LVS3) is working discontinuously, i.e. after sampling has occurred, the filters must be changed manually.

The impaction plates of the PM10 sampling inlets have been cleaned approximately every 4 weeks and have been prepared with silicon paste, which ensures a secure separation of the coarse particles on the impaction plate.

The flow rate of the candidate systems as well as of the reference samplers have been checked with a dry gas meter, connected with a hose to the air inlet of the instrument, before and after the field test, as well as before and after every change of test site.

Test sites and arrangement of the measuring systems

The measuring systems have been installed in the field test in that way, that only the sampling inlets are arranged outside of the measurement cabinet above its roof. The central units of both candidate systems and those of the reference samplers have been installed inside the climate-controlled measurement cabinet. The connection of the central units with the sampling inlets was realized for the BAM-1020 -systems and for the reference samplers with the sampling tube. Only at field test site Cologne, parking lot, the complete reference samplers (LVS3) have been installed outside on the roof due to lack of space (old measurement cabinet). The classifying sampler was generally installed outside on the cabinet roof.

The field test was carried out at the following measurement sites:

Table 3: Field test sites

No.	Test site	Time period	Characterization
1	Cologne, parking lot	02/2006 –04/2006	Urban background
2	Titz-Roedingen	07/2006 – 09/2006	Rural situation
3	Cologne, Frankf. Str.	09/2006 – 11/2006	Traffic

Figure 16 to Figure 18 show the course of the PM-concentrations at the field test sites, which have been obtained with the reference systems.

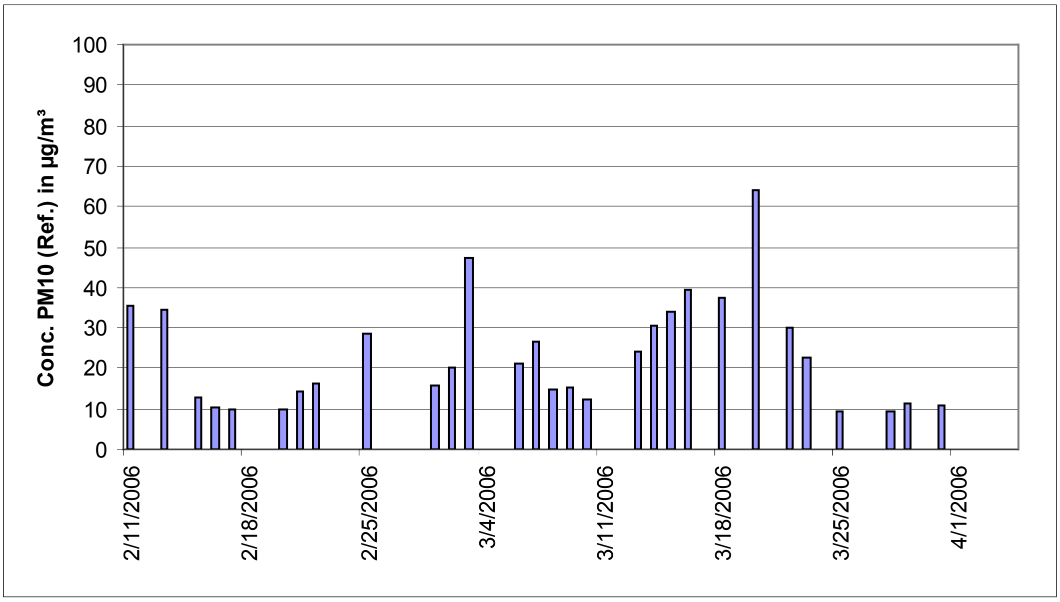

Figure 16: Course of PM10-concentrations (reference) at test site „Cologne, parking lot“

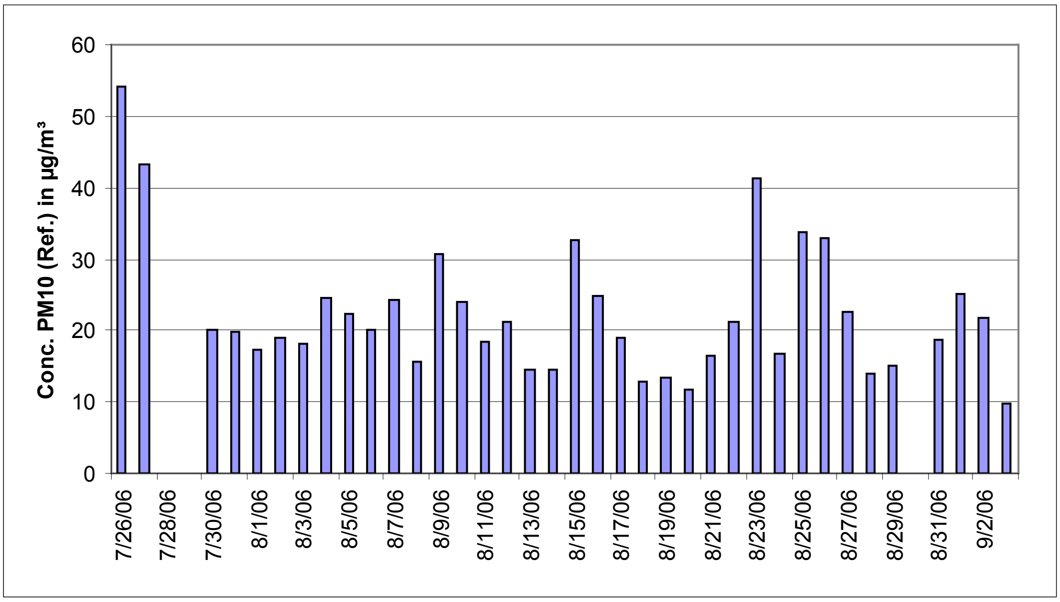

Figure 17: Course of PM10-concentrations (reference) at test site „Titz-Roedingen“

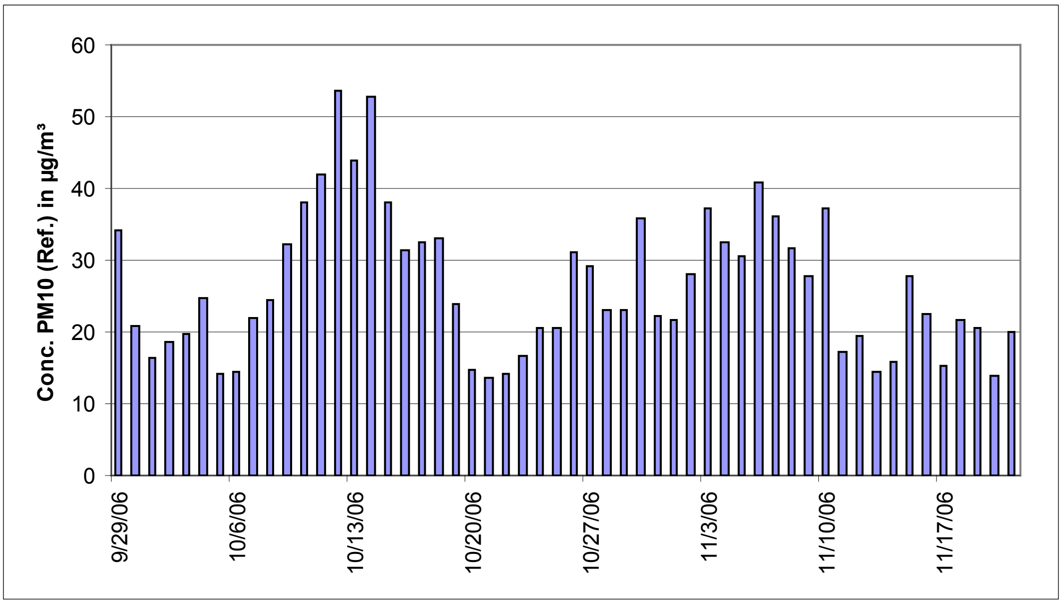

Figure 18: Course of PM10-concentrations (reference) at test site „Cologne, Frankfurter Str.“

The following pictures show the measurement cabinet at the field test sites Cologne (parking lot), Titz-Roedingen and Cologne (Frankfurter Str.).

Figure 19: Field test site „Cologne, parking lot“

Figure 20: Field test site „Titz-Roedingen“

Figure 21: Field test site Cologne, Frankfurter Str.

Together with the measuring systems for suspended particulate matter, a weather station for the determination of meteorological data has been installed at the measurement cabinet. There has been a continuous recording of ambient temperature, ambient pressure, relative air humidity, wind velocity, wind direction and precipitation. The data have been saved as 10min average values.

The set-up of the (old) cabinet itself (only at test site Cologne, parking lot), as well as the arrangement of the sampling probes has been characterized by the following dimensions:

- Height of roof of cabinet: 2.7 m
- Height of sampling point for candidate / reference / 1.2 / 1.3 / 1.0 m above roof
- classifying sampler(s) 3.9 / 4.0 / 3.7 m above ground
- Height of weather vane: 4.5 m above ground

The height of the sampling point of both candidate systems has been restricted due to the length of the sampling probe – the heights of the reference and classifying sampler(s) have been adapted accordingly.

- Distance between candidates: 0.7 m
- Distance candidate 1 – reference 1: 1.0 m
- Distance candidate 1 – reference 2: 1.6 m
- Distance candidate 2 – reference 1: 1.6 m
- Distance candidate 2 – reference 2: 1.0 m
- Distance candidate 1 – classifier 1: 2.1 m
- Distance candidate 2 – classifier 1: 2.8 m

The set-up of the (new) cabinet itself (since test site Titz), as well as the arrangement of the sampling probes has been characterized by the following dimensions:

- Height of roof of cabinet: 2.7 m
- Height of sampling point for candidate / reference / 1.2 / 1.2 / 1.0 m above roof
- classifying sampler(s) 3.9 / 3.9 / 3.7 m above ground
- Height of weather vane: 4.5 m above ground

The height of the sampling point of both candidate systems has been restricted due to the length of the sampling probe – the heights of the reference and classifying sampler(s) have been adapted accordingly.

- Distance between candidates: 1.4 m
- Distance candidate 1 – reference 1: 1.1 m
- Distance candidate 1 – reference 2: 1.8 m
- Distance candidate 2 – reference 1: 1.8 m
- Distance candidate 2 – reference 2: 1.1 m
- Distance candidate 1 – classifier 1: 1.0 m
- Distance candidate 2 – classifier 1: 1.0 m

The following Table 4 contains, besides an overview on the most important meteorological characteristics, which have been obtained at the 3 field test sites, also an overview on the suspended particulate matter conditions during the test period. Occasionally appearing ratios of suspended particulate matter >100 % have been rejected as implausible ones. All single values can be found in the annexes 4 and 5.

Table 4: Ambient conditions at the field test sites, daily mean values

	Cologne, parking lot	Titz-Roedingen	Cologne, Frankfurter Str. (US+EU-inlet)
No. of paired values (reference)	29	37	54
PM 10-ratio under ambient conditions [%]			
Range	26.1 – 91.3	42.3 – 96.3	55.5 – 99.7
Average	62.1	78.3	79.7
Ambient temperature [°C]			
Range	-3.2 – 15.6	12.7 – 26.5	5.5 – 19.1
Average	4.7	17.3	12.7
Ambient pressure [kPa]			
Range	98.2 – 102.4	99.2 – 101.0	98.9 – 102.4
Average	100.3	100.0	100.8
Rel. humidity [%]			
Range	33.7 – 89.1	55.8 – 81.7	63.8 – 82.7
Average	64.0	74.2	71.8
Wind velocity [m/s]			
Range	0.0 – 3.0	0.0 – 2.7	0.0 – 3.8
Average	1.1	0.4	1.1
Precipitation [mm]			
Range	0.0 – 15.2	0.0 – 35.7	0.0 – 19.8
Average	2.6	5.6	2.2

Sampling time

DIN EN 12341 requires a sampling time of 24 h. In case of low concentrations. A longer sampling time is allowed, likewise in case of higher concentrations, a shorter sampling time is allowed.

Whilst during the field test, the sampling time has always been 24 h (from 8 am until 8 am), the sampling time was decreased for some tests in the laboratory in order to get a higher number of measured values.

Handling of data

The determined pairs of measured values from the field investigations for the candidate as well as for the reference samplers have been undergone a statistical outlier test according to Grubbs (99 %) before the respective evaluations for each test site. This procedure has been done to avoid any effects from obviously implausible data on the results. Pairs of measured values that have been identified as significant outliers may be removed as long from the pool of values as the critical value for the test parameter has been fallen below target. However, for each test site, at maximum 5 % of the pairs of measured values may be removed in total.

Table 5 gives an overview on the results of the performed outlier tests (candidate and reference) for each test site. There have been no significant outliers identified.

Table 5: Overview on outliers – candidates and reference

	Reference PM10				BAM 1020, PM10			
Test site	n	Date	G1	G2	n	Date	SN 4924	SN 4925
Cologne, parking lot	29	no outliers			52	no outliers		
Titz-Rödingen	37	no outliers			37	no outliers		
Cologne, Frankfurter Str.	28	no outliers			28	no outliers		
Cologne, Frankfurter Str. EU-Head	26	no outliers			26	no outliers		

Filter handling – mass determination

The following filters have been used during the suitability test:

Table 6: Used filter materials

Measuring instrument	Filter material, type	Manufacturer
Reference sampler LVS3 respectively SEQ47/50	Quartz fiber, ∅ 50mm	Whatman
Classifying sampler GS 050	Quartz fiber, ∅ 50mm	Whatman

The clean filters for the reference and classifying samplers have been conditioned in the weighing room for at least 48h with a temperature of 20 ± 1 °C and a constant relative humidity. The weighing process has taken place on a balance of the company Sartorius, model MC 210P, which has an absolute resolution of 10µg. The filters for the reference sampler have been inserted in the filter holders and have been carried to and from the cabinet in filter containers. The filters for the classifying sampler have been inserted into the TSP-sampling heads in the weighing room, so only a changing of the entire sampling head on the field test sites has been necessary. Sampled filters have been carried back to the laboratory in their sampling heads and have been taken out of them in the weighing room.

The sampled filters have been treated in the weighing room the same way than the clean ones.

Thus the filter treatment has been according to the requirements of EN 12341, annex C.

5 Reference method

According to DIN EN 12341, the following devices have been used during the field test:

1. as reference sampler: Small Filter Device Low Volume Sampler LVS3 (field test site Cologne, parking lot)
Manufacturer: Ingenieurbüro Sven Leckel, Leberstraße 63, Berlin, Germany
Date of manufacture: 2000
PM10-sampling inlet

as well as

Filter Changer SEQ47/50, indoor version, (since test site Titz)
Manufacturer: Ingenieurbüro Sven Leckel, Leberstraße 63, Berlin, Germany
Date of manufacture: 2005
PM10-sampling inlet

2. as classifying sampler: Small Filter Device GS 050
Manufacturer: Derenda, Xantener Str. 22, Berlin, Germany
Date of manufacture: 1992
TSP-sampling inlet

During the test, two reference samplers have been used in parallel with a controlled flow rate of 2.3 m³/h. The accuracy of the flow rate control is less than 1 % of the nominal flow rate under real operating conditions.

Since the field test site “Titz-Roedingen”, two reference systems of the type Filter Changer SEQ47/50 have been used. The systems have been installed as indoor version, which means, that the central unit of the filter changer is installed inside the cabinet and the connection to the sampling inlet is realized with a sampling tube. The entire sampling system is conditioned by an ambient air layer – for this sake, the sampling tube itself is installed in a cladding tube, made of aluminum and purged with ambient air.

The filter changer is technically based on the small filter device LVS3 and because of its shape and manufacture, it complies on principle with the reference sampler according to EN 12341. The mechanism of filter change together with the clean and collect filter storage system allows a continuous 24-h-sampling over a period up to 15 days.

The sampling air for the LVS3 as well as for the SEQ47/50 is drawn through the sampling inlet with a rotary slide valve vacuum pump. The flow rate of the sampled air is measured between filter and vacuum pump via a measuring orifice. The inlet air is flowing from the pump to the air outlet, while passing a separator for the abrasion of the rotary slide valve.

After finished sampling, the measurement electronics show the sampled air intake volume in standard or actual-m³, respectively stores the measured data in the internal buffer (SEQ47/50).

The PM10 – concentration has been determined by dividing the gravimetrically determined dust amount on the filter by the associated sampled air volume in standard m³ (DIN EN 12341) respectively in ambient m³ (according to Guidance „Demonstration of equivalence of ambient air monitoring methods“).

As there have been two reference samplers in parallel available throughout the entire test work, the final PM10 – concentrations for the evaluations have been determined by averaging the two results of the respective parallel measurements.

The classifying sampler samples the suspended particulate matter in the ambient air according to German guideline VDI 2463, sheet 7. It includes the entire range of particle sizes (TSP = **T**otal **S**uspended **P**articulate Matter).

On principle, the performance of the classifying sampler is the same than the performance of the reference sampler in unregulated operating mode. The flow rate is measured with an impeller anemometer and is indicated in m³ through a coupled electro-mechanical counter, which has an precision of reading of 0,01 m³. The nominal flow should be 2.7 to 2.8 m³/h. During the sampling, the hourly flow should not fall below 2.6 m³/h. The sampled volume is determined with the difference of counts at the beginning and at the end of sampling.

The conversion of the sampled volume to standard conditions (273 K, 101.3 kPa) was made with the determined quantities ambient temperature, ambient pressure and under pressure at the gas meter.

The TSP – concentration has been determined by dividing the gravimetrically determined dust amount on the filter by the belonging sampled air volume in standard m³. The PM10-TSP ratio was calculated by division of the PM10 reference concentration by the associated content of TSP.

The sampling time was set with the aid of an electrical timer.

6 Test results

6.1 4.1.1 Measured value display

The measuring system shall be fitted with a measured value display.

6.2 Equipment

No additional equipment required.

6.3 Performance of test

It was checked, if the measuring system has got a measured value display.

6.4 Evaluation

The measuring system has got a measured value display. The respective measured concentration value from the last measurement cycle can be indicated on different screens of the users display.

6.5 Findings

The measuring system has got a measured value display.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Figure 22 shows the users display with the measured concentration value from the last measurement cycle.

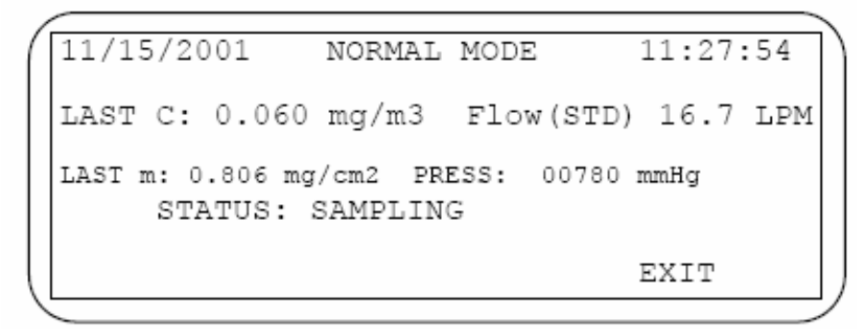

Figure 22: Display of measured concentration value from last measurement cycle

6.1 4.1.2 Easy maintenance

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

6.2 Equipment

No additional equipment required.

6.3 Performance of test

The necessary periodical maintenance work was carried out according to the instructions of the manual.

6.4 Evaluation

The following maintenance work has to be carried out by the user:

1. Check of device status
   The device status can be monitored and controlled by controlling the system itself or controlling it on-line.
2. Monthly cleaning of the device. In any case, the measuring system has to be cleaned after each measuring activity.
3. Check of the filter tape stock – a 21 m-filter tape is hereby sufficient for approximately 60 days in case of a measurement cycle of 60 min. It is recommended, to check as a matter of routine the filter tape stock at every visit of the measurement site.
4. At intervals of longest 4 weeks, the sampling inlet has to be cleaned and the impaction plate has to be re-lubricated with grease.
5. According to the manufacturer, a flow rate check shall be carried out every 4 weeks. Furthermore a plausibility check of the ambient temperature and air pressure measurement is recommended within this context.
   These workings can be done together with the workings according to point 4.
6. Replacement of filter tape after approx. 2 months (measurement cycle: 60 min)
7. The area around the entry nozzle above the filter tape should be cleaned every 2 months. This cleaning can normally be done together with the replacement of the filter tape.
8. The muffler at the pump should be replaced semiannually.
9. The sensors for the ambient temperature, air pressure as well as the flow rate measurement have to be re-calibrated every 6 months according to the manual.
10. Once a year, the carbon vanes of the vacuum pump (only rotary vane pump) have to be checked and replaced if necessary during an annual base maintenance.
11. During the annual base maintenance, it is also to pay attention to the cleaning of the sampling tube.

For the performance of the maintenance work, the instructions in the manual have to be respected. All workings can be done with common tools.

It is generally recommended to perform a self-test according to chapter 4.9 of the manual after each action, which interrupts the measurement operation.

Findings

Maintenance work can be done from outside with common tools and justifiable operating expense. The workings according to point 6, 7, 10 and 11 have to be done at a shutdown of the system. These workings are only necessary in a two month interval as well as semiannually or annually. During the remaining time, the maintenance can be basically restricted to the check of contaminations, plausibility checks and possible status/error messages.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

The operations at the devices have been carried out during the test on basis of the operations and operational procedures, described in the manual. There couldn't be noticed any difficulties when adhering to the described procedures. All maintenance work could be done with common tools without any problems.

6.1 4.1.3 Functional check

If the operation or the functional check of the measuring system requires 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.
Test gas units included in the measuring system shall indicate their operational readiness to the measuring system by a status signal and shall provide direct as well as remote control via the measuring system.
The uncertainty of the test gas unit included in the measuring system shall not exceed 1 % of reference value B_2 within three months.

6.2 Equipment

Manual, filter tape, built-in reference foil.

6.3 Performance of test

It was checked, whether all instrument functions, which are listed in the manual, are available, can be activated and are fully functional.

To check the zero point of the radiometric measurement, it is resorted to the count rates I_1 respectively I_{1x}, which are determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functionality of the measuring system). The zero point of the radiometric measurement is thereby determined manually according to the following equation:

$$C_0[mg/m^3] = \frac{A}{Q} * \frac{K}{mu2} * \ln\left(\frac{I_1}{I_{1X}}\right)$$

with

C_0	particle mass concentration at ZP	A	particle collection area (filter spot)
Q	sampling flow rate	K, mu2	coefficients beta measurement
I_1	initial beta count rate	I_{1X}	final beta count rate

In order to check the stability of the sensitivity of the radiometric measurement, it is resorted to the count rates I_1 (clean filter spot) respectively I_2 (clean filter spot + retracted reference foil), which are determined at every measurement cycle (refer to point 3.2 Functionality of the measuring system). The mass density m [mg/cm²] of the reference foil is calculated device-internal from the determined count rates. The value is continuously compared to the nominal value ABS, which has been determined in the factory (refer to appendix B in the manual of the respective device), and in case of a deviation of >5% to the nominal value, an error message is generated.
With the aid of the reference foil, only the mass density can be determined.

The measured values, which are required for calculation / evaluation, can be continuously recorded via the serial interface #2 (printer output).

Hence there is the possibility to determine the zero point (manually) as well as the reference value (automatically) for each measurement cycle (here: once per hour). The obtained hourly values at zero point and at reference point have been compressed to suitable mean values and been evaluated (e.g. 24-h-mean for drift investigations) within the scope of the test.

6.4 Evaluation

All instrument functions, which are listed in the manual, are available and can be activated. The current status of the system is monitored continuously and is indicated by a series of different status messages (operational, alarm and error status).

The measuring system carries out by default an internal check of the zero point (zero measurement, manually evaluable) as well as of the sensitivity (measurement with reference foil, automatically evaluated) at every measurement cycle. It must be pointed out, that only the mass density can be determined by the application of the reference foil. Therefore a direct comparison with the reference values is not possible. For the purpose of evaluation, the percental changes of the determined mass densities have been calculated.

6.5 Findings

All instrument functions, listed in the manual, are available, can be activated and are functioning. The current status of the system is monitored continuously and is indicated by a series of different status messages (operational, alarm and error status.
The results of the device-internal checks of the zero point and of the radiometric measurement during the field investigations are described in chapter 6.1 5.2.9 Drift of zero point and in chapter 6.1 5.2.10 Drift of measured value in this report.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Please refer to the points
6.1 5.2.9 Drift of zero point and
6.1 5.2.10 Drift of measured value

6.1 4.1.4 Set-up times and warm-up times

The set-up times and warm-up times shall be specified in the instruction manual.

6.2 Equipment

To check this minimum requirement, a clock has been additionally provided.

6.3 Performance of test

The measuring instruments have been put into operation according the descriptions of the manufacturer. The required times for set-up time and warm-up time was recorded separately.

Necessary constructional measures in the forefront of installation, like e.g. the set-up of a breakthrough in the roof of the cabinet have not been assessed here.

6.4 Evaluation

The set-up time contains the time need for the assembling of the measuring system until the start of operation.

The measuring system has to be installed independent from atmospheric conditions, e.g. in a climate-controlled measurement cabinet. Moreover the roof-lead through of the sampling tube requires larger constructional measures at the measurement location. A non-stationary application is therefore only assumed together with the belonging peripheral devices.

The following steps for the assembling of the measuring system are generally necessary:

- Unpacking and installation of the measuring system (in a rack or on a table)
- Connection of the sampling tube + PM 10-sampling inlet
- Installation of the heating system
- Connection of the pump
- Mounting of ambient air sensor + radiation protection shield (nearby the sampling in-let)
- Mounting of air pressure sensor
- Connection of all connecting and control lines
- Connection of power supply
- Switch-on of the measuring system
- Insertion of the filter tape
- Performance of self-test according to point 4.9 in the manual
- Optional check of the tightness
- Optional connection of peripheral recording and control systems (data logger, PC with HyperTerminal) to the respective interfaces

The performance of these actions and therewith the set-up time takes 1 hour.

The warm-up time contains the time need between the start of operation of the measuring system and the readiness for measurement.

After switching on the system and the successful performed self-test, the measuring system remains in a waiting position until reaching the next hour. When reaching the hour, the next measurement cycle as described in point 3.2 Functionality of the measuring system. The sampling starts according to the set measurement time for the radiometry (during the suitability test 4 min) immediately after the radiometric measurement I_0 (zero value of filter spot for sampling).

If required, possible changes of the basic parameterization of the measuring system can likewise be performed within few minutes by personal, familiar with the devices.

6.5 Findings

The set-up times and the warm-up times have been determined.

The measuring system can be operated at different measurement sites with manageable effort. The set-up time is approximately 1 hour and the warm-up time is at maximum the time need of a complete measurement cycle (here: 60 min).

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required here.

6.1 4.1.5 Instrument design

The instruction manual shall include specifications of 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.

6.2 Equipment

For the test, a measuring device for recording the power consumption and a balance is used.

6.3 Performance of test

The set-up of the handed over devices was compared to the description in the manuals. The mentioned power consumption was checked over 24 h during normal operation at 3 days during the field test.

6.4 Evaluation

The measuring system has to be installed in horizontal mounting position, independent from atmospheric conditions. At this, the system should be installed on an even plane (e.g. table). The installation in a 19“rack is also possible.

The dimensions and the weights of the measuring system are in compliance with the specifications in the manual.

The power consumption of the measuring system with the used pump is specified by the manufacturer with at maximum 370 W. During 3 tests, each with 24 h, this specification was checked. At no time the mentioned value was exceeded during these investigations. The mean power consumption during the investigation for a measurement cycle of 60 min (50 min sampling) was approximately 150 W.

6.5 Findings

The specifications for the instrument design, mentioned in the manual, are complete and correct.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 4.1.6 Unintended adjustment

It shall be possible to secure the adjustment of the measuring system against illicit or unintended adjustment during operation.

6.2 Equipment

No additional equipment required for the testing of this minimum requirement.

6.3 Performance of test

The operation of the measuring device is carried out via the keypad at the front panel or via the RS232-interfaces and modem from an external computer.

The menu “Setup” is completely protected by a password, except for the sub-point time setting. An alteration of the set parameters without the knowledge of the password is not possible.

An adjustment of the sensors for the ambient temperature, air pressure as well as for the flow rate measurement in the menu „Test/Flow“ as well as of the sensors for the control of the sample heater in the menu „Test/Heater“ is only possible via several key sequences.

It must be pointed out, that the current measurement cycle is interrupted by pressing the keys „Setup“, „Test“ or „Tape“ and the next measurement cycle does not begin until the following next hour.

As an outside installation of the measuring device is not possible, additional protection is given by installation at locations, to which unauthorized people have no access (e.g. locked measurement cabinet).

6.4 Evaluation

Unintended adjustment of instrument parameters is avoided by the pass word protection of the menu “Setup”. The adjustment of sensors for the flow rate measurement and for the operation of the sample heater can only be done via several key sequences. Moreover there is an additional protection against unauthorized intervention by the installation in a locked measurement cabinet.

6.5 Findings

The measurement system is protected against unintended and unauthorized adjustment of instrument parameters. Moreover the measuring system has to be locked in a measurement cabinet.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 4.1.7 Data output

The output signals shall be provided digitally (e.g. RS 232) and/or as analogue signals (e.g. 4 mA to 20 mA).

6.2 Equipment

PC with software „HyperTerminal“, data logger Yokogawa (for analogue signal)

6.3 Performance of test

The test was carried out using an electronic data recording system of the type Yokogawa (analogue output, only test in laboratory) and a PC with the software „HyperTerminal“(digital output, serial interfaces RS 232 #1 & #2).

The data recording systems were connected to the analogue as well as digital output. The test was performed by comparing the measured values from the display, analogue and digital output in the laboratory.

6.4 Evaluation

The measured signals are offered at the rear side of the instrument in the following way:

Analogue:	0-1 resp. 10 V resp. 0–16 mA / 4-20 mA concentration range selectable
Digital:	via 2xRS 232-interface - via direct or modem connection to a computer, the device can be completely controlled – e.g. it is possible to readout the buffer with all data to past measurements (serial interface #1).

The determined measured values have been output analogue as well as digital in compliance with the indicated value in the instrument buffer.

6.5 Findings

The measured signals are offered analogue (0-1 resp. 10 V resp. 0–16 mA / 4-20 mA) and digital (via RS 232).

The connection of additional measuring and peripheral devices to the respective ports of the devices is possible.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Figure 23 shows a view of the rear side of the instrument with the respective measured value outputs.

Figure 23: View on rear of the device BAM-1020

6.1 4.2 Requirements for measuring systems for mobile application

Measuring systems for mobile application shall also comply with the requirements on measuring systems for stationary application in the case of mobile application. The measuring system shall be in a permanent operational stand-by mode during mobile application, e.g. measurements in running traffic, time-limited measurements at different locations or measurements on aircraft.

6.2 Equipment

No additional equipment required for the testing of this minimum requirement.

6.3 Performance of test

Within the scope of the field test, the measuring system was tested at several field test sites.

6.4 Evaluation

The measuring systems have been designed for fixed installation in a measurement station / a measurement cabinet. A mobile application is only possible together with a measurement cabinet.

The permanent operational stand-by for time-limited measurements at different sites is ensured when considering the conditions of mounting (choice of measurement site, infrastructure).

For a mobile application, the set-up and warm-up times have to be considered beside the mounting conditions.

6.5 Findings

In the context of the field test, the measuring system was operated at several different sites. A mobile application of the measuring system was not tested within the scope of the test.

Minimum requirement fulfilled? no

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.1 General

The manufacturer's specifications shall not be contrary to the results of the suitability test.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

The results of the tests are compared to the specifications in the manual.

6.4 Evaluation

The detected deviations between the first draft of the manual and the real instrument layout have been corrected.

6.5 Findings

Differences between instrument layout and manuals have not been observed.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Refer to point 6.4 of this module.

6.1 5.2.1 Measuring range

The upper limit of measurement range of the measuring systems shall be greater or equal to reference value B_2.

6.2 Equipment

No additional equipment required for the testing of this minimum requirement.

6.3 Performance of test

It was tested, whether the upper limit of measuring range of the measuring system is greater or equal to the reference value B_2.

6.4 Evaluation

The following measuring ranges can be set at the measuring system:
0 – 0.100, 0 – 0.200, 0 – 0.250, 0 – 0.500, 0 – 1.000, 0 – 2.000, 0 – 5.000 as well as
0 – 10.000 mg/m³.

During the suitability test, the measuring range has been set to 0 – 1.000 mg/m³ = 0 – 1000 µg/m³.

Measuring range: 0 – 1.000 µg/m³ (standard)

Reference value: VDI: B_2 = 200 µg/m³.

6.5 Findings

A measuring range of 0 -1,000 µg/m³ is set by default. Other measuring ranges in the range between at minimum 0-100 µg/m³ and at maximum 0-10,000 µg/m³ are possible.

The upper limit of measuring range of the measuring system is greater than the reference value B_2.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.2.2 Negative output signals

Negative output signals or measured values may not be suppressed (life zero).

6.2 Equipment

No additional equipment required for the testing of this minimum requirement.

6.3 Performance of test

It has been tested during the laboratory test as well as during the field test, if the measuring system can also output negative measured values.

6.4 Evaluation

The measuring system can output negative values via the display as well as via the analogue and digital outputs.

6.5 Findings

Negative measuring signals are displayed directly and are output correctly via the respective measured value outputs by the measuring system.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.2.3 Analytical function

The relationship between the output signal and the value of the air quality characteristic shall be represented by the analytical function and determined by regression analysis.

6.2 Equipment

Refer to module 5.3.1.

6.3 Performance of test

For particulate measuring systems, this test has to be performed according to the minimum requirement 5.3.1 „Equivalency of the sampling system".

6.4 Evaluation

The comparability of the measuring systems according to the minimum requirement 5.3.1 „Equivalency of the sampling system" has been proved within the scope of the test (refer to module 5.3.1).

For the determination of the calibration respectively analytical function, it has been accessed to the complete dataset (94 valid paired values).

The characteristics of the calibration function

$$y = m * x + b$$

have been determined by linear regression. The analytical function is the reversion of the calibration function. It is:

$$x = 1/m * y - b/m$$

The slope m of the regression line characterizes the sensitivity of the measuring device; the ordinate intercept b characterizes the zero point.

There are the following characteristics, mentioned in Table 7.

Table 7: Results of the calibration and analytical function

Device-No.	Calibration function		Analytical function	
	Y = m * x + b		x = 1/m * y - b/m	
	m	b	1/m	b/m
	µg/m³ / µg/m³	µg/m³	µg/m³ / µg/m³	µg/m³
Device 1 (SN 4924)	0.9679	1.5452	1.0332	-1.5954
Device 2 (SN 4925)	0.9866	2.2503	1.0136	-2.2809

6.5 Findings

A statistically secured relationship between the reference method and the instrument reading could be proved.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Refer to module 5.3.1.

6.1 5.2.4 Linearity

Reliable linearity is given, if deviations of the group averages of measured values about the calibration function are smaller than 5 % of B_1 in the range of zero to B_1, and smaller than 1 % of B_2 in the range of zero to B_2.

6.2 Equipment

Refer to module 5.3.1.

6.3 Performance of test

For particulate measuring systems, this test has to be performed according to the minimum requirement 5.3.1 „Equivalency of the sampling system“.

6.4 Evaluation

Refer to module 5.3.1.

6.5 Findings

For particulate measuring systems, this test has to be performed according to the minimum requirement 5.3.1 „Equivalency of the sampling system“.

Refer to module 5.3.1.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Refer to module 5.3.1.

6.1 5.2.5 Detection limit

The detection limit of the measuring system shall be smaller or equal to reference value B_0. The detection limit shall be determined in the field.

6.2 Equipment

Filter tape

6.3 Performance of test

The determination of the detection limit has been carried out for the candidates SN 4924 and SN 4925 by evaluating the device-internal check of the zero point of the radiometric measurement while operating the measuring system in the laboratory over a period of 18 days. Hereby the count rates I_1 respectively I_{1x}, which are determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functionality of the measuring system) have been evaluated.

The obtained hourly values at the zero point have been compressed to 24-h-mean values and have been evaluated within the scope of the test.

6.4 Evaluation

The detection limit X is determined from the standard deviation s_{x0} of the measured values at the zero point (24-h-mean of the device-internal performed zero measurements on the filter tape) of the candidates. It corresponds to the mean value of the zero measurements, added with the (multiplied with student factor) standard deviation of the mean value $\overline{x_0}$ of the measured values x_{0i} during suction of dust-free sampling air for the respective candidate.

$$X = \overline{x_0} + t_{n-1;0,95} \cdot s_{x0} \qquad \text{with} \cdot s_{x0} = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1,n} (x_{0i} - \overline{x_0})^2}$$

Reference value: VDI: B_0 = 2 µg/m³

6.5 Findings

The detection limit has been determined from the investigations to 1.7 µg/m³ for device 1 (SN 4924) and to 1.9 µg/m³ for device 2 (SN 4925).

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 8: Detection limit

		Device SN 4924	Device SN 4925
Number of values n		18	18
Mean of zero values $\overline{x_0}$	µg/m³	0.54	0.87
Standard deviation of values s_{x0}	µg/m³	0.55	0.49
Student factor $t_{n-1;0,95}$		2.12	2.12
Detection limit X	µg/m³	1.69	1.90

The single values for the determination of the detection limit can be found in annex 1 in the appendix.

6.1 5.2.6 Response time

The response time (90%-time) of the measuring system shall be smaller or equal to 5 % of the averaging time (180 s).

According to Guideline VDI Sheet 3, point 5.3, this test point is not relevant for particulate measuring systems with pre-separation, based on a physical measurement method.

6.2 Equipment

Not applicable.

6.3 Performance of test

Not applicable.

6.4 Evaluation

Not applicable.

6.5 Findings

Not applicable.

Minimum requirement fulfilled? -

6.6 Presentation of test results

Not applicable.

6.1 5.2.7 Dependence of the zero point on ambient temperature

The temperature dependence of the measured value at zero concentration shall not exceed the reference value B_0 if ambient temperature is changed by 15 K in the range of +5°C to +20°C or by 20 K in the range of +20°C to +40°C.

6.2 Equipment

Climate chamber for the temperature range +5 to +40 °C, filter tape.

6.3 Performance of test

For the investigation of the dependence of the zero point on the ambient temperature, the complete measuring systems have been operated in the climate chamber. For both candidates SN 4924 and SN 4925, the device-internal check of the zero point of the radiometric measurement has been determined while operating the measuring system. Hereby the count rates I_1 respectively I_{1x}, which are determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functionality of the measuring system) have been evaluated.

The ambient temperatures in the climate chamber were varied in triple repetition in the order 20 °C – 5 °C – 20 °C – 40 °C – 20 °C. After a respective time for equilibration of approximately 3 h per temperature step, the measured values at the zero point have been recorded. The obtained hourly values at the zero point have been compressed to 7-h-mean values respectively 21-h-mean values and have been evaluated within the scope of the test. The relative humidity was kept constant.

6.4 Evaluation

The measured values for the concentration were recorded via the serial interface #2 and were evaluated. The absolute deviation in µg/m³ per temperature step, related to the start point of 20 °C, has been considered

Reference value: VDI: B_0 = 2 µg/m³.

6.5 Findings

Considering the values offered from the device, a maximum influence of the ambient temperature on the zero point of 0.7 µg/m³ could be detected.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 9: Dependence of the zero point on the ambient temperature, deviation in µg/m³, mean values of three measurements

Temperature		Deviation	
Start temperature	End temperature	Device 1 (SN 4924)	Device 2 (SN 4925)
°C	°C	µg/m³	µg/m³
20	5	0.0	0.3
5	20	0.5	0.1
20	40	0.7	0.0
40	20	0.3	0.2

Also in the single steps (21-h-mean), no deviations > 1.4 µg/m³ could be determined. The results of the 3 single measurements (21-h-mean) can be found in annex 2 in the appendix.

6.1 5.2.8 Dependence of the measured value on ambient temperature

The temperature dependence of the measured value in the range of reference value B_1 shall not exceed 5 % of the measured value if ambient temperature is changed by 15 K in the range of +5°C to +20°C or by 20 K in the range of +20°C to +40°C.

6.2 Equipment

Climate chamber for the temperature range +5 - +40 °C, built-in reference foil.

6.3 Performance of test

For the investigation of the dependence of the measured values on the ambient temperature, the complete measuring systems have been operated in the climate chamber. To check the stability of the sensitivity of the radiometric measurement for the candidates SN 4924 and SN 4925, it is resorted to the count rates I_1 (clean filter spot) respectively I_2 (clean filter spot + retracted reference foil), which are determined at every measurement cycle (refer to point 3.2 Functionality of the measuring system). The mass density m [mg/cm²] of the reference foil is calculated device-internal from the determined count rates.

The ambient temperatures in the climate chamber were varied in triple repetition in the order 20 °C – 5 °C – 20 °C – 40 °C – 20 °C. After a respective time for equilibration of approximately 3 h per temperature step, the measured values at the reference point have been recorded. The obtained hourly values at the reference point have been compressed to 7-h-mean values respectively 21-h-mean values and have been evaluated within the scope of the test. The relative humidity was kept constant .

6.4 Evaluation

The percental changing of the determined mass density value (built-in reference foil) for each temperature step, related to the start point of 20 °C, has been considered.

As remark it should be mentioned, that only masses and no concentration values can be simulated by the application of the built-in reference foil, a consideration in the range of B_1 (= 40 µg/m³) was not possible because of this reason.

6.5 Findings

There have been no deviations > 0.1 % for device 1 (SN 4924), and no deviations > 0.2 % for device 2 (SN 4925), related to the start value at 20 °C.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 10: Dependence of the sensitivity on the ambient temperature SN 4924 & SN 4925, deviation in %, mean value of three measurements

Temperature		Deviations	
		Device 1 (SN 4924)	Device 2 (SN 4925)
Start temperature °C	End temperature °C	built-in reference foil %	built-in reference foil %
20	5	0.1	0.2
5	20	0.1	0.0
20	40	0.0	-0.1
40	20	0.0	0.1

Also in the single steps, no deviations > 0.3 % could be found. The single results can be found in annex 2 in the appendix.

6.1 5.2.9 Drift of zero point

The temporal change in the measured value at zero concentration shall not exceed the reference value B_0 in 24 h and in the maintenance interval.

6.2 Equipment

Filter tape.

6.3 Performance of test

The test was carried out in the context of the field test over a time period of approximately 6 months. The daily zero point check, required in the test plan, is on principle possible for this particulate measuring system by evaluating the device-internal check of the zero point of the radiometric measurement. Hereby the count rates I_1 respectively I_{1x}, which are determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functionality of the measuring system) are evaluated.

For the evaluation, the automatically calculated, hourly values at the zero point have been compressed to a 24-h-mean value and have been evaluated for averagely one day per week during the complete field test. Within the scope of the test, a daily evaluation of the complete dataset has been renounced due to reasons of practicability (large amount of data). However an exemplary evaluation and graphic presentation of the results for the time period from 10/03/2006 until 10/16/2006 has been carried out.

The evaluation of the internal zero point measurement leads to no interruption of the ongoing measuring operation at all.

6.4 Evaluation

The evaluation is carried out on basis of the measurement results of the regular internal zero point measurements by comparison the respective values with the measured values from the previous test and with the measured values from the initial test.

The regression analysis for the zero point drift leads to the following values for the 1-week-drift:

SN 4924: 0.0095 µg/(m³*Week) + 0.3461 µg/m³

SN 4925: 0.002 µg/(m³*Week) + 0.6847 µg/m³

Hence there are the following medium temporal changes in the maintenance interval of 4 weeks:

SN 4924: 0.384 µg/m³ in 4 weeks

SN 4925: 0.693 µg/m³ in 4 weeks

6.5 Findings

The measuring system carries out a regular device-internal check of the zero point of the radiometric measurement during each measurement cycle. This test leads to no interruption of the ongoing measuring operation at all. The obtained values, determined within the scope of the drift investigations, are within the allowed limits in the maintenance interval.

The determined single measured values are normally within the allowed limits. Merely for SN 4924, the single measured value on 08/05/2006 has been outside the allowed tolerance interval. However there has been no adjustment of the measuring system at the zero point.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 11 and Table 12 contain the determined measured values for the zero point and the calculated deviations, related to the previous value and related to the initial value in µg/m³. Figure 24 and Figure 25 show a graphic presentation of the zero point drift over the time period of testing. Figure 26 and Figure 27 show exemplarily the results of the daily evaluation of the device-internal zero point check during the time period from 10/03/2006 until 10/16/2006.

Table 11: Zero point drift SN 4924

Date	Measured value (single value)	Deviation to previous value (single value)	Deviation to start value (single value)
	µg/m³	µg/m³	µg/m³
02/11/2006	1.03	-	-
02/18/2006	1.01	-0.02	-0.02
02/25/2006	0.56	-0.45	-0.47
03/04/2006	-0.44	-1.00	-1.47
03/11/2006	-0.55	-0.11	-1.58
03/18/2006	-0.46	0.09	-1.49
03/25/2006	-0.06	0.40	-1.09
04/01/2006	0.45	0.51	-0.58
08/05/2006	2.20	1.75	1.17
08/12/2006	0.61	-1.59	-0.42
08/19/2006	1.20	0.59	0.17
08/26/2006	1.16	-0.04	0.13
09/02/2006	0.78	-0.38	-0.25
10/01/2006	0.13	0.65	-0.90
10/07/2006	0.66	0.53	-0.37
10/14/2006	0.50	0.16	-0.53
10/21/2006	-0.19	-0.69	-1.22
10/28/2006	1.47	1.66	0.44
11/04/2006	0.51	-0.96	-0.52
11/11/2006	0.20	-0.31	-0.83
11/18/2006	-0.32	-0.52	-1.35

Table 12: Zero point drift SN 4925

Date	Measured value (single value)	Deviation to previous value (single value)	Deviation to start value (single value)
	µg/m³	µg/m³	µg/m³
02/11/2006	0.44	-	-
02/18/2006	-0.08	-0.52	-0.52
02/25/2006	1.91	1.99	1.47
03/04/2006	0.45	-1.46	0.01
03/11/2006	0.23	-0.22	-0.21
03/18/2006	1.28	1.05	0.84
03/25/2006	0.25	-1.03	-0.19
04/01/2006	0.79	0.54	0.35
08/05/2006	1.08	0.29	0.64
08/12/2006	1.12	0.04	0.68
08/19/2006	-0.45	-1.57	-0.89
08/26/2006	1.47	1.92	1.03
09/02/2006	0.59	-0.88	0.15
10/01/2006	1.39	0.80	0.95
10/07/2006	1.35	-0.04	0.91
10/14/2006	0.54	-0.81	0.10
10/21/2006	0.23	-0.31	-0.21
10/28/2006	0.91	0.68	0.47
11/04/2006	0.33	-0.58	-0.11
11/11/2006	0.81	0.48	0.37
11/18/2006	0.41	-0.40	-0.03

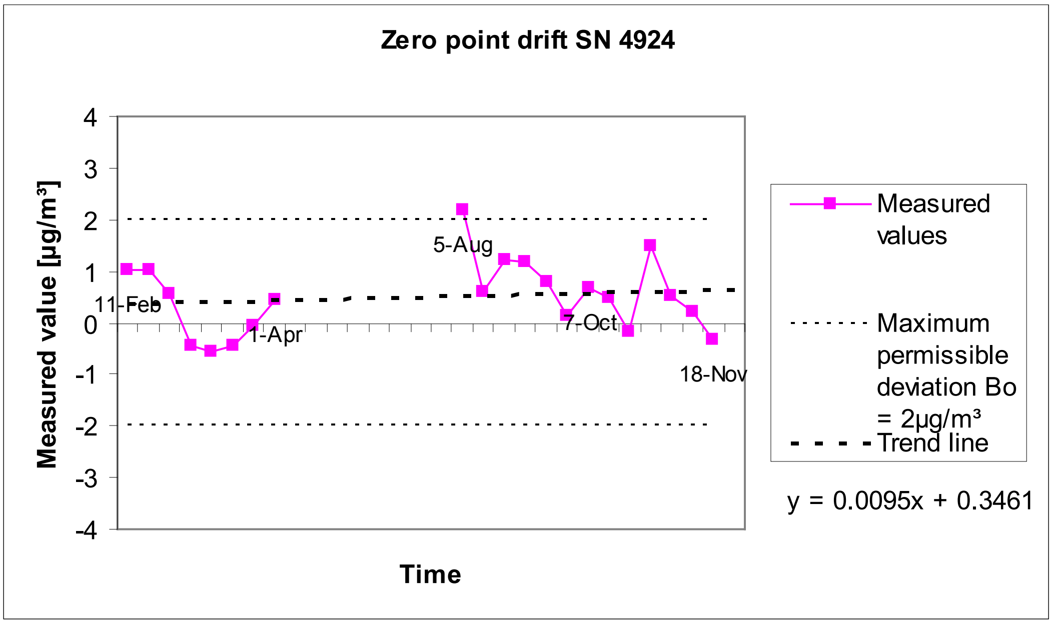

Figure 24: Zero point drift SN 4924 (complete testing period)

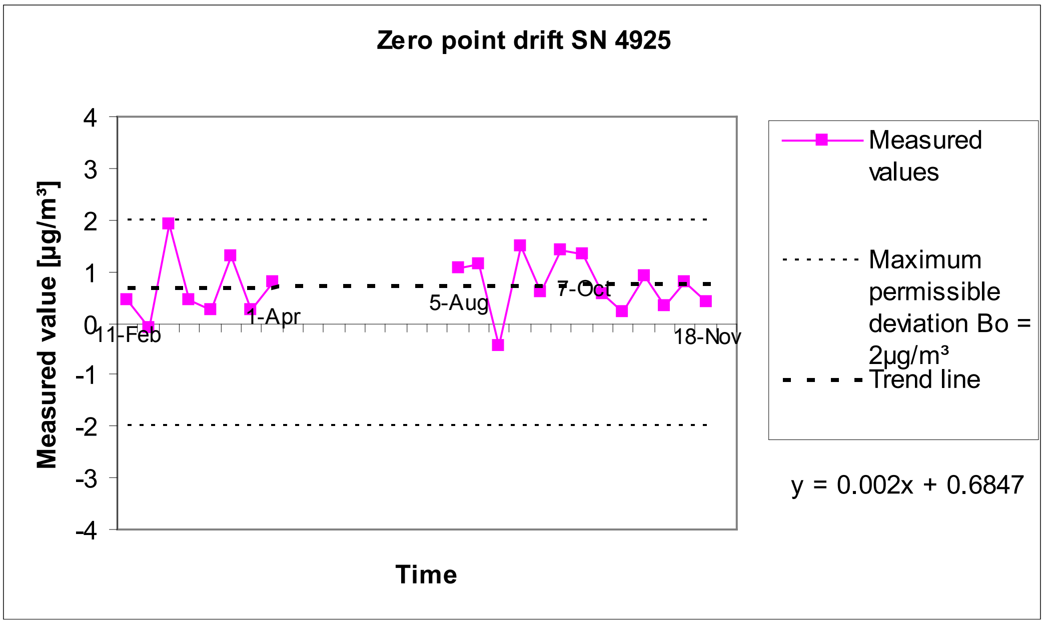

Figure 25: Zero point drift SN 4925 (complete testing period)

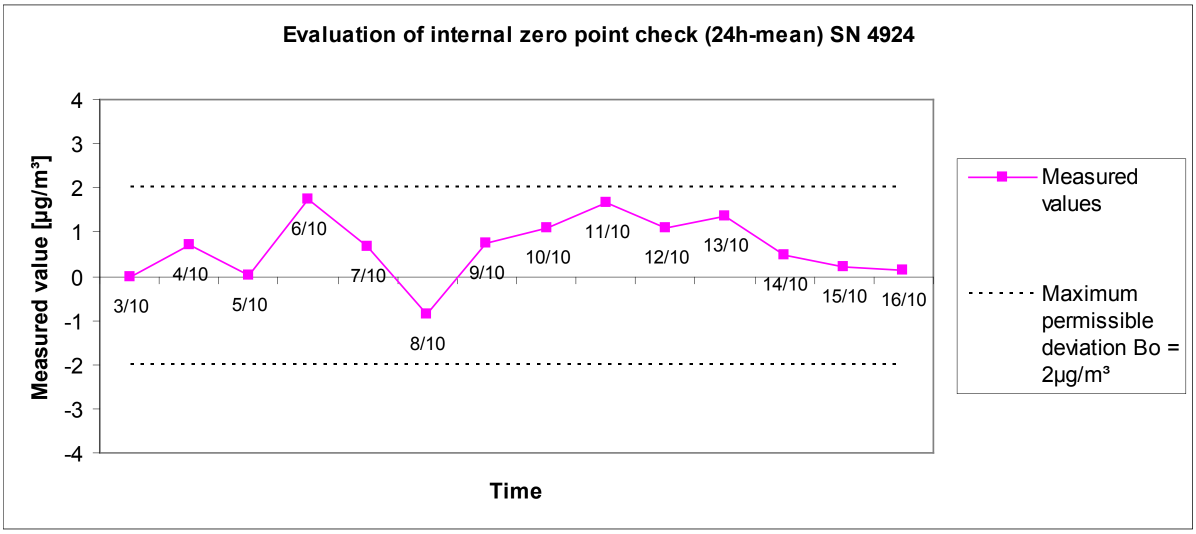

Figure 26: Zero point drift SN 4924 (10/03/2006-10/16/2006)

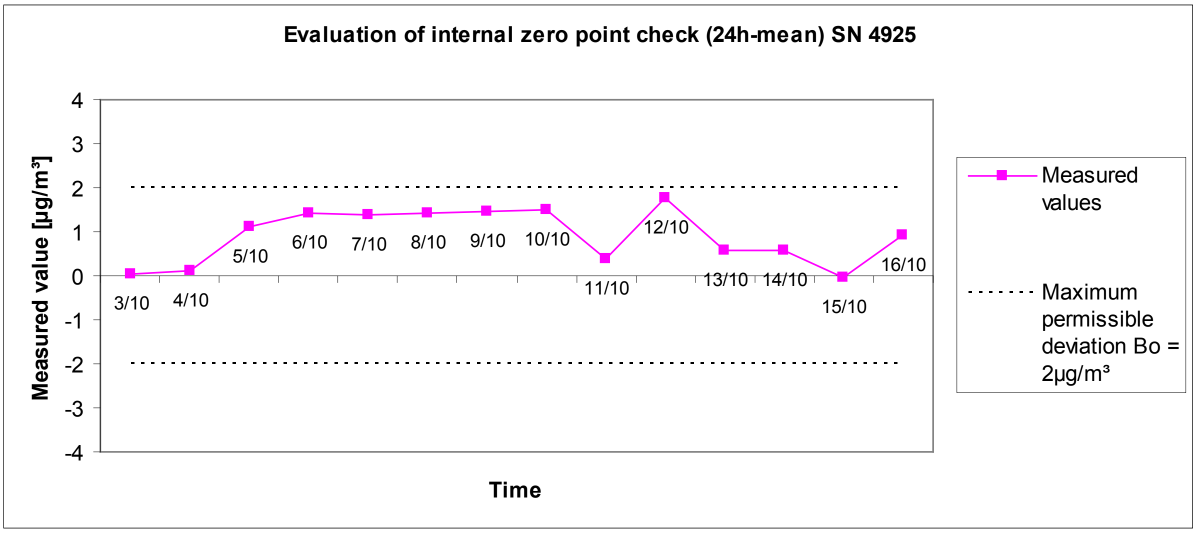

Figure 27: Zero point drift SN 4925 (10/03/2006-10/16/2006)

6.1 5.2.10 Drift of measured value

The temporal change in the measured value in the range of reference value B_1 shall not exceed 5 % of B_1 in 24 h and in the maintenance interval.

6.2 Equipment

Built-in reference foil.

6.3 Performance of test

The test has been performed within the scope of the field test over a time period of approximately 6 months. The daily reference point check, required in the test plan, is on principle possible for this particulate measuring system by evaluating the device-internal check of the stability of the sensitivity of the radiometric measurement. Hereby it is resorted to the count rates I_1 (clean filter spot) respectively I_2 (clean filter spot + retracted reference foil), which are determined at every measurement cycle (refer to point 3.2 Functionality of the measuring system). The mass density m [mg/cm²] of the reference foil is calculated device-internal from the determined count rates.

For the evaluation, the automatically calculated, hourly values at the reference point have been compressed to a 24-h-mean value and have been evaluated for averagely one day per week during the complete field test. Within the scope of the test, a daily evaluation of the complete dataset has been renounced due to reasons of practicability (large amount of data). However an exemplary evaluation and graphic presentation of the results for the time period from 10/03/2006 until 10/16/2006 has been carried out.

The evaluation of the internal reference point measurement leads to no interruption of the ongoing measuring operation at all.

6.4 Evaluation

The evaluation is carried out on basis of the measurement results of the internal reference point measurements by comparison the respective values with the measured values from the previous test and with the measured values from the initial test.

Hereby the percental changing of the determined mass density value in the interval of 1 week as well as related to the initial value has been considered

The regression analysis for the reference point drift leads to the following values for the 1-week-drift:

SN 4924: -0.0065 % / Week + 0.4619 %

SN 4925: 0.0202 % / Week - 0.1036 %

Hence there are the following medium temporal changes in the maintenance interval of 4 weeks:

SN 4924: 0.436 % in 4 weeks

SN 4925: -0.023 % in 4 weeks

As remark it should be mentioned, that only mass densities and no concentration values can be simulated by the application of the reference foil, a consideration in the range of B_1 (= 40 µg/m³) was not possible because of this reason.

6.5 Findings

The determined single measured values are normally within the allowed limits. Merely for SN 4924, the single measured value on 08/05/2006 has been outside the allowed tolerance interval. However there has been no adjustment of the measuring system at the zero point.

The measuring system carries out a regular device-internal check of the sensitivity of the radiometric measurement during each measurement cycle. This test leads to no interruption of the ongoing measuring operation at all. The values for the drift of the sensitivity, determined within the scope of the test, were at maximum 0.44 % (SN 4924) respectively -0.02 % (SN 4925) in the maintenance interval.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

The deviations of the measured values in % of the respective previous value respectively to the initial value are shown in Table 13 and in Table 14. Figure 28 and Figure 29 show a graphic presentation of the drift of the measured values (referred to the initial value) for the reference foil. Figure 30 and Figure 31 show exemplarily the results of the daily evaluation of the device-internal reference point check during the time period from 10/03/2006 until 10/16/2006.

Table 13: Drift of measured value SN 4924

Date	Measured value (single value)	Deviation to previous value (single value)	Deviation to start value (single value)
	µg/cm²	%	%
02/11/2006	829.2	-	-
02/18/2006	823.4	-0.7	-0.7
02/25/2006	822.8	-0.1	-0.8
03/04/2006	824.5	0.2	-0.6
03/11/2006	822.5	-0.2	-0.8
03/18/2006	827.4	0.6	-0.2
03/25/2006	824.2	-0.4	-0.6
04/01/2006	824.9	0.1	-0.5
08/05/2006	825.9	0.1	-0.4
08/12/2006	825.7	0.0	-0.4
08/19/2006	825.5	0.0	-0.5
08/26/2006	825.8	0.0	-0.4
09/02/2006	825.4	-0.1	-0.5
10/01/2006	823.0	-0.3	-0.8
10/07/2006	824.0	0.1	-0.6
10/14/2006	824.2	0.0	-0.6
10/21/2006	822.9	-0.1	-0.8
10/28/2006	823.7	0.1	-0.7
11/04/2006	823.9	0.0	-0.6
11/11/2006	823.7	0.0	-0.7
11/18/2006	822.5	-0.1	-0.8

Table 14: Drift of measured value SN 4925

Date	Measured value (single value)	Deviation to previous value (single value)	Deviation to start value (single value)
	µg/cm²	%	%
02/11/2006	811.3	-	-
02/18/2006	810.4	-0.1	-0.1
02/25/2006	809.1	-0.2	-0.3
03/04/2006	808.8	0.0	-0.3
03/11/2006	812.8	0.5	0.2
03/18/2006	811.1	-0.2	0.0
03/25/2006	811.6	0.1	0.0
04/01/2006	812.0	0.1	0.1
08/05/2006	815.3	0.4	0.5
08/12/2006	815.5	0.0	0.5
08/19/2006	814.4	-0.1	0.4
08/26/2006	816.4	0.2	0.6
09/02/2006	814.8	-0.2	0.4
10/01/2006	814.4	-0.1	0.4
10/07/2006	814.6	0.0	0.4
10/14/2006	813.5	-0.1	0.3
10/21/2006	812.9	-0.1	0.2
10/28/2006	813.7	0.1	0.3
11/04/2006	813.6	0.0	0.3
11/11/2006	813.4	0.0	0.3
11/18/2006	815.7	0.3	0.5

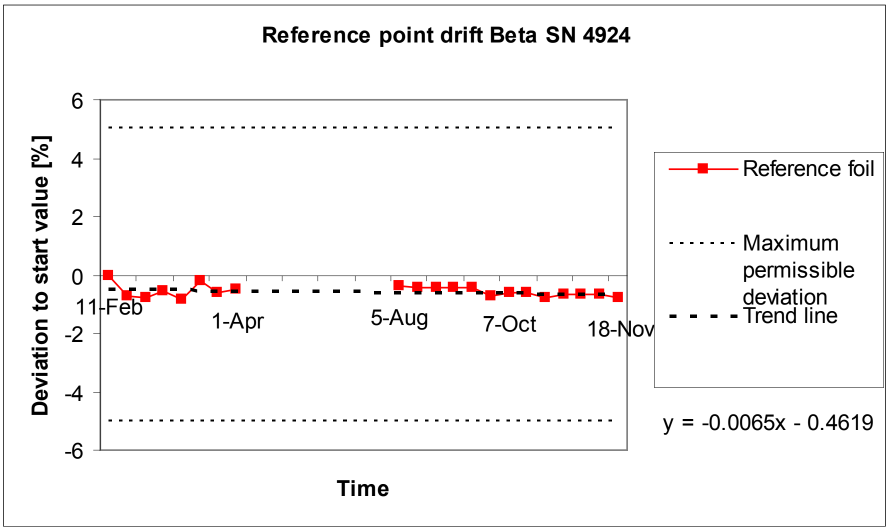

Figure 28: Drift of measured value SN 4924 (complete testing period)

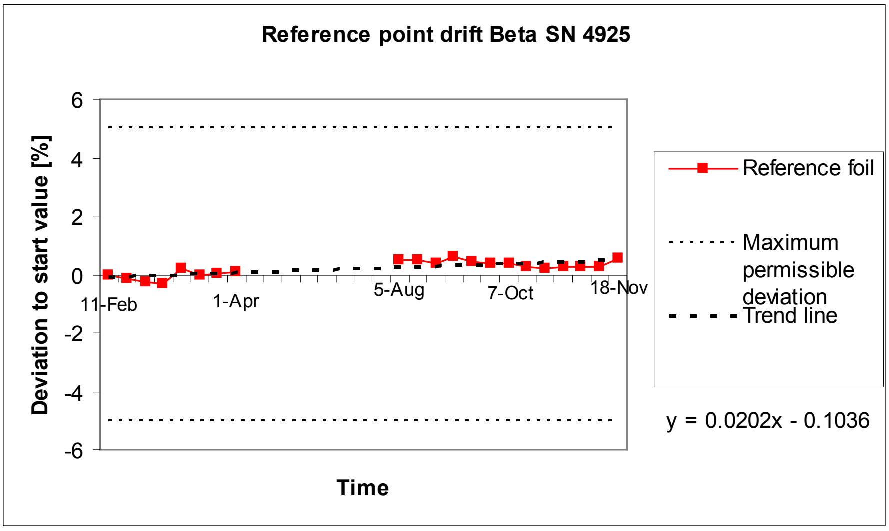

Figure 29: Drift of measured value SN 4925 (complete testing period)

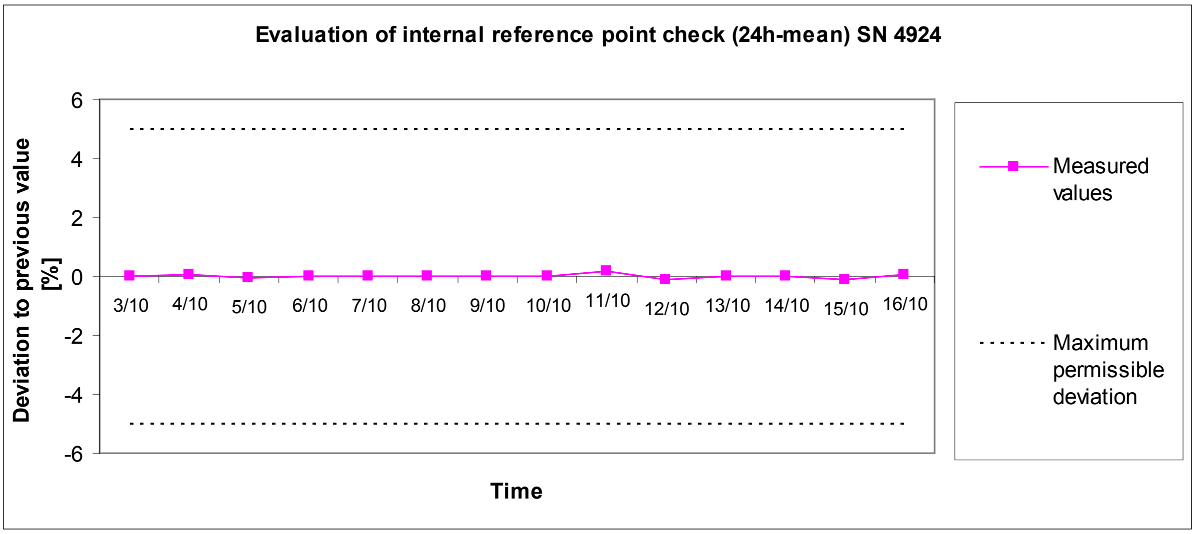

Figure 30: Drift of measured value SN 4924 (10/03/2006-10/16/2006)

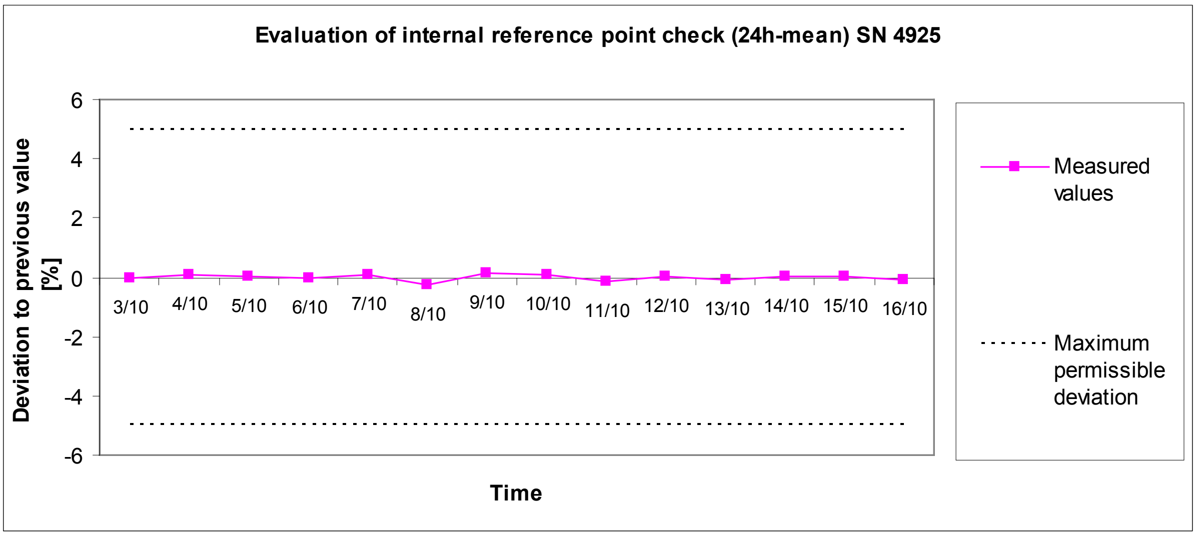

Figure 31: Drift of measured value SN 4925 (10/03/2006-10/16/2006)

6.1 5.2.11 Cross-sensitivity

The absolute values of the sum of the positive and the sum of negative deviations caused by cross-sensitivities of interfering components in the measured sample shall not exceed B_0 at the zero point and shall not exceed 3 % of B_2 in the range of B_2. The concentration of interfering components shall correspond to the B_2 value of the respective interfering component. If reference values have not been specified, the test institute shall specify and declare suitable reference values in agreement with other test institutes.

For particulate measuring systems, this test point is not relevant. Minimum requirement 5.3.4. is essential. The results to these investigations can therefore be found in module 5.3.4.

6.2 Equipment

Not applicable.

6.3 Performance of test

Not applicable.

6.4 Evaluation

Not applicable.

6.5 Findings

Not applicable.

Minimum requirement fulfilled? -

6.6 Presentation of test results

Not applicable.

6.1 5.2.12 Reproducibility R_D

The reproducibility R_D of the measuring system shall be determined by parallel measurements with two identical measuring systems and shall be at least equal to 10. B_1 shall be used as the reference value.

6.2 Equipment

For the determination of the reproducibility R_D, the instruments mentioned in chapter 5 have additionally been used.

6.3 Performance of test

The reproducibility R_D is defined as the value, from which two stochastically chosen single values, determined under comparison conditions, differ at the most. The reproducibility R_D was determined with two identical and parallel operated devices during the field test. For this, measurement data from the entire field investigation was used .

The field investigations at the three different test sites were performed with an US-PM10-sampling inlet (BX-802). After having finished these investigations, the candidates have been additionally operated with the EU-PM10-sampling inlet (BX-809) at the field test site Cologne, Frankfurter Str. and have been separately evaluated. Target of these additional investigations has been the proof that the results, obtained with both different types of sampling inlets, do not differ significantly from each other and thus the operation of the system is basically possible with both types of sampling inlets.

6.4 Evaluation

The reproducibility R_D is calculated as follows:

$$R = \frac{B_1}{U} \geq 10 \qquad \text{with} \qquad U = \pm s_D \cdot t_{(n;0,95)} \quad \text{and} \quad s_D = \sqrt{\frac{1}{2n} \cdot \sum_{i=1}^{n} (x_{1i} - x_{2i})^2}$$

- R = Reproducibility R_D at B_1
- U = Uncertainty
- B_1 = 40 µg/m³ (VDI)
- s_D = Standard deviation from paired measurements
- n = Number of paired measurements
- $t_{(n;0,95)}$ = Student factor for 95% confidence
- x_{1i} = Measured signal of device 1 (e.g. SN 4924) at i-th concentration
- x_{2i} = Measured signal of device 2 (e.g. SN 4925) at i-th concentration

.

6.5 Findings

The reproducibility R_D was at minimum 16 during the field test.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

The results of the investigations are summed up in Table 15. The graphic presentations can be found in Figure 44 to Figure 48.

Remark: The determined uncertainties are referred to the reference value B_1 for each test site:

Table 15: Concentration mean values, standard deviation, range of uncertainty and reproducibility R in field

Test site	No.	$\overline{c}$ (SN 4924)	$\overline{c}$ (SN 4925)	$\overline{c}_{ges}$	s_D	t	U	R
		µg/m³	µg/m³	µg/m³	µg/m³		µg/m³	
Cologne, Parking lot	52	25.2	26.6	25.9	1.267	2.007	2.54	16
Titz-Roedingen	37	24.0	24.9	24.5	0.795	2.026	1.61	25
Cologne, Frankfurter Str.	28	26.7	27.9	27.3	1.074	2.049	2.20	18
All test sites	117	24.8	26.0	25.4	1.000	1.980	1.98	20
additional Cologne, Frankfurter Str. (EU-inlet)	26	25.7	25.6	25.7	0.800	2.056	1.64	24

- $\overline{c}$ (SN 4924): Mean value of the concentrations device SN 4924
- $\overline{c}$ (SN 4925): Mean value of the concentrations device SN 4925
- $\overline{c}_{ges}$: Mean value of the concentrations of the devices SN 4924 & SN 4925

Single values can be found in annex 4 in the appendix.

6.1 5.2.13 Hourly averages

The measurement method shall allow for formation of hourly averages.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

It was checked, whether the measuring system allows the formation of hourly averages.

6.4 Evaluation

According to the valid Guideline [7], the limit values for suspended particulate matter PM10 are to refer to a minimum averaging period of 24 hours. A formation of hourly averages is therefore not necessary for measuring systems for monitoring this limit value. The tested measuring systems operates by default with a measurement cycle of 60 min and thus outputs every hour a new measured value. Hence the measuring system allows an on-line measurement of the particulate concentrations with hourly resolution.

6.5 Findings

The formation of hourly averages for the component SPM PM10 is not necessary for the monitoring of the relevant limit values, but possible.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

In the following figures, the course of the suspended particulate matter concentrations during the time period from 10/03/2006 until 10/16/2006 (Cologne, Frankf. Str.) as well as the correlation between both candidates on basis of 1 h-mean values is shown. The suitability of the measuring system for on-line measurement of the particulate concentrations with hourly resolution and therewith the possibility to supply information on the time courses of SPM concentrations is obviously demonstrated.

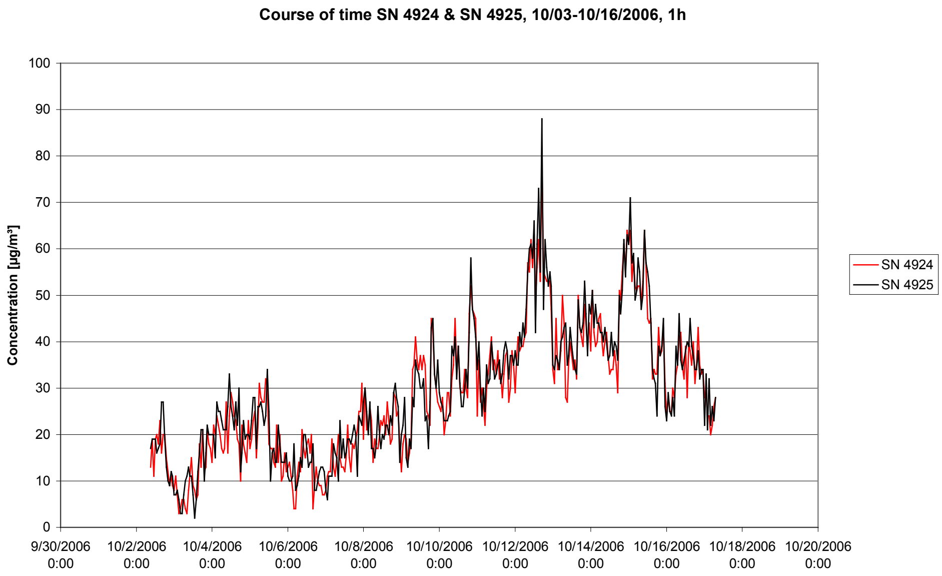

Figure 32: Course of time of suspended particulate matter concentration PM10 from 10/03/2006 until 10/16/2006, 1 h-measured values

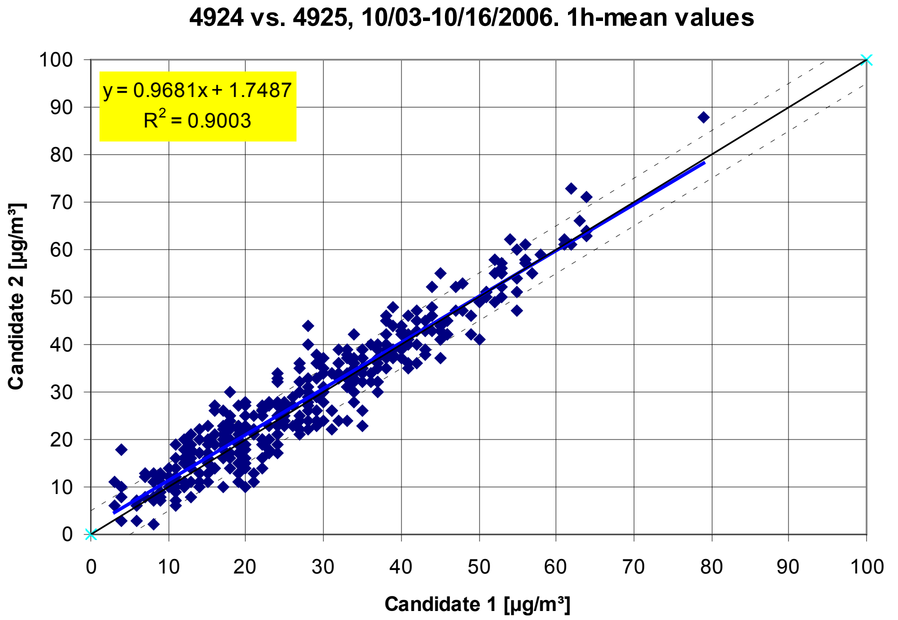

Figure 33: SN 4924 vs. SN 4925, 10/03/2006 until 10/16/2006, 1 h-measured values

6.1 5.2.14 Mains voltage and frequency

The change in the measured values at reference value B_1 caused by normal changes in the mains voltage in the interval (230 +15/-20) V shall not exceed B_0. In addition, for mobile applications the change in the measured value caused by changes in frequency of the mains voltage in the interval (50 ± 2) Hz shall not exceed B_0.

6.2 Equipment

Adjustable isolating transformer, filter tape, built-in reference foil.

6.3 Performance of test

For the investigation of the dependence of the measured signal on the mains voltage, the mains voltage has been reduced to 210 V, starting at 230 V and afterwards increased to 245 V via the intermediate stage 230 V.

To check the dependence of the zero point on the mains voltage for the candidates SN 4924 and SN 4925, the device-internal check of the zero point of the radiometric measurement has been determined while operating the measuring system. Hereby the count rates I_1 respectively I_{1x}, which are determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functionality of the measuring system) have been evaluated.

To check the dependence of the measured values on the mains voltage for the candidates SN 4924 and SN 4925, it is resorted to the count rates I_1 (clean filter spot) respectively I_2 (clean filter spot + retracted reference foil), which are determined at every measurement cycle (refer to point 3.2 Functionality of the measuring system). The mass density m [mg/cm²] of the reference foil is calculated device-internal from the determined count rates.

As the mobile application of the measuring system is not planned, the separate investigation of the dependence of the measured signal on the power frequency has been renounced.

6.4 Evaluation

For the investigations at the zero point, the measured values at the different mains voltages have been recorded. The absolute deviation in µg/m³ per test step, related to the start point of 230 V.

At the reference point, the percental changing of the determined mass density value for each test step, related to the start point of 230 V has been considered.

As remark it should be mentioned, that only mass densities and no concentration values can be simulated by the application of the reference foil, a consideration in the range of B_1 (= 40 µg/m³) was not possible because of this reason.

6.5 Findings

The evaluation of the minimum requirement was performed on basis of the above mentioned instructions.

Through changes in the mains voltage, maximum deviations of -1.6 µg/m³ at the zero point and maximum 0.2 % at the tested reference points could be detected.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 16 to Table 17 show a recapitulating presentation of the test results.

Table 16: Dependence of the zero point on mains voltage, deviation in µg/m³

Mains voltage		Deviation	
Start voltage	End voltage	Device 1 (SN 4924)	Device 2 (SN 4925)
V	V	µg/m³	µg/m³
230	210	0.3	-0.1
210	230	-1.6	-0.4
230	245	-0.7	-0.4
245	230	0.4	0.7

Table 17: Dependence of the measured value on mains voltage, deviation in %

Mains voltage		Deviation	
		Device 1 (SN 4924)	Device 2 (SN 4925)
Start voltage	End voltage	Reference foil	Reference foil
V	V	%	%
230	210	0.1	0.0
210	230	0.2	-0.1
230	245	0.0	-0.1
245	230	0.1	0.0

Single value can be found in annex 3 in the appendix.

6.1 5.2.15 Failure in mains voltage

In case of malfunction of the measuring system or failure in the mains voltage, uncontrolled emission of operation and calibration gas shall be avoided. The instrument parameters shall be secured by buffering against loss caused by failure in the mains voltage. When mains voltage returns, the instrument shall automatically reach the operation mode and start the measurement according to the operating instructions.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

A power loss has been simulated and it has been checked, whether the device remains undamaged and whether it is ready for measurement after return of power supply.

6.4 Evaluation

As the devices need neither operation nor calibration gases, an uncontrolled emission of gases is not possible.

In case of a power loss, the measuring systems restarts independently the next measurement cycle and thus again the measuring operations with reaching the next hour (refer to point 6.1 4.1.4 Set-up times and warm-up times).

6.5 Findings

All instrument parameters are protected against loss by buffering.
The measuring system is in normal operating condition after return of power supply and continues independently the measurements with reaching the next hour.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.2.16 Operating states

Measuring systems shall be able to telemetrically transmit important operating states by status signals.

6.2 Equipment

Modem, PC for data acquisition (RS 232-host-device).

6.3 Performance of test

A modem has been connected to the measuring system. By remote data recording, i.e. the status signals of the device have been recorded.

6.4 Evaluation

The measuring system allows the complete telemetric check and control of the measuring system. There is a series of read, write and control commands available. A complete overview can be found in the manual of the measuring system.

6.5 Findings

The measuring systems can be controlled and monitored extensively from an external PC via a modem.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.2.17 Switch-over

Switch-over between measurement and functional check and/or calibration shall be possible telemetrically by computer control or manual intervention.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

The measuring device can be monitored as well as partly controlled by the user at the device or by telemetric remote control. The internal checks of the zero and reference point are an integral part of each measurement cycle and therefore must be merely recorded via the printer output during operation.

Some function, i.e. the performance of the extensive self-test of the measuring system, can only be activated directly at the device.

6.4 Evaluation

All operational procedures can be monitored as well by the user at the device as by telemetric remote control. The internal checks of the zero and reference point are an integral part of each measurement cycle and therefore must be merely recorded via the printer output during operation.

6.5 Findings

Generally all necessary operations for functional check and calibration can be monitored directly at the device or via telemetric remote control.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.2.18 Availability

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

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

Start time and end time of the investigations of availability are defined by start time and end time at each of the four field test sites. Therefore all interruptions during the test, e.g. by malfunctions or maintenance work, are recorded.

6.4 Evaluation

Table 18 and Table 19 show a record of the operation, maintenance and malfunction times. The measuring systems have been operated over a time period of 147 measurement days during the field test. Losses, caused by external influences, which cannot be charged to the device itself, have been recorded on 07/28/2007 and 07/29/2006 (48 h because of power loss) and on 08/30/2006 (24 h because of the installation of an electric meter). The total operating time is thereby reduced to 144 measurement days.

The regular care of the sampling inlets in the maintenance interval (approx. every 4 weeks, 5 times during the test), the replacement of the filter tape (approx. every 2 months, 2 times during the test) as well as the check of the sampling flow rates before the field test sites Titz-Roedingen and Cologne, Frankf. Str. have lead in each case to losses of less than 1 h per device (in total 9 times). These times have been evaluated as outage times of respectively 1 h per date, however they have not been regarded for the formation of the respective daily mean values. Merely at the test site Cologne, parking lot on 02/14/2006, the required actions have taken more than 1 h due to organizational reasons and the measured values of this day have been rejected. This outage of 24 h is not to charge to the device, but is caused by the organization and performance of the test itself.

No malfunctions of the devices have been observed.

6.5 Findings

The availability was 99.7 % for both devices without outages, caused by testing, respectively 99.0 % incl. outages, caused by testing.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 18: Determination of availability (without outages, caused by testing)

		Device 1 (SN 4924)	Device 2 (SN 4925)
Operating time	h	3456	3456
Outage time	h	-	-
Maintenance time	h	10	10
Actual operating time	h	3446	3446
Availability	%	99.7	99.7

Table 19: Determination of availability (incl. outages, caused by testing)

		Device 1 (SN 4924)	Device 2 (SN 4925)
Operating time	h	3456	3456
Outage time	h	-	-
Maintenance time	h	9 + 24	9 + 24
Actual operating time	h	3423	3423
Availability	%	99.0	99.0

6.1 5.2.19 Efficiency of the converter

In case of measuring systems with a converter, the efficiency of the converter shall be at least 95 %.

According to Guideline VDI Sheet 3, point 5.3, this test point is not relevant for particulate measuring systems with pre-separation, based on a physical measurement method for mass determination.

6.2 Equipment

Not applicable.

6.3 Performance of test

Not applicable.

6.4 Evaluation

Not applicable.

6.5 Findings

Not applicable.

Minimum requirement fulfilled? not applicable

6.6 Presentation of test results

Not applicable.

6.1 5.2.20 Maintenance interval

The maintenance interval of the measuring system shall be determined and specified. The maintenance interval should be 28 days, if possible, but at least 14 days.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

For this minimum requirement it was investigated, which maintenance work in which time intervals is required for a proper functional efficiency of the measuring system. Furthermore the results of the drift determination for zero and reference point according to module 5.2.9 respectively module 5.2.10 have been taken into account to determine the maintenance interval.

6.4 Evaluation

There have been observed no unallowable drift effects during a time period of 4 weeks. The maintenance interval is defined by the accruing maintenance work. To ensure a proper functional efficiency of the measuring system, all instrument functions should be checked latest every 4 weeks (refer to module 4.1.2).

Within the operational time, the maintenance can basically be restricted to the check for contaminations, plausibility checks and possible status / error messages.

6.5 Findings

The maintenance interval is defined by the accruing maintenance work and it is 4 weeks.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

The necessary maintenance workings can be found in the module 4.1.2 in this report and in the chapters 10 in the manual.

6.1 5.2.21 Overall uncertainty

The expanded uncertainty of the measuring system shall be determined. The value determined shall not exceed the corresponding data quality objectives in the EU Daughter Directives on air quality [G11 to G13].

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

The expanded overall uncertainty of the measuring system has been determined for single values in the range of concentrations of the short-time ambient air quality limit value and for mean values in the range of concentrations of the long-time ambient air quality limit value. The performance characteristics (laboratory test and field test with US-sampling inlet), determined in the suitability test, have been compiled.

6.4 Evaluation

The expanded overall uncertainty of the measuring system was determined according Guideline VDI 4202, Sheet 1, Annex C [1].

6.5 Findings

For the calculation of the expanded measurement uncertainties, the single results from the respective test points have been recapitulating assessed. As far as there have been several independent results from the single investigations available, the respective most disadvantageous value has been used.

The overall uncertainties have been 7.23 % respectively 7.89 % for U(c) and 7.44 % respectively 8.28 % for $U(\bar{c})$.

Single values can be found in Table 20 to Table 23. The obtained values are all below the required overall uncertainties of 25 %.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 20: Expanded measurement uncertainty U(c) for the measuring system SN 4924 Reference value: 50 µg/m³

Performance characteristics for Device SN 4924	Requirement	Result		Uncertainty u	Square of uncertainty u²
				µg/m³	(µg/m³)²
Reproducibility R	≥ 10	20		1.00	1.00
Confidence interval CI_{95} according to EN 12341	≤ 5 µg/m³	2.23	µg/m³	1.29	1.66
Temperature dependence at zero point	≤ 2 µg/m³	0.70	µg/m³	0.40	0.16
Temperature dependence at ref. point (Beta)	≤ 5 % of B1	0.04	µg/m³	0.02	0.00
Drift at zero point	≤ 2 µg/m³	0.38	µg/m³	0.22	0.05
Drift of measured value	≤ 5 % of B1	0.17	µg/m³	0.10	0.01
Mains voltage (measured value)	≤ 2 µg/m³	0.08	µg/m³	0.05	0.00
Cross-sensitivities	≤ 6 µg/m³	0.40	µg/m³	0.23	0.05
Uncertainty of test standard	≤ 1 µg/m³	1.00	µg/m³	0.58	0.33
				Σu²	3.27
				U(c) = 2u(c)	3.62
				U(c) / Ref.	7.23

Table 21: Expanded measurement uncertainty U(c) for the measuring system SN 4925 Reference value: 50 µg/m³

Performance characteristics for Device SN 4925	Requirement	Result		Uncertainty u	Square of uncertainty u²
				µg/m³	(µg/m³)²
Reproducibility R	≥ 10	20		1.00	1.00
Confidence interval CI_{95} according to EN 12341	≤ 5 µg/m³	2.23	µg/m³	1.29	1.66
Temperature dependence at zero point	≤ 2 µg/m³	0.30	µg/m³	0.17	0.03
Temperature dependence at ref. point (Beta)	≤ 5 % of B1	0.08	µg/m³	0.05	0.00
Drift at zero point	≤ 2 µg/m³	0.69	µg/m³	0.40	0.16
Drift of measured value	≤ 5 % of B1	-0.01	µg/m³	-0.01	0.00
Mains voltage (measured value)	≤ 2 µg/m³	-0.04	µg/m³	-0.02	0.00
Cross-sensitivities	≤ 6 µg/m³	1.46	µg/m³	0.84	0.71
Uncertainty of test standard	≤ 1 µg/m³	1.00	µg/m³	0.58	0.33
				Σu²	3.89
				U(c) = 2u(c)	3.95
				U(c) / Ref.	7.89

Table 22: Expanded measurement uncertainty U ($\bar{c}$) for the measuring system SN 4924 Reference value: 40 µg/m³

Performance characteristics for Device SN 4924	**Uncertainty (single value)**	**Time basis**	**Number nk**	**Square of uncertainty (mean value)**
				(µg/m³)²
Reproducibility R	1.00	24 h	365	0.003
Confidence interval CI_{95} according to EN 12341	1.29	1 year	1	1.658
Temperature dependence at zero point	0.40	1 year	1	0.163
Temperature dependence at ref. point (Beta)	0.02	1 year	1	0.001
Drift at zero point	0.22	1 week	52	0.001
Drift of measured value	0.10	1 week	52	0.000
Mains voltage (measured value)	0.05	1 year	1	0.002
Cross-sensitivities	0.23	1 year	1	0.053
Uncertainty of test standard	0.58	1 year	1	0.333
			$\Sigma u_m^2(c_k)$	2.214
			$U(\bar{c}) = 2u(\bar{c})$	2.98
			$\frac{U(\bar{c})}{Reference}$	7.44

Table 23: Expanded measurement uncertainty U ($\bar{c}$) for the measuring system SN 4925 Reference value: 40 µg/m³

Performance characteristics for Device SN 4925	**Uncertainty (single value)**	**Time basis**	**Number nk**	**Square of uncertainty (mean value)**
				(µg/m³)²
Reproducibility R	1.00	24 h	365	0.003
Confidence interval CI_{95} according to EN 12341	1.29	1 year	1	1.658
Temperature dependence at zero point	0.17	1 year	1	0.030
Temperature dependence at ref. point (Beta)	0.05	1 year	1	0.002
Drift at zero point	0.40	1 week	52	0.003
Drift of measured value	-0.01	1 week	52	0.000
Mains voltage (measured value)	-0.02	1 year	1	0.001
Cross-sensitivities	0.84	1 year	1	0.711
Uncertainty of test standard	0.58	1 year	1	0.333
			$\Sigma u_m^2(c_k)$	2.740
			$U(\bar{c}) = 2u(\bar{c})$	3.31
			$\frac{U(\bar{c})}{Reference}$	8.28

6.1 5.3.1 Equivalency of the sampling system

The equivalency between the PM10 sampling system and the reference method according to DIN EN 12 341 [T5] shall be demonstrated.

6.2 Equipment

For this test point, the instruments mentioned in point 5 of the report at hand have been additionally used.

6.3 Performance of test

The test work has been performed in the field test at different test sites according to chapter 4 of this report. During the test, different seasons and different PM10-concentrations have been taken into consideration.

For every test site, at least 15 valid data pairs have been determined.

The field investigations at the three different test sites were performed with an US-PM10-sampling inlet (BX-802). After having finished these investigations, the candidates have been additionally operated with the EU-PM10-sampling inlet (BX-809) at the field test site Cologne, Frankfurter Str. and have been separately evaluated. Target of these additional investigations has been the proof that the results, obtained with both different types of sampling inlets, do not differ significantly from each other and thus the operation of the system is basically possible with both types of sampling inlets.

6.4 Evaluation

Requirement of EN 12341

The calculated functional relationship y = f(x) between concentration values measured with candidate sampler (y) and concentration values measured with reference sampler (x) has to be limited by a two-sided acceptance envelope. This acceptance envelope is given through:

$y = (x \pm 10)$ µg/m³ for concentration average values $\leq$ 100 µg/m³ and

$y = 0.9x$ µg/m³ respectively $1.1x$ µg/m³ for concentration average values > 100 µg/m³

Furthermore the variance coefficient R^2 of the calculated reference-equivalence-function has to be ≥ 0.95.

The test procedure regards the functional relationship between the concentration values, which have been determined through double measurements with the candidate and the reference sampler. Ideally both instruments sample the same suspended particulate matter fraction, thus we have the relationship y = x. The evaluation process is as follows.

For every single test site and, after summary of the measurement data from all test sites, for all four test sites together, a linear regression analysis with the measurement data has been made.

One receives for every measurement value y_i of the candidate sampler i and the concentration x, measured with the reference sampler – both in µg/m³ - a reference-equivalence-function according to the general relation:

$y_i = m \cdot x + b$ with i = candidate BAM-1020

6.5 Findings

The reference-equivalence functions are bounded within the limits of the acceptance envelope. Furthermore the variance coefficient R^2 of the determined reference-equivalence functions is ≥ 0.95 for the respective concentration range. This is also fulfilled for all single test sites as well as for the additional investigations with the EU-sampling inlet at test site Cologne, Frankf. Str..

Minimum requirement fulfilled? yes

6.6 Presentation of test results

The results of the linear regression analysis are summarized in Table 24 and in Table 25. The graphic presentation can be found in Figure 34 to Figure 43. Together with the linear regression curve of the instruments, the ideal curve y = x and the two-sided acceptance envelope are shown. All single values for the candidates as well as for the reference samplers can be found, separately for each test site, in annex 4.

Table 24: Results of the linear regression analysis of the measurements with candidate SN 4924 at the three test sites

SN 4924	Number of values N	Slope m	Ordinate intercept b	R^2
Cologne, parking lot	29	0.926	2.647	0.959
Titz-Roedingen	37	1.04	0.805	0.964
Cologne, Frankfurter Str.	28	1.01	0.891	0.958
Total	94	0.968	1.545	0.952
additional Cologne, Frankfurter Str., EU-inlet	26	1.022	0.449	0.947

Table 25: Results of the linear regression analysis of the measurements with candidate SN 4925 at the three test sites

SN 4925	Number of values N	Slope m	Ordinate intercept b	R^2
Cologne, parking lot	29	0.972	3.081	0.969
Titz-Roedingen	37	1.04	1.716	0.963
Cologne, Frankfurter Str.	28	1.009	0.284	0.962
Total	94	0.987	2.250	0.958
additional Cologne, Frankfurter Str., EU-inlet	26	0.965	0.930	0.966

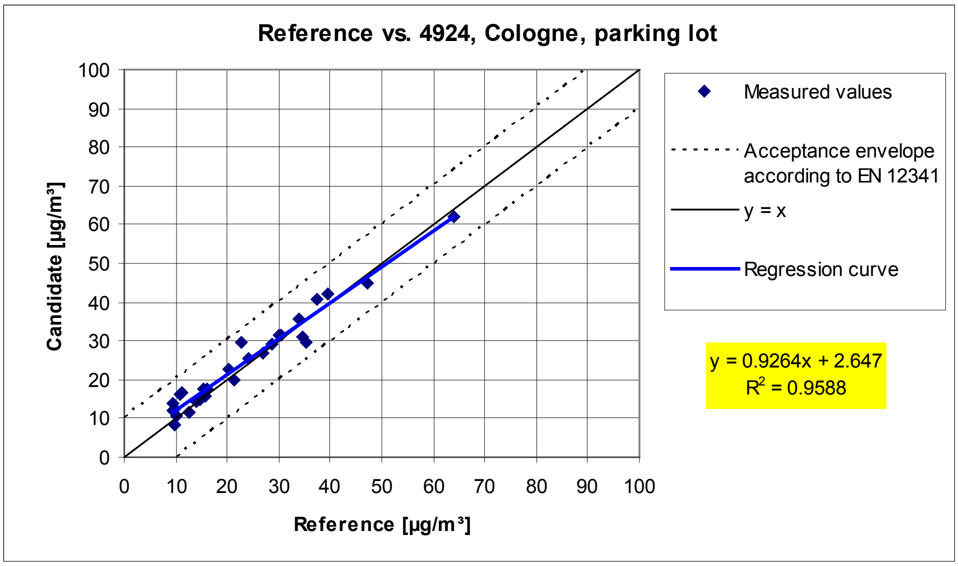

Figure 34: Reference-equivalence-function SN 4924, test site Cologne, parking lot

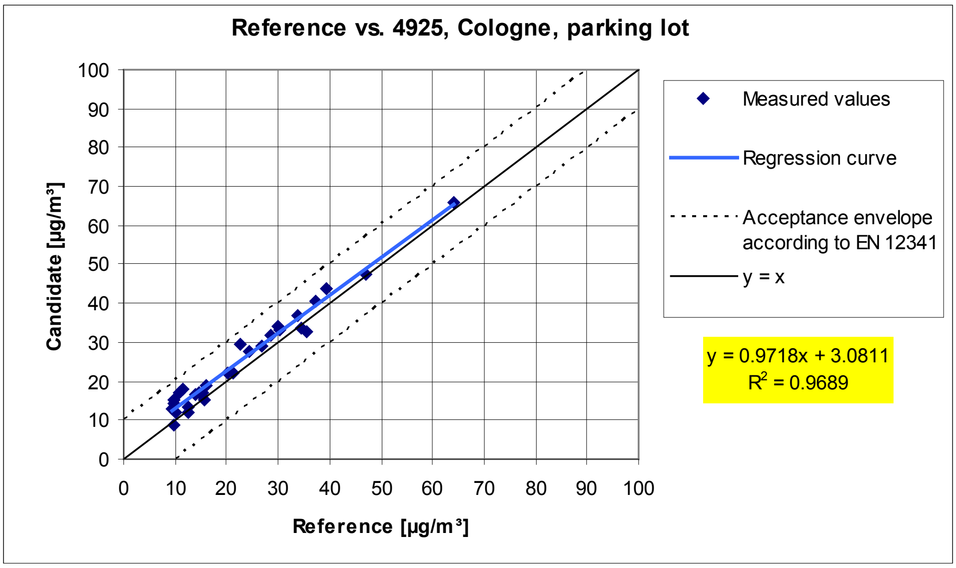

Figure 35: Reference-equivalence-function SN 4925, test site Cologne, parking lot

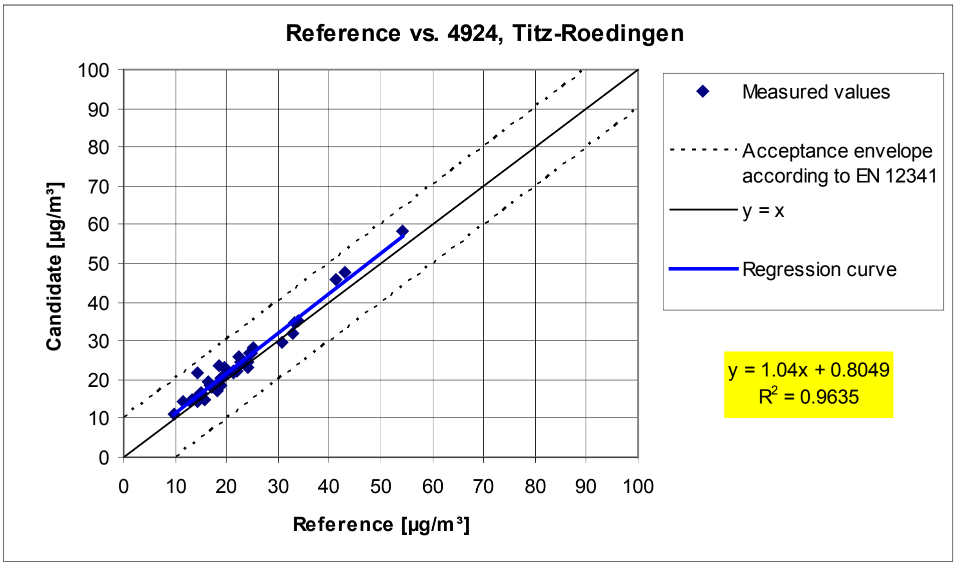

Figure 36: Reference-equivalence-function SN 4924, test site Titz-Roedingen

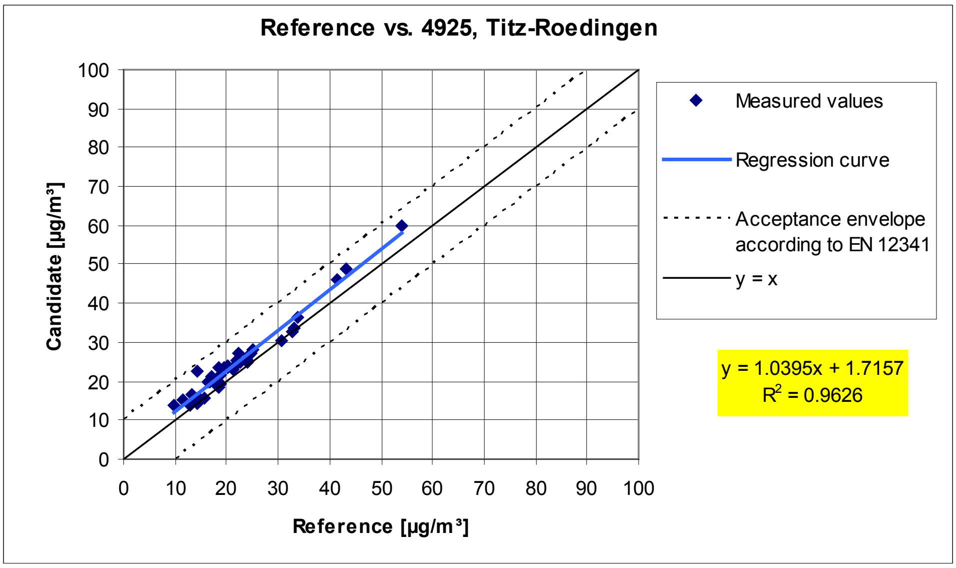

Figure 37: Reference-equivalence-function SN 4925, test site Titz-Roedingen

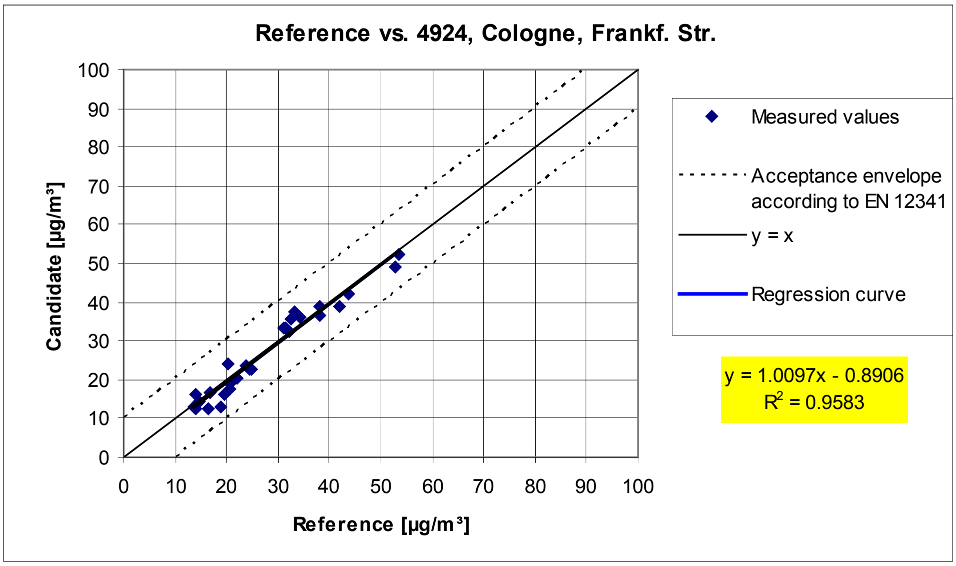

Figure 38: Reference-equivalence-function SN 4924, test site Cologne, Frankfurter Str.

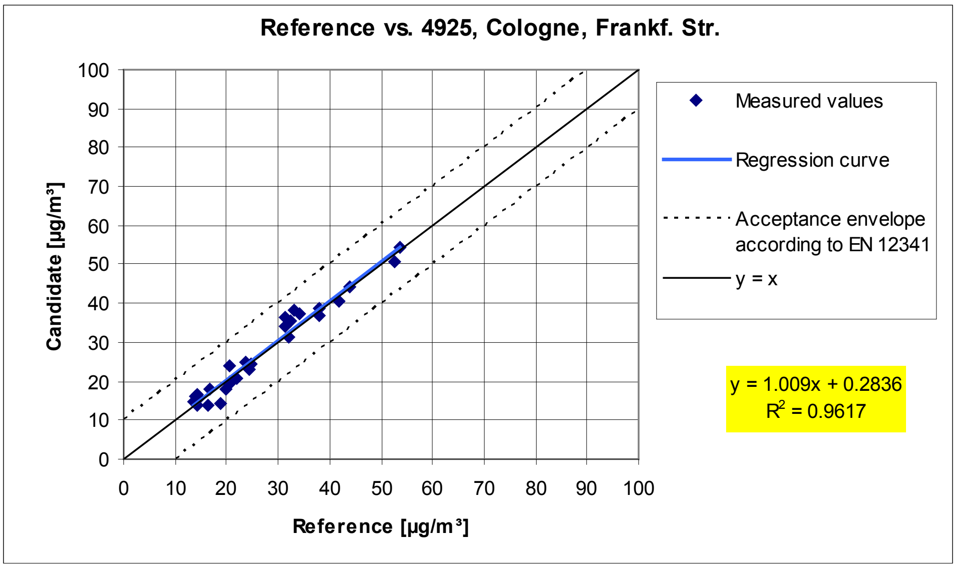

Figure 39: Reference-equivalence-function SN 4925, test site Cologne, Frankfurter Str.

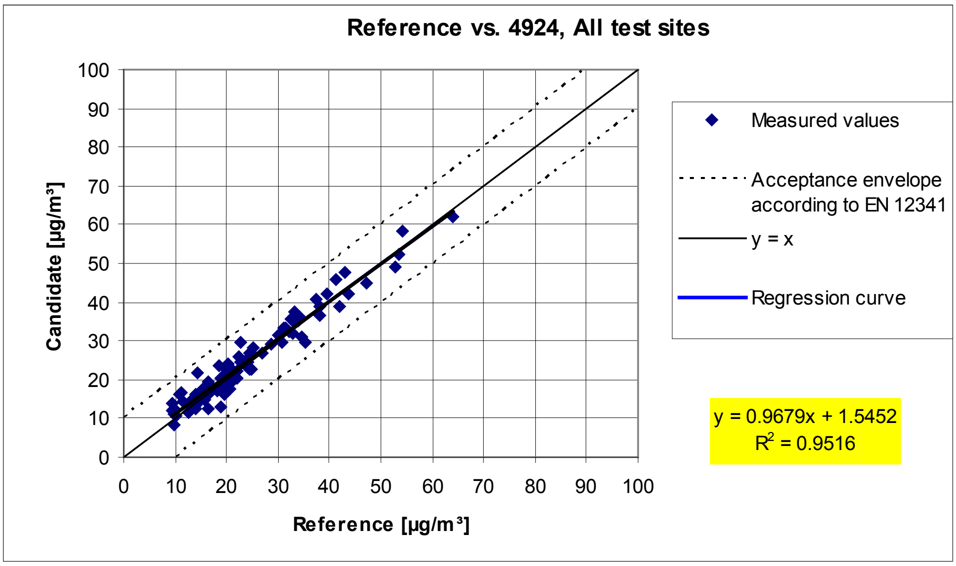

Figure 40: Reference-equivalence-function SN 4924, all test sites

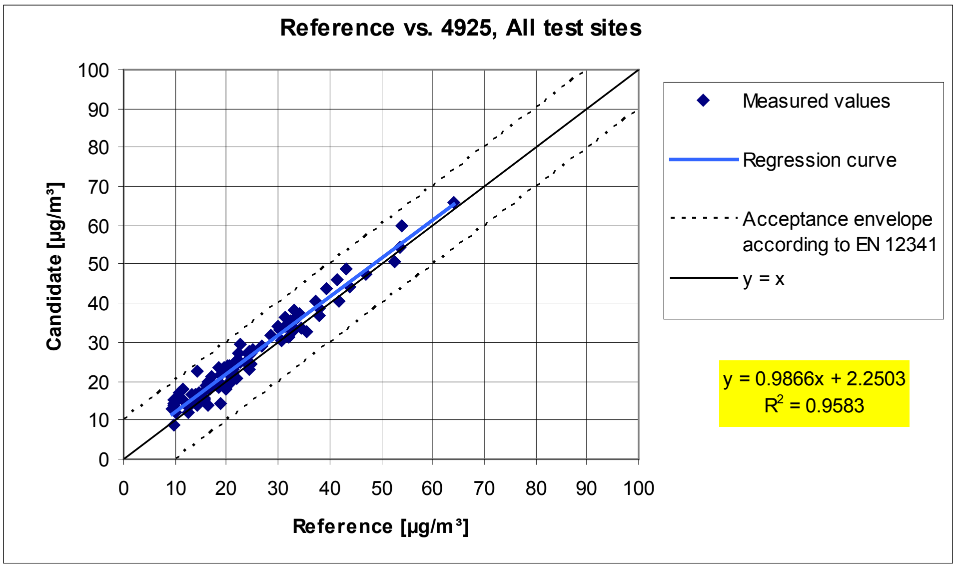

Figure 41: Reference-equivalence-function SN 4925, all test sites

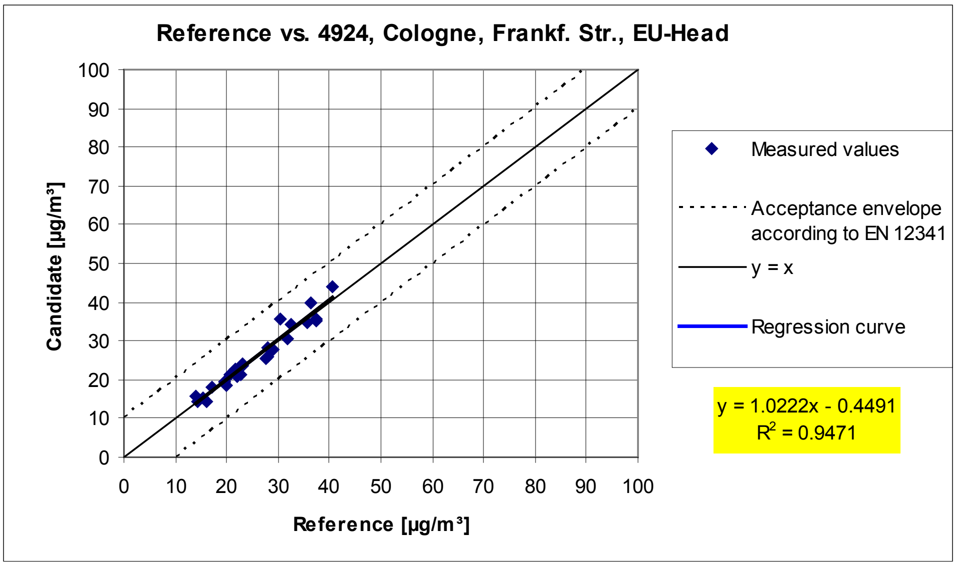

Figure 42: Reference-equivalence-function SN 4924, additional test site "Cologne, Frankfurter Str." with EU-sampling inlet

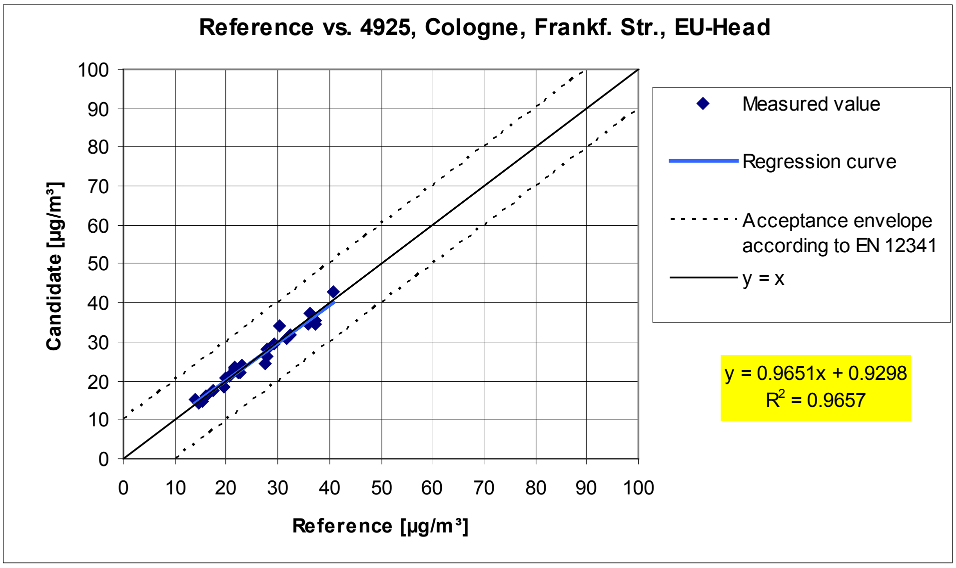

Figure 43: Reference-equivalence-function SN 4925, additional test site "Cologne, Frankfurter Str." with EU-sampling inlet

6.1 5.3.2 Reproducibility of the sampling systems

The PM10 sampling systems of two identical systems under test shall be reproducible among themselves according to DIN EN 12 341 [T5]. This shall be demonstrated in the field test.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

The test work has been performed in the field test at different test sites. During the test, different seasons, different PM10-concentrations as well as different ratios between TSP and PM10 have been taken into consideration.

For every test site, at least 15 valid data pairs have been determined.

The field investigations at the three different test sites were performed with an US-PM10-sampling inlet (BX-802). After having finished these investigations, the candidates have been additionally operated with the EU-PM10-sampling inlet (BX-809) at the field test site Cologne, Frankfurter Str. and have been separately evaluated. Target of these additional investigations has been the proof that the results, obtained with both different types of sampling inlets, do not differ significantly from each other and thus the operation of the system is basically possible with both types of sampling inlets.

6.4 Evaluation

The two-sided acceptance envelope CI_{95} , calculated from the concentration average values measured with the candidate samplers, may not exceed a value of 5 µg/m³ for concentration average values ≤ 100 µg/m³ and of 0.05 for concentration average values > 100 µg/m³.

The demonstration of the comparability of the candidate samplers is focusing on the differences D_i of the concentration values Y_i of the candidate samplers. Ideally both candidate samplers are equal and thus sample the same suspended particulate matter fraction, implying $D_i = 0$. The procedure is as follows:

First the average concentrations Y_i of the i-th parallel measurement of the candidate samplers are calculated. Following the average concentrations Y_i are divided into two separated data sets:

a) Data set with $Y_i \leq 100$ µg/m³ with number of paired values $n_{\leq}$ and
b) Data set with $Y_i > 100$ µg/m³ with number of paired values $n_{>}$

Re a):

The absolute standard deviation s_a is calculated from the paired values of the data set with $Y_i \leq 100$ µg/m³:

$$s_a = \sqrt{(\sum D_i^2 / 2n_{\leq})}$$

The corresponding Student factor $t_{f_{\leq};0,975}$, defined as the 0.975 quantile of the two-sided 95 % confidence interval of the Student t-distribution with $f_{\leq} = n_{\leq} - 2$ degrees of freedom is used.

The two-sided confidence interval CI_{95} for the average concentration values ≤ 100 µg/m³ is then calculated as follows:

$$CI_{95} = s_a \cdot t_{f_{\leq};0,975}$$

Re b):

The relative standard deviation s_r is calculated from the paired values of the data set with Y_i > 100 µg/m³ as follows:

$$s_r = \sqrt{(\sum (D_i / Y_i)^2 / 2n_{>})}$$

Again the corresponding Student factor $t_{f_{\leq};0,975}$, defined as the 0.975 quantile of the two-sided 95 % confidence interval of the Student t-distribution with $f_{\leq} = n_{\leq} - 2$ degrees of freedom is used.

The two-sided confidence interval CI_{95} for the average concentration values > 100 µg/m³ is then calculated as follows:

$$CI_{95} = s_r \cdot t_{f_{>};0,975}$$

During the field test, no concentration values > 100 µg/m³ have been measured. A statistical evaluation for this concentration range is not possible due to this reason. Therefore an assessment according to b) is omitted.

6.5 Findings

For all investigated test sites, it is imperative:

The two-sided confidence interval CI_{95} is, with maximum 2.54 µg/m³, below the specified level of 5 µg/m³. This is also fulfilled for all single test sites as well as for the additional investigations with the EU-sampling inlet at test site Cologne, Frankf. Str.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 26 shows the calculated values for the standard deviation s_a and the two-sided confidence interval CI_{95}. The graphic presentation can be found in Figure 44 to Figure 48. Together with the linear regression curve of the instruments (determined by linear regression analysis), the ideal curve y = x and the two-sided acceptance envelope are shown. All single values can be found in annex 4.

Table 26: Two-sided 95%-confidence interval CI_{95} for the candidates SN 4924 and SN 4925

Candidates	**Test site**	**Number of values**	**Standard deviation s_a**	**Student-factor t_f**	**Confidence interval CI_{95}**
SN			µg/m³		µg/m³
4924 / 4925	Cologne, parking lot	52	1.27	2.009	2.54
4924 / 4925	Titz-Roedingen	37	0.93	2.030	1.89
4924 / 4925	Cologne, Frankf. Str.	28	1.07	2.056	2.21
4924 / 4925	Total	117	1.12	1.981	2.23
4924 / 4925	additional Cologne, Frankf. Str., EU-inlet	26	0.80	2.064	1.65

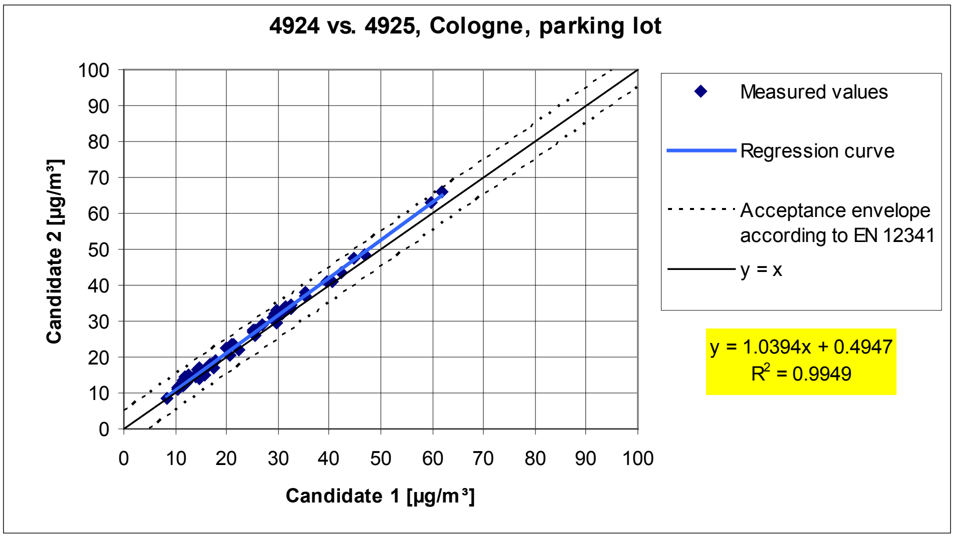

Figure 44: Result of the parallel measurements with the candidates SN 4924 / SN 4925, test site Cologne, parking lot

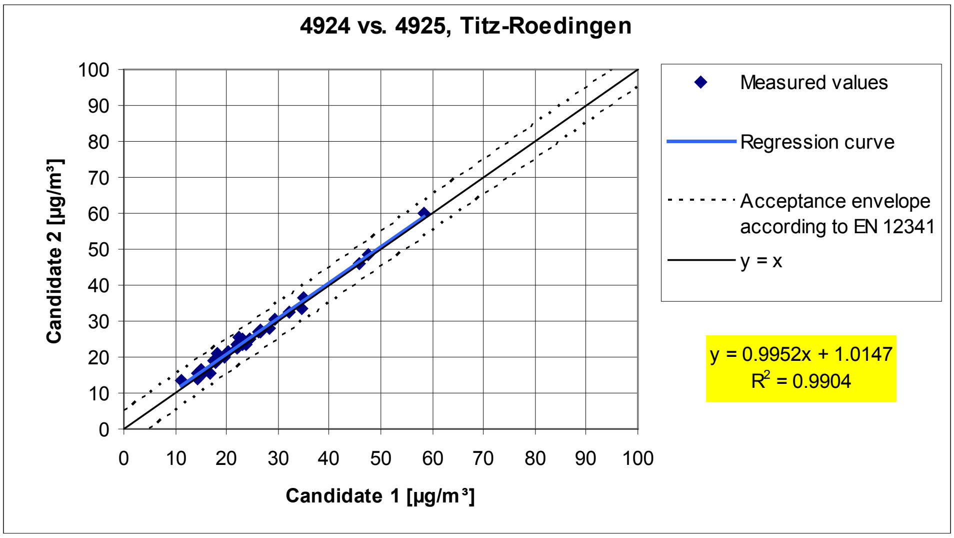

Figure 45: Result of the parallel measurements with the candidates SN 4924 / SN 4925, test site Titz-Roedingen

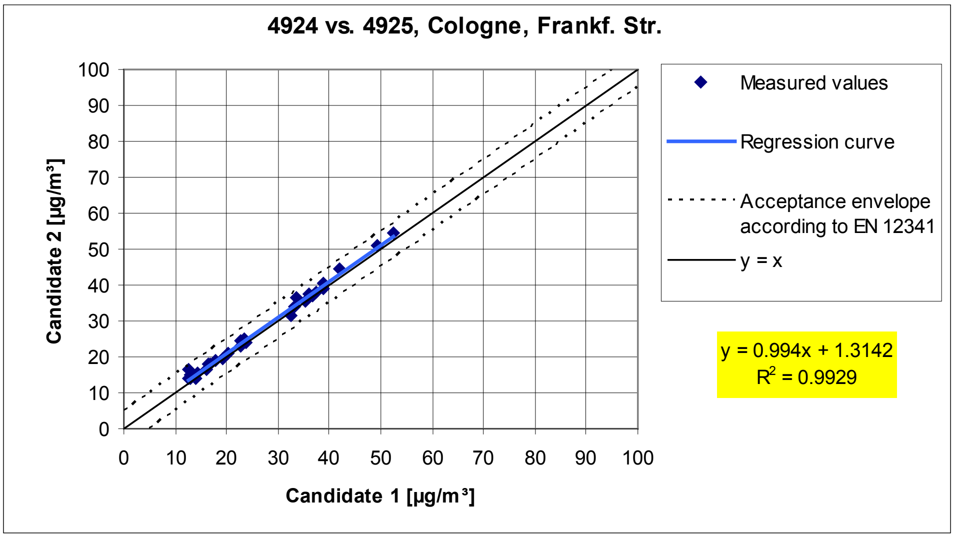

Figure 46: Result of the parallel measurements with the candidates SN 4924 / SN 4925, test site Cologne, Frankfurter Str.

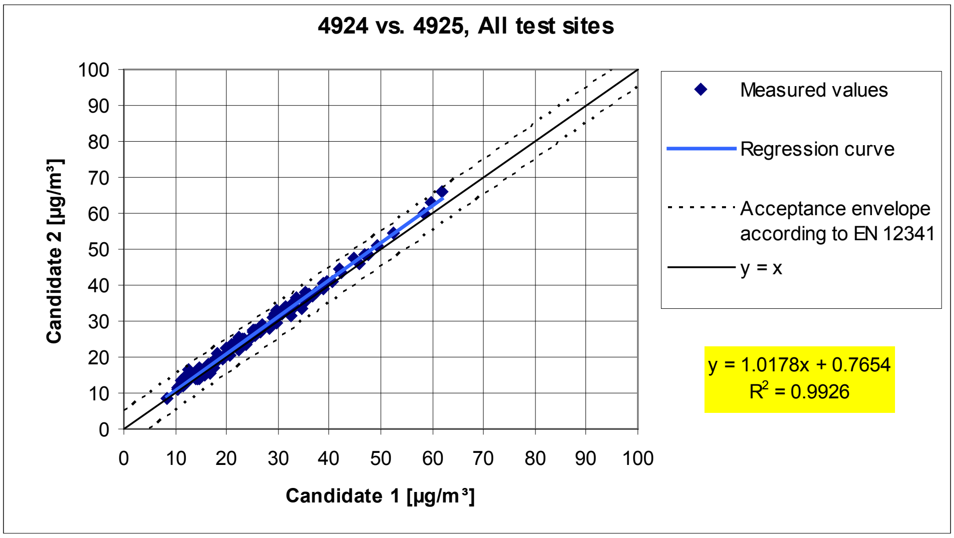

Figure 47: Result of the parallel measurements with the candidates SN 4924 / SN 4925, all test sites

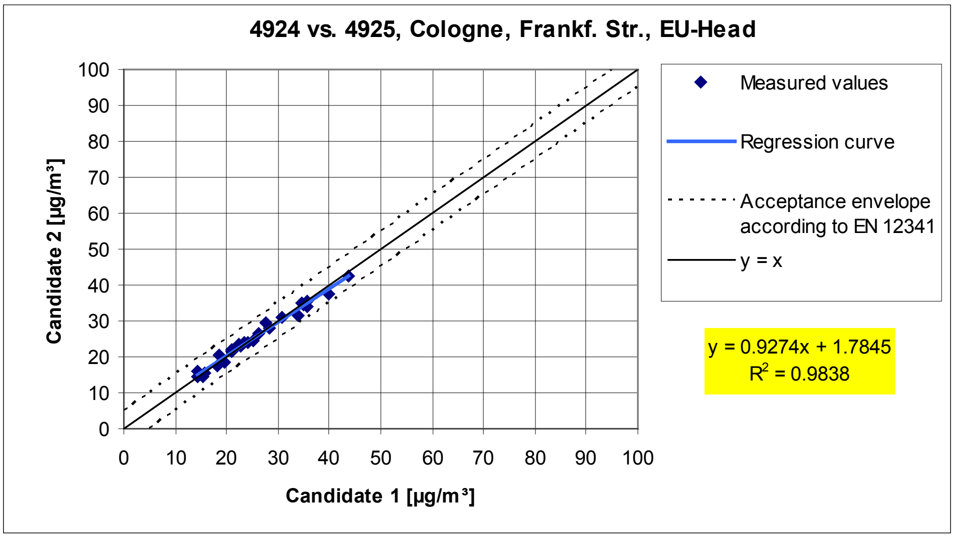

Figure 48: Result of the parallel measurements with the candidates SN 4924 / SN 4925, additional test site Cologne, Frankfurter Str. with EU-sampling inlet

6.1 5.3.3 Calibration

The PM10 systems under test shall be calibrated in the field test by comparison measurements with a reference method according to DIN DIN EN 12341 [T5]. Here, the relationship between the output signal and the gravimetrically determined reference concentration shall be determined as a steady function.

The results of these investigations can be found in module 5.2.3.

6.2 Equipment

Refer to module 5.2.3.

6.3 Performance of test

Refer to module 5.2.3.

6.4 Evaluation

Refer to module 5.2.3.

6.5 Findings

Refer to module 5.2.3.

Minimum requirement fulfilled? -

6.6 Presentation of test results

Refer to module 5.2.3.

6.1 5.3.4 Cross-sensitivity

The interference caused by moisture in the sample shall not exceed 10 % of B_1 in the range of B_1. In case of a heated sampling line, the reproducibility to the gravimetric reference method shall be determined at the specified temperature.

6.2 Equipment

Not required for this minimum requirement.

6.3 Performance of test

The determination of an interfering influence through the air humidity, which is contained in the medium being measured, under laboratory conditions was renounced, because a test at the zero point did not lead to a reliable statement and at the reference point (in the range of B1) it cannot be carried out in a secured way.

Alternatively, the differences between the determined reference value (= nominal value) and the measured value of the respective candidate system have been calculated during the field test for days with a relative humidity > 70 % and the mean difference has been set as a conservative estimation of the interfering effect through the air humidity, which is contained in the medium being measured.

Additionally, the reference-equivalence functions for both candidate systems have been determined from the field investigations for days with a relative humidity > 70 %.

The investigations on the basis of the field test have been restricted to the measured data that have been obtained while using the US-sampling inlet.

During the entire field investigations, the sample heater BX-830 has been activated.

The control of the heater is done exclusively via the control variable relative humidity RH at the filter tape (factory setting: 45 %).

6.4 Evaluation

The mean difference between the determined reference value (= nominal value) and the measured value of the respective candidate system have been calculated from the field test investigations for days with a relative humidity > 70 %.

Reference value: VDI: B_1 = 40 µg/m³ 10 % of B_1 = 4 µg/m³

Furthermore it has been investigated, if the comparability of the candidate systems with the reference method according to Guideline DIN EN 12341 is also given for the case, that the measured values have been determined at days a relative humidity > 70 %.

6.5 Findings

No interfering influence > 1.46 µg/m³ deviation from the nominal value on the measured signal through the air humidity, which is contained in the medium being measured could be detected. During the field test, it could be observed no negative influence on the measured values during varying relative air humidity and activated heating system. The comparability of the candidate systems to the reference method according to Guideline DIN EN 12341 is also given for days with a relative humidity > 70 %.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 27 shows a recapitulating presentation.

Table 27: Deviation between reference measurement and candidate on days with a relative humidity > 70 %

Field test, days with relative humidity >70%				
		Reference	SN 4924	SN 4925
Mean	µg/m³	22.7	23.1	24.2
Deviation to mean value reference in µg/m³	µg/m³	-	0.4	1.46
Deviation in % of the mean value reference	%	-	1.7	6.4
Deviation in % of B1	%	-	1.0	3.6

Single values can be found in the annexes 4 and 5 in the appendix.

The graphic presentation of the measured values at days with a relative humidity > 70 % is shown in Figure 49 and in Figure 50. Single values can be found in the annexes 4 and 5 in the appendix.

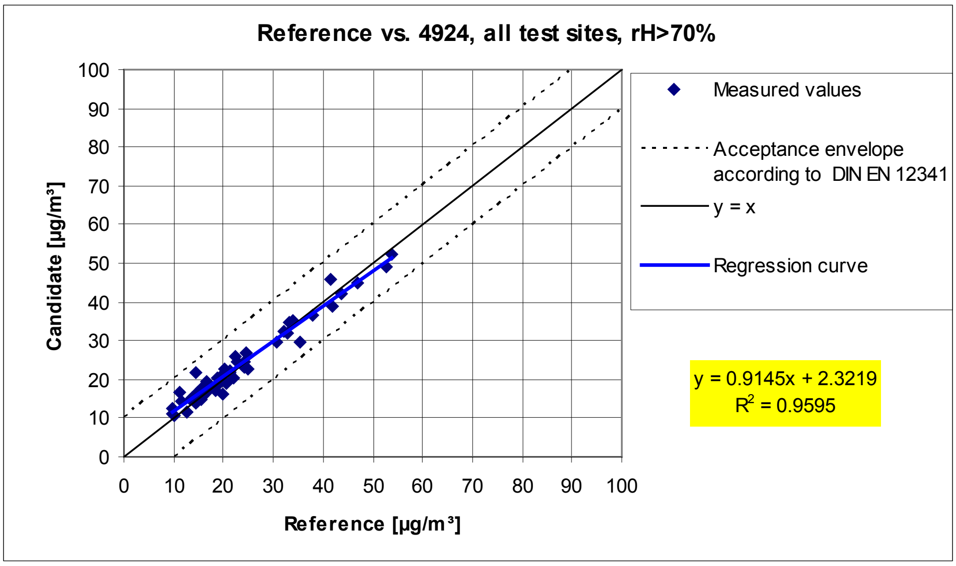

Figure 49: Reference-equivalence-function SN 4924, rel. air humidity > 70 %, all test sites

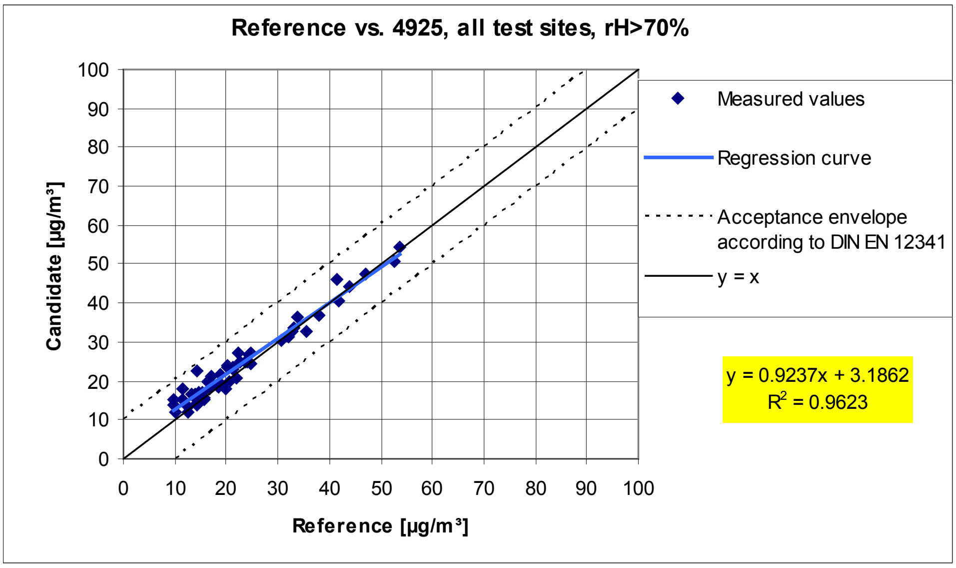

Figure 50: Reference-equivalence-function SN 4925, rel. air humidity > 70 %, all test sites

6.1 5.3.5 Daily averages

The measuring system shall allow for formation of daily averages. In case of filter changes, the time needed for the filter changes shall not exceed 1 % of the averaging time.

6.2 Equipment

For this test, a clock has been additionally provided.

6.3 Performance of test

It has been checked, whether the measuring system allows the formation of a daily average. The time need for a filter change has been determined.

6.4 Evaluation

The measuring system operates by default with a measurement cycle of 60 min. After each measurement cycle, the filter tape is moved forward for one position. The data of each measurement cycle are stored and are available for the user for further processing. Furthermore the measuring system allows the formation of a 24-h-mean value, which is output in the daily protocol via the serial interface.

Within the scope of the suitability test, the cycle time has been set to 60 min with a time need for the radiometric measurement of respectively 4 min.

The cycle time therefore consists of 2 x 4 min for the radiometric measurement (I_0 & I_3) as well as approx. 1-2 min for filter tape movements. Hence the sampling time is approx. 51 min per hour.

Thus the available sampling time per measurement cycle is approx. 85 % of the total cycle time. The results from the field investigations according to point 6.1 5.3.1 Equivalency of the sampling system in this report show, that the comparability of the candidates with the reference method could be securely proved in case of this system configuration and thus the formation of daily mean values is securely possible.

6.5 Findings

With the described system configuration and with a measurement cycle of 60 min, the formation of valid daily averages on the basis of 24 single measurements is possible.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Not required for this minimum requirement.

6.1 5.3.6 Constancy of sample volumetric flow

The sample volumetric flow averaged over the sampling time shall be constant within ± 3 % of the rated value. All instantaneous values of the sample volumetric flow shall be within a range of ± 5 % of the rated value during sampling.

6.2 Equipment

Inlet adapter BX-305, flow meter according to point 4.

6.3 Performance of test

The sample volumetric flow has been calibrated before the first field test site and afterwards checked on correctness and re-adjusted if necessary before each field test site with the help of a dry gas meter. In order to determine the constancy of the sample volumetric flow, a flow meter has been connected to the measuring systems and 5-second-values for the flow rate have been recorded and evaluated over a time period of 6 h (=6 measurement cycles).

6.4 Evaluation

From the determined measured values for the flow rate, the mean value, the standard deviation as well as maximum and minimum value have been determined.

6.5 Findings

The results of the check of the sample volumetric flow, carried out before each field test site, are shown in Table 28.

Table 28: Results of sampling flow rate check

Check of flow rate before test site:	SN 4924		SN 4925	
	[l/min]	Dev. from nominal value [%]	[l/min]	Dev. from nominal value [%]
Cologne, parking lot	16.67	-	16.67	-
Titz-Roedingen	16.51	-1.0	17.09	2.5
Cologne, Frankfurter Str.	16.45	-1.3	15.5	-7.0*

* flow rate re-adjusted

The graphic presentation of the flow rate over 6 measurement cycles shows, that all measured values, which have been determined during sampling, deviate less than ±5 % from the nominal value of 16.67 l/min. Likewise the deviation of the daily averages is smaller than the required ±3 % of nominal value.

All determined averages over the measurement cycle deviate less than ± 3 %, all instantaneous values deviate less than ± 5 % from the nominal value.

Minimum requirement fulfilled? yes

6.6 Presentation of test results

The determined characteristics for the flow rate are presented in Table 29 and in Table 30. Figure 51 and Figure 52 show a graphic presentation of the flow rate measurements at both candidate systems SN 4924 and SN 4925.

Table 29: Characteristics for the flow rate measurement, SN 4924

Characteristic	Unit	1	2	3	4	5	6
Average	l/min	16.67	16.74	16.69	16.78	16.69	16.70
Dev. from AVG	% of nominal value	0.00	0.43	0.12	0.66	0.12	0.17
Standard deviation	l/min	0.02	0.04	0.03	0.05	0.04	0.04
Maximum	l/min	16.74	16.90	16.86	17.02	16.94	16.94
Minimum	l/min	16.66	16.66	16.46	16.66	16.66	16.34

Table 30: Characteristics for the flow rate measurement, SN 4925

Characteristic	Unit	1	2	3	4	5	6
Average	l/min	16.67	16.61	16.55	16.52	16.56	16.56
Dev. from AVG.	% of nominal value	0.00	-0.36	-0.69	-0.89	-0.67	-0.67
Standard deviation	l/min	0.14	0.05	0.01	0.04	0.02	0.03
Maximum	l/min	16.83	16.83	16.59	16.59	16.83	16.83
Minimum	l/min	15.99	16.55	16.51	15.95	16.55	16.51

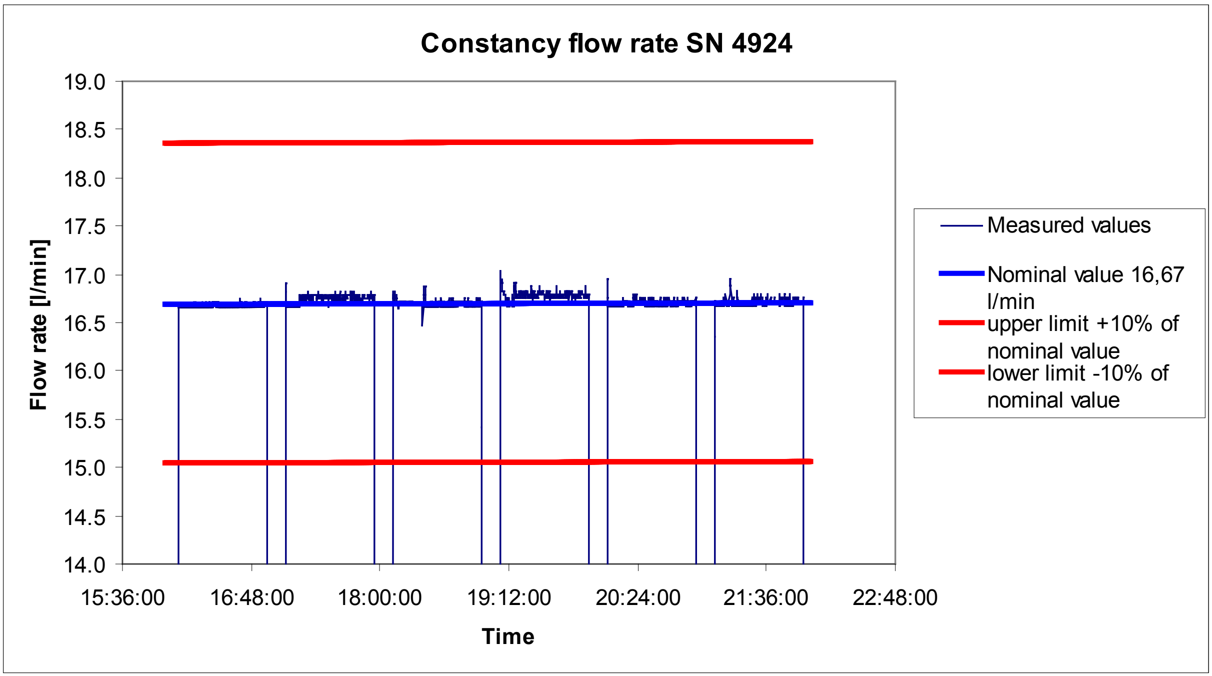

Figure 51: Flow rate at candidate SN 4924

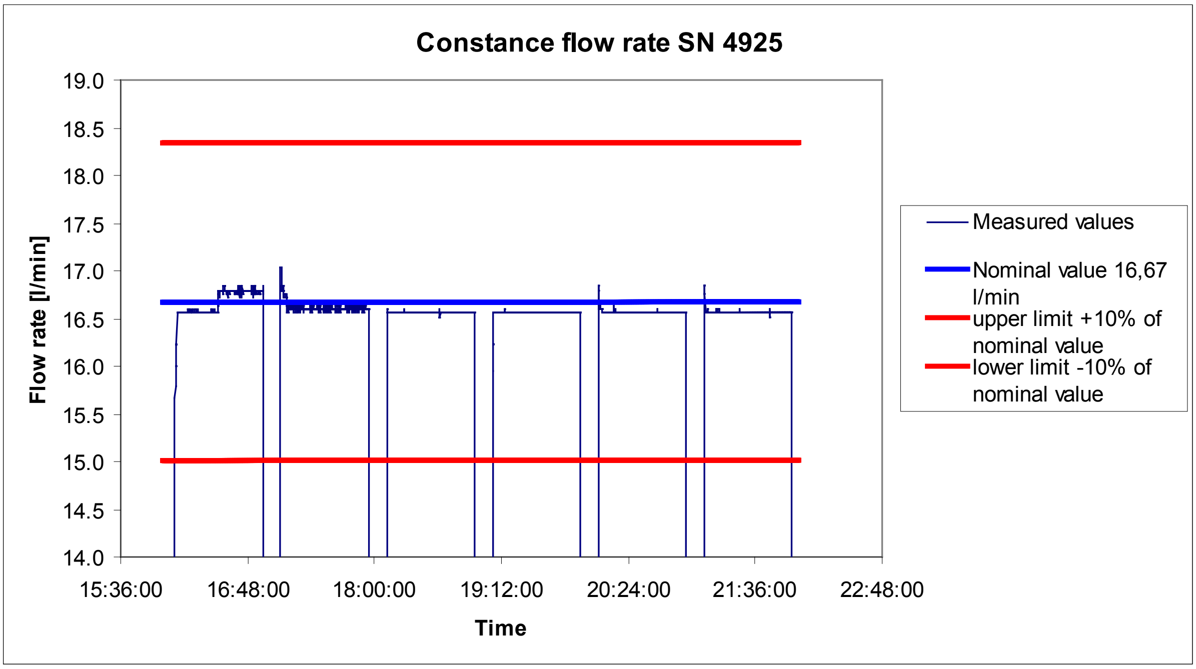

Figure 52: Flow rate at candidate SN 4925

6.1 5.3.7 Tightness of the sampling system

The complete sampling system shall be checked for tightness. Leakage shall not exceed 1 % of the sample volume sucked.

6.2 Equipment

Inlet adapter BX-305.

6.3 Performance of test

In order to determine the leak rate, the inlet adapter BX-305 has been installed at the inlet of the sampling tube and the ball valve of the adapter has been closed slowly. The leak rate has been determined from the difference between the flow rate with switched-off pump (zero point of flow rate measurement), measured in the device, and the measured flow rate with sealed instrument inlet.

The procedure has been repeated three times.

6.4 Evaluation

The leak rate has been determined from the difference between the flow rate with switched-off pump (zero point of flow rate measurement), measured in the device, and the measured flow rate with sealed instrument inlet.

The maximum value of the three determined leak rates has been specified.

6.5 Findings

The maximum determined leakages have been 0.6 % for device 1 (SN 4924) as well as 0.6 % for device 2 (SN 4925).

Minimum requirement fulfilled? yes

6.6 Presentation of test results

Table 31 contains the determined values from the tightness test.

Table 31: Determination of leak rate

	Flow rate (pump off)	Flow rate (pump on, inlet sealed)				
		1	2	3	Mean	Maximum leak rate
	l/min	l/min	l/min	l/min	l/min	% of nom. value
SN 4924	0.0	0.1	0.0	0.1	0.067	0.6
SN 4925	0.0	0.1	0.1	0.1	0.1	0.6

6.1 5.4 Requirements for multiple-component measuring systems

Multiple-component measuring systems shall comply with the requirements set for each component, also in the case of simultaneous operation of all measuring channels. In case of sequential operation, the formation of hourly averages shall be possible.

6.2 Equipment

Not applicable.

6.3 Performance of test

Not applicable.

6.4 Evaluation

Not applicable.

6.5 Findings

Not applicable.

Minimum requirement fulfilled? -

6.6 Presentation of test results

Not applicable.

7 Additional test criteria according to Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods"

7.1 Determination of the between-instrument uncertainty u_{bs} [9.5.2.1]

The between-sampler uncertainty u_{bs} has to be determined according to point 9.5.2.1 of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods".

7.2 Equipment

Not required for this minimum requirement.

7.3 Performance of test

The investigations according to the Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods" have been carried out exemplarily on the basis of the measured data according to [1], [2] and [3], obtained during the field test. Hereby the investigations have been performed deviant to the requirement of the Guidance only at three instead of four field test sites and with less than respectively 40 valid paired measurements per field test site.

The test work has been performed in the field test at three different test sites. During the test, different seasons, different PM10-concentrations as well as different ratios between TSP and PM10 have been taken into consideration.

For every test site, at least 15 valid data pairs have been determined. From the entire data set (3 test sites), in total 32 % of the measured values are above 50 % of the limit value for the daily mean of 50 µg/m³ for PM10. The measured concentrations have been referred to ambient conditions.

7.4 Evaluation

According to **point 9.5.2.1** of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods", it is imperative:

The between-instrument uncertainty u_{bs} shall be ≤ 3 µg/m³. An uncertainty larger than 3 µg/m³ between the candidate systems is an indication of unsuitable performance of one or both instruments and that the equivalence cannot be declared.

The uncertainty is hereby determined for:

- each test site separately
- all test sites together
- 1 data set with measured values ≥ 50 % of the limit value for the daily average of 50 µg/m³ for PM10 (basis: mean values of reference measurement)
- 1 data set with measured values < 50 % of the limit value for the daily average of 50 µg/m³ for PM10 (basis: mean values of reference measurement)

The between-instrument uncertainty u_{bs} is calculated from the differences of all 24-hour results of the candidate systems operated in parallel according to the following equation:

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

with $y_{i,1}$ and $y_{i,2}$ = results of parallel measurements for a single 24-hour period i

n = number of 24-hour measurement results

7.5 Findings

The between-instrument uncertainty u_{bs} is with at maximum 1.22 µg/m³ below the required value of 3 µg/m³.

Minimum requirement fulfilled? yes

7.6 Presentation of test results

Table 32 shows the calculated values for the between-instrument uncertainty u_{bs}. The graphic presentation can be found in Figure 53 to Figure 58.

Table 32: Between-instrument uncertainty u_{bs} for the candidates SN 4924 and SN 4925

Candidates	**Test sites**	**No. of values**	**Uncertainty u_{bs}**
SN			µg/m³
4924 / 4925	Cologne, parking lot	52	1.22
4924 / 4925	Titz-Roedingen	37	0.86
4924 / 4925	Cologne, Frankf. Str.	28	0.99
4924 / 4925	All test sites	117	1.07
4924 / 4925	Values ≥ 50 % of limit value (≥ 25 µg/m³)	30	1.22
4924 / 4925	Values < 50 % of limit value (< 25 µg/m³)	64	0.95
4924 / 4925	additional Cologne, Frankf. Str., EU-inlet	26	0.74

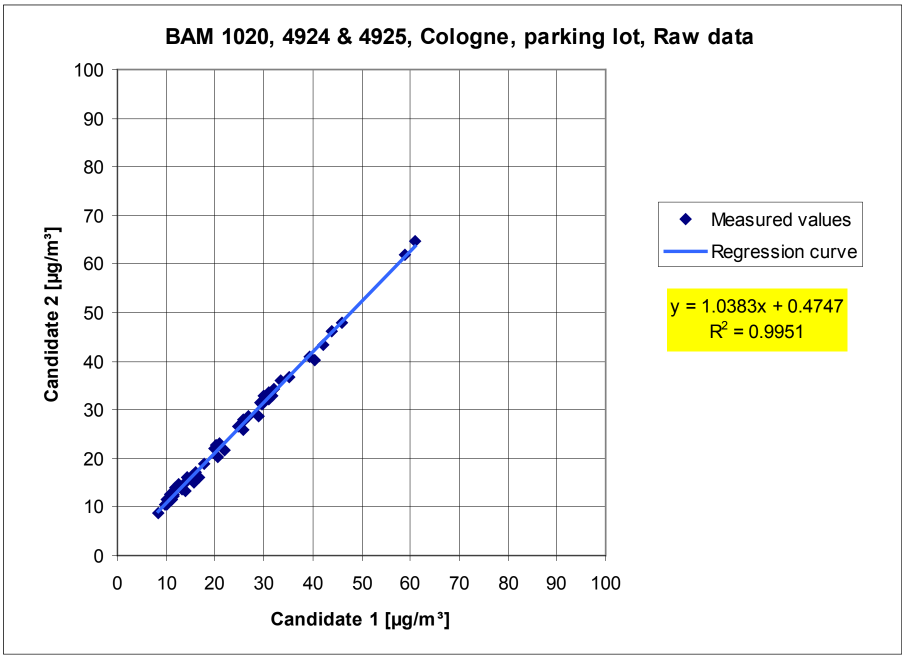

Figure 53: Result of the parallel measurements with the candidates SN 4924 / SN 4925, test site Cologne, parking lot

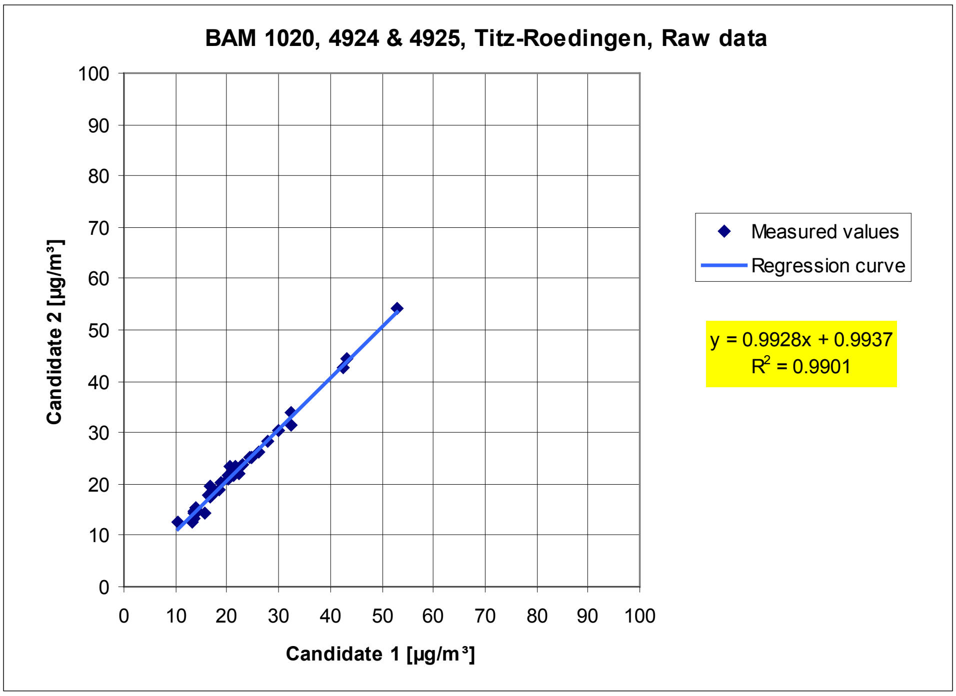

Figure 54: Result of the parallel measurements with the candidates SN 4924 / SN 4925, test sites Titz-Roedingen

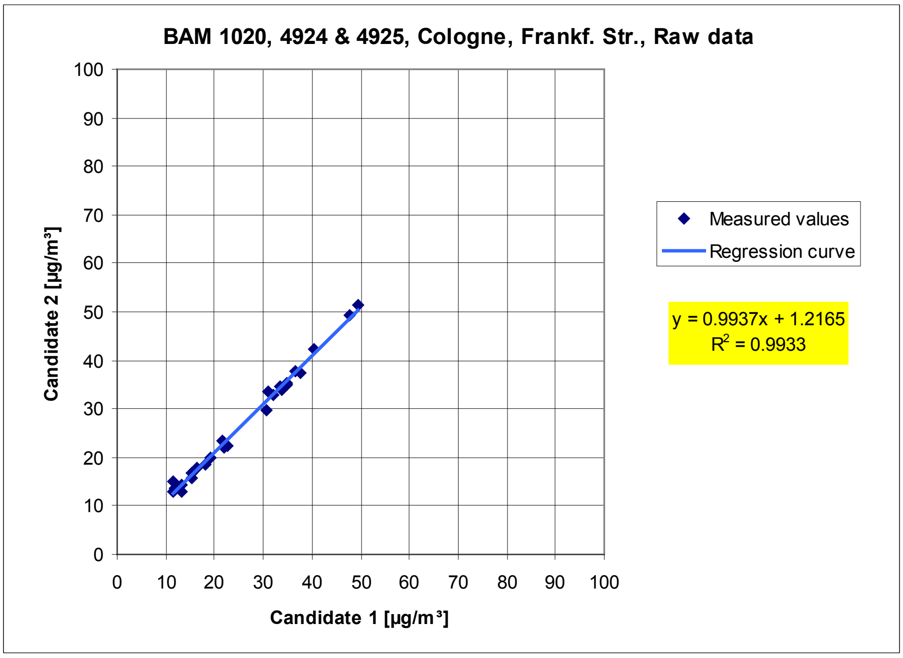

Figure 55: Result of the parallel measurements with the candidates SN 4924 / SN 4925, test site Cologne, Frankfurter Str.

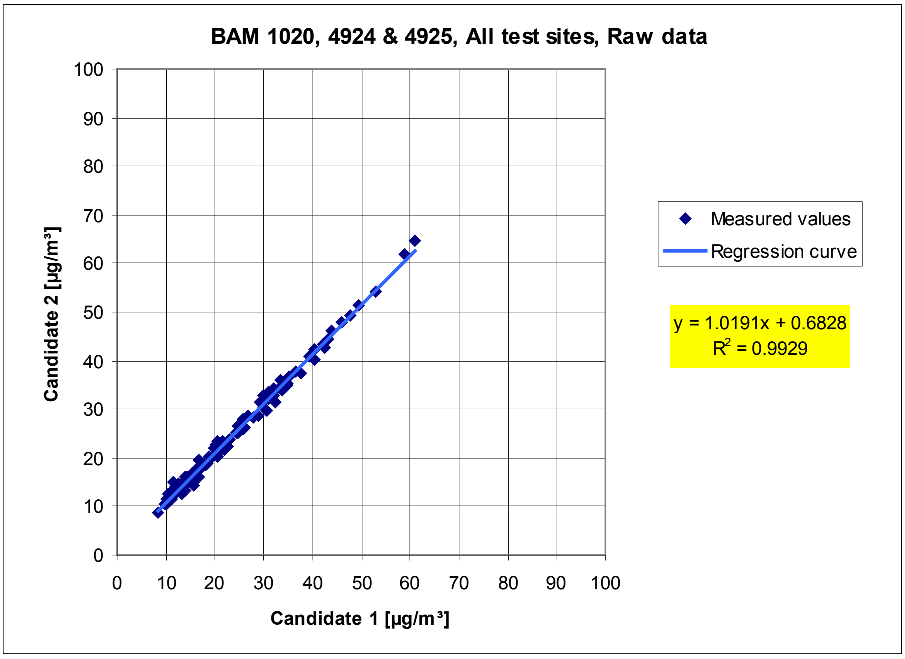

Figure 56: Result of the parallel measurements with the candidates SN 4924 / SN 4925, all test sites

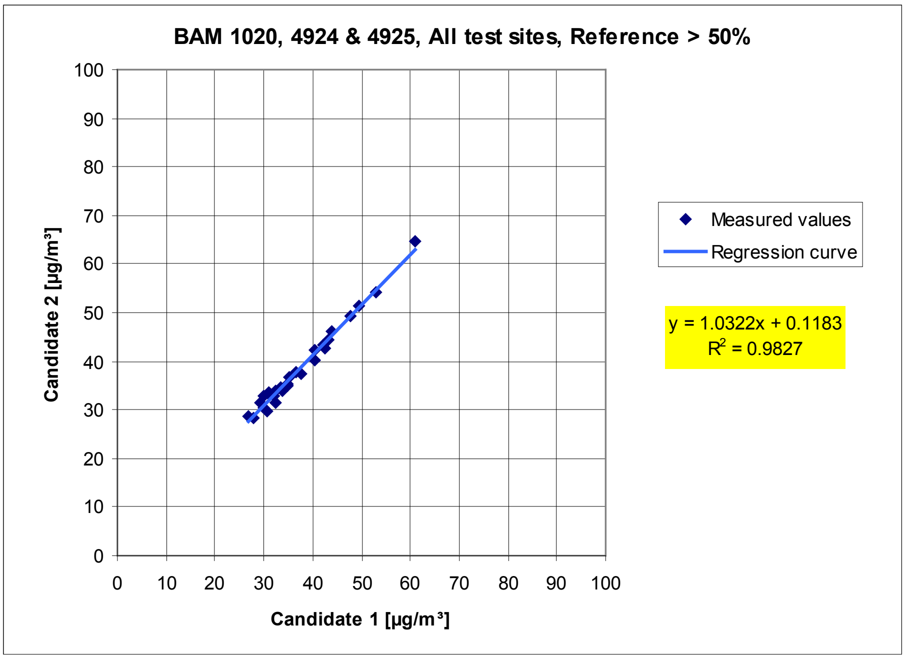

Figure 57: Result of the parallel measurements with the candidates SN 4924 / SN 4925, all test sites, values ≥ 50 % limit value (≥ 25 µg/m³)

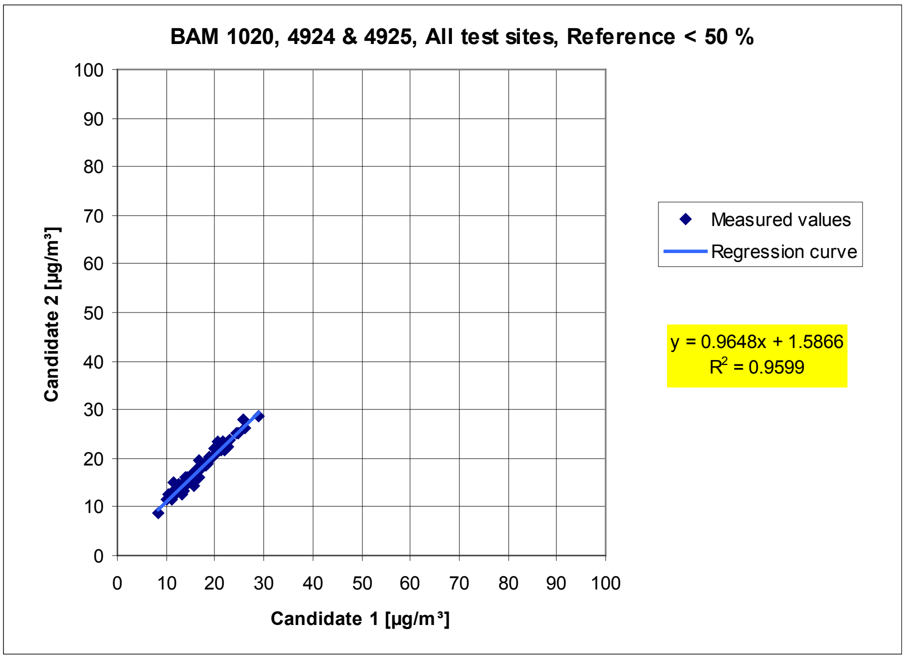

Figure 58: Result of the parallel measurements with the candidates SN 4924 / SN 4925, all test sites, values < 50 % limit value (< 25 µg/m³)

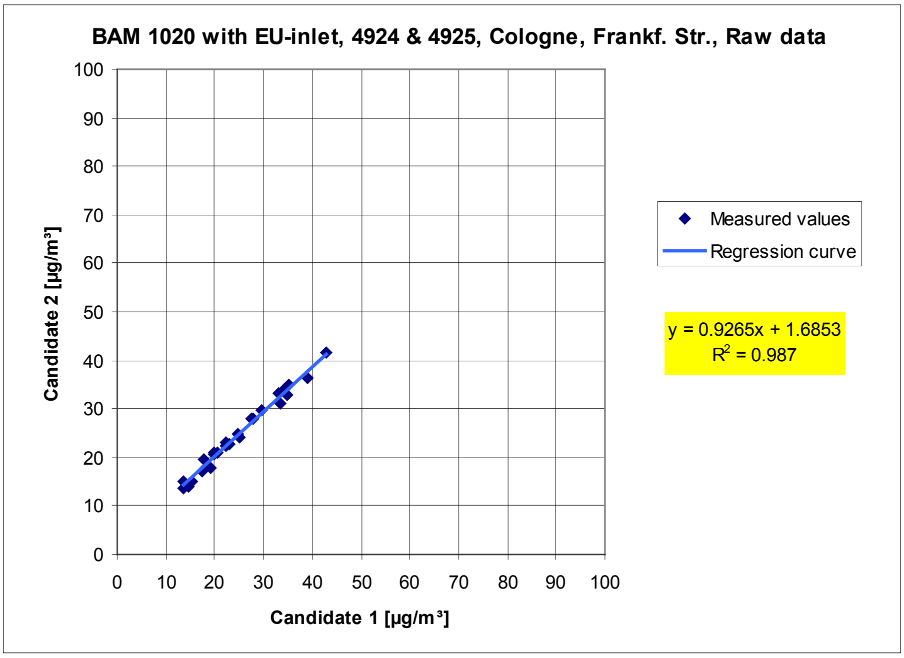

Figure 59: Result of the parallel measurements with the candidates SN 4924 / SN 4925, additional test site Cologne, Frankfurter Str. with EU-sampling inlet

7.1 Calculation of the expanded uncertainty of the instruments [9.5.2.2-9.5.6]

The equivalency of the candidate instruments to the reference method has to be demonstrated according to the points 9.5.2.2 to 9.5.4 of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods“. The highest resulting expanded uncertainty of the candidate method is to compare with the requirements on the data quality of ambient air measurements according to EU-guideline [7].

7.2 Equipment

For this test point, the instruments mentioned in point 5 of the report at hand have been additionally used.

7.3 Performance of test

The investigations according to the Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods" have been carried out exemplarily on the basis of the measured data according to [1], [2] and [3], obtained during the field test. Hereby the investigations have been performed deviant to the requirement of the Guidance only at three instead of four field test sites and with less than respectively 40 valid paired measurements per field test site.

The test work has been performed in the field test at four different test sites. During the test, different seasons, different PM10-concentrations as well as different ratios between TSP and PM10 have been taken into consideration.

For every test site, at least 15 valid data pairs have been determined. From the entire data set (3 test sites), in total 32 % of the measured values are above 50 % of the limit value for the daily mean of 50 µg/m³ for PM10. The measured concentrations have been referred to ambient conditions.

7.4 Evaluation

[Point 9.5.2.2] The check of the uncertainty between the reference instruments u_{ref} operated in parallel is prefixed to the calculation of the expanded uncertainty of the candidate systems. The uncertainty between the reference instruments u_{ref} operated in parallel is determined analogically to the between-instrument uncertainty of the candidate systems as shall be ≤ 2 µg/m³. The results of the evaluation are shown in point 7.6 of this test point.

To assess the comparability of the candidates y with the reference method x, a linear relation $y_i = a + bx_i$ between the measured results of both methods is assumed. The relation between the average results of the reference instruments and of the candidates is established by orthogonal regression [9].

The regression is calculated for:

- each test site separately
- all test sites together
- 1 data set with measured values ≥ 50 % of the limit value for the daily average of 50 µg/m³ for PM10 (basis: mean values of reference measurement)

For further evaluations, the uncertainty of the results u_{c_s} of the candidate system from the comparison with the reference method is described by the following equation, which describes u_{c_s} as a function of the PM concentration x_i.

$$u_{c\_s}^2(y_i) = \frac{RSS}{(n-2)} - u^2(x_i) + [a + (b-1)x_i]^2$$

with RSS = sum of (relative) residues resulting from orthogonal regression

$u(x_i)$ = random uncertainty of the reference method; as such, the value of u_{bs} calculated for the application of the reference method is these tests may be used (refer to point 7.1 Determination of the between-instrument uncertainty u_{bs})

Algorithms for the calculation of the ordinate intercept a as well as of the slope b and their variances by orthogonal regression are described in detail in annex B of [9].

The sum of the (relative) residues RSS is calculated using the following equation:

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

The uncertainty u_{c_s} is calculated for:

- each test site separately
- all test sites together
- 1 data set with measured values ≥ 50 % of the limit value for the daily average of 50 µg/m³ for PM10 (basis: mean values reference measurement)

[Point 9.5.3] For all datasets the combined relative uncertainty of the candidate systems $w_{c,CM}$ is calculated by combining the contributions found in 9.5.2.1 and 9.5.2.2 as follows:

$$w_{c,CM}^2(y_i) = \frac{u_{c\_s}^2(y_i)}{y_i^2}$$

For each of the data sets the uncertainty at the daily limit value $w_{c,CM}$ is calculated by taking as y_i the concentration at the limit value.

[Point 9.5.4] For each of the datasets the expanded relative uncertainty of the results of the candidate systems is calculated by multiplying $w_{c,CM}$ by a coverage factor k according to the following equation:

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

In practice, k=2 for large n.

[Point 9.6] The highest resulting uncertainty W_{CM} is compared and assessed with the requirements on data quality for ambient air quality measurements according to EU-Guideline [7]. Two cases are possible:

1. $W_{CM} \leq W_{dqo}$ → Candidate method is accepted as equivalent to the standard method.
2. $W_{CM} > W_{dqo}$ → Candidate method is not accepted as equivalent to the standard method.

The defined expanded relative uncertainty W_{dqo} is 25 % for PM [7].

7.5 Findings

The determined uncertainties W_{CM} are below the set expanded relative uncertainty W_{dqo} of 25 % for PM for all regarded datasets without the application of correction factors.

Minimum requirement fulfilled? yes

7.6 Presentation of test results

Table 33 gives an overview on the between-instrument uncertainties u_{ref} for the reference instruments form the field investigations. In Table 34 a recapitulating presentation of the results for the expanded measurement uncertainties W_{CM} from the field investigations is shown. Table 35 to Table 39 show the results of the evaluations for the single datasets.

Table 33: Uncertainty between the reference instruments u_{ref}

Reference instruments	Test site	No. of values	Uncertainty u_{bs}
No.			µg/m³
1 / 2	Cologne, parking lot	29	0.55
1 / 2	Titz-Roedingen	37	0.65
1 / 2	Cologne, Frankf. Str.	28	1.02
1 / 2	All test sites	94	0.76
1 / 2	additional Cologne, Frankf. Str., candidates with EU-inlet	26	1.49

The uncertainty between the reference instruments u_{ref} is < 2 µg/m³ for all test sites.

Table 34: Compilation and evaluation of the expanded measurement uncertainties W_{CM} from the field investigations, raw data

Test site	**Slope b** (µg/m³)/(µg/m³)	**Ordinate intercept a** µg/m³	**u_{c_s} at limit value** µg/m³	**w_{CM}** %	**W_{CM}** %	**$W_{CM} \leq W_{dqo}$** (W_{dqo} = 25 %)
Cologne, parking lot	0.97	2.46	2.49	4.98	9.95	yes
Titz-Roedingen	1.06	0.85	3.97	7.93	15.87	yes
Cologne, Frankf. Str.	1.02	-0.70	1.90	3.79	7.58	yes
All test sites	0.99	1.41	2.40	4.81	9.61	yes
Values ≥ 50 % limit value (≥ 25 µg/m³)	0.99	1.45	2.31	4.62	9.23	yes
additional Cologne, Frankf. Str., EU-inlet	1.01	-0.90	0.91	1.82	3.63	yes

Table 35: Comparison candidate with reference, test site Cologne, parking lot

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	Cologne, parking lot	Limit value	50	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**0.97**	**not significant**		
Uncertainty of b	**0.03**			
Ordinate intercept a	**2.46**	**significant**		
Uncertainty of a	**0.86**			
Results of the equivalence test				
Deviation at limit value	**0.87**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.49**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**4.98**	**%**		
Expanded measurement uncertainty W_{CM}	**9.95**	**%**		
Status equivalence test	**pass**			

Table 36: Comparison candidate with reference, test site Titz-Roedingen

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	Titz-Roedingen	Limit value	50	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**1.06**	**not significant**		
Uncertainty of b	**0.03**			
Ordinate intercept a	**0.85**	**not significant**		
Uncertainty of a	**0.75**			
Results of the equivalence test				
Deviation at limit value	**3.62**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**3.97**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**7.93**	**%**		
Expanded measurement uncertainty W_{CM}	**15.87**	**%**		
Status equivalence test	**pass**			

Table 37: Comparison candidate with reference, test site Cologne, Frankfurter Str.

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	Cologne, Frankf. Str.	Limit value	50	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**1.02**	**not significant**		
Uncertainty of b	**0.04**			
Ordinate intercept a	**-0.70**	**not significant**		
Uncertainty of a	**1.01**			
Results of the equivalence test				
Deviation at limit value	**0.40**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**1.90**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**3.79**	**%**		
Expanded measurement uncertainty W_{CM}	**7.58**	**%**		
Status equivalence test	**pass**			

Table 38: Comparison candidate with reference, all test sites

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	All test sites	Limit value	50	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**0.99**	**not significant**		
Uncertainty of b	**0.02**			
Ordinate intercept a	**1.41**	**significant**		
Uncertainty of a	**0.52**			
Results of the equivalence test				
Deviation at limit value	**1.13**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.40**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**4.81**	**%**		
Expanded measurement uncertainty W_{CM}	**9.61**	**%**		
Status equivalence test	**pass**			

Table 39: Comparison candidate with reference, all test sites, values ≥ 50 % limit value (≥ 25 µg/m³)

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	All test sites	Limit value	50	µg/m³
Status of measured values	Reference > 50%	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**0.99**	**not significant**		
Uncertainty of b	**0.05**			
Ordinate intercept a	**1.45**	**not significant**		
Uncertainty of a	**1.88**			
Results of the equivalence test				
Deviation at limit value	**0.97**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.31**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**4.62**	**%**		
Expanded measurement uncertainty W_{CM}	**9.23**	**%**		
Status equivalence test	**pass**			

Table 40: Comparison candidate with reference, additional test site Cologne, Frankfurter Str. with EU-sampling inlet

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020 with EU-inlet	SN	4924 & 4925	
Test site	Cologne, Frankf. Str.	Limit value	50	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**1.01**	**not significant**		
Uncertainty of b	**0.04**			
Ordinate intercept a	**-0.90**	**not significant**		
Uncertainty of a	**1.10**			
Results of the equivalence test				
Deviation at limit value	**-0.52**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**0.91**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**1.82**	**%**		
Expanded measurement uncertainty W_{CM}	**3.63**	**%**		
Status equivalence test	**pass**			

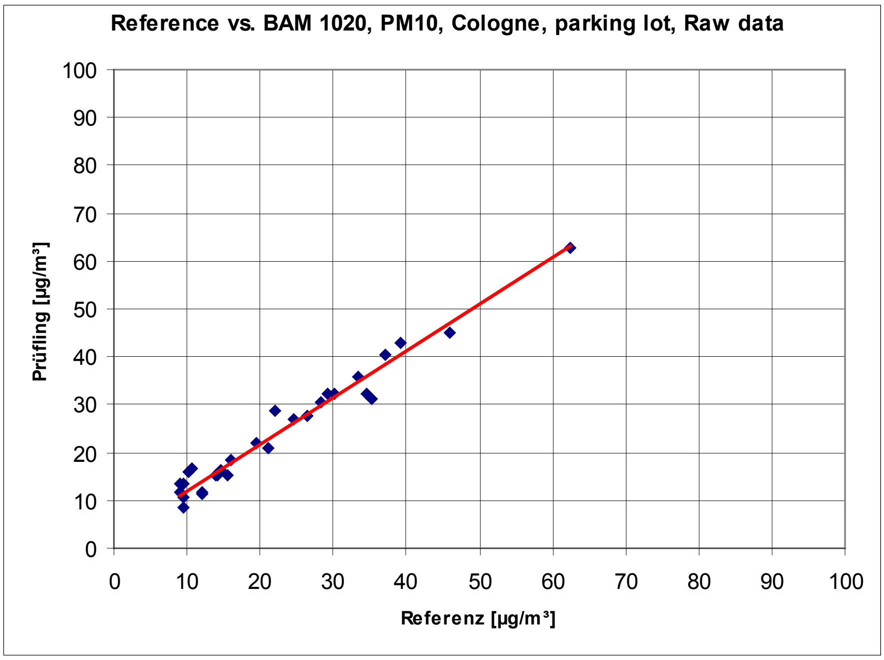

Figure 60: *Reference vs. candidate, test site Cologne, parking lot*

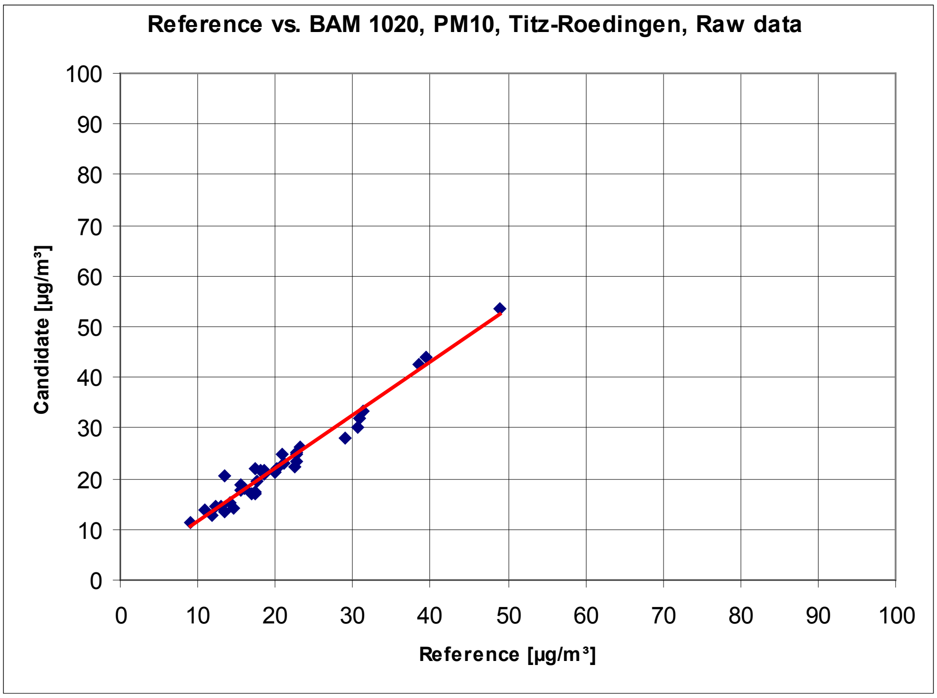

Figure 61: *Reference vs. candidate, test site Titz-Roedingen*

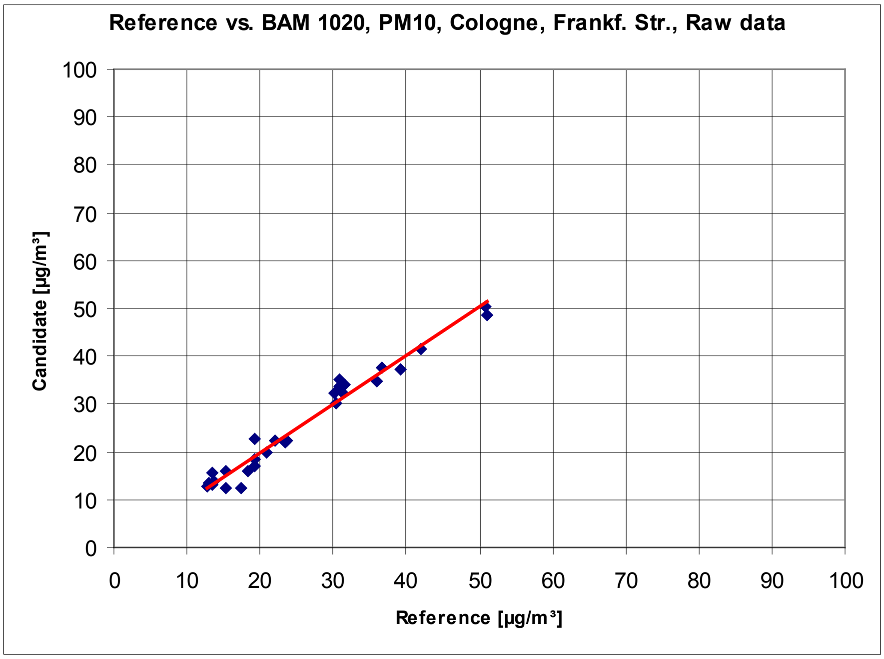

Figure 62: Reference vs. candidate, test site Cologne, Frankfurter Str.

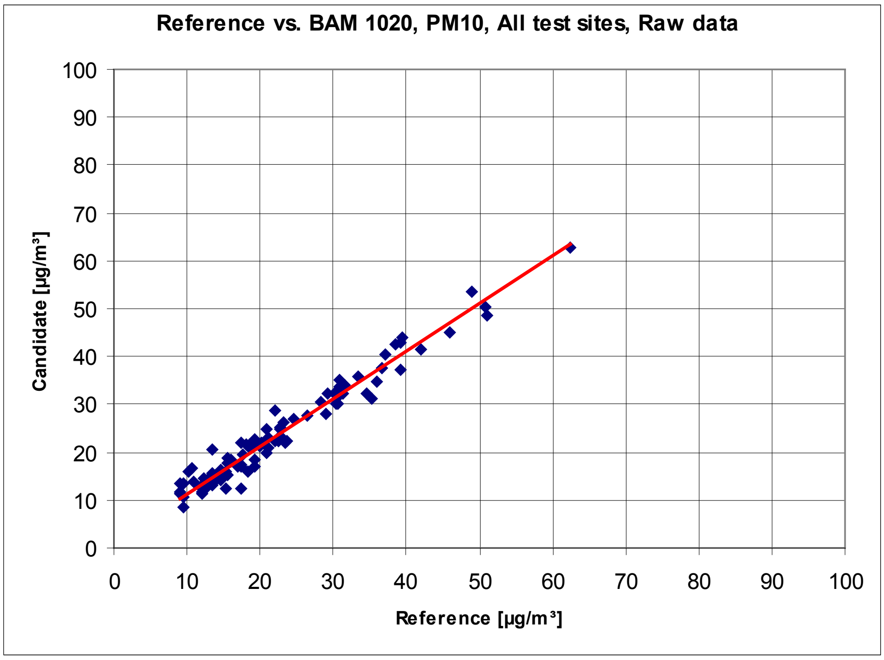

Figure 63: Reference vs. candidate, all test sites

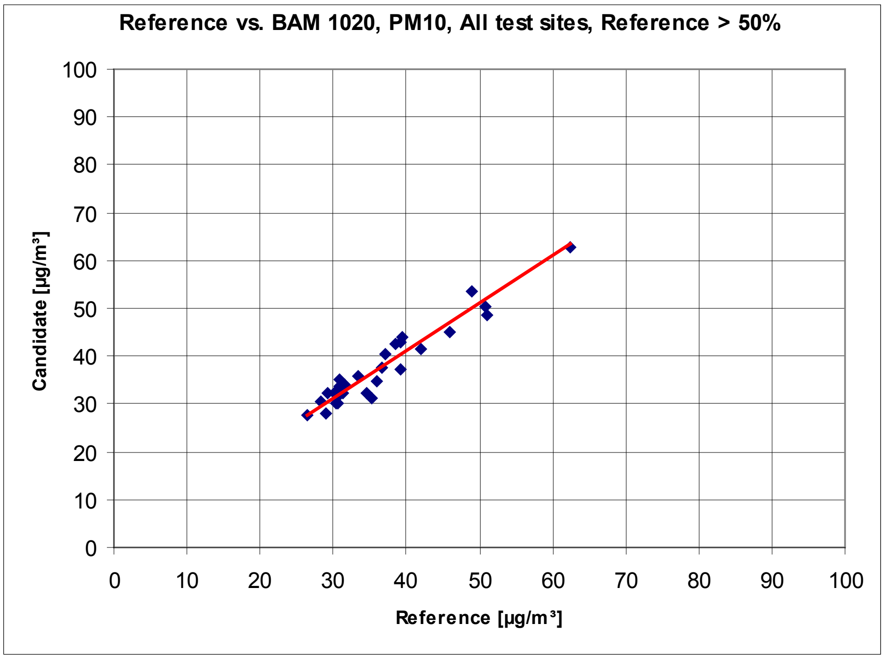

Figure 64: *Reference vs. candidate, all test sites, values ≥ 50 % limit value (≥ 25 µg/m³)*

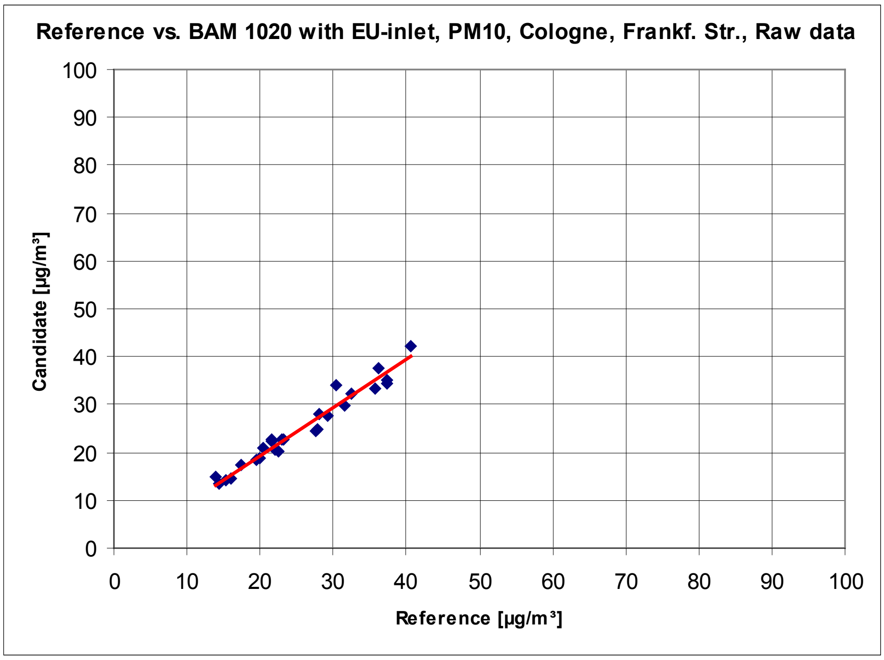

Figure 65: *Reference vs. candidate, additional test site Cologne, Frankfurter Str. with EU-sampling inlet*

7.1 Application of correction factors or terms [9.7]

If the highest resulting expanded uncertainty of the candidate method is larger than the expanded relative uncertainty, which is defined in the requirements on the data quality of ambient air measurements according to EU-Guideline [7], the application of correction factors or terms is permitted. The corrected values have to fulfill the requirements according to the points 9.5.2.2 et seqq. of the Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods".

7.2 Equipment

Not required for this minimum requirement.

7.3 Performance of test

Refer to module 9.5.2.2 – 9.5.6.

7.4 Evaluation

If the evaluation of the raw data according to module 9.5.2.2 – 9.5.6 leads to a case $W_{CM} > W_{dqo}$, which means that the candidate systems is not regarded equivalent to the reference method, it is permitted to apply a correction factor or –term, resulting from the regression equation obtained for the full dataset. The corrected values shall satisfy the requirements for all datasets or subsets (refer to module 9.5.2.2 – 9.5.6).
However, even when it is the case, that $W_{CM} \leq W_{dqo}$, a correction may be applied in order to improve the accuracy of the candidate systems.

Three distinct situations may arise:

a) Slope b not significantly different from 1: $|b-1| \leq 2u(b)$,
Intercept a significantly different from 0: $|a| > 2u(a)$

b) Slope b significantly different from 1: $|b-1| > 2u(b)$,
Intercept a not significantly different from 0: $|a| \leq 2u(a)$

c) Slope b significantly different from 1: $|b-1| > 2u(b)$
Intercept a significantly different from 0: $|a| > 2u(a)$

Re a)

The value of the 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 resulting values of $y_{i,corr}$ may then be used to calculate by linear regression the following new terms:

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

and

$$u^2_{c\_s}(y_{i,corr}) = \frac{RSS}{(n-2)} - u^2(x_i) + [c + (d-1)x_i]^2 + u^2(a)$$

with u(a) = uncertainty of the original intercept a, the value of which has been used to obtain $y_{i,corr}$.

Algorithms for the calculation of intercepts as well as slopes and their variances by orthogonal regression are described in detail in annex B of [9]. RSS is determined analogically to the calculation in module 9.5.2.2 – 9.5.6.

Re b)

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

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

The resulting values of $y_{i,corr}$ may then be used to calculate by linear regression the following new terms:

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

and

$$u^2_{c\_s}(y_{i,corr}) = \frac{RSS}{(n-2)} - u^2(x_i) + [c + (d-1)x_i]^2 + x_i^2 u^2(b)$$

with u(b) = uncertainty of the original slope b, the value of which has been used to obtain $y_{i,corr}$.

Algorithms for the calculation of intercepts as well as slopes and their variances by orthogonal regression are described in detail in annex B of [9]. RSS is determined analogically to the calculation in module 9.5.2.2 – 9.5.6.

Re c)

The values of the slope b and of the 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 resulting values of $y_{i,corr}$ may then be used to calculate by linear regression the following new terms:

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

and

$$u^2_{c\_s}(y_{i,corr}) = \frac{RSS}{(n-2)} - u^2(x_i) + [c + (d-1)x_i]^2 + x_i^2 u^2(b) + u^2(a)$$

with u(b) = uncertainty of the original slope b, the value of which has been used to obtain $y_{i,corr}$ and with u(a) = uncertainty of the original intercept a, the value of which has been used to obtain $y_{i,corr}$.

Algorithms for the calculation of intercepts as well as slopes and their variances by orthogonal regression are described in detail in annex B of [9]. RSS is determined analogically to the calculation in module 9.5.2.2 – 9.5.6.

The values for $u_{c\_s,corr}$ are used for the calculation of the combined relative uncertainty of the candidate systems after correction according to the following equation:

$$w^2_{c,CM,corr}(y_i) = \frac{u^2_{c\_s,corr}(y_i)}{y_i^2}$$

For the corrected dataset the uncertainty at the daily limit value $w_{c,CM,corr}$ is calculated by taking as y_i the concentration at the limit value.

The expanded relative uncertainty $W_{CM,corr}$ is calculated according to the following equation:

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

In practice, k=2 for large n.

The highest resulting uncertainty $W_{CM,corr}$ is compared and assessed with the requirements on data quality for ambient air quality measurements according to EU-Guideline [7]. Two cases are possible:

1. $W_{CM,corr} \leq W_{dqo}$ → Candidate method is accepted as equivalent to the standard method.
2. $W_{CM,corr} > W_{dqo}$ → Candidate method is not accepted as equivalent to the standard method.

The defined expanded relative uncertainty W_{dqo} is 25 % for PM [7].

7.5 Findings

The candidate systems fulfill the requirements on the data quality of ambient air quality measurements during the test without the application of correction factors. A correction of the complete data set can be additionally carried out to show possible potential for improvements in the accuracy of the candidate systems. It has been shown, that by the appliance of correction factors and –terms, the accuracy of the candidate systems for the complete dataset can be changed from 9.61 % (raw data) to 8.81 % (correction of intercept), 11.05°% (correction of slope) and 9.69 % (correction of intercept and slope) and thus there are no significant differences in the respective measurement uncertainties after applying of correction factors and terms.

Minimum requirement fulfilled? yes

7.6 Presentation of test results

Table 41 to Table 44 show the results of the evaluations for the complete dataset after applying the possible correction factors/ terms.

Table 41: Comparison candidate with reference, all test sites, raw data

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	All test sites	Limit value	50	µg/m³
Status of measured values	Raw data	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**0.99**	**not significant**		
Uncertainty of b	**0.02**			
Ordinate intercept a	**1.41**	**significant**		
Uncertainty of a	**0.52**			
Results of the equivalence test				
Deviation at limit value	**1.13**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.40**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**4.81**	**%**		
Expanded measurement uncertainty W_{CM}	**9.61**	**%**		
Status equivalence test	**pass**			

Table 42: Comparison candidate with reference, all test sites, correction of ordinate intercept

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	All test sites	Limit value	50	µg/m³
Status of measured values	Correction offset	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**0.99**	**not significant**		
Uncertainty of b	**0.02**			
Ordinate intercept a	**0.00**	**not significant**		
Uncertainty of a	**0.52**			
Results of the equivalence test				
Deviation at limit value	**-0.29**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.20**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**4.41**	**%**		
Expanded measurement uncertainty W_{CM}	**8.81**	**%**		
Status equivalence test	**pass**			

Table 43: Comparison candidate with reference, all test sites, correction of slope

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	All test sites	Limit value	50	µg/m³
Status of measured values	Correction slope	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**1.00**	**not significant**		
Uncertainty of b	**0.02**			
Ordinate intercept a	**1.42**	**significant**		
Uncertainty of a	**0.52**			
Results of the equivalence test				
Deviation at limit value	**1.43**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.76**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**5.53**	**%**		
Expanded measurement uncertainty W_{CM}	**11.05**	**%**		
Status equivalence test	**pass**			

Table 44: Comparison candidate with reference, all test sites, correction of ordinate intercept and slope

Comparison candidate with reference according to Guidance "Demonstration of Equivalence Of Ambient Air Monitoring Methods"				
Candidate	BAM 1020	SN	4924 & 4925	
Test site	All test sites	Limit value	50	µg/m³
Status of measured values	Correction offset & slope	Allowed uncertainty	25	%
Results of regression analysis				
Slope b	**1.00**	**not significant**		
Uncertainty of b	**0.02**			
Ordinate intercept a	**0.00**	**not significant**		
Uncertainty of a	**0.52**			
Results of the equivalence test				
Deviation at limit value	**0.00**	**µg/m³**		
Uncertainty u_{c_s} at limit value	**2.42**	**µg/m³**		
Combined measurement uncertainty w_{CM}	**4.84**	**%**		
Expanded measurement uncertainty W_{CM}	**9.69**	**%**		
Status equivalence test	**pass**			

8 Recommendations for the use in practice

Work in the maintenance interval

The following work is required for the tested measuring system in a regular interval:

- Regular visual inspection / telemetric monitoring
- - Device status o.k.
- - No error messages
- - No contaminations
- Check of the instrument functions according to the instructions of the manufacturer
- Check of filter tape stock
- Maintenance of the sampling head according manufacturer's specifications
- At least all 4 weeks: cleaning/lubricating of the impaction plates
- All 4 weeks: plausibility check of temperature, pressure sensors, if necessary re-calibration
- All 4 weeks: check of the flow rate

Furthermore it is to pay attention to the advices of the manufacturer.

The measuring systems carries out by default at each measurement cycle an internal check of the zero point (zero measurement, manually evaluable) as well as of the sensitivity (measurement with reference foil, automatically evaluated). The results of these checks can be used for the continuous check of the stability of the radiometric measurement.

Functional check and calibration

For the performance of the functional check respectively before the calibration, the following procedure is proposed:

- Visual inspection of the device and of the sampling system
- At least once a year: check of the carbon vanes of the pump, followed by check of the flow rate and if necessary re-calibration
- At least once a year: annual base maintenance, incl. check and replacement of the carbon vanes of the pump (only rotary vane), cleaning of sampling tube
- Check of data transmission (e.g. analogue- and status signals) to the evaluation system.

Further details to the functional check and to the calibration can be found in the manual.

Department of Environmental Protection

Karsten Pletscher	Dr. Peter Wilbring

Cologne, December 06, 2006
936/21205333/A

9 Literature

[1] Guideline VDI 4202, Sheet 1, „Minimum requirements for suitability tests of automated ambient air quality measuring systems – Point-related measurement methods of gaseous and particulate pollutants “, June 2002

[2] Guideline VDI 4203, Sheet 3, „Testing of automated measuring systems – Test procedures for point-related ambient air quality measuring systems of gaseous and particulate pollutants “, August 2004

[3] European Standard EN 12341, „Air quality – Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement methods“, German version DIN EN 12341: 1998

[4] Guideline VDI 2463, Sheet 7, „Particulate measurement – Measurement of mass concentration in ambient air. Filter method. Small filter device GS 050, 1982

[5] Manual for BAM-1020

[6] Manual for SEQ47/50, status 2004

[7] DIRECTIVE 1999/30/EC of the council of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

[8] Uniform Federal Practice for Ambient Air Quality Monitoring

Guidelines for the execution of construction work and the approval testing for measuring systems for continuous monitoring of ambient air quality. Circular of BMI of 08/19/1981 – U II 8 – 556 134/4

[9] Guidance „Demonstration of Equivalence of Ambient Air Monitoring Methods”, English version of November 2005

10 Appendix

Appendix 1 Measured and calculated values

Appendix 2 Manuals

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

Manufacturer	Met One Instruments				
Meas. Range	0 to 1000	µg/m³		Temperature climate chamber	20 °C
Type	BAM 1020			Rel. Humidity climate chamber	60%
Serial-No.	SN 4924 & SN 4925			Zero point	internal zero measurement on filter tape

No.	Date	24-h-Measured values [µg/m³] SN 4924	SN 4925
1	4/21/06	0.42	0.80
2	4/22/06	-0.10	1.61
3	4/23/06	1.11	1.68
4	4/24/06	0.42	1.35
5	4/25/06	0.16	0.07
6	4/26/06	-0.42	0.69
7	4/27/06	0.25	0.95
8	4/28/06	0.96	-0.05
9	4/29/06	1.28	1.19
10	4/30/06	1.44	0.06
11	5/1/06	0.88	1.01
12	5/2/06	0.37	1.03
13	5/3/06	0.90	0.78
14	5/4/06	0.76	1.05
15	5/5/06	-0.30	0.56
16	5/6/06	1.01	1.20
17	5/7/06	-0.09	0.96
18	5/8/06	0.64	0.76
	No. of values	18	18
	Mean	0.54	0.87
	Standard deviation s_{x0}	0.55	0.49
	Detection limit X	**1.69**	**1.90**

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

Annex 2 **Dependence of zero point / reference point on ambient temperature** **Page 1 of 1**

Manufacturer Met One Instruments

Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Standards: Zero point – internal zero meas. at filter tape; Reference point – built-in reference foil

			Cycle 1		Cycle 2		Cycle 3	
SN 4924	No.	Temperature [°C]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]
ZP	1	20	0.0	-	0.5	-	0.2	-
	2	5	1.5	1.4	-0.7	-1.2	-0.1	-0.3
	3	20	0.8	0.8	0.2	-0.3	1.4	1.1
	4	40	0.8	0.8	0.8	0.3	1.2	0.9
	5	20	0.8	0.8	0.1	-0.4	0.6	0.4
SN 4925	No.	Temperature [°C]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]
ZP	1	20	1.2	-	1.1	-	0.2	-
	2	5	0.8	-0.4	1.6	0.5	1.1	0.9
	3	20	0.7	-0.5	0.8	-0.3	1.2	1.0
	4	40	0.8	-0.4	0.6	-0.5	0.9	0.7
	5	20	0.4	-0.8	1.6	0.5	1.2	1.0
SN 4924	No.	Temperature [°C]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]
RP	1	20	823.6	-	824.9	-	826.9	-
	2	5	825.9	0.3	825.5	0.1	825.9	-0.1
	3	20	825.0	0.2	825.7	0.1	826.3	-0.1
	4	40	825.8	0.3	825.0	0.0	825.5	-0.2
	5	20	825.4	0.2	824.9	0.0	824.6	-0.3
SN 4925	No.	Temperature [°C]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]
RP	1	20	814.8	-	814.9	-	813.5	-
	2	5	817.5	0.3	815.7	0.1	815.8	0.3
	3	20	815.1	0.0	815.0	0.0	813.5	0.0
	4	40	813.7	-0.1	813.8	-0.1	813.6	0.0
	5	20	814.6	0.0	815.0	0.0	814.9	0.2

Annex 3 — Dependence of zero point / reference point on the mains voltage — Page 1 of 1

Manufacturer Met One Instruments
Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Standards: Zero point — internal zero meas. at filter tape; Reference point — built-in reference foil

			Cycle 1		Cycle 2		Cycle 3	
SN 4924	No.	Mains voltage [V]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]
ZP	1	230	-0.2	-	0.0	-	2.1	-
	2	190	0.2	0.5	-0.1	-0.1	2.6	0.5
	3	230	0.0	0.3	-0.6	-0.6	-2.4	-4.5
	4	245	1.3	1.6	-0.8	-0.9	-0.8	-2.9
	5	230	1.8	2.0	1.1	1.1	0.2	-1.9
SN 4925	No.	Mains voltage [V]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]	Meas. value MetOne [µg/m³]	Dev. [µg/m³]
ZP	1	230	0.8	-	0.7	-	1.4	-
	2	190	1.1	0.3	-0.1	-0.8	1.6	0.2
	3	230	0.5	-0.2	0.4	-0.3	0.9	-0.5
	4	245	0.4	-0.3	-0.2	-0.9	1.4	0.0
	5	230	3.3	2.6	0.2	-0.5	1.3	-0.1
SN 4924	No.	Mains voltage [V]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]
RP	1	230	822.0	-	823.7	-	823.4	-
	2	190	822.6	0.1	824.7	0.1	824.6	0.1
	3	230	824.2	0.3	823.6	0.0	825.5	0.3
	4	245	823.3	0.2	824.7	0.1	821.9	-0.2
	5	230	824.7	0.3	822.7	-0.1	823.9	0.1
SN 4925	No.	Mains voltage [V]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]	Meas. value foil [µg/cm²]	Dev. [%]
RP	1	230	812.4	-	812.2	-	810.8	-
	2	190	811.5	-0.1	811.9	0.0	812.8	0.2
	3	230	812.6	0.0	811.0	-0.1	809.5	-0.2
	4	245	811.1	-0.2	810.7	-0.2	811.0	0.0
	5	230	811.1	-0.2	812.4	0.0	811.1	0.0

Annex 4 **Measured values from the field test sites, related to standard conditions** **Page 1 of 10**

Manufacturer Met One Instruments
Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object SPM PM 10, ambient air
Test site Cologne, parking lot
Measured values in µg/m³ std. conditions

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	TSP [µg/m³]	PM10/TSP [%]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
1	2/11/06	35.2	35.6	48.5	73.0	29.7	32.8		Cologne, parking lot
2	2/12/06					25.7	26.0		
3	2/13/06	33.8	35.2	49.9	69.1	31.2	33.7		
4	2/14/06							Flow rate check	
5	2/15/06	13.1	12.3	48.9	26.0	11.4	13.3		
6	2/16/06	10.4	10.0			10.7	12.2		
7	2/17/06	10.1	9.7	32.1	30.8	8.3	8.7		
8	2/18/06					14.6	13.8		
9	2/19/06					10.8	12.0		
10	2/20/06	9.6	10.2	20.0	49.5	12.7	15.1		
11	2/21/06	14.2	14.0	30.5	46.2	14.4	16.5		
12	2/22/06	16.0	16.2	28.3	56.9	17.7	18.9		
13	2/23/06					20.5	20.3		
14	2/24/06					29.7	31.4		
15	2/25/06	28.1	29.1	39.2	73.0	29.2	31.8		
16	2/26/06					30.8	31.9		
17	2/27/06					32.4	34.4		
18	2/28/06					12.0	14.3		
19	3/1/06	15.8	15.9	19.2	82.6	15.8	15.1		
20	3/2/06	19.9	20.5	31.2	64.7	22.5	22.2		
21	3/3/06	47.1	47.0	63.1	74.6	44.8	47.3		
22	3/4/06					46.9	48.7		
23	3/5/06					21.4	23.5		
24	3/6/06	21.4	21.3			19.9	22.3		
25	3/7/06	26.5	27.1	29.3	91.5	27.1	29.0		
26	3/8/06	15.2	14.2	42.6	34.5	14.8	16.8		
27	3/9/06	15.6	15.3	22.0	70.2	17.5	17.0		
28	3/10/06	12.6	12.4	17.9	69.8	11.5	12.0		
29	3/11/06					25.6	27.5		
30	3/12/06					29.0	30.8		

Annex 4 **Measured values from the field test sites, related to standard conditions** **Page 2 of 10**

Manufacturer Met One Instruments

Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object SPM PM 10, ambient air
Test site Cologne, parking lot / Titz-Roedingen
Measured values in µg/m³ std. conditions

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	TSP [µg/m³]	PM10/TSP [%]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
31	3/13/06	24.4	24.2	36.2	67.1	25.2	27.6		Cologne, parking lot
32	3/14/06	30.3	30.3	92.7	32.7	31.4	33.2		
33	3/15/06	33.7	34.1	49.0	69.2	35.5	37.0		
34	3/16/06	39.6	39.3	44.5	88.7	42.2	43.6		
35	3/17/06					39.6	41.0		
36	3/18/06	37.2	37.5			40.7	40.8		
37	3/19/06					59.8	63.0		
38	3/20/06	64.0	64.0			62.0	66.0		
39	3/21/06					32.5	33.6		
40	3/22/06	29.9	30.0			31.4	34.0		
41	3/23/06	22.0	23.5			29.6	29.6		
42	3/24/06					35.2	37.8		
43	3/25/06	8.7	10.4			12.2	12.9		
44	3/26/06					11.8	12.3		
45	3/27/06					14.2	15.5		
46	3/28/06	9.4	9.8			14.0	14.5		
47	3/29/06	10.8	11.9			16.8	18.0		
48	3/30/06					10.4	11.3		
49	3/31/06	10.2	11.5	15.3	70.9	16.1	17.2		
50	4/1/06					12.0	13.1		
51	4/2/06					10.4	11.0		
52	4/3/06					20.8	23.4		
53	4/4/06					25.2	27.2		
54	7/26/06	54.3	53.8	85.6	63.1	58.5	60.1		Titz-Roedingen
55	7/27/06	42.7	43.6	67.9	63.5	47.6	48.7		
56	7/28/06							Power loss	
57	7/29/06							Power loss	
58	7/30/06	19.3	20.9	26.1	77.0	21.9	23.6		
59	7/31/06	19.0	20.3	25.1	78.4	23.1	23.6		
60	8/1/06	17.2	17.3	22.8	75.6	18.1	21.2		

Annex 4 **Measured values from the field test sites, related to standard conditions** **Page 3 of 10**

Manufacturer Met One Instruments

Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object SPM PM 10, ambient air
Test site Titz-Roedingen
Measured values in µg/m³ std. conditions

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	TSP [µg/m³]	PM10/TSP [%]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
61	8/2/06	18.7	19.2	22.2	85.3	20.1	21.7		Titz-Roedingen
62	8/3/06	17.7	18.9			17.3	19.0		
63	8/4/06	24.2	24.9	27.1	90.5	26.7	26.9		
64	8/5/06	21.7	23.1			26.1	27.1		
65	8/6/06	20.0	20.1	23.0	87.2	22.5	24.0		
66	8/7/06	23.6	24.7	28.0	86.3	23.2	25.0		
67	8/8/06	15.5	15.7	17.9	87.2	14.6	15.7		
68	8/9/06	31.7	29.8	36.0	85.4	29.5	30.3		
69	8/10/06	23.9	24.4	26.0	92.8	24.5	25.2		
70	8/11/06	19.1	17.6			17.9	18.5		
71	8/12/06	21.8	20.9			21.9	23.3		
72	8/13/06	14.8	13.9	16.9	85.1	14.4	14.1		
73	8/14/06	14.9	13.9	24.4	59.0	21.9	22.5		
74	8/15/06	32.9	32.6	34.1	96.2	32.1	32.7		
75	8/16/06	23.8	25.7	30.9	80.0	26.7	27.3		
76	8/17/06	18.4	19.5	23.1	82.0	18.5	19.3		
77	8/18/06	13.1	12.5	16.6	77.2	14.2	13.8		
78	8/19/06	12.4	14.2			14.9	16.6		
79	8/20/06	10.9	12.4			14.3	15.3		
80	8/21/06	16.3	16.6	18.9	87.1	19.7	20.0		
81	8/22/06	20.7	21.7	23.3	91.0	22.3	23.0		
82	8/23/06	41.0	41.9	55.4	74.8	45.7	45.9		
83	8/24/06	16.1	17.3	21.9	76.3	18.4	19.7		
84	8/25/06	34.2	33.3	56.8	59.5	35.0	36.6		
85	8/26/06	33.3	32.8			34.6	33.7		
86	8/27/06	22.8	22.5	26.7	84.7	24.4	25.1		
87	8/28/06	13.6	14.0	16.4	84.3	15.3	15.6		
88	8/29/06	14.5	15.4			16.7	15.4		
89	8/30/06							Electric meter installed	
90	8/31/06	17.7	19.4			23.7	23.4		

Annex 4 **Measured values from the field test sites, related to standard conditions** **Page 4 of 10**

Manufacturer Met One Instruments
Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object SPM PM 10, ambient air
Test site Titz-Roedingen / Cologne, Frankf. Str.
Measured values in µg/m³ std. conditions

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	TSP [µg/m³]	PM10/TSP [%]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
91	9/1/06	25.1	25.0	43.9	57.1	28.2	28.2		Titz-Roedingen
92	9/2/06	22.1	21.7			22.2	25.5		
93	9/3/06	10.1	9.7	23.5	42.1	11.1	13.7		
94	9/29/06	35.4	32.8	42.4	80.4	36.0	37.3		Cologne, Frankf. Str.
95	9/30/06	20.2	21.2			17.7	19.1		
96	10/1/06	16.3	16.6	17.2	95.8	12.4	14.0		
97	10/2/06	19.2	18.3	21.0	89.2	12.9	14.1		
98	10/3/06	20.0	19.3			16.4	18.0		
99	10/4/06	24.7	25.0	29.1	85.3	22.6	24.5		
100	10/5/06	14.9	13.4	17.4	81.1	16.0	16.6		
101	10/6/06	15.0	13.7	17.4	82.6	14.0	13.8		
102	10/7/06	21.5	22.3			20.1	21.0		
103	10/8/06	24.7	24.0			22.8	23.0		
104	10/9/06	32.0	32.2	39.6	81.0	32.4	31.3		
105	10/10/06	38.1	37.9			36.7	36.9		
106	10/11/06	42.2	41.6			38.8	40.3		
107	10/12/06	54.0	53.4			52.4	54.4		
108	10/13/06	43.8	43.9			42.1	44.4		
109	10/14/06	53.7	51.6	52.9	99.5	49.3	50.8		
110	10/15/06	38.9	37.0			38.8	38.9		
111	10/16/06	32.2	30.4	38.1	82.1	33.2	34.1		
112	10/17/06	33.3	31.7	40.1	81.0	35.4	35.6		
113	10/18/06	33.9	32.2	51.2	64.5	37.5	38.2		
114	10/19/06	24.3	23.2	31.6	75.3	23.4	24.9		
115	10/20/06	15.3	14.1	18.8	78.1	14.3	15.7		
116	10/21/06	14.6	12.7	18.5	73.7	12.8	14.8		
117	10/22/06	14.3	13.9			12.5	16.4		
118	10/23/06	16.7	16.8	18.6	89.9	16.7	18.1		
119	10/24/06	20.6	20.5	26.4	77.9	19.1	19.7		
120	10/25/06	21.0	19.9	30.9	66.1	23.9	23.9		

Annex 4 **Measured values from the field test sites, related to standard conditions** **Page 5 of 10**

Manufacturer Met One Instruments
Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object SPM PM 10, ambient air
Test site Cologne, Frankf. Str.
Measured values in µg/m³ std. conditions

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	TSP [µg/m³]	PM10/TSP [%]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
121	10/26/06	31.0	31.4	41.5	75.2	33.5	36.4		Cologne, Frankf. Str.
122	10/27/06	29.8	28.6	41.5	70.3	27.6	29.4	Change to EU-inlet	Cologne, Frankf. Str.
123	10/28/06	23.6	22.4	26.9	85.5	24.0	23.9		
124	10/29/06	23.9	22.4			23.5	23.8		
125	10/30/06	36.3	35.3	50.8	70.4	34.7	34.8		
126	10/31/06	22.1	22.2	33.1	66.9	20.9	22.2		
127	11/1/06	22.3	21.0	34.6	62.6	22.5	23.3		
128	11/2/06	28.7	27.3	32.8	85.4	28.2	28.1		
129	11/3/06	37.4	37.2	43.9	85.0	35.6	35.6		
130	11/4/06	32.3	32.7			34.0	31.7		
131	11/5/06	29.9	31.0	43.2	70.5	35.7	34.0		
132	11/6/06	39.9	41.6	56.4	72.2	43.8	42.7		
133	11/7/06	35.6	36.9			40.0	37.3		
134	11/8/06	31.3	32.0	38.6	82.0	30.7	30.9		
135	11/9/06	27.5	27.8	35.6	77.7	25.3	24.5		
136	11/10/06	38.0	36.6	50.4	74.1	35.1	34.6		
137	11/11/06	17.9	16.7	20.6	84.0	18.2	17.7		
138	11/12/06	19.3	19.8	22.1	88.6	19.6	18.6		
139	11/13/06	14.3	14.7	16.8	86.1	14.3	14.3		
140	11/14/06	16.3	15.6	19.6	81.4	14.4	16.0		
141	11/15/06	28.1	27.8	39.3	71.0	26.1	26.3		
142	11/16/06	21.9	23.3			21.2	22.2		
143	11/17/06	15.2	15.4	22.9	66.7	15.2	14.7		
144	11/18/06	21.7	21.6	30.9	70.1	22.9	23.0		
145	11/19/06	19.9	21.1	22.0	93.2	21.1	21.3		
146	11/20/06	13.7	13.9	19.7	70.2	15.8	15.4		
147	11/21/06	19.5	20.5	24.9	80.3	18.5	20.5		

Annex 4 **Measured values from the field test sites, related to ambient conditions** **Page 6 of 10**

Manufacturer	Met One Instruments						
				Measured object	SPM PM 10, ambient air		
Meas. Range	0 to 1000 µg/m³			Test site	Cologne, parking lot		
Type	BAM 1020				Measured values in µg/m³ amb. conditions for evaluation according to Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods"		
Serial-No.	SN 4924 & SN 4925						

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
1	2/11/06	35.2	35.5	29.8	32.9		Cologne, parking lot
2	2/12/06			25.7	26.0		
3	2/13/06	33.4	35.7	30.9	33.3		
4	2/14/06					Flow rate check	
5	2/15/06	12.5	11.7	10.9	12.7		
6	2/16/06	9.8	9.4	10.1	11.5		
7	2/17/06	9.6	9.2	8.2	8.7		
8	2/18/06			14.0	13.3		
9	2/19/06			10.4	11.5		
10	2/20/06	9.2	10.0	12.4	14.7		
11	2/21/06	14.0	13.8	14.1	16.1		
12	2/22/06	16.0	16.1	17.7	18.9		
13	2/23/06			20.5	20.3		
14	2/24/06			29.5	31.1		
15	2/25/06	27.9	28.8	29.1	31.6		
16	2/26/06			31.1	32.2		
17	2/27/06			32.1	34.1		
18	2/28/06			11.8	14.0		
19	3/1/06	15.5	15.7	15.6	14.9		
20	3/2/06	19.1	20.0	22.1	21.8		
21	3/3/06	45.8	45.9	43.9	46.3		
22	3/4/06			46.1	47.8		
23	3/5/06			21.0	23.1		
24	3/6/06	21.1	21.0	19.8	22.0		
25	3/7/06	26.2	26.6	26.8	28.7		
26	3/8/06	14.6	13.6	14.3	16.3		
27	3/9/06	14.8	14.6	16.8	16.2		
28	3/10/06	12.1	12.0	11.1	11.6		
29	3/11/06			25.8	27.5		
30	3/12/06			29.9	31.7		

Annex 4 **Measured values from the field test sites, related to ambient conditions** **Page 7 of 10**

Manufacturer Met One Instruments

Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object: SPM PM 10, ambient air
Test site: Cologne, parking lot / Titz-Roedingen
Measured values in µg/m³ amb. conditions for evaluation according to Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods"

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
31	3/13/06	24.7	24.5	25.7	28.0		Cologne, parking lot
32	3/14/06	30.2	30.1	31.4	33.2		
33	3/15/06	33.3	33.6	35.2	36.7		
34	3/16/06	39.2	39.1	42.1	43.5		
35	3/17/06			39.5	40.8		
36	3/18/06	37.0	37.2	40.3	40.4		
37	3/19/06			58.8	61.9		
38	3/20/06	62.5	62.5	60.9	64.8		
39	3/21/06			31.8	32.9		
40	3/22/06	29.3	29.4	31.1	33.6		
41	3/23/06	21.3	22.7	28.8	28.7		
42	3/24/06			33.6	36.1		
43	3/25/06	8.1	9.8	11.5	12.2		
44	3/26/06			11.1	11.5		
45	3/27/06			13.4	14.7		
46	3/28/06	8.9	9.3	13.4	13.8		
47	3/29/06	10.3	11.2	16.1	17.3		
48	3/30/06			9.8	10.6		
49	3/31/06	9.6	10.9	15.3	16.3		
50	4/1/06			11.5	12.5		
51	4/2/06			10.0	10.5		
52	4/3/06			20.3	22.8		
53	4/4/06			24.7	26.7		
54	7/26/06	49.1	48.6	52.8	54.2		Titz-Roedingen
55	7/27/06	39.0	39.7	43.4	44.4		
56	7/28/06					Power loss	
57	7/29/06					Power loss	
58	7/30/06	17.8	19.2	20.0	21.6		
59	7/31/06	17.6	18.7	21.3	21.8		
60	8/1/06	15.9	16.0	16.8	19.6		

Annex 4 **Measured values from the field test sites, related to ambient conditions** **Page 8 of 10**

Manufacturer	Met One Instruments		
		Measured object	SPM PM 10, ambient air
Meas. Range	0 to 1000 µg/m³	Test site	Titz-Roedingen
Type	BAM 1020		Measured values in µg/m³ amb. conditions for evaluation according to Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods"
Serial-No.	SN 4924 & SN 4925		

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
61	8/2/06	17.4	17.8	18.7	20.2		Titz-Roedingen
62	8/3/06	16.5	17.6	16.2	17.8		
63	8/4/06	22.5	23.0	24.8	25.0		
64	8/5/06	20.1	21.4	24.3	25.2		
65	8/6/06	18.7	18.7	21.0	22.4		
66	8/7/06	22.0	22.9	21.6	23.3		
67	8/8/06	14.6	14.8	13.7	14.8		
68	8/9/06	29.8	28.0	27.7	28.5		
69	8/10/06	22.6	22.9	23.0	23.7		
70	8/11/06	18.0	16.6	16.9	17.5		
71	8/12/06	20.4	19.5	20.5	21.8		
72	8/13/06	13.8	12.9	13.5	13.2		
73	8/14/06	13.8	12.9	20.4	20.9		
74	8/15/06	30.7	30.3	29.9	30.5		
75	8/16/06	22.0	23.6	24.8	25.3		
76	8/17/06	16.9	17.8	16.9	17.7		
77	8/18/06	12.1	11.6	13.1	12.7		
78	8/19/06	11.5	13.2	13.8	15.4		
79	8/20/06	10.3	11.6	13.5	14.4		
80	8/21/06	15.4	15.5	18.5	18.8		
81	8/22/06	19.5	20.4	21.0	21.7		
82	8/23/06	38.2	38.9	42.6	42.8		
83	8/24/06	15.0	16.1	17.1	18.4		
84	8/25/06	31.9	31.0	32.5	34.0		
85	8/26/06	31.1	30.6	32.3	31.5		
86	8/27/06	21.3	21.0	22.8	23.5		
87	8/28/06	12.8	13.2	14.4	14.6		
88	8/29/06	13.7	14.5	15.7	14.5		
89	8/30/06					Electric meter installed	
90	8/31/06	16.7	18.2	22.3	22.0		

Annex 4 **Measured values from the field test sites, related to ambient conditions** **Page 9 of 10**

Manufacturer	Met One Instruments		
		Measured object	SPM PM 10, ambient air
Meas. Range	0 to 1000 µg/m³	Test site	Titz-Roedingen / Cologne, Frankf. Str.
Type	BAM 1020		Measured values in µg/m³ amb. conditions
Serial-No.	SN 4924 & SN 4925		for evaluation according to Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods"

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
91	9/1/06	23.3	23.1	26.1	26.1		Titz-Roedingen
92	9/2/06	20.4	20.0	20.5	23.5		
93	9/3/06	9.3	8.9	10.3	12.6		
94	9/29/06	32.9	30.4	33.5	34.6		Cologne, Frankf. Str.
95	9/30/06	18.8	19.7	16.5	17.8		
96	10/1/06	15.2	15.4	11.5	13.0		
97	10/2/06	17.9	17.0	12.0	13.1		
98	10/3/06	18.8	18.1	15.4	16.9		
99	10/4/06	23.5	23.7	21.5	23.3		
100	10/5/06	14.1	12.6	15.2	15.7		
101	10/6/06	14.1	12.8	13.1	13.0		
102	10/7/06	20.6	21.3	19.3	20.1		
103	10/8/06	23.7	23.0	21.8	22.0		
104	10/9/06	30.4	30.4	30.8	29.7		
105	10/10/06	36.2	35.9	34.8	35.0		
106	10/11/06	39.7	38.9	36.5	37.9		
107	10/12/06	51.1	50.4	49.5	51.3		
108	10/13/06	42.0	42.0	40.3	42.5		
109	10/14/06	52.1	50.0	47.8	49.3		
110	10/15/06	37.7	35.7	37.5	37.6		
111	10/16/06	31.0	29.2	32.0	32.8		
112	10/17/06	31.8	30.1	33.8	33.9		
113	10/18/06	31.8	30.1	34.8	35.4		
114	10/19/06	22.7	21.6	21.8	23.2		
115	10/20/06	14.2	13.1	13.3	14.5		
116	10/21/06	13.6	11.8	12.0	13.8		
117	10/22/06	13.2	12.9	11.6	15.2		
118	10/23/06	15.4	15.4	15.4	16.7		
119	10/24/06	19.4	19.2	18.1	18.6		
120	10/25/06	19.8	18.7	22.5	22.5		

Annex 4 **Measured values from the field test sites, related to ambient conditions** **Page 10 of 10**

Manufacturer Met One Instruments

Meas. Range 0 to 1000 µg/m³
Type BAM 1020
Serial-No. SN 4924 & SN 4925

Measured object: SPM PM 10, ambient air
Test site: Cologne, Frankf. Str.
Measured values in µg/m³ amb. conditions for evaluation according to Guidance "Demonstration of Equivalence of Ambient Air Monitoring Methods"

No.	Date	Reference 1 [µg/m³]	Reference 2 [µg/m³]	SN 4924 [µg/m³]	SN 4925 [µg/m³]	Remark	Test site
121	10/26/06	33.4	29.0	31.1	33.7		Cologne, Frankf. Str.
122	10/27/06	31.1	27.2	27.5	28.1	Change to EU-inlet	Cologne, Frankf. Str.
123	10/28/06	24.8	21.2	22.8	22.7		
124	10/29/06	25.0	21.4	22.5	22.8		
125	10/30/06	37.8	33.7	33.3	33.3		
126	10/31/06	23.2	21.0	19.8	21.0		
127	11/1/06	22.6	20.7	22.2	23.0		
128	11/2/06	28.9	27.0	28.0	27.8		
129	11/3/06	37.8	36.6	35.1	35.1		
130	11/4/06	33.0	31.9	33.3	31.0		
131	11/5/06	30.7	30.1	34.8	33.0		
132	11/6/06	40.9	40.4	42.7	41.6		
133	11/7/06	36.4	35.9	39.0	36.3		
134	11/8/06	32.5	30.8	29.6	29.8		
135	11/9/06	27.9	27.3	25.0	24.2		
136	11/10/06	38.5	36.0	34.6	34.2		
137	11/11/06	18.5	16.1	17.5	17.1		
138	11/12/06	19.9	19.2	19.0	18.0		
139	11/13/06	15.0	13.9	13.6	13.6		
140	11/14/06	17.1	14.8	13.6	15.2		
141	11/15/06	29.6	26.2	24.7	24.9		
142	11/16/06	23.4	21.7	19.8	20.7		
143	11/17/06	15.9	14.6	14.5	14.0		
144	11/18/06	22.3	21.0	22.3	22.4		
145	11/19/06	20.3	20.6	20.7	20.8		
146	11/20/06	14.3	13.4	15.2	14.9		
147	11/21/06	20.4	19.5	17.7	19.6		

Annex 5 **Ambient conditions at the field test sites** **Page 1 of 5**

No.	Date	Test site	Ambient temperature [°C]	Ambient pressure [kPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
1	2/11/06	Cologne,	1.9	102.0	82.9	0.0	187.4	0.7
2	2/12/06	Parking lot	2.5	101.6	65.3	0.7	193	0.0
3	2/13/06		4.1	101.2	61.0	1.0	186	0.0
4	2/14/06		5.4	100.6	79.7	1.4	179	1.5
5	2/15/06		7.1	98.7	84.8	1.4	198	13.3
6	2/16/06		7.2	98.2	75.8	0.9	211	2.2
7	2/17/06		6.6	98.5	66.7	1.1	205	1.1
8	2/18/06		5.4	98.9	80.2	0.2	199	8.5
9	2/19/06		6.9	99.3	69.2	0.8	159	2.2
10	2/20/06		3.2	100.0	82.6	1.0	112	6.7
11	2/21/06		4.0	100.9	72.2	1.0	112	1.5
12	2/22/06		1.8	101.6	60.9	1.4	111	0.0
13	2/23/06		0.5	101.2	50.9	1.1	116	0.0
14	2/24/06		2.6	100.9	49.7	1.9	112	0.0
15	2/25/06		1.0	100.8	50.8	1.3	112	0.0
16	2/26/06		-1.9	101.1	72.8	0.5	105	0.0
17	2/27/06		1.2	100.3	89.1	0.2	185	3.7
18	2/28/06		1.2	99.2	88.9	1.7	234	4.8
19	3/1/06		-0.7	99.4	71.4	1.2	194	1.9
20	3/2/06		0.7	99.4	60.2	0.3	158	0.4
21	3/3/06		0.3	98.9	80.6	0.5	196	1.1
22	3/4/06		0.2	99.2	69.4	0.0	198	0.4
23	3/5/06		2.6	100.0	65.8	1.6	217	1.1
24	3/6/06		2.4	100.8	69.6	2.4	243	1.5
25	3/7/06		2.8	100.8	54.0	0.5	171	0.0
26	3/8/06		4.9	99.1	86.9	0.9	158	15.2
27	3/9/06		7.9	99.1	81.5	1.1	194	3.7
28	3/10/06		4.9	99.3	77.4	0.5	206	13.3
29	3/11/06		-1.2	100.9	68.7	2.3	199	1.1
30	3/12/06		-3.2	102.4	51.9	0.7	126	0.0

Annex 5 **Ambient conditions at the field test sites** **Page 2 of 5**

No.	Date	Test site	Ambient temperature [°C]	Ambient pressure [kPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
31	3/13/06	Cologne,	-0.1	102.2	42.0	0.5	152	0.0
32	3/14/06	Parking lot	2.2	101.6	39.6	0.8	146	0.0
33	3/15/06		4.4	101.4	42.9	0.9	135	0.0
34	3/16/06		2.6	101.6	46.4	1.0	131	0.0
35	3/17/06		2.8	101.5	52.3	1.9	108	0.0
36	3/18/06		3.8	101.0	57.7	1.2	128	0.0
37	3/19/06		4.5	100.4	55.5	0.7	168	0.0
38	3/20/06		3.9	100.2	62.4	0.5	124	0.0
39	3/21/06		3.6	100.1	43.3	1.0	114	0.0
40	3/22/06		3.3	100.3	42.2	2.0	62	0.0
41	3/23/06		6.6	100.1	33.7	1.8	150	0.0
42	3/24/06		8.7	99.2	72.3	0.3	162	3.3
43	3/25/06		13.4	99.9	66.4	1.7	208	4.4
44	3/26/06		15.6	100.0	66.7	0.5	162	1.1
45	3/27/06		13.4	99.6	60.2	1.4	186	4.8
46	3/28/06		9.8	99.6	58.2	0.7	188	1.9
47	3/29/06		9.1	100.1	70.2	0.9	184	8.5
48	3/30/06		12.8	99.5	68.7	1.3	205	8.9
49	3/31/06		12.2	100.2	61.9	2.6	218	5.6
50	4/1/06		10.7	100.2	65.2	0.8	179	7.8
51	4/2/06		11.5	100.2	46.8	3.0	230	3.7
52	4/3/06		8.3	100.9	59.9	1.2	220	2.6
53	4/4/06		5.5	100.7	54.0	1.4	179	0.0
54	7/26/06	Titz-Roedingen	26.5	100.3	55.8	0.0	197	0.0
55	7/27/06		24.1	100.3	64.7	0.0	256	3.0
56	7/28/06		20.6	99.9	80.1	0.0	237	26.6
57	7/29/06		21.7	99.9	70.5	0.0	267	0.0
58	7/30/06		21.0	100.1	70.5	0.0	207	8.0
59	7/31/06		20.1	100.1	63.0	0.0	223	0.0
60	8/1/06		17.5	99.5	71.6	1.0	229	9.8

Annex 5 **Ambient conditions at the field test sites** **Page 3 of 5**

No.	Date	Test site	Ambient temperature [°C]	Ambient pressure [kPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
61	8/2/06	Titz-Roedingen	15.7	99.4	72.8	0.8	224	2.1
62	8/3/06		15.1	99.6	79.8	0.0	280	5.3
63	8/4/06		17.9	100.0	77.2	0.2	176	35.7
64	8/5/06		19.3	100.6	73.3	0.1	254	0.0
65	8/6/06		18.7	100.7	71.0	0.1	277	0.0
66	8/7/06		18.8	100.6	75.0	0.3	241	2.7
67	8/8/06		15.9	100.6	71.7	0.2	236	0.0
68	8/9/06		15.0	100.2	78.3	0.0	234	3.9
69	8/10/06		13.7	100.1	78.1	0.0	246	9.2
70	8/11/06		12.7	99.8	81.0	0.1	231	10.4
71	8/12/06		14.1	99.5	74.4	0.1	163	4.1
72	8/13/06		15.0	99.4	71.8	0.6	169	0.3
73	8/14/06		15.2	99.4	80.4	0.4	246	11.2
74	8/15/06		16.0	99.7	79.4	0.2	164	3.8
75	8/16/06		17.4	99.3	75.3	0.2	120	1.5
76	8/17/06		18.9	99.2	73.9	0.2	122	4.5
77	8/18/06		18.8	99.8	68.8	1.6	203	1.5
78	8/19/06		18.3	100.2	72.4	0.1	175	3.0
79	8/20/06		16.5	100.5	75.0	1.7	233	12.1
80	8/21/06		15.7	100.4	80.3	0.3	200	18.3
81	8/22/06		14.8	100.6	79.5	0.0	221	0.0
82	8/23/06		17.5	100.1	72.0	0.1	183	0.0
83	8/24/06		16.0	99.5	75.1	1.2	203	5.3
84	8/25/06		16.1	99.7	80.5	0.1	269	2.4
85	8/26/06		15.5	99.8	79.9	0.0	210	0.9
86	8/27/06		15.6	100.0	80.5	0.1	242	11.2
87	8/28/06		12.7	99.5	81.7	0.4	200	12.1
88	8/29/06		12.7	99.7	77.8	0.2	198	8.9
89	8/30/06		13.1	100.8	79.6	0.0	170	4.2
90	8/31/06		16.9	101.0	69.9	0.6	255	0.0

Annex 5 **Ambient conditions at the field test sites** **Page 4 of 5**

No.	Date	Test site	Ambient temperature [°C]	Ambient pressure [kPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
91	9/1/06	Titz-Roedingen	20.0	100.3	66.1	0.6	225	0.0
92	9/2/06		19.8	100.0	65.5	2.1	224	0.0
93	9/3/06		20.2	100.3	75.9	2.7	172	3.5
94	9/29/06	Cologne, Frankf. Str.	18.7	100.3	68.5	0.4	175	0.6
95	9/30/06		18.2	100.4	67.3	0.1	199	1.2
96	10/1/06		18.6	100.3	63.8	0.5	207	0.3
97	10/2/06		16.6	99.9	64.2	0.3	201	0.0
98	10/3/06		14.3	99.6	73.4	0.2	286	1.5
99	10/4/06		12.7	100.6	75.6	0.4	227	2.7
100	10/5/06		14.9	100.9	68.1	0.2	199	6.8
101	10/6/06		15.9	100.2	72.1	1.2	214	11.8
102	10/7/06		12.1	101.1	70.4	2.0	243	0.3
103	10/8/06		12.7	101.4	69.6	0.0	184	0.0
104	10/9/06		15.4	101.3	70.2	0.1	170	0.0
105	10/10/06		15.1	101.2	74.7	0.1	139	0.0
106	10/11/06		16.7	100.7	70.6	0.7	173	0.0
107	10/12/06		17.4	101.7	75.3	0.1	231	0.0
108	10/13/06		15.3	102.3	77.8	0.0	155	0.0
109	10/14/06		11.7	102.2	73.8	0.6	111	0.0
110	10/15/06		11.6	102.0	67.7	0.4	119	0.0
111	10/16/06		11.7	101.5	67.3	2.0	168	0.0
112	10/17/06		12.6	100.7	65.8	2.6	172	0.0
113	10/18/06		15.1	99.8	65.3	1.3	174	0.0
114	10/19/06		15.1	99.3	76.0	1.6	166	1.8
115	10/20/06		14.9	99.2	76.7	0.1	183	6.2
116	10/21/06		15.7	99.7	69.1	0.3	188	0.3
117	10/22/06		16.6	99.4	69.3	1.6	186	0.9
118	10/23/06		16.7	98.9	76.9	1.2	192	19.8
119	10/24/06		13.2	99.6	74.5	2.2	250	2.4
120	10/25/06		14.5	100.2	66.3	2.8	168	0.0

Annex 5 **Ambient conditions at the field test sites** **Page 5 of 5**

No.	Date	Test site	Ambient temperature [°C]	Ambient pressure [kPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
121	10/26/06	Cologne,	19.1	100.3	64.2	0.5	222	0.0
122	10/27/06	Frankf. Str.	14.7	101.7	68.8	0.3	252	0.0
123	10/28/06		15.7	101.4	75.6	0.2	252	0.9
124	10/29/06		13.4	101.6	72.0	2.1	259	0.0
125	10/30/06		11.9	101.0	70.4	0.1	174	0.0
126	10/31/06		11.5	100.1	68.1	3.3	273	2.4
127	11/1/06		5.6	101.7	65.4	3.8	225	1.5
128	11/2/06		5.5	102.2	76.8	1.0	262	2.1
129	11/3/06		7.4	102.4	76.3	0.0	311	0.0
130	11/4/06		9.8	102.4	70.6	1.2	275	0.0
131	11/5/06		10.7	102.1	73.3	1.2	291	0.0
132	11/6/06		9.6	102.0	71.3	0.5	261	0.0
133	11/7/06		7.9	101.4	70.7	0.2	172	0.0
134	11/8/06		11.3	101.4	72.6	0.5	266	7.7
135	11/9/06		8.3	102.4	70.9	2.2	248	0.0
136	11/10/06		7.0	102.2	69.4	1.3	173	2.4
137	11/11/06		9.3	100.7	73.9	3.8	261	9.5
138	11/12/06		7.9	100.9	74.5	2.8	282	4.2
139	11/13/06		10.5	100.1	79.5	0.6	237	2.4
140	11/14/06		12.8	100.5	74.0	0.2	186	1.5
141	11/15/06		13.1	100.3	73.0	2.4	177	0.0
142	11/16/06		15.8	99.8	65.5	2.4	195	3.0
143	11/17/06		11.2	100.3	74.4	1.9	182	0.3
144	11/18/06		8.3	101.2	77.1	0.3	194	1.2
145	11/19/06		6.0	101.1	82.7	1.4	199	10.0
146	11/20/06		9.9	100.0	80.1	0.1	282	13.6
147	11/21/06		7.1	99.2	76.4	0.4	218	2.4

Annex 6: Software version **Page 1 of 1**

Remark: During the test work, the software was continuously enhanced and optimized up to the version 3236-02 3.2.1b. There is no influence to expect on the instruments performance due to the performed alterations up to the version 3236-02 3.2.1b.

Appendix 2

Manual BAM-1020-9800 REV E

together with

Software Revision 3.0.0

Software Revision 3.1.0

Software Revision 3.2.0

Software Revision 3.2.1b

Manual temperature sensor BX-592

Manual air pressure sensor BX-594

TÜV RHEINLAND
ENERGIE UND UMWELT GMBH

Addendum

Addendum to the type approval test report of the measuring system BAM-1020 with PM_{10} pre-separator of the company Met One Instruments, Inc. for the component PM_{10} to the TÜV-report 936/21205333/A of Dec 06, 2006

TÜV-Report: 936/21220762/A
Cologne, December 12, 2012

luft@de.tuv.com

The accreditation is valid up to 31-01-2013. DAkkS-register number: D-PL-11120-02-00.

TÜV Rheinland Energie und Umwelt GmbH
is accredited for the following work areas:

- Determination of emissions and ambient airs of air pollution and odor substances;
- Inspection of correct installation, function and calibration of continuously running emission measuring devices including systems for data evaluation and remote monitoring of emissions;
- Suitability testing of measuring systems for continuous monitoring of emissions and ambient air, and of electronic systems for data evaluation and remote monitoring of emissions

according to EN ISO/IEC 17025.

TÜV Rheinland Energie und Umwelt GmbH
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Summary

The ambient air quality measuring system BAM-1020 with PM_{10} pre-separator of the company Met One Instrument, Inc. has been type-approved and published as follows.

1. BAM-1020 with PM_{10} pre-separator with announcement of the Federal Environment Agency of April 12, 2007 (BAnz. p. 4139, chapter III No. 1.2)

   The last notification on the measuring systems has been:

   BAM-1020 with PM_{10} pre-separator with announcement of the Federal Environment Agency of July 06, 2012 (BAnz AT 20.07.2012 B11, Chapter IV 6th notification), statement of March 21, 2012

The test of the measuring system BAM-1020 with PM_{10} pre-separator in the year 2006 has been designed in the way that the tests have been evaluated and documented according to the minimum requirements of the Standard VDI 4202, Sheet 1 as well as according to the respective European Standard EN 12341. Furthermore an evaluation of the available data sets of the three campaigns according to the Guide „Demonstration of Equivalence of Ambient Air Monitoring Methods“ in its version of 2005 has been carried out. However, due to formal reasons, it was not possible to demonstrate equivalence back then, because there has been only three instead of the required four comparisons and the number of valid data pairs for the single comparisons has been below the required minimum number of 40.

Nevertheless - in order to demonstrate equivalence according to the Guide „Demonstration of Equivalence of Ambient Air Monitoring Methods“ in its current version of 2010, taking into account the already available data sets, the following approach has been agreed upon together with the English project partner of the UK-GER PM Equivalence Programme:

There will be a new evaluation of the equivalence for the following data sets according to the Guide 2010 for the following test sites:

> Test sites Cologne, parking lot, Titz-Rödingen and Cologne, Frankfurter Str. from the existing German type approval
>
> Additionally with BAM-1020 of the same design
>
> 2 test sites (Steyregg, Graz) from Austrian equivalence testings of 2007 / 2008, carried out by the Environment Agency Austria,

1 test site (Tusimice) from Czech equivalence testing of 2010, carried out by the Czech Hydrometeorological Institute,

1 test site (Teddington) from English equivalence testing of 2012, carried out by NPL / Bureau Veritas UK.

Therewith 7 comparison campaigns in total are considered for the evaluation and the formal requirements for an equivalence testing according to the Guide 2010 (at least 4 comparisons with each 40 data pairs) is fulfilled. All data from all stations of the used equivalence testing have been used. Furthermore the approach shall demonstrate, that also under these circumstances (different sites in different countries, different candidates of the same design, different operators), the demonstration of equivalence is possible.

In the following Addendum to the type approval test report, the evaluation of the equivalence testing is described in detail. After its publication, this addendum is an inherent part of the TÜV Rheinland test report with the No. 936/212053333/A.

Content

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1. General and methodology of the equivalence check (modules 5.4.9 – 5.4.11)

For the subsequent equivalence check, the following historical comparison campaigns have been used:

Table 1: Overview on comparison campaigns

No.	Country	Test site	Time period	Candidates	Characterisation	Test institute
1	D	Cologne, parking lot	02/2006 – 04/2006	SN4924 / SN 4925	Urban background	TÜV Rheinland
2	D	Titz-Rödingen	07/2006 – 09/2006	SN4924 / SN 4925	Rural	TÜV Rheinland
3	D	Cologne, Frankf. Str.	09/2006 – 11/2006	SN4924 / SN 4925	Traffic-influenced	TÜV Rheinland
4	A	Steyregg	06/2008 – 08/2008	AUSTRIA 1 / AUSTRIA 2	Sub-urban	UBA Austria
5	A	Graz	12/2007 – 03/2008	AUSTRIA 1 / AUSTRIA 2	Urban back-ground + traffic	UBA Austria
6	CZ	Tusimice	01/2010 – 06/2010	J7860 / J7863	Industrial	CHMI
7	UK	Teddington	04/2012 – 05/2012	17011 / 17022	Urban back-ground	NPL / Bureau Veritas

All measured data have been obtained either by accredited test houses or by national reference laboratories. The respective evidence of the accreditation can be found in the appendix in Figure 28 to Figure 31.

The comparison campaigns are characterized by the following conditions:

Table 2: Ambient conditions during the comparison campaigns

No.	Test site	Ambient temperature [°C]	Rel. Humidity [%]	Wind velocity [m/s]	No. of valid data pairs	No. ≥40*
1	Cologne, parking lot	4.7 -3.2 – 15.6	64.0 33.7 – 89.1	1.1 0.0 – 3.0	29	No
2	Titz-Rödingen	17.3 12.7 – 26.5	74.2 55.8 – 81.7	0.4 0.0 – 2.7	37	No
3	Cologne, Frankf. Str.	15.1 11.6 – 19.1	70.5 63.8 – 77.8	0.8 0.0 – 2.8	28	No
4	Steyregg	19.7 10.9 – 26.2	74.0 58.7 – 94.6	1.3 0.3 – 2.5	45	Yes
5	Graz	2.7 -5.9 – 13.3	73.8 33.9 - 100	0.6 0.0 – 3.1	45	Yes
6	Tusimice	2.7 -13.0 – 19.0	82.9 24.0 – 96.0	0.7 0.0 – 3.1	97 (J7860) 96 (J7863)	Yes
7	Teddington	10.3 5.8 – 14.9	74.0 51.9 – 91.8	1.1 0.1 – 3.5	40	Yes

* The Guide in its version of 2010 requires at least 4 comparison campaigns with each at least 40 valid data pairs. This formal requirement is fulfilled by including the test sites Steyregg, Graz, Tusimice and Teddington. The three comparison campaigns from the original type approval tests of 2006 are additionally added and evaluated to the available data sets.

All single values can be found in the appendix of this addendum.

According to the version of the Guide from January 2010, the following 5 criteria must be fulfilled to proof the equivalence.

1. Of the full dataset at least 20 % of the results obtained using the standard method shall be greater than the upper assessment threshold specified in 2008/50/EC for annual limit values *i.e.*: 28 µg/m³ for PM_{10} and currently 17 µg/m³ for $PM_{2.5}$.

2. The intra instrument uncertainty of the candidate must be less than 2.5 µg/m³ for all data and for two sub datasets corresponding to all the data split greater than or equal to and lower than 30 µg/m³ or 18 µg/m³ for PM_{10} and $PM_{2.5}$ respectively.

3. The intra instrument uncertainty of the reference method must be less than 2.0 µg/m³.

4. The expanded uncertainty (W_{CM}) is calculated at 50 µg/m³ for PM_{10} and 30 µg/m³ for $PM_{2.5}$ for each individual candidate instrument against the average results of the reference method. For each of the following permutations, the expanded uncertainty must be less than 25 %:

   - Full dataset;
   - Datasets representing PM concentrations greater than or equal to 30 µg/m³ for PM_{10}, or concentrations greater than or equal to 18 µg/m³ for $PM_{2.5}$, provided that the subset contains 40 or more valid data pairs;
   - Datasets for each individual test site.

5. Preconditions for acceptance of the full dataset 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 preconditions are not met, the candidate method may be calibrated using the values obtained for slope and/or intercept of all paired instruments together.

The fulfilment of the 5 criteria is checked in the following chapters:

In chapter 2. 5.4.9 Determination of uncertainty between candidates u_{bs} criteria 1 and 2 will be checked.

In chapter 3. 5.4.10 Calculation of the expanded uncertainty of the instruments criteria 3, 4 and 5 will be checked.

In chapter 4. 5.4.11 Application of correction factors and terms, there is evaluation for the case, that criterion 5 cannot be fulfilled without the application of correction factors or terms.

2. 5.4.9 Determination of uncertainty between candidates u_{bs}

For the test of PM2.5 measuring systems the uncertainty between the systems under test shall be determined according to chapter 9.5.3.1 of the guidance document „Demonstration of Equivalence of Ambient Air Monitoring Methods“ in the field test at least at four sampling test sites representative of the future application.

The tests are performed as well for the component PM_{10}

Performance of test

The test was carried out in field tests at in total seven different comparison campaigns during field test. Different seasons and varying concentrations for PM_{10} were taken into consideration.

Of the complete data set, at least 20 % of the concentration values determined with the reference method, shall be greater than the upper assessment threshold according to 2008/50/EC. For PM_{10} the upper assessment threshold is at 28 µg/m³.

There have been 4 comparison campaigns (A-Steyregg, A-Graz, CZ-Tusimice, UK-Teddington) each with at least 40 valid data pairs. Additionally the three comparison campaigns (D-Cologne, parking lot, D-Titz-Rödingen, D-Cologne, Frankf. Str.) from the original type approval (test report 936/21205333/A) have been also evaluated, even if these comparisons contain less than 40 valid data pairs. Of the complete data set (7 comparisons, 320 valid data pairs), in total 35.3 % of the measured values are above the upper assessment threshold of 28 µg/m³ for PM_{10}. The measured concentrations were referred to ambient conditions.

Evaluation

According to **Point 9.5.2.1** of the Guide „Demonstration of Equivalence of Ambient Air Monitoring Methods“ applies:

The uncertainty between the candidates u_{bs} must be ≤ 2.5 µg/m³. An uncertainty of more than 2,5 µg/m³ between the two candidates is an indication that the performance of one or both systems is not sufficient and the equivalence cannot be declared.

The uncertainty is determined for:

- All test sites respectively comparisons together (complete data set)
- 1 data set with measured values ≥ 30 µg/m³ for PM_{10} (Basis: averages reference measurement)

Furthermore the evaluation of the following data sets is done:

- Each test site respectively comparison individually
- 1 Data set with measured values < 30 µg/m³ for PM_{10} (Basis: averages of reference measurement)

The in-between-instrument uncertainty u_{bs} is calculated from the differences of all 24-hour results of the simultaneously operated candidate systems according to the following equation::

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

with $y_{i,1}$ and $y_{i,2}$ = results of the parallel measurements of individual 24h-values i
n = No. of 24h-values

Assessment

The in-between-uncertainty between the candidates u_{bs} is with a maximum of 1.96 µg/m³ for PM_{10} below the required value of 2.5 µg/m³.

Minimum requirement fulfilled? yes

6.6 Detailed representation of the test results

Table 3 shows the calculated values for the uncertainty between the candidates u_{bs}. The graphical representation is done in Figure 1 to Figure 10

Table 3: Uncertainty between the candidates u_{bs}, measured component PM_{10}

Candidates	Test site	No. of values	Uncertainty u_{bs}
SN			µg/m³
Various	**All test sites**	**363**	**1.22**
Single test sites			
4924 / 4925	D-Cologne, parking lot	52	1.22
4924 / 4925	D-Titz-Rödingen	37	0.86
4924 / 4925	D-Cologne, Frankf. Str.	28	0.99
AUSTRIA 1 / AUSTRIA 2	A-Steyregg	51	0.75
AUSTRIA 1 / AUSTRIA 2	A-Graz	50	1.96
J7860 / J7863	CZ-Tusimice	103	1.18
17011 / 17022	UK-Teddington	42	1.00
Classification via reference value			
Various	**Values ≥ 30 µg/m³**	**105**	**1.49**
Various	Values < 30 µg/m³	215	1.09

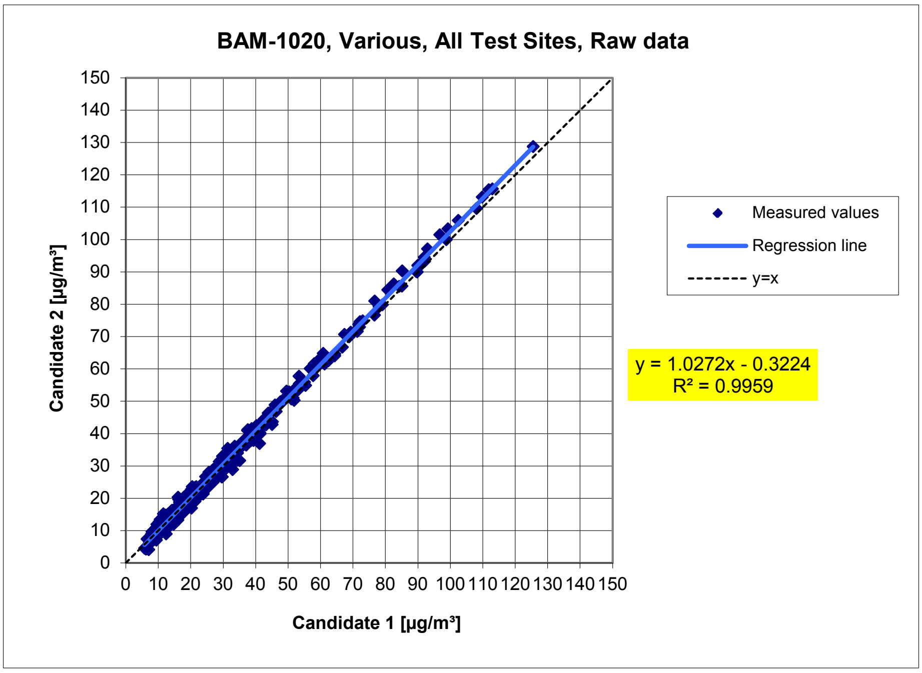

Figure 1: Results of the parallel measurements with the candidates, Measured component PM_{10}, all test sites

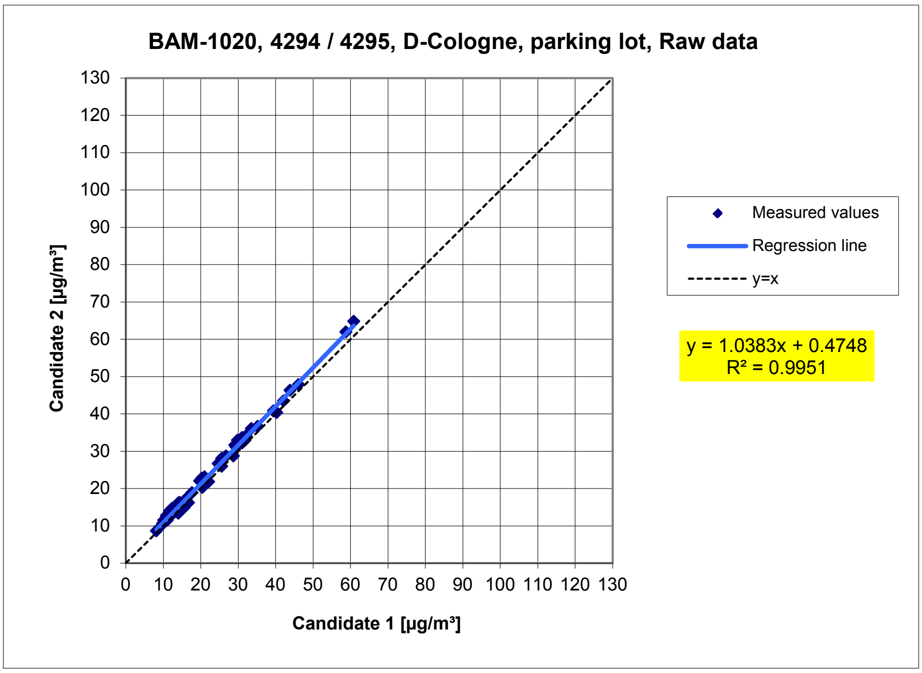

Figure 2: Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Cologne, parking lot

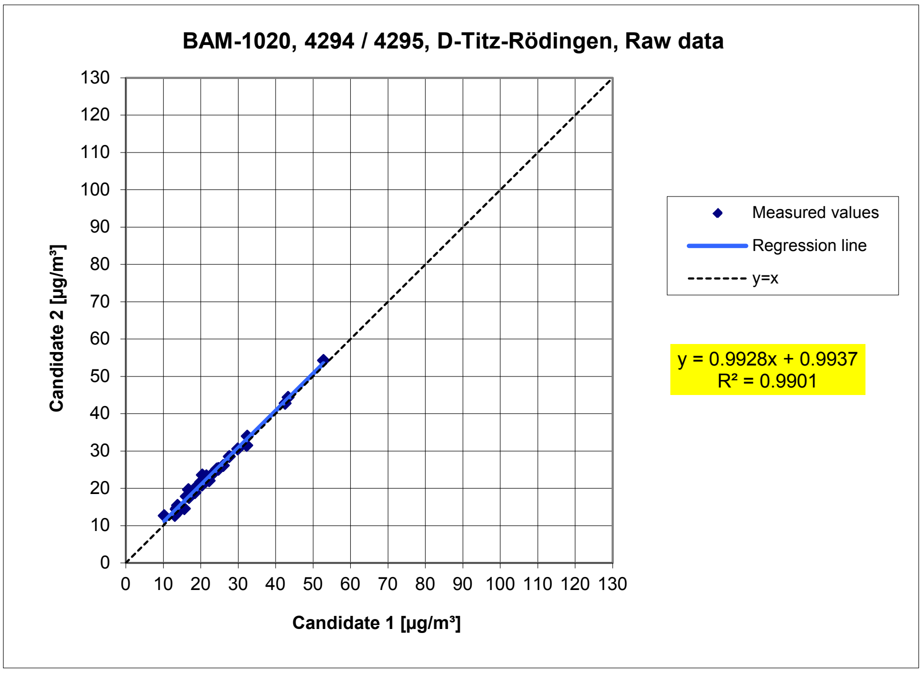

Figure 3: Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Titz-Rödingen

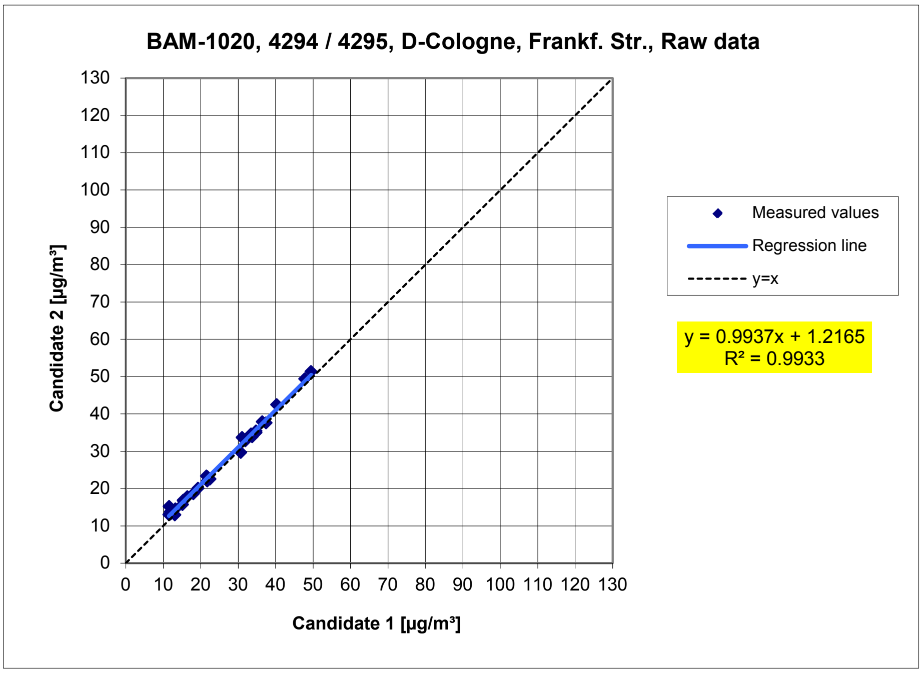

Figure 4: Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Cologne, Frankf. Str.

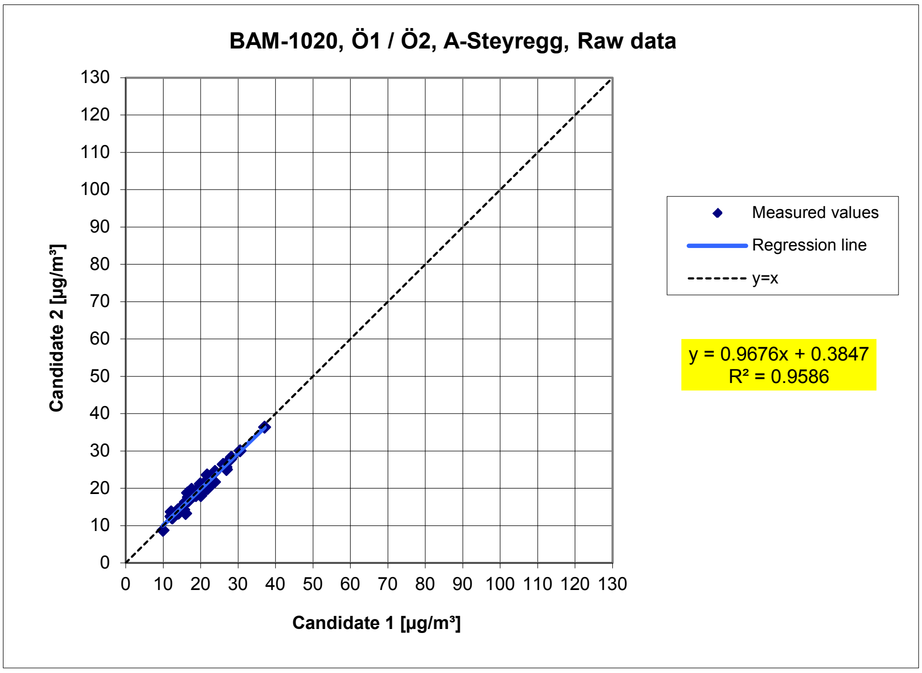

Figure 5: **Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Steyregg**

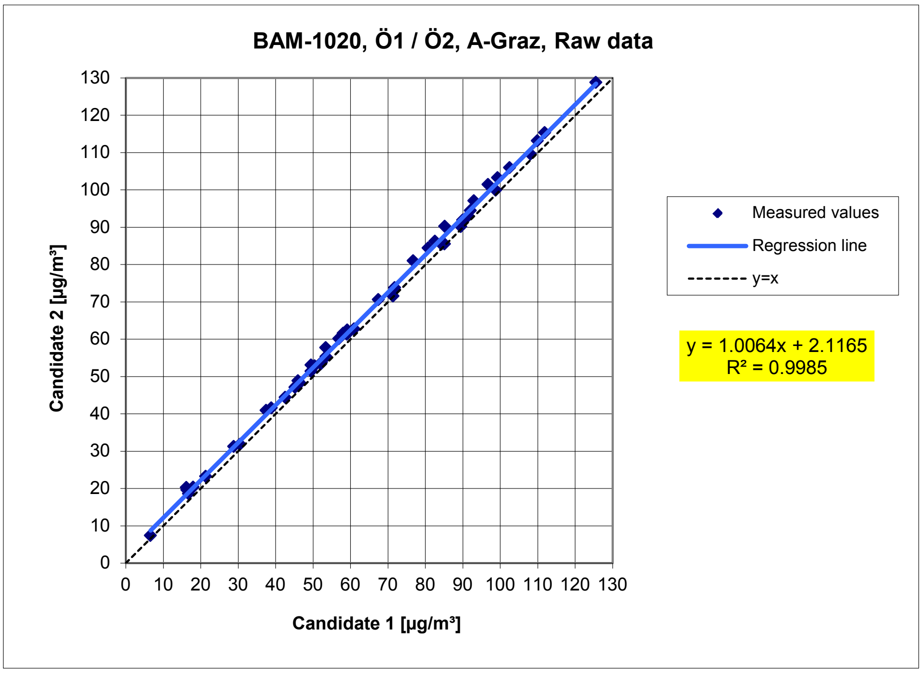

Figure 6: **Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Graz**

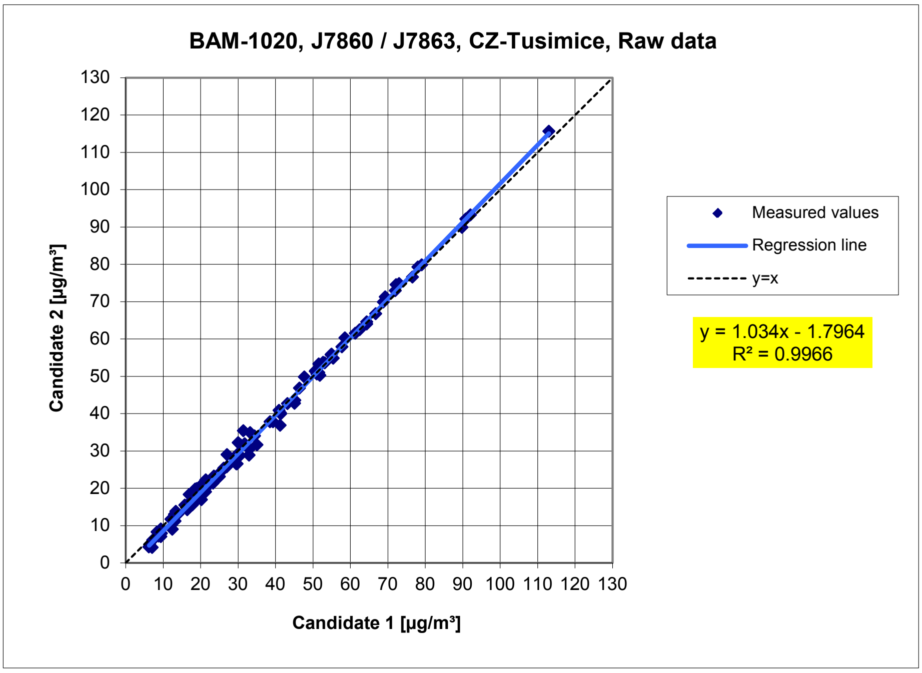

Figure 7: **Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Tusimice**

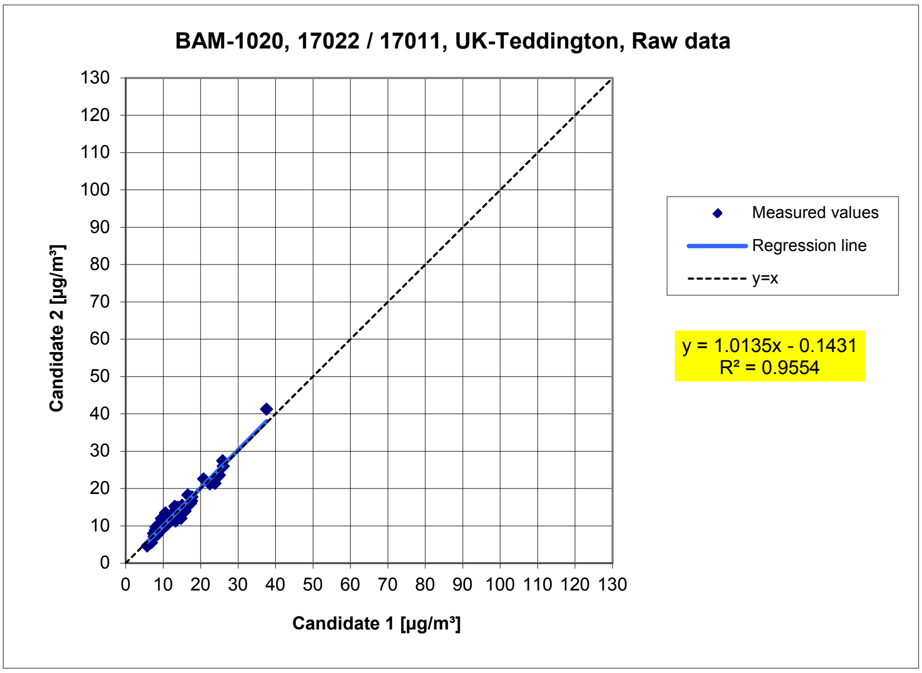

Figure 8: **Results of the parallel measurements with the candidates, Measured component PM_{10}, Test site Teddington**

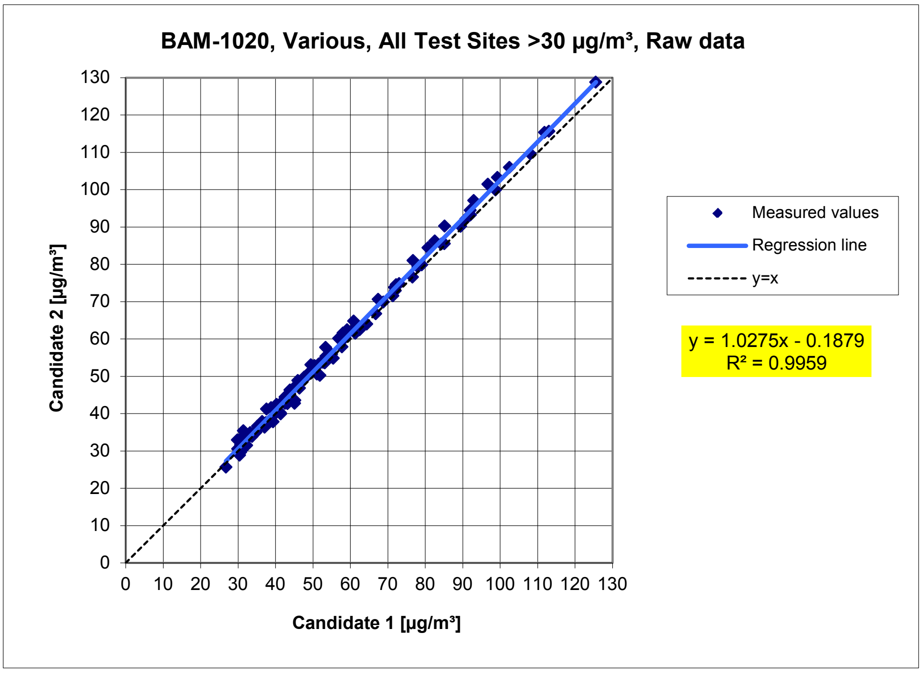

Figure 9: Results of the parallel measurements with the candidates, Measured component PM_{10}, all test sites, values ≥ 30 µg/m³

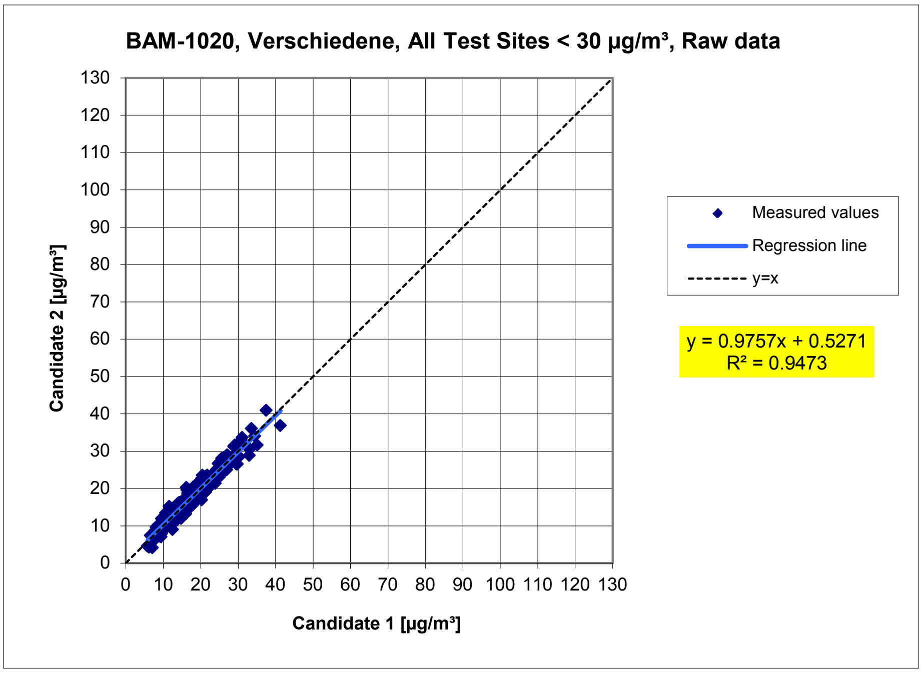

Figure 10: Results of the parallel measurements with the candidates, Measured component PM_{10}, all test sites, values < 30 µg/m³

3. 5.4.10 Calculation of the expanded uncertainty of the instruments

For the test of $PM_{2,5}$ measuring systems the equivalency with the reference method shall be demonstrated according to chapter 9.5.3.2 to chapter 9.6 of the guidance document „Demonstration of Equivalence of Ambient Air Monitoring Methods" in the field test at least at four sampling test sites representative of the future application. The maximum expanded uncertainty of the systems under test shall be compared with data quality objectives according to Annex A of Standard VDI 4202 Part 1 (September 2010)

The tests are performed as well for the components PM_{10}.

Performance of test

The test was carried out in field tests at in total seven different comparison campaigns during field test. Different seasons and varying concentrations for PM_{10} were taken into consideration.

Of the complete data set, at least 20 % of the concentration values determined with the reference method, shall be greater than the upper assessment threshold according to 2008/50/EC. For PM_{10} the upper assessment threshold is at 28 µg/m³.

There has been 4 comparison campaigns (A-Steyregg, A-Graz, CZ-Tusimice, UK-Teddington) each with at least 40 valid data pairs. Additionally the three comparison campaigns (D-Cologne, parking lot, D-Titz-Rödingen, D-Cologne, Frankf. Str.) from the original type approval (test report 936/21205333/A) have been also evaluated, even if these comparisons contain less than 40 valid data pairs. Of the complete data set (7 comparisons, 320 valid data pairs), in total 35.3 % of the measured values are above the upper assessment threshold of 28 µg/m³ for $PM_{10.}$ The measured concentrations were referred to ambient conditions.

Evaluation

[Point 9.5.3.2] The calculation of the in-between-instrument uncertainty u_{ref} of the reference devices is carried out prior to the calculation of the expanded uncertainty of the candidates.

The in-between-instrument uncertainty u_{ref} of the reference devices shall be ≤ 2 µg/m³.

A linear correlation $y_i = a + bx_i$ is assumed between the results of both methods in order to evaluate the comparability of the candidates y and the reference procedure x. The correlation between the average values of the reference devices and the candidates is established by orthogonal regression.

Regression is calculated for:

- All test sites respectively comparisons
- Each test site respectively comparisons separately
- 1 data set with measured values PM_{10} ≥ 30 µg/m³ (Basis: average value of reference measurement)

For further evaluation, the results of the uncertainty u_{c_s} of the candidates compared with the reference method are described with the following equation, which describes u_{CR} as a function of the PM concentration x_i:

$$u_{CR}^2(y_i) = \frac{RSS}{(n-2)} - u^2(x_i) + [a + (b-1)x_i]^2$$

With RSS = Sum of the (relative) residuals from orthogonal regression

$u(x_i)$ = random uncertainty of the reference procedure if value u_{bs}, which is calculated for using the candidates, can be used in this test (refer to point 2. 5.4.9 Determination of uncertainty between candidates u_{bs})

Algorithm for the calculation of ordinate intercept a as well as slope b and its variances by orthogonal regression are described in detail in annex B of the Guide.

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

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

Uncertainty u_{c_s} is calculated for:

- All test sites respectively comparisons
- Each test site respectively comparisons separately
- 1 data set with measured values ≥ 30 µg/m³ (Basis: average values of the reference measurement)

Preconditions for acceptance of the full dataset are that:

- The slope b is significantly different from 1: $|b-1| \leq 2 \cdot u(b)$

  and

- The intercept a is insignificantly different from 0: $|a| \leq 2 \cdot u(a)$

Where u(b) and u(a) are the standard uncertainties of the slope and intercept, respectively calculated as the square root of their variances. If these preconditions are not met, the candidate method may be calibrated according to point 9.7 of the Guide (refer to 4. 5.4.11 Application of correction factors and terms). The calibration shall only be applied to the full dataset.

[Point 9.5.4] The combined uncertainty of the candidates $w_{c,CM}$ is calculated for each data set by combining the contributions from 9.5.3.1 and 9.5.3.2 according to the following equation:

$$w^2_{c,CM}(y_i) = \frac{u^2_{CR}(y_i)}{y_i^2}$$

For each dataset, the uncertainty $w_{c,CM}$ is calculated at the level of y_i = 50 µg/m³ for PM_{10}.

[Point 9.5.5] The expanded relative uncertainty of the results of the candidates is calculated for each data set by multiplication of $w_{c,CM}$ with a coverage factor k according to the following equation:

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

In practice: k=2 for large n

[Point 9.6] The highest resulting uncertainty W_{CM} is compared and assessed with the requirements on data quality of ambient air measurements according to EU Directive 2008/50/EC.

Two results are possible:

1. $W_{CM} \leq W_{dqo} \rightarrow$ Candidate method is accepted as equivalent to the standard method.
2. $W_{CM} > W_{dqo} \rightarrow$ Candidate method is not accepted as equivalent to the standard method.

The specified expanded relative uncertainty W_{dqo} for particulate matter is 25 % [7].

Assessment

The determined uncertainties W_{CM} without application of correction factors are below the defined expanded relative uncertainty W_{dqo} of 25 % for particulate matter for all investigated data sets except for the test site A-Graz (for candidate AUSTRIA 2) as well as for UK-Teddington (for candidate 17011). It is necessary to check, whether all test sites incl. the test sites A-Graz (for candidate AUSTRIA 2) and UK-Teddington (for candidate 17011) will be below the defined expanded relative uncertainty W_{dqo} of 25 % for particulate matter after application of correction factors / terms (refer to chapter 4. 5.4.11 Application of correction factors and terms).

Minimum requirement fulfilled? no

The following Table 4 shows an overview of the results of the equivalence check for the candidate BAM-1020 für PM_{10}. For the case, that a criterion is fulfilled or not, the text is represented in green or red colour. Furthermore the five criteria from chapter 1. General and methodology of the equivalence check (modules 5.4.9 – 5.4.11) are taken into account, the related cells are highlighted in colour.

Table 4: Overview equivalence check BAM-1020 for PM_{10}

PM10 Smart BAM 1020	35.3% > 28 µg m-3	Orthogonal Regression				Between Instrument Uncertainties	
	W_{CM} / %	n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	Reference	Candidate
All Paired Data	16.0	320	0.982	1.034 +/- 0.008	0.843 +/- 0.290	0.67	1.22
< 30 µg m³	24.7	215	0.826	1.119 +/- 0.032	-0.446 +/- 0.557	0.53	1.09
> 30 µg m³	17.7	105	0.971	1.042 +/- 0.017	0.141 +/- 1.031	0.91	1.49

4294	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Cologne, Parking Lot	29	0.960	0.948 +/- 0.036	2.202 +/- 0.950	10.13	34.5
	Titz - Rödingen	37	0.962	1.058 +/- 0.035	0.376 +/- 0.782	14.75	18.9
	Cologne, Frankfurter Str.	28	0.963	1.025 +/- 0.039	-1.293 +/- 1.083	8.07	42.9
Combined Datasets	< 30 µg m³	68	0.814	1.040 +/- 0.055	0.162 +/- 0.981	12.58	4.4
	> 30 µg m³	26	0.897	0.964 +/- 0.063	1.810 +/- 2.438	9.75	100.0
	All Data	94	0.953	0.987 +/- 0.022	1.048 +/- 0.563	9.16	35.3

4295	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Cologne, Parking Lot	29	0.970	0.990 +/- 0.033	2.681 +/- 0.862	12.53	34.5
	Titz - Rödingen	37	0.961	1.056 +/- 0.035	1.260 +/- 0.785	17.52	18.9
	Cologne, Frankfurter Str.	28	0.969	1.021 +/- 0.035	-0.154 +/- 0.994	8.10	42.9
Combined Datasets	< 30 µg m³	68	0.830	1.056 +/- 0.053	0.935 +/- 0.952	17.24	4.4
	> 30 µg m³	26	0.929	1.025 +/- 0.056	0.713 +/- 2.151	11.49	100.0
	All Data	94	0.960	1.004 +/- 0.021	1.735 +/- 0.528	11.41	30.9

Austria1	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Graz	45	0.969	1.025 +/- 0.027	-0.202 +/- 1.848	20.89	82.2
	Steyregg	45	0.824	1.049 +/- 0.067	-1.750 +/- 1.392	9.31	8.9
Combined Datasets	< 30 µg m³	50	0.644	1.339 +/- 0.109	-6.789 +/- 2.135	42.75	2.0
	> 30 µg m³	40	0.960	1.057 +/- 0.034	-2.826 +/- 2.431	19.58	100.0
	All Data	90	0.983	1.039 +/- 0.015	-1.294 +/- 0.729	15.95	45.6

Austria2	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Graz	45	0.966	1.033 +/- 0.029	1.948 +/- 1.962	26.05	82.2
	Steyregg	45	0.793	1.035 +/- 0.072	-1.668 +/- 1.489	9.56	8.9
Combined Datasets	< 30 µg m³	50	0.557	1.492 +/- 0.130	-9.462 +/- 2.545	62.86	2.0
	> 30 µg m³	40	0.956	1.084 +/- 0.037	-2.296 +/- 2.635	22.65	100.0
	All Data	90	0.980	1.079 +/- 0.016	-1.702 +/- 0.818	19.84	45.6

J7860	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	59	0.906	1.172 +/- 0.047	1.204 +/- 0.839	40.46	6.8
	> 30 µg m³	38	0.974	1.002 +/- 0.027	3.154 +/- 1.548	17.67	100.0
	All Data (Tusimice)	97	0.984	0.999 +/- 0.013	3.739 +/- 0.492	18.45	43.3

J7863	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	58	0.913	1.158 +/- 0.045	0.159 +/- 0.812	33.73	6.9
	> 30 µg m³	38	0.978	1.032 +/- 0.025	1.948 +/- 1.450	17.98	100.0
	All Data (Tusimice)	96	0.987	1.035 +/- 0.012	2.035 +/- 0.461	18.18	43.8

17011	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	39	0.960	1.039 +/- 0.034	0.632 +/- 0.458	11.13	0.0
	> 30 µg m³	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.949	1.162 +/- 0.042	-0.766 +/- 0.602	29.99	2.5

17022	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	39	0.958	1.051 +/- 0.035	0.603 +/- 0.477	13.45	0.0
	> 30 µg m³	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.963	1.110 +/- 0.034	-0.050 +/- 0.488	22.28	2.5

KEY

- Criterion 1
- Criterion 2
- Criterion 3
- Criterion 4
- Criterion 5

The check of the five criteria according to chapter 1. General and methodology of the equivalence check (modules 5.4.9 – 5.4.11) resulted as follows:

Criterion 1: Greater than 20 % of the data are greater than 28 µg/m³.

Criterion 2: The intra instrument uncertainty of the candidates is smaller than 2.5 µg/m³.

Criterion 3: The intra instrument uncertainty of the reference is smaller than 2.0 µg/m³.

Criterion 4: All of the expanded uncertainties are below 25 %.

This requirement is not fulfilled for the raw data set of A-Graz (Austria 2) and UK-Teddington (17011)

Criterion 5: On closer inspection of the slopes and intercepts for the individual candidates, they are several time significantly greater than allowed. Al so the slope and the intercept of the complete data set is significantly greater than allowed.

Other: The evaluation of the All data set for both candidates together shows that the AMS demonstrates a very good correlation with the reference method with a slope of 1.034 and an intercept of 0.843 at an expended total uncertainty of 16.0 %.

However, since the expanded uncertainty for the raw data sets A-Graz (Austria 2) and UK-Teddington (17011) is greater than 25 %, the application of correction factors / terms is inevitable for the demonstration of equivalence.

The January 2010 version of The Guidance is ambiguous with respect to which slope and intercept should be used to correct a candidate should it fail the test for equivalence. After communication with the convenor of the EC working group, which is responsible for setting up the Guide Mr. Theo Hafkenscheid), it was decided that the requirement of the November 2005 version of the Guidance are still valid, and that the slope and intercept from the orthogonal regression of all the paired data should be used. These are shaded gold and marked ‘other’ in the key on the above Table 4.

The 2006 UK Equivalence Report highlighted that this was a flaw in the mathematics required for equivalence as per the November 2005 version of The Guidance as it penalised instruments that were more accurate (Appendix E Section 4.2 therein). This same flaw is copied in the January 2010 version. It is the opinion of TŰV Rheinland and their UK partners that the BAM-1020 for PM_{10} is indeed being penalised by the mathematics for being accurate.

In this particular case, the slope for the „All data“ data set is 1.034.

The intercept for for the „All data“ data set is 0.843.

Thus an additional evaluation after application of the respective correction factors / terms to the data sets has been carried out in chapter 4. 5.4.11 Application of correction factors and terms for the following cases:

a) Correction for intercept
b) Correction for slope
c) Correction for intercept and slope

The revised version of the Guide of January 2010 requires that when operating in networks, a candidate method needs to be tested annually at a number of sites and that the number of the instruments to be tested is dependent on the expanded measurement uncertainty of the device. The respective realization is the responsibility of the network operator or of the responsible authority of the member state. However TÜV Rheinland and their UK partners recommend, that the expanded uncertainty for the full data set is referred to for this, namely 16.0 %, which again would require an annual test at 4 measurement sites (Guide [4], chapter 9.9.2, table 6).

Detailed representation of the test results

Table 5 shows an overview on the uncertainties between the reference devices $u_{ref\ from}$ the field tests. In Table 6 a summarized representation of the results of the equivalence test incl. the determined expanded measuring uncertainties W_{CM} from the field test is shown.

Table 5: Uncertainty between the reference devices u_{ref} for PM_{10}

Reference devices	Test site	No. of values	Uncertainty u_{bs}
Nr.			µg/m³
1 / 2	All test sites	320	0.67
1 / 2	D-Cologne, parking lot	29	0.55
1 / 2	D-Titz-Rödingen	37	0.65
1 / 2	D-Cologne, Frankf. Str.	28	1.02
1 / 2	A-Steyregg	45	0.53
1 / 2	A-Graz	45	0.82
1 / 2	CZ-Tusimice	96	-*
1 / 2	UK-Teddington	40	0.25

* only 1 reference device in operation, for the evaluation the uncertainty for the complete data set of 0.67 µg/m³ is applied

The uncertainty between the reference devices u_{ref} is for all test sites < 2 µg/m³.

Table 6: Summary of the results of the equivalence test, Measured component PM_{10}, raw data

PM_{10} Smart BAM 1020	35.3% > 28 µg m-3	Orthogonal Regression				Between Instrument Uncertainties	
	W_{CM} / %	n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	Reference	Candidate
All Paired Data	16.0	320	0.982	1.034 +/- 0.008	0.843 +/- 0.290	0.67	1.22
< 30 µg m-3	24.7	215	0.826	1.119 +/- 0.032	-0.446 +/- 0.557	0.53	1.09
> 30 µg m-3	17.7	105	0.971	1.042 +/- 0.017	0.141 +/- 1.031	0.91	1.49

4294	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Cologne, Parking Lot	29	0.960	0.948 +/- 0.036	2.202 +/- 0.950	10.13	34.5
	Titz - Rödingen	37	0.962	1.058 +/- 0.035	0.376 +/- 0.782	14.75	18.9
	Cologne, Frankfurter Str.	28	0.963	1.025 +/- 0.039	-1.293 +/- 1.083	8.07	42.9
Combined Datasets	< 30 µg m^3	68	0.814	1.040 +/- 0.055	0.162 +/- 0.981	12.58	4.4
	> 30 µg m^3	26	0.897	0.964 +/- 0.063	1.810 +/- 2.438	9.75	100.0
	All Data	94	0.953	0.987 +/- 0.022	1.048 +/- 0.563	9.16	35.3

4295	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Cologne, Parking Lot	29	0.970	0.990 +/- 0.033	2.681 +/- 0.862	12.53	34.5
	Titz - Rödingen	37	0.961	1.056 +/- 0.035	1.260 +/- 0.785	17.52	18.9
	Cologne, Frankfurter Str.	28	0.969	1.021 +/- 0.035	-0.154 +/- 0.994	8.10	42.9
Combined Datasets	< 30 µg m^3	68	0.830	1.056 +/- 0.053	0.935 +/- 0.952	17.24	4.4
	> 30 µg m^3	26	0.929	1.025 +/- 0.056	0.713 +/- 2.151	11.49	100.0
	All Data	94	0.960	1.004 +/- 0.021	1.735 +/- 0.528	11.41	30.9

Austria1	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Graz	45	0.969	1.025 +/- 0.027	-0.202 +/- 1.848	20.89	82.2
	Steyregg	45	0.824	1.049 +/- 0.067	-1.750 +/- 1.392	9.31	8.9
Combined Datasets	< 30 µg m^3	50	0.644	1.339 +/- 0.109	-6.789 +/- 2.135	42.75	2.0
	> 30 µg m^3	40	0.960	1.057 +/- 0.034	-2.826 +/- 2.431	19.58	100.0
	All Data	90	0.983	1.039 +/- 0.015	-1.294 +/- 0.729	15.95	45.6

Austria2	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Graz	45	0.966	1.033 +/- 0.029	1.948 +/- 1.962	26.05	82.2
	Steyregg	45	0.793	1.035 +/- 0.072	-1.668 +/- 1.489	9.56	8.9
Combined Datasets	< 30 µg m^3	50	0.557	1.492 +/- 0.130	-9.462 +/- 2.545	62.86	2.0
	> 30 µg m^3	40	0.956	1.084 +/- 0.037	-2.296 +/- 2.635	22.65	100.0
	All Data	90	0.980	1.079 +/- 0.016	-1.702 +/- 0.818	19.84	45.6

J7860	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	59	0.906	1.172 +/- 0.047	1.204 +/- 0.839	40.46	6.8
	> 30 µg m^3	38	0.974	1.002 +/- 0.027	3.154 +/- 1.548	17.67	100.0
	All Data (Tusimice)	97	0.984	0.999 +/- 0.013	3.739 +/- 0.492	18.45	43.3

J7863	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	58	0.913	1.158 +/- 0.045	0.159 +/- 0.812	33.73	6.9
	> 30 µg m^3	38	0.978	1.032 +/- 0.025	1.948 +/- 1.450	17.98	100.0
	All Data (Tusimice)	96	0.987	1.035 +/- 0.012	2.035 +/- 0.461	18.18	43.8

17011	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	39	0.960	1.039 +/- 0.034	0.632 +/- 0.458	11.13	0.0
	> 30 µg m^3	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.949	1.162 +/- 0.042	-0.766 +/- 0.602	29.99	2.5

17022	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	39	0.958	1.051 +/- 0.035	0.603 +/- 0.477	13.45	0.0
	> 30 µg m^3	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.963	1.110 +/- 0.034	-0.050 +/- 0.488	22.28	2.5

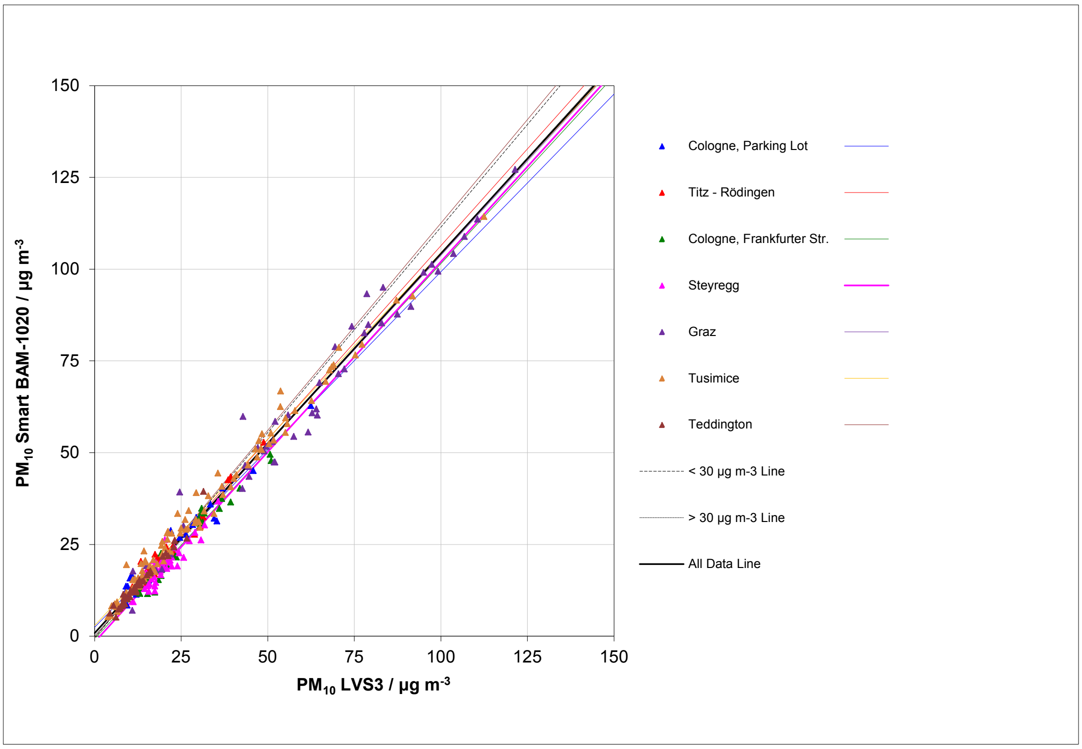

Figure 11: Reference vs. candidate, Measured component PM_{10}, all test sites

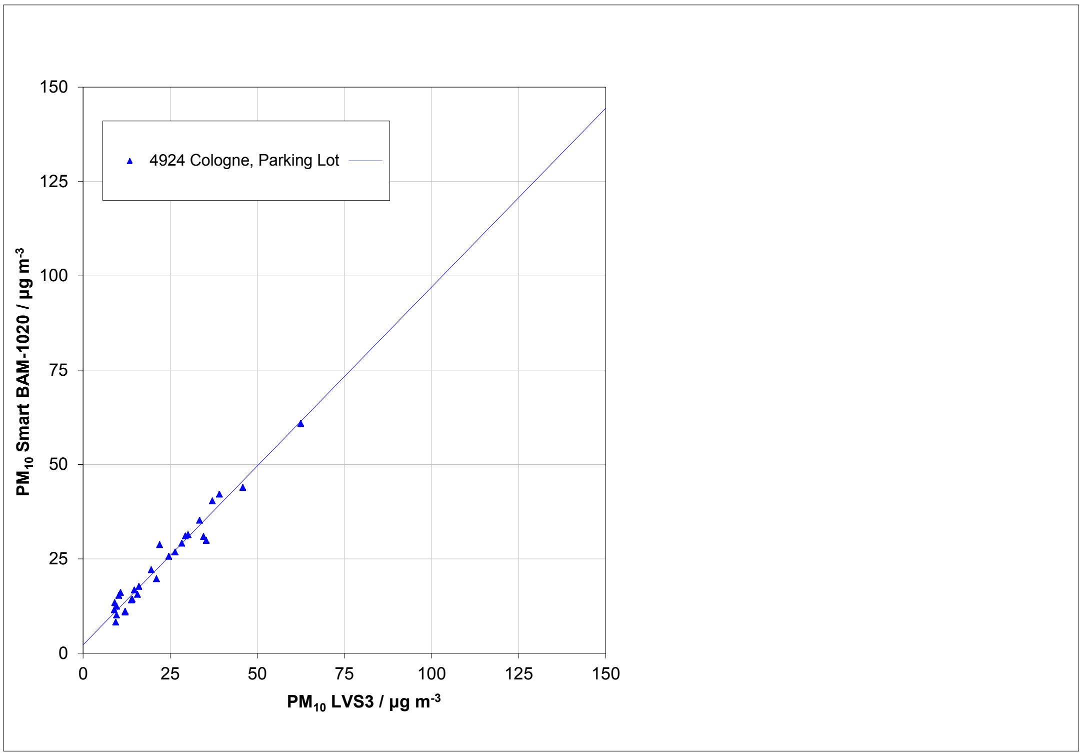

Figure 12: Reference vs. candidate, SN 4924, Measured component PM_{10}, D-Cologne, parking lot

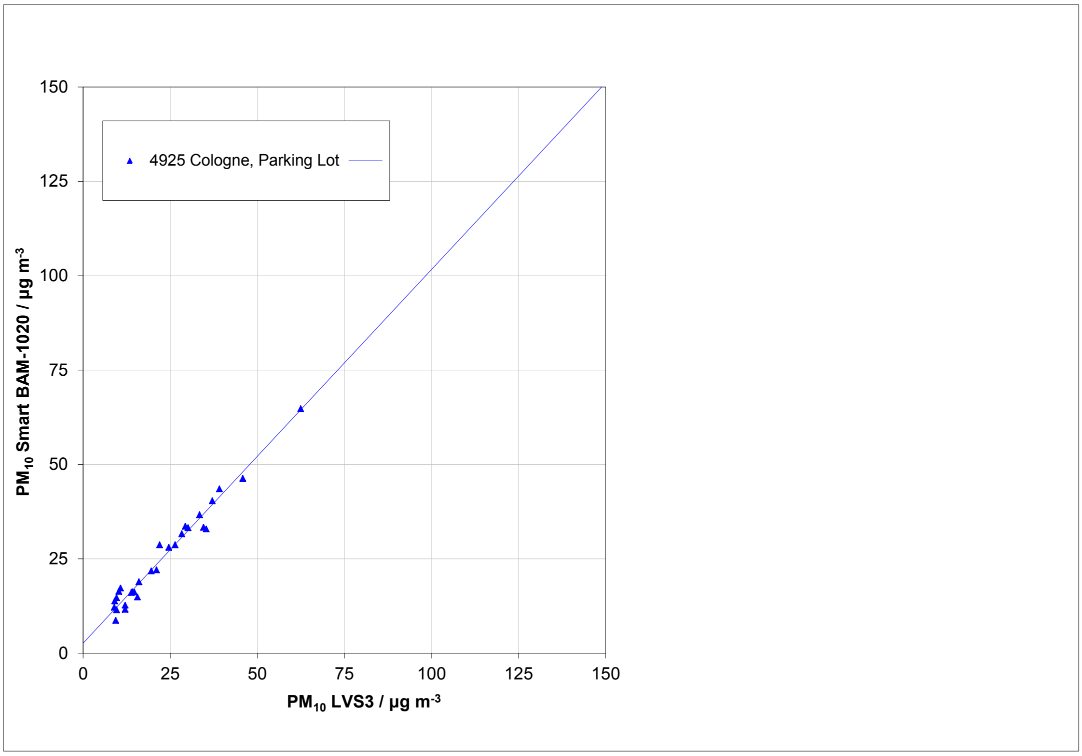

Figure 13: Reference vs. candidate, SN 4925, Measured component PM_{10}, D-Cologne, parking lot

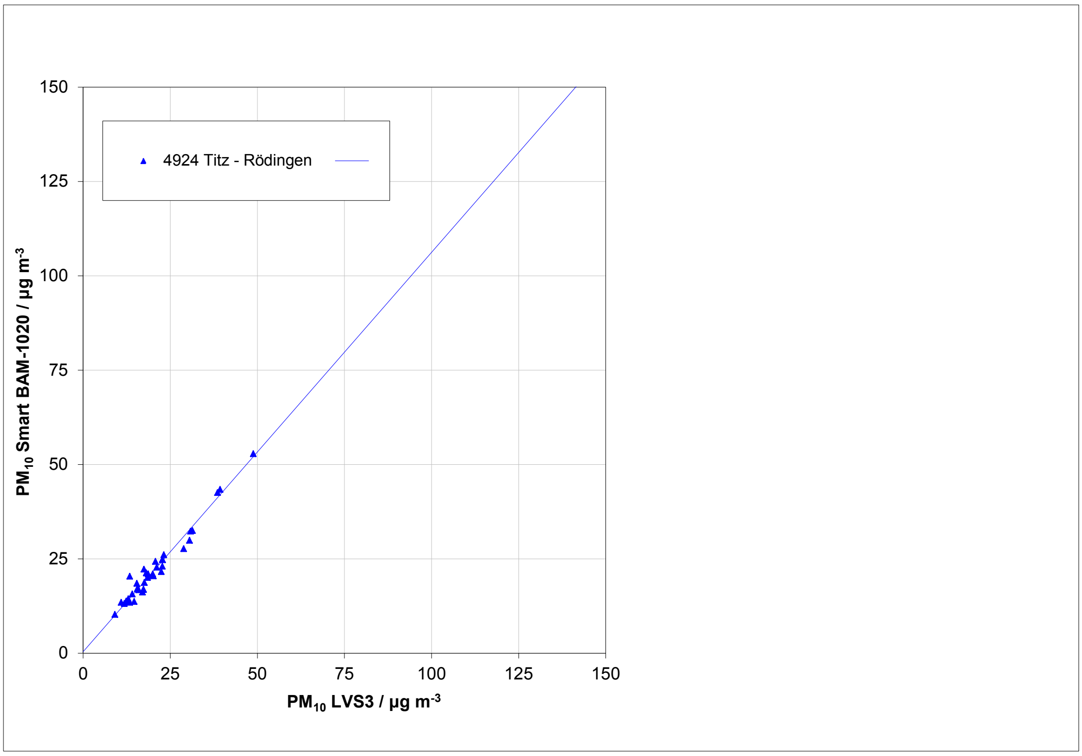

Figure 14: Reference vs. candidate, SN 4924, Measured component PM_{10}, D-Titz-Rödingen

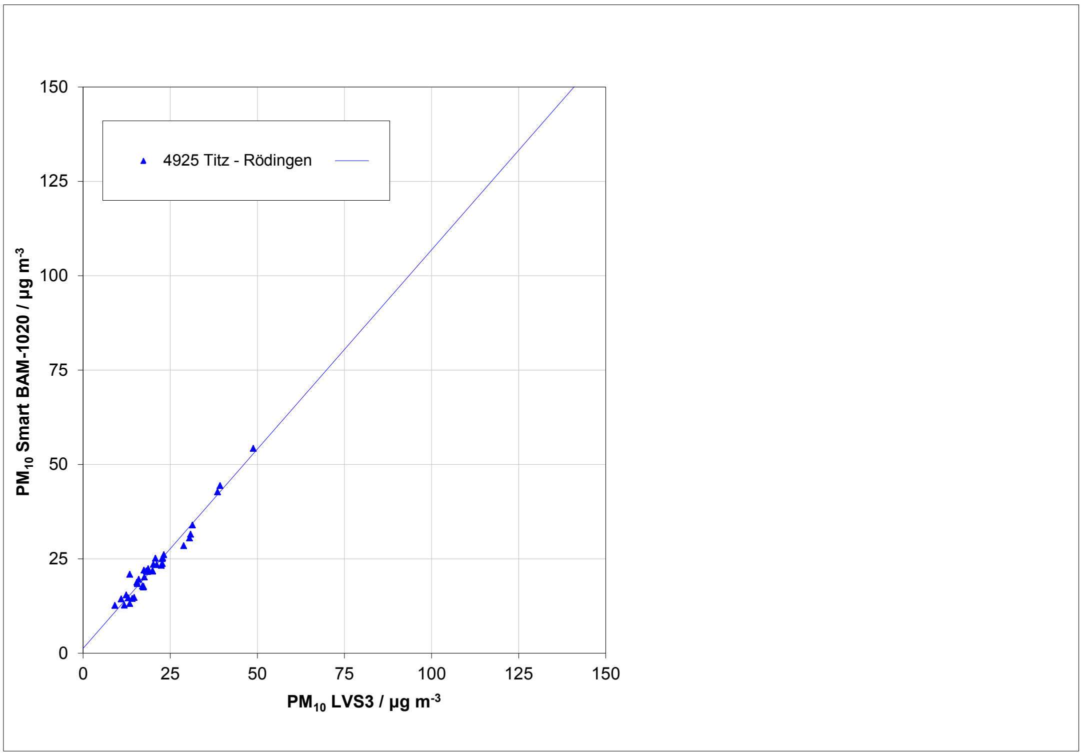

Figure 15: Reference vs. candidate, SN 4925, Measured component PM_{10}, D-Titz-Rödingen

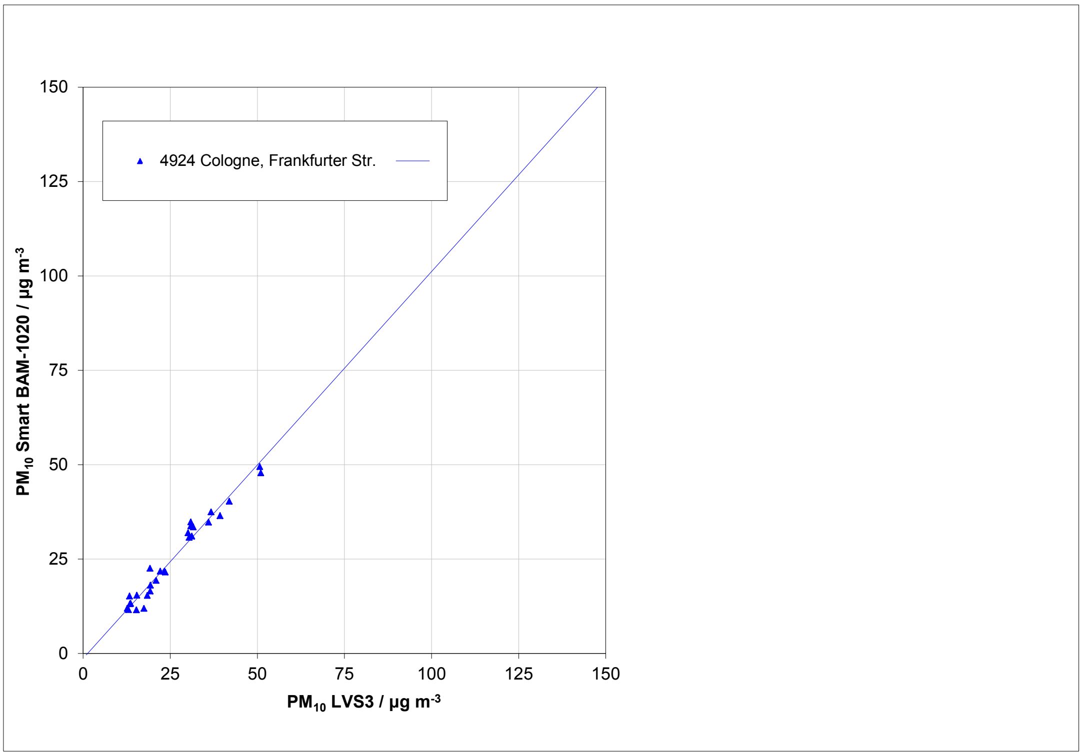

Figure 16: **Reference vs. candidate, SN 4924, Measured component PM_{10}, D-Cologne, Frankf. Str.**

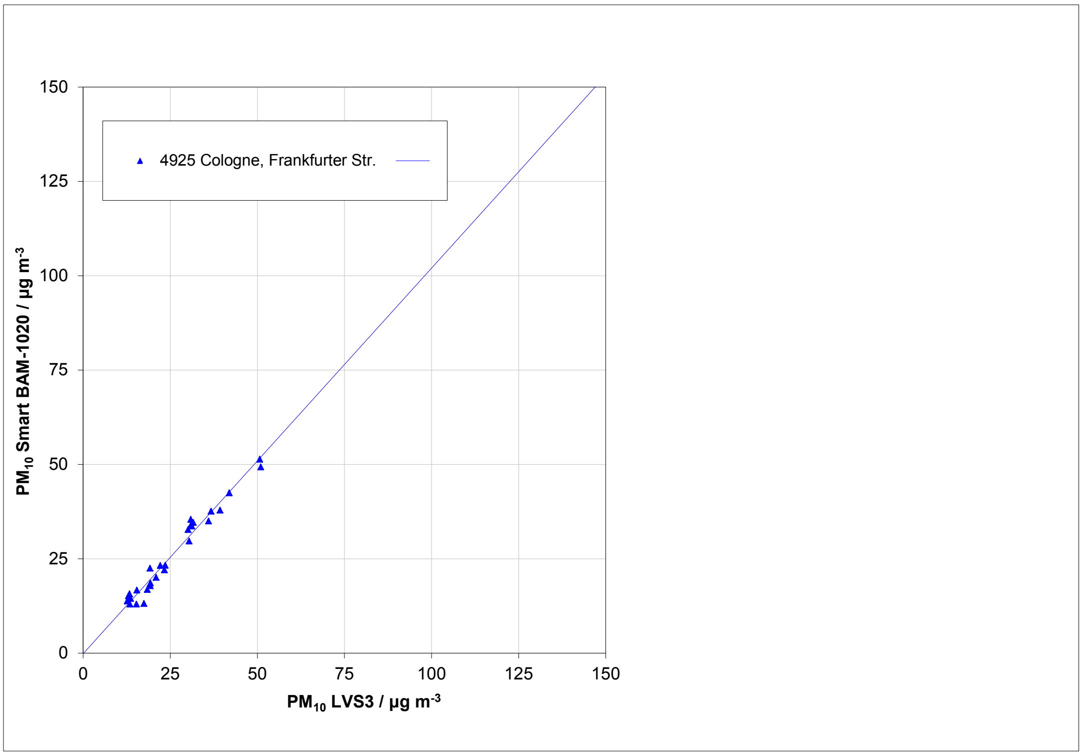

Figure 17: **Reference vs. candidate, SN 4925, Measured component PM_{10}, D-Cologne, Frankf. Str.**

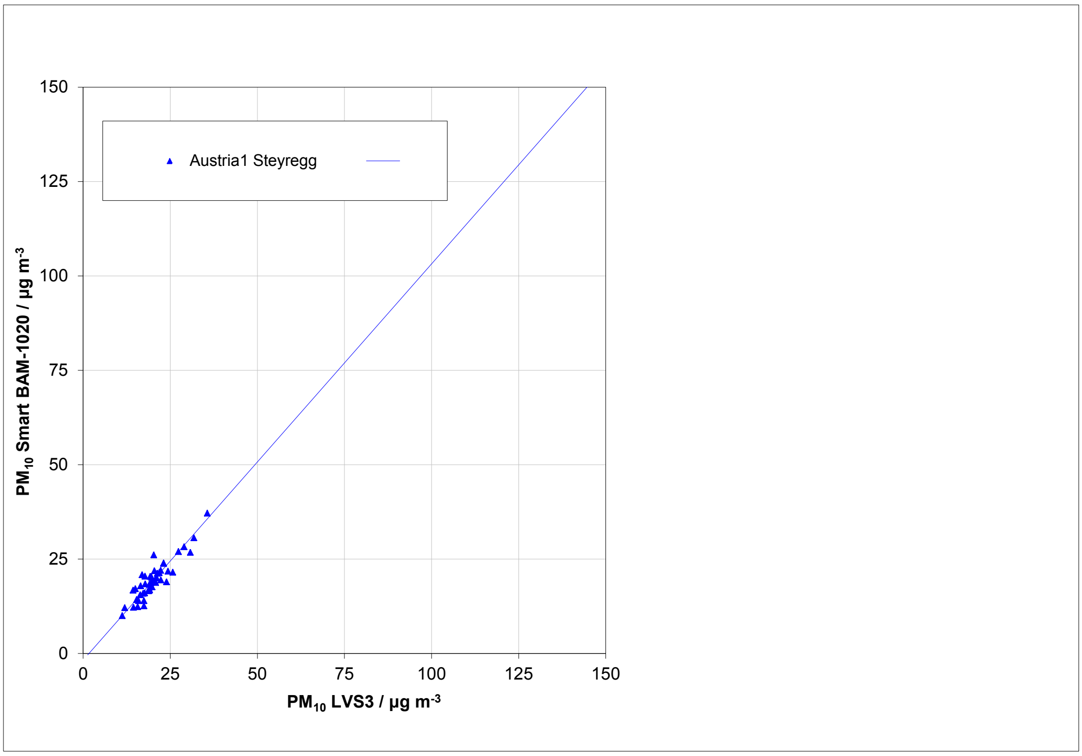

Figure 18: Reference vs. candidate, Austria 1, Measured component PM_{10}, A-Steyregg

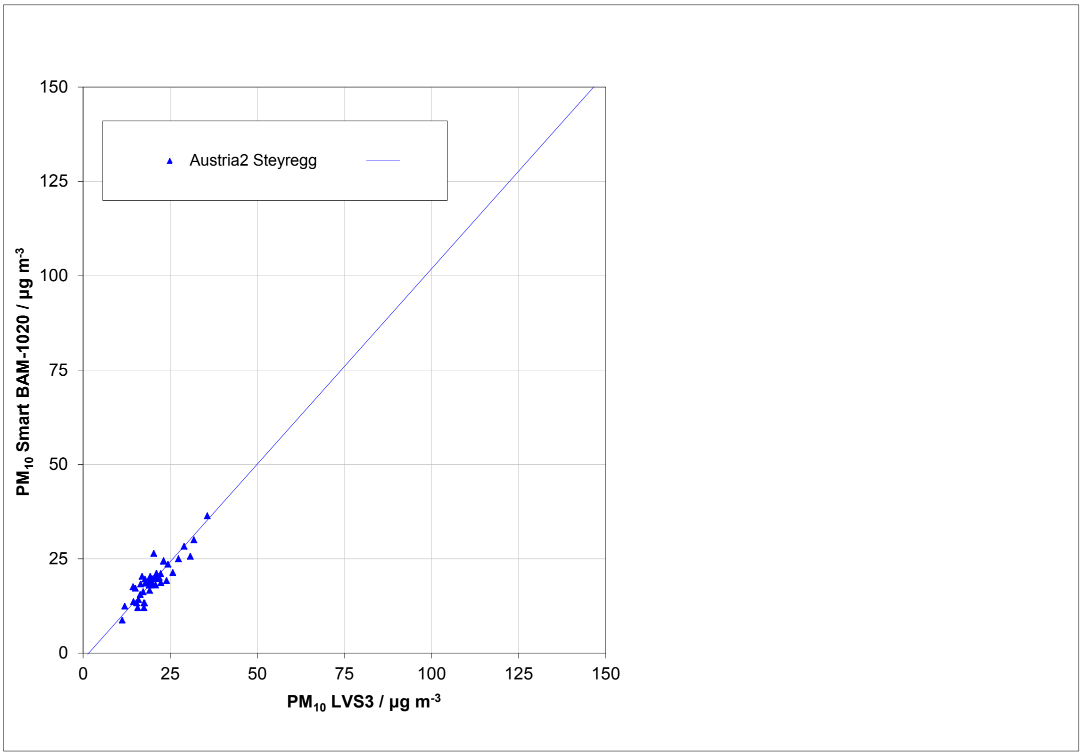

Figure 19: Reference vs. candidate, Austria 2, Measured component PM_{10}, A-Steyregg

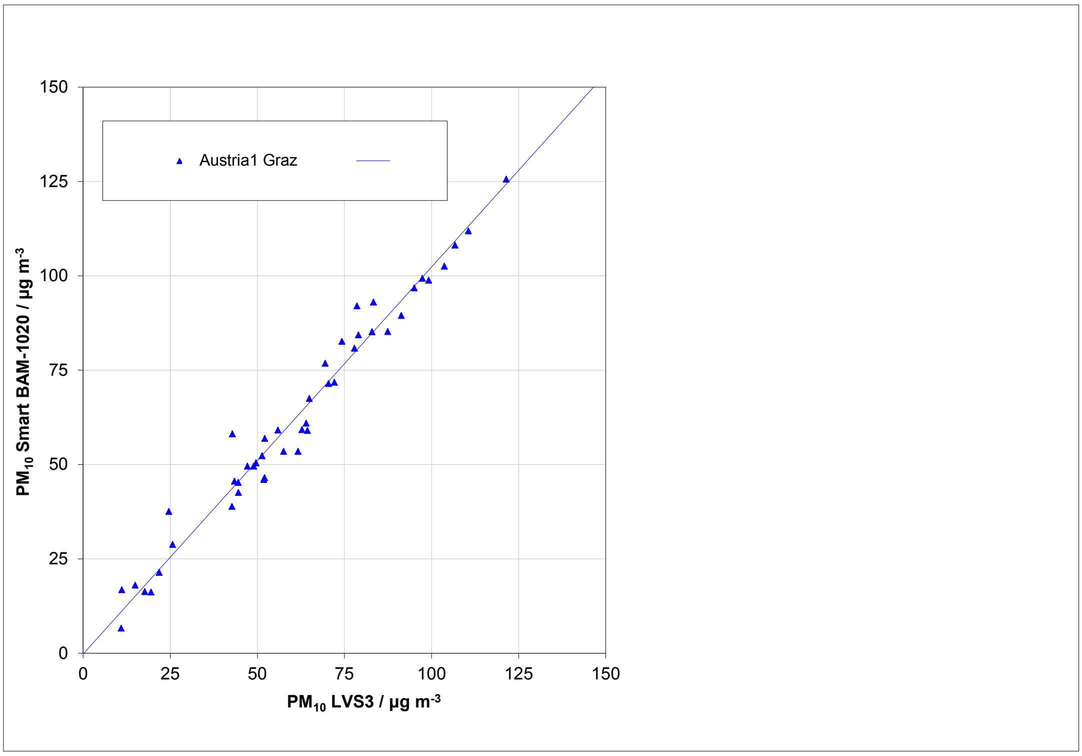

Figure 20: Reference vs. candidate, Austria 1, Measured component PM_{10}, A-Graz

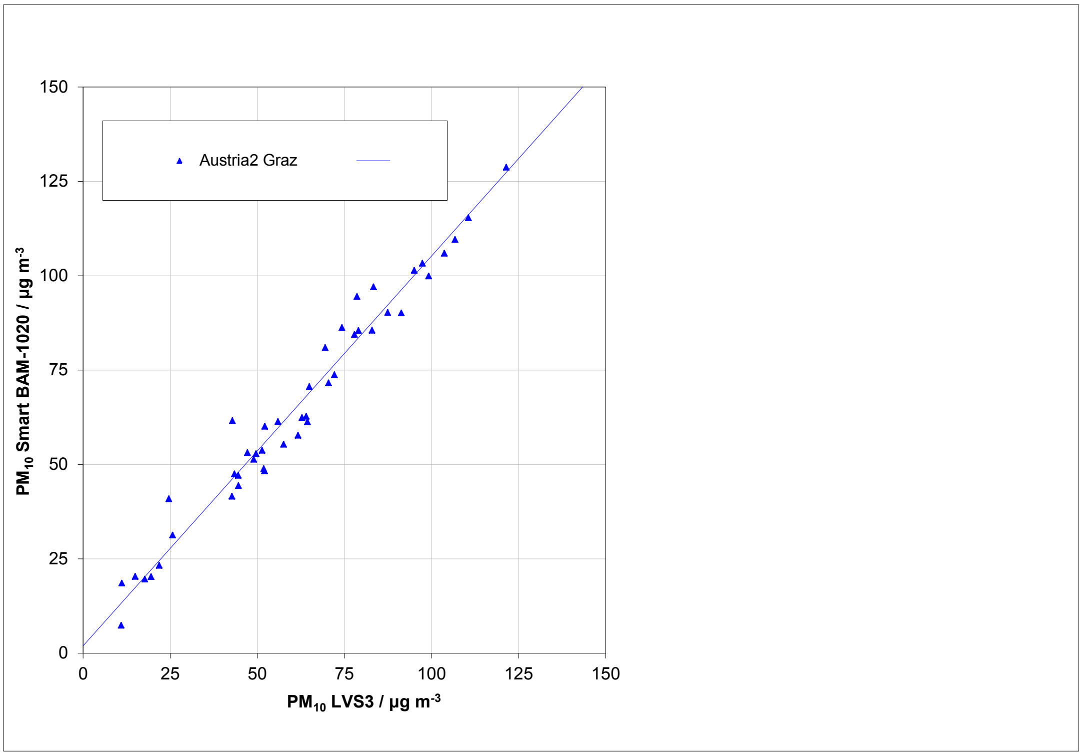

Figure 21: Reference vs. candidate, Austria 2, Measured component PM_{10}, A-Graz

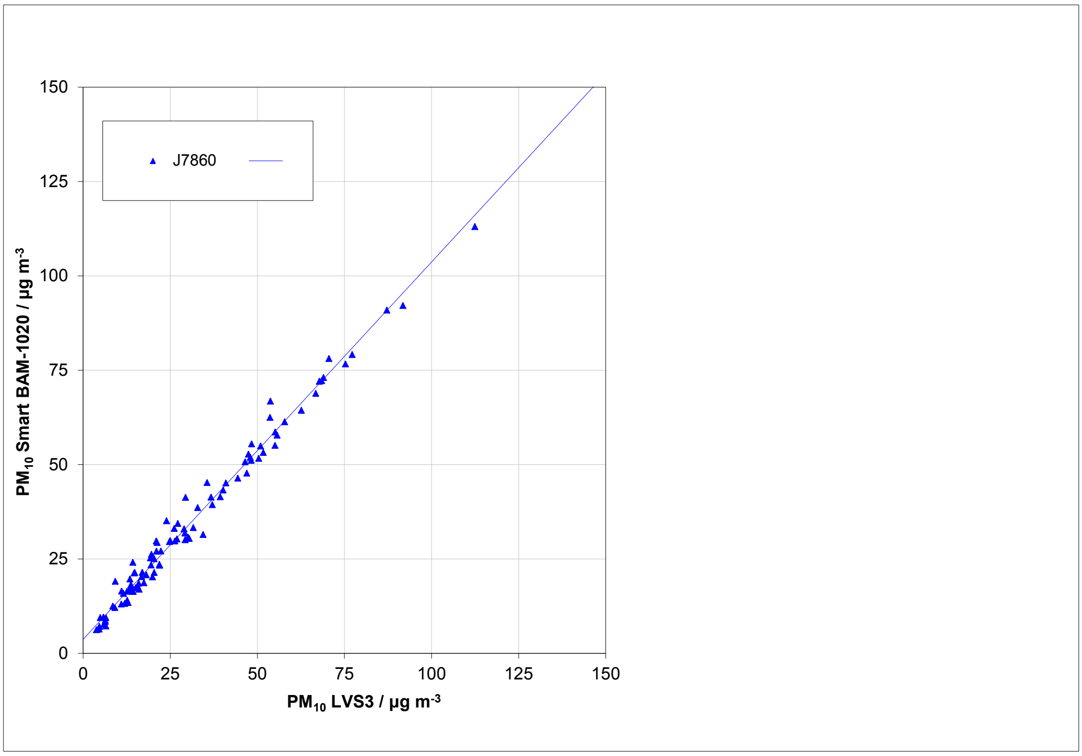

Figure 22: Reference vs. candidate, J7860, Measured component PM$_{10}$, CZ-Tusimice

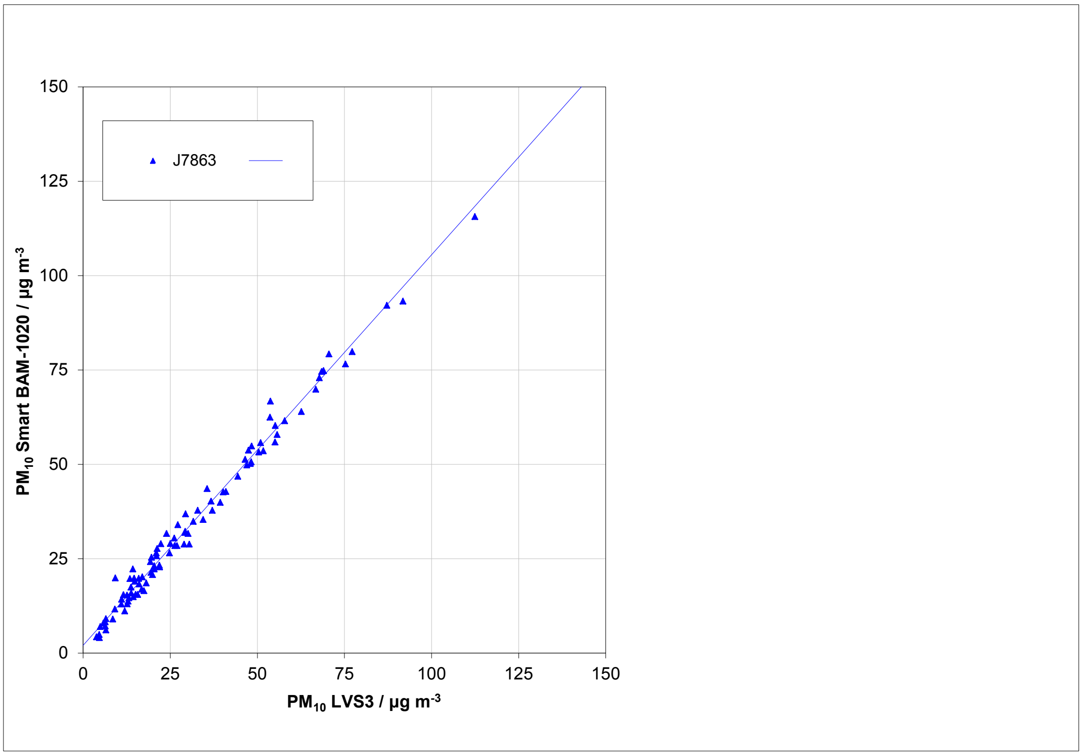

Figure 23: Reference vs. candidate, J7863, Measured component PM$_{10}$, CZ-Tusimice

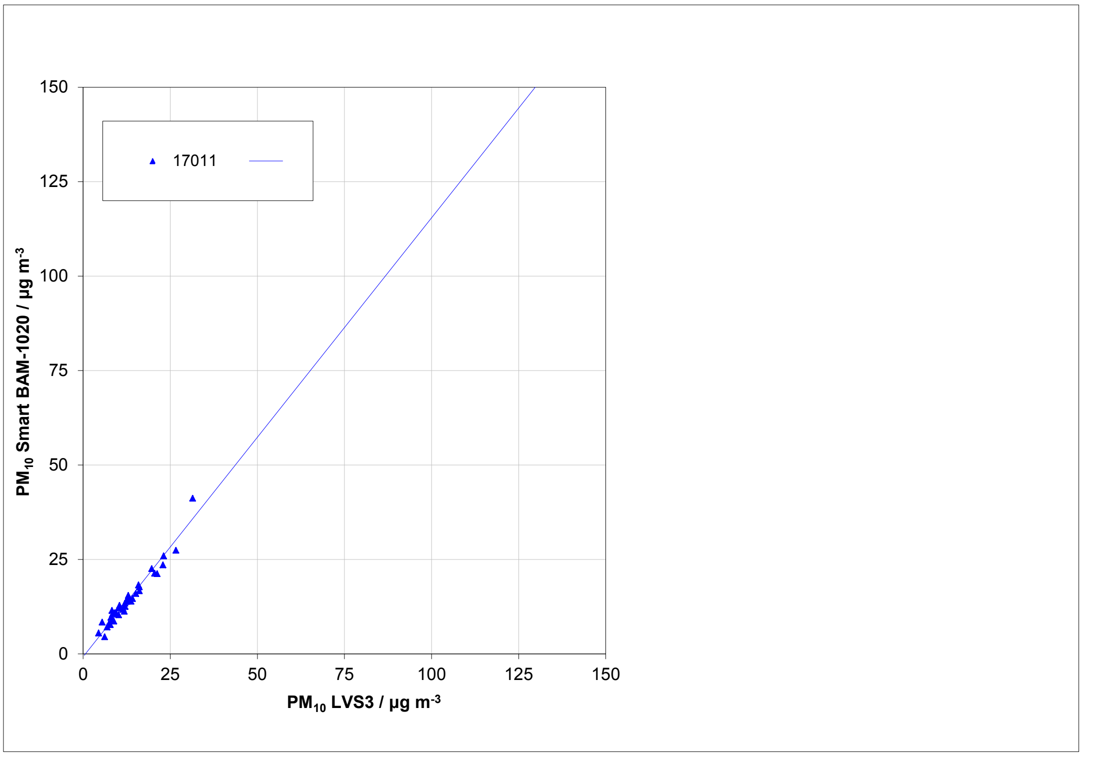

Figure 24: Reference vs. candidate, SN 17011, Measured component PM_{10}, UK-Teddington

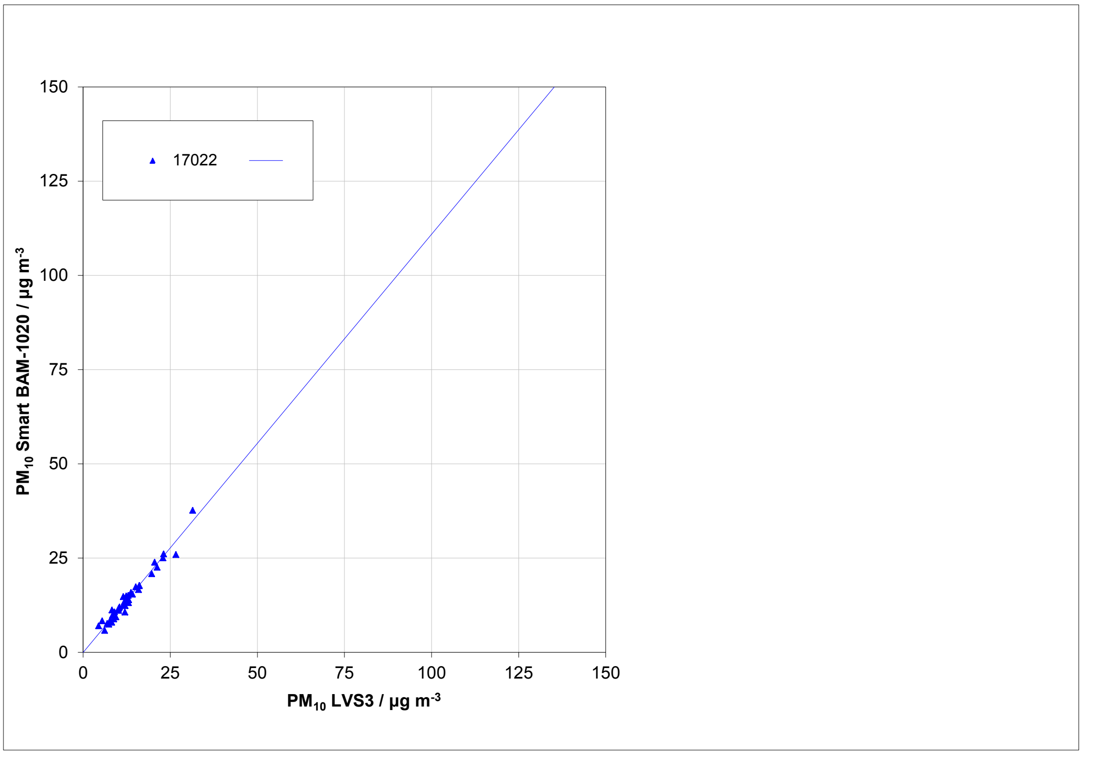

Figure 25: Reference vs. candidate, SN 17022, Measured component PM_{10}, UK-Teddington

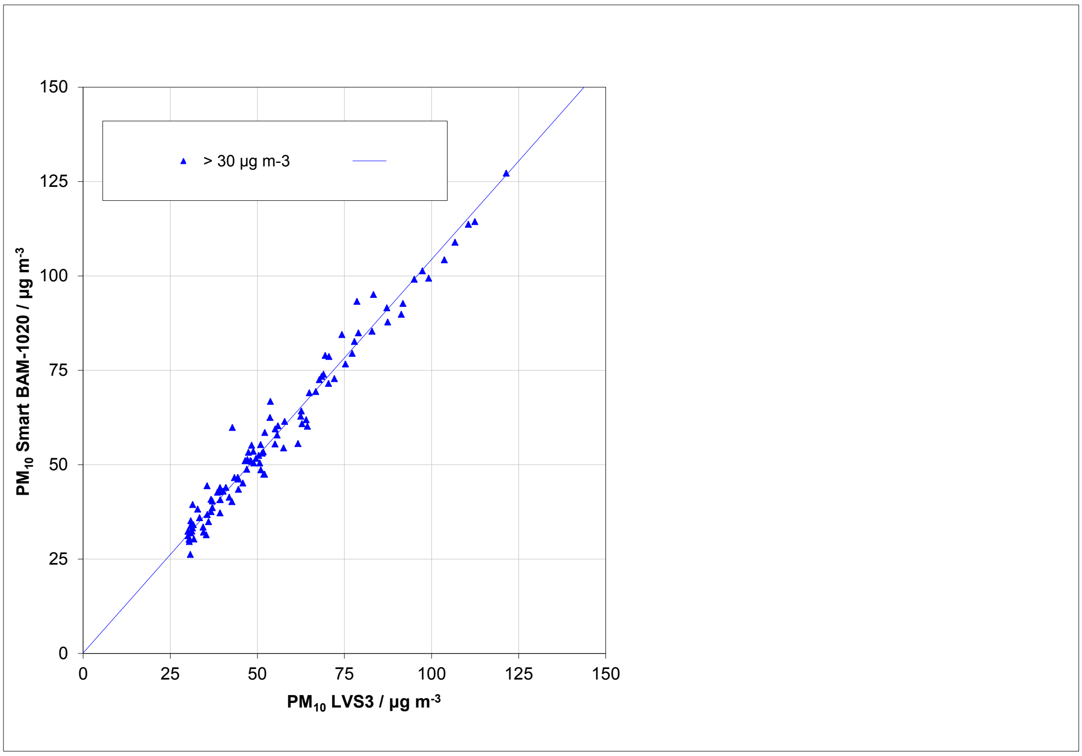

Figure 26: **Reference vs. candidate, Measured component PM_{10}, All test sites, Values ≥ 30 µg/m³**

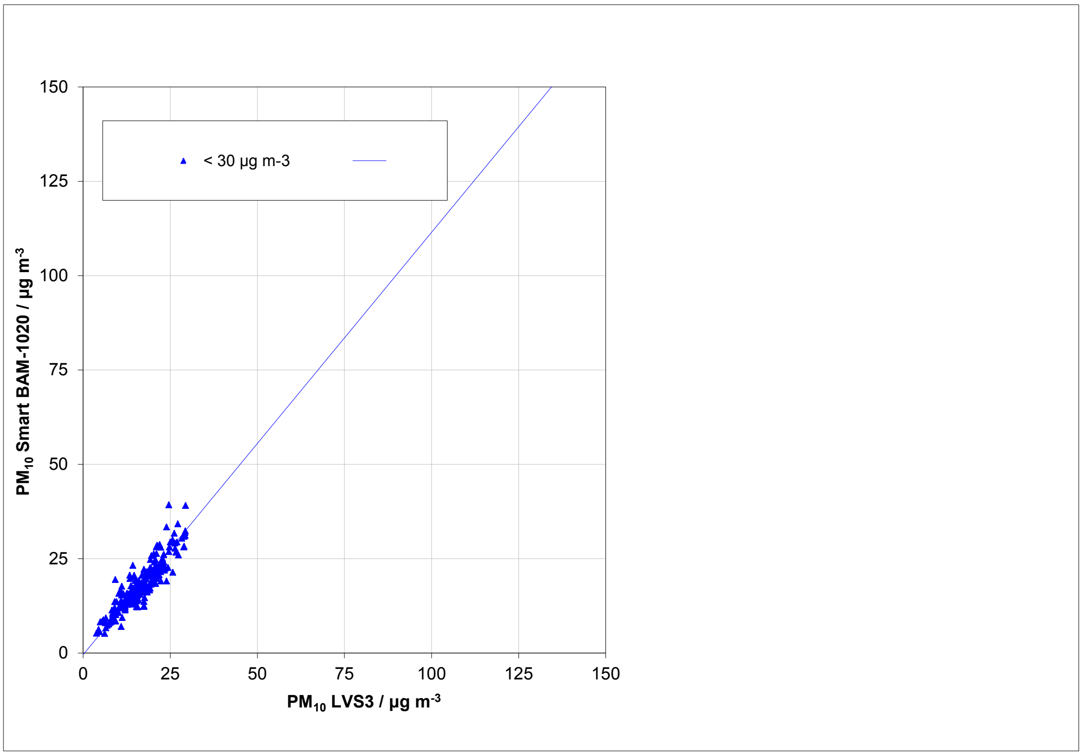

Figure 27: **Reference vs. candidate, Measured component PM_{10}, All test sites, Values < 30 µg/m³**

4. 5.4.11 Application of correction factors and terms

If the highest resulting expanded uncertainty of the candidate method is larger than the expanded relative uncertainty, which is defined in the requirements on the data quality of ambient air measurements according to EU-Directive, the application of correction factors or terms is permitted. The corrected values have to fulfill the requirements according to point 9.5.3.2 et seqq. of the Guide „Demonstration of Equivalence of Ambient Air Monitoring Methods“.

The tests are performed as well for the component PM_{10}

Performance of test

Refer to module 5.4.10

Evaluation

If evaluation of the raw data according to module 5.4.10 leads to a case where $W_{CM} > W_{dqo}$, which means that the candidate systems is not regarded equivalent to the reference method, it is permitted to apply a correction factor or term resulting from the regression equation obtained from the full data set. The corrected values shall satisfy the requirements for all data sets or subsets (refer to module 5.4.10). Moreover, a correction factor may be applied even for $W_{CM} \leq W_{dqo}$ in order to improve the accuracy of the candidate systems.

Three different cases may occur:

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

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

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

With respect to a)

The value of the 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 resulting values of $y_{i,corr}$ may then be used to calculate the following new terms by linear regression:

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

and

$$u_{c\_s}^2(y_{i,corr}) = \frac{RSS}{(n-2)} - u^2(x_i) + [c + (d-1)x_i]^2 + u^2(a)$$

with u(a) = uncertainty of the original intercept a, the value of which has been used to obtain $y_{i,corr}$.

Algorithms for the calculation of intercepts as well as slopes and their variances by orthogonal regression are described in detail in annex B of of the Guide. RSS is determined analogue to the calculation in module 5.4.10.

With respect to b)

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

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

The resulting values of $y_{i,corr}$ may then be used to calculate the following new terms by linear regression:

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

and

$$u^2_{c\_s}(y_{i,corr}) = \frac{RSS}{(n-2)} - u^2(x_i) + [c + (d-1)x_i]^2 + x_i^2 u^2(b)$$

with u(b) = uncertainty of the original slope b, the value of which has been used to obtain $y_{i,corr}$.

Algorithms for the calculation of intercepts as well as slopes and their variances by orthogonal regression are described in detail in annex B of the Guide. RSS is determined analogue to the calculation in module 5.4.10.

With respect to c)

The values of the slope b and of the 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 resulting values of $y_{i,corr}$ may then be used to calculate the following new terms by linear regression:

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

and

$$u^2_{c\_s}(y_{i,corr}) = \frac{RSS}{(n-2)} - u^2(x_i) + [c + (d-1)x_i]^2 + x_i^2 u^2(b) + u^2(a)$$

with u(b) = uncertainty of the original slope b, the value of which has been used to obtain $y_{i,corr}$ and with u(a) = uncertainty of the original intercept a, the value of which has been used to obtain $y_{i,corr}$.

Algorithms for the calculation of intercepts as well as slopes and their variances by orthogonal regression are described in detail in annex B of the Guide. RSS is determined analogue to the calculation in module 5.4.10.

The values for $u_{c\_s,corr}$ are used for the calculation of the combined relative uncertainty of the candidate systems after correction according to the following equation:

$$w^2_{c,CM,corr}(y_i) = \frac{u^2_{c\_s,corr}(y_i)}{y_i^2}$$

For the corrected data set, uncertainty is calculated at the daily limit value $w_{c,CM,corr}$ by taking as y_i the concentration at the limit value.

The expanded relative uncertainty $W_{CM,corr}$ is calculated according to the following equation:

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

In practice: k=2 for large number of available experimental results

The highest resulting uncertainty W_{CM} is compared and assessed with the requirements on data quality of ambient air measurements according to EU Directive.

Two results are possible:

1. $W_{CM} \leq W_{dqo} \rightarrow$ Candidate method is accepted as equivalent to the standard method.
2. $W_{CM} > W_{dqo} \rightarrow$ Candidate method is not accepted as equivalent to the standard method.

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

6.5 Assessment

The candidates fulfill the requirements on the data quality of ambient air quality measurements after slope correction. The correction furthermore leads to an additional significant improvement of the expanded uncertainties for the complete data set.

Minimum requirement fulfilled? yes

The evaluation of the All data set for both candidates together shows that the AMS demonstrates a very good correlation with the reference method with a slope of 1.034 and an intercept of 0.843 at an expended total uncertainty of 16.0 %.

However, since the expanded uncertainty for the raw data sets A-Graz (Austria 2) and UK-Teddington (17011) is greater than 25 %, the application of correction factors / terms is inevitable for the demonstration of equivalence.

The January 2010 version of The Guidance is ambiguous with respect to which slope and intercept should be used to correct a candidate should it fail the test for equivalence. After communication with the convenor of the EC working group, which is responsible for setting up the Guide Mr. Theo Hafkenscheid), it was decided that the requirement of the November 2005 version of the Guidance are still valid, and that the slope and intercept from the orthogonal regression of all the paired data should be used.

The 2006 UK Equivalence Report highlighted that this was a flaw in the mathematics required for equivalence as per the November 2005 version of The Guidance as it penalised instruments that were more accurate (Appendix E Section 4.2 therein). This same flaw is copied in the January 2010 version. It is the opinion of TŰV Rheinland and their UK partners that the BAM-1020 for PM_{10} is indeed being penalised by the mathematics for being accurate.

In this particular case, the slope for the „All data“ data set is 1.034.

The intercept for for the „All data“ data set is 0.843.

Thus an additional evaluation after application of the respective correction factors / terms to the data sets has been carried out for the following cases:

a) Correction for intercept

   The data set is corrected for the intercept of 0.843. The evaluation shows, that after this correction the expanded uncertainty for the data set UK-Teddington (17011) is still greater than 25% (refer to Table 7). Thus the correction for the intercept only is not sufficient to demonstrate equivalence.

b) Correction for slope

   The data set is corrected for the slope of 1.034. The evaluation shows, that after this correction the expanded uncertainty for all data sets is smaller than 25% (refer to Table 8). Thus equivalence can be demonstrated after slope correction The expanded measurement uncertainty improves from 16.0 % to 12.5 %.

c) Correction for intercept and slope

   The data set is corrected for the intercept of 0.843 and for the slope of 1.034. The evaluation shows, that after this correction the expanded uncertainty for all data sets is smaller than 25% (refer to Table 9). Thus equivalence can be demonstrated after intercept and slope correction The expanded measurement uncertainty improves from 16.0 % to 12.1 %.

Basically the correction for slope is regarded as sufficient, as the additional correction for the intercept only leads to marginal improvement of the data quality.

The version of the Guide of January 2010 requires that when operating in networks, a candidate method needs to be tested annually at a number of sites corresponding to the highest expanded uncertainty found during equivalence testing. These criteria are banded in 5 % steps (Guide [4], point 9.9.2, table 6). We have to bear in mind that the highest determined expanded uncertainty after correction for the slope respectively after correction for the intercept and the slope lays in the range 10 % to 15 %.

The respective realization of the above mentioned requirement on ongoing QA/QC in networks is the responsibility of the network operator or of the responsible authority of the member state. However TÜV Rheinland and their UK partners recommend, that the expanded uncertainty for the full data set is referred to for this, namely 16.0 % (uncorrected dataset) respectively 12.5 % (dataset after slope correction) respectively 12.1 % (dataset after intercept and slope correction), which again would require an annual test at four respectively three measurement sites.

6.6 Detailed representation of the test results

Table 7 to Table 9 show the results of the evaluations of the equivalence tests after application of correction factors and terms on the complete data set.

Table 7: Summary of the results of the equivalence test, after correction for intercept

PM_{10} Smart BAM 1020 Intercept Corrected	35.3% > 28 µg m-3	Orthogonal Regression			Between Instrument Uncertainties	
	W_{CM} / %	n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	Reference	Candidate
All Paired Data	14.2	320	0.982	1.034 +/- 0.008	0.000 +/- 0.290	0.67	1.22
< 30 µg m-3	21.7	215	0.826	1.119 +/- 0.032	-1.288 +/- 0.557	0.53	1.09
> 30 µg m-3	16.3	105	0.971	1.042 +/- 0.017	-0.701 +/- 1.031	0.91	1.49

4294	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Cologne, Parking Lot	29	0.960	0.948 +/- 0.036	1.359 +/- 0.950	11.22	34.5
	Titz - Rödingen	37	0.962	1.058 +/- 0.035	-0.466 +/- 0.782	11.91	18.9
	Cologne, Frankfurter Str.	28	0.963	1.025 +/- 0.039	-2.136 +/- 1.083	8.92	42.9
Combined Datasets	< 30 µg m^3	68	0.814	1.040 +/- 0.055	-0.680 +/- 0.981	10.58	4.4
	> 30 µg m^3	26	0.897	0.964 +/- 0.063	0.967 +/- 2.438	10.38	100.0
	All Data	94	0.953	0.987 +/- 0.022	0.206 +/- 0.563	9.30	35.3

4295	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Cologne, Parking Lot	29	0.970	0.990 +/- 0.033	1.839 +/- 0.862	10.54	34.5
	Titz - Rödingen	37	0.961	1.056 +/- 0.035	0.417 +/- 0.785	14.52	18.9
	Cologne, Frankfurter Str.	28	0.969	1.021 +/- 0.035	-0.996 +/- 0.994	7.32	42.9
Combined Datasets	< 30 µg m^3	68	0.830	1.056 +/- 0.053	0.092 +/- 0.952	14.49	4.4
	> 30 µg m^3	26	0.929	1.025 +/- 0.056	-0.129 +/- 2.151	9.57	100.0
	All Data	94	0.960	1.004 +/- 0.021	0.892 +/- 0.528	9.53	30.9

Austria1	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Graz	45	0.969	1.025 +/- 0.027	-1.045 +/- 1.848	20.50	82.2
	Steyregg	45	0.824	1.049 +/- 0.067	-2.593 +/- 1.392	8.95	8.9
Combined Datasets	< 30 µg m^3	50	0.644	1.339 +/- 0.109	-7.631 +/- 2.135	39.58	2.0
	> 30 µg m^3	40	0.960	1.057 +/- 0.034	-3.668 +/- 2.431	19.88	100.0
	All Data	90	0.983	1.039 +/- 0.015	-2.137 +/- 0.729	15.78	45.6

Austria2	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Graz	45	0.966	1.033 +/- 0.029	1.106 +/- 1.962	24.39	82.2
	Steyregg	45	0.793	1.035 +/- 0.072	-2.511 +/- 1.489	10.09	8.9
Combined Datasets	< 30 µg m^3	50	0.557	1.492 +/- 0.130	-10.304 +/- 2.545	59.63	2.0
	> 30 µg m^3	40	0.956	1.084 +/- 0.037	-3.138 +/- 2.635	21.77	100.0
	All Data	90	0.980	1.079 +/- 0.016	-2.544 +/- 0.818	18.61	45.6

J7860	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	59	0.906	1.172 +/- 0.047	0.361 +/- 0.839	37.23	6.8
	> 30 µg m^3	38	0.974	1.002 +/- 0.027	2.311 +/- 1.548	15.38	100.0
	All Data (Tusimice)	97	0.984	0.999 +/- 0.013	2.896 +/- 0.492	15.92	43.3

J7863	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	58	0.913	1.158 +/- 0.045	-0.684 +/- 0.812	30.54	6.9
	> 30 µg m^3	38	0.978	1.032 +/- 0.025	1.105 +/- 1.450	15.50	100.0
	All Data (Tusimice)	96	0.987	1.035 +/- 0.012	1.193 +/- 0.461	15.54	43.8

17011	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	39	0.960	1.039 +/- 0.034	-0.210 +/- 0.458	8.21	0.0
	> 30 µg m^3	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.949	1.162 +/- 0.042	-1.608 +/- 0.602	26.73	2.5

17022	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	39	0.958	1.051 +/- 0.035	-0.240 +/- 0.477	10.40	0.0
	> 30 µg m^3	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.963	1.110 +/- 0.034	-0.893 +/- 0.488	19.05	2.5

Table 8: Summary of the results of the equivalence test, after correction for slope

PM_{10} Smart BAM 1020 Slope Corrected	35.3% > 28 µg m-3	Orthogonal Regression				Between Instrument Uncertainties	
	W_{CM} / %	n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	Reference	Candidate
All Paired Data	12.5	320	0.982	1.000 +/- 0.008	0.824 +/- 0.280	0.67	1.18
< 30 µg m-3	17.9	215	0.826	1.079 +/- 0.031	-0.372 +/- 0.538	0.53	1.06
> 30 µg m-3	14.9	105	0.971	1.007 +/- 0.017	0.164 +/- 0.997	0.91	1.44

4294	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Cologne, Parking Lot	29	0.960	0.917 +/- 0.035	2.144 +/- 0.919	12.72	34.5
	Titz - Rödingen	37	0.962	1.023 +/- 0.034	0.378 +/- 0.756	9.03	18.9
	Cologne, Frankfurter Str.	28	0.963	0.990 +/- 0.037	-1.235 +/- 1.048	10.44	42.9
Combined Datasets	< 30 µg m^3	68	0.814	1.003 +/- 0.053	0.219 +/- 0.949	8.97	4.4
	> 30 µg m^3	26	0.897	0.931 +/- 0.061	1.815 +/- 2.358	11.57	100.0
	All Data	94	0.953	0.954 +/- 0.022	1.032 +/- 0.545	10.23	35.3

4295	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Cologne, Parking Lot	29	0.970	0.957 +/- 0.032	2.605 +/- 0.834	9.04	34.5
	Titz - Rödingen	37	0.961	1.021 +/- 0.034	1.233 +/- 0.760	11.24	18.9
	Cologne, Frankfurter Str.	28	0.969	0.988 +/- 0.034	-0.135 +/- 0.962	7.70	42.9
Combined Datasets	< 30 µg m^3	68	0.830	1.018 +/- 0.052	0.961 +/- 0.921	11.33	4.4
	> 30 µg m^3	26	0.929	0.990 +/- 0.054	0.737 +/- 2.080	8.24	100.0
	All Data	94	0.960	0.971 +/- 0.020	1.693 +/- 0.510	8.28	30.9

Austria1	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Graz	45	0.969	0.991 +/- 0.027	-0.164 +/- 1.787	19.96	82.2
	Steyregg	45	0.824	1.012 +/- 0.065	-1.624 +/- 1.347	9.63	8.9
Combined Datasets	< 30 µg m^3	50	0.644	1.285 +/- 0.105	-6.378 +/- 2.065	34.09	2.0
	> 30 µg m^3	40	0.960	1.022 +/- 0.033	-2.687 +/- 2.351	20.01	100.0
	All Data	90	0.983	1.005 +/- 0.014	-1.240 +/- 0.705	15.78	45.6

Austria2	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Individual Datasets	Graz	45	0.966	0.998 +/- 0.028	1.920 +/- 1.898	22.33	82.2
	Steyregg	45	0.793	0.997 +/- 0.069	-1.531 +/- 1.441	11.48	8.9
Combined Datasets	< 30 µg m^3	50	0.557	1.429 +/- 0.126	-8.879 +/- 2.462	52.84	2.0
	> 30 µg m^3	40	0.956	1.048 +/- 0.036	-2.167 +/- 2.549	20.66	100.0
	All Data	90	0.980	1.043 +/- 0.016	-1.631 +/- 0.791	17.32	45.6

J7860	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	59	0.906	1.131 +/- 0.046	1.195 +/- 0.812	32.66	6.8
	> 30 µg m^3	38	0.974	0.969 +/- 0.026	3.074 +/- 1.498	13.09	100.0
	All Data (Tusimice)	97	0.984	0.966 +/- 0.012	3.625 +/- 0.476	13.28	43.3

J7863	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	58	0.913	1.119 +/- 0.044	0.182 +/- 0.786	26.26	6.9
	> 30 µg m^3	38	0.978	0.998 +/- 0.025	1.904 +/- 1.403	12.97	100.0
	All Data (Tusimice)	96	0.987	1.001 +/- 0.012	1.975 +/- 0.446	12.77	43.8

17011	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	39	0.960	1.004 +/- 0.033	0.620 +/- 0.443	5.53	0.0
	> 30 µg m^3	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.949	1.123 +/- 0.041	-0.728 +/- 0.583	22.58	2.5

17022	Dataset	Orthogonal Regression				Limit Value of 50 µg m^3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m^3
Combined Datasets	< 30 µg m^3	39	0.958	1.016 +/- 0.034	0.592 +/- 0.461	7.27	0.0
	> 30 µg m^3	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.963	1.073 +/- 0.033	-0.040 +/- 0.473	15.26	2.5

Table 9: Summary of the results of the equivalence test, after correction for intercept and slope

PM_{10} Smart BAM 1020 Slope and Intercept Corrected	35.3% > 28 µg m-3	Orthogonal Regression				Between Instrument Uncertainties	
	W_{CM} / %	n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	Reference	Candidate
All Paired Data	12.1	320	0.982	1.000 +/- 0.008	0.009 +/- 0.280	0.67	1.18
< 30 µg m-3	15.5	215	0.826	1.079 +/- 0.031	-1.187 +/- 0.538	0.53	1.06
> 30 µg m-3	14.9	105	0.971	1.007 +/- 0.017	-0.651 +/- 0.997	0.91	1.44

4294	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Cologne, Parking Lot	29	0.960	0.917 +/- 0.035	1.329 +/- 0.919	15.05	34.5
	Titz - Rödingen	37	0.962	1.023 +/- 0.034	-0.437 +/- 0.756	7.33	18.9
	Cologne, Frankfurter Str.	28	0.963	0.990 +/- 0.037	-2.050 +/- 1.048	12.87	42.9
Combined Datasets	< 30 µg m³	68	0.814	1.003 +/- 0.053	-0.596 +/- 0.949	9.11	4.4
	> 30 µg m³	26	0.897	0.931 +/- 0.061	1.000 +/- 2.358	13.74	100.0
	All Data	94	0.953	0.954 +/- 0.022	0.217 +/- 0.545	12.26	35.3

4295	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Cologne, Parking Lot	29	0.970	0.957 +/- 0.032	1.790 +/- 0.834	9.04	34.5
	Titz - Rödingen	37	0.961	1.021 +/- 0.034	0.418 +/- 0.760	8.91	18.9
	Cologne, Frankfurter Str.	28	0.969	0.988 +/- 0.034	-0.950 +/- 0.962	9.54	42.9
Combined Datasets	< 30 µg m³	68	0.830	1.018 +/- 0.052	0.146 +/- 0.921	9.59	4.4
	> 30 µg m³	26	0.929	0.990 +/- 0.054	-0.078 +/- 2.080	8.55	100.0
	All Data	94	0.960	0.971 +/- 0.020	0.878 +/- 0.510	8.65	30.9

Austria1	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Graz	45	0.969	0.991 +/- 0.027	-0.979 +/- 1.787	20.64	82.2
	Steyregg	45	0.824	1.012 +/- 0.065	-2.439 +/- 1.347	11.48	8.9
Combined Datasets	< 30 µg m³	50	0.644	1.285 +/- 0.105	-7.193 +/- 2.065	31.13	2.0
	> 30 µg m³	40	0.960	1.022 +/- 0.033	-3.502 +/- 2.351	21.30	100.0
	All Data	90	0.983	1.005 +/- 0.014	-2.055 +/- 0.705	16.94	45.6

Austria2	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Individual Datasets	Graz	45	0.966	0.998 +/- 0.028	1.105 +/- 1.898	21.51	82.2
	Steyregg	45	0.793	0.997 +/- 0.069	-2.346 +/- 1.441	13.69	8.9
Combined Datasets	< 30 µg m³	50	0.557	1.429 +/- 0.126	-9.694 +/- 2.462	49.76	2.0
	> 30 µg m³	40	0.956	1.048 +/- 0.036	-2.982 +/- 2.549	20.80	100.0
	All Data	90	0.980	1.043 +/- 0.016	-2.446 +/- 0.791	17.28	45.6

J7860	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	59	0.906	1.131 +/- 0.046	0.380 +/- 0.812	29.59	6.8
	> 30 µg m³	38	0.974	0.969 +/- 0.026	2.259 +/- 1.498	11.97	100.0
	All Data (Tusimice)	97	0.984	0.966 +/- 0.012	2.810 +/- 0.476	11.73	43.3

J7863	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	58	0.913	1.119 +/- 0.044	-0.633 +/- 0.786	23.28	6.9
	> 30 µg m³	38	0.978	0.998 +/- 0.025	1.089 +/- 1.403	11.54	100.0
	All Data (Tusimice)	96	0.987	1.001 +/- 0.012	1.160 +/- 0.446	11.08	43.8

17011	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	39	0.960	1.004 +/- 0.033	-0.195 +/- 0.443	4.58	0.0
	> 30 µg m³	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.949	1.123 +/- 0.041	-1.543 +/- 0.583	19.51	2.5

17022	Dataset	Orthogonal Regression				Limit Value of 50 µg m³	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% > 28 µg m³
Combined Datasets	< 30 µg m³	39	0.958	1.016 +/- 0.034	-0.223 +/- 0.461	5.30	0.0
	> 30 µg m³	1		+/-	+/-		100.0
	All Data (Teddington)	40	0.963	1.073 +/- 0.033	-0.855 +/- 0.473	12.29	2.5

5. Appendix (Accreditations)

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 die

TÜV Rheinland Energie und Umwelt GmbH

mit ihrer

Messstelle für Immissionsschutz (Environmental Protection)
Am Grauen Stein, 51105 Köln

und ihrer unselbständigen Messstelle

Robert-Koch-Straße 27, 55129 Mainz

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

Bestimmung (Probenahme und Analytik) von anorganischen und organischen gas- oder partikelförmigen 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 arbeiten-der Messgeräte für Luftinhaltsstoffe einschließlich Systemen zur Datenauswertung und Emissionsfernüberwachung; Eignungsprüfungen von automatisch arbeitenden Emissions- und Immissionsmesseinrichtungen einschließlich Systemen zur Datenauswertung und Emissionsfernüberwachung; Feuerraummessungen; Ermittlung der Emissionen und Immissionen von Geräuschen; Ermittlung von Geräuschen und Vibrationen am Arbeitsplatz;
Modul Immissionsschutz

Die Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 13.05.2011 mit der Akkreditierungsnummer D-PL-11120-02 und ist gültig bis 31.01.2013. Sie besteht aus diesem Deckblatt, der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 32 Seiten.

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

Berlin, 13.05.2011

Andrea Valbuena
Abteilungsleiterin

Siehe Hinweise auf der Rückseite

Figure 28: Accreditation deed of TÜV Rheinland Energie und Umwelt GmbH

Bundesministerium für Wirtschaft, Familie und Jugend

Bestätigung der Akkreditierung

Das Bundesministerium für Wirtschaft, Familie und Jugend bestätigt, dass die

Umweltbundesamt GmbH
Spittelauer Lände 5, 1090 Wien
ÖKD Nr.: 30
Datum der Erstakkreditierung: 29. Juli 2009

ÖKD

als Kalibrierstelle akkreditiert ist und die Anforderungen des Maß- und Eichgesetzes, BGBl.Nr. 152/1950, zuletzt geändert durch BGBl. I Nr. 115/2010, der Kalibrierdienstverordnung, BGBl.Nr. 42/1994, zuletzt geändert durch BGBl. II Nr. 490/2001, des Akkreditierungsgesetzes, BGBl.Nr. 468/1992, zuletzt geändert durch BGBl. I Nr. 85/2002, und der ÖVE/ÖNORM EN ISO/IEC 17025:2007 erfüllt.

Der detaillierte Umfang der Akkreditierung ist dem jeweils gültigen Bescheid zu entnehmen.

Die akkreditierten Fachgebiete sind in der Liste der akkreditierten Stellen unter
www.bmwfj.gv.at/technikundvermessung/akkreditierung
veröffentlicht.

Wien, am 13.02.2012

Dipl.-Ing. Gerald Freistetter

Abteilung I/11 - Akkreditierungsstelle
1011 Wien | Stubenring 1 | Tel.: +43 (0)1 711 00 - 8235 | Fax: +43 (0)1 711 00 93 - 8235 | DVR 0037257
E-Mail: post@I11.bmwfj.gv.at | **www.bmwfj.gv.at/akkreditierung**

Figure 29: Accreditation deed of Environment Agency Austria

CZECH HYDROMETEOROLOGICAL INSTITUTE

Na Šabatce 17, 143 06 Praha 4 – Komořany, Czech Republic

To whom it may concern :

Subject: certification

Prague, 5.12.2012

We declare that our Ambient Air Monitoring Network and Laboratories as Imission Monitoring (IM) department-system by CHMI is designated as National Reference Laboratory (NRL) for air pollution by MoE CR and IM is accredited according to EN ISO/IEC 17025:2005.

Jiri Novak

Head of Imission Monitoring system
Czech Hydrometeorological Institute

Figure 30: Accreditation deed of CHMI, CZ

Schedule of Accreditation
Issued by
United Kingdom Accreditation Service
21 - 47 High Street, Feltham, Middlesex, TW13 4UN, UK

UKAS TESTING 0002 Accredited to ISO/IEC 17025:2005	**NPL Management Ltd** **Issue No:** 047 **Issue date:** 22 October 2012	
	Hampton Road **Teddington** **Middlesex** **TW11 0LW**	**Contact: Customer Helpline** **Tel: +44 (0)20 8943 7070** **Fax: +44 (0)20 8943 6184** **E-Mail: measurement_services@npl.co.uk** **Website: www.npl.co.uk**

Testing performed by the Organisation at the locations specified below

Locations covered by the organisation and their relevant activities

Laboratory locations:

Location details		**Activity**	**Location code**
Address Hampton Road Teddington Middlesex TW11 0LW	**Local contact** Mr Tahir Maqba Customer Services Manager Tel: +44 (0)20 8943 6796 Fax: +44 (0)20 8943 6184 E-Mail: tahir.maqba@npl.co.uk Website: www.npl.co.uk	**Support Functions:** Quality System Quality Audit Administration **Testing:** Mechanical, metallurgical, physical and chemical testing **Sampling and Testing:** Stack Emissions Testing	A
Address University of Huddersfield Queensgate Huddersfield Building T4/04 HD1 3DH	**Local contact** Lisa Leonard Tel: +44 (0) 20 8943 8716 Fax: +44 (0) 208 614 0482 E-mail: lisa.leonard@npl.co.uk Website: http://www.npl.co.uk/huddersfield	**Testing:** Dimensional testing	D

Site activities performed away from the locations listed above:

Location details	**Activity**	**Location code**
Customers' premises/sites	Sampling and analysis	B
Customer Sites requiring Stack Emissions Testing	Stack Emissions Testing	C

Assessment Manager: TSO Page 1 of 15

Schedule of Accreditation
issued by
United Kingdom Accreditation Service
21 - 47 High Street, Feltham, Middlesex, TW13 4UN, UK

UKAS TESTING
0002
Accredited to
ISO/IEC 17025:2005

NPL Management Ltd
Issue No: 047 **Issue date:** 22 October 2012

Testing performed by the Organisation at the locations specified

Materials/Products tested	Type of test/Properties measured/Range of measurement	Standard specifications/ Equipment/Techniques used	Location Code
WORKPLACE AND AMBIENT ATMOSPHERIC POLUTANTS, AND OTHER GAS SAMPLES (cont'd)	Chemical Tests (cont'd)		
Volatile organic compounds using pumped sorbent tubes	0.0001 to 200 ml/m³ (ppm v/v) for some individual species	Documented in-house method based on MDHS 60 and 72 and ISO standard TC/146/SC2/N142 using Gas Chromatography with a FID end point QPDQM/B/527	A
	Physical Tests		
Volatile organic compounds using sorbent sampler tubes	0.0001 to 200 ml/m³ (ppm v/v) for some individual species with opinions and interpretations based on NIST research library	Documented in-house method based on BS EN ISO 16017-1&2, UK HSE MDHS 63, 72 & 80 using an automated thermal desorber gas chromatogram with a mass spectrometer and optional simultaneous flame ionisation detector (ATD/GC/MS-FID)	A
Total mercury from glass adsorption tubes containing gold-coated silica	Total mercury	Thermal desorption-atomic fluorescence spectroscopy. Documented in-house method QPAS/B/544 in accordance with BS EN 15852:2010	A
Weight of suspended particulate matter	25 ug to 7 mg equivalent to 1 µg/m³ for a 1 m³/hour sampler to 120 µg/m³ for a 2.3 m³/hour sampler	Documented in-house method based on BS EN 14907:2005	A
Pumped and diffusive sorbent tubes	C2 to C10 hydrocarbons, Nitrogen dioxide Nitrogen monoxide Sulphur dioxide Volatile organic compounds	Documented in-house methods QPDQM/B/522, 523, 525, 526, 527	B

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Figure 31: Accreditation deed of NPL, UK (excerpts)

6. Appendix (Measured values)

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 1 of 13**

Manufacturer	Net One Instruments		
Type of instrument	BAM-1020	Suspended particulate matter PM10	Measured values in µg/m³ (ACT)
Serial-No.	Device 1 / Device 2		

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
1	2/11/2006	35.2	35.5	29.8	32.9	Devices 4294 / 4295	D-Cologne, parking lot
2	2/12/2006			25.7	26.0		
3	2/13/2006	33.4	35.7	30.9	33.3		
4	2/14/2006						
5	2/15/2006	12.5	11.7	10.9	12.7		
6	2/16/2006	9.8	9.4	10.1	11.5		
7	2/17/2006	9.6	9.2	8.2	8.7		
8	2/18/2006			14.0	13.3		
9	2/19/2006			10.4	11.5		
10	2/20/2006	9.2	10.0	12.4	14.7		
11	2/21/2006	14.0	13.8	14.1	16.1		
12	2/22/2006	16.0	16.1	17.7	18.9		
13	2/23/2006			20.5	20.3		
14	2/24/2006			29.5	31.1		
15	2/25/2006	27.9	28.8	29.1	31.6		
16	2/26/2006			31.1	32.2		
17	2/27/2006			32.1	34.1		
18	2/28/2006			11.8	14.0		
19	3/1/2006	15.5	15.7	15.6	14.9		
20	3/2/2006	19.1	20.0	22.1	21.8		
21	3/3/2006	45.8	45.9	43.9	46.3		
22	3/4/2006			46.1	47.8		
23	3/5/2006			21.0	23.1		
24	3/6/2006	21.1	21.0	19.8	22.0		
25	3/7/2006	26.2	26.6	26.8	28.7		
26	3/8/2006	14.6	13.6	14.3	16.3		
27	3/9/2006	14.8	14.6	16.8	16.2		
28	3/10/2006	12.1	12.0	11.1	11.6		
29	3/11/2006			25.8	27.5		
30	3/12/2006			29.9	31.7		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 2 of 13**

Manufacturer: Net One Instruments

Type of instrument: BAM-1020

Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
31	3/13/2006	24.7	24.5	25.7	28.0	Devices 4294 / 4295	D-Cologne, parking lot
32	3/14/2006	30.2	30.1	31.4	33.2		
33	3/15/2006	33.3	33.6	35.2	36.7		
34	3/16/2006	39.2	39.1	42.1	43.5		
35	3/17/2006			39.5	40.8		
36	3/18/2006	37.0	37.2	40.3	40.4		
37	3/19/2006			58.8	61.9		
38	3/20/2006	62.5	62.5	60.9	64.8		
39	3/21/2006			31.8	32.9		
40	3/22/2006	29.3	29.4	31.1	33.6		
41	3/23/2006	21.3	22.7	28.8	28.7		
42	3/24/2006			33.6	36.1		
43	3/25/2006	8.1	9.8	11.5	12.2		
44	3/26/2006			11.1	11.5		
45	3/27/2006			13.4	14.7		
46	3/28/2006	8.9	9.3	13.4	13.8		
47	3/29/2006	10.3	11.2	16.1	17.3		
48	3/30/2006			9.8	10.6		
49	3/31/2006	9.6	10.9	15.3	16.3		
50	4/1/2006			11.5	12.5		
51	4/2/2006			10.0	10.5		
52	4/3/2006			20.3	22.8		
53	4/4/2006			24.7	26.7		
54	7/26/2006	49.1	48.6	52.8	54.2	Devices 4294 / 4295	D-Titz-Rödingen
55	7/27/2006	39.0	39.7	43.4	44.4		
56	7/28/2006						
57	7/29/2006						
58	7/30/2006	17.8	19.2	20.0	21.6		
59	7/31/2006	17.6	18.7	21.3	21.8		
60	8/1/2006	15.9	16.0	16.8	19.6		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 3 of 13**

Manufacturer	Net One Instruments	
Type of instrument	BAM-1020	Suspended particulate matter PM10 Measured values in µg/m³ (ACT)
Serial-No.	Device 1 / Device 2	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
61	8/2/2006	17.4	17.8	18.7	20.2	Devices 4294 / 4295	D-Titz-Rödingen
62	8/3/2006	16.5	17.6	16.2	17.8		
63	8/4/2006	22.5	23.0	24.8	25.0		
64	8/5/2006	20.1	21.4	24.3	25.2		
65	8/6/2006	18.7	18.7	21.0	22.4		
66	8/7/2006	22.0	22.9	21.6	23.3		
67	8/8/2006	14.6	14.8	13.7	14.8		
68	8/9/2006	29.8	28.0	27.7	28.5		
69	8/10/2006	22.6	22.9	23.0	23.7		
70	8/11/2006	18.0	16.6	16.9	17.5		
71	8/12/2006	20.4	19.5	20.5	21.8		
72	8/13/2006	13.8	12.9	13.5	13.2		
73	8/14/2006	13.8	12.9	20.4	20.9		
74	8/15/2006	30.7	30.3	29.9	30.5		
75	8/16/2006	22.0	23.6	24.8	25.3		
76	8/17/2006	16.9	17.8	16.9	17.7		
77	8/18/2006	12.1	11.6	13.1	12.7		
78	8/19/2006	11.5	13.2	13.8	15.4		
79	8/20/2006	10.3	11.6	13.5	14.4		
80	8/21/2006	15.4	15.5	18.5	18.8		
81	8/22/2006	19.5	20.4	21.0	21.7		
82	8/23/2006	38.2	38.9	42.6	42.8		
83	8/24/2006	15.0	16.1	17.1	18.4		
84	8/25/2006	31.9	31.0	32.5	34.0		
85	8/26/2006	31.1	30.6	32.3	31.5		
86	8/27/2006	21.3	21.0	22.8	23.5		
87	8/28/2006	12.8	13.2	14.4	14.6		
88	8/29/2006	13.7	14.5	15.7	14.5		
89	8/30/2006						
90	8/31/2006	16.7	18.2	22.3	22.0		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 4 of 13**

Manufacturer: Net One Instruments
Type of instrument: BAM-1020
Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
91	9/1/2006	23.3	23.1	26.1	26.1	Devices 4294 / 4295	D-Titz-Rödingen
92	9/2/2006	20.4	20.0	20.5	23.5		
93	9/3/2006	9.3	8.9	10.3	12.6		
94	9/29/2006	32.9	30.4	33.5	34.6	Devices 4294 / 4295	D-Cologne, Frankf. Str.
95	9/30/2006	18.8	19.7	16.5	17.8		
96	10/1/2006	15.2	15.4	11.5	13.0		
97	10/2/2006	17.9	17.0	12.0	13.1		
98	10/3/2006	18.8	18.1	15.4	16.9		
99	10/4/2006	23.5	23.7	21.5	23.3		
100	10/5/2006	14.1	12.6	15.2	15.7		
101	10/6/2006	14.1	12.8	13.1	13.0		
102	10/7/2006	20.6	21.3	19.3	20.1		
103	10/8/2006	23.7	23.0	21.8	22.0		
104	10/9/2006	30.4	30.4	30.8	29.7		
105	10/10/2006	36.2	35.9	34.8	35.0		
106	10/11/2006	39.7	38.9	36.5	37.9		
107	10/12/2006	51.1	50.4	49.5	51.3		
108	10/13/2006	42.0	42.0	40.3	42.5		
109	10/14/2006	52.1	50.0	47.8	49.3		
110	10/15/2006	37.7	35.7	37.5	37.6		
111	10/16/2006	31.0	29.2	32.0	32.8		
112	10/17/2006	31.8	30.1	33.8	33.9		
113	10/18/2006	31.8	30.1	34.8	35.4		
114	10/19/2006	22.7	21.6	21.8	23.2		
115	10/20/2006	14.2	13.1	13.3	14.5		
116	10/21/2006	13.6	11.8	12.0	13.8		
117	10/22/2006	13.2	12.9	11.6	15.2		
118	10/23/2006	15.4	15.4	15.4	16.7		
119	10/24/2006	19.4	19.2	18.1	18.6		
120	10/25/2006	19.8	18.7	22.5	22.5		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 5 of 13**

Manufacturer: Net One Instruments
Type of instrument: BAM-1020
Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
121	10/26/2006	33.4	29.0	31.1	33.7	Devices 4294 / 4295	D-Cologne, Frankf. Str.
122	6/5/2008	20.2	20.4	26.1	26.4	Devices Austria 1 / Austria 2	A-Steyregg
123	6/6/2008	16.6	17.3	20.8	20.3		
124	6/7/2008	13.9	14.9	16.7	17.6		
125	6/8/2008	20.7	21.5	20.0	21.2		
126	6/9/2008	14.7	15.4	17.1	17.2		
127	6/10/2008						
128	6/11/2008	24.1	24.7	21.8	23.5		
129	6/12/2008	21.9	22.7	22.0	21.1		
130	6/13/2008	19.6	20.1	17.6	19.7		
131	6/14/2008	17.6	17.9	20.4	19.6		
132	6/15/2008	16.2	16.6	15.5	15.5		
133	6/16/2008	12.0	11.9	12.1	12.4		
134	6/17/2008						
135	6/18/2008		14.4	15.5	14.3		
136	6/19/2008						
137	6/20/2008		20.4	23.8	21.6		
138	6/21/2008		19.5	18.9	18.6		
139	6/22/2008		27.6	21.2	21.6		
140	6/23/2008		23.1	22.3	22.1		
141	6/24/2008						
142	6/25/2008	28.6	29.4	28.2	28.3		
143	6/26/2008	31.2	32.4	30.6	30.0		
144	6/27/2008	25.4		28.0	27.8		
145	6/28/2008	16.5	16.5	17.9	18.3		
146	6/29/2008	16.7	17.7	15.9	16.2		
147	6/30/2008	19.4	18.6	18.3	18.0		
148	7/1/2008						
149	7/2/2008						
150	7/3/2008	35.6	35.8	37.1	36.4		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 6 of 13**

Manufacturer: Net One Instruments
Type of instrument: BAM-1020
Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
151	7/4/2008	19.5	19.1	20.4	20.4	Devices Austria 1 / Austria 2	A-Steyregg
152	7/5/2008	18.1	17.6	18.4	18.5		
153	7/6/2008	14.4	14.6	12.2	13.7		
154	7/7/2008	23.6	24.2	19.0	19.2		
155	7/8/2008						
156	7/9/2008	15.6	16.3	14.0	14.2		
157	7/10/2008	19.7	18.3	17.2	18.0		
158	7/11/2008	20.0	18.8	18.7	19.2		
159	7/12/2008	19.0	19.2	16.8	16.6		
160	7/13/2008	15.7	15.7	12.4	12.0		
161	7/14/2008	20.5	21.5	20.2	20.0		
162	7/15/2008						
163	7/16/2008	22.9	23.4	23.8	24.3		
164	7/17/2008	17.3	17.6	12.6	12.1		
165	7/18/2008	20.9	20.8	18.8	18.0		
166	7/19/2008	15.5	15.2	14.2	13.3		
167	7/20/2008	17.3	17.6	14.0	13.3		
168	7/21/2008	18.6	18.9	16.6	18.8		
169	7/22/2008						
170	7/23/2008	22.6	22.0	19.4	18.7		
171	7/24/2008	30.5	31.1	26.8	25.7		
172	7/25/2008	26.8	28.0	27.0	25.0		
173	7/26/2008	20.4	20.5	21.9	19.9		
174	7/27/2008	21.7	22.0	21.4	20.1		
175	7/28/2008	22.5	23.7	23.9	24.5		
176	7/29/2008						
177	7/30/2008	19.5	20.4	19.4	18.5		
178	7/31/2008	19.3	20.1	20.1	18.0		
179	8/1/2008	25.6	25.9	21.5	21.3		
180	8/2/2008	16.8	18.4	16.0	13.2		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 7 of 13**

Manufacturer: Net One Instruments

Type of instrument: BAM-1020

Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
181	8/3/2008	10.7	11.7	10.0	8.7	Devices Austria 1 / Austria 2	A-Steyregg
182	8/4/2008	20.5	22.1	21.2	19.7		
183	12/5/2007	121.1	121.8	125.6	128.7	Devices Austria 1 / Austria 2	A-Graz
184	12/6/2007	107.7	105.9	108.1	109.6		
185	12/10/2007	71.4	69.5	71.4	71.6		
186	12/13/2007	11.3	11.0	16.8	18.6		
187	12/16/2007		31.1	30.5	31.9		
188	12/17/2007	53.8		52.1	53.4		
189	12/19/2007		82.5	90.0	91.9		
190	12/20/2007	78.6	79.5	84.3	85.5		
191	1/7/2008		107.4	109.9	113.1		
192	1/8/2008	95.5	94.6	96.8	101.4		
193	1/9/2008		86.5	91.4	93.0		
194	1/10/2008	65.0	64.9	67.4	70.6		
195	1/13/2008	63.7	62.1	59.2	62.4		
196	1/14/2008	50.4	48.8	50.4	52.9		
197	1/15/2008	49.3	48.6	49.5	51.4		
198	1/16/2008	52.9	51.3	46.5	48.3		
199	1/17/2008	57.9	57.1	53.5	55.3		
200	1/20/2008	63.9	64.2	61.0	62.8		
201	1/21/2008	100.5	97.9	98.8	99.9		
202	1/22/2008	44.6	44.6	42.6	44.4		
203	1/23/2008	52.4	50.3	52.3	53.7		
204	1/24/2008	90.6	92.0	89.5	90.1		
205	1/28/2008	20.1	18.9	16.2	20.3		
206	1/30/2008	78.2	77.6	80.8	84.4		
207	1/31/2008	72.8	71.4	71.8	73.8		
208	2/3/2008	22.0	21.7	21.4	23.3		
209	2/4/2008	55.5	56.3	59.1	61.4		
210	2/5/2008	44.7	44.3	45.2	47.1		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 8 of 13**

Manufacturer: Net One Instruments
Type of instrument: BAM-1020
Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
211	2/6/2008	43.3	43.6	45.6	47.5	Devices Austria 1 / Austria 2	A-Graz
212	2/7/2008	43.2	42.2	38.9	41.5		
213	2/10/2008	64.6	64.1	59.0	61.3		
214	2/11/2008	83.6	82.3	85.1	85.5		
215	2/12/2008	87.9	87.0	85.2	90.2		
216	2/13/2008	111.4	109.8	111.9	115.3		
217	2/14/2008	97.9	96.8	99.3	103.3		
218	2/17/2008	52.6	51.2	46.0	48.9		
219	2/18/2008	47.1	47.2	49.5	53.1		
220	2/19/2008	69.7	69.2	76.8	81.0		
221	2/20/2008	102.8	104.5	102.5	105.9		
222	2/21/2008	84.0	82.7	93.0	97.1		
223	2/24/2008	60.9	62.4	53.4	57.7		
224	2/25/2008	73.8	74.8	82.6	86.2		
225	2/26/2008	79.6	77.7	92.0	94.5		
226	2/27/2008	43.1	42.6	58.1	61.6		
227	2/28/2008	52.7	51.6	56.9	60.1		
228	3/2/2008	10.8	11.1	6.6	7.4		
229	3/3/2008	24.3	24.9	37.5	40.9		
230	3/4/2008	15.2	14.7	18.0	20.4		
231	3/5/2008	17.3	18.2	16.3	19.6		
232	3/6/2008	26.0	25.3	28.8	31.3		
233	1/7/2010	47.0		47.7	49.8	Devices J7860 / J7863	CZ-Tusimice
234	1/8/2010	50.4		51.6	53.3		
235	1/9/2010			50.8	51.6		
236	1/10/2010			17.6	16.7		
237	1/11/2010	40.2		43.2	42.7		
238	1/12/2010	53.7		62.5	62.5		
239	1/13/2010	68.5		72.2	74.6		
240	1/14/2010	31.6		33.3	34.9		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 9 of 13**

Manufacturer: Net One Instruments

Type of instrument: BAM-1020

Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
241	1/15/2010	44.4		46.4	46.8	Devices J7860 / J7863	CZ-Tusimice
242	1/16/2010			41.0	40.8		
243	1/17/2010			51.6	51.0		
244	1/18/2010	21.9		23.6	23.3		
245	1/19/2010	29.3		30.1	32.2		
246	1/20/2010	51.7		53.2	53.6		
247	1/21/2010	77.2		79.1	79.8		
248	1/22/2010	91.8		92.1	93.2		
249	1/23/2010			89.9	89.9		
250	1/24/2010			69.4	71.3		
251	1/25/2010			64.4	64.6		
252	1/26/2010	53.8		66.8	66.7		
253	1/27/2010	48.4		55.4	54.8		
254	1/28/2010	5.8		9.6	7.9		
255	1/29/2010	6.0		7.7			
256	1/30/2010			10.4			
257	1/31/2010						
258	2/1/2010	12.7		14.0	13.0		
259	2/2/2010	6.4		8.4	8.3		
260	2/3/2010	9.2		12.1	11.7		
261	2/4/2010	55.7		57.8	57.9		
262	2/5/2010	55.1		55.1	55.9		
263	2/6/2010	66.8		68.9	69.9		
264	2/7/2010	46.5		50.7	51.3		
265	2/8/2010	48.3		51.1	50.6		
266	2/9/2010	62.7		64.4	64.0		
267	2/10/2010	87.2		90.9	92.1		
268	2/11/2010	50.9		54.9	55.7		
269	2/12/2010	16.1		17.0	18.3		
270	2/13/2010	11.0		13.0	13.0		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 10 of 13**

Manufacturer	Net One Instruments
Type of instrument	BAM-1020
Serial-No.	Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
271	2/14/2010	29.2		31.8	31.9	Devices J7860 / J7863	CZ-Tusimice
272	2/15/2010	47.5		52.8	53.8		
273	2/16/2010	57.9		61.3	61.5		
274	2/17/2010	75.3		76.6	76.6		
275	2/18/2010	69.0		73.0	74.8		
276	2/19/2010	55.2		58.6	60.3		
277	2/20/2010	20.4		21.4	22.3		
278	2/21/2010	19.9		20.2	20.8		
279	2/22/2010	67.8		72.0	72.9		
280	2/23/2010	112.5		113.0	115.6		
281	2/24/2010	70.6		78.1	79.2		
282	2/25/2010	64.6					
283	2/26/2010	37.1		39.4	37.8		
284	2/27/2010	25.0		29.8	29.0		
285	2/28/2010	13.5		19.7	19.7		
286	3/1/2010	6.5		9.5	9.1		
287	3/2/2010	13.8		18.2	17.4		
288	3/3/2010	12.6		16.4	15.3		
289	3/4/2010	14.9		21.4	19.0		
290	3/5/2010	14.3		24.1	22.3		
291	3/6/2010	24.0		35.1	31.7		
292	4/20/2010	41.0		45.1	42.8		
293	4/21/2010	13.8		17.2	15.9		
294	4/22/2010	19.6		26.2	25.4		
295	4/23/2010	32.9		38.6	37.8		
296	4/24/2010	48.0		51.9	50.2		
297	4/25/2010	36.8		41.4	40.2		
298	4/26/2010	20.4		25.1	23.1		
299	4/27/2010	19.5		23.4	21.4		
300	4/28/2010	26.2		33.1	30.5		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 11 of 13**

Manufacturer Net One Instruments

Type of instrument BAM-1020

Serial-No. Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
301	4/29/2010	35.6		45.2	43.6	Devices J7860 / J7863	CZ-Tusimice
302	4/30/2010	27.2		34.4	34.0		
303	5/1/2010	13.2		16.6	14.7		
304	5/2/2010	29.0		33.0	28.9		
305	5/3/2010	15.1		17.4	15.5		
306	5/4/2010	21.1		27.0	25.7		
307	5/5/2010	24.8		29.6	26.6		
308	5/6/2010	12.0		13.2	11.2		
309	5/7/2010	8.5		12.5	9.0		
310	5/8/2010	18.1		20.8	18.5		
311	5/9/2010	15.7		17.8	15.6		
312	5/10/2010	39.4		41.5	39.9		
313	5/11/2010	30.5		30.4	28.8		
314	5/12/2010	14.4		16.3	14.9		
315	5/13/2010	17.5		18.7	16.5		
316	5/14/2010	4.7		6.4	4.9		
317	5/15/2010	12.9		13.4	13.8		
318	5/16/2010	16.0		18.6	19.8		
319	5/17/2010	19.4		25.3	24.2		
320	5/18/2010	11.6		15.9	15.5		
321	5/19/2010	6.4		8.8	7.2		
322	5/20/2010	11.0		16.5	14.2		
323	5/21/2010	26.4		29.8	28.5		
324	5/22/2010	27.0		30.3	28.5		
325	5/23/2010	16.8		20.3	16.9		
326	5/24/2010	17.0		21.4	20.2		
327	5/25/2010	21.2		29.3	27.7		
328	5/26/2010	30.2		30.7	31.7		
329	5/27/2010	29.4		41.3	36.9		
330	5/28/2010	22.3		27.1	29.0		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 12 of 13**

Manufacturer	Net One Instruments		
Type of instrument	BAM-1020		Suspended particulate matter PM10 Measured values in µg/m³ (ACT)
Serial-No.	Device 1 / Device 2		

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
331	5/29/2010	34.5		31.5	35.4	Devices J7860 / J7863	CZ-Tusimice
332	5/30/2010	6.6		7.2	6.1		
333	5/31/2010	3.9		6.2	4.3		
334	6/1/2010	4.7		7.1	4.1		
335	6/2/2010	4.9		9.4	7.0		
336	6/3/2010	9.2		19.1	19.9		
337	6/4/2010	14.7		21.3	19.8		
338	6/5/2010	21.0		29.8	26.6		
339	6/6/2010	22.0		23.3	22.9		
340	4/10/2012			8.8	9.8	Devices 17022 / 17011	UK-Teddington
341	4/11/2012			9.6	11.9		
342	4/12/2012	13.8	13.7	15.9	13.9		
343	4/13/2012	21.3	21.2	22.5	21.2		
344	4/14/2012	11.4	11.7	14.8	12.0		
345	4/15/2012	11.5	12.2	13.4	11.3		
346	4/16/2012	10.4	10.0	11.1	10.3		
347	4/17/2012	8.7	8.4	9.8	9.1		
348	4/18/2012	8.3	8.2	7.9	8.9		
349	4/19/2012	12.1	10.9	12.6	11.8		
350	4/20/2012	6.9	6.9	7.6	7.1		
351	4/21/2012	7.9	7.7	8.6	7.7		
352	4/22/2012	9.1	8.5	8.8	8.7		
353	4/23/2012	7.4	7.4	7.4	7.9		
354	4/24/2012	12.1	12.0	12.4	12.5		
355	4/25/2012	9.4	9.5	9.4	10.9		
356	4/26/2012	12.4	12.3	14.9	13.9		
357	4/27/2012	13.9	14.4	15.4	14.6		
358	4/28/2012	4.4	4.5	7.0	5.5		
359	4/29/2012	8.2	8.4	11.2	11.5		
360	4/30/2012	15.1	15.2	17.4	16.0		

Annex 1 **Measured values from field test sites, related to ambient conditions** **Page 13 of 13**

Manufacturer: Net One Instruments

Type of instrument: BAM-1020

Serial-No.: Device 1 / Device 2

Suspended particulate matter PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	Device 1 PM10 [µg/m³]	Device 2 PM10 [µg/m³]	Remark	Test site
361	5/1/2012	20.5	20.6	23.9	21.3	Devices 17022 / 17011	UK-Teddington
362	5/2/2012	22.8	23.1	25.0	23.5		
363	5/3/2012	16.0	16.3	17.7	17.8		
364	5/4/2012	12.8	13.1	15.1	15.5		
365	5/5/2012	10.2	10.2	11.6	12.2		
366	5/6/2012	16.4	15.9	17.6	16.7		
367	5/7/2012	10.3	10.6	12.0	12.8		
368	5/8/2012	12.6	13.0	13.9	13.9		
369	5/9/2012	5.5	5.5	8.3	8.4		
370	5/10/2012	6.1	6.2	5.8	4.5		
371	5/11/2012	8.4	8.6	9.9	10.6		
372	5/12/2012	12.9	13.2	13.9	15.0		
373	5/13/2012	12.1	11.9	10.6	13.4		
374	5/14/2012	8.0	8.0	8.1	9.7		
375	5/15/2012	8.9	9.1	10.7	10.9		
376	5/16/2012	13.0	13.1	13.1	15.2		
377	5/17/2012	26.4	27.0	25.9	27.4		
378	5/18/2012	22.9	23.4	26.1	25.9		
379	5/19/2012	19.4	20.0	20.9	22.5		
380	5/20/2012	15.9	16.0	16.6	18.2		
381	5/21/2012	31.2	31.7	37.7	41.2		

Annex 2 **Ambient conditions at the field test sites** **Page 1 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
1	2/11/2006	D-Cologne, parking lot	1.9	82.9	0.0		
2	2/12/2006		2.5	65.3	0.7		
3	2/13/2006		4.1	61.0	1.0		
4	2/14/2006		5.4	79.7	1.4		
5	2/15/2006		7.1	84.8	1.4		
6	2/16/2006		7.2	75.8	0.9		
7	2/17/2006		6.6	66.7	1.1		
8	2/18/2006		5.4	80.2	0.2		
9	2/19/2006		6.9	69.2	0.8		
10	2/20/2006		3.2	82.6	1.0		
11	2/21/2006		4.0	72.2	1.0		
12	2/22/2006		1.8	60.9	1.4		
13	2/23/2006		0.5	50.9	1.1		
14	2/24/2006		2.6	49.7	1.9		
15	2/25/2006		1.0	50.8	1.3		
16	2/26/2006		-1.9	72.8	0.5		
17	2/27/2006		1.2	89.1	0.2		
18	2/28/2006		1.2	88.9	1.7		
19	3/1/2006		-0.7	71.4	1.2		
20	3/2/2006		0.7	60.2	0.3		
21	3/3/2006		0.3	80.6	0.5		
22	3/4/2006		0.2	69.4	0.0		
23	3/5/2006		2.6	65.8	1.6		
24	3/6/2006		2.4	69.6	2.4		
25	3/7/2006		2.8	54.0	0.5		
26	3/8/2006		4.9	86.9	0.9		
27	3/9/2006		7.9	81.5	1.1		
28	3/10/2006		4.9	77.4	0.5		
29	3/11/2006		-1.2	68.7	2.3		
30	3/12/2006		-3.2	51.9	0.7		

Annex 2 **Ambient conditions at the field test sites** **Page 2 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
31	3/13/2006	D-Cologne, parking lot	-0.1	42.0	0.5		
32	3/14/2006		2.2	39.6	0.8		
34	3/15/2006		4.4	42.9	0.9		
34	3/16/2006		2.6	46.4	1.0		
35	3/17/2006		2.8	52.3	1.9		
36	3/18/2006		3.8	57.7	1.2		
37	3/19/2006		4.5	55.5	0.7		
38	3/20/2006		3.9	62.4	0.5		
39	3/21/2006		3.6	43.3	1.0		
40	3/22/2006		3.3	42.2	2.0		
41	3/23/2006		6.6	33.7	1.8		
42	3/24/2006		8.7	72.3	0.3		
43	3/25/2006		13.4	66.4	1.7		
44	3/26/2006		15.6	66.7	0.5		
45	3/27/2006		13.4	60.2	1.4		
46	3/28/2006		9.8	58.2	0.7		
47	3/29/2006		9.1	70.2	0.9		
48	3/30/2006		12.8	68.7	1.3		
49	3/31/2006		12.2	61.9	2.6		
50	4/1/2006		10.7	65.2	0.8		
51	4/2/2006		11.5	46.8	3.0		
52	4/3/2006		8.3	59.9	1.2		
53	4/4/2006		5.5	54.0	1.4		
54	7/26/2006	D-Titz-Rödingen	26.5	55.8	0.0		
55	7/27/2006		24.1	64.7	0.0		
56	7/28/2006		20.6	80.1	0.0		
57	7/29/2006		21.7	70.5	0.0		
58	7/30/2006		21.0	70.5	0.0		
59	7/31/2006		20.1	63.0	0.0		
60	8/1/2006		17.5	71.6	1.0		

Annex 2 **Ambient conditions at the field test sites** **Page 3 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
61	8/2/2006	D-Titz-Rödingen	15.7	72.8	0.8		
62	8/3/2006		15.1	79.8	0.0		
63	8/4/2006		17.9	77.2	0.2		
64	8/5/2006		19.3	73.3	0.1		
65	8/6/2006		18.7	71.0	0.1		
66	8/7/2006		18.8	75.0	0.3		
67	8/8/2006		15.9	71.7	0.2		
68	8/9/2006		15.0	78.3	0.0		
69	8/10/2006		13.7	78.1	0.0		
70	8/11/2006		12.7	81.0	0.1		
71	8/12/2006		14.1	74.4	0.1		
72	8/13/2006		15.0	71.8	0.6		
73	8/14/2006		15.2	80.4	0.4		
74	8/15/2006		16.0	79.4	0.2		
75	8/16/2006		17.4	75.3	0.2		
76	8/17/2006		18.9	73.9	0.2		
77	8/18/2006		18.8	68.8	1.6		
78	8/19/2006		18.3	72.4	0.1		
79	8/20/2006		16.5	75.0	1.7		
80	8/21/2006		15.7	80.3	0.3		
81	8/22/2006		14.8	79.5	0.0		
82	8/23/2006		17.5	72.0	0.1		
83	8/24/2006		16.0	75.1	1.2		
84	8/25/2006		16.1	80.5	0.1		
85	8/26/2006		15.5	79.9	0.0		
86	8/27/2006		15.6	80.5	0.1		
87	8/28/2006		12.7	81.7	0.4		
88	8/29/2006		12.7	77.8	0.2		
89	8/30/2006		13.1	79.6	0.0		
90	8/31/2006		16.9	69.9	0.6		

Annex 2 **Ambient conditions at the field test sites** **Page 4 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
91	9/1/2006	D-Titz-Rödingen	20.0	66.1	0.6		
92	9/2/2006		19.8	65.5	2.1		
93	9/3/2006		20.2	75.9	2.7		
94	9/29/2006	D-Cologne, Frankf. Str.	18.7	68.5	0.4		
95	9/30/2006		18.2	67.3	0.1		
96	10/1/2006		18.6	63.8	0.5		
97	10/2/2006		16.6	64.2	0.3		
98	10/3/2006		14.3	73.4	0.2		
99	10/4/2006		12.7	75.6	0.4		
100	10/5/2006		14.9	68.1	0.2		
101	10/6/2006		15.9	72.1	1.2		
102	10/7/2006		12.1	70.4	2.0		
103	10/8/2006		12.7	69.6	0.0		
104	10/9/2006		15.4	70.2	0.1		
105	10/10/2006		15.1	74.7	0.1		
106	10/11/2006		16.7	70.6	0.7		
107	10/12/2006		17.4	75.3	0.1		
108	10/13/2006		15.3	77.8	0.0		
109	10/14/2006		11.7	73.8	0.6		
110	10/15/2006		11.6	67.7	0.4		
111	10/16/2006		11.7	67.3	2.0		
112	10/17/2006		12.6	65.8	2.6		
113	10/18/2006		15.1	65.3	1.3		
114	10/19/2006		15.1	76.0	1.6		
115	10/20/2006		14.9	76.7	0.1		
116	10/21/2006		15.7	69.1	0.3		
117	10/22/2006		16.6	69.3	1.6		
118	10/23/2006		16.7	76.9	1.2		
119	10/24/2006		13.2	74.5	2.2		
120	10/25/2006		14.5	66.3	2.8		

Annex 2 **Ambient conditions at the field test sites** **Page 5 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
121	10/26/2006	D-Cologne, Frankf. Str.	19.1	64.2	0.5		
122	6/5/2008	A-Steyregg	18.1	73.1	2.2		
123	6/6/2008		17.8	77.2	1.9		
124	6/7/2008		17.9	76.6	1.0		
125	6/8/2008		17.4	85.0	0.8		
126	6/9/2008		19.9	71.1	1.3		
127	6/10/2008		22.4	64.9	1.2		
128	6/11/2008		18.5	74.5	1.8		
129	6/12/2008		16.8	65.2	1.5		
130	6/13/2008		10.9	80.0	1.3		
131	6/14/2008		13.3	71.9	0.6		
132	6/15/2008		16.9	58.7	0.8		
134	6/16/2008		16.9	69.1	1.0		
134	6/17/2008		16.6	83.1	1.0		
135	6/18/2008		16.8	84.0	1.0		
136	6/19/2008		20.0	70.9	0.8		
137	6/20/2008		21.2	65.3	1.3		
138	6/21/2008		22.5	63.9	1.0		
139	6/22/2008		26.2	62.6	0.8		
140	6/23/2008		24.8	64.4	1.1		
141	6/24/2008		21.9	75.4	1.0		
142	6/25/2008		25.1	70.1	1.3		
143	6/26/2008		20.5	85.6	0.9		
144	6/27/2008		20.5	71.3	0.8		
145	6/28/2008		20.5	67.6	1.4		
146	6/29/2008		23.7	65.1	1.0		
147	6/30/2008		21.0	73.3	1.3		
148	7/1/2008		22.8	65.0	1.6		
149	7/2/2008		24.2	68.6	1.2		
150	7/3/2008		24.0	69.5	1.9		

Annex 2 **Ambient conditions at the field test sites** **Page 6 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
151	7/4/2008	A-Steyregg	18.1	70.5	1.9		
152	7/5/2008		18.9	60.3	1.3		
153	7/6/2008		21.6	76.4	1.2		
154	7/7/2008		14.8	93.0	1.2		
155	7/8/2008		17.6	70.3	1.2		
156	7/9/2008		17.7	73.8	1.1		
157	7/10/2008		20.7	72.0	0.7		
158	7/11/2008		24.6	61.9	1.6		
159	7/12/2008		19.8	80.8	1.4		
160	7/13/2008		17.0	87.1	1.6		
161	7/14/2008		15.8	82.8	1.5		
162	7/15/2008		19.5	61.0	1.9		
163	7/16/2008		21.2	66.8	1.4		
164	7/17/2008		15.6	92.5	0.7		
165	7/18/2008		15.9	86.4	0.9		
166	7/19/2008		21.4	69.7	1.0		
167	7/20/2008		17.8	82.5	1.4		
168	7/21/2008		15.1	68.3	1.7		
169	7/22/2008		13.9	81.5	2.5		
170	7/23/2008		16.1	80.1	1.4		
171	7/24/2008		15.6	93.9	1.3		
172	7/25/2008		18.2	94.6	0.8		
173	7/26/2008		20.9	87.5	0.3		
174	7/27/2008		22.3	72.5	1.4		
175	7/28/2008		23.6	64.4	1.8		
176	7/29/2008		24.3	69.9	0.9		
177	7/30/2008		23.2	74.6	1.2		
178	7/31/2008		22.8	71.3	1.1		
179	8/1/2008		24.3	68.3	1.5		
180	8/2/2008		20.4	84.9	0.7		

Annex 2 **Ambient conditions at the field test sites** **Page 7 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]		
181	8/3/2008	A-Steyregg	22.1	72.7	0.9		
182	8/4/2008		22.2	69.2	2.1		
183	12/5/2007	A-Graz	1.1	83.9	0.1		
184	12/6/2007						
185	12/10/2007		1.1	98.4	0.2		
186	12/13/2007		4.7	41.4	1.8		
187	12/16/2007		-1.3	84.7	0.6		
188	12/17/2007		-2.7	83.5	0.3		
189	12/19/2007		-4.8	84.8	0.8		
190	12/20/2007		-5.9	89.1	0.7		
191	1/7/2008		-1.2	93.9	0.3		
192	1/8/2008						
193	1/9/2008		-1.6	88.0	0.2		
194	1/10/2008		-1.9	90.6	0.3		
195	1/13/2008		3.1	100.0	0.0		
196	1/14/2008		2.2	97.9	0.2		
197	1/15/2008		0.6	98.0	0.4		
198	1/16/2008		3.4	91.6	0.3		
199	1/17/2008		4.5	97.9	0.1		
200	1/20/2008		5.9	90.5	0.1		
201	1/21/2008		3.9	89.2	0.2		
202	1/22/2008		4.4	58.3	1.2		
203	1/23/2008		0.4	61.6	0.7		
204	1/24/2008						
205	1/28/2008		4.6	67.4	0.9		
206	1/30/2008		2.2	80.1	0.3		
207	1/31/2008		2.6	78.2	0.6		
208	2/3/2008		2.7	77.3	0.8		
209	2/4/2008		3.5	89.4	0.3		
210	2/5/2008						

Annex 2 **Ambient conditions at the field test sites** **Page 8 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]	Windrichtung [°]	Niederschlagsmenge [mm]
211	2/6/2008	A-Graz	3.1	93.7	0.4		
212	2/7/2008		2.8	58.1	1.1		
213	2/10/2008		1.4	69.0	0.2		
214	2/11/2008		0.2	73.7	0.4		
215	2/12/2008		-0.7	72.5	0.3		
216	2/13/2008						
217	2/14/2008						
218	2/17/2008		-3.5	46.3	0.4		
219	2/18/2008		4.4	33.9	0.6		
220	2/19/2008		4.5	53.3	0.7		
221	2/20/2008						
222	2/21/2008						
223	2/24/2008		8.1	61.0	0.3		
224	2/25/2008						
225	2/26/2008		8.4	65.5	0.4		
226	2/27/2008		10.2	53.1	0.6		
227	2/28/2008		7.1	68.1	0.6		
228	3/2/2008		13.3	41.7	1.9		
229	3/3/2008		12.2	51.9	1.2		
230	3/4/2008		3.2	77.6	0.8		
231	3/5/2008		1.7	46.5	1.3		
232	3/6/2008		2.0	42.8	0.6		
234	1/7/2010	CZ-Tusimice	-7.0	85.0	0.0		
234	1/8/2010		-7.0	92.0	0.6		
235	1/9/2010		-6.0	93.0	0.6		
236	1/10/2010		-4.0	94.0	1.2		
237	1/11/2010		-7.0	92.0	0.0		
238	1/12/2010		-8.0	92.0	0.0		
239	1/13/2010		-7.0	94.0	0.0		
240	1/14/2010		-3.0	91.0	0.0		

Annex 2 **Ambient conditions at the field test sites** **Page 9 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]	Windrichtung [°]	Niederschlagsmenge [mm]
241	1/15/2010	CZ-Tusimice	-3.0	92.0	0.0		
242	1/16/2010		-2.0	88.0	0.6		
243	1/17/2010		-3.0	93.0	0.0		
244	1/18/2010			94.0	0.0		
245	1/19/2010		-13.0	24.0			
246	1/20/2010		-8.0	53.0			
247	1/21/2010		-5.0	91.0	0.0		
248	1/22/2010		-8.0	88.0	0.0		
249	1/23/2010		-9.0	91.0	0.0		
250	1/24/2010		-8.0	87.0	0.0		
251	1/25/2010		-9.0	87.0	0.6		
252	1/26/2010		-10.0	85.0	0.6		
253	1/27/2010		-13.0	79.0	0.6		
254	1/28/2010		-2.0	85.0	2.5		
255	1/29/2010		-1.0	88.0	1.2		
256	1/30/2010		-2.0	82.0	1.2		
257	1/31/2010		-7.0	85.0	0.0		
258	2/1/2010		-8.0	84.0	0.0		
259	2/2/2010		-2.0	80.0	1.2		
260	2/3/2010		-1.0	82.0	1.2		
261	2/4/2010		-5.0	92.0	0.6		
262	2/5/2010		-2.0	89.0	0.0		
263	2/6/2010		-2.0	96.0	0.0		
264	2/7/2010		-7.0	89.0	0.6		
265	2/8/2010		-9.0	84.0	0.0		
266	2/9/2010		-8.0	85.0	0.0		
267	2/10/2010		-6.0	91.0	0.0		
268	2/11/2010		-6.0	90.0	1.2		
269	2/12/2010		-5.0	90.0	0.0		
270	2/13/2010		-5.0	86.0	0.0		

Annex 2 **Ambient conditions at the field test sites** **Page 10 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]	Windrichtung [°]	Niederschlagsmenge [mm]
271	2/14/2010	CZ-Tusimice	-6.0	85.0	0.0		
272	2/15/2010		-5.0	82.0	0.0		
273	2/16/2010		-7.0	84.0	0.6		
274	2/17/2010		-7.0	91.0	0.0		
275	2/18/2010		-1.0	93.0	0.0		
276	2/19/2010		0.0	96.0	0.0		
277	2/20/2010		1.0	82.0	0.6		
278	2/21/2010		-1.0	84.0	0.6		
279	2/22/2010		-2.0	92.0	0.0		
280	2/23/2010		0.0	89.0	0.0		
281	2/24/2010		3.0	92.0	0.0		
282	2/25/2010		3.0	86.0	0.6		
283	2/26/2010		2.0	90.0	0.6		
284	2/27/2010		4.0	73.0	1.2		
285	2/28/2010		0.0	88.0	0.0		
286	3/1/2010		3.0	71.0	2.5		
287	3/2/2010		0.0	78.0	0.6		
288	3/3/2010		-1.0	75.0	1.2		
289	3/4/2010		-3.0	82.0	0.6		
290	3/5/2010		-5.0	74.0	1.9		
291	3/6/2010		-6.0	82.0	1.2		
292	4/20/2010		9.0	72.0	0.6		
293	4/21/2010		6.0	70.0	1.9		
294	4/22/2010		4.0	63.0	1.2		
295	4/23/2010		5.0	67.0	0.6		
296	4/24/2010		10.0	60.0	0.6		
297	4/25/2010		11.0	64.0	0.6		
298	4/26/2010		11.0	73.0	1.2		
299	4/27/2010		11.0	74.0	1.2		
300	4/28/2010		11.0	70.0	0.6		

Annex 2 **Ambient conditions at the field test sites** **Page 11 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]	Windrichtung [°]	Niederschlagsmenge [mm]
301	4/29/2010	CZ-Tusimice	15.0	60.0	0.6		
302	4/30/2010		17.0	60.0	1.2		
303	5/1/2010		14.0	73.0	0.0		
304	5/2/2010		11.0	93.0	0.6		
305	5/3/2010		11.0	87.0	0.6		
306	5/4/2010		8.0	89.0	0.6		
307	5/5/2010		7.0	85.0	1.2		
308	5/6/2010		8.0	96.0	0.0		
309	5/7/2010		9.0	80.0	0.6		
310	5/8/2010		9.0	74.0	0.6		
311	5/9/2010		9.0	83.0	0.6		
312	5/10/2010		10.0	92.0	0.0		
313	5/11/2010		13.0	90.0	0.6		
314	5/12/2010		13.0	79.0	1.2		
315	5/13/2010		9.0	84.0	0.6		
316	5/14/2010		7.0	91.0	0.6		
317	5/15/2010		6.0	89.0	1.9		
318	5/16/2010		9.0	74.0	2.5		
319	5/17/2010		11.0	71.0	2.5		
320	5/18/2010		9.0	73.0	3.1		
321	5/19/2010		8.0	88.0	1.2		
322	5/20/2010		11.0	92.0	0.6		
323	5/21/2010		13.0	86.0	1.2		
324	5/22/2010		16.0	76.0	0.6		
325	5/23/2010		14.0	80.0	1.2		
326	5/24/2010		15.0	84.0	1.2		
327	5/25/2010		14.0	84.0	1.2		
328	5/26/2010		11.0	90.0	0.0		
329	5/27/2010		14.0	87.0	1.2		
330	5/28/2010		14.0	85.0	0.6		

Annex 2 **Ambient conditions at the field test sites** **Page 12 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]	Windrichtung [°]	Niederschlagsmenge [mm]
331	5/29/2010	CZ-Tusimice	14.0	77.0	0.6		
332	5/30/2010		13.0	87.0	0.6		
333	5/31/2010		10.0	83.0	1.9		
334	6/1/2010		10.0	87.0	2.5		
335	6/2/2010		11.0	91.0	2.5		
336	6/3/2010		12.0	95.0	1.2		
337	6/4/2010		14.0	78.0	1.2		
338	6/5/2010		16.0	73.0	0.6		
339	6/6/2010		19.0	74.0	0.6		
340	4/10/2012	UK-Teddington	8.1	69.5	0.2		
341	4/11/2012		8.6	69.6	0.4		
342	4/12/2012		7.3	81.6	0.2		
343	4/13/2012		9.6	69.1	0.7		
344	4/14/2012		8.1	60.1	2.2		
345	4/15/2012		5.8	63.9	1.5		
346	4/16/2012		8.4	51.9	1.0		
347	4/17/2012		8.5	75.4	0.9		
348	4/18/2012		8.4	85.8	0.9		
349	4/19/2012		8.1	86.1	0.1		
350	4/20/2012		7.8	79.4	0.2		
351	4/21/2012		8.9	70.6	0.2		
352	4/22/2012		9.7	75.8	0.5		
353	4/23/2012		7.9	84.4	2.0		
354	4/24/2012		9.4	70.5	1.5		
355	4/25/2012		10.0	83.6	1.9		
356	4/26/2012		11.4	71.7	1.2		
357	4/27/2012		11.3	77.8	0.7		
358	4/28/2012		7.5	91.8	3.5		
359	4/29/2012		11.3	73.8	2.4		
360	4/30/2012		14.6	69.7	2.4		

Annex 2 **Ambient conditions at the field test sites** **Page 13 of 13**

No.	Date	Test site	Amb. temperature (avg) [°C]	Rel. humidity [%]	Wind velocity [m/s]	Windrichtung [°]	Niederschlagsmenge [mm]
361	5/1/2012	UK-Teddington	14.0	76.2	0.6		
362	5/2/2012		10.8	80.9	1.2		
363	5/3/2012		8.5	86.7	0.6		
364	5/4/2012		8.4	77.4	1.7		
365	5/5/2012		7.8	66.5	1.8		
366	5/6/2012		7.2	72.9	0.7		
367	5/7/2012		11.9	82.2	0.8		
368	5/8/2012		13.9	78.5	0.4		
369	5/9/2012		14.9	91.0	0.8		
370	5/10/2012		14.8	82.0	0.7		
371	5/11/2012		11.5	56.0	1.2		
372	5/12/2012		10.8	58.0	0.8		
373	5/13/2012		12.1	58.7	0.4		
374	5/14/2012		8.7	83.0	0.3		
375	5/15/2012		7.5	76.4	1.0		
376	5/16/2012		11.1	62.7	0.4		
377	5/17/2012		12.6	58.1	1.5		
378	5/18/2012		13.6	79.0	0.6		
379	5/19/2012		13.1	69.8	1.6		
380	5/20/2012		12.2	76.2	1.9		
381	5/21/2012		14.5	75.5	1.5		

TÜV RHEINLAND ENERGY GMBH

ADDENDUM

Addendum to the report No. 936/21205333/A of 6 December 2006 on the performance test of the BAM-1020 ambient air quality measuring system with PM_{10} pre-separator for suspended particulate matter PM_{10} manufactured by Met One Instruments, Inc., TÜV Report No. of 6 December 2006.

TÜV Report: 936/21243375/B
Cologne, 21 September 2018

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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, functionality and calibration of continuous emission monitoring systems including systems for data evaluation and remote monitoring of emissions
- Measurements in combustion chambers;
- Performance testing of measuring systems for continuous monitoring of emissions and air quality as well as electronic data evaluation and remote monitoring systems for emissions
- 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 will expire on 10-12-2022 and
covers the scope specified in the annex to certificate D-PL-11120-02-00.

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1. Summary Overview

Met One Instruments, Inc. commissioned TÜV Rheinland Energy GmbH to carry out performance testing of the BAM-1020 ambient air quality measuring system for suspended particulate matter PM10 in accordance with the following standards:

- VDI Guideline 4202, Part 1 – "Performance criteria for performance tests of automated ambient air measuring systems – Point-related measurement methods for gaseous and particulate air pollutants," dated June 2002.
- VDI Guideline 4203, part 3 – "Testing of automated measuring systems – Test procedures for point-related ambient air measuring systems for gaseous and particulate air pollutants", dated August 2004
- [3] EN 12341 "Air Quality - Determination of the PM_{10} fraction of suspended particulate matter - Reference method and field test procedure to demonstrate reference equivalence of measurement methods", German version EN 12341: 1998
- Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods, English version of November 2005 (original test) and January 2010 (supplementary test in 2012).

On the basis of the cited standards for testing, the BAM-1020 ambient air quality measuring system for suspended particulate matter, PM_{10}, has already been performance-tested and publically announce as such as follows:

- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10}, UBA announcement of 12 April 2007 (BAnz. S. 4139, Chapter III Number 1.2) – original announcement
- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10}, UBA announcement of 3 August 2009 (BAnz. p. 2929, Chapter III, 6th notification) – Notification regarding first notice of the original announcement referring to the available options and regarding a new software version.

- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10}, UBA announcement of 25 January 2010 (BAnz. p. 552, Chapter III 10th and 11th notification) – regarding the replacement of notice 1 of the original announcement referring to the available options and regarding a new software version and the public announcement of the OEM version APDA-371 provided by Horiba Europe GmbH
- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10}, UBA announcement of 12 April 2010 (BAnz. S. 2597, Chapter III 2nd notification) – notification regarding a new software version.
- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10}, UBA announcement of 15 April 2011 (BAnz. S. 2725, Chapter III 12th notification) – notification of design changes (alternative pump, tough screen display option) and new software version
- BAM-1020 ambient air quality measuring system for suspended particulate matter, PM_{10}; UBA announcement of 6 July 2012 (BAnz AT 20.07.2012 B11, chapter IV 6h notification) – Notification of design changes (re-designed back plate) and software changes
- BAM-1020 ambient air quality measuring system UBA announcement of 12 February 2013 (BAnz AT 05.03.2013 B10, Chapter V 2nd notification) - Notification regarding the demonstration of equivalence with the requirements of the the Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods of January 2010 as well as compliance with the requirements of EN 15267.
- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10} UBA announcement of 3 July 2013 (BAnz AT 23.07.2013 B4, Chapter V 5th notification) – notification regarding a new software version.
- BAM-1020 ambient air quality measuring system UBA announcement of 25 February 2015 (BAnz AT 02.04.2015 B5, Chapter IV 11th notification) – Notification regarding a new pressure sensor because of discontinued production
- BAM-1020 ambient air quality measuring system for suspended particulate matter PM_{10} UBA announcement of 21 February 2018 (BAnz AT 26.03.2018 B8, Chapter V 8th notification) – notification regarding a new software version.

Standard EN 16450 “Ambient air — Automated measuring systems for the measurement of the concentration of particulate matter (PM_{10}; $PM_{2,5}$) has been available since July 2017. This standard, for the first time, harmonises requirements for the performance testing of automated measuring systems for the determination of dust concentrations (PM_{10} and $PM_{2.5}$) on a European level and will form the basis for the approval of such AMS in the future.

The present addendum presents an assessment of the BAM-1020 measuring system with PM_{10} pre-separator regarding compliance with the requirements defined in standard EN 16450 (July 2017). At present, the assessment does not cover the instrument version with touch screen display (BX-970 option), as the necessary adjustments to the firmware have not yet been made for this instrument version.

As most of the performance characteristics and performance criteria defined in chapter 7 of standard EN 16450 (July 2017) have been tested and assessed already in the context of the original performance test, the majority of test results can be taken from the original test report [9] and or the addendum on that test report [16]. It was possible to re-assess some of the data from the original performance test [9] and the addendum [16] for a number of test criteria. Entirely new tests were performed only for test items 7.4.4 “Flow rate accuracy”, 7.4.8 “Dependence of span on supply voltage” and 7.4.9 “Dependence of reading on water vapour concentration” in Summer 2018. A new test was also performed for test item 7.4.3 “Zero level and detection limit, lower detection limit” in order to submit the GF0.009 filter band used and qualified by Met One Instruments, Inc. since 2013 and manufactured by Whatman to testing. In the meantime, this filter band has completely replaced the type 460130 filter band manufactured by Sibata, which had been used during the original performance test.

On its publication, this addendum will become an integral part of TÜV Rheinland test report no. 936/21205333/A dated 6 December 2006 and addendum no. 936/21220762/A dated 12 December 2012 and will be available online at www.qal1.de.

The BAM-1020 measuring system uses a radiometric measuring principle to determine dust concentrations. A pump sucks in ambient air through the PM_{10} sampling head sampling head. The dust-loaded sample air is then pulled to a filter tape. The determination of the mass concentration precipitated on the filter tape is then performed relying on the principle of beta absorption.

The tests were performed in the laboratory and in a several-months long field test.

The several-months long field test was performed at the sites listed in Table 1.

Table 1: Description of the test sites

	Cologne, parking lot	Titz-Rödingen	Cologne, Frankf. Str.	Steyregg (A)
Period	02/2006 – 04/2006	07/2006 – 09/2006	09/2006 – 10/2006	06/2008 – 08/2008
Number of measurement pairs: Test specimens	52	37	28	51
Description	Urban area	Rural area	Affected by traffic	Suburban
Classification of ambient air pollution	average to high	low	average to high	average

	Graz (A)	Tusimice (CZ)	Teddington (UK)
Period	12/2007 – 03/2008	01/2010 – 06/2010	04/2012 – 05/2012
Number of measurement pairs: Test specimens	50	103	42
Description	Urban area + traffic	Industrial	Urban area
Classification of ambient air pollution	to high	average to high	low

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

Table 2: Equivalence test results (raw data)

PM_x	Slope	Axis intercept	All Data sets W_{CM}<25 % Raw data	Calibration yes/no	All Data sets W_{CM}<25% cal. Data
PM_{10}	1.034	0.843	16.11	yes	12.27

* Given the significance of the slope or the axis intercept, a calibration became necessary.

1.1 Summary report on test results

Summary of test results in accordance with standard EN 16450 (July 2017)

Performance criterion	Requirement	Test result	satis-fied	Page
1 Measuring 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 measuring range is set to 0–1,000 µg/m³ by default. Supplementary measuring ranges are possible up to 0–10,000 µg/m³.	yes	56
2 negative signals	Shall not be suppressed	Negative signals are directly displayed and correctly output by the measuring system.	yes	57
3 Zero level and detection limit (7.4.3)	Zero level: ≤ 2.0 µg/m³ Detection limit: ≤ 2.0 µg/m³	On the basis of testing both instruments, the zero level was determined at a maximum of -0.49 µg/m³ and the detection limit at a maximum of 1.69 µg/m³.	yes	58
4 Flow rate accuracy (7.4.4)	≤ 2.0%	The relative difference determined for the mean of the measuring results at +5°C and at +40°C did not exceed -1.93%.	yes	60
5 Constancy of sample flow rate (7.4.5)	≤ 2.0% sampling flow (averaged flow) ≤ 5% rated flow (instantaneous flow)	The 24h-averages deviate from their rated values by less then ± 2.0%, all instantaneous values deviate by less than ± 5%.	yes	62
6 Leak tightness of the sampling system (7.4.6)	≤ 2.0% of sample flow rate	The maximum leak rate was determined at 0.1 l/min and was smaller than 2% of the nominal flow rate 16.67 l/min. The criterion for passing the leak test as specified by the AMS manufacturer – maximum flow rate of 1.0 l/min – proves to be an adequate criterion for monitoring the instrument's leak tightness. The method described reliably detects potential leakages in the system (e.g. contaminations in the area of the inlet nozzle at the filter band caused by filter abrasion.	yes	65

Performance criterion	Requirement	Test result	satis-fied	Page
7 Dependence of measured value on surrounding temperature (7.4.7)	≤ 2.0 µg/m³	The tested temperature range at the site of installation was +5 °C to +40 °C. Taking into account at the values displayed by the instrument, we determined a maximum dependence of the zero point on the on surrounding temperature of 0.4 µg/m³.	yes	68
8 Dependence of measured value (span) on surrounding temperature (7.4.7)	≤ 5% from the value at the nominal test temperature	The tested temperature range at the site of installation was +5 °C to +40 °C. At span point, the deviations determined did not exceed 0.2%.	yes	70
9 Dependence of span on supply voltage (7.4.8)	≤ 5% from the value at the nominal test voltage	Voltage variations did not result in deviations > -0.4% compared to the initial value of 230 V.	yes	72
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.	Buffering protects all instrument parameters against loss. On return of mains voltage, the instrument returns to normal operating mode and automatically resumes measuring at the next full hour.	yes	74

Performance criterion	Requirement	Test result	satis-fied	Page
11 Dependence of reading on water vapour concentration (**7.4.9)**	≤ 2.0 µg/m^3 in zero air	Differences between readings determined at relative humidifies of 40% and 90% did not exceed 2.0 µg/m³. Various water vapour concentrations were not observed to cause any significant effect on zero readings.	yes	75
12 Zero checks (7.5.3)	Absolute value ≤ 3.0 µg/m^3	The maximum measured value determined for PM10 at zero point was 2.2 µg/m³.	yes	77
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 measuring system allows for comprehensive remote monitoring and control via various connectors (Ethernet, RS232). The instrument provides operating statuses and all relevant parameters.	yes	80
14 Daily averages (7.5.5)	The AMS shall allow for the formation of daily averages or values.	The instrument configuration described and a measurement cycle set to 60 min allow the formation of valid daily averages based on 24 individual measurements.	yes	82

Performance criterion	Requirement	Test result	satis-fied	Page
15 Availability (7.5.6)	At least 90%.	The availability for SN 4924 was 99.3%, for SN 4925 it was 99.3%.	yes	83
16 Between-AMS uncertainty ubs,AMS (7.5.8.4)	≤ 2.5 µg/m³	At no more than 1.49 µg/m³ for PM_{10}, the between-AMS uncertainty u_{bs} remains well below the permissible maximum of 2.5 µg/m³.	yes	87
17 Expanded uncertainty of AMS results (7.5.8.5–7.5.8.8)	≤ 25% at the level of the relevant limit value related to 24-hour average results (if required, after calibration)	With the exception of data obtained in A-Graz (instrument Ö2) and UK-Teddington (instrument 17011), the uncertainty WCM determined without applying correction factors for all observed data sets is below the determined expanded relative uncertainty Wdqo of 25% for fine particulate matter. It must be checked whether the use of correction factors/terms will mean that the expanded relative uncertainty Wdqo remains below the maximum defined at 25% for particulate matter for the data obtained at all sites including A-Graz (S/N Ö2) and UK-Teddington (S/N 17011) (see criterion 6.1 17 Use of correction factors/terms (7.5.8.5–7.5.8.8).	no	95
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 a correction of the slope and intercept, the candidates satisfy the requirements for the data quality of ambient air monitors. This correction also results in a significant improvement of the expanded uncertainty of the complete dataset.	yes	111

Performance criterion	Requirement	Test result	satis-fied	Page
18 Maintenance interval (7.5.7)	At least 14 d	The period of unattended operation is determined by the necessary maintenance works. It is 4 weeks.	yes	117
19 Automatic diagnostic check (7.5.4)	Shall be possible for the AMS	All instrument functions described in the operation manual are available and can be activated. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages. it is possible to automatically check and record the zero point and sensitivity.	yes	119
20 Checks of temperature sensors, pressure and/or humidity sensors	Shall be checked for the AMS to be within the following criteria ± 2°C ± 1kPa ± 5 % RH	It is easy to check and adjust the sensors for determining ambient temperature, ambient pressure and relative humidity on-site (filter band area).	yes	121

2. Task Definition

2.1 Nature of the test

TÜV Rheinland Energy GmbH was commissioned by Met One Instruments, Inc. to carry out performance testing of the BAM-1020 ambient air quality measuring system.

The BAM-1020 ambient air quality measuring system for suspended particulate matter, PM_{10}, has already been performance-tested and published as such in the Federal Gazette.

The present addendum presents an assessment of the BAM-1020 ambient air quality measuring system regarding compliance with the requirements for automated measuring systems defined in the new standard EN 16450 (July 2017). At present, the assessment does not cover the instrument version with touch screen display (BX-970 option), as the necessary adjustments to the firmware have not yet been made for this instrument version.

2.2 Objectives

The measuring system is designed to determine the PM_{10} fraction of dust concentrations in the range between 0–1 000 µg/m³.

The existing performance test had been performed in respect of the requirements applicable at the time of testing while at the same time taking into account the latest developments.

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

- VDI Guideline 4202, Part 1 – "Performance criteria for performance tests of automated ambient air measuring systems – Point-related measurement methods for gaseous and particulate air pollutants," dated June 2002 [1]
- VDI Guideline 4203, part 3 – "Testing of automated measuring systems – Test procedures for point-related ambient air measuring systems for gaseous and particulate air pollutants", dated August 2004 [2]
- [3] EN 12341 "Air Quality - Determination of the PM_{10} fraction of suspended particulate matter - Reference method and field test procedure to demonstrate reference equivalence of measurement methods", German version EN 12341: 1998 [3]
- Guide "Demonstration of Equivalence of Ambient Air Monitoring Methods", English version of November 2005 and January 2010 [4]

Since July 2017, the European Standard

- Standard EN 16450 "Ambient air — Automated measuring systems for the measurement of the concentration of particulate matter (PM_{10}; $PM_{2,5}$), German version EN 16450:2017 [8]

has been available. This standard, for the first time, harmonises requirements for the performance testing of automated measuring systems for the determination of dust concentrations (PM_{10} and $PM_{2.5}$) on a European level and will form the basis for the approval of such AMS in the future.

The present addendum presents an assessment of the BAM-1020 measuring system with PM_{10} pre-separator regarding compliance with the requirements defined in standard EN 16450 (July 2017). At present, the assessment does not cover the instrument version with touch screen display (BX-970 option), as the necessary adjustments to the firmware have not yet been made for this instrument version.

As most of the performance characteristics and performance criteria defined in chapter 7 of standard EN 16450 (July 2017) have been tested and assessed already in the context of the original performance test, the majority of test results can be taken from the original test report [9] and or the addendum on that test report [16]. It was possible to re-assess some of the data from the original performance test [9] and the addendum [16] for a number of test criteria. Entirely new tests were performed only for test items 7.4.4 “Flow rate accuracy”, 7.4.8 “Dependence of span on supply voltage” and 7.4.9 “Dependence of reading on water vapour concentration” in Summer 2018. A new test was also performed for test item 7.4.3 “Zero level and detection limit, lower detection limit” in order to submit the GF0.009 filter band used and qualified by Met One Instruments, Inc. since 2013 and manufactured by Whatman to testing. In the meantime, this filter band has completely replaced the type 460130 filter band manufactured by Sibata, which had been used during the original performance test.

On its publication, this addendum will become an integral part of TÜV Rheinland test report no. 936/21205333/A dated 6 December 2006 and will be available online at www.qal1.de.

3. Description of the AMS tested

3.1 Measuring principle

The BAM-1020 ambient air measuring system uses beta-attenuation as its measuring principle.

The principle of the radiometric determination of mass is based on the physical law beta-ray attenuation when passing through a thin layer of material. The following equation holds:

$$c\left(\frac{\mu g}{m^3}\right) = \frac{10^6 A(cm^2)}{Q\left(\frac{l}{min}\right)\Delta t(min)\mu\left(\frac{cm^2}{g}\right)} \ln\left(\frac{I_0}{i}\right)$$

Where:

C is the particle-mass concentration

A is the sampling area for particles (filter spot)

Q is the sampling flow rate

Δt is the sampling time

μ is the mass absorption coefficient

I_0 is the beta count rate at the beginning (clean)

I is the beta count at the end (collect)

The radiometric determination of mass is calibrated in the factory and is checked hourly as part of internal quality assurance at the zero point (clean filter spot) and at the span point (built-in span foil) during operation. Measured values at zero and at span point can easily be derived from the generated data. They can be compared with any stability requirements (drift effects) or with the nominal value for the span foil (factory setting).

3.2 Functioning of the measuring system

The particle sample passes the PM_{10} sampling inlet at a flow rate of 1 m³/h and reaches the BAM-1020 analyser via the sampling tube.

During performance testing, the measuring system was operated with the BX-830 sample heater (Smart Inlet Heater).

The following process variables were used to control the sample heater:

1. Relative humidity RH at the filter tape (factory setting: 45 %)

The heater switches off as soon as the relative humidity (RH) drops below 1%.

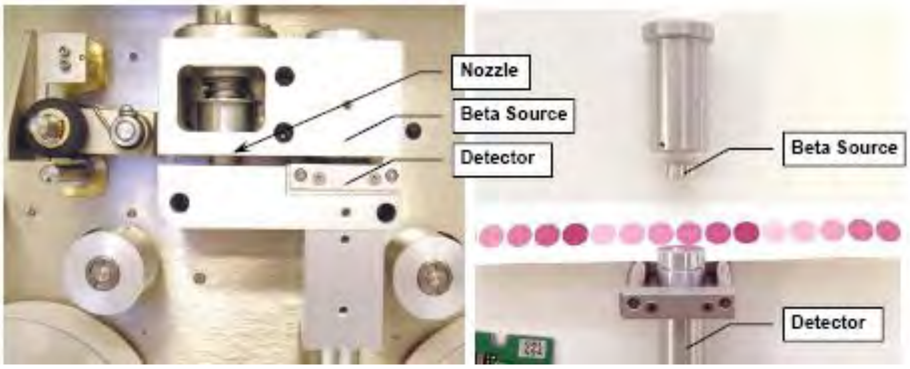
The particles reach the measuring instrument to be loaded onto the glass fibre filter tape for radiometric measurement.

One measurement cycle (incl. automatic check of the radiometric measurement) consists of the following steps (measuring time for PM_{10} set to 4 min):

1. Each cycle starts with an initial/blank measurement of a clean filter spot (I_0). It takes 4 minutes.
2. The filter tape is transported forward over a distance of 4 dust spots and pushed under the sampling point. The sample is taken from the filter spot where I_0 was previously determined. For a sampling duration of 50 min. particulate-loaded air is then sucked through that filter spot.
3. At the same time, the spot 4 positions upstream on the filter tape is submitted to radiometric measurement I_1 for a duration of 4 minutes. This measurement is performed to check for potential drift effects caused by changes in external parameters such as temperature or relative moisture. The same spot is subjected to a third radiometric measurement I_2 with an inserted span foil. The same spot of the filter tape is subjected to yet another $I_{1x,}$ four minutes before the end of the collection time in order to monitor stability of the zero point with the help of I_1 and I_{1x}.

4. Once sampling is completed, the filter tape is reversed back four sampling spots and the sampled filter spot is measured radiometrically (I_3). The calculation of the concentration completes the measurement cycle.
5. The next cycle will start again with step 1.

Figure 1 gives an overview of the sampling and measurement parts of the BAM-1020.



Legend: Nozzle Beta Source = Beta Source
Detector

Figure 1: BAM-1020 – Illustration of sampling and measurement

During the performance test, the cycle time was set to 60 min, radiometric measurement taking 4 min.

Thus, the cycle time consists of 2 x 4 min for the radiometric measurement (I_0 & I_3) as well as approximately 1–2 min for filter tape movements. Consequently, the effective sampling time is around 50 min.

3.3 AMS scope and set-up

The ambient air measuring system BAM-1020 relies on beta attenuation as its measuring principle.

The tested measuring system consists of the PM_{10}-sampling inlet BX-802, the sampling tube, the sample heater BX-830, the combined pressure and temperature sensor BX-596 (incl. radiation protection shield, as an alternative the ambient temperature sensor BX-592), the vacuum pump BX-127 (or BX-125), the measuring instrument BAM-1020 (incl. glass fibre filter tape), the required connecting tubes and lines as well as adapters, the roof flange as well as the manual in English language.

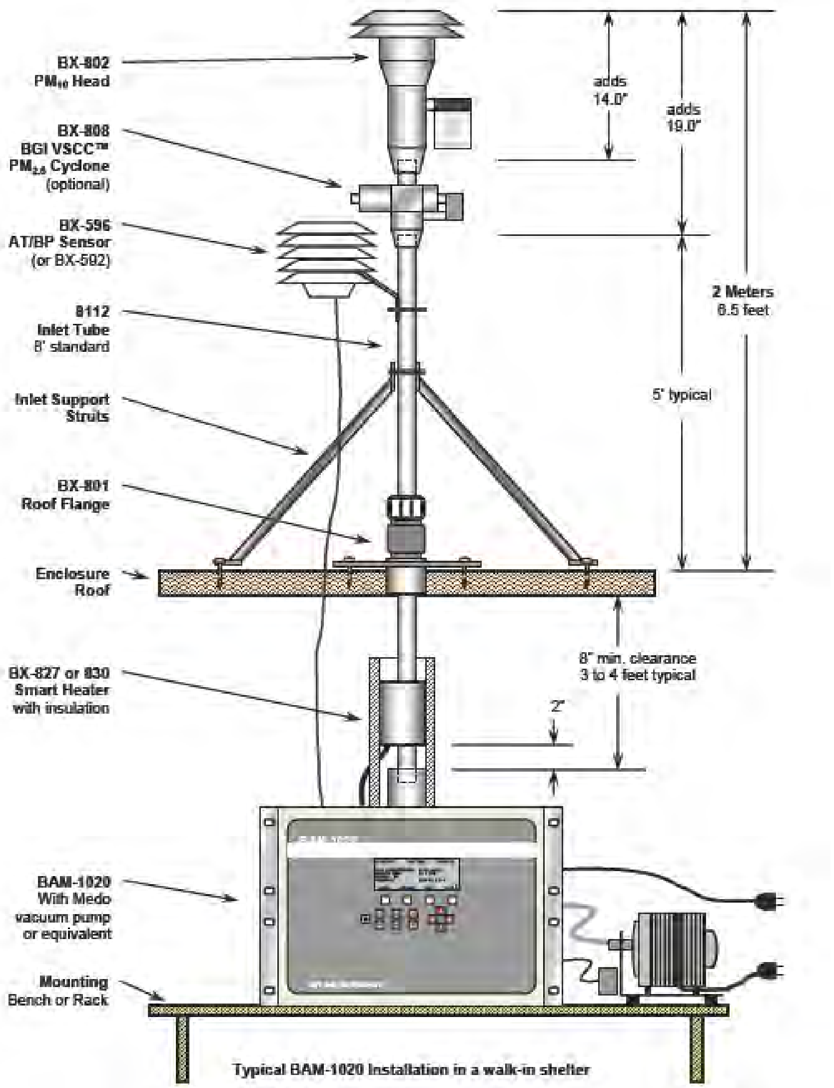


Figure 2: Overview of the BAM-1020 measuring system (presented here with an additional $PM_{2.5}$ VSCC BX-808, which is not part of the performance-tested measuring system)

The BAM-1020 measuring system offers the possibility to connect up to 6 different sensors to the available analogue inputs. Thus, besides the combined pressure and temperature sensor BX-596 or the ambient temperature sensor BX-592, it is also possible to connect sensors for air pressure (BX-594), wind direction (BX-590), wind velocity (BX-591), humidity (BX-593) as well as solar radiation (BX-595).

A US-EPA-PM_{10} sampling inlet (type BX-802 used for performance testing) is available. The sampling inlet serves as a pre-separator for the suspended particulate matter, PM_{10} fraction. The instruments are operated with a constant, regulated flow rate of 16.67 l/min = 1.0 m³/h.

Alternatively, it is also possible to use TSP sample inlets or $PM_{2.5}$ cyclones downstream of the PM_{10} sample inlet.

Figure 3: US-EPA PM_{10} sampling head BX-802 for BAM-1020

The sampling tube connects the sampling inlet to the measuring instrument. The length of the sampling tube was 2.4 m during the test, different lengths can be manufactured with respect to the local conditions.

The BX-830 sample heater is installed at the lower end of the sampling tube (approximately 50 mm above the instrument inlet of BAM-1020). The operation of the heating systems is performed as described in chapter 3.2 Functioning of the measuring system.

Figure 4: BX-830 sample heater

The BX-127 (or BX-125) vacuum pump is connected to the measuring system proper at the end of the sampling path via a hose. The pump is controlled to regulate the operational flow with reference to the ambient conditions (ACTUAL mode).

In addition to the radiometric measuring component, the BAM-1020 measuring system contains the glass fibre filter tape incl. transport system, large parts of the pneumatic system (flow measurement by mass flow sensor), the control unit of the sample heater and all necessary electronic parts and microprocessors for the control and operation of the measuring system and for communication with the system.

Figure 5: BAM-1020 measuring system

Figure 6: BAM-1020 measuring system, installed in measurement cabinet

Figure 7: BX-127 vacuum pump

Figure 8: Front view BAM-1020, front cover opened

A soft keypad in combination with a display at the front of the instrument serve to control the measuring system.

The user is can retrieve stored data, change parameters and perform several tests to verify correct operation of the measuring system. The main screen of the user display is found on the top level – here, the current time and date, last 1h-concentration value, the actual flow rate, current software version and the status of the instrument are displayed.

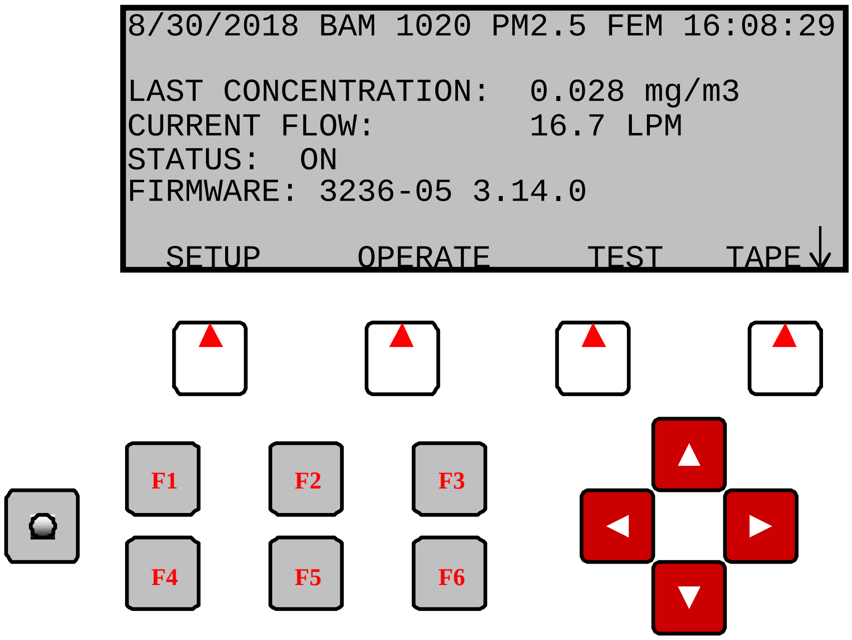


Figure 9: Display (main screen of the user interface) + soft keypad of the BAM-1020

The function keys F1 to F6 allow easy access to various functions from the main screen. For example it is possible, to access information on the last concentration values as well as measured values from other sensors (ambient temperature etc.), error messages and stored data for the measurements of the last ten days.

Starting form the main screen, it is also possible to access sub menus via the soft keys.

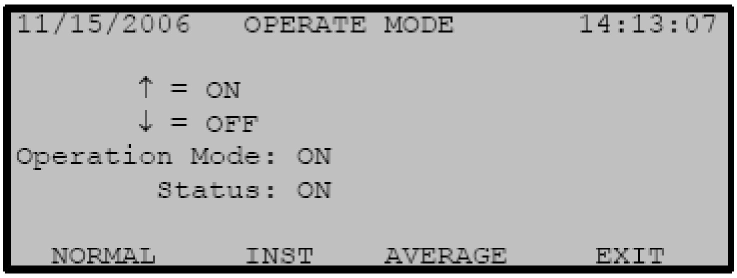
1. Menu „SETUP“ (Press soft key „SETUP“): The “SETUP” menu serves configuration and parameterisation of the measuring system. This menu is used to choose parameter settings such as date/time, sampling duration, measuring range, flow rate, measured value output under operating or standard conditions, or to change the password and choose settings for interfaces, external sensors and sample heater.

```
                     SETUP MODE SELECT

CLOCK     SAMPLE    CALIBRATE EXTRA
ERRORS    PASSWORD  INTERFACE SENSOR
HEATER    QUERY     REPORTS   HJ 653


 SELECT                         EXIT
```

The SETUP Menu

Figure 10: Menu “SETUP”

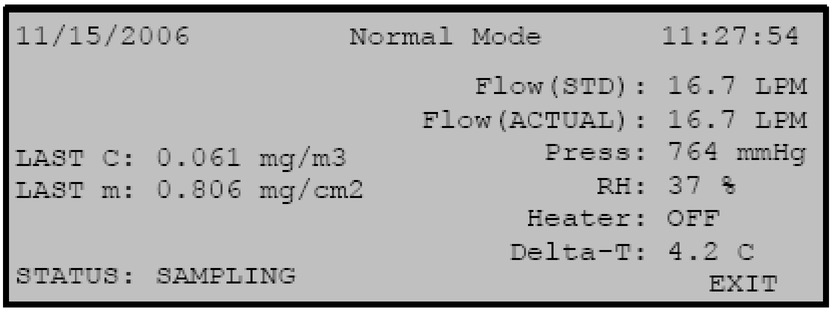
2. Menu “OPERATION” (press soft key “OPERATION”): In the “OPERATION” menu , users can call up information during the operation of the measuring system. As long as the operating mode is switched “ON”, the measuring system operates according to the settings. The on-going measurement will be interrupted by switching “OFF” the operating mode, by calling up the “SETUP”, “TEST”, or “TAPE” menus during on-going operation or as a result of a severe error (e.g. tape fault).



The OPERATE Menu

Figure 11: “OPERATION” menu

Recent measured values are presented in different ways in the NORMAL, INST and AVERAGE submenus. The “NORMAL” screen shows the most common form of presentation. In this screen, the user can check the most important parameters relevant for operation.



The NORMAL Menu

Figure 12: Screen shot “NORMAL”

3. “TEST” menu (press soft key “TEST”): Use the “TEST” menu to perform several tests for checking the hardware and components, e.g. a check of the radiometric measurement (span foil test), a check of the flow rate or a calibration of temperature and pressure sensors as well as of the flow rate.

```
TEST MENU

COUNT       PUMP        TAPE       DAC
CALIBRATE   INTERFACE   FLOW       ALIGN
HEATER      FILTER-T    FILTER-RH


 SELECT                             EXIT
```

The TEST Menu

Figure 13: “TEST” menu

4. Menu „TAPE“ (press soft key “TAPE”): Use the “TAPE” to start an extensive self test of the measuring system at any time (this aborts the ongoing measurement). This self test takes about 4 minutes and checks various mechanic parts (e.g. filter transport system) for correct functioning, the flow rate or the state of the filter tape (tension, tape fault). In case of irregularities or excessive deviations, a “FAIL” error message is displayed which allows to start identifying the problem. “SELF TEST PASSED” will be displayed if the self test does not identify any problems. Measurement operation can be resumed. The performance of this test is generally recommended after each re-start of the measurement after any interruption, in any case after a change of the filter tape.

```
02/08/1999          15:29:30
LATCH: OFF          TAPE BREAK: OK
CAPSTAN: OK         TAPE TENSION: OK
NOZZLE DN: OK       SHUTTLE: OK
NOZZLE UP: OK       REF EXTEND: OK
FLOW: OK            REF WITHDRAW: OK
Status:   SELF TEST PASSED
TENSION   SELF TEST               EXIT
```

Self-Test Status Screen

Figure 14: Screen shot “TAPE/SELF TEST”

In addition to direct communication via keys/display, there are numerous possibilities to communicate via different analogue outputs, relays (status and alarm messages) as well the RS232 interfaces. A printer, PC and modem can be connected to the RS232 interface. The Hyperterminal software can be used for communication with the instrument.

Interface #1 serves the purposes of data transfer and communication of the instrument status. The interface is frequently used for remote control with the help of a modem.

The following system menu is available:

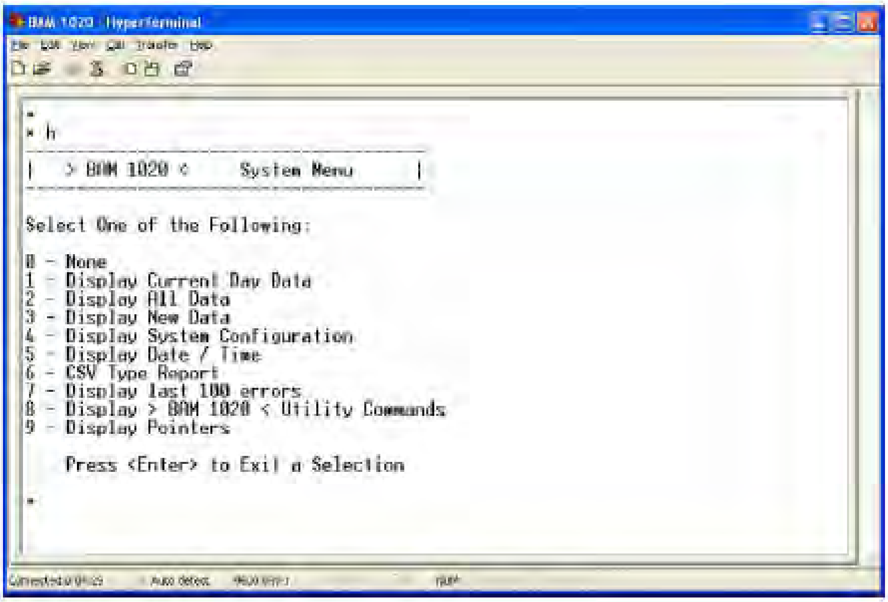


Figure 15: Communication via serial interface #1 - system menu

During the performance test, data were usually retrieved and recorded once a week. The data are suitable to be aggregated in the form of daily averages in an external spreadsheet. The following provides an example of the data thus recorded:

Station	1							
Time	Conc(mg)	Qtot(m3)	BP(mm)	WS(MPS)	no(V)	RH(%)	Delta(C)	AT(C)
9/28/2006 14:00	0.029	0.834	755.1	2.3	0.015	35	58.3	20.7
9/28/2006 15:00	0.031	0.834	754.9	2.1	0.012	33	58.4	21.7
9/28/2006 16:00	0.024	0.834	754.7	2.1	0.012	32	58.5	22
9/28/2006 17:00	0.03	0.834	754.5	2	0.011	32	58.5	22.3
9/28/2006 18:00	0.025	0.834	754.4	2	0.01	32	58.5	22.3
9/28/2006 19:00	0.029	0.834	754.3	2	0.01	33	58.5	21.5
9/28/2006 20:00	0.034	0.834	754.4	2	0.01	35	58.5	20.4
9/28/2006 21:00	0.048	0.834	754.5	2	0.01	36	58.5	19.1
9/28/2006 22:00	0.047	0.834	754.6	2	0.01	37	58.5	18.1
9/28/2006 23:00	0.051	0.834	754.8	2	0.01	37	58.5	17.1
9/29/2006 0:00	0.036	0.834	754.8	2	0.01	37	58.5	16.6
9/29/2006 1:00	0.035	0.834	754.7	2	0.01	37	58.5	16
9/29/2006 2:00	0.029	0.834	754.6	2	0.01	38	58.5	15.8
9/29/2006 3:00	0.03	0.834	754.6	2	0.01	38	58.5	15.3

Conc(µg/m³): Dust concentration measured in mg/m³, ambient conditions

Qtot(m³): Throughput in m³ (here at a 50 min sampling time)

BP(mm-Hg): Air pressure in mm-Hg

WS (MPS): Wind speed, not used in this case

no(V): not assigned

RH(%): relative humidity underneath the filter tape in % - for heating control

Delta(C): Difference ambient temperature – temperature at the filter tape – used to control the heater, in this case deactivated, no longer available from firmware version 3236-05 3.14.0

AT(C): Ambient temperature in °C

For information and diagnosis purposes, menu item 4 (Display System Configuration) allows to display and print the current parameterisation of the BAM-1020 measuring system (see Figure 16).

BAM 1020 Settings Report
07/09/2018 17:42:43

Station ID, 1
Serial Number, X14465

Firmware, 3236-05 V3.14.1

K, 00.979
BKGD, -0.0056
usw, 00.299
ABS, 00.815
Range, 1.000
Offset, -0.015
Clamp, -0.015
Conc Units, mg/m3
Conc Type, ACTUAL
Count Time, 4
Conc Error, FULL SCALE VALUE
Inlet Type, PM10

Cv, 00.970
Qo, 00.000
Flow Type, ACTUAL
Flow Setpt, 0016.7
Std Temp, 25

Heat Mode, AUTO
FRH Ctrl, YES
FRH SetPt, 45
Low Power, 6
FRH Log, YES
FT Log, YES

BAM Sample, 50
MET Sample, 60
Cycle Mode, STANDARD
Fault Polarity, NORM
Reset Polarity, NORM
Maintenance, OFF

HJ 653, NO

EUMILRNFPDCT
111111111111

AP, 000150
Baud Rate, 9600
Printer Report, 2
e3, 00,000
e4, 15,000

Channel,	1,	2,	3,	4,	5,	6,
Sensor ID,	4,	2,	2,	255,	255,	35,
Channel ID,	254,	254,	254,	255,	255,	254,
Name,	WS ,	WS ,	WS ,	FRH ,	FT ,	AT ,
Units,	KPH,	MPS,	MPS,	% ,	C ,	C ,
Prec,	1,	1,	1,	0,	1,	1,
FS Volts,	1.000,	1.000,	1.000,	0.500,	2.500,	2.500,
Mult,	160.9,	44.7,	44.7,	32,	-147.1,	95.0,

```
Offset,        0.0,   0.0,   0.0,   -26,   95.8,  -40.0,
Vect/Scalar,   S,     S,     S,     S,     S,     S,
Inv Slope,     N,     N,     N,     N,     N,     N,

Calibration,  Offset,  Slope,
     Flow,    0.384,   0.980,
       AT,    0.391,
       BP,   -1.000,
      FRH,    0.000,
       FT,    0.000,

QUERY,      1,  CONC_A,
Daily Range, 01:00 - 24:00
Dynamic Range, STANDARD
Span Check, 24 HR
Log BP, NONE
Log Membrane, NONE
X3043
```

Figure 16: Typical print-out of a set of parameters for the BAM-1020

The serial interface #2 only serves as a print output and can be connected to a printer or PC. This allows the continues recording of up-to-date information regarding measurement operation.

For external check of the zero point of the measuring system and for determination of the background value BKGD (offset correction for concentration values) according to manual chapter 7.7, a zero filter (BX-302, Zero Filter Calibration Kit) is mounted to the instrument inlet. The use of this filter allows the provision of PM-free air.

Figure 17: BX-302 zero filter during application in the field

With the available shut-off valve, it is also possible to check the leak tightness of the measuring system with the BX-302 zero filter according to the manual chapters 5.4 et seq.

For the purpose of monitoring the inlet flow rate according to the manual chapter 5.7, a BX-305 adapter (Flow Inlet Adapter Kit) is available. As this is largely the same as the BX-302 zero filter kit (apart from the HEPA filter itself), this too allows performing a leak tightness check with the help of the shut-off valve following the manual instructions in chapters 5.4 et seq.

Table 3 lists a number of important instrument characteristics of the BAM-1020 monitor for suspended particulate matter.

Table 3: Instrument-related data BAM-1020 (Manufacturer's specifications)

Dimension/weight	**BAM-1020**
Measuring device	310 x 430 x 400 mm / 24.5 kg (without pump)
Sampling tube	2.4 m (additional lengths available)
Sampling head	BX-802 (US-EPA)
Power supply	100/115/230 V, 50/60 Hz
Power requirement	75 W, main unit
Ambient conditions	
Temperature	-30 - +60 °C (manufacturer specification) +5 - +40 °C during performance testing
Moisture	non-condensing
Sample flow rate	16.67 l/min = 1 m³/h
Radiometry Light source	^{14}C, <2,2 MBq (< 60 µCi)
Detector	Scintillation probe
Checking procedure	Hourly internal zero and span point checks (internal span foil), deviations form the target value are recorded
Parameters of filter replacement	
Measurement cycle (cycle time)	1 min – 200 min Default: 60 min
Measuring time radiometry	4.6 or 8 min selectable for PM_{10}: 4 min
Sampling time	depending on measuring time radiometry 50, 46 or 42 min for PM_{10}: 50 min
Parameters BX-830 sample heater	
Target value for relative humidity at filter tape	Default: 45% (active during performance testing)

Date storage capacity (internal)	approx. 180 days for 1h-measured values
Analogue output	0 – 1 (10) V or 0 – 16 mA / 4 – 20 mA – can be set to 0-0.100, 0.200, 0.250, 0.500, 1.000, 2.000, 5.000 or 10.000 mg/m³
Digital output	2 x RS 232 – interface for data transmission and remote control, c/w BX-965 report processor option (not part of the test) additional RS 232 and USB ports
Status signals/error messages	available, for an overview see chapters 7.2 and 9.9 in the manual

4. Test programme

4.1. General

The original performance test [9] was performed using two identical instruments, type BAM-1020, serial numbers S/N 4924 and S/N 4925 in accordance with the minimum requirements specified in [1; 2; 3; 4].

The test was performed with software versions 3236-02 2.65 and 3236-02 3.2.1b.

The original test comprised a laboratory test to determine the performance characteristics as well as field test at a total of 3 test sites in Germany.

The original performance test [9] included an evaluation of the data sets in accordance with the Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods dated 2005 for all three measurement campaigns. For formal reasons, however, it was not possible at the time to demonstrated equivalence, as only three of the required four comparisons were available and the number of validated data pairs for comparison did not reach the required minimum of 40. To enable the demonstration of equivalence in compliance with the Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods in its latest version of 2010 on the basis on the available datasets, the following approach was defined in 2012 together with the British project partners of the UK-GER PM Equivalence Programme.

Equivalence of the datasets obtained at the following sites is re-evaluated in line with the Guide of 2010:

- Cologne, parking lot; Titz-Rödingen and Cologne, Frankfurter Str. from the existing German performance test;

Additional evaluation using BAM-1020 of identical design:

- 2 sites (Steyregg, Graz) from equivalence tests performed by the Environment Agency Austria in 2007/2008; Candidates Ö1 and Ö2
- 1 site (Tusimice) from tests performed by the Czech Hydrometeorological Institute in the Czech Republic in 2010, candidates J7860 and J7863;
- 1 site (Teddington) from tests performed by NPL/Bureau Veritas in England in 2012, candidates S/N 17011 and S/N 17022.

Thus, a total of 7 comparison campaigns can be taken into account for analysis and the formal requirements of equivalence testing defined in the Guide (2010) (at least 4 comparisons based on 40 pairs of measured values) are met. All data from all sites were used for equivalence testing. This approach also aims to show that equivalence can be demonstrated under a variety of different conditions (different sites in different countries, various instruments of identical design, different users).

Addendum no. 936/21220762/A of 12 December 2012 prepared by TÜV Rheinland evaluates and presents the results of this comprehensive equivalence test [16].

New tests for items 6.1 4 Flow rate accuracy (7.4.4), 6.1 9 Dependence of span on supply voltage (7.4.8), 6.1 11 Dependence of reading on water vapour concentration (7.4.9) and 6.1 3 Zero level and detection limit (7.4.3) were performed with two identical BAM-1020 instruments, serial numbers X14465 and X14499.

The software version most recently announced publically is 3236-07 5.5.0. Software version 3236-05 3.14.1 was installed during the additional tests. The new software version provides new features regarding Chinese requirements, additional features and adaptations of the operational parameters to the requirements of EN 16450 [8].

In the course of the additional tests performed in summer 2018, the software was further updated to reach version 3236-05 3.14.2. Changes related to scaling sensor recording to ambient pressure as well as the data format for “Report Processor Option BX-965”.

In line with the requirements of EN 15267-2, these changes have been documented and classified correctly. No effect on instrument performance was observed. A separate notification is prepared for the relevant body.

Concentrations are indicated as µg/m³ (operating conditions).

The present addendum presents an assessment of the BAM-1020 measuring system with PM_{10} pre-separator regarding compliance with the requirements defined in standard EN 16450 [8].

In this report, the heading for each performance criterion cites the requirements according to [8] including its chapter number and wording.

4.2 Laboratory test

A large portion of the laboratory test is taken from the original performance test [9]. For the present report, test results were either taken from the previous report or re-assessed.

For the following test items, additional tests had to be performed in 2018.

- Zero level and detection limit
- Flow rate accuracy
- Influence of mains voltage on measured signal
- Effect of humidity on measured value

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 DK 37 E Sturdy metal flow meter (manufactured by Krohne)
- 1 reference flow meter, type BIOS Met Lab 500 (manufacturer: Mesa Lab)
- Zero filter kit BX-302 for external zero point check
- Internal span foils

The measured values were recorded internally. Stored measured values were retrieved using a hyperterminal connected to the RS232 interface.

Chapter 6 summarizes the results of the laboratory tests.

4.3 Field test

The original field test was carried out in the context of the existing performance test [9] with 2 identical measuring systems. These were:

Sites in Cologne (parking lot) and Titz

Cologne, Frankf. Str.:	Instrument 1:	S/N 4924
	Instrument 2:	S/N 4925

In the context of the extended equivalence test [16], the following additional instruments were used:

Sites in Steyregg & Graz (A):	Instrument 1:	Ö1
	Instrument 2:	Ö2
Site in Tusimice (CZ):	Instrument 1:	J7860
	Instrument 2:	J7863
Site in Teddington:	Instrument 1:	SN 17022
	Instrument 2:	S/N 17011

For the present report, test results were either taken from the previous report or re-assessed. No further testing was required.

The following instruments were used during the field test [9].

- Measurement container provided by TÜV Rheinland, air-conditioned to about 20 °C
- Weather station (WS 500 manufactured by ELV Elektronik AG) for collecting meteorological data such as temperature, air pressure, humidity, wind speed, wind direction and precipitation.
- 2 reference instruments for PM_{10} in accordance with section 5
- 1 DK 37 E Sturdy metal flow meter (manufactured by Krohne)
- Bellows meter with pulser (manufactured by Elster-Instromet)
- Measuring system for power consumption; Metratester 5 (manufacturer: Gossen Metrawatt)
- Zero filter kit BX-302 for external zero point check
- Internal span foils

Measurement data for all additional measurement campaigns in Austria, the Czech Republic and England [16] were obtained by accredited test laboratories or national reference laboratories.

Two BAM-1020 systems and two reference measuring systems for PM_{10} were simultaneously operated for 24 h each during the field test. The site in Tusimice (CZ) is the only exception: here only one reference system was in use. In line with section 8.2.1, note 2, of standard EN 16450 [8], this fact was taken into account for the determination of the uncertainty contribution of the reference method.

As part of the performance test, the impaction plates of the PM_{10} sampling inlet were cleaned approximately every four weeks and greased with silicone grease in order to ensure reliable separation of particles. The BX-802 PM_{10} sampling inlets of the $candidates_{2.5}$ were cleaned every four weeks. The sampling head generally has to be cleaned following the manufacturer's instruction taking into account local concentrations of suspended particulate matter.

The flow rates of the tested and the reference instruments were checked before and after the field test as well as before and after each re-location using a bellows meter connected to the instrument's air inlet via a hose line.

No information is available on this aspect for the additional measurement campaigns carried out in Austria, the Czech Republic and Great Britain [16].

Sites of measurement and instrument installation

Measuring systems in the field test were installed in such a way that only the sampling inlets were outside the measuring cabinet on its roof. The central units of the tested instruments and the reference systems were positioned inside the air-conditioned measurement cabinet. In the BAM-1020 systems and in the reference instruments, the central units were connected to the sampling heads via the sampling tube. Only at the field test site Cologne, parking lot, the complete reference systems (LVS3) were installed outside on the roof for lack of space (old measurement container).

No information is available on this aspect for the additional measurement campaigns carried out in Austria, the Czech Republic and Great Britain [16].

The field test was performed at the following measurement sites:

Table 4: Field test sites

No.	Measurement site	Period	Description
1	Cologne, parking lot	02/2006 –04/2006	Urban area
2	Titz-Rödingen	07/2006 – 09/2006	Rural area
3	Cologne, Frankf. Str.	09/2006 – 11/2006	Affected by traffic
4	Steyregg (A)	06/2008 – 08/2008	Suburban
5	Graz (A)	12/2007 – 03/2008	Urban area + traffic
6	Tusimice (CZ)	01/2010 – 06/2010	Industrial
7	Teddington (UK)	04/2012 – 05/2012	Urban area

Figure 11 to Figure 14 show the PM_{10} concentrations measured with the reference systems at the field test sites.

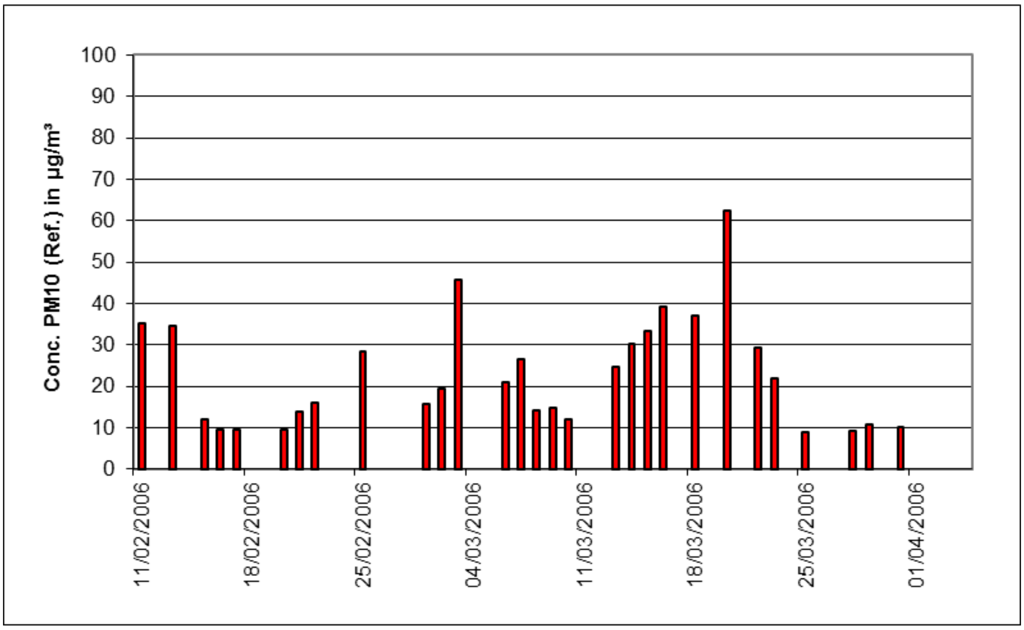


Figure 18: PM_{10} concentrations (reference) in “Cologne, parking lot”

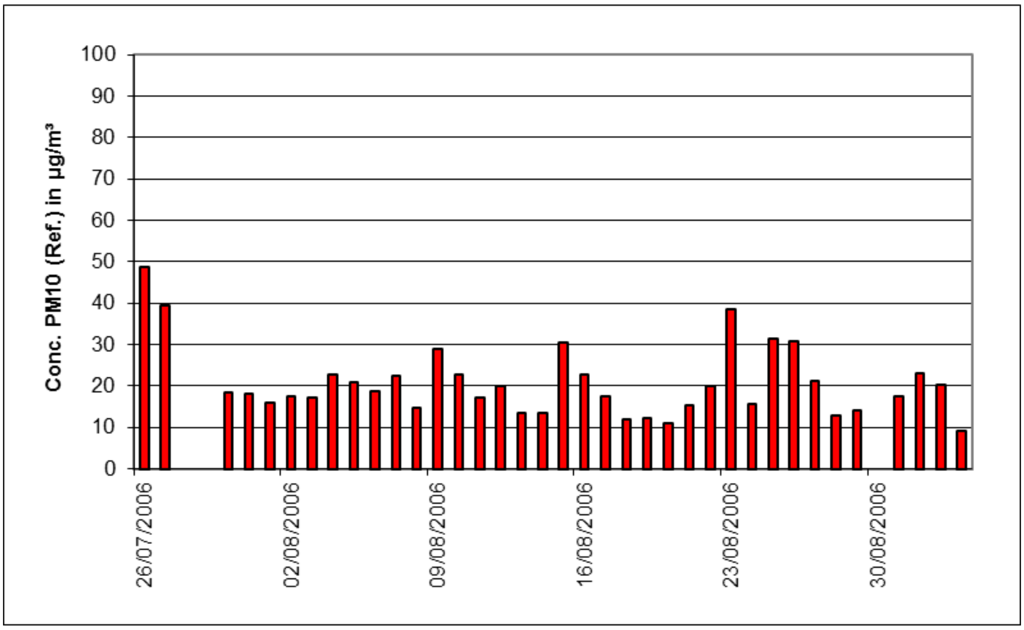


Figure 19: PM_{10} concentrations (reference) in “Titz-Rödingen”

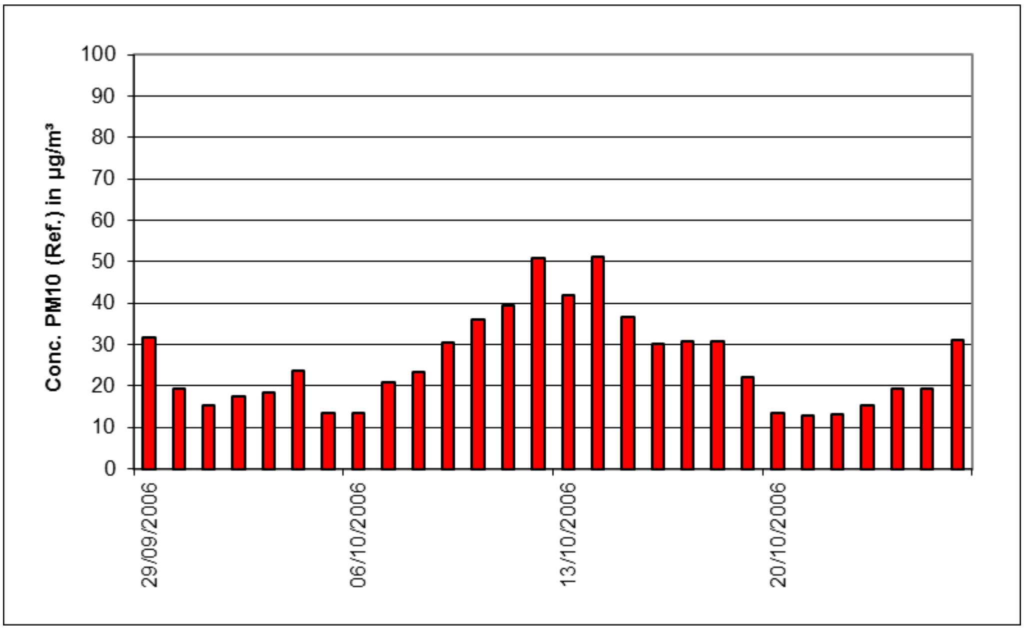


Figure 20: PM$_{10}$ concentrations (reference) in “Cologne, Frankf. Str.“

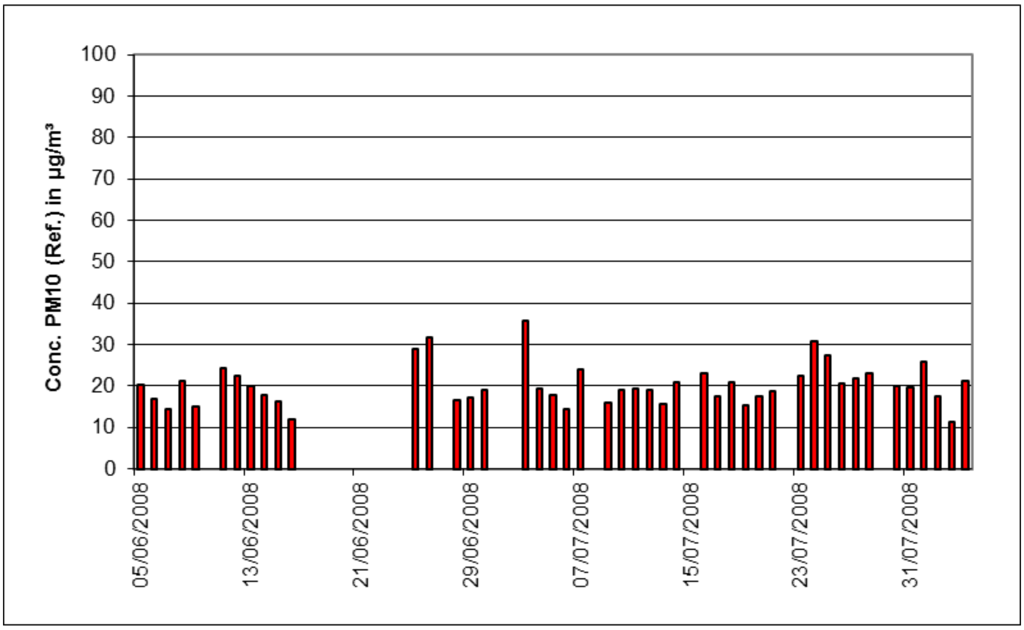


Figure 21: PM$_{10}$ concentrations (reference) in “Steyregg (A)”

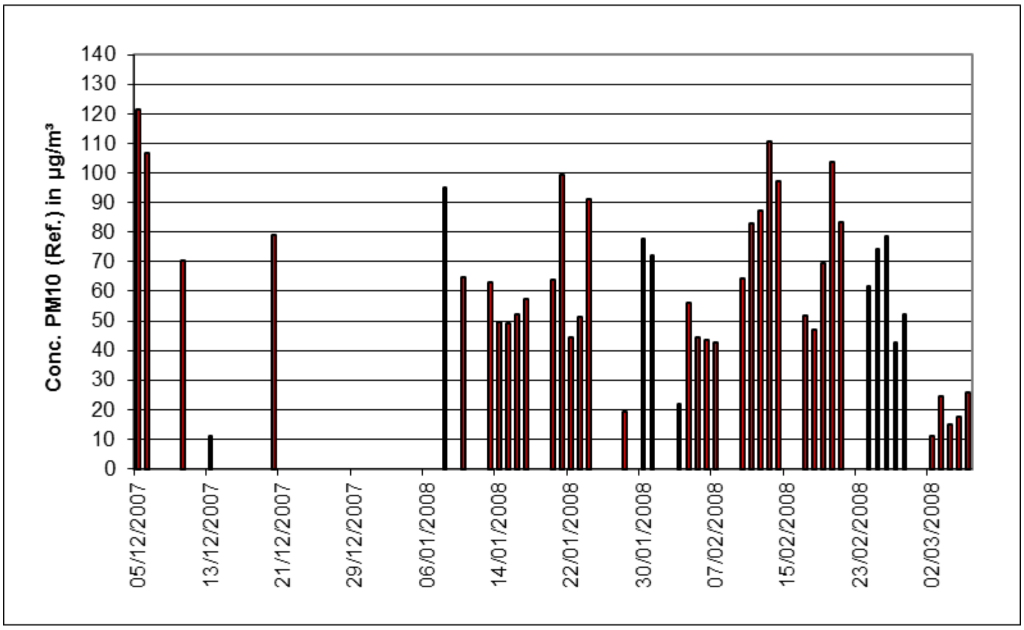


Figure 22: PM10 concentrations (reference) in “Graz (A)”

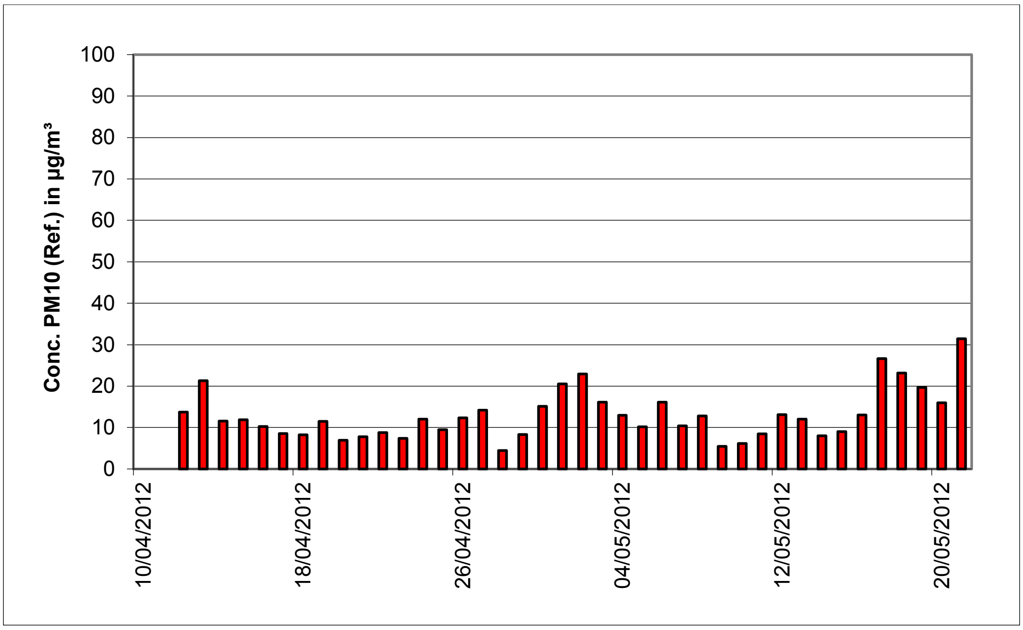


Figure 23: PM10 concentrations (reference) in “Teddington (UK)”

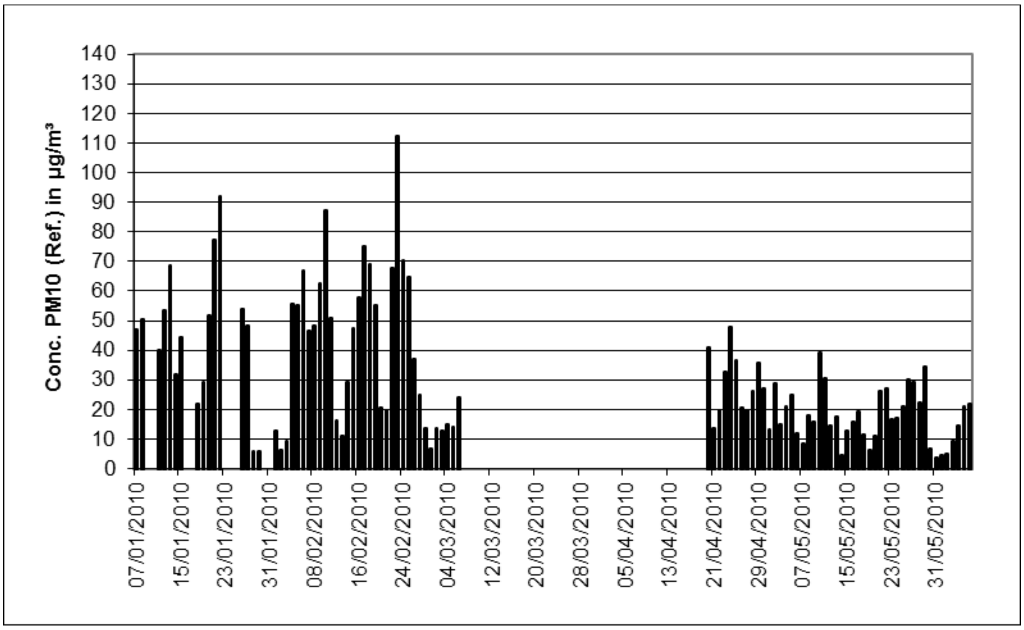


Figure 24: PM$_{10}$ concentrations (reference) in “Tusimice (CZ)”

The following pictures show the various field test sites:

Figure 25: Field test site Cologne, parking lot

Figure 26: Field test site Titz-Rödingen

Figure 27: Field test site Cologne, Frankfurter Str.

Figure 28: Field test site Steyregg (A) [20]

Figure 29: Field test site Graz (A) [20]

Figure 30: Field test site Tusimice (CZ) [20]

Figure 31: Field test site in Teddington, UK

In addition to the air quality measuring systems for monitoring suspended particulate matter, a data logger for meteorological data was installed at the container/measurement site for the campaigns which were part of the performance testing [9]. Data on air temperature, pressure, humidity, wind speed, wind direction and precipitation were continually measured. 10-min-averages were saved.

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

- Height of cabinet roof. 2.70m
- Height of the sampling system for test/ 1.2 m/1.2 m above cabinet roof
- Reference system 3.9 / 3.9 m over ground level
- Height of the wind vane: 4.5 m above ground level

Essential data was also recorded for the additional campaigns in accordance with [16].

In addition to an overview of the meteorological conditions determined during measurements at the 7 field test sites, the following Table 5 therefore provides information on the concentrations of suspended particulate matter. All individual values are presented in appendices 5 and 6.

Table 5: Ambient conditions at the field test sites as daily averages

	Cologne, parking lot	Titz-Rödingen	Cologne, Frankf. Str.	Steyregg (A)
number of measurements Reference	29	37	28	45
Air temperature [°C]				
Range	-3.2 – 15.6	12.7 – 26.5	5.5 – 19.1	10.9 – 26.2
Average	4.7	17.3	12.7	19.7
Air pressure [hPa]				
Range	982 – 1024	992 – 1010	989 – 1024	not available
Average	1003	1000	1008	
Rel. Humidity [%]				
Range	33.7 – 89.1	55.8 – 81.7	63.8 – 82.7	58.7 – 94.6
Average	64.0	74.2	71.8	74.0
Wind speed [m/s]				
Range	0.0 – 3.0	0.0 – 2.7	0.0 – 3.8	0.3 – 2.5
Average	1.1	0.4	1.1	1.3
Precipitation rate [mm/d]				
Range	0.0 – 15.2	0.0 – 35.7	0.0 – 19.8	not available
Average	2.6	5.6	2.2	

	Graz (A)	Tusimice (CZ)*	Teddington (UK)
number of measurements Reference	45	97 (J7860) 96 (J7863)	40
Air temperature [°C] Range Average	 -5.9 – 13.3 2.7	 -13.0 – 19.0 2.7	 5.8 – 14.9 10.3
Air pressure [hPa] Range Average	not available	not available	not available
Rel. Humidity [%] Range Average	 33.9 – 100 73.8	 24.0 – 96.0 82.9	 51.9 – 91.8 74.0
Wind speed [m/s] Range Average	 0.0 – 1.9 0.6	 0.0 – 3.1 0.7	 0.1 – 3.5 1.1
Precipitation rate [mm/d] Range Average	not available	not available	not available

* only 1 reference instrument in use

Sampling duration

Standard EN 12341 fixes the sampling time at 24h.

The sampling time was set to 24 h for all systems in the field test.

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 Grubb'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. The January 2010 version of the guideline [4] requires that no more than 2.5% of the data pairs be detected and removed as outliers.

No outliers were expunged for the reference measurements.

In principle, no measured value pairs are expunged for the tested AMS, unless there are justifiable technical reasons for implausible values. During the entire test, no measured values were expunged for the tested AMS.

Filter handling – Mass measurement

The following filters were used during performance testing:

Table 6: Filter materials used during the performance test [9]

Measuring device	Filter material, type	Manufacturer
Leckel LVS3 or SEQ47/50	Quartz wool, ∅ 50 mm	Whatman

Filter treatment complied with the requirements of standard EN 12341, annex C [3].

The following information is available for the additional measurement campaigns carried out in Austria, the Czech Republic and Great Britain [16, 20].

Table 7: Filter materials used during the additional tests [16; 20]

Location	Measuring device	Filter material, type	Manufacturer
Steyregg / Graz	Leckel SEQ47/50	Optical fibre, ∅ 46 mm	Munktell
Tusimice	Derenda	Optical fibre, ∅ 47 mm	Whatman
Teddington	Leckel LVS3	Emfab, ∅ 47 mm	Pall

Measurement data for all additional measurement campaigns were obtained by accredited test laboratories or national reference laboratories.

5. Reference Measurement Method

The following instruments were used during the field test [9] in accordance with EN 12341:

1. As reference system: low volume sampler LVS3 (Cologne, parking lot)
   Manufacturer: Engineering office Sven Leckel, Leberstraße 63, Berlin, Germany
   Date of manufacture: 2000
   PM_{10} sampling inlet

   and

   SEQ47/50 sampler holder, indoor version (from site in Titz)
   Manufacturer: Engineering office Sven Leckel, Leberstraße 63, Berlin, Germany
   Date of manufacture: 2005
   PM_{10} sampling inlet

Two reference devices were simultaneously operated with a controlled volume flow of 2.3 m³/h. Filter replacement took place at 8:00.

Under normal conditions the accuracy of flow control is < 1% of the nominal flow rate.

Starting with the site in Titz, two reference systems type SEQ47/50 sampler holder were introduced. It was installed as an indoor version, i.e. the filter changer itself was installed inside the measurement container, an intake pipe ensured the connection with the sample inlet. The entire sampling system is cooled by an air jacket – this is why the actual intake pipe is installed in an aluminium cladding tube.

Technically speaking, the filter changer is based on the small dust collector LVS3 and, given its design, essentially complies with the requirements for reference collectors as specified in EN 12341. The filter replacement mechanism combined with the filter cartridge and unloader system facilitates continuous 24-hour sampling for a period of up to 15 days.

For the LVS3 and the SEQ47/50, the rotary vane vacuum pump takes in sample air via the sampling inlet. 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.

After sampling has been completed, the electronics display the sample air volume in standard and operating m³ or save the measurement data on the hard drive ((SEQ 47/50).

The following information is available for the additional measurement campaigns carried out in Austria, the Czech Republic and Great Britain [16, 20].

Table 8: Reference instruments used during the additional tests [16; 20]

Location	Measuring device	Filter replacement
Steyregg / Graz	Leckel SEQ47/50	automatically at 8:00
Tusimice	Derenda	manually at 7:00
Teddington	Leckel LVS3	manually at 10:00

Measurement data for all additional measurement campaigns were obtained by accredited test laboratories or national reference laboratories.

6. Test results

6.1 1 Measuring ranges

The measuring ranges should meet the following requirements:
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

The following measuring ranges can be set at the measuring system: 0 – 0.100, 0 – 0.200, 0 – 0.250, 0 – 0.500, 0 – 1.000, 0 – 2.000, 0 – 5.000 0 – 10.000 mg/m³.

During the performance test, the measuring range was set to 0–1.000 mg/m³ = 0–1,000 µg/m³.

Measuring range: 0 –1,000 µg/m³ (standard)

6.5 Assessment

The measuring range is set to 0–1,000 µg/m³ by default. Supplementary measuring ranges are possible up to 0–10,000 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

The possibility of displaying negative signals was tested both in the laboratory and in the field test.

6.4 Evaluation

The measuring system is able to output negative signals both via its display and its data outputs.

6.5 Assessment

Negative signals are directly displayed and correctly output by the measuring system.

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 24h-averages.

The zero level and the detection limit were determined with zero filters installed at the AMS inlets of instruments with SN X14465 and SN X14499 during normal operation. Air free of suspended particulate matter is applied over a period of 15 days for a duration of 24h 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.

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

6.5 Assessment

On the basis of testing both instruments, the zero level was determined at a maximum of -0.49 µg/m³ and the detection limit at a maximum of 1.69 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 9: Zero level and detection limit PM_{10}

		Device SN X14465	Device SN X14499
Number of values n		15	15
Average of the zero values (Zero level) $\overline{x}_0$	µg/m³	-0.49	0.08
Standard deviation of the values s_{x0}	µg/m³	0.51	0.47
Detection limit x	µg/m³	**1.69**	**1.56**

Schedule 1 in the annex 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 of +5°C to +40°C; a reference flow meter in accordance with item 4 was provided.

6.3 Testing

The BAM-1020 measuring system operates at a flow rate of 16.67 l/min (1 m³/h).

At a temperature of +5 °C and +40 °C the flow rate was measured with the help of a reference flow meter for both measuring systems by taking 10 measurements over a period of 1h at the flow rate specified by the manufacturer for operation. The measurements were performed at equal intervals throughout the measurement period.

6.4 Evaluation

Averages were calculated from the 10 measured values determined at each temperature and deviations from the operating flow rate determined.

6.5 Assessment

The relative difference determined for the mean of the measuring results at +5°C and at +40°C did not exceed -1.93%.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 10 summarises the results of the flow rate measurements.

Table 10: Flow rate accuracy at +5°C and +40°C

		Device SN X14465	Device SN X14499
Nominal value flow rate	l/min	16.67	16.67
Mean value at 5°C	l/min	16.41	16.35
Dev. from nominal value	%	-1.54	-1.93
Mean value at 40°C	l/min	16.87	16.88
Dev. from nominal value	%	1.18	1.24

Schedule 2 in the annex contains the individual measured values for the determination of the flow rate accuracy.

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% sample flow (instantaneous flow)

≤ 5% rated flow (instantaneous flow)

6.2 Equipment

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

6.3 Testing

The BAM-1020 measuring system operates at a flow rate of 16.67 l/min (1 m³/h).

During the performance test, the sample flow rate was calibrated before the first field test and then checked with the help of a bellows meter at every new field test site and re-adjusted when necessary.

In order to determine the consistency of the sample flow rate, a flow meter was connected to the measuring systems and the flow rate was recorded as 5-second-values and evaluated over a period of 6 h (= 6 measurement cycles).

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.

6.5 Assessment

Table 11 presents the results of the flow rate checks performed at every field test site.

Table 11: Results of the flow rate checks

Flow rate check before:	SN 4924		SN 4925	
Field test site:	[l/min]	Dev. from target [%]	[l/min]	Dev. from target [%]
Cologne, parking lot	16.67	-	16.67	-
Titz-Rödingen	16.51	-1.0	17.09	2.5
Cologne, Frankfurter Str.	16.45	-1.3	15.5	-7,0*

* adjusted flow rate

The charts illustrating the constancy of the sample flow rate demonstrate that all measured values determined during sampling deviate from their respective rated values by less than ±5%. At 16.67 l/min, the deviation of the 24h-mean for the overall flow rate also remains well below the required maximum of ±2.0% from the rated value.

The 24h-averages deviate from their rated values by less then ± 2.0%, all instantaneous values deviate by less than ± 5%.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table Table 12 lists the characteristics determined for the flow rate. Figure 32 to Figure 33 provide a chart of the flow rate measurement for both instruments - SN 4924 and SN 4925.

Table 12: Characteristics of the overall flow rate measurement (24h mean), SN 4924 and SN 4925

		Device SN 4924	Device SN 4925
Mean value	l/min	16.71	16.58
Dev. from nominal value	%	0.25	-0.52
Standard deviation	l/min	0.05	0.08
Minimum value	l/min	16.34	15.95
Maximum value	l/min	17.02	16.83

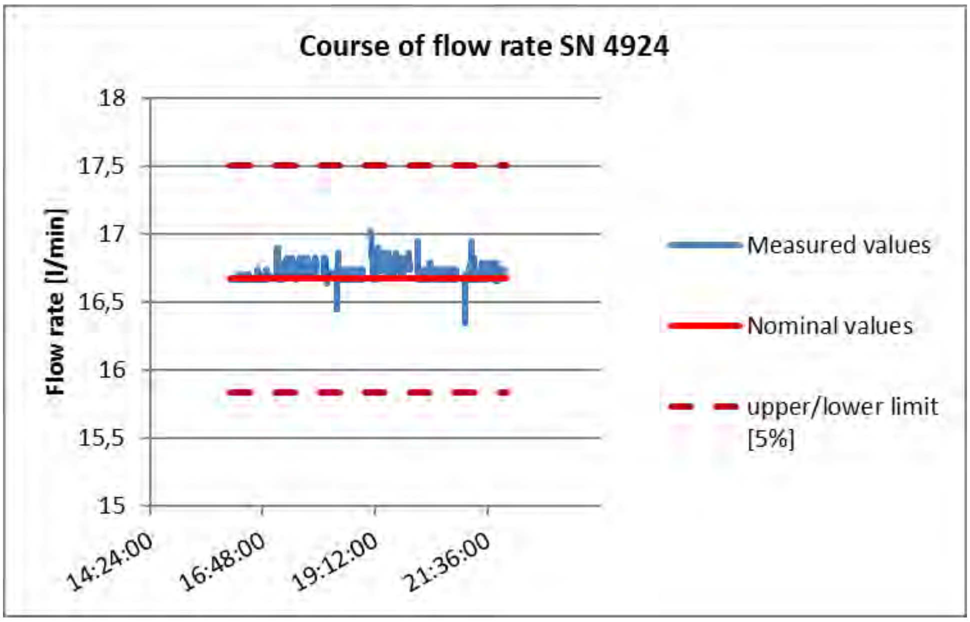


Figure 32: Flow rate of tested instrument SN 4924

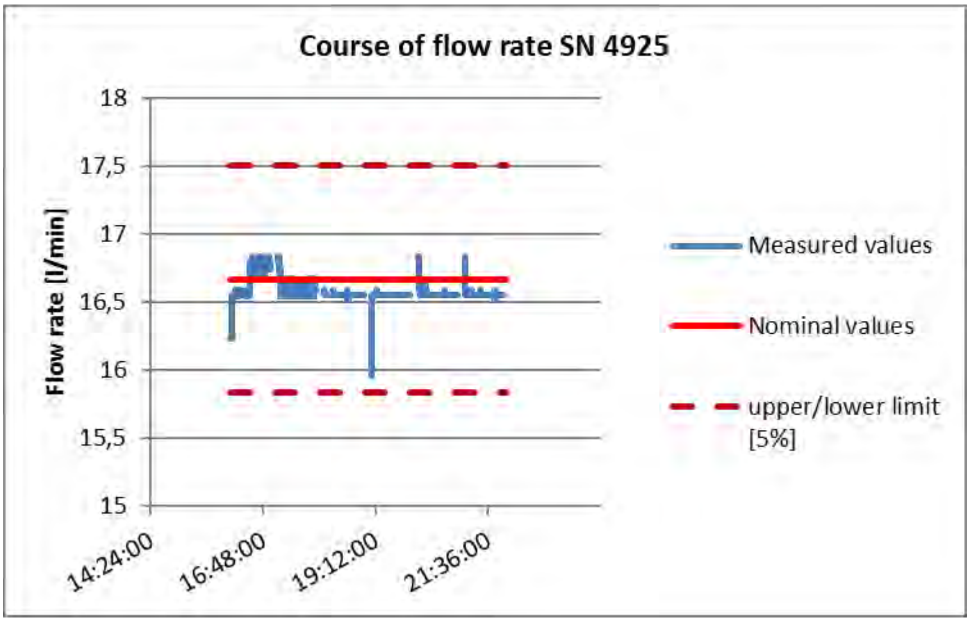


Figure 33: Flow rate of tested instrument SN 4925

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

BX-302 zero filter kit or BX-305 inlet adapter

6.3 Testing

To determine the leak rate, the BX-305 inlet adapter was attached to the inlet of the sampling tube and the adapter's ball valve was closed slowly. The leak rate was determined from the difference between the flow rate when the pump was switched off (zero point of flow rate measurement) and the measured flow rate with a sealed instrument inlet.

This procedure was repeated three times.

It is re recommended to test the instrument's tightness with the procedure described above once a month.

6.4 Evaluation

The leak rate was determined from the difference between the flow rate when the pump was switched off (zero point of flow rate measurement) and the measured flow rate with a sealed instrument inlet.

The maximum of three observed leak rates was determined.

Under the test conditions described, the manufacturer allows a maximum leak rate of 1 l/min as a completely sealed instrument results in a very strong vacuum inside the measuring system which significantly exceeds any vacuum that could be created during normal operation by filter loading.

However, this maximum can be converted to a value which can realistically occur in normal operation. It is recommended to use the determined, converted leak rate for the evaluation of the measuring system.

The Hagen-Poiseuille law applies to laminar flowing liquids and gases in a tube. It describes the quantity of the medium flowing through a tube (with the length l and the radius r) per unit of time as follows:

$$\dot{V} = \frac{dV}{dt} = \frac{\pi\, r^4}{8\eta}\,\frac{\Delta p}{l}$$

For the present situation, the following may be derived:

1. The flow length l, the radius r and the dynamic viscosity η (for gases no pressure dependence in the range up to 10 bar) remain constant.
2. Thus, the leak rate $\dot{V}$ is immediately proportional to the differential pressure Δp.
3. During the leak tightness test, the nominal differential pressure is at 438 mbar when using the BX-127 pump (MEDO 230 V, 50 Hz).
4. Differential pressure in normal operation is at around 200–250 mbar.
5. Accordingly, the displayed leak rate exceeds the actual rate at least by the factor 438/250 = 1.75.
6. Applying this factor to the data obtained results in the following leak rate related to the standard flow rate of 16.67 l/min.

   Gerät1: 0.34%
   System 2 0.34%

6.5 Assessment

The maximum leak rate was determined at 0.1 l/min and was smaller than 2% of the nominal flow rate 16.67 l/min.

The criterion for passing the leak test as specified by the AMS manufacturer – maximum flow rate of 1.0 l/min – proves to be an adequate criterion for monitoring the instrument's leak tightness. The method described reliably detects potential leakages in the system (e.g. contaminations in the area of the inlet nozzle at the filter band caused by filter abrasion.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 13 lists the result from the leak test.

Table 13: Results of the leak test during the field test

	Flow (Pump off)	Flow (Pump on, inlet closed)						
		1	2	3	Max. value	Max. value divided by 1.75	part target value	Max. acceptable leak rate acc. manufacturer
	l/min	l/min	l/min	l/min	l/min	l/min	%	l/min
SN 4924	0	0.1	0.0	0.1	0.1	0.057	0.34	1.0
SN 4925	0	0.1	0.1	0.1	0.1	0.057	0.34	1.0

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 between +5 and +40 °C; filter tape

6.3 Testing

The dependence of the zero reading on the surrounding temperature was determined at the following temperatures (within the specifications of the manufacturer):

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

b) at a minimum temperature $T_{S,1}$ = +5 °C;

c) at a maximum temperature $T_{S,2}$ = +40 °C.

The complete measuring systems were operated inside a climatic chamber in order to evaluate the influence of ambient temperature on the zero point.

For the test instruments S/N 4924 and S/N 4925, the zero point was determined by evaluating the internal verification of the zero point of the radiometric measurement during operation of the measuring system. To this effect, the count rates I_1 and I_{1x}, which were determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functioning of the measuring system) were evaluated.

The tests were performed in the temperature sequence $T_{S,n}$ — $T_{S,1}$ — $T_{S,n}$ — $T_{S,2}$ — $T_{S,n}$.

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

6.4 Evaluation

The required measured values were recorded and evaluated via the serial interface #2.

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 $T_{S,lab}$ were determined.

6.5 Assessment

The tested temperature range at the site of installation was +5 °C to +40 °C. Taking into account at the values displayed by the instrument, we determined a maximum dependence of the zero point on the on surrounding temperature of 0.4 µg/m³.

Criterion satisfied?   yes

6.6 Detailed presentation of test results

Table 14: Dependence of the zero point on surrounding temperature, BAM-1020, Deviation as µg/m³, mean from three measurements S/N 4924 & S/N 4925

Temperature	SN 4924		SN 4925	
	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	0.5	0.0	0.9	-0.1
5	0.2	-0.3	1.2	0.2
20	0.3	-0.2	1.2	0.2
40	0.9	0.4	0.8	-0.2
20	0.7	0.2	0.9	-0.1
Mean value at 20°C	0.5	-	1.0	-

Schedule 3 in the annex contains the individual measuring 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 adjusted to +5 °C to +40 °C, internal span foil used to check the span point.

6.3 Testing

The dependence of AMS sensitivity (span) on the surrounding temperature was determined at the following temperatures (within the specifications of the manufacturer):

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

b) at a minimum temperature $T_{S,1}$ = +5 °C;

c) at a maximum temperature $T_{S,2}$ = +40 °C.

For the purpose of testing the dependence of the AMS sensitivity on the surrounding temperature, the complete measuring system was operated in the climatic chamber without the outdoor rack.

For the purpose of span checks the sensitivity of the internal span foil was verified for the tested instruments SN 4924 and SN 4925 in order to test the stability of the sensitivity.

The tests were performed in the temperature sequence $T_{S,n}$ — $T_{S,1}$ — $T_{S,n}$ — $T_{S,2}$ — $T_{S,n}$.

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

6.4 Evaluation

Measured values for the internal span foil were recorded at different temperatures and evaluated.

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 $T_{S,lab}$ were determined.

6.5 Assessment

The tested temperature range at the site of installation was +5 °C to +40 °C. At span point, the deviations determined did not exceed 0.2%.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 15: Dependence on surrounding temperature (internal span foil), BAM-1020, deviation in %, average from 3 readings
S/N 4924 & S/N 4925

Temperature	SN 4924		SN 4925	
	Measured value	Deviation to mean value at 20°C	Measured value	Deviation to mean value at 20°C
°C	[µg/cm²]	%	[µg/cm²]	%
20	824.7	-0.1	814.8	0.0
5	825.8	0.1	816.3	0.2
20	825.2	0.0	815.0	0.0
40	825.4	0.0	813.7	-0.1
20	825.9	0.1	814.0	-0.1
Mean value at 20°C	825.3	-	814.6	-

Schedule 3 in the annex contains the results from 3 individual measurements.

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, internal span foil for span checks

6.3 Testing

In order to test the dependence of span on supply voltage, supply voltage was reduced to 195 V starting from 230 V, it was then increased to 253 V via an intermediary step of 230 V.

For the purpose of span checks, the sensitivity of the internal span foil was verified for the tested instruments SN X14465 and SN X14499 in order to test the stability of the sensitivity.

6.4 Evaluation

At span point, the percentage change of the measured value determined for every step related to the starting point at 230 V was considered.

6.5 Assessment

Voltage variations did not result in deviations > -0.4% compared to the initial value of 230 V.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table16 shows a summary of the test results.

Table16: Influence of mains voltage on measured value, deviation in %
SN X14465 & SN X14499

Supply voltage	SN X14465		SN X14499	
	Measured value	Deviation to start value at 230 V	Measured value	Deviation to start value at 230 V
V	[mg]	%	[mg]	%
230	0.815	-	0.826	-
195	0.816	0.2	0.828	0.3
230	0.817	0.3	0.822	-0.4
253	0.816	0.2	0.827	0.1
230	0.815	0.0	0.824	-0.2

Schedule 4 in the annex 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 and reached operation mode on return of the mains voltage.

6.4 Evaluation

In the event of a failure in mains voltage, the measuring system automatically starts a new measuring cycle at the next full hour and thus resumes normal operation.

6.5 Assessment

Buffering protects all instrument parameters against loss. On return of mains voltage, the instrument returns to normal operating mode and automatically resumes measuring at the next full hour.

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 c/w humidity control for the range between 40% and 90% relative humidity, zero filter for zero checks

6.3 Testing

The dependence of reading on water vapour concentration in the sample air was determined by feeding humidified zero air in the range between 40% and 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 SN X14465 and SN X14499 after fitting two zero filters at either AMS inlet in order to perform zero point checks.

After stabilisation of relative humidity and the concentration values, a reading over an 24h-averaging period at 40% relative humidity was recorded. Relative humidity was then increased to 90% at a constant pace. The time needed until an equilibrium was reached (ramp) and the measured value over an averaging time of 24h at 90% relative humidity were recorded. Subsequently, humidity was decreased to 40% at a constant pace. Again, the time needed until an equilibrium was reached (ramp) and the reading over an averaging time of 24h at 40% relative humidity were recorded.

6.4 Evaluation

The measured value for the zero level of 24-hour individual measurements at stable humidity levels were obtained and assessed. The characteristic concerned is the largest difference in µg/m³ between values in the range of 40% to 90% relative humidity.

6.5 Assessment

Differences between readings determined at relative humidifies of 40% and 90% did not exceed 2.0 µg/m³. Various water vapour concentrations were not observed to cause any significant effect on zero readings.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 17: Dependence of reading on water vapour concentration. dev. in µg/m³. $PM_{2.5}$. SN X14465 & SN X14499

rel. Humidity	SN X14465		SN X14499	
	Measured value	Deviation to previous value	Measured value	Deviation to previous value
%	µg/m³	µg/m³	µg/m³	µg/m³
40	0.2	-	-1.3	-
90	-1.1	-1.3	-2.8	-1.5
40	-0.7	0.4	-0.8	2.0
Maximum deviation	-1.3		2.0	

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

Filter Tape

6.3 Testing

As part of the field test of the original performance test [9], the checks were performed over a period of 8-9 months.

For the purpose of checking the zero point, the count rates I_1 and I_{1x}, which were determined on a clean filter tape spot at every measurement cycle (refer to point 3.2 Functioning of the measuring system) were evaluated.

For the evaluation, the automatically calculated hourly values at zero were aggregated and evaluated on average once a week for one day to a 24-hour mean value during the entire field test. For reasons of practicability (large volume of data), the daily evaluation of the overall data set was dispensed with as part of the test. However, an evaluation and graphic representation of the results for the period from 3 October 2006 to 16 October 2006 was carried out by way of example.

The evaluation of the internal zero point measurement did not result in an interruption of the ongoing measuring operation.

An external test with zero filter at the instrument inlet is also easily possible at any time.

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 maximum measured value determined for PM_{10} at zero point was 2.2 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 18 shows the determined measured values for the zero point in µg/m³.

Figure 3434Figure 35 illustrate the zero drift observed during the test period.

Table 18: Zero point checks S/N 4924 & S/N 4925, PM_{10}, with zero filter

Date	SN 4924		Date	SN 4925	
	Measured Value µg/m³	Measured value (absolute) > 3.0 µg/m³		Measured Value µg/m³	Measured value (absolute) > 3.0 µg/m³
2/11/2006	1.0	ok	2/11/2006	0.4	ok
2/18/2006	1.0	ok	2/18/2006	-0.1	ok
2/25/2006	0.6	ok	2/25/2006	1.9	ok
3/4/2006	-0.4	ok	3/4/2006	0.4	ok
3/11/2006	-0.6	ok	3/11/2006	0.2	ok
3/18/2006	-0.5	ok	3/18/2006	1.3	ok
3/25/2006	-0.1	ok	3/25/2006	0.3	ok
4/1/2006	0.5	ok	4/1/2006	0.8	ok
8/5/2006	2.2	ok	8/5/2006	1.1	ok
8/12/2006	0.6	ok	8/12/2006	1.1	ok
8/19/2006	1.2	ok	8/19/2006	-0.5	ok
8/26/2006	1.2	ok	8/26/2006	1.5	ok
9/2/2006	0.8	ok	9/2/2006	0.6	ok
10/1/2006	0.1	ok	10/1/2006	1.4	ok
10/7/2006	0.7	ok	10/7/2006	1.3	ok
10/14/2006	0.5	ok	10/14/2006	0.5	ok
10/21/2006	-0.2	ok	10/21/2006	0.2	ok
10/28/2006	1.5	ok	10/28/2006	0.9	ok

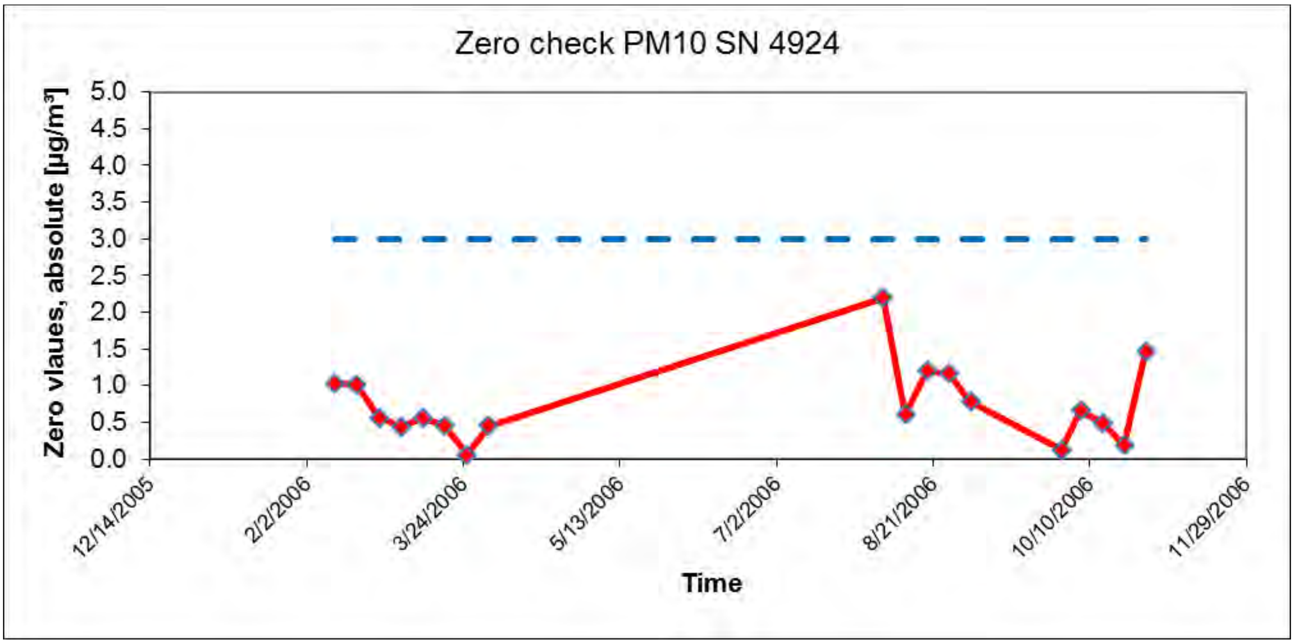


Figure 34: Zero drift S/N 4924, measured component PM_{10}

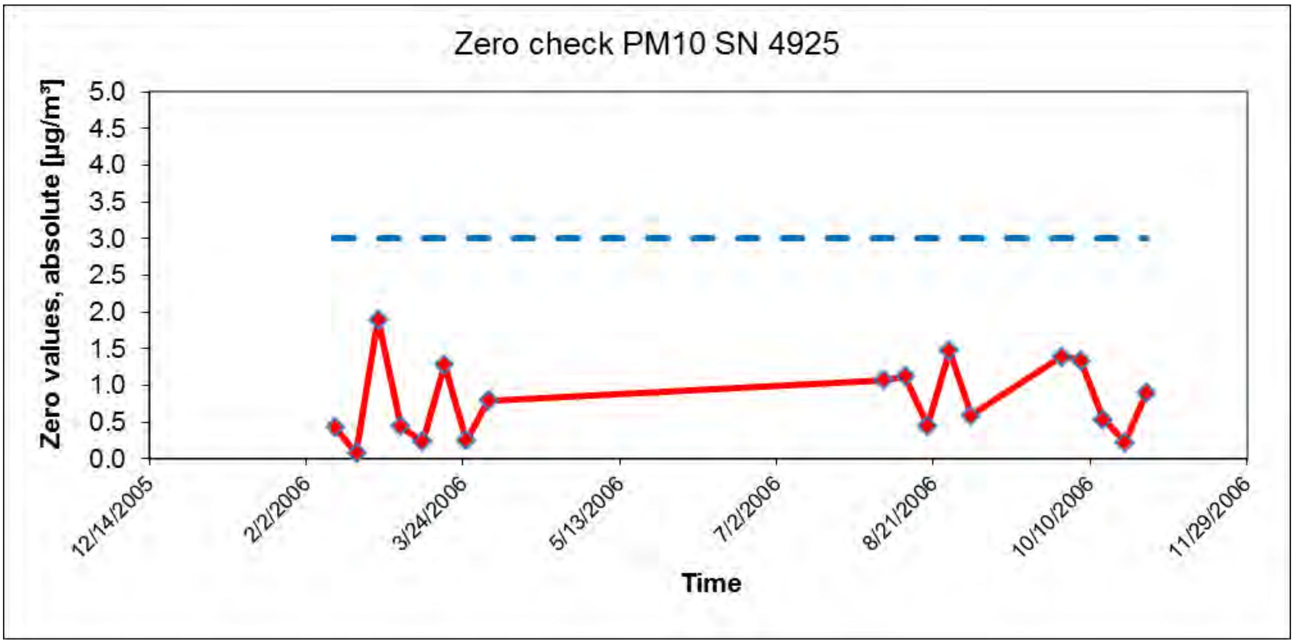


Figure 35: Zero drift S/N 4925, measured component PM_{10}

6.1 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 the sampling inlet if a heated inlet is used;*

Results of automated/functional checks, where available, shall be recorded.

6.2 Equipment

Modem, PC for data acquisition (RS 232-host-device)

6.3 Testing

The measuring system allows for comprehensive remote monitoring and control e.g. via an RS232 interface. It can communicate measured values and status information via the Bavaria-Hesse protocol.

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

- Concentration measured values from the previous test cycle,
- Sampled volume,
- Sample flow rate
- Ambient temperature and pressure,
- Internal measurement of zero point (STAB) and span point (REF)
- Pressure drop across the filter band (5min flow file),
- Also configurable: relative humidity in the area of filter band (monitoring / control of heating) or other meteorological parameters
- ….

The parameters “sampling duration” (set via the cycle time) and “temperature of the sample inlet” are irrelevant to the measuring system.

Remote monitoring and control is easily possible via routers or modems.

Access to the instrument and the data during the performance test was ensured by terminal software.

6.4 Evaluation

The measuring system allows for comprehensive remote monitoring and control via various connectors (Ethernet, RS232). The instrument provides operating statuses and all relevant parameters.

6.5 Assessment

The measuring system allows for comprehensive remote monitoring and control via various connectors (Ethernet, RS232). 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

We verified whether the measuring system allows for the formation of daily averages.

6.4 Evaluation

By default, the measuring system operates with a measurement cycle of 60 min. After each measurement cycle, the filter tape is moved forward by one position. The data of each measurement cycle are stored and are available to the user for further processing. Furthermore, the measuring system allows the formation of a 24 h average, which is output in the daily protocol via the serial interface.

During the performance test, the cycle time was set to 60 min, radiometric measurements taking 4 min each.

Thus, the cycle time consists of 2 x 4 min for the radiometric measurement (I_0 & I_3) as well as approximately 1–2 min for filter tape movements. Accordingly, the sampling time per hour is 50 min.

Thus, the available sampling time per measurement cycle corresponds to approx. 83 % of the total cycle time. The results of the field test in accordance with item 6.1 17 Expanded uncertainty of AMS results (7.5.8.5–7.5.8.8) in this report show that reproducibility of the test specimen compared to the reference method for this instrument configuration was clearly demonstrated and thus daily averages can reliably be formed.

6.5 Assessment

The instrument configuration described and a measurement cycle set to 60 min allow the formation of valid daily averages based on 24 individual measurements.

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 at each of the three field test sites from the initial test [9] marked the start and end time for the availability test. 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. 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 19 establishes the operation, maintenance and outage times. During the field test of the original test [9], the measuring systems were operated for a total of 147 measuring days (see annex 5).

Outages caused by external events not attributed to the measuring system occurred on 28/07/2006 and 29/07/2006 (48h due to power failure) and on 30/08/2006 (24h caused by the installation of an electricity meter). This reduces the total time of operation to 144 measuring days.

Regular cleaning of the sampling inlets in the maintenance interval, filter tape replacement (approx. every 2 months) and regular checks of the flow rate and the leak tightness each resulted in outages of less than 1 h per instrument (outage time = 1 cycle). These tasks cause down times of less than 1h per check (16 times during testing) and did not require daily averages to be discarded. Only on 14 February 2006, was a period of more than 1 hour required for the necessary work at the Cologne site, parking lot, for organisational reasons. The measured values from that day were therefore completely discarded. However, this 24-hour failure is not attributable to the instrument, but is due to the organisation and performance of the tests themselves.

No errors in functioning were observed.

6.5 Assessment

The availability for SN 4924 was 99.3%, for SN 4925 it was 99.3%.
Criterion satisfied?   yes

6.6 Detailed presentation of test results

Table 19: Determination of the availability

		System 1 (SN 4924)	System 2 (SN 4925)
Operation time (t_{field})	d	144	144
Outage time	d	-	-
Maintenance time incl. zero filter ($t_{cal,maint}$)	d	1	1
Actual operating time (t_{valid})	d	143	143
Availability	%	99.3	99.3

6.1 Method used for equivalence testing (7.5.8.4 & 7.5.8.8)

The initial test in 2006 of the BAM-1020 measuring system with PM_{10} pre-separator was designed in such a way that the tests were evaluated and documented in accordance with the minimum requirements of the guideline VDI 4202 Part 1 and the corresponding European standard EN 12341. Moreover, an evaluation of the data sets in accordance with the Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods (2005) was performed for all three measurement campaigns. For formal reasons, however, it was not possible at the time to demonstrated equivalence, as only three of the required four comparisons were available and the number of validated data pairs for comparison did not reach the required minimum of 40.

To enable the demonstration of equivalence in compliance with the Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods in its latest version of 2010 on the basis on the available datasets, the following approach was defined together with the British project partners of the UK-GER PM Equivalence Programme.

Equivalence of the datasets obtained at the following sites is re-evaluated in line with the Guide of 2010:

- Cologne, parking lot; Titz-Rödingen and Cologne, Frankfurter Str. from the existing German performance test;

Additional evaluation using BAM-1020 of identical design:

- 2 sites (Steyregg, Graz) from equivalence tests performed by the Environment Agency Austria in 2007/2008;
- 1 site (Tusimice) from tests performed by the Czech Hydrometeorological Institute in the Czech Republic in 2010
- 1 site (Teddington) from tests performed by NPL/Bureau Veritas in England in 2012

Thus, a total of 7 comparison campaigns can be taken into account for analysis and the formal requirements of equivalence testing defined in the Guide (2010) (at least 4 comparisons based on 40 pairs of measured values) are met. All data from all sites were used for equivalence testing. This approach also aims to show that equivalence can be demonstrated under a variety of different conditions (different sites in different countries, various instruments of identical design, different users).

The January 2010 Guide [4] requires compliance with the following five criteria in order to recognise equivalence:

1. Of the full data set, at least 20% of the concentration values (determined with the reference method) shall be greater than the upper assessment threshold specified in 2008/50/EC [7], i.e. 28 µg/m³ for PM_{10} and 17 µg/m³ for $PM_{2.5}$. Should this not be assured because of low concentration levels, a minimum of 32 value pairs 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 PM_{10} and 18 µg/m³ $PM_{2.5}$.
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:
   - datasets 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
   - Datasets for each individual site
5. Preconditions for acceptance of the full dataset 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 preconditions are not met, the candidate method may be calibrated using the values obtained for slope and/or intercept.

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

Chapter 6.1 16 Between-AMS uncertainty $u_{bs,AMS}$ (7.5.8.4) addresses verification of criteria 1 and 2.

Verification of criteria 3, 4 and 5 is reported on in chapter 6.1 17 Expanded uncertainty of AMS results (7.5.8.5–7.5.8.8)

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 $u_{bs,AMS}$ (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 seven separate comparison campaigns. Different seasons as well as different concentrations of PM_{10} were taken into consideration.

In the full dataset, at least 20% of the results obtained using the reference method should be greater than the upper assessment threshold of the annual limit value specified in 2008/50/EC [7]. The assessment threshold for PM_{10} is 28 µg/m³.

Four comparison campaigns (A-Steyregg, A-Graz, CZ-Tusimice, UK-Teddington) with at least 40 valid value pairs each were determined. In addition, the 3 comparison measurement campaigns (D-Cologne, parking lot, D-Titz-Rödingen, D-Colonge, Frankf. Str.) from the original performance test [9] were also evaluated, although these comparisons each contained less than 40 valid value pairs. Of the full dataset, (7 locations, 320 valid pairs of measured values), a total of 35.3% of the measured values exceeded the upper assessment threshold of 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 locations or comparisons together (full data set)
- 1 data set with measured values ≥ 30 µg/m³ for PM_{10} (basis: averages reference measurement)

Furthermore, this report also covers an evaluation of the following data sets:

- Every location or comparison separately
- 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 1.49 µg/m³ for PM_{10}, the between-AMS uncertainty u_{bs} remains well below the permissible maximum of 2.5 µg/m³.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Table 20 lists the calculated values for the between-AMS uncertainties u_{bs}. A corresponding chart is provided in Figure 36 to Figure 45.

Table 20: Between-AMS uncertainty $u_{bs,AMS}$, measured component PM_{10}

Tested instruments	**Location**	**Number of measurements**	**Uncertainty u_{bs}**
SN			µg/m³
4924/Ö1/J7860/17022 vs. 4925/Ö2/J7863/17011	**All locations**	**363**	**1.22**
Individual locations			
4924 / 4925	Cologne, parking lot	52	1.22
4924 / 4925	Titz-Rödingen	37	0.86
4924 / 4925	Cologne, Frankf. Str.	28	0.99
Ö1 / Ö2	Steyregg (A)	51	0.75
Ö1 / Ö2	Graz (A)	50	1.96
J7860 / J7863	Tusimice (CZ)	103	1.18
17022 / 17011	Teddington (UK)	42	1.00
Classing over reference values			
4924/Ö1/J7860/17022 vs. 4925/Ö2/J7863/17011	**Values ≥ 30 µg/m³**	**105**	**1.49**
4924/Ö1/J7860/17022 vs. 4925/Ö2/J7863/17011	Values < 30 µg/m³	215	1.09

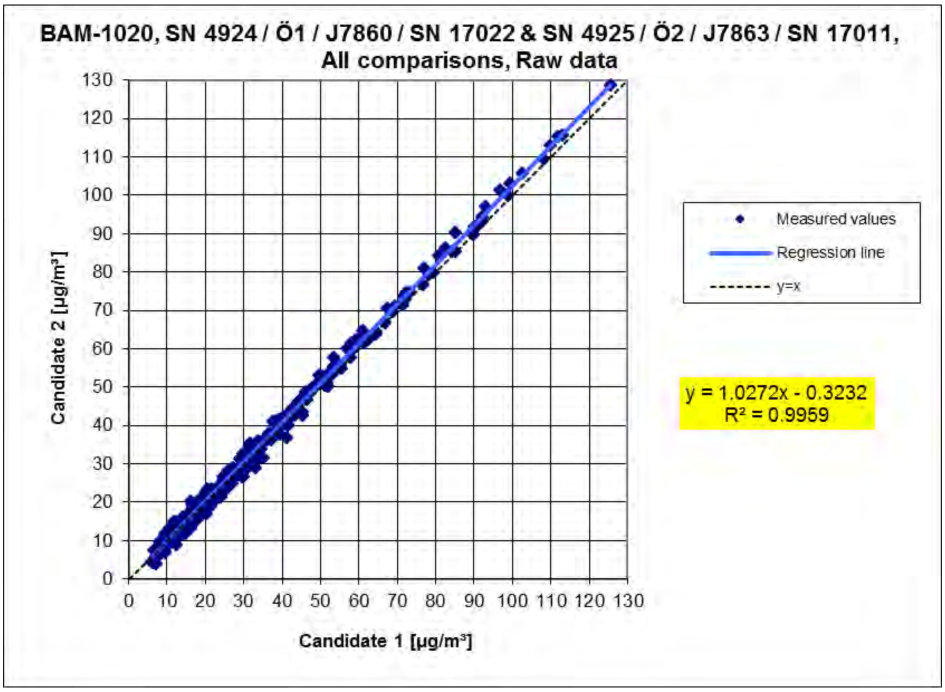


Figure 36: Results of the parallel measurements with tested instruments SN 4924/Ö1/J7860/SN 17022 vs. SN 4925/Ö2/J7863/SN 17011, PM_{10} particulate matter, all sites

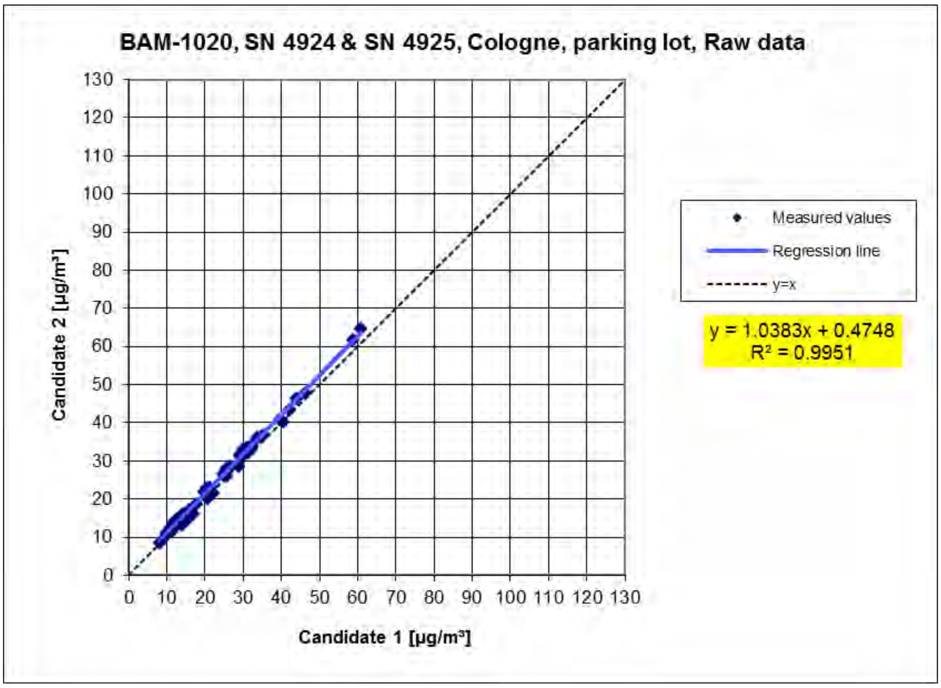


Figure 37: Results of the parallel measurements for instruments S/N 4924 / S/N 4925, Measured component PM_{10}, Cologne, parking lot

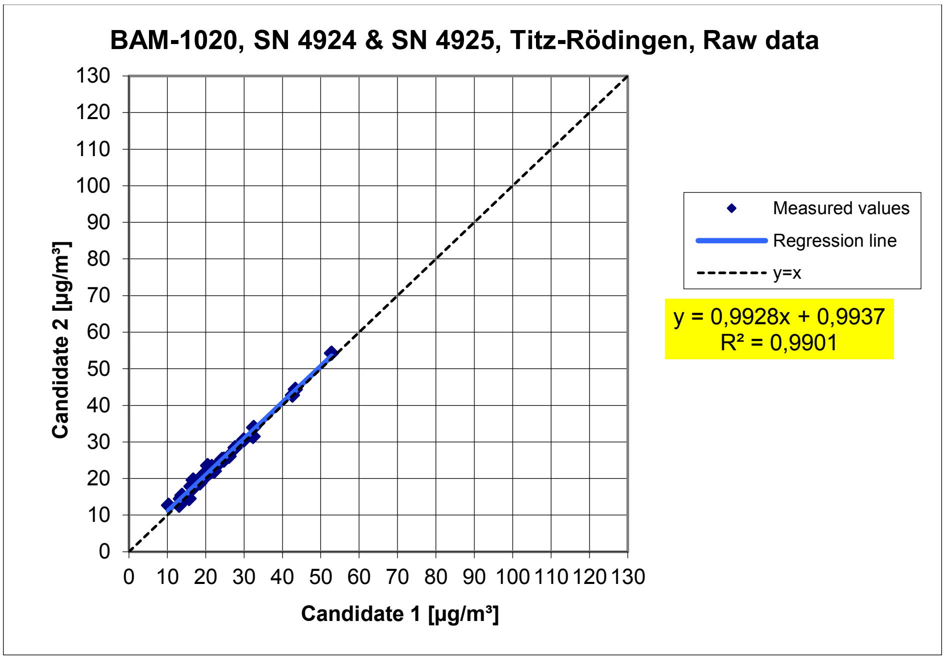


Figure 38: Results of the parallel measurements for instruments S/N 4924 / S/N 4925, Measured component PM_{10}, Titz-Rödingen

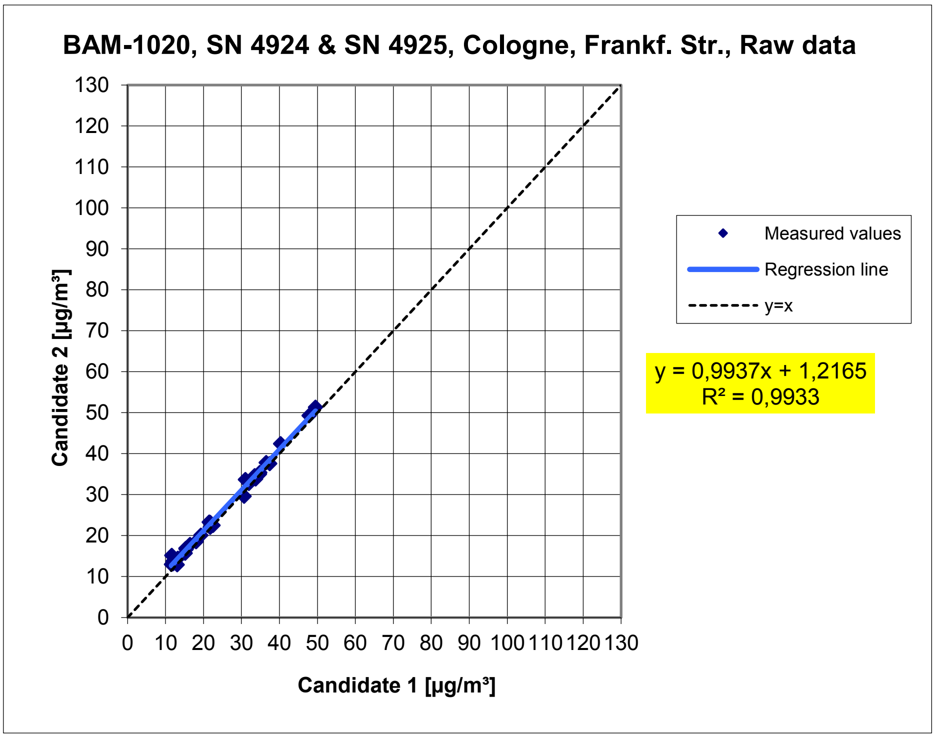


Figure 39: Results of the parallel measurements for instruments S/N 4924 / S/N 4925, Measured component PM_{10}, Cologne, Frankf. Str.

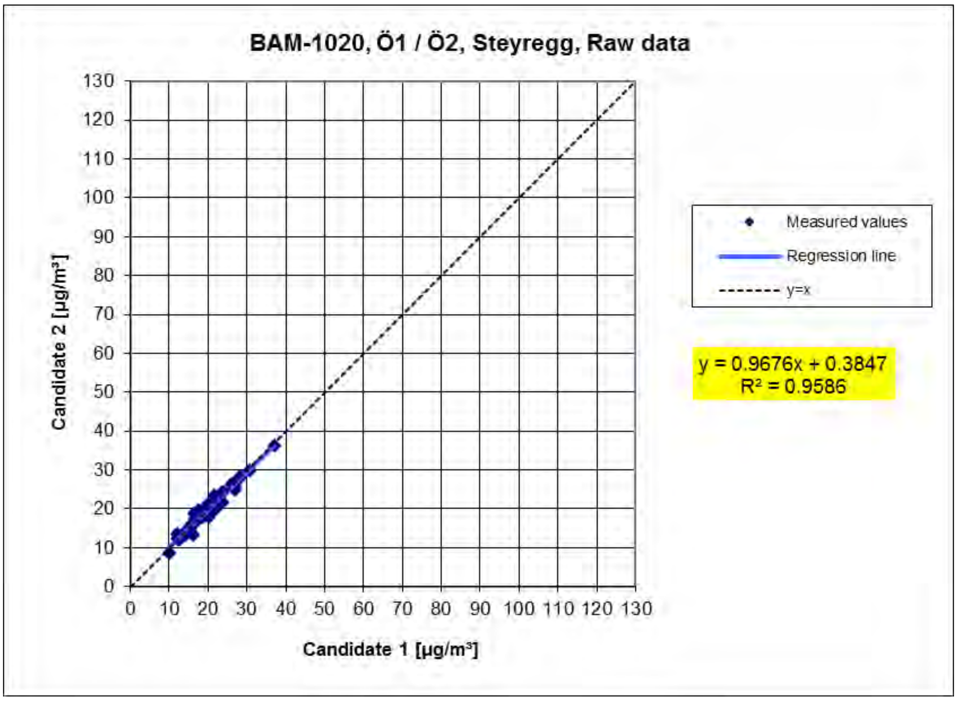


Figure 40: Results of the parallel measurements for instruments Ö1 / Ö2
Measured component PM_{10}, Steyregg (A)

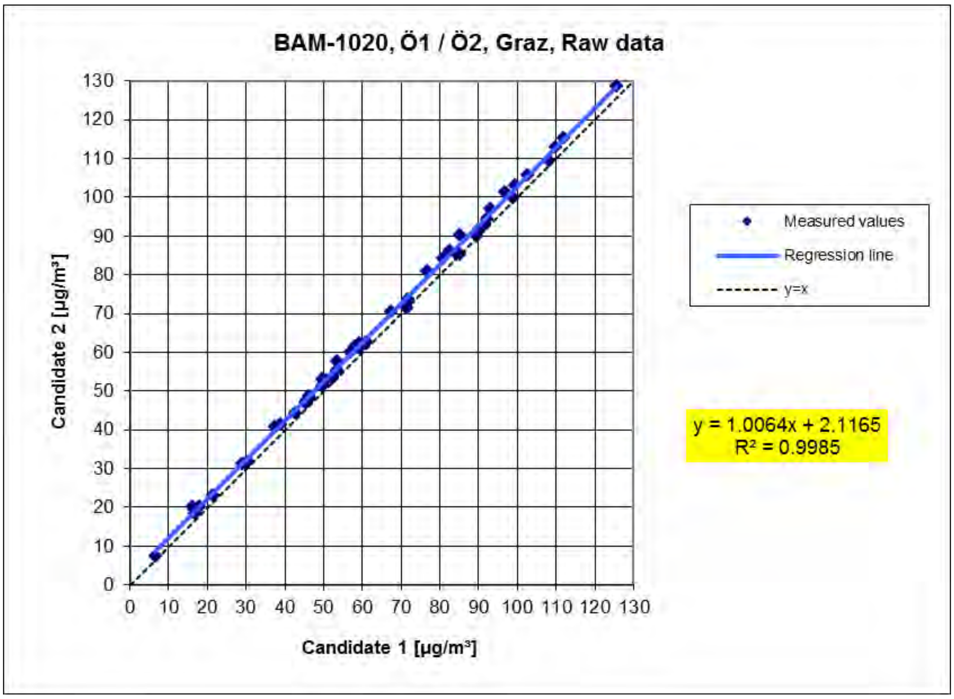


Figure 41: Results of the parallel measurements for instruments Ö1 / Ö2
Measured component PM_{10}, Graz (A)

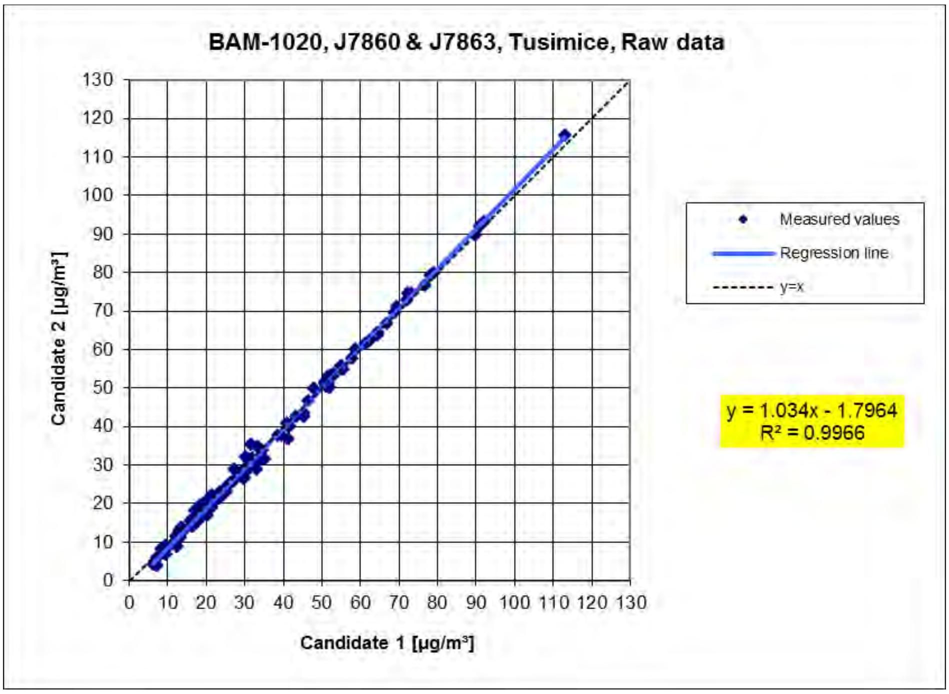


Figure 42: Results of the parallel measurements for instruments J7860 / J7863 Measured component PM_{10}, Tusimice (CZ)

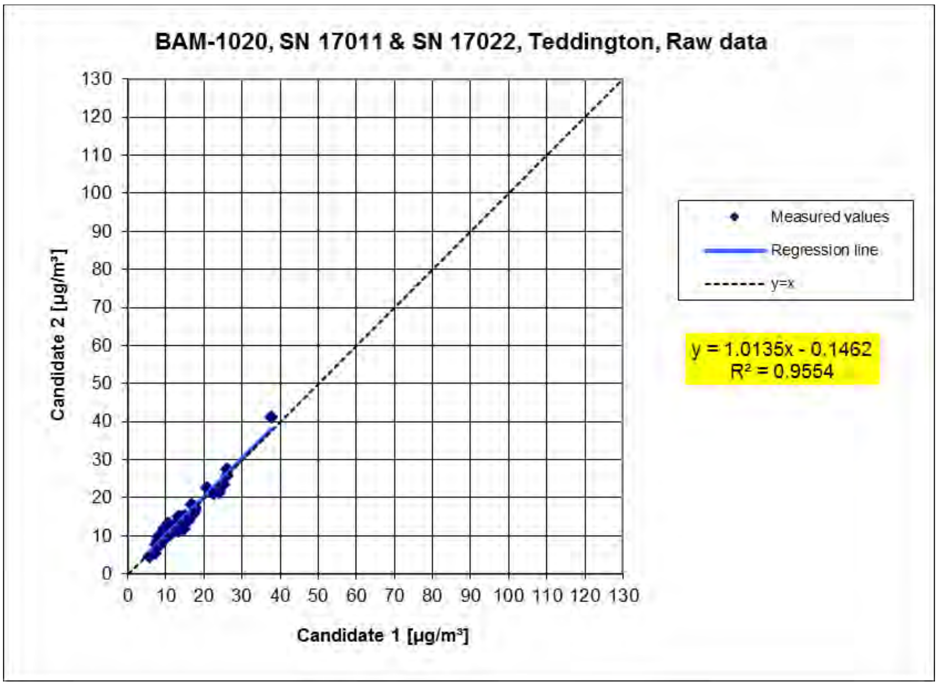


Figure 43: Results of the parallel measurements for instruments S/N 17022 / S/N 17011, Measured component PM_{10},Teddington (UK)

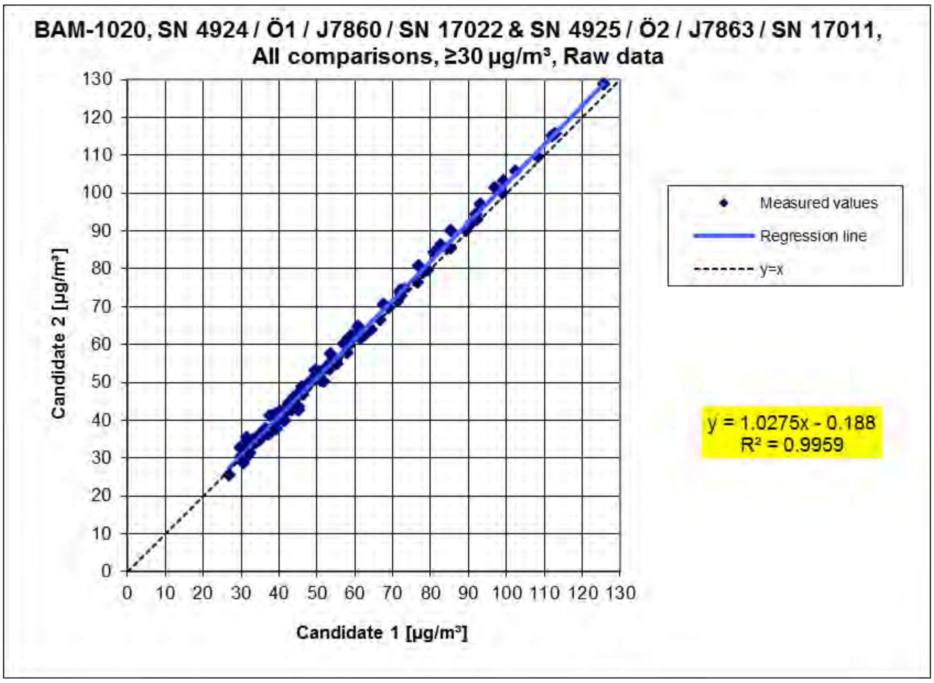


Figure 44: Results of the parallel measurements with tested instruments SN 4924/Ö1/J7860/SN 17022 vs. SN 4925/Ö2/J7863/SN 17011, PM_{10} particulate matter, all sites Values ≥ 30 µg/m³

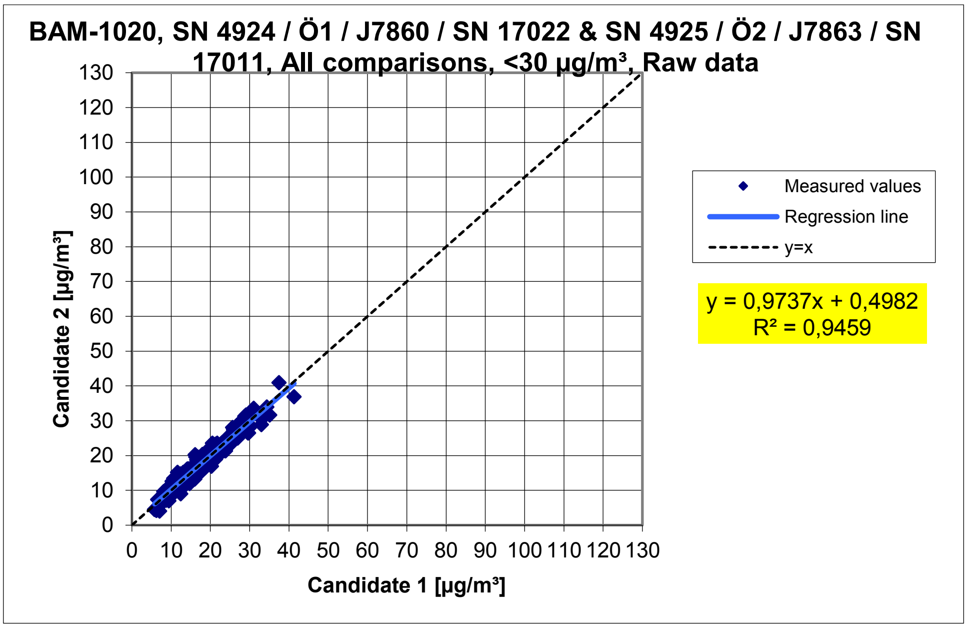


Figure 45: Results of the parallel measurements with tested instruments SN 4924/Ö1/J7860/SN 17022 vs. SN 4925/Ö2/J7863/SN 17011, PM_{10} particulate matter, all sites Values < 30 µg/m³

6.1 17 Expanded uncertainty of AMS results (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 equipment as described in chapter 5 of this report was used for this test.

6.3 Testing

The test was performed as part of the field test with seven separate comparison campaigns. Different seasons as well as different concentrations of PM_{10} were taken into consideration.

In the full dataset, at least 20% of the results obtained using the reference method should be greater than the upper assessment threshold of the annual limit value specified in 2008/50/EC [7]. The assessment threshold for PM_{10} is 28 µg/m³.

Four comparison campaigns (A-Steyregg, A-Graz, CZ-Tusimice, UK-Teddington) with at least 40 valid value pairs each were determined. In addition, the 3 comparison measurement campaigns (D-Cologne, parking lot, D-Titz-Rödingen, D-Colonge, Frankf. Str.) from the original performance test [9] were also evaluated, although these comparisons each contained less than 40 valid value pairs. Of the full dataset, (7 locations, 320 valid pairs of measured values), a total of 35.3% of the measured values exceeded the upper assessment threshold of 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 means 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
- 1 data set with measured values PM_{10} ≥ 30 µg/m³ (basis: averages of reference measurement)

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.

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

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

u_{RM} = is the random uncertainty of the reference method; u_{RM} is calculated as $u_{bs,RM}/\sqrt{2}$, with $u_{bs,RM}$ as the between-RM uncertainty.

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 the annex to [8].

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
- 1 data set with measured values PM_{10} ≥ 30 µg/m³ (basis: averages of reference measurement)

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 9.7 of the Guideline (also see 6.1 17 Use of correction factors/terms). The calibration may only be performed for the full data set.

[EN 16450, 7.5.8.7] For all datasets the combined relative uncertainty of the AMS $w_{c,CM}$ is calculated from a combination of contributions from 9.5.3.1 and 9.5.3.2 in accordance with the following equation:

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

For each data set the uncertainty w_{AMS} is calculated at a level of L = 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 an coverage factor k according to the following equation:

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

In practice, k is specified at k=2 for large n.

[Item 9.6]

The largest resulting uncertainty W_{AMS} is compared and assessed against the criteria for data quality of air quality measurements in accordance with EU Directive [7]. Two situations are conceivable:

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

The expanded relative uncertainty W_{dqo} specified is 25% [7].

7.5 Assessment

With the exception of data obtained in A-Graz (instrument Ö2) and UK-Teddington (instrument 17011), the uncertainty W_{CM} determined without applying correction factors for all observed data sets is below the determined expanded relative uncertainty W_{dqo} of 25% for fine particulate matter. It must be checked whether the use of correction factors/terms will mean that the expanded relative uncertainty W_{dqo} remains below the maximum defined at 25% for particulate matter for the data obtained at all sites including A-Graz (S/N Ö2) and UK-Teddington (S/N 17011) (see criterion 6.1 17 Use of correction factors/terms (7.5.8.5–7.5.8.8).

Criterion satisfied? no

The following Table 21 shows an overview on all results of the equivalence test for the BAM-1020 for PM_{10}. Where a criterion was not satisfied, the corresponding line is marked in red.

Table 21: Overview of the equivalence test for the BAM-1020 for PM_{10}

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	BAM-1020		SN	60 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011	
			Limit value	50	µg/m³
Status of measured values	Raw data		Allowed uncertainty	25	%
All comparisons					
Uncertainty between Reference	**0.67**	**µg/m³**			
Uncertainty between Candidates	**1.22**	**µg/m³**			
SN 4924 / Ö1 / J7860 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011					
Number of data pairs	**320**				
Slope b	**1.034**	**signifikant**			
Uncertainty of b	**0.008**				
Ordinate intercept a	**0.843**	**signifikant**			
Uncertainty of a	**0.290**				
Expanded measured uncertainty WCM	**16.11**	**%**			
All comparisons, ≥30 µg/m³					
Uncertainty between Reference	**0.91**	**µg/m³**			
Uncertainty between Candidates	**1.49**	**µg/m³**			
SN 4924 / Ö1 / J7860 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011					
Number of data pairs	**105**				
Slope b	**1.042**				
Uncertainty of b	**0.017**				
Ordinate intercept a	**0.141**				
Uncertainty of a	**1.031**				
Expanded measured uncertainty WCM	**17.85**	**%**			
All comparisons, <30 µg/m³					
Uncertainty between Reference	**0.53**	**µg/m³**			
Uncertainty between Candidates	**1.09**	**µg/m³**			
SN 4924 / Ö1 / J7860 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011					
Number of data pairs	**215**				
Slope b	**1.119**				
Uncertainty of b	**0.032**				
Ordinate intercept a	**-0.445**				
Uncertainty of a	**0.557**				
Expanded measured uncertainty WCM	**24.70**	**%**			

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	BAM-1020		SN	30 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011	
			Limit value	50	µg/m³
Status of measured values	Raw data		Allowed uncertainty	25	%
Cologne, parking lot					
Uncertainty between Reference	**0.55**	**µg/m³**			
Uncertainty between Candidates	**1.22**	**µg/m³**			
	SN 4924			**SN 4925**	
Number of data pairs	**29**			**29**	
Slope b	**0.948**			**0.990**	
Uncertainty of b	**0.036**			**0.033**	
Ordinate intercept a	**2.202**			**2.681**	
Uncertainty of a	**0.950**			**0.862**	
Expanded measured uncertainty W_{CM}	**10.25**	**%**		**12.62**	**%**
Titz-Rödingen					
Uncertainty between Reference	**0.65**	**µg/m³**			
Uncertainty between Candidates	**0.86**	**µg/m³**			
	SN 4924			**SN 4925**	
Number of data pairs	**37**			**37**	
Slope b	**1.058**			**1.056**	
Uncertainty of b	**0.035**			**0.035**	
Ordinate intercept a	**0.376**			**1.260**	
Uncertainty of a	**0.782**			**0.785**	
Expanded measured uncertainty W_{CM}	**14.86**	**%**		**17.62**	**%**
Cologne, Frankf. Str.					
Uncertainty between Reference	**1.02**	**µg/m³**			
Uncertainty between Candidates	**0.99**	**µg/m³**			
	SN 4924			**SN 4925**	
Number of data pairs	**28**			**28**	
Slope b	**1.025**			**1.021**	
Uncertainty of b	**0.039**			**0.035**	
Ordinate intercept a	**-1.293**			**-0.154**	
Uncertainty of a	**1.083**			**0.994**	
Expanded measured uncertainty W_{CM}	**8.57**	**%**		**8.60**	**%**
Steyregg					
Uncertainty between Reference	**0.53**	**µg/m³**			
Uncertainty between Candidates	**0.75**	**µg/m³**			
	Ö1			**Ö2**	
Number of data pairs	**45**			**45**	
Slope b	**1.049**			**1.035**	
Uncertainty of b	**0.067**			**0.072**	
Ordinate intercept a	**-1.750**			**-1.668**	
Uncertainty of a	**1.392**			**1.489**	
Expanded measured uncertainty W_{CM}	**9.43**	**%**		**9.68**	**%**
Graz					
Uncertainty between Reference	**0.81**	**µg/m³**			
Uncertainty between Candidates	**1.96**	**µg/m³**			
	Ö1			**Ö2**	
Number of data pairs	**45**			**45**	
Slope b	**1.025**			**1.033**	
Uncertainty of b	**0.027**			**0.029**	
Ordinate intercept a	**-0.202**			**1.948**	
Uncertainty of a	**1.848**			**1.962**	
Expanded measured uncertainty W_{CM}	**21.02**	**%**		**26.16**	**%**
Tusimice					
Uncertainty between Reference	**0.95**	**µg/m³**			
Uncertainty between Candidates	**1.18**	**µg/m³**			
	J7860			**J7863**	
Number of data pairs	**97**			**96**	
Slope b	**0.999**			**1.035**	
Uncertainty of b	**0.013**			**0.012**	
Ordinate intercept a	**3.739**			**2.035**	
Uncertainty of a	**0.492**			**0.461**	
Expanded measured uncertainty W_{CM}	**18.45**	**%**		**18.18**	**%**
Teddington					
Uncertainty between Reference	**0.25**	**µg/m³**			
Uncertainty between Candidates	**1.00**	**µg/m³**			
	SN 17022			**SN 17011**	
Number of data pairs	**40**			**40**	
Slope b	**1.110**			**1.162**	
Uncertainty of b	**0.034**			**0.042**	
Ordinate intercept a	**-0.050**			**-0.766**	
Uncertainty of a	**0.488**			**0.602**	
Expanded measured uncertainty W_{CM}	**22.29**	**%**		**30.00**	**%**
All comparisons, ≥30 µg/m³					
Uncertainty between Reference	**0.91**	**µg/m³**			
Uncertainty between Candidates	**1.49**	**µg/m³**			
	SN 4924 / Ö1 / J7860 / SN 17022			**SN 4925 / Ö2 / J7863 / SN 17011**	
Number of data pairs	**67**			**67**	
Slope b	**1.035**			**1.067**	
Uncertainty of b	**0.022**			**0.023**	
Ordinate intercept a	**-1.068**			**-0.891**	
Uncertainty of a	**1.309**			**1.39**	
Expanded measured uncertainty W_{CM}	**16.92**	**%**		**20.28**	**%**
All comparisons, <30 µg/m³					
Uncertainty between Reference	**0.53**	**µg/m³**			
Uncertainty between Candidates	**1.09**	**µg/m³**			
	SN 4924 / Ö1 / J7860 / SN 17022			**SN 4925 / Ö2 / J7863 / SN 17011**	
Number of data pairs	**157**			**157**	
Slope b	**1.044**			**1.095**	
Uncertainty of b	**0.036**			**0.040**	
Ordinate intercept a	**-0.141**			**-0.496**	
Uncertainty of a	**0.625**			**0.698**	
Expanded measured uncertainty W_{CM}	**12.79**	**%**		**20.33**	**%**
All comparisons					
Uncertainty between Reference	**0.67**	**µg/m³**			
Uncertainty between Candidates	**1.22**	**µg/m³**			
	SN 4924 / Ö1 / J7860 / SN 17022			**SN 4925 / Ö2 / J7863 / SN 17011**	
Number of data pairs	**224**			**224**	
Slope b	**1.018**	**signifikant**		**1.054**	**signifikant**
Uncertainty of b	**0.009**			**0.010**	
Ordinate intercept a	**0.157**	**nicht signifikant**		**0.079**	**nicht signifikant**
Uncertainty of a	**0.329**			**0.358**	
Expanded measured uncertainty W_{CM}	**12.89**	**%**		**17.28**	**%**

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

Criterion 1: More than 20% of the data exceed 28 µg/m³.

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: All expanded uncertainties remained below 25%.

This requirement has **not** been met for A-Graz (Ö2) and UK-Teddington (S/N 17011).

Criterion 5: Several individual instruments exceed the permissible slope significantly. The slope and intercept of the full data set are also significant and exceed the permissible limits.

The evaluation of the full data set for both test specimen shows that the measuring system provides good correlation with the reference method: the slope is 1.034 and the intercept is 0.843 at an expanded total uncertainty of 16.11%.

The January 2010 version of the Guideline does not specify clearly which axis intercept and which slope to use for correcting test specimens if a test specimen does not meet the requirements for equivalence testing. After double-checking with the chair of the EU working group responsible for issuing the Guideline (Mr Theo Hafkenscheid), we decided to apply the requirements of the November 2005 version of the Guideline and to use the slope and the intercept determined by means of orthogonal regression for the full data set. These are listed for each criterion under “Additional”

As a result of the significance determined, the axis intercept and the slope have to be corrected for PM_{10} according to Table 21. It must also be checked whether the use of correction factors/terms will mean that the expanded relative uncertainty W_{dqo} remains below the maximum defined at 25% for particulate matter for the data obtained at all sites including A-Graz (S/N Ö2) and UK-Teddington (S/N 17011).

For compliant monitoring, the revised version of the January 2010 Guideline and standard EN 16450 require continuous random checks of a certain number of instruments in a measurement grid and specify the number of measurement sites to be checked as a function of the expanded uncertainty of a measuring system. The operator of the measurement grid or the competent authority of a member state is responsible for compliant implementation. However, TÜV Rheinland recommends that the expanded uncertainty of the entire data set (in the present case, the uncorrected raw data) be used for this purpose: 16.11% for PM_{10}, implying annual checks at four measurement sites (Guideline [4], Chapter 9.9.2, Table 6 or EN 16450 [8], Chapter 8.6.2, Table 5). As a result of the necessary use of calibration factors, this assessment should be based on the evaluation of the corrected data sets (see chapter 6.1 17 Use of correction factors/terms).

6.6 Detailed presentation of test results

Table 22 provides an overview of the between-RM uncertainties $u_{bs,RM}$ determined during the field tests.

Table 22: Between-RM uncertainty $u_{bs,RM}$ for PM_{10}

Reference instruments	Location	Number of measurements	Uncertainty $u_{bs,RM}$
No.			µg/m³
1 / 2	Cologne, parking lot	29	0.55
1 / 2	Titz-Rödingen	37	0.65
1 / 2	Cologne, Frankf. Str.	28	1.02
1 / 2	Steyregg (A)	45	0.53
1 / 2	Graz (A)	45	0.81
1*	Tusimice (CZ)	97	0.95
1 / 2	Teddington (UK)	40	0.25
1 / 2	All locations	320	0.67

* a single reference system, thus $u_{RM} = u_{bs,RM} / \sqrt{2}$ = 0.67 µg/m³ ([8], Chapter 8.2.1, remark 2)

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

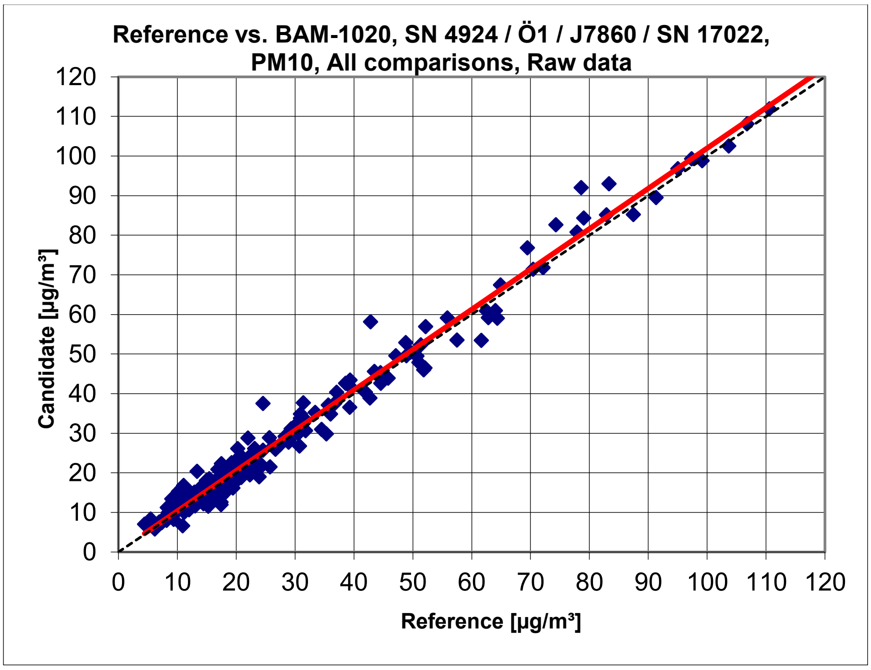


Figure 46: Reference vs. tested instrument, S/N 4924, Ö1 , J7860; S/N 17022, measured component PM_{10}, all sites

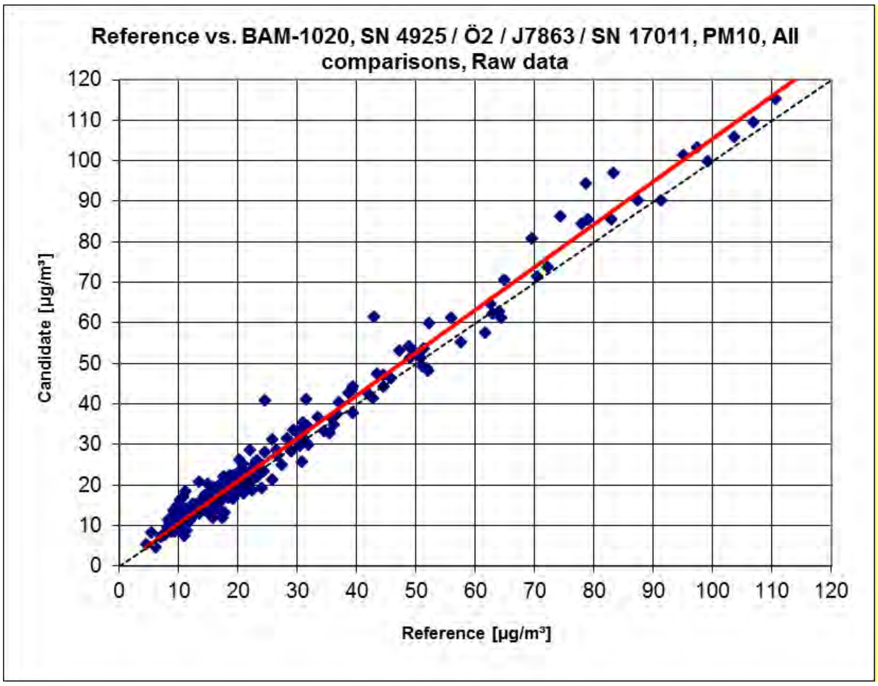


Figure 47: Reference vs. tested instrument, S/N 4925, Ö2 , J7863; S/N 17011, measured component PM_{10}, all sites

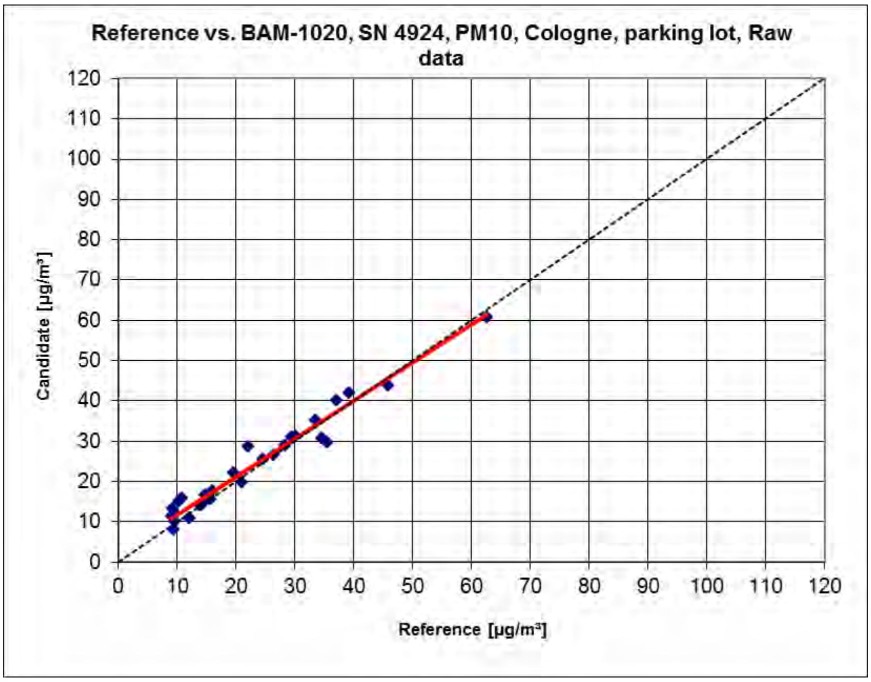


Figure 48: Reference vs. tested instrument, S/N 4924, measured component PM_{10}, Cologne, parking lot

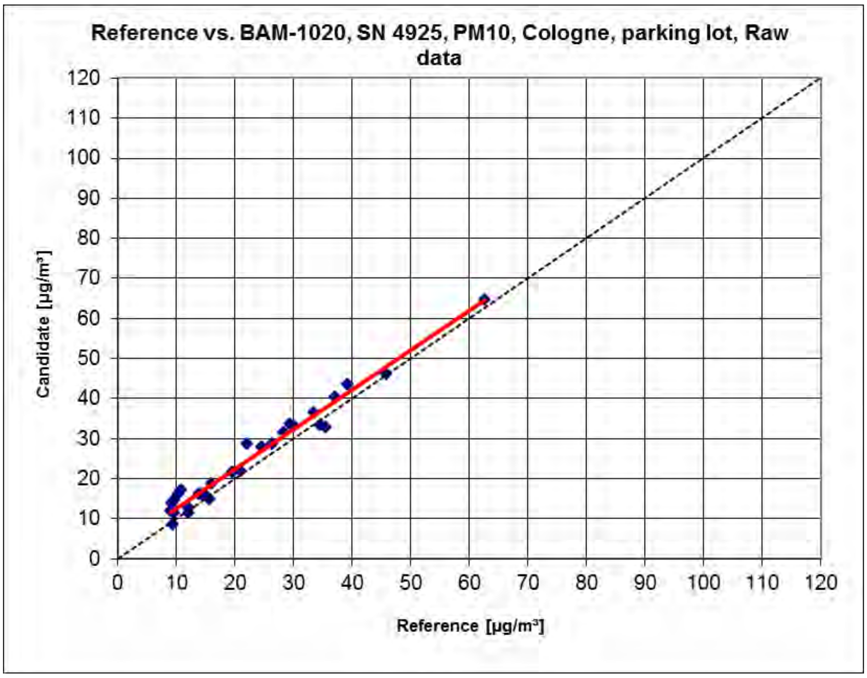


Figure 49: Reference vs. tested instrument, S/N 4925, measured component PM_{10}, Cologne, parking lot

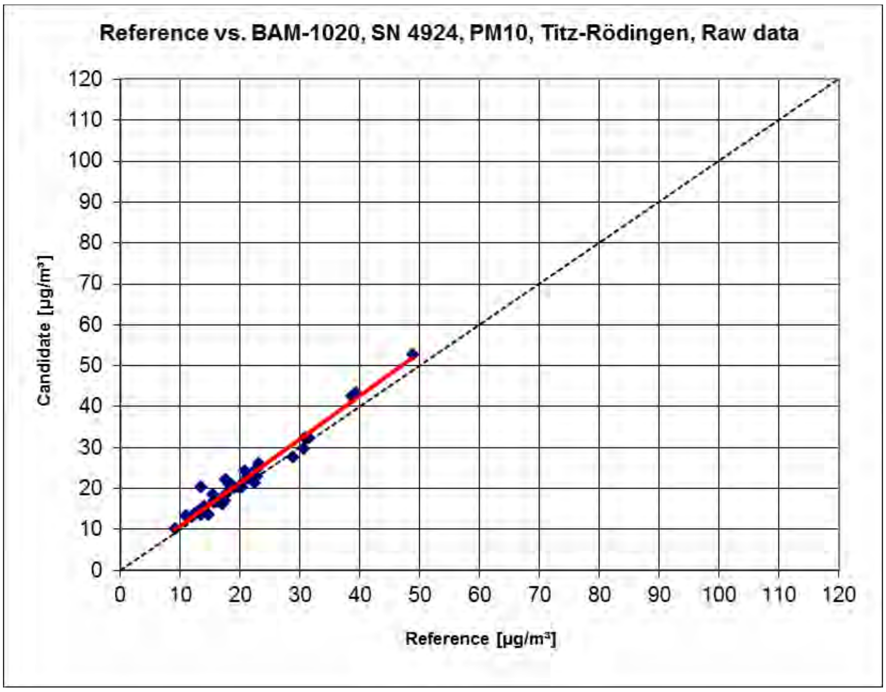


Figure 50: Reference vs. tested instrument, S/N 4924, measured component PM_{10}, Titz-Rödingen

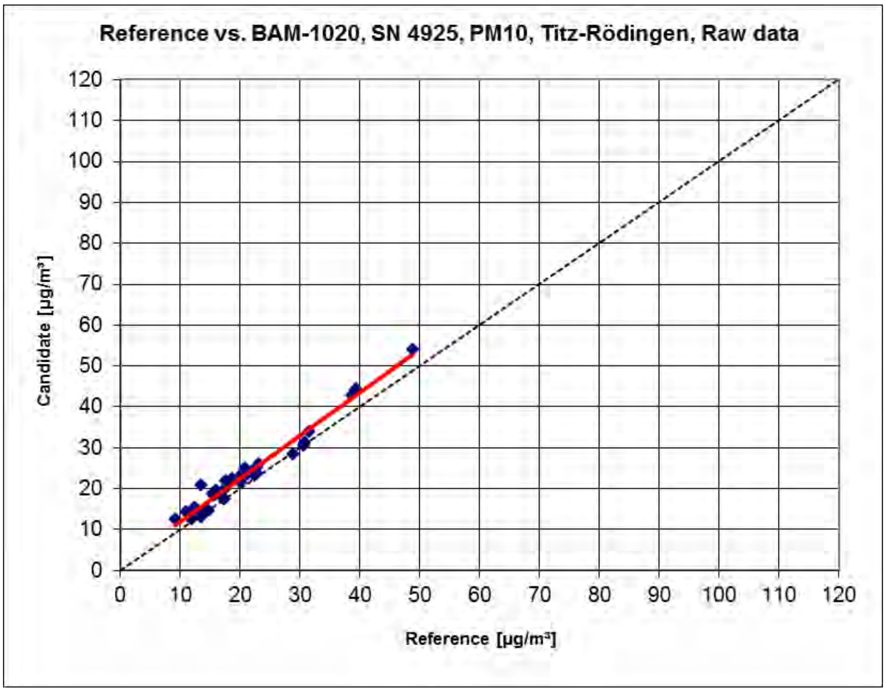


Figure 51: Reference vs. tested instrument, S/N 4925, measured component PM_{10}, Titz-Rödingen

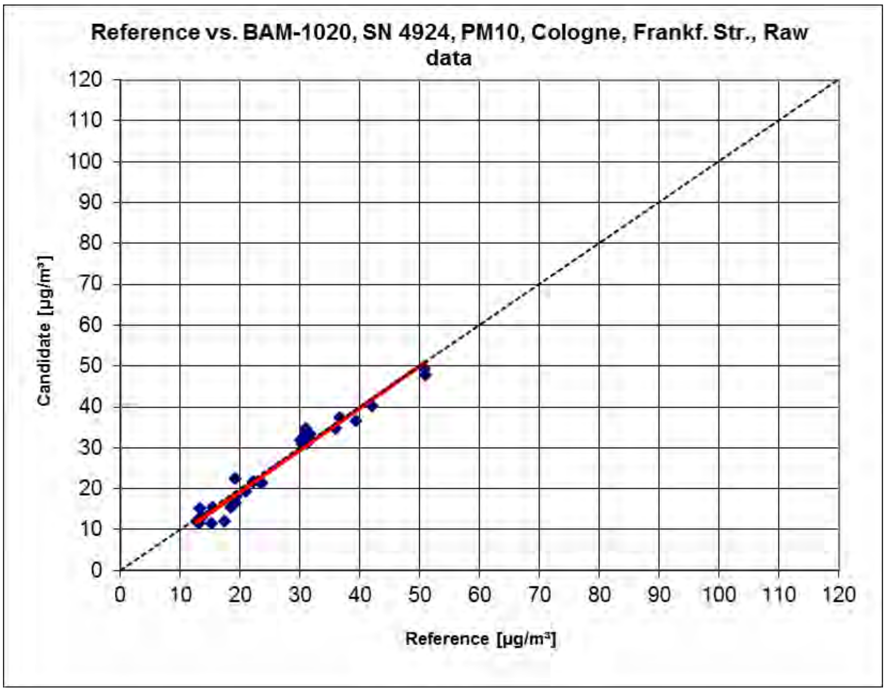


Figure 52: Reference vs. tested instrument, S/N 4924, measured component PM_{10}, Cologne, Frankf. Str.

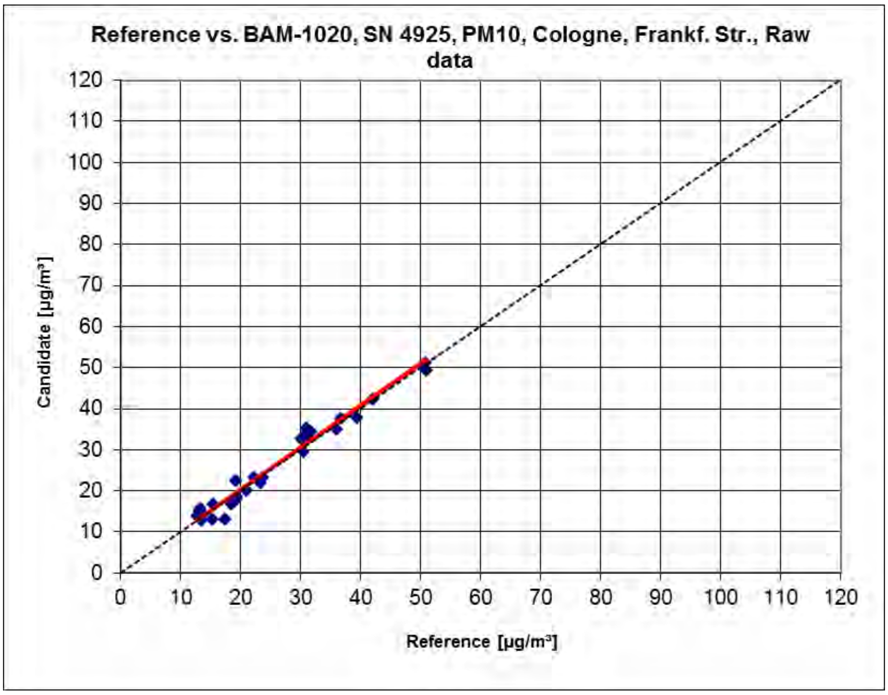


Figure 53: Reference vs. tested instrument, S/N 4925, measured component PM_{10}, Cologne, Frankf. Str.

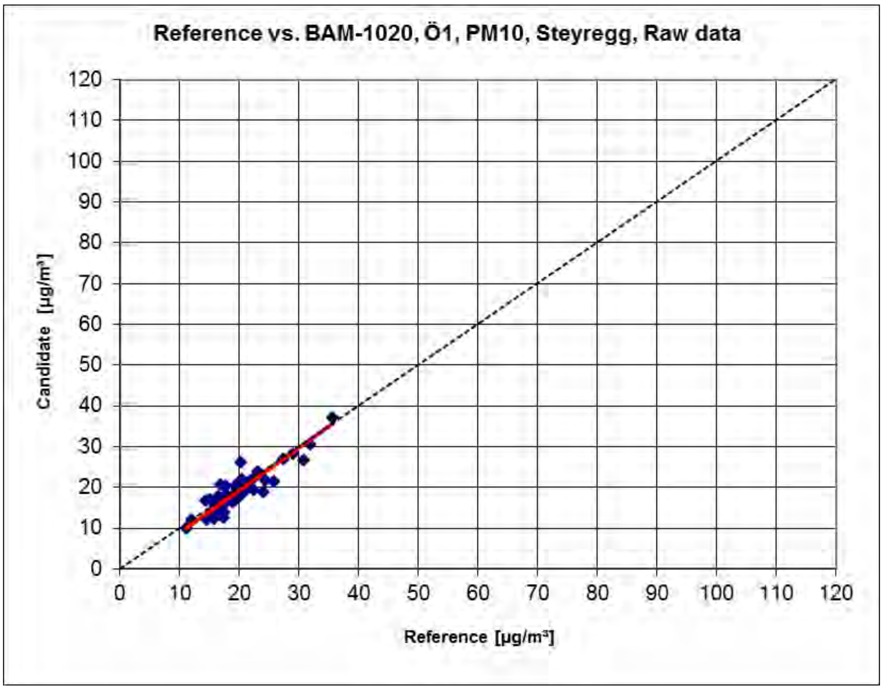


Figure 54: Reference vs. tested instrument, Ö1, measured component PM_{10}, Steyregg (A)

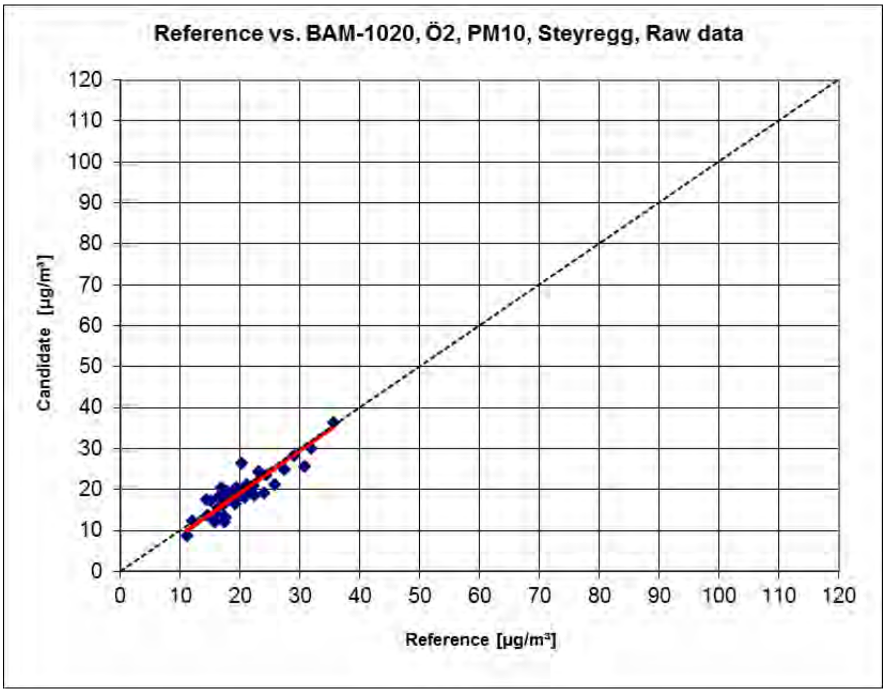


Figure 55: Reference vs. tested instrument, Ö2, measured component PM_{10}, Steyregg (A)

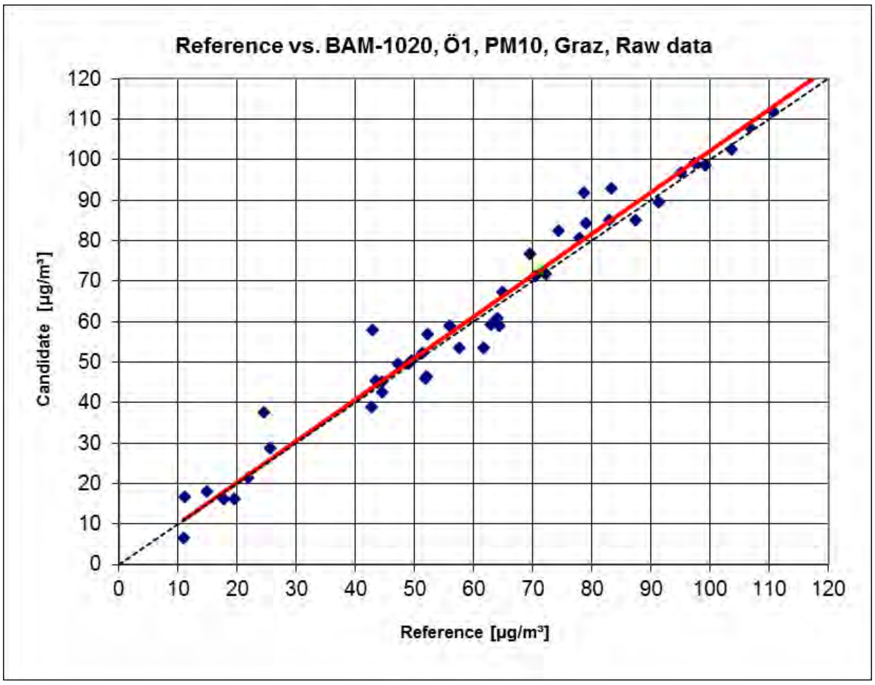


Figure 56: Reference vs. tested instrument, Ö1, measured component PM_{10}, Graz (A)

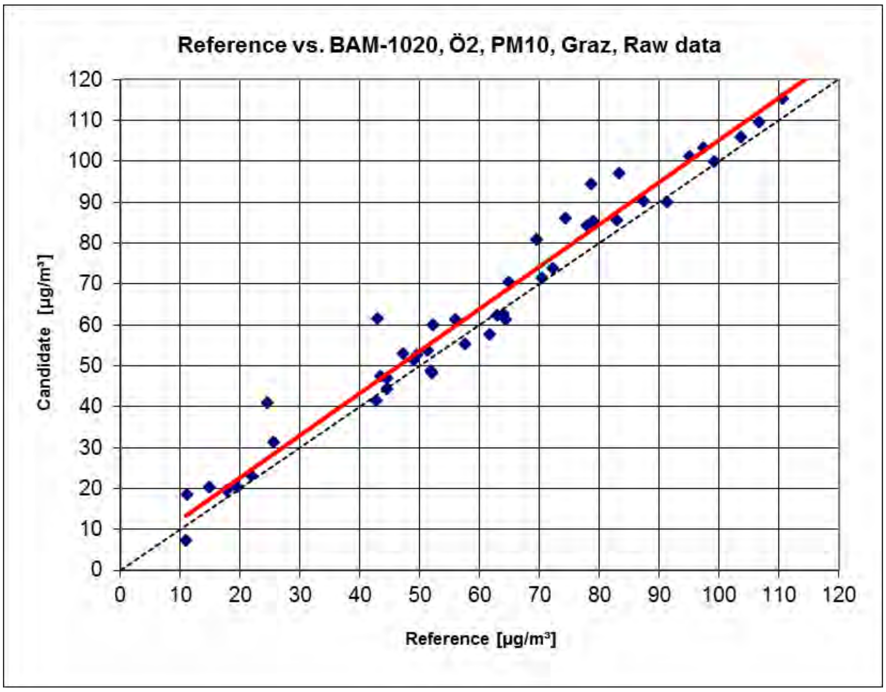


Figure 57: Reference vs. tested instrument, Ö2, measured component PM_{10}, Graz (A)

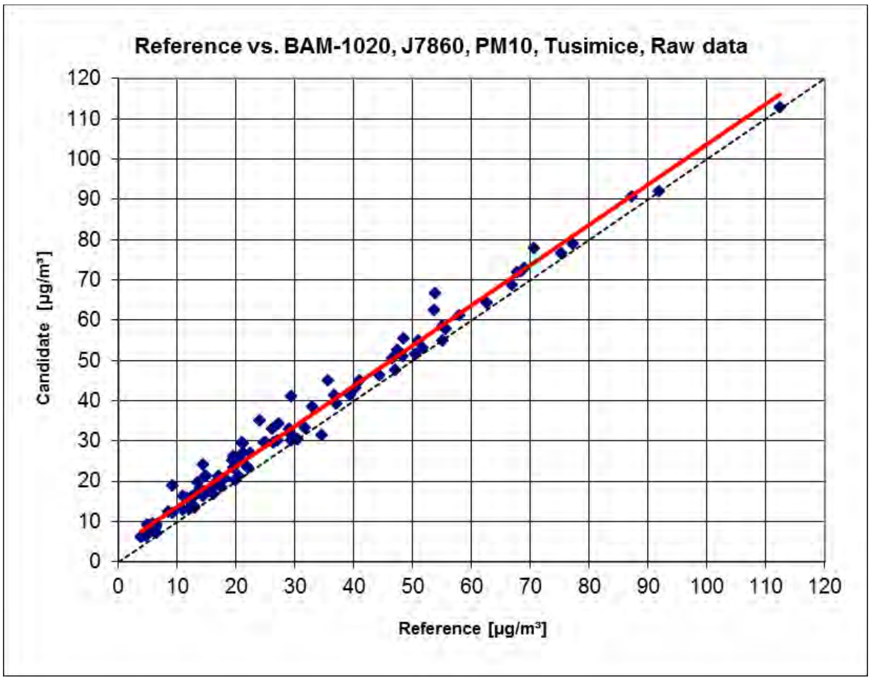


Figure 58: Reference vs. tested instrument, J7860, measured component PM_{10}, Tusimice (CZ)

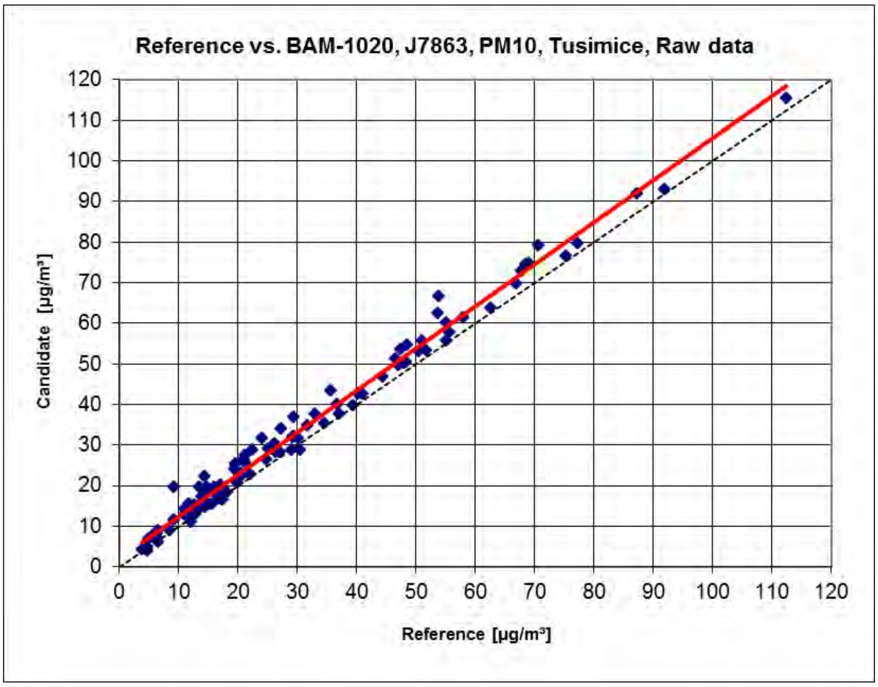


Figure 59: Reference vs. tested instrument, J7863, measured component PM_{10}, Tusimice (CZ)

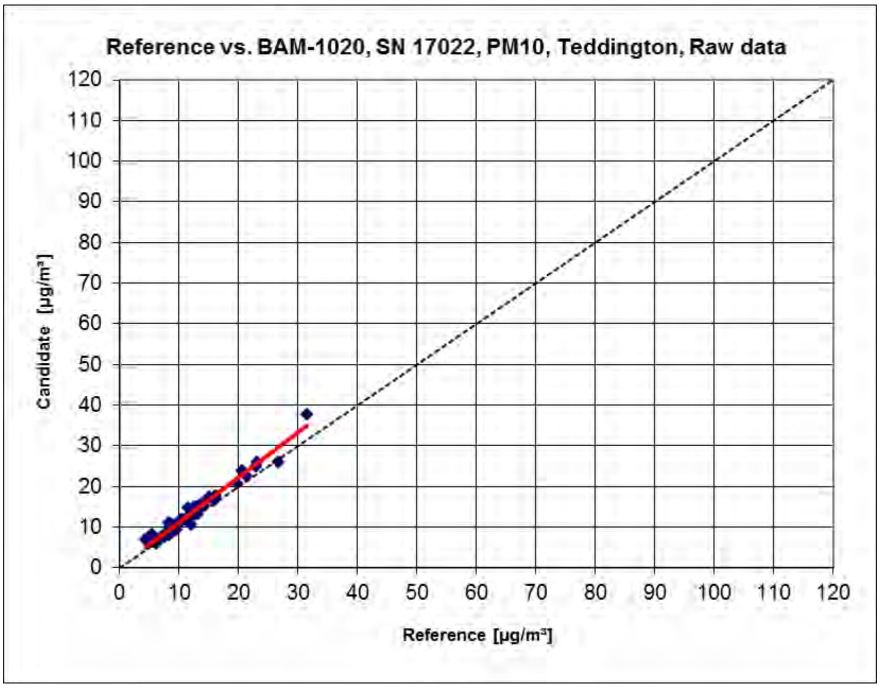


Figure 60: Reference vs. tested instrument, S/N 17022, measured component PM_{10}, Teddington (UK)

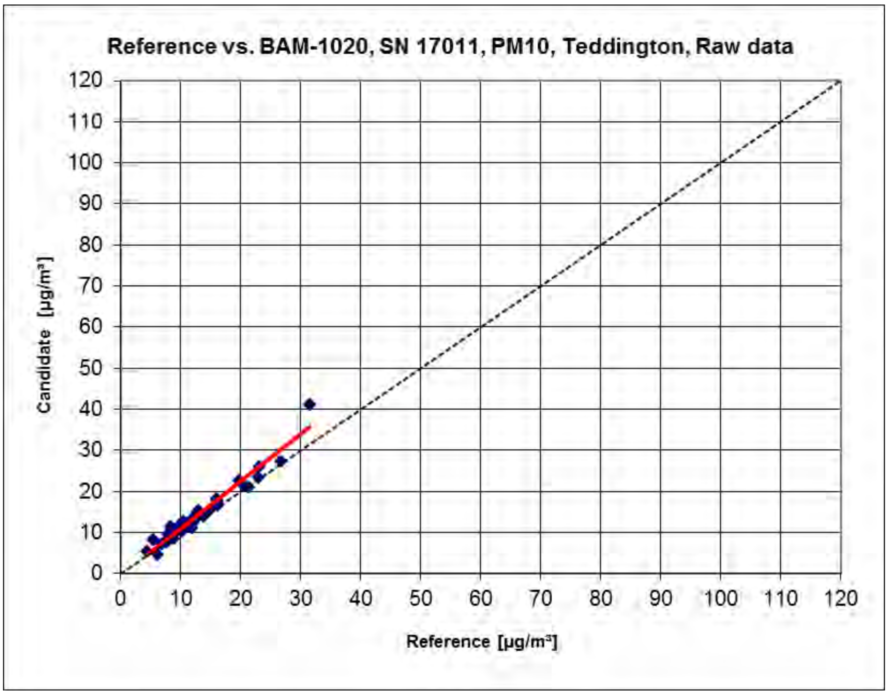


Figure 61: Reference vs. tested instrument, S/N 17011, measured component PM_{10}, Teddington (UK)

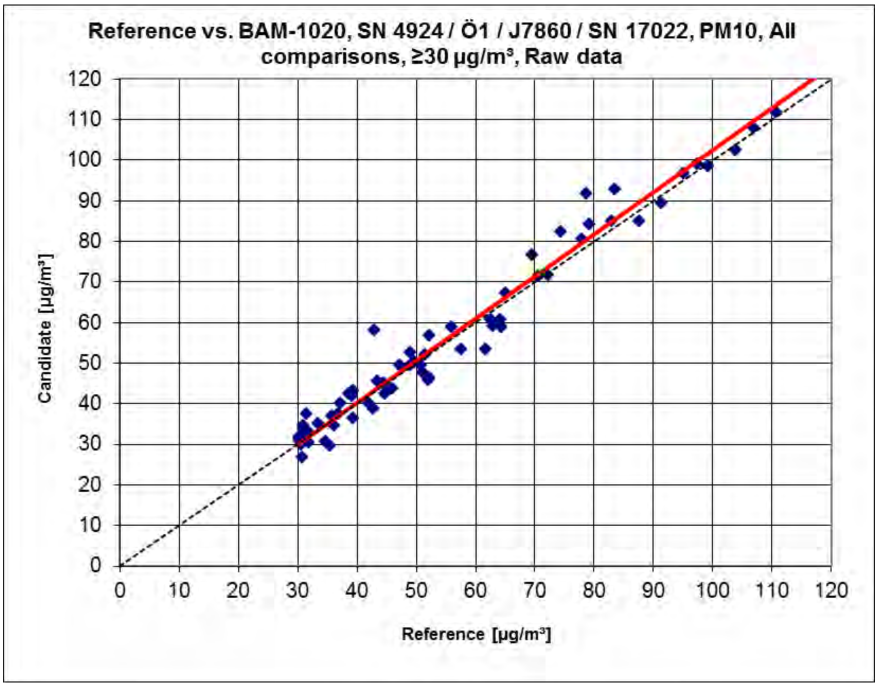


Figure 62: Reference vs. tested instrument, S/N 4924, Ö1 , J7860; S/N 17022, measured component PM_{10}, values ≥ 30 µg/m³

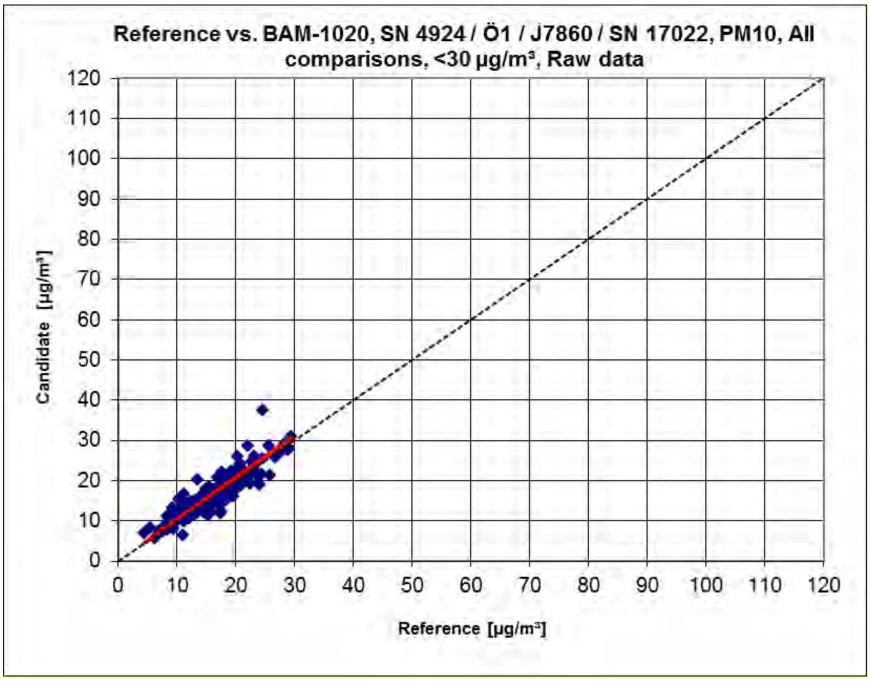


Figure 63: Reference vs. tested instrument, S/N 4925, Ö2 , J7863; S/N 17011, measured component PM_{10}, values ≥ 30 µg/m³

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

Correction factors/terms (=calibration) shall be applied in the event the highest expanded uncertainty calculated for the tested instruments exceeds the relative expanded uncertainty specified under 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 item 6.1 17 Expanded uncertainty of AMS results (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. 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 the full data set. 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 $W_{AMS} \leq W_{dqo}$ in order to improve the accuracy of the tested instruments.

Three different situations may occur:

a) Slope b is not significantly different from 1: $|b-1| \leq 2u(b)$
   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: $|a| \leq 2u(a)$

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

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

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 the annex to [8].

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

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

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 the annex to [8].

concerning c)

The values of the slope b and the axis intercept a may be used as a 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

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

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 the annex to [8].

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:

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

In practice, k is specified at k=2 for large n.

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 [7]. 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% [7].

6.5 Assessment

After a correction of the slope and intercept, the candidates satisfy the requirements for the data quality of ambient air monitors. This correction also results in a significant improvement of the expanded uncertainty of the complete dataset.

Criterion satisfied? yes

The evaluation of the full data set for both test specimen resulted in a significant slope and a significant intercept for the component PM_{10}.

The slope for the entire data set is 1.034. The intercept for the full data set is 0.843 (see Table 21)

For the component PM_{10}, the full data set was thus corrected in terms of the slope and intercept. All data sets were re-evaluated using the corrected values.

After the correction, all data sets meet the requirements for data quality. The use of a correction factor for the BAM-1020 measuring PM_{10} in part significantly improves the expanded uncertainty.

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's expanded uncertainty determined during equivalence testing. The criterion used for specifying the number of sites for annual testing is grouped into 5% steps (Guideline [4], Chapter 9.9.2, Table 6 and/or EN 16450 [8], Chapter 8.6.2, Table 5). It should be noted that the highest expanded uncertainty determined for PM_{10} after applying the correction was in the range 20–25%.

The operator of the measurement grid 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 overall data set be used for this purpose, namely 16.1% (PM_{10}, uncorrected data set), which would require an annual check at 4 measuring sites, or 12.3% (PM_{10}, data set after slope and intercept correction), which in turn would require an annual check at 3 measuring sites.

6.6 Detailed presentation of test results

Table 23 shows the evaluation results of the equivalence test after applying the correction factor to the full data set.

Table 23: Overview of equivalence test results after correcting the slope and intercept, BAM-1020, PM_{10}

Comparison candidate with reference according to Standard EN 16450:2017					
Candidate	BAM-1020		SN	60 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011	
			Limit value	50	µg/m³
Status of measured values	Slope and offset corrected		Allowed uncertainty	25	%
All comparisons					
Uncertainty between Reference	**0.67**	**µg/m³**			
Uncertainty between Candidates	**1.18**	**µg/m³**			
SN 4924 / Ö1 / J7860 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011					
Number of data pairs	**320**				
Slope b	**1.000**	**nicht signifikant**			
Uncertainty of b	**0.008**				
Ordinate intercept a	**0.009**	**nicht signifikant**			
Uncertainty of a	**0.280**				
Expanded measured uncertainty WCM	**12.27**	**%**			
All comparisons, ≥30 µg/m³					
Uncertainty between Reference	**0.91**	**µg/m³**			
Uncertainty between Candidates	**1.44**	**µg/m³**			
SN 4924 / Ö1 / J7860 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011					
Number of data pairs	**105**				
Slope b	**1.007**				
Uncertainty of b	**0.017**				
Ordinate intercept a	**-0.652**				
Uncertainty of a	**0.997**				
Expanded measured uncertainty WCM	**15.09**	**%**			
All comparisons, <30 µg/m³					
Uncertainty between Reference	**0.53**	**µg/m³**			
Uncertainty between Candidates	**1.06**	**µg/m³**			
SN 4924 / Ö1 / J7860 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011					
Number of data pairs	**215**				
Slope b	**1.079**				
Uncertainty of b	**0.031**				
Ordinate intercept a	**-1.187**				
Uncertainty of a	**0.538**				
Expanded measured uncertainty WCM	**15.57**	**%**			

Comparison candidate with reference according to Standard EN 16450:2017				
Candidate	BAM-1020		SN	60 / SN 17022 & SN 4925 / Ö2 / J7863 / SN 17011
			Limit value	50 µg/m³
Status of measured values	Slope and offset corrected		Allowed uncertainty	25 %
Cologne, parking lot				
Uncertainty between Reference	**0.55**	**µg/m³**		
Uncertainty between Candidates	**1.18**	**µg/m³**		
	SN 4924		**SN 4925**	
Number of data pairs	**29**		**29**	
Slope b	**0.917**		**0.957**	
Uncertainty of b	**0.035**		**0.032**	
Ordinate intercept a	**1.329**		**1.789**	
Uncertainty of a	**0.919**		**0.834**	
Expanded measured uncertainty W_{CM}	**15.13**	**%**	**9.18**	**%**
Titz-Rödingen				
Uncertainty between Reference	**0.65**	**µg/m³**		
Uncertainty between Candidates	**0.83**	**µg/m³**		
	SN 4924		**SN 4925**	
Number of data pairs	**37**		**37**	
Slope b	**1.023**		**1.021**	
Uncertainty of b	**0.034**		**0.034**	
Ordinate intercept a	**-0.438**		**0.417**	
Uncertainty of a	**0.756**		**0.760**	
Expanded measured uncertainty W_{CM}	**7.56**	**%**	**9.10**	**%**
Cologne, Frankf. Str.				
Uncertainty between Reference	**1.02**	**µg/m³**		
Uncertainty between Candidates	**0.96**	**µg/m³**		
	SN 4924		**SN 4925**	
Number of data pairs	**28**		**28**	
Slope b	**0.990**		**0.988**	
Uncertainty of b	**0.037**		**0.034**	
Ordinate intercept a	**-2.050**		**-0.951**	
Uncertainty of a	**1.048**		**0.962**	
Expanded measured uncertainty W_{CM}	**13.19**	**%**	**9.97**	**%**
Steyregg				
Uncertainty between Reference	**0.53**	**µg/m³**		
Uncertainty between Candidates	**0.73**	**µg/m³**		
	Ö1		**Ö2**	
Number of data pairs	**45**		**45**	
Slope b	**1.012**		**0.997**	
Uncertainty of b	**0.065**		**0.069**	
Ordinate intercept a	**-2.439**		**-2.347**	
Uncertainty of a	**1.347**		**1.441**	
Expanded measured uncertainty W_{CM}	**11.58**	**%**	**13.77**	**%**
Graz				
Uncertainty between Reference	**0.81**	**µg/m³**		
Uncertainty between Candidates	**1.90**	**µg/m³**		
	Ö1		**Ö2**	
Number of data pairs	**45**		**45**	
Slope b	**0.991**		**0.998**	
Uncertainty of b	**0.027**		**0.028**	
Ordinate intercept a	**-0.979**		**1.105**	
Uncertainty of a	**1.787**		**1.898**	
Expanded measured uncertainty W_{CM}	**20.77**	**%**	**21.63**	**%**
Tusimice				
Uncertainty between Reference	**0.95**	**µg/m³**		
Uncertainty between Candidates	**1.15**	**µg/m³**		
	J7860		**J7863**	
Number of data pairs	**97**		**96**	
Slope b	**0.966**		**1.001**	
Uncertainty of b	**0.012**		**0.012**	
Ordinate intercept a	**2.809**		**1.160**	
Uncertainty of a	**0.476**		**0.446**	
Expanded measured uncertainty W_{CM}	**11.73**	**%**	**11.08**	**%**
Teddington				
Uncertainty between Reference	**0.25**	**µg/m³**		
Uncertainty between Candidates	**0.97**	**µg/m³**		
	SN 17022		**SN 17011**	
Number of data pairs	**40**		**40**	
Slope b	**1.073**		**1.123**	
Uncertainty of b	**0.033**		**0.041**	
Ordinate intercept a	**-0.856**		**-1.544**	
Uncertainty of a	**0.473**		**0.583**	
Expanded measured uncertainty W_{CM}	**12.31**	**%**	**19.52**	**%**
All comparisons, ≥30 µg/m³				
Uncertainty between Reference	**0.91**	**µg/m³**		
Uncertainty between Candidates	**1.44**	**µg/m³**		
	SN 4924 / Ö1 / J7860 / SN 17022		**SN 4925 / Ö2 / J7863 / SN 17011**	
Number of data pairs	**67**		**67**	
Slope b	**1.001**		**1.032**	
Uncertainty of b	**0.021**		**0.022**	
Ordinate intercept a	**-1.821**		**-1.648**	
Uncertainty of a	**1.266**		**1.34**	
Expanded measured uncertainty W_{CM}	**17.71**	**%**	**17.26**	**%**
All comparisons, <30 µg/m³				
Uncertainty between Reference	**0.53**	**µg/m³**		
Uncertainty between Candidates	**1.06**	**µg/m³**		
	SN 4924 / Ö1 / J7860 / SN 17022		**SN 4925 / Ö2 / J7863 / SN 17011**	
Number of data pairs	**157**		**157**	
Slope b	**1.006**		**1.055**	
Uncertainty of b	**0.035**		**0.039**	
Ordinate intercept a	**-0.892**		**-1.223**	
Uncertainty of a	**0.605**		**0.675**	
Expanded measured uncertainty W_{CM}	**9.99**	**%**	**12.48**	**%**
All comparisons				
Uncertainty between Reference	**0.67**	**µg/m³**		
Uncertainty between Candidates	**1.18**	**µg/m³**		
	SN 4924 / Ö1 / J7860 / SN 17022		**SN 4925 / Ö2 / J7863 / SN 17011**	
Number of data pairs	**224**		**224**	
Slope b	**0.985**	**nicht signifikant**	**1.019**	**signifikant**
Uncertainty of b	**0.009**		**0.010**	
Ordinate intercept a	**-0.655**	**signifikant**	**-0.729**	**signifikant**
Uncertainty of a	**0.319**		**0.346**	
Expanded measured uncertainty W_{CM}	**13.17**	**%**	**12.96**	**%**

6.1 18 Maintenance interval (7.5.7)

The maintenance interval shall be at least 2 weeks.

6.2 Equipment

Not required for this performance criterion.

6.3 Testing

With regard to this minimum requirement, the maintenance tasks required in a specific period and the length of that period for the correct functioning of the measuring system were identified.

Moreover, the results of the zero drift tests in accordance with 6.1 12 Zero checks (7.5.3) were taken into account when determining the maintenance interval .

6.4 Evaluation

Over the entire period of the field test, no unacceptable drift was observed.

The maintenance interval is thus determined by the necessary maintenance works.

1. Checking the operational status
   The instrument status can be verified by checking the AMS; alternatively it can be monitored online.
2. The sampling inlet must in principle be cleaned in accordance with the manufacturer's instructions, taking into account the local suspended particulate concentrations (every 4 weeks in the performance test).
3. Clean the instrument every month This also applies to cleaning the area of the inlet nozzle above the filter tape. In any case, the measuring system must be cleaned after every measurement application.
4. Check of the filter tape stock – a 21 m-filter tape is usually sufficient for approximately 60 days for a measurement cycle set to 60 min. It is recommended to check the filter tape stock routinely at every visit of the measurement site.
5. According to the manufacturer, a flow rate check and a leak check should be carried out every 4 weeks. Furthermore, a plausibility check of the ambient temperature and air pressure measurement is recommended. This can be done together with the other work carried out according to number 4.
6. Replace the filter tape after approx. 2 months (measurement cycle: 60 min). After the replacement, it is strongly recommended to perform a self test as described in chapter 3.5 of the manual.
7. According to the manufacturer, the calibration of the flow rate should be performed every 3 months.
8. The muffler at the pump should be replaced semi-annually.
9. The sensors for ambient temperature, air pressure, filter temperature and filter rH must be checked every 6 months according to the operating manual.
10. The sample heater must be checked every 6 months according to the operating manual.
11. A 72-hour BKGD test should be performed annually using the BX-302 Zero Filter Kit as described in section 7.7 of the manual.
12. Once a year, the carbon vanes of the vacuum pump (only rotary vane pump) have to be checked and replaced if necessary during an annual maintenance.

13. During the annual basic maintenance, care must also be taken to clean the sampling tube.

The instructions in the manual (chapter 7) must be observed when carrying out maintenance work. All work can generally be carried out with standard tools. During operation times, maintenance may be limited to contamination and plausibility checks and potential status/error messages.

6.5 Assessment

The period of unattended operation is determined by the necessary maintenance works. It is 4 weeks.

Criterion satisfied?   yes

6.6 Detailed presentation of test results

The necessary maintenance works are listed in chapter 7 of the operation manual.

6.1 19 Automatic diagnostic check (7.5.4)

Results of automated/functional checks, where available, shall be recorded.

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. When a monitored parameter falls outside the permissible ranges of tolerance, an error bit appears.

The measuring system offers the possibility of an internal check of the zero point and the sensitivity:

The count rates I_1 and I_{1x}, which were determined on a clean filter tape spot at every measurement cycle were used to check the zero point of the radiometric measurement (see chapter 3.2 Functioning of the measuring system). The zero point of the radiometric measurement is determined according to the following equation:

$$C_0\left[mg/m^3\right] = \frac{A}{Q} * \frac{K}{mu2} * \ln\left(\frac{I_1}{I_{1X}}\right)$$

C_0 is the particle mass concentration at ZP A is the particle collection area (filter spot)

Q is the sampling flow rate K, mu2 are coefficients for beta measurement

I_1 is the initial beta count rate I_{1X} is the final beta count rate

To check the stability of the sensitivity of the radiometric measurement, the count rates I_1 (clean filter spot) or I_2 (clean filter spot + retracted reference foil) determined during each measurement cycle are used (see chapter 3.2 Functioning of the measuring system). The mass density m [µg/cm²] of the span foil is calculated internally from the count rates determined. The value is continuously compared with the target value ABS determined in the factory and an error message is generated in the event of a deviation exceeding 5 %.

The instrument thus offers the possibility to determine the zero point as well as the reference value for each measuring cycle (here once an hour) within the instrument. The obtained hourly values at the zero point and span point are output via the serial interface and are easily available for evaluation with a spreadsheet programme.

6.4 Evaluation

All instrument functions described in the operation manual are available and can be activated. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages. it is possible to automatically check and record the zero point and sensitivity.

6.5 Assessment

All instrument functions described in the operation manual are available and can be activated. The current operating status is continuously monitored and any issues will be flagged via a series of different warning messages. it is possible to automatically check and record the zero point and sensitivity.

Criterion satisfied? yes

6.6 Detailed presentation of test results

Available status signals are listed in chapter 6 of the operation manual.

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

Not required for this performance criterion.

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.

6.4 Evaluation

The BAM-1020 measuring systems use meteorological sensors to measure ambient temperature and air pressure (BX-596 or BX-592) for mass flow control, among other things. In addition, the relative humidity is measured in the area of the filter tape (control of the sample heating).

The manufacturer of the weather station indicates the sensors' accuracy as follows: ±1.5°K (ambient temperature), ±4% (relative humidity) ±0.25 mmHg, which corresponds to 0.03 kPa, (air pressure).

Relying on transfer standards, it is easily possible to perform comparison measurements on-site at any time and to adjust the sensors in the event of any deviation.

6.5 Assessment

It is easy to check and adjust the sensors for determining ambient temperature, ambient pressure and relative humidity on-site (filter band area).

Criterion satisfied? yes

6.6 Detailed presentation of test results

Not required for this performance criterion.

7. Recommendations for use in practice

7.1 Tasks to be performed in the maintenance interval (4 weeks)

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

- Regular visual inspections/telemetric inspections
- Instrument status ok
- No error messages
- No contaminations
- Check of the instrument functions according to the instructions of the manufacturer
- Check of filter tape stock
- Maintenance of the sampling inlet according to the manufacturer’s instructions
- Every 4 weeks Plausibility checks of temperature, pressure sensors and, where necessary, readjustment
- Every 4 weeks Leak check and check of the flow rate

Apart from that please consider the manufacturer’s instructions.

By default, the measuring system carries out an internal check of the zero point (zero measurement) and the sensitivity (measurement with span foil) for each measuring cycle. The results of these checks can be used for the continuous check of the stability of the radiometric measurement.

7.2 Additional maintenance tasks

In addition to the regular tasks to be performed during the maintenance interval, the following tasks need to be performed.

- Replace the filter tape after approx. 2 months (measurement cycle: 60 min). After the replacement, it is strongly recommended to perform a self test as described in chapter 3.5 of the manual.
- According to the manufacturer, the calibration of the flow rate should be performed every 3 months.
- The muffler at the pump should be replaced semi-annually.
- The sensors for ambient temperature, air pressure, filter temperature and filter rH must be checked every 6 months according to the operating manual.
- The sample heater must be checked every 6 months according to the operating manual.
- A 72-hour BKGD test should be performed annually using the BX-302 Zero Filter Kit as described in section 7.7 of the manual.
- Once a year, the carbon vanes of the vacuum pump (only rotary vane pump) have to be checked and replaced if necessary during an annual maintenance.
- During the annual basic maintenance, care must also be taken to clean the sampling tube.

Further details are provided in the operation manual.

Environmental Protection/Air Pollution Control

Dipl.-Ing. Guido Baum	Dipl.-Ing. Karsten Pletscher

Cologne, 21 September 2018
936/21243375/B

8. Bibliography

[1] VDI Guideline 4202, Part 1 – "Performance criteria for performance tests of automated ambient air measuring systems – Point-related measurement methods for gaseous and particulate air pollutants," dated June 2002.

[2] VDI Guideline 4203, part 3 – "Testing of automated measuring systems – Test procedures for point-related ambient air measuring systems for gaseous and particulate air pollutants", dated August 2004

[3] EN 12341 "Air Quality - Determination of the PM_{10} fraction of suspended particulate matter - Reference method and field test procedure to demonstrate reference equivalence of measurement methods", German version EN 12341 1998

[4] Guideline "Demonstration of Equivalence of Ambient Air Monitoring Methods", English version of November 2005 and January 2010

[5] BAM-1020 operation manual version W

[6] Operation manual LVS3 of 2000

[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

[8] 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)

[9] TÜV Rheinland Report No. 936/21205333/A dated 6 December 2006; Report on the performance test of the BAM-1020 measuring system with PM_{10} pre-separator for suspended particulate matter PM_{10} manufactured by Met One Instruments, Inc.

[10] Statement issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 30 March 2009

[11] 2 statements issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 9 October 2009

[12] Statement issued by TÜV Rheinland Immissionsschutz und Energiesysteme GmbH dated 16 March 2010

[13] Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 24 March 2011

[14] Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 21 March 2012

[15] Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 4 October 2012

[16] TÜV Rheinland report No. 936/21220762/A dated 12 December 2012; Addendum to the report No. 936/21205333/A of 6 December 2006 on the performance test of the BAM-1020 ambient air quality measuring system with PM_{10} pre-separator for suspended particulate matter PM_{10} manufactured by Met One Instruments, Inc.

[17] Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 18 March 2013

[18] Statement issued by TÜV Rheinland Energie und Umwelt GmbH dated 20 September 2014

[19] Statement issued by TÜV Rheinland Energy GmbH dated 18 August 2017

[20] UK Report on the Equivalence of the Smart Heated PM_{10} BAM-1020, Bureau Veritas (UK), May 2014

1.2 BAM-1020 mit PM 10 -Vorabscheider
Hersteller:
Met One Instruments Inc., Grants Pass, USA
Eignung:
Zur kontinuierlichen Immissionsmessung der PM 10 -Fraktion im Schwebstaub im stationären Einsatz.
Messbereich bei der Eignungsprüfung:
Schwebstaub PM 10 : 0-1,000 mg/m³ = 0-1000 µg/m³
Softwareversion: 3236-02 3.2.1b
Hinweise:
- Das Gerät ist zur Erfassung von PM 10 mit folgenden Optionen auszustatten: Probenahmeheizung (BX830), Probenahmekopf (BX802), Umgebungstemperatursensor (BX592) und Luftdrucksensor (BX594)
- Die Heizung darf nur in der während der Eignungsprüfung verwendeten Betriebsweise eingesetzt werden.
- Die Volumenstromregelung hat auf Betriebsvolumen in Bezug auf die Umgebungsbedingungen zu erfolgen (Betriebsart ACTUAL).
- Die Messeinrichtung wurde während der gesamten Eignungsprüfung mit der Probenahmeheizung BX-830 betrieben.
- Die Zykluszeit während der Eignungsprüfung betrug 1 h, d. h. jede Stunde wurde ein automatischer Filterwechsel durchgeführt. Jeder Filterfleck wurde nur einmal beprobt.
- Die Messeinrichtung ist in einem verschließbaren Messcontainer zu betreiben.
- Die Messeinrichtung ist mit dem gravimetrischen PM 10 -Referenzverfahren nach DIN/EN 12341 regelmäßig am Standort zu kalibrieren.

Prüfinstitut:
TÜV Rheinland Immissionsschutz und Energiesysteme GmbH, Köln, TÜV Rheinland Group
Bericht-Nr.: 936/21205333/A vom 6. Dezember 2006

Figure 64: Original publication BAnz. of 20 April 2007, p. 4139, Chapter III Number 1.2

6. Mitteilung zur Bekanntmachung des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139)
Die aktuelle Softwareversion der Immissionsmesseinrichtung BAM-1020 der Firma Met One Instruments, Inc. lautet:
Version 3236-02 5.0.2.
Der Hinweis 1 ist wie folgt zu ändern:

1. Das Gerät ist zur Erfassung von PM10 mindestens mit folgenden Optionen auszustatten: Probenahmeheizung (BX-830), Probenahmekopf (BX-802) und Umgebungstemperatursensor (BX-592).
Stellungnahme der TÜV Rheinland Immissionsschutz und Energiesysteme GmbH vom 30. März 2009

Figure 65: UBA announcement BAnz. of 25 July 2009, p. 2929, Chapter III 6th Notification

10 Mitteilung zu Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139) und vom 3. August 2009 (BAnz. S. 2935)
Die aktuelle Softwareversion der Immissionsmesseinrichtung BAM-1020 der Firma MetOne Instruments lautet:
Version 3236-07 V5.0.5
Der Hinweis 1 wird ersetzt durch:
1. Das Gerät ist zur Erfassung von PM10 mindestens mit folgenden Optionen auszustatten:
Probenahmeheizung (BX-830), Probenahmekopf (BX-802) und Umgebungstemperatursensor (BX-592) bzw. kombinierter Druck- und Temperatursensor (BX-596).
Stellungnahme der TÜV Rheinland Immissionsschutz und Energiesysteme GmbH vom 9. Oktober 2009

Figure 66: UBA announcement BAnz. of 12 January 2010, p. 552, Chapter IV 10th Notification

11 Mitteilung zu Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139) und vom 3. August 2009 (BAnz. S. 2935)
Die Messeinrichtung BAM-1020 der Firma MetOne Instruments (TÜV-Bericht-Nr. 936/21205333/A vom 6. Dezember 2006) wird baugleich auch von der Firma Horiba Europe GmbH, 61440 Oberursel unter dem Namen APDA-371 vertrieben.
Die aktuelle Softwareversion der Immissionsmesseinrichtung APDA-371 lautet:
Version 3236-07 V5.0.5
Stellungnahme der TÜV Rheinland Immissionsschutz und Energiesysteme GmbH vom 9. Oktober 2009

Figure 67: UBA announcement BAnz. of 12 January 2010, p. 552, Chapter IV 11th Notification

2 Mitteilung zu Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139) und vom 25. Januar 2010 (BAnz. S. 555)

Die aktuelle Softwareversion der Immissionsmesseinrichtung BAM-1020 mit PM10-Vorabscheider der Firma Met One Instruments lautet:
Version 3236-07 V5.0.10
Stellungnahme der TÜV Rheinland Immissionsschutz und Energie-systeme GmbH vom 16. März 2010

Figure 68: UBA announcement BAnz. of 28 July 2010, p. 2597, Chapter III 2nd Notification

12. Mitteilung zu Bekanntmachungen des Umweltbundesam-tes vom 12. April 2007 (BAnz. S. 4139, Kapitel III Nummer 1.2) und vom 12. Juli 2010 (BAnz. S. 2597, Kapitel III 2. Mitteilung)
Die Messeinrichtung BAM-1020 mit PM10-Vorabscheider der Firma Met One Instruments, Inc. für die Messkomponente Schwebstaub PM10 kann optional mit der Pumpe BX-125 betrieben werden.
Die Messeinrichtung kann optional mit einem Touch Screen Display (Option BX-970) ausgerüstet werden. Die aktuelle Soft-wareversion lautet:
3236-77 V5.1.0
Die Softwareversion für die Messeinrichtung ohne Option BX-970 Touch Screen Display lautet weiterhin 3236-07 5.0.10.
Stellungnahme der TÜV Rheinland Energie und Umwelt GmbH vom 24. März 2011

Figure 69: UBA announcement BAnz. of 29 July 2011, p. 2725, Chapter III 12th Notification

6 Mitteilung zu Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139, Kapitel III Nummer 1.2) und vom 15. Juli 2011 (BAnz. S. 2725, Kapitel III 12. Mitteilung)

Die Messeinrichtung BAM-1020 mit PM_{10}-Vorabscheider der Firma Met One Instruments, Inc. für die Messkomponente Schwebstaub PM_{10} erhält eine neu designte Rückplatte um die erweiterten Schnittstellen des optionalen Reportprozessors BX-965 unterzubringen.

Die aktuelle Softwareversion der Messeinrichtung lautet:

3236-07 5.0.15

Die aktuelle Softwareversion der Messeinrichtung mit Touch Screen Display (Option BX-970) lautet:

3236-77 V5.1.2

Stellungnahme der TÜV Rheinland Energie und Umwelt GmbH vom 21. März 2012

Figure 70: UBA announcement BAnz AT 20.07.2012 B11 chapter IV 6th Notification

2 Mitteilung zu den Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139, Kapitel III Nummer 1.2) und vom 6. Juli 2012 (BAnz AT 20.07.2012 B11, Kapitel IV, 6. Mitteilung)

Die Messeinrichtung BAM-1020 mit PM_{10}-Vorabscheider der Fa. Met One Instruments, Inc. für die Messkomponente Schwebstaub PM_{10} erfüllt die Anforderungen der DIN EN 12341 (Ausgabe März 1998) sowie des Leitfadens „Demonstration of Equivalence of Ambient Air Monitoring Methods" in der Version vom Januar 2010. Darüber hinaus erfüllt die Herstellung und das Qualitätsmanagement der Messeinrichtung BAM-1020 mit PM_{10}-Vorabscheider die Anforderungen der DIN EN 15267.

Der Prüfbericht über die Eignungsprüfung mit der Berichtsnummer 936/21205333/A sowie ein Addendum zum Prüfbericht mit der Berichtsnummer 936/21220762/A sind im Internet unter www.qal1.de einsehbar.

Stellungnahme der TÜV Rheinland Energie und Umwelt GmbH vom 4. Oktober 2012

Figure 71: UBA announcement BAnz AT 05.03.2013 B10 chapter V 2nd Notification

5 Mitteilung zu den Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139, Kapitel III Nummer 1.2) und vom 12. Februar 2013 (BAnz AT 05.03.2013 B10, Kapitel V 2. Mitteilung)

Die aktuelle Softwareversion der Messeinrichtung BAM-1020 mit PM_{10}-Vorabscheider der Firma Met One Instruments, Inc. für die Messkomponente Schwebstaub PM_{10} lautet:

3236-07 5.1.1

Die aktuelle Softwareversion der Messeinrichtung mit Touch Screen Display (Option BX-970) lautet:

3236-77 V5.2.0

Stellungnahme der TÜV Rheinland Energie und Umwelt GmbH vom 18. März 2013

Figure 72: UBA announcement BAnz AT 23.07.2013 B4 chapter V 5th Notification

11 Mitteilung zu den Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139, Kapitel III Nummer 1.2) und vom 3. Juli 2013 (BAnz AT 23.07.2013 B4, Kapitel V 5. Mitteilung)

Der Drucksensor 970603 (MICROSWITCH #185PC15AT) in der Messeinrichtung BAM-1020 mit PM_{10}-Vorabscheider der Fa. Met One Instruments, Inc. wurde abgekündigt und durch den Drucksensor 970595 (HONEYWELL SSCDANN015PAAA5) ersetzt.

Stellungnahme der TÜV Rheinland Energie und Umwelt GmbH vom 20. September 2014

Figure 73: UBA announcement BAnz AT 02.04.2015 B5 chapter IV 11th Notification

8 Mitteilung zu den Bekanntmachungen des Umweltbundesamtes vom 12. April 2007 (BAnz. S. 4139, Kapitel III Nummer 1.2) und vom 25. Februar 2015 (BAnz AT 02.04.2015 B5, Kapitel IV 11. Mitteilung)

Die aktuelle Softwareversion der Messeinrichtung BAM-1020 mit PM_{10}-Vorabscheider der Firma Met One Instruments, Inc. lautet:

3236-07 5.5.0

Die aktuelle Softwareversion der Messeinrichtung mit Touch Screen Display (Option BX-970) lautet:

3236-77 V5.2.0

Stellungnahme der TÜV Rheinland Energy GmbH vom 18. August 2017

Figure 74: UBA announcement BAnz AT 26.03.2018 B8 chapter V 8th Notification

9. Appendices

Annex 1 **Measured and calculated values**

Schedule 1: Zero level and detection limit

Schedule 2: Flow rate accuracy

Schedule 3: Temperature dependence of the zero point and sensitivity

Schedule 4: Independence of supply voltage

Annex 5: Measured values from the field test sites

Schedule 6: Ambient condition at the field test locations

Annex 2 **Operation manuals**

Annex 1 **Zero level and Detection limit** **Page 1 of 1**

Manufacturer Met One Instruments

Type BAM-1020

Standards ZP Measured values with zero filter

Serial-No. SN X14465 / SN X14499

No.	Date	Measured values [µg/m³] SN X14465	Date	Measured values [µg/m³] SN X14499
1	8/19/2018	-0.3	8/19/2018	-0.6
2	8/20/2018	0.1	8/20/2018	0.3
3	8/21/2018	-1.2	8/21/2018	0.6
4	8/22/2018	-0.3	8/22/2018	0.3
5	8/23/2018	-0.4	8/23/2018	-0.2
6	8/24/2018	0.2	8/24/2018	-0.3
7	8/25/2018	-1.0	8/25/2018	0.5
8	8/26/2018	-0.9	8/26/2018	-0.8
9	8/27/2018	-0.3	8/27/2018	-0.1
10	8/28/2018	0.5	8/28/2018	0.8
11	8/29/2018	-0.4	8/29/2018	0.0
12	8/30/2018	-1.3	8/30/2018	0.8
13	8/31/2018	-0.5	8/31/2018	-0.2
14	9/1/2018	-0.9	9/1/2018	-0.2
15	9/2/2018	-0.7	9/2/2018	0.3
	No. of values	15	No. of values	15
	Mean (Zero level)	-0.49	Mean (Zero level)	0.08
	Standard deviation s_{x0}	0.51	Standard deviation s_{x0}	0.47
	Detection limit x	1.69	Detection limit x	1.56

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

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

Manufacturer: Met One Instruments

Type: BAM-1020

Serial-No.: SN X14465 / SN X14499

Nominal flow rate [l/min]: 16.67

		SN X14465			SN X14499		
Temperature 1	5°C	No.	Date/Time	Measured value [l/min]	No.	Date/Time	Measured value [l/min]
		1	8/15/2018 6:11	16.46	1	8/15/2018 6:13	16.36
		2	8/15/2018 6:15	16.44	2	8/15/2018 6:17	16.34
		3	8/15/2018 6:19	16.43	3	8/15/2018 6:21	16.36
		4	8/15/2018 6:23	16.42	4	8/15/2018 6:25	16.35
		5	8/15/2018 6:27	16.42	5	8/15/2018 6:29	16.36
		6	8/15/2018 6:31	16.42	6	8/15/2018 6:33	16.35
		7	8/15/2018 6:35	16.39	7	8/15/2018 6:37	16.34
		8	8/15/2018 6:39	16.40	8	8/15/2018 6:41	16.33
		9	8/15/2018 6:43	16.40	9	8/15/2018 6:45	16.35
		10	8/15/2018 6:47	16.33	10	8/15/2018 6:49	16.34
			Mean	**16.41**		**Mean**	**16.35**

		SN X14465			SN X14499		
Temperature 2	40°C	No.	Date/Time	Measured value [l/min]	No.	Date/Time	Measured value [l/min]
		1	8/16/2018 6:12	16.80	1	8/16/2018 6:14	16.84
		2	8/16/2018 6:16	16.86	2	8/16/2018 6:18	16.90
		3	8/16/2018 6:20	16.84	3	8/16/2018 6:22	16.86
		4	8/16/2018 6:24	16.91	4	8/16/2018 6:26	16.91
		5	8/16/2018 6:28	16.87	5	8/16/2018 6:30	16.87
		6	8/16/2018 6:32	16.87	6	8/16/2018 6:34	16.87
		7	8/16/2018 6:36	16.88	7	8/16/2018 6:38	16.86
		8	8/16/2018 6:40	16.86	8	8/16/2018 6:42	16.91
		9	8/16/2018 6:44	16.90	9	8/16/2018 6:46	16.88
		10	8/16/2018 6:48	16.87	10	8/16/2018 6:50	16.86
			Mean	**16.87**		**Mean**	**16.88**

Annex 3 **Dependence of zero point on surrounding temperature** **Page 1 of 2**

Manufacturer: Met One Instruments

Standards: internal zero measurement on filter tape

Type: BAM-1020

Serial-No.: SN 4924 / SN 4925

Test period: 05.09.2006 - 20.09.2006

SN 4924	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	0.8	0.8	0.5	0.5
	2	5	1.5	-0.7	-0.1	0.2	
	3	20	0.5	0.2	0.1	0.3	
	4	40	0.8	0.8	1.2	0.9	
	5	20	0.2	1.4	0.6	0.7	

SN 4925	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	1.2	0.7	0.8	0.9	1.0
	2	5	0.8	1.6	1.1	1.2	
	3	20	1.1	0.8	1.6	1.2	
	4	40	0.8	0.6	0.9	0.8	
	5	20	0.2	1.2	1.2	0.9	

Annex 3 Dependence of span on surrounding temperature Page 2 of 2

Manufacturer: Met One Instruments

Used test standard: internal reference foil

Type: BAM-1020

Serial-No.: SN 4924 / SN 4925

Test period: 05.09.2006 - 20.09.2006

SN 4924	No.	Temperature [°C]	Measurement 1 Measured value [µg/cm²]	Measurement 2 Measured value [µg/cm²]	Meaurement 3 Measured value [µg/cm²]	Mean value of 3 measurements [µg/cm²]	Mean value at 20°C [µg/cm²]
Span	1	20	823.6	825.0	825.4	824.7	825.3
	2	5	825.9	825.5	825.9	825.8	
	3	20	824.9	825.7	824.9	825.2	
	4	40	825.8	825.0	825.5	825.4	
	5	20	826.9	826.3	824.6	825.9	

SN 4925	No.	Temperature [°C]	Measured value [µg/cm²]	Measured value [µg/cm²]	Measured value [µg/cm²]	Mean value of 3 measurements [µg/cm²]	Mean value at 20°C [µg/cm²]
Span	1	20	814.8	815.1	814.6	814.8	814.6
	2	5	817.5	815.7	815.8	816.3	
	3	20	814.9	815.0	815.0	815.0	
	4	40	813.7	813.8	813.6	813.7	
	5	20	813.5	813.5	814.9	814.0	

Annex 4 — Dependence of span on supply voltage — Page 1 of 1

Manufacturer ABC

Type XYZ

Serial-No. SN X14465 / SN X14499

Used test standard Internal reference foil

SN X14465	No.	Mains voltage [V]	Measurement 1 Measured value [mg]	Measurement 2 Measured value [mg]	Measurement 3 Measured value [mg]	Mean value of 3 measurements [mg]
Span	1	230	0.813	0.815	0.816	0.815
	2	195	0.811	0.819	0.818	0.816
	3	230	0.815	0.817	0.819	0.817
	4	253	0.813	0.818	0.818	0.816
	5	230	0.815	0.815	0.815	0.815

SN X14499	No.	Mains voltage [V]	Measured value [mg]	Measured value [mg]	Measured value [mg]	Mean value of 3 measurements [mg]
Span	1	230	0.824	0.827	0.826	0.826
	2	195	0.827	0.827	0.830	0.828
	3	230	0.822	0.820	0.824	0.822
	4	253	0.824	0.830	0.826	0.827
	5	230	0.822	0.824	0.826	0.824

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 1 of 13**

Manufacturer	Met One Instruments	
Type of instrument	BAM-1020	PM10 Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
1	2/11/2006			29.8	32.9	SN 4294 / SN 4295	Cologne, parking lot
2	2/12/2006			25.7	26.0		
3	2/13/2006	33.4	35.7	30.9	33.3		
4	2/14/2006					Flowcheck	
5	2/15/2006	12.5	11.7	10.9	12.7		
6	2/16/2006			10.1	11.5		
7	2/17/2006	9.6	9.2	8.2	8.7		
8	2/18/2006			14.0	13.3		
9	2/19/2006			10.4	11.5		
10	2/20/2006	9.2	10.0	12.4	14.7		
11	2/21/2006	14.0	13.8	14.1	16.1		
12	2/22/2006	16.0	16.1	17.7	18.9		
13	2/23/2006			20.5	20.3		
14	2/24/2006			29.5	31.1		
15	2/25/2006	27.9	28.8	29.1	31.6		
16	2/26/2006				32.2		
17	2/27/2006			32.1	34.1		
18	2/28/2006			11.8	14.0		
19	3/1/2006	15.5	15.7	15.6	14.9		
20	3/2/2006			22.1	21.8		
21	3/3/2006	45.8	45.9	43.9	46.3		
22	3/4/2006			46.1	47.8		
23	3/5/2006			21.0	23.1		
24	3/6/2006			19.8	22.0		
25	3/7/2006	26.2	26.6	26.8	28.7		
26	3/8/2006			14.3	16.3		
27	3/9/2006			16.8	16.2		
28	3/10/2006						
29	3/11/2006			25.8	27.5		
30	3/12/2006			29.9	31.7		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 2 of 13**

Manufacturer	Met One Instruments	
Type of instrument	BAM-1020	PM10 Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
31	3/13/2006	24.7	24.5	25.7	28.0	SN 4294 / SN 4295	Cologne, parking lot
32	3/14/2006	30.2	30.1	31.4	33.2		
33	3/15/2006						
34	3/16/2006						
35	3/17/2006						
36	3/18/2006	37.0	37.2	40.3	40.4		
37	3/19/2006			58.8	61.9		
38	3/20/2006	62.5	62.5	60.9	64.8		
39	3/21/2006			31.8	32.9		
40	3/22/2006	29.3	29.4	31.1	33.6		
41	3/23/2006			28.8	28.7		
42	3/24/2006			33.6	36.1		
43	3/25/2006	8.1	9.8	11.5	12.2		
44	3/26/2006			11.1	11.5		
45	3/27/2006			13.4	14.7		
46	3/28/2006	8.9	9.3	13.4	13.8		
47	3/29/2006	10.3	11.2	16.1	17.3		
48	3/30/2006			9.8	10.6		
49	3/31/2006	9.6	10.9	15.3	16.3		
50	4/1/2006			11.5	12.5		
51	4/2/2006			10.0	10.5		
52	4/3/2006			20.3	22.8		
53	4/4/2006			24.7	26.7		
54	7/26/2006	49.1	48.6	52.8	54.2	SN 4294 / SN 4295	Titz-Rödingen
55	7/27/2006			43.4	44.4		
56	7/28/2006					Power failure	
57	7/29/2006					Power failure	
58	7/30/2006	17.8	19.2	20.0	21.6		
59	7/31/2006	17.6	18.7	21.3	21.8		
60	8/1/2006	15.9	16.0	16.8	19.6		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 3 of 13**

Manufacturer	Met One Instruments	PM10
Type of instrument	BAM-1020	Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
61	8/2/2006	17.4	17.8	18.7	20.2	SN 4294 / SN 4295	Titz-Rödingen
62	8/3/2006			16.2	17.8		
63	8/4/2006	22.5	23.0	24.8	25.0		
64	8/5/2006	20.1	21.4	24.3	25.2		
65	8/6/2006	18.7	18.7	21.0	22.4		
66	8/7/2006	22.0	22.9	21.6	23.3		
67	8/8/2006	14.6	14.8	13.7	14.8		
68	8/9/2006						
69	8/10/2006						
70	8/11/2006						
71	8/12/2006	20.4	19.5	20.5	21.8		
72	8/13/2006	13.8	12.9	13.5	13.2		
73	8/14/2006	13.8	12.9	20.4	20.9		
74	8/15/2006	30.7	30.3	29.9	30.5		
75	8/16/2006	22.0	23.6	24.8	25.3		
76	8/17/2006			16.9	17.7		
77	8/18/2006	12.1	11.6	13.1	12.7		
78	8/19/2006	11.5	13.2	13.8	15.4		
79	8/20/2006	10.3	11.6	13.5	14.4		
80	8/21/2006	15.4	15.5	18.5	18.8		
81	8/22/2006	19.5	20.4	21.0	21.7		
82	8/23/2006	38.2	38.9	42.6	42.8		
83	8/24/2006			17.1	18.4		
84	8/25/2006	31.9	31.0	32.5	34.0		
85	8/26/2006	31.1	30.6	32.3	31.5		
86	8/27/2006	21.3	21.0	22.8	23.5		
87	8/28/2006	12.8	13.2	14.4	14.6		
88	8/29/2006	13.7	14.5	15.7	14.5		
89	8/30/2006					Power meter installed	
90	8/31/2006			22.3	22.0		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 4 of 13**

Manufacturer	Met One Instruments	
Type of instrument	BAM-1020	PM10 Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
91	9/1/2006	23.3	23.1	26.1	26.1	SN 4294 / SN 4295	Titz-Rödingen
92	9/2/2006	20.4	20.0	20.5	23.5		
93	9/3/2006	9.3	8.9	10.3	12.6		
94	9/29/2006	32.9	30.4	33.5	34.6	SN 4294 / SN 4295	Cologne, Frankf. Str.
95	9/30/2006	18.8	19.7	16.5	17.8		
96	10/1/2006						
97	10/2/2006						
98	10/3/2006						
99	10/4/2006	23.5	23.7	21.5	23.3		
100	10/5/2006	14.1	12.6	15.2	15.7		
101	10/6/2006	14.1	12.8	13.1	13.0		
102	10/7/2006	20.6	21.3	19.3	20.1		
103	10/8/2006	23.7	23.0	21.8	22.0		
104	10/9/2006			30.8	29.7		
105	10/10/2006	36.2	35.9	34.8	35.0		
106	10/11/2006	39.7	38.9	36.5	37.9		
107	10/12/2006	51.1	50.4	49.5	51.3		
108	10/13/2006	42.0	42.0	40.3	42.5		
109	10/14/2006	52.1	50.0	47.8	49.3		
110	10/15/2006	37.7	35.7	37.5	37.6		
111	10/16/2006			32.0	32.8		
112	10/17/2006	31.8	30.1	33.8	33.9		
113	10/18/2006						
114	10/19/2006						
115	10/20/2006						
116	10/21/2006			12.0	13.8		
117	10/22/2006	13.2	12.9	11.6	15.2		
118	10/23/2006			15.4	16.7		
119	10/24/2006	19.4	19.2	18.1	18.6		
120	10/25/2006	19.8	18.7	22.5	22.5		

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

Manufacturer	Met One Instruments
Type of instrument	BAM-1020
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011

PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
121	10/26/2006	33.4	29.0	31.1	33.7	SN 4294 / SN 4295	Cologne, Frankf. Str.
122	6/5/2008	20.2	20.4	26.1	26.4	Ö1 / Ö2	A-Steyregg
123	6/6/2008	16.6	17.3	20.8	20.3		
124	6/7/2008	13.9	14.9	16.7	17.6		
125	6/8/2008			20.0	21.2		
126	6/9/2008	14.7	15.4	17.1	17.2		
127	6/10/2008						
128	6/11/2008	24.1	24.7	21.8			
129	6/12/2008	21.9	22.7		21.1		
130	6/13/2008	19.6	20.1	17.6	19.7		
131	6/14/2008	17.6	17.9	20.4	19.6		
132	6/15/2008			15.5			
133	6/16/2008	12.0	11.9	12.1			
134	6/17/2008						
135	6/18/2008		14.4	15.5	14.3		
136	6/19/2008						
137	6/20/2008		20.4	23.8	21.6		
138	6/21/2008		19.5	18.9	18.6		
139	6/22/2008			21.2	21.6		
140	6/23/2008		23.1	22.3	22.1		
141	6/24/2008						
142	6/25/2008	28.6	29.4	28.2	28.3		
143	6/26/2008	31.2	32.4	30.6	30.0		
144	6/27/2008	25.4		28.0	27.8		
145	6/28/2008	16.5	16.5	17.9	18.3		
146	6/29/2008			15.9	16.2		
147	6/30/2008			18.3	18.0		
148	7/1/2008						
149	7/2/2008						
150	7/3/2008			37.1	36.4		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 6 of 13**

Manufacturer	Met One Instruments	PM10
Type of instrument	BAM-1020	Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
151	7/4/2008			20.4	20.4	Ö1 / Ö2	A-Steyregg
152	7/5/2008			18.4	18.5		
153	7/6/2008			12.2	13.7		
154	7/7/2008			19.0	19.2		
155	7/8/2008						
156	7/9/2008						
157	7/10/2008	19.7	18.3	17.2	18.0		
158	7/11/2008	20.0	18.8	18.7	19.2		
159	7/12/2008	19.0	19.2	16.8	16.6		
160	7/13/2008			12.4	12.0		
161	7/14/2008	20.5	21.5	20.2	20.0		
162	7/15/2008						
163	7/16/2008	22.9	23.4	23.8	24.3		
164	7/17/2008	17.3	17.6	12.6	12.1		
165	7/18/2008	20.9	20.8	18.8	18.0		
166	7/19/2008						
167	7/20/2008						
168	7/21/2008						
169	7/22/2008						
170	7/23/2008	22.6	22.0	19.4	18.7		
171	7/24/2008	30.5	31.1	26.8	25.7		
172	7/25/2008	26.8	28.0	27.0	25.0		
173	7/26/2008	20.4	20.5	21.9	19.9		
174	7/27/2008	21.7	22.0	21.4	20.1		
175	7/28/2008	22.5	23.7	23.9	24.5		
176	7/29/2008						
177	7/30/2008	19.5	20.4	19.4	18.5		
178	7/31/2008	19.3	20.1	20.1	18.0		
179	8/1/2008	25.6	25.9	21.5	21.3		
180	8/2/2008	16.8	18.4	16.0	13.2		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 7 of 13**

Manufacturer	Met One Instruments	PM10
Type of instrument	BAM-1020	Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
181	8/3/2008	10.7	11.7	10.0	8.7	Ö1 / Ö2	A-Steyregg
182	8/4/2008	20.5	22.1	21.2	19.7		
183	12/5/2007	121.1	121.8	125.6	128.7	Ö1 / Ö2	A-Graz
184	12/6/2007	107.7	105.9	108.1	109.6		
185	12/10/2007	71.4	69.5	71.4	71.6		
186	12/13/2007	11.3	11.0	16.8	18.6		
187	12/16/2007		31.1	30.5	31.9		
188	12/17/2007			52.1	53.4		
189	12/19/2007			90.0	91.9		
190	12/20/2007			84.3	85.5		
191	1/7/2008						
192	1/8/2008						
193	1/9/2008						
194	1/10/2008						
195	1/13/2008	63.7	62.1	59.2	62.4		
196	1/14/2008			50.4	52.9		
197	1/15/2008	49.3	48.6	49.5	51.4		
198	1/16/2008	52.9	51.3	46.5	48.3		
199	1/17/2008	57.9	57.1	53.5	55.3		
200	1/20/2008	63.9	64.2	61.0	62.8		
201	1/21/2008	100.5	97.9	98.8	99.9		
202	1/22/2008	44.6	44.6	42.6	44.4		
203	1/23/2008			52.3	53.7		
204	1/24/2008	90.6	92.0	89.5	90.1		
205	1/28/2008	20.1	18.9	16.2	20.3		
206	1/30/2008	78.2	77.6	80.8	84.4		
207	1/31/2008	72.8	71.4	71.8	73.8		
208	2/3/2008	22.0	21.7	21.4	23.3		
209	2/4/2008	55.5	56.3	59.1	61.4		
210	2/5/2008			45.2	47.1		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 8 of 13**

Manufacturer	Met One Instruments	
Type of instrument	BAM-1020	PM10 Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
211	2/6/2008	43.3	43.6	45.6	47.5	Ö1 / Ö2	A-Graz
212	2/7/2008	43.2	42.2	38.9	41.5		
213	2/10/2008	64.6	64.1	59.0	61.3		
214	2/11/2008	83.6	82.3	85.1	85.5		
215	2/12/2008	87.9	87.0	85.2	90.2		
216	2/13/2008	111.4	109.8	111.9	115.3		
217	2/14/2008			99.3	103.3		
218	2/17/2008	52.6	51.2	46.0	48.9		
219	2/18/2008	47.1	47.2	49.5	53.1		
220	2/19/2008	69.7	69.2	76.8	81.0		
221	2/20/2008	102.8	104.5	102.5	105.9		
222	2/21/2008			93.0	97.1		
223	2/24/2008	60.9	62.4	53.4	57.7		
224	2/25/2008						
225	2/26/2008						
226	2/27/2008						
227	2/28/2008	52.7	51.6	56.9	60.1		
228	3/2/2008	10.8	11.1	6.6	7.4		
229	3/3/2008	24.3	24.9	37.5	40.9		
230	3/4/2008	15.2	14.7	18.0	20.4		
231	3/5/2008			16.3	19.6		
232	3/6/2008	26.0	25.3	28.8	31.3		
233	1/7/2010	47.0	0.0	47.7	49.8	J7860 / J7863	CZ-Tusimice
234	1/8/2010	50.4	0.0	51.6	53.3		
235	1/9/2010		0.0	50.8	51.6		
236	1/10/2010		0.0	17.6	16.7		
237	1/11/2010	40.2	0.0	43.2	42.7		
238	1/12/2010			62.5	62.5		
239	1/13/2010	68.5	0.0	72.2	74.6		
240	1/14/2010	31.6	0.0	33.3	34.9		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 9 of 13**

Manufacturer	Met One Instruments	PM10
Type of instrument	BAM-1020	Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
241	1/15/2010	44.4	0.0	46.4	46.8	J7860 / J7863	CZ-Tusimice
242	1/16/2010		0.0	41.0	40.8		
243	1/17/2010		0.0	51.6	51.0		
244	1/18/2010	21.9	0.0	23.6	23.3		
245	1/19/2010			30.1	32.2		
246	1/20/2010	51.7	0.0	53.2	53.6		
247	1/21/2010	77.2	0.0	79.1	79.8		
248	1/22/2010	91.8	0.0	92.1	93.2		
249	1/23/2010		0.0	89.9	89.9		
250	1/24/2010		0.0	69.4	71.3		
251	1/25/2010						
252	1/26/2010						
253	1/27/2010						
254	1/28/2010	5.8	0.0	9.6	7.9		
255	1/29/2010			7.7			
256	1/30/2010		0.0	10.4			
257	1/31/2010						
258	2/1/2010	12.7	0.0	14.0	13.0		
259	2/2/2010	6.4	0.0	8.4	8.3		
260	2/3/2010	9.2	0.0	12.1	11.7		
261	2/4/2010						
262	2/5/2010						
263	2/6/2010	66.8		68.9	69.9		
264	2/7/2010	46.5		50.7	51.3		
265	2/8/2010			51.1	50.6		
266	2/9/2010			64.4	64.0		
267	2/10/2010	87.2		90.9	92.1		
268	2/11/2010	50.9		54.9	55.7		
269	2/12/2010			17.0	18.3		
270	2/13/2010			13.0	13.0		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 10 of 13**

Manufacturer	Met One Instruments	PM10
Type of instrument	BAM-1020	Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
271	2/14/2010	29.2		31.8	31.9	J7860 / J7863	CZ-Tusimice
272	2/15/2010			52.8	53.8		
273	2/16/2010	57.9		61.3	61.5		
274	2/17/2010	75.3		76.6	76.6		
275	2/18/2010	69.0		73.0	74.8		
276	2/19/2010			58.6	60.3		
277	2/20/2010			21.4	22.3		
278	2/21/2010			20.2	20.8		
279	2/22/2010			72.0	72.9		
280	2/23/2010	112.5		113.0	115.6		
281	2/24/2010	70.6		78.1	79.2		
282	2/25/2010	64.6					
283	2/26/2010	37.1		39.4	37.8		
284	2/27/2010	25.0		29.8	29.0		
285	2/28/2010	13.5		19.7	19.7		
286	3/1/2010			9.5	9.1		
287	3/2/2010	13.8		18.2	17.4		
288	3/3/2010	12.6		16.4	15.3		
289	3/4/2010	14.9		21.4	19.0		
290	3/5/2010	14.3		24.1	22.3		
291	3/6/2010	24.0		35.1	31.7		
292	4/20/2010	41.0		45.1	42.8		
293	4/21/2010	13.8		17.2	15.9		
294	4/22/2010	19.6		26.2	25.4		
295	4/23/2010	32.9		38.6	37.8		
296	4/24/2010	48.0		51.9	50.2		
297	4/25/2010	36.8		41.4	40.2		
298	4/26/2010	20.4		25.1	23.1		
299	4/27/2010	19.5		23.4	21.4		
300	4/28/2010	26.2					

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

Manufacturer	Met One Instruments
Type of instrument	BAM-1020
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011

PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
301	4/29/2010	35.6				J7860 / J7863	CZ-Tusimice
302	4/30/2010	27.2		34.4	34.0		
303	5/1/2010	13.2		16.6	14.7		
304	5/2/2010	29.0		33.0	28.9		
305	5/3/2010	15.1		17.4	15.5		
306	5/4/2010	21.1		27.0	25.7		
307	5/5/2010	24.8		29.6	26.6		
308	5/6/2010	12.0		13.2	11.2		
309	5/7/2010	8.5		12.5	9.0		
310	5/8/2010	18.1		20.8	18.5		
311	5/9/2010	15.7		17.8	15.6		
312	5/10/2010	39.4		41.5	39.9		
313	5/11/2010	30.5		30.4	28.8		
314	5/12/2010	14.4		16.3	14.9		
315	5/13/2010	17.5		18.7	16.5		
316	5/14/2010	4.7		6.4	4.9		
317	5/15/2010	12.9		13.4	13.8		
318	5/16/2010	16.0		18.6	19.8		
319	5/17/2010	19.4		25.3	24.2		
320	5/18/2010			15.9	15.5		
321	5/19/2010	6.4		8.8	7.2		
322	5/20/2010	11.0		16.5	14.2		
323	5/21/2010	26.4		29.8	28.5		
324	5/22/2010	27.0		30.3	28.5		
325	5/23/2010	16.8		20.3	16.9		
326	5/24/2010	17.0		21.4	20.2		
327	5/25/2010	21.2		29.3	27.7		
328	5/26/2010	30.2		30.7	31.7		
329	5/27/2010	29.4		41.3	36.9		
330	5/28/2010	22.3		27.1	29.0		

Annex 5 **Measured values from field test sites, related to actual conditions** **Page 12 of 13**

Manufacturer	Met One Instruments	PM10
Type of instrument	BAM-1020	Measured values in µg/m³ (ACT)
Serial-No.	SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011	

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
331	5/29/2010	34.5		31.5	35.4	J7860 / J7863	CZ-Tusimice
332	5/30/2010	6.6		7.2	6.1		
333	5/31/2010	3.9		6.2	4.3		
334	6/1/2010	4.7		7.1	4.1		
335	6/2/2010	4.9		9.4	7.0		
336	6/3/2010	9.2		19.1	19.9		
337	6/4/2010	14.7		21.3	19.8		
338	6/5/2010	21.0		29.8	26.6		
339	6/6/2010	22.0		23.3	22.9		
340	4/10/2012			8.8	9.8	SN 17022 / SN 17011	UK-Teddington
341	4/11/2012			9.6	11.9		
342	4/12/2012	13.8	13.7	15.9	13.9		
343	4/13/2012	21.3	21.2	22.5	21.2		
344	4/14/2012	11.4	11.7	14.8	12.0		
345	4/15/2012	11.5	12.2	13.4	11.3		
346	4/16/2012	10.4	10.0	11.1	10.3		
347	4/17/2012	8.7	8.4	9.8	9.1		
348	4/18/2012	8.3	8.2	7.9	8.9		
349	4/19/2012	12.1	10.9	12.6	11.8		
350	4/20/2012	6.9	6.9	7.6	7.1		
351	4/21/2012	7.9	7.7	8.6	7.7		
352	4/22/2012	9.1	8.5	8.8	8.7		
353	4/23/2012	7.4	7.4	7.4	7.9		
354	4/24/2012	12.1	12.0	12.4	12.5		
355	4/25/2012	9.4	9.5	9.4	10.9		
356	4/26/2012	12.4	12.3	14.9	13.9		
357	4/27/2012	13.9	14.4	15.4	14.6		
358	4/28/2012	4.4	4.5	7.0	5.5		
359	4/29/2012	8.2	8.4	11.2	11.5		
360	4/30/2012	15.1	15.2	17.4	16.0		

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

Manufacturer: Met One Instruments

Type of instrument: BAM-1020

Serial-No.: SN 4924 / Ö1 / J7860 / SN 17022 / SN 4925 / Ö2 / J7863 / SN 17011

PM10
Measured values in µg/m³ (ACT)

No.	Date	Ref. 1 PM10 [µg/m³]	Ref 2. PM10 [µg/m³]	SN 4924 / Ö1 / J7860 / SN 17022 PM10 [µg/m³]	SN 4925 / Ö2 / J7863 / SN 17011 PM10 [µg/m³]	Remark	Test site
361	5/1/2012	20.5	20.6	23.9	21.3	SN 17022 / SN 17011	UK-Teddington
362	5/2/2012	22.8	23.1	25.0	23.5		
363	5/3/2012	16.0	16.3	17.7	17.8		
364	5/4/2012	12.8	13.1	15.1	15.5		
365	5/5/2012	10.2	10.2	11.7	12.2		
366	5/6/2012	16.4	15.9	17.7	16.7		
367	5/7/2012	10.3	10.6	12.0	12.8		
368	5/8/2012	12.6	13.0	13.9	13.9		
369	5/9/2012	5.5	5.5	8.3	8.4		
370	5/10/2012	6.1	6.2	5.8	4.5		
371	5/11/2012	8.4	8.6	9.9	10.6		
372	5/12/2012	12.9	13.2	13.9	15.0		
373	5/13/2012	12.1	11.9	10.7	13.4		
374	5/14/2012	8.0	8.0	8.1	9.7		
375	5/15/2012	8.9	9.1	10.7	10.9		
376	5/16/2012	13.0	13.1	13.2	15.2		
377	5/17/2012	26.4	27.0	25.9	27.4		
378	5/18/2012	22.9	23.4	26.1	25.9		
379	5/19/2012	19.4	20.0	20.9	22.5		
380	5/20/2012	15.9	16.0	16.7	18.2		
381	5/21/2012	31.2	31.7	37.7	41.2		

Annex 6 **Ambient conditions from field test sites**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
1	2/11/2006	Cologne, parking lot	1.9	1020	82.9	0.0	187	0.7
2	2/12/2006		2.5	1016	65.3	0.7	193	0.0
3	2/13/2006		4.1	1013	61.0	1.0	186	0.0
4	2/14/2006		5.4	1006	79.7	1.4	180	1.5
5	2/15/2006		7.1	987	84.8	1.4	198	13.3
6	2/16/2006		7.2	982	75.8	0.9	211	2.2
7	2/17/2006		6.6	985	66.7	1.1	205	1.1
8	2/18/2006		5.4	989	80.2	0.2	200	8.5
9	2/19/2006		6.9	993	69.2	0.8	159	2.2
10	2/20/2006		3.2	1000	82.6	1.0	112	6.7
11	2/21/2006		4.0	1009	72.2	1.0	112	1.5
12	2/22/2006		1.8	1016	60.9	1.4	111	0.0
13	2/23/2006		0.5	1012	50.9	1.1	116	0.0
14	2/24/2006		2.6	1009	49.7	1.9	112	0.0
15	2/25/2006		1.0	1008	50.8	1.3	112	0.0
16	2/26/2006		-1.9	1011	72.8	0.5	105	0.0
17	2/27/2006		1.2	1003	89.1	0.2	185	3.7
18	2/28/2006		1.2	992	88.9	1.7	234	4.8
19	3/1/2006		-0.7	995	71.4	1.2	194	1.9
20	3/2/2006		0.7	994	60.2	0.3	158	0.4
21	3/3/2006		0.3	989	80.6	0.5	196	1.1
22	3/4/2006		0.2	992	69.4	0.0	198	0.4
23	3/5/2006		2.6	1000	65.8	1.6	217	1.1
24	3/6/2006		2.4	1008	69.6	2.4	243	1.5
25	3/7/2006		2.8	1008	54.0	0.5	171	0.0
26	3/8/2006		4.9	991	86.9	0.9	158	15.2
27	3/9/2006		7.9	991	81.5	1.1	194	3.7
28	3/10/2006		4.9	993	77.4	0.5	206	13.3
29	3/11/2006		-1.2	1009	68.7	2.3	199	1.1
30	3/12/2006		-3.2	1024	51.9	0.7	126	0.0

Annex 6 **Ambient conditions from field test sites** **Page 2 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
31	3/13/2006	Cologne, parking lot	-0.1	1022	42.0	0.5	153	0.0
32	3/14/2006		2.2	1016	39.6	0.8	146	0.0
34	3/15/2006		4.4	1014	42.9	0.9	135	0.0
34	3/16/2006		2.6	1016	46.4	1.0	131	0.0
35	3/17/2006		2.8	1015	52.3	1.9	108	0.0
36	3/18/2006		3.8	1010	57.7	1.2	129	0.0
37	3/19/2006		4.5	1005	55.5	0.7	168	0.0
38	3/20/2006		3.9	1002	62.4	0.5	124	0.0
39	3/21/2006		3.6	1001	43.3	1.0	114	0.0
40	3/22/2006		3.3	1003	42.2	2.0	62	0.0
41	3/23/2006		6.6	1001	33.7	1.8	150	0.0
42	3/24/2006		8.7	992	72.3	0.3	162	3.3
43	3/25/2006		13.4	1000	66.4	1.7	208	4.4
44	3/26/2006		15.6	1000	66.7	0.5	162	1.1
45	3/27/2006		13.4	996	60.2	1.4	186	4.8
46	3/28/2006		9.8	996	58.2	0.7	188	1.9
47	3/29/2006		9.1	1001	70.2	0.9	184	8.5
48	3/30/2006		12.8	995	68.7	1.3	205	8.9
49	3/31/2006		12.2	1002	61.9	2.6	218	5.6
50	4/1/2006		10.7	1002	65.2	0.8	179	7.8
51	4/2/2006		11.5	1002	46.8	3.0	230	3.7
52	4/3/2006		8.3	1009	59.9	1.2	220	2.6
53	4/4/2006		5.5	1007	54.0	1.4	179	0.0
54	7/26/2006	Titz-Rödingen	26.5	1003	55.8	0.0	197	0.0
55	7/27/2006		24.1	1003	64.7	0.0	256	3.0
56	7/28/2006		20.6	1000	80.1	0.0	237	26.6
57	7/29/2006		21.7	999	70.5	0.0	267	0.0
58	7/30/2006		21.0	1001	70.5	0.0	207	8.0
59	7/31/2006		20.1	1001	63.0	0.0	223	0.0
60	8/1/2006		17.5	995	71.6	1.0	229	9.8

Annex 6 **Ambient conditions from field test sites** **Page 3 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
61	8/2/2006	Titz-Rödingen	15.7	994	72.8	0.8	224	2.1
62	8/3/2006		15.1	996	79.8	0.0	280	5.3
63	8/4/2006		17.9	1000	77.2	0.2	176	35.7
64	8/5/2006		19.3	1006	73.3	0.1	254	0.0
65	8/6/2006		18.7	1007	71.0	0.1	277	0.0
66	8/7/2006		18.8	1006	75.0	0.3	241	2.7
67	8/8/2006		15.9	1006	71.7	0.2	236	0.0
68	8/9/2006		15.0	1002	78.3	0.0	234	3.9
69	8/10/2006		13.7	1001	78.1	0.0	246	9.2
70	8/11/2006		12.7	998	81.0	0.1	231	10.4
71	8/12/2006		14.1	995	74.4	0.1	163	4.1
72	8/13/2006		15.0	994	71.8	0.6	169	0.3
73	8/14/2006		15.2	994	80.4	0.4	247	11.2
74	8/15/2006		16.0	997	79.4	0.2	165	3.8
75	8/16/2006		17.4	993	75.3	0.2	120	1.5
76	8/17/2006		18.9	992	73.9	0.2	122	4.5
77	8/18/2006		18.8	998	68.8	1.6	203	1.5
78	8/19/2006		18.3	1002	72.4	0.1	175	3.0
79	8/20/2006		16.5	1005	75.0	1.7	233	12.1
80	8/21/2006		15.7	1004	80.3	0.3	200	18.3
81	8/22/2006		14.8	1006	79.5	0.0	221	0.0
82	8/23/2006		17.5	1001	72.0	0.1	183	0.0
83	8/24/2006		16.0	995	75.1	1.2	203	5.3
84	8/25/2006		16.1	997	80.5	0.1	269	2.4
85	8/26/2006		15.5	998	79.9	0.0	210	0.9
86	8/27/2006		15.6	1000	80.5	0.1	242	11.2
87	8/28/2006		12.7	995	81.7	0.4	200	12.1
88	8/29/2006		12.7	997	77.8	0.2	198	8.9
89	8/30/2006		13.1	1008	79.6	0.0	170	4.2
90	8/31/2006		16.9	1010	69.9	0.6	255	0.0

Annex 6 **Ambient conditions from field test sites** **Page 4 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
91	9/1/2006	Titz-Rödingen	20.0	1003	66.1	0.6	225	0.0
92	9/2/2006		19.8	1000	65.5	2.1	224	0.0
93	9/3/2006		20.2	1003	75.9	2.7	172	3.5
94	9/29/2006	Cologne, Frankf. Str.	18.7	1003	68.5	0.4	175	0.6
95	9/30/2006		18.2	1004	67.3	0.1	199	1.2
96	10/1/2006		18.6	1003	63.8	0.5	207	0.3
97	10/2/2006		16.6	999	64.2	0.3	201	0.0
98	10/3/2006		14.3	996	73.4	0.2	287	1.5
99	10/4/2006		12.7	1006	75.6	0.4	227	2.7
100	10/5/2006		14.9	1009	68.1	0.2	199	6.8
101	10/6/2006		15.9	1002	72.1	1.2	214	11.8
102	10/7/2006		12.1	1012	70.4	2.0	243	0.3
103	10/8/2006		12.7	1014	69.6	0.0	184	0.0
104	10/9/2006		15.4	1014	70.2	0.1	170	0.0
105	10/10/2006		15.1	1012	74.7	0.1	139	0.0
106	10/11/2006		16.7	1007	70.6	0.7	173	0.0
107	10/12/2006		17.4	1017	75.3	0.1	231	0.0
108	10/13/2006		15.3	1023	77.8	0.0	155	0.0
109	10/14/2006		11.7	1022	73.8	0.6	111	0.0
110	10/15/2006		11.6	1020	67.7	0.4	119	0.0
111	10/16/2006		11.7	1015	67.3	2.0	168	0.0
112	10/17/2006		12.6	1007	65.8	2.6	172	0.0
113	10/18/2006		15.1	998	65.3	1.3	175	0.0
114	10/19/2006		15.1	993	76.0	1.6	166	1.8
115	10/20/2006		14.9	992	76.7	0.1	183	6.2
116	10/21/2006		15.7	997	69.1	0.3	188	0.3
117	10/22/2006		16.6	994	69.3	1.6	187	0.9
118	10/23/2006		16.7	989	76.9	1.2	192	19.8
119	10/24/2006		13.2	997	74.5	2.2	250	2.4
120	10/25/2006		14.5	1002	66.3	2.8	168	0.0

Annex 6 **Ambient conditions from field test sites** **Page 5 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
121	10/26/2006	Cologne, Frankf. Str.	19.1	1003	64.2	0.5	222	0.0
122	6/5/2008	A-Steyregg	18.1		73.1	2.2		
123	6/6/2008		17.8		77.2	1.9		
124	6/7/2008		17.9		76.6	1.0		
125	6/8/2008		17.4		85.0	0.8		
126	6/9/2008		19.9		71.1	1.3		
127	6/10/2008		22.4		64.9	1.2		
128	6/11/2008		18.5		74.5	1.8		
129	6/12/2008		16.8		65.2	1.5		
130	6/13/2008		10.9		80.0	1.3		
131	6/14/2008		13.3		71.9	0.6		
132	6/15/2008		16.9		58.7	0.8		
134	6/16/2008		16.9		69.1	1.0		
134	6/17/2008		16.6		83.1	1.0		
135	6/18/2008		16.8		84.0	1.0		
136	6/19/2008		20.0		70.9	0.8		
137	6/20/2008		21.2		65.3	1.3		
138	6/21/2008		22.5		63.9	1.0		
139	6/22/2008		26.2		62.6	0.8		
140	6/23/2008		24.8		64.4	1.1		
141	6/24/2008		21.9		75.4	1.0		
142	6/25/2008		25.1		70.1	1.3		
143	6/26/2008		20.5		85.6	0.9		
144	6/27/2008		20.5		71.3	0.8		
145	6/28/2008		20.5		67.6	1.4		
146	6/29/2008		23.7		65.1	1.0		
147	6/30/2008		21.0		73.3	1.3		
148	7/1/2008		22.8		65.0	1.6		
149	7/2/2008		24.2		68.6	1.2		
150	7/3/2008		24.0		69.5	1.9		

Annex 6 **Ambient conditions from field test sites** **Page 6 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
151	7/4/2008	A-Steyregg	18.1		70.5	1.9		
152	7/5/2008		18.9		60.3	1.3		
153	7/6/2008		21.6		76.4	1.2		
154	7/7/2008		14.8		93.0	1.2		
155	7/8/2008		17.6		70.3	1.2		
156	7/9/2008		17.7		73.8	1.1		
157	7/10/2008		20.7		72.0	0.7		
158	7/11/2008		24.6		61.9	1.6		
159	7/12/2008		19.8		80.8	1.4		
160	7/13/2008		17.0		87.1	1.6		
161	7/14/2008		15.8		82.8	1.5		
162	7/15/2008		19.5		61.0	1.9		
163	7/16/2008		21.2		66.8	1.4		
164	7/17/2008		15.6		92.5	0.7		
165	7/18/2008		15.9		86.4	0.9		
166	7/19/2008		21.4		69.7	1.0		
167	7/20/2008		17.8		82.5	1.4		
168	7/21/2008		15.1		68.3	1.7		
169	7/22/2008		13.9		81.5	2.5		
170	7/23/2008		16.1		80.1	1.4		
171	7/24/2008		15.6		93.9	1.3		
172	7/25/2008		18.2		94.6	0.8		
173	7/26/2008		20.9		87.5	0.3		
174	7/27/2008		22.3		72.5	1.4		
175	7/28/2008		23.6		64.4	1.8		
176	7/29/2008		24.3		69.9	0.9		
177	7/30/2008		23.2		74.6	1.2		
178	7/31/2008		22.8		71.3	1.1		
179	8/1/2008		24.3		68.3	1.5		
180	8/2/2008		20.4		84.9	0.7		

Annex 6 **Ambient conditions from field test sites** **Page 7 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
181	8/3/2008	A-Steyregg	22.1		72.7	0.9		
182	8/4/2008		22.2		69.2	2.1		
183	12/5/2007	A-Graz	1.1		83.9	0.1		
184	12/6/2007							
185	12/10/2007		1.1		98.4	0.2		
186	12/13/2007		4.7		41.4	1.8		
187	12/16/2007		-1.3		84.7	0.6		
188	12/17/2007		-2.7		83.5	0.3		
189	12/19/2007		-4.8		84.8	0.8		
190	12/20/2007		-5.9		89.1	0.7		
191	1/7/2008		-1.2		93.9	0.3		
192	1/8/2008							
193	1/9/2008		-1.6		88.0	0.2		
194	1/10/2008		-1.9		90.6	0.3		
195	1/13/2008		3.1		100.0	0.0		
196	1/14/2008		2.2		97.9	0.2		
197	1/15/2008		0.6		98.0	0.4		
198	1/16/2008		3.4		91.6	0.3		
199	1/17/2008		4.5		97.9	0.1		
200	1/20/2008		5.9		90.5	0.1		
201	1/21/2008		3.9		89.2	0.2		
202	1/22/2008		4.4		58.3	1.2		
203	1/23/2008		0.4		61.6	0.7		
204	1/24/2008							
205	1/28/2008		4.6		67.4	0.9		
206	1/30/2008		2.2		80.1	0.3		
207	1/31/2008		2.6		78.2	0.6		
208	2/3/2008		2.7		77.3	0.8		
209	2/4/2008		3.5		89.4	0.3		
210	2/5/2008							

Annex 6 **Ambient conditions from field test sites**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
211	2/6/2008	A-Graz	3.1		93.7	0.4		
212	2/7/2008		2.8		58.1	1.1		
213	2/10/2008		1.4		69.0	0.2		
214	2/11/2008		0.2		73.7	0.4		
215	2/12/2008		-0.7		72.5	0.3		
216	2/13/2008							
217	2/14/2008							
218	2/17/2008		-3.5		46.3	0.4		
219	2/18/2008		4.4		33.9	0.6		
220	2/19/2008		4.5		53.3	0.7		
221	2/20/2008							
222	2/21/2008							
223	2/24/2008		8.1		61.0	0.3		
224	2/25/2008							
225	2/26/2008		8.4		65.5	0.4		
226	2/27/2008		10.2		53.1	0.6		
227	2/28/2008		7.1		68.1	0.6		
228	3/2/2008		13.3		41.7	1.9		
229	3/3/2008		12.2		51.9	1.2		
230	3/4/2008		3.2		77.6	0.8		
231	3/5/2008		1.7		46.5	1.3		
232	3/6/2008		2.0		42.8	0.6		
234	1/7/2010	CZ-Tusimice	-7.0		85.0	0.0		
234	1/8/2010		-7.0		92.0	0.6		
235	1/9/2010		-6.0		93.0	0.6		
236	1/10/2010		-4.0		94.0	1.2		
237	1/11/2010		-7.0		92.0	0.0		
238	1/12/2010		-8.0		92.0	0.0		
239	1/13/2010		-7.0		94.0	0.0		
240	1/14/2010		-3.0		91.0	0.0		

Annex 6 **Ambient conditions from field test sites**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
241	1/15/2010	CZ-Tusimice	-3.0		92.0	0.0		
242	1/16/2010		-2.0		88.0	0.6		
243	1/17/2010		-3.0		93.0	0.0		
244	1/18/2010				94.0	0.0		
245	1/19/2010		-13.0		24.0			
246	1/20/2010		-8.0		53.0			
247	1/21/2010		-5.0		91.0	0.0		
248	1/22/2010		-8.0		88.0	0.0		
249	1/23/2010		-9.0		91.0	0.0		
250	1/24/2010		-8.0		87.0	0.0		
251	1/25/2010		-9.0		87.0	0.6		
252	1/26/2010		-10.0		85.0	0.6		
253	1/27/2010		-13.0		79.0	0.6		
254	1/28/2010		-2.0		85.0	2.5		
255	1/29/2010		-1.0		88.0	1.2		
256	1/30/2010		-2.0		82.0	1.2		
257	1/31/2010		-7.0		85.0	0.0		
258	2/1/2010		-8.0		84.0	0.0		
259	2/2/2010		-2.0		80.0	1.2		
260	2/3/2010		-1.0		82.0	1.2		
261	2/4/2010		-5.0		92.0	0.6		
262	2/5/2010		-2.0		89.0	0.0		
263	2/6/2010		-2.0		96.0	0.0		
264	2/7/2010		-7.0		89.0	0.6		
265	2/8/2010		-9.0		84.0	0.0		
266	2/9/2010		-8.0		85.0	0.0		
267	2/10/2010		-6.0		91.0	0.0		
268	2/11/2010		-6.0		90.0	1.2		
269	2/12/2010		-5.0		90.0	0.0		
270	2/13/2010		-5.0		86.0	0.0		

Annex 6 **Ambient conditions from field test sites** **Page 10 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
271	2/14/2010	CZ-Tusimice	-6.0		85.0	0.0		
272	2/15/2010		-5.0		82.0	0.0		
273	2/16/2010		-7.0		84.0	0.6		
274	2/17/2010		-7.0		91.0	0.0		
275	2/18/2010		-1.0		93.0	0.0		
276	2/19/2010		0.0		96.0	0.0		
277	2/20/2010		1.0		82.0	0.6		
278	2/21/2010		-1.0		84.0	0.6		
279	2/22/2010		-2.0		92.0	0.0		
280	2/23/2010		0.0		89.0	0.0		
281	2/24/2010		3.0		92.0	0.0		
282	2/25/2010		3.0		86.0	0.6		
283	2/26/2010		2.0		90.0	0.6		
284	2/27/2010		4.0		73.0	1.2		
285	2/28/2010		0.0		88.0	0.0		
286	3/1/2010		3.0		71.0	2.5		
287	3/2/2010		0.0		78.0	0.6		
288	3/3/2010		-1.0		75.0	1.2		
289	3/4/2010		-3.0		82.0	0.6		
290	3/5/2010		-5.0		74.0	1.9		
291	3/6/2010		-6.0		82.0	1.2		
292	4/20/2010		9.0		72.0	0.6		
293	4/21/2010		6.0		70.0	1.9		
294	4/22/2010		4.0		63.0	1.2		
295	4/23/2010		5.0		67.0	0.6		
296	4/24/2010		10.0		60.0	0.6		
297	4/25/2010		11.0		64.0	0.6		
298	4/26/2010		11.0		73.0	1.2		
299	4/27/2010		11.0		74.0	1.2		
300	4/28/2010		11.0		70.0	0.6		

Annex 6 **Ambient conditions from field test sites**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
301	4/29/2010	CZ-Tusimice	15.0		60.0	0.6		
302	4/30/2010		17.0		60.0	1.2		
303	5/1/2010		14.0		73.0	0.0		
304	5/2/2010		11.0		93.0	0.6		
305	5/3/2010		11.0		87.0	0.6		
306	5/4/2010		8.0		89.0	0.6		
307	5/5/2010		7.0		85.0	1.2		
308	5/6/2010		8.0		96.0	0.0		
309	5/7/2010		9.0		80.0	0.6		
310	5/8/2010		9.0		74.0	0.6		
311	5/9/2010		9.0		83.0	0.6		
312	5/10/2010		10.0		92.0	0.0		
313	5/11/2010		13.0		90.0	0.6		
314	5/12/2010		13.0		79.0	1.2		
315	5/13/2010		9.0		84.0	0.6		
316	5/14/2010		7.0		91.0	0.6		
317	5/15/2010		6.0		89.0	1.9		
318	5/16/2010		9.0		74.0	2.5		
319	5/17/2010		11.0		71.0	2.5		
320	5/18/2010		9.0		73.0	3.1		
321	5/19/2010		8.0		88.0	1.2		
322	5/20/2010		11.0		92.0	0.6		
323	5/21/2010		13.0		86.0	1.2		
324	5/22/2010		16.0		76.0	0.6		
325	5/23/2010		14.0		80.0	1.2		
326	5/24/2010		15.0		84.0	1.2		
327	5/25/2010		14.0		84.0	1.2		
328	5/26/2010		11.0		90.0	0.0		
329	5/27/2010		14.0		87.0	1.2		
330	5/28/2010		14.0		85.0	0.6		

Annex 6 **Ambient conditions from field test sites**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
331	5/29/2010	CZ-Tusimice	14.0		77.0	0.6		
332	5/30/2010		13.0		87.0	0.6		
333	5/31/2010		10.0		83.0	1.9		
334	6/1/2010		10.0		87.0	2.5		
335	6/2/2010		11.0		91.0	2.5		
336	6/3/2010		12.0		95.0	1.2		
337	6/4/2010		14.0		78.0	1.2		
338	6/5/2010		16.0		73.0	0.6		
339	6/6/2010		19.0		74.0	0.6		
340	4/10/2012	UK-Teddington	8.1		69.5	0.2		
341	4/11/2012		8.6		69.6	0.4		
342	4/12/2012		7.3		81.6	0.2		
343	4/13/2012		9.6		69.1	0.7		
344	4/14/2012		8.1		60.1	2.2		
345	4/15/2012		5.8		63.9	1.5		
346	4/16/2012		8.4		51.9	1.0		
347	4/17/2012		8.5		75.4	0.9		
348	4/18/2012		8.4		85.8	0.9		
349	4/19/2012		8.1		86.1	0.1		
350	4/20/2012		7.8		79.4	0.2		
351	4/21/2012		8.9		70.6	0.2		
352	4/22/2012		9.7		75.8	0.5		
353	4/23/2012		7.9		84.4	2.0		
354	4/24/2012		9.4		70.5	1.5		
355	4/25/2012		10.0		83.6	1.9		
356	4/26/2012		11.4		71.7	1.2		
357	4/27/2012		11.3		77.8	0.7		
358	4/28/2012		7.5		91.8	3.5		
359	4/29/2012		11.3		73.8	2.4		
360	4/30/2012		14.6		69.7	2.4		

Annex 6 **Ambient conditions from field test sites** **Page 13 of 13**

No.	Date	Test site	Amb. temperature (AVG) [°C]	Amb. pressure [hPa]	Rel. humidity [%]	Wind velocity [m/s]	Wind direction [°]	Precipitation [mm]
361	5/1/2012	UK-Teddington	14.0		76.2	0.6		
362	5/2/2012		10.8		80.9	1.2		
363	5/3/2012		8.5		86.7	0.6		
364	5/4/2012		8.4		77.4	1.7		
365	5/5/2012		7.8		66.5	1.8		
366	5/6/2012		7.2		72.9	0.7		
367	5/7/2012		11.9		82.2	0.8		
368	5/8/2012		13.9		78.5	0.4		
369	5/9/2012		14.9		91.0	0.8		
370	5/10/2012		14.8		82.0	0.7		
371	5/11/2012		11.5		56.0	1.2		
372	5/12/2012		10.8		58.0	0.8		
373	5/13/2012		12.1		58.7	0.4		
374	5/14/2012		8.7		83.0	0.3		
375	5/15/2012		7.5		76.4	1.0		
376	5/16/2012		11.1		62.7	0.4		
377	5/17/2012		12.6		58.1	1.5		
378	5/18/2012		13.6		79.0	0.6		
379	5/19/2012		13.1		69.8	1.6		
380	5/20/2012		12.2		76.2	1.9		
381	5/21/2012		14.5		75.5	1.5		

Annex 2:

Manual

BAM 1020
PARTICULATE MONITOR
OPERATION MANUAL

BAM-1020-9800 REV E

Met One Instruments, Inc
1600 NW Washington Blvd.
Grants Pass, Oregon 97526
Telephone 541-471-7111
Facsimile 541-541-7116

Regional Service
3206 Main St. Suite 106
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Copyright Notice

BAM 1020 Particulate Monitor Operation Manual

Technical Support

Should you require support, please consult your printed documentation to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours—7:30 a.m. to 4:00 p.m. Pacific Standard Time, Monday through Friday.

Voice: (541) 471-7111

Fax: (541) 471-7116

E-Mail: service@metone.com

Mail: Technical Services Department
Met One Instruments, Inc.
1600 Washington Boulevard
Grants Pass, OR 97526

CAUTION—For Your Safety

The Met One Instruments BAM-1020 contains a small ^{14}C (Carbon 14) beta radiation-emitting source. The activity of the source is 60 μCi +/-15μCi (micro curies) (2.2E6 Bq), which is below the "Exempt Concentration Limit", as defined in 10 CFR, Section 30.70 – Schedule A. This source is below the activity limits in most countries. For instance in Germany/Europe are the limits currently at 1.0E7 Bq. Please check your local requirements. The customer/owner of the Model BAM-1020 may elect to return the device to Met One Instruments for recycling of the ^{14}C source when the device has reached the end of its useable life, although the customer/owner is under no obligation to do so.

Neither the ^{14}C source, nor the detector, is serviceable in the field. Should these components require servicing and/or replacement, the BAM-1020 must be returned to the factory or one of our service stations for servicing and/or recalibration.

The Met One Instruments Model BAM 1020 “Equivalent Method”

DESIGNATED AS AN EQUIVALENT METHOD FOR PM_{10} BY THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY ON AUGUST 3, 1998, DESIGNATION NO.: EQPM-0798-122.

The EPA designation applies to the G, -1 and the G -1 PM_{10} Beta Attenuation Monitor, when used in conjunction with the BX-802 sampling inlet, operated for 24-hour average measurements, with a filter change frequency of one hour, with glass fiber filter tape, and with or without any of the following options: BX-823, tube extension; BX-825, heater kit; BX-826, 230 VAC heater kit; BX-828, roof tripod; BX-902 exterior enclosure; BX-903, exterior enclosure with temperature control; BX-961, mass flow controller; BX-967, internal calibration device. Users are advised that configurations that deviate from this specific description may not meet the applicable requirements of 40 CFR, parts 50 and 53. The system must be operated under the following conditions:

RANGE, Concentration range:	1.000-milligram/cubic meter
SAMPLE, Pump time:	50 minutes

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1 GENERAL INFORMATION

1.1 Introduction

The Met One Instruments BAM-1020 automatically measures and records dust concentration with built-in data logging. It uses the principle of beta ray attenuation to provide a simple determination of mass concentration. A small ^{14}C ($<$ 60 μCi) element emits a constant source of high-energy electrons, also known as beta particles. These beta particles are efficiently detected by an ultra-sensitive scintillation counter placed nearby. An external pump pulls a measured amount of air through a filter tape. Filter tape, impregnated with ambient dust is placed between the source and the detector thereby causing the attenuation of the measured beta-particle signal. The degree of attenuation of the beta-particle signal may be used to determine the mass concentration of particulate matter on the filter tape and hence the volumetric concentration of particulate matter in ambient air.

1.2 Description

The BAM-1020 consists of three basic components: the detector/logger, the pump and a sampling inlet. Each of these components is self-contained and may be easily disconnected for servicing or replacement. The BAM-1020 is certified by the United States Environmental Protection Agency (US-EPA) as an Equivalent Method (EQPM-0798-122), only when equipped with the PM_{10} sampling inlet and only when operated under specific conditions, delineated on the fourth page of this manual. However, the unit may be outfitted with $PM_{2.5}$ or total suspended particulate (TSP) sampling heads for monitoring of those components.

1.3 Specifications

Performance specifications of the BAM-1020 are given in Appendix A.

1.4 Organization and Scope

This manual has been written to address the normal issues that the user is likely to encounter. It covers all routine aspects of setting up, operation, and routine maintenance. It also covers basic trouble-shooting. This manual is not meant as a reference for major instrument servicing or repair. Major instrument repairs should only be performed by a factory-certified technician.

2 UNPACKING AND INSTALLATION

2.1 Unpacking and Installation

NOTE: If any damage to the shipment is noticed BEFORE unpacking, a claim MUST be filed with the commercial carrier immediately. If any damage occurred during shipment, notify Met One Instruments after notification of the commercial carrier.

Remove the unit from the shipping container and then carefully remove the two white plastic rings from the inside of the door of the BAM-1020. Do not remove the rings until the BAM-1020 is ready to be installed. These rings must be replaced anytime the unit is being moved in order to avoid damaging the tape transport mechanism.

NOTE: Keep the package and the packing material in case the unit is returned to the factory.

2.2 Packing

Prior to returning equipment to Met One Instruments, contact the Service Department for a Return Authorization Number.

NOTE: The BAM-1020 must be returned with the two plastic rings in place around the transport rollers. If the rings have been misplaced contact the factory for replacements.

Met One Instruments is not responsible for damage to BAM-1020 if the rings are not properly installed.

2.3 Siting

The BAM-1020 is designed to mount in a temperature-controlled enclosure, such as a mobile shelter or building. The standard inlet is designed to mount through the roof of the building. The BAM-1020 must be located in an area whose operating temperature is between 0^{o} C and $+40^{o}$ C and where the relative humidity is not condensing and does not exceed 90%. The BAM-1020 must be located in a level, vibration and dust free environment. Met One Instruments offers the following environmentally controlled enclosures for the BAM1020: BX-902 heating only, and the BX-903 Heating and Cooling. See section 10.3 for a complete list of the BAM1020 options. Consider the following criteria when siting the BAM 1020.

1) Inlet radius clearance: The BAM-1020 inlet must have a one (1) meter radius free of any objects that may influence airflow characteristics, including the airflow radius of another instrument. For example, if a BAM-1020 is to be installed at a station with another BAM-1020 or a PM2.5 FRM filter sampler, the inlets of each sampler must be no less than 2 meters apart from each other. If installing near a PM10 SSI HiVol sampler, then the distance between the inlets of the BAM-1020 and the HiVol must be no less than three (3) meters. These distances are Federal EPA requirements (40 CFR Part 58).

2) Inlet height: The height of the inlet should be equal to the height of the federal reference

method filter samplers such as the PM10 head on the PM2.5 FRM or the large round PM10 impactor on the SSI HiVol. If the BAM 1020 is not collocated then the height of the inlet should equal 2 meters from the roof.

3) Distance between BAM-1020 and station ceiling: A minimum distance of at least eight (8) inches is required between the top of the BAM-1020 and ceiling. This distance is necessary to safely accommodate the inlet heater kit.

4) Heater Kit: Two versions of the Heater are available. 1. The inlet heater kit includes a heat strip that wraps around the lower end of the inlet tube (inside the station). When installed, the heater tape will cover approximately four (4) inches in length of the inlet tube. The installed heater tape should be a minimum of two (2) inches away from any object at either end of the heater tape, such as the instrument rack or ceiling. 2. Aluminum can style that incorporates a filter RH and Filter temperature sensor to control the heater based on these measurements. The Aluminum can heater is 4" long and connects to the back of the BAM-1020. These measurements suggest that the minimum distance between the BAM-1020 central unit and the ceiling should be NO less than eight (8) inches.

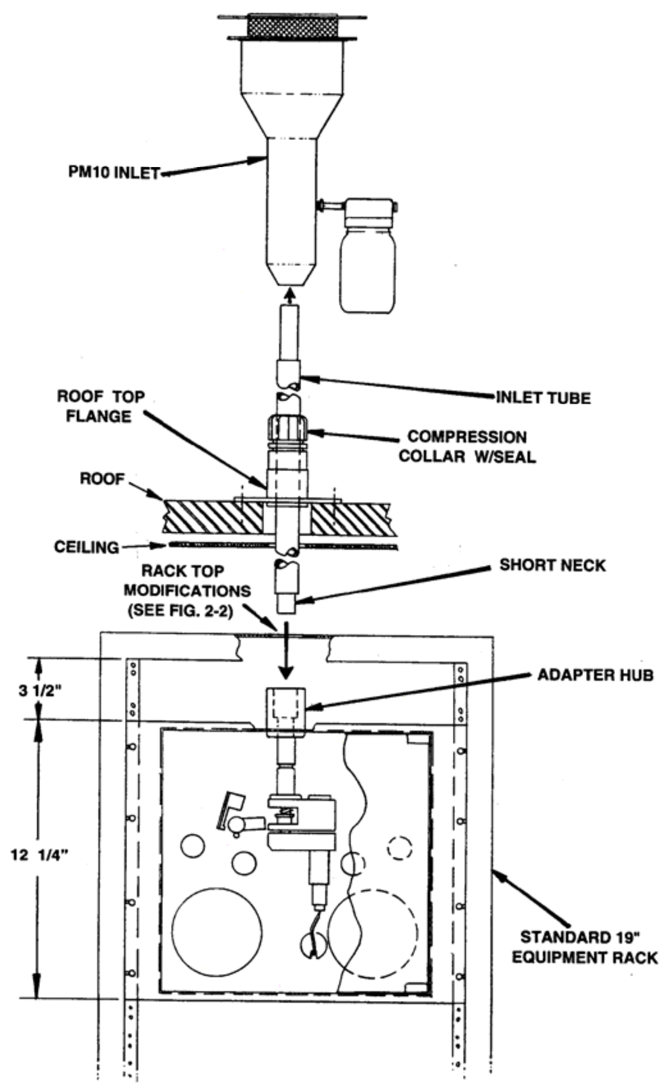
5) Inlet: The straight, vertical inlet tubing of the BAM-1020 limits the placement of the BAM-1020 central unit. The BAM-1020 inlet tubing is a 1 5/16" OD, 8' long rigid aluminum tube. The lower end of the inlet tube inserts directly into the top of the BAM-1020 housing, the other end points horizontally upward through all roofing material and above the roofline. The selected particle size inlet(s) are mounted on the upper end of the inlet tube. The BAM-1020 FRM PM10 head should be installed so that its height is equal the same inlet height of the PM2.5 FRM or HiVol SSI filter sampler heads (approximately six (6) feet above the roof line). Provisions must be made during installation to allow future removal, maintenance and re-installation of all equipment.

Specifications: Specifications for siting a BAM-1020 will mirror the Federal EPA PM2.5 criteria listed in the Code of Federal Regulations (40 CFR, Part 58).

2.4 Bench Top Mounting

Locate the BAM-1020 on a bench surface that will allow the installation of the inlet sample head directly above the unit. The BAM-1020 is furnished with rubber feet for bench top usage. The bench should be level and with rear access for connections, adjustments and maintenance. The distance between the sample inlet on the top of the BAM-1020 detector/controller unit and the sampling head should not exceed sixteen (16) feet. If a length longer than 16 feet is required, please contact Met One Instruments Service Department. Refer to Figure 1 for detail on mounting the BAM-1020.

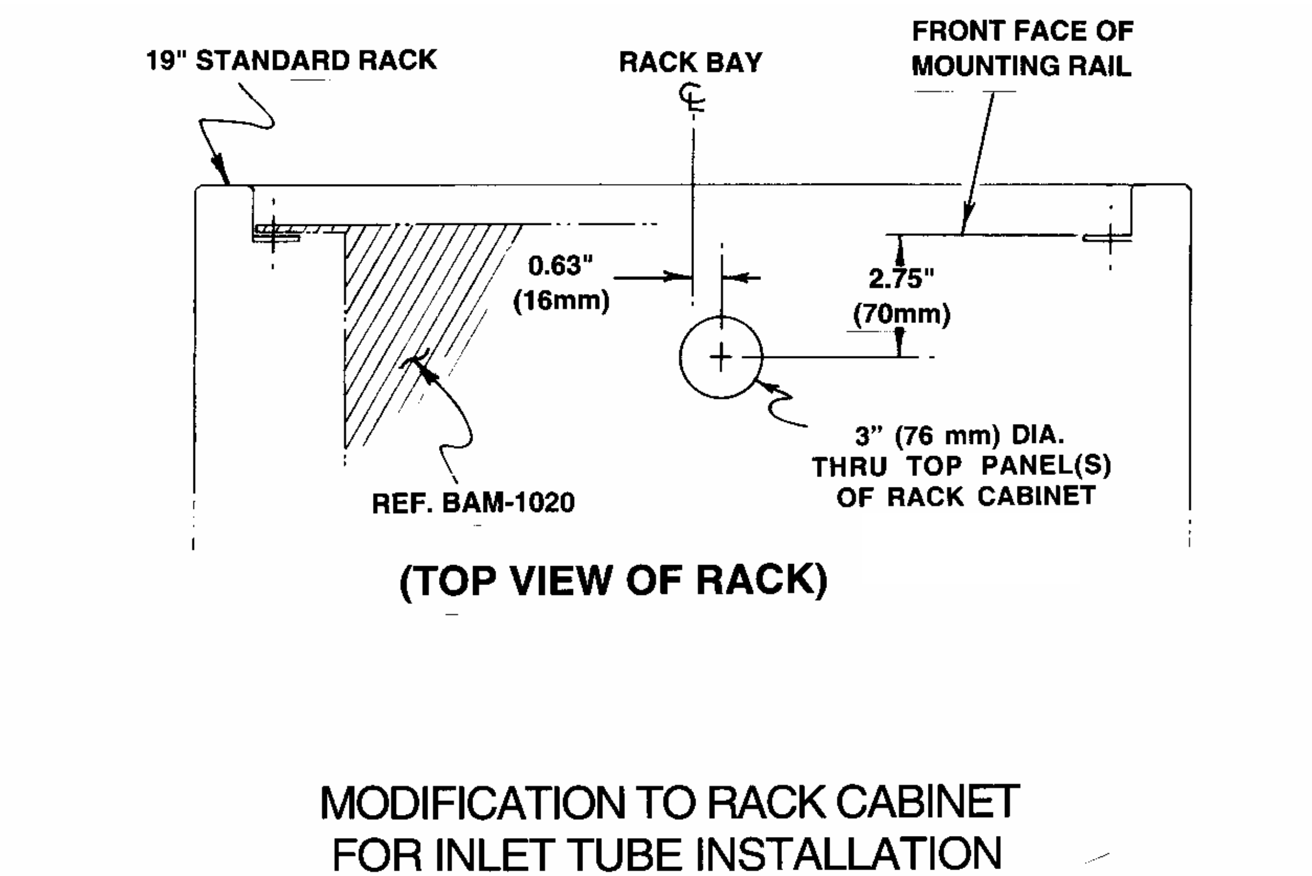
Figure 1: BAM-1020 Mounting Detail



2.5 Rack Mounting

Mount the BAM-1020 to rack using the supplied mounting hardware. Rack mounting hardware is supplied as standard equipment with every BAM-1020. If the BAM-1020 is used in a mobile van then the side rails should be supported. When in transit the transport should be retained from lateral motion. Refer to Figure 2 for modifications to rack mounting.

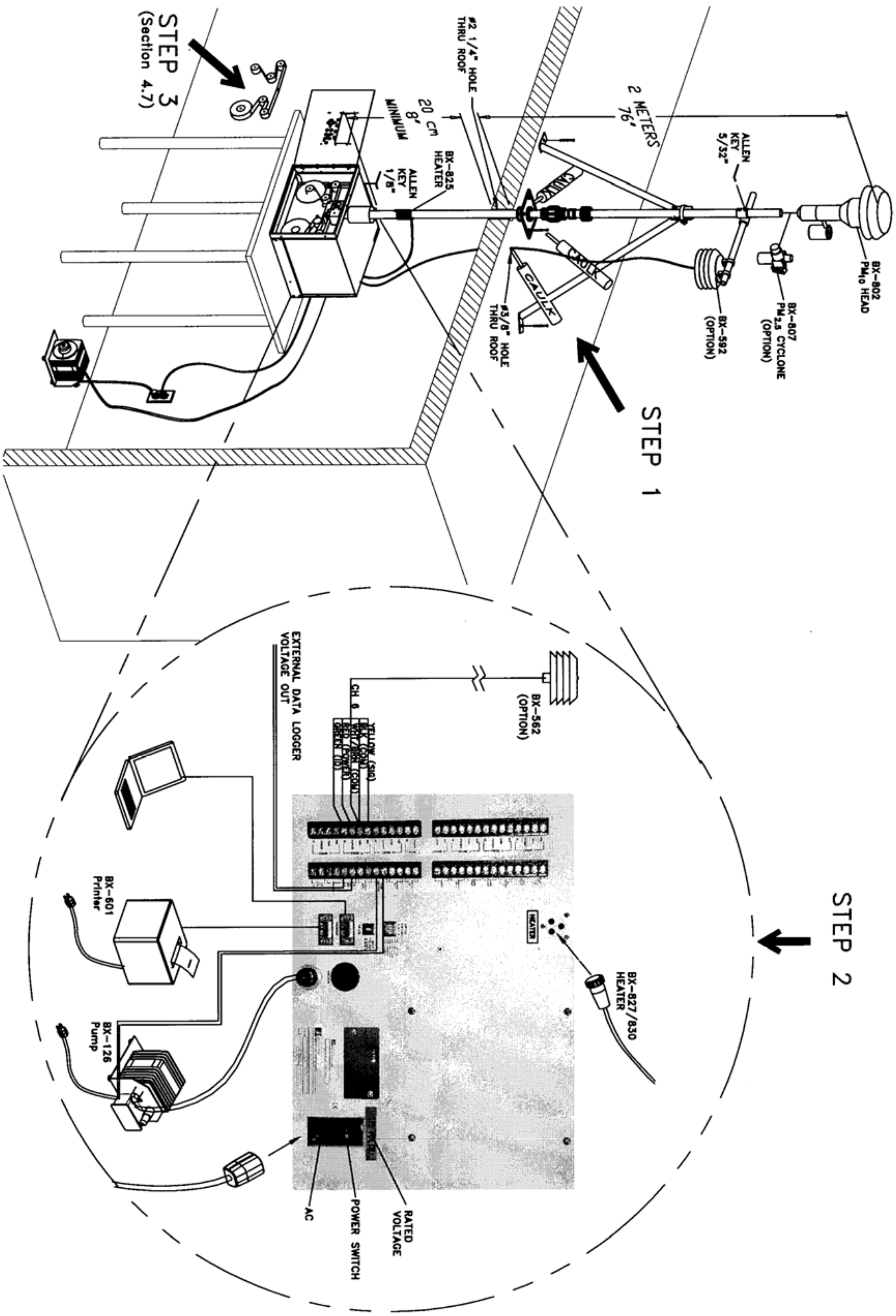
Figure 2: BAM-1020 Rack Mount Detail



2.6 Installation Instructions

Installation of the BAM1020 should be executed by personnel familiar with environmental monitoring equipment. There are no special precautions or handling concerns only the normal care required for scientific equipment.

Figure 3 BAM1020 Installation Instructions



The following procedure is a step-by-step process for Figure 3.

1. INLET
    a. Determine the location of the BAM inlet tube on the roof of the enclosure.
    b. Drill a 2 ¼" (57mm) diameter hole at that location through the roof.
    c. Drill a 3/8" (10 mm) diameter hole 6" (150 mm) from the 2 ¼" hole. This is for the ambient temperature probe. (Option: for the BX-592 cable)
    d. Caulk around the 2 ¼" hole and place the roof flange over the hole.
    e. Secure in place with 4 self-taping screws. Caulk around the screws to prevent leaks.
    f. Thread the gray roof fitting into the roof flange.
    g. Push the Temperature sensor wires through the 3/8" (10 mm) diameter hole. Caulk to prevent leaks. (Option: BX-592)
    h. Remove the white cap and rubber fitting.
    i. Place the Inlet tube through the Roof assembly and into the top of the BAM.
    j. Press the Inlet Tube firmly into the BAM until it stops. It is very important for the inlet tube to be perpendicular to the top of the BAM. The nozzle will not close properly if there is a bind caused by misalignment. A simple check is to check that the inlet tube rotates freely when installed.
    k. Slide the rubber fitting and white cap over the inlet tube. The rubber fitting will slide easier if the inlet tube is lightly dampened with water.
    l. Tighten the white cap onto the gray roof fitting.
    m. Slide the temperature support over the Inlet tube about 6" (150 mm) and tighten the setscrews. (Option: BX-592)
    n. Clamp the 592 temperature assembly to the support. (Option: BX-592)
    o. Place the inlet struts at 90 degrees to one another and secure to the inlet with hose clamp.
    p. Secure the opposite end of the inlet struts with a self-tapping screw into the roof. Caulk around the screw to prevent leaks.
    q. Slide the PM2.5 cyclone over the Inlet tube. (Option: BX-807)
    r. Slide the PM10 Head over the Inlet Tube.

2. ELECTRICAL
    a. Heater Installation: Two Heaters exist see description for installation.
        i. Aluminum Can heater – Slide the inlet tube into the Aluminum heater with the wires facing down. Bottom of heater should be 2" (50 mm) above the top of the BAM. Tighten Set Screws. (Option: BX-827, BX-830)
        ii. Included with the BX-827/830 is a 12" (300mm) tube of insulation. The tube is split down its length to enable easy application. Wrap the insulation around the Aluminum Heater and the inlet tube and peel back the adhesive cover strip to secure in place. If space requires the insulation may be cut to fit.
        iii. Heater Tape - Wrap the Heater around the Inlet Tube 2" (50 mm) above the top of the BAM. Secure with included aluminum tape. (Option: BX-825, BX-826)
    b. There are 3 options for heater AC power.
        i. Standard plug – directly into 120VAC/220VAC.
        ii. Green metal connector it plugs directly to the back of the BAM.
        iii. Smart heater box (8891) plug the box into the 120VAC/220VAC and plug the heater into the box.
    c. Connect the Pump electrical cable to the BAM. Connect the opposite end to the Pump. Polarity is not important
    d. Connect vacuum tube to the pump and BAM.

e. Plug the Pump into AC power.
f. Connect Ground wire to BAM. (See section 4.3)
g. Connect the temperature sensor to CH6 of the BAM. (Option: BX-592)
h. Connect External data logger to voltage out (Option: Customer Logger)

3. OPERATE
   a. Load filter tape Sec 4.7.
   b. Close BAM door. Press TAPE hot key on the front panel keypad.
   c. Press SELF TEST hot key on keypad.
   d. When everything is OK press exit.
   e. The LCD should now say OPERATE ON.
   f. Unit is now operating.
   g. Section 4 and 5 give details on BAM1020 Operational Setup.

3 PRINCIPLE OF OPERATION

This section is divided into three parts. The first part gives the basic theory of operation of the BAM-1020. The second part incorporates more practical aspects of translating the basic theory of operation into an actual measurement. Finally, the third part discusses how the BAM-1020 software works in conjunction with the instrument operating principle.

3.1 Basic Theory of Operation

When the high-energy electrons emanating from the radioactive decay of ^{14}C (carbon-14) interact with nearby matter, they loose their energy and, in some cases, are absorbed by the matter. These high-energy electrons emitted through radioactive decay are known as beta rays and the process is known as beta-ray attenuation. When matter is placed between the radioactive ^{14}C source and a device designed to detect beta rays, the beta rays are absorbed and/or their energy diminished. This results in a reduction in the number of beta particles detected. The magnitude of the reduction in detected beta particles is a function of the mass of the absorbing matter between the ^{14}C beta source and the detector.

The number of beta particles passing through absorbing matter, such as dust deposited on a filter tape, decrease nearly exponentially with the mass through which they much pass. Equation 1 shows this relationship.

Equation 1

$$I = I_0 e^{-\mu x}$$

In Equation 1, I is the measured beta ray intensity (counts per unit time), of the attenuated beta ray (dust laden filter tape), I_0 is the measured beta ray intensity of the un-attenuated beta ray (clean filter tape), μ is the absorption cross section of the material absorbing the beta rays (cm^2/g), and x is the mass density of the absorbing matter (g/cm^2).

Equation 1 very closely resembles the Lambert-Beers Law, which is used in spectrometric analysis. Just as the Lambert-Beers Law is an idealization of what is actually observed, Equation 1 is also an idealized simplification of the true processes occurring meant to simplify the corresponding mathematics. However, experimental measurement shows that in properly designed monitors, such as the BAM-1020, the use of this equation introduces no substantial error.

Equation 1 may be rearranged to solve for x, the mass density of the absorbing matter. This is shown in Equation 2.

Equation 2

$$-\frac{1}{\mu}\ln\left[\frac{I}{I_0}\right] = \frac{1}{\mu}\ln\left[\frac{I_0}{I}\right] = x$$

In practice, the absorption cross section is experimentally determined during the calibration process. Once I and I_0 are experimentally measured, it is a simple matter to calculate x, the predicted mass density.

In practice, ambient air is sampled at a constant flow rate (Q) for a specified time Δt. This sampled air is passed through a filter of surface area A. Once x, the mass density of collected particles, has been determined, it is possible to calculate the ambient concentration of particulate matter ($\mu g/m^3$) with Equation 3.

Equation 3

$$c\left(\frac{\mu g}{m^3}\right) = \frac{10^6 A(cm^2)}{Q\left(\frac{liter}{min}\right)\Delta t(min)\mu\left(\frac{cm^2}{g}\right)} \bullet x$$

In Equation 3, c is the ambient particulate concentration ($\mu g/m^3$), A is the cross sectional area on the tape over which dust is being deposited (cm^2), Q is the rate at which particulate matter is being collected on the filter tape (liters/minute), and Δt is the sampling time (minutes). Combining these equations yields to the final expression for the ambient particulate concentration in terms of measured quantities. This is shown in Equation 4.

Equation 4

$$c\left(\frac{\mu g}{m^3}\right) = \frac{10^6 A(cm^2)}{Q\left(\frac{liter}{min}\right)\Delta t(min)\mu\left(\frac{cm^2}{g}\right)} \bullet \ln\left(\frac{I_0}{I}\right)$$

The key to the success of the beta attenuation monitor is due in part to the fact that μ, the absorption cross-section is almost insensitive to the nature of the matter being measured. This makes the BAM-1020 very insensitive to the chemical composition of the material being collected.

It is instructive to perform a conventional propagation of errors analysis on Equation 4. Doing so, one can develop an equation for the relative measurement error (σ_c/c) as a function of the uncertainty in each of the parameters comprising Equation 4. This leads to Equation 5.

Equation 5

$$\frac{\sigma_c}{c} = \sqrt{\frac{\sigma_A^2}{A^2} + \frac{\sigma_Q^2}{Q^2} + \frac{\sigma_t^2}{t^2} + \frac{\sigma_\mu^2}{\mu^2} + \frac{\sigma_I^2}{I^2 \ln\left[I/I_0\right]^2} - \frac{\sigma_{I_0}^2}{I_0^2 \ln\left[I/I_0\right]^2}}$$

Inspection of Equation 5 reveals several things. The relative uncertainty of the measurement (σ_c/c) is decreased (improved) by increasing the cross sectional area of the filter tape (A), the flow rate (Q), the sampling time (t), the absorption cross-section (μ), I and I_0.

In practice, the uncertainty associated with the filter area (σ_A/A), may be minimized by ensuring that the tape is in exactly the same position during the I_0 measurement as in the I measurement phase. Proper design of the shuttle mechanism inside of the BAM-1020 will lead to minimal error here.

The uncertainty in the flow rate (σ_Q/Q) may be minimized by properly controlling the flow of the instrument. For the standard BAM-1020, this value is on the order of $\pm$ 3%. For the BAM-1020 equipped with the optional mass flow controller device, (σ_Q/Q) decreases to $\pm$ 1%.

The relative error due to the uncertainly in the absorption cross section (σ_μ/μ), is due to its slight variation as a function of the chemical composition of the matter being monitored. Generally, this relative error is on the order of $\pm$ 2-3%, with judicious selection of the calibrated value of μ.

The uncertainty associated with the measurement of I and I_0 has to do with the physical nature of the process leading to the emission of beta particles from the decay of ^{14}C. This process follows Poisson statistics. Poisson statistics show the uncertainty in the measurement of I (σ_I/I) and I_0 (σ_{I0}/I_0) are minimized by increasing the sampling time. Mathematical analysis shows that doubling the sampling time and hence the measured intensity of I or I_0 will reduce the uncertainty of the measurement by a factor of 1.41 (square root of 2).

3.2 Practical Considerations

The BAM-1020 uses a sampling algorithm that optimizes the total time required to complete a cycle. The basic cycle always includes an automatic calibration that is performed during the sampling period, but at a different point on the filter tape, as the data is being sampled.

1. The initial count of clean filter tape (I_0) is performed at the beginning of the cycle for a period of four minutes.

2. The filter tape is advanced 4 windows, and the sampling (vacuum pumping) begins on the spot in which I_0 was just measured. Air is drawn through this spot on the filter tape for 50 minutes.

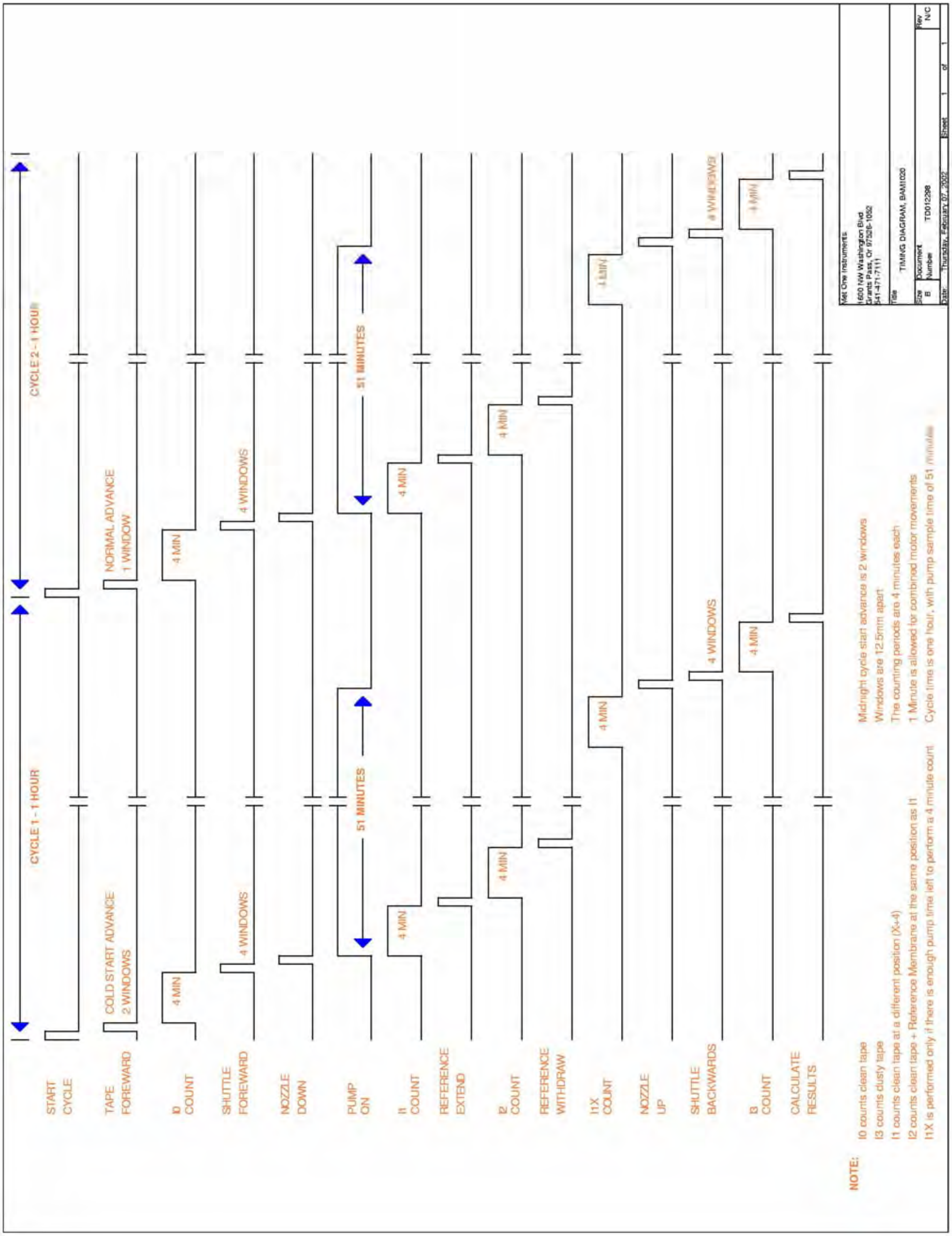
3. At the same time the second count (I_1) occurs (at a point on the tape 4 windows back) for a period of four minutes. The purpose for this measurement is to perform verification for instrument drift caused by varying external parameters such as temperature and relative humidity. A third count (I_2) occurs with the reference membrane extended over the same place on the tape. The sample time should be chosen greater than or equal to 5 minutes, so as to allow for the overlapping Auto calibration time. The purpose of this measurement is to verify that the instrument is operational.

4. The tape is moved back 4 windows to measure the beta ray absorption through the section that has collected dust (I_3). Finally the concentration calculation is performed to complete the cycle.

5. A new measurement cycle then begins.

Figure 4 shows a timing diagram of the measurement sequence for the BAM-1020.

Figure 4: Timing Diagram of Measurement Sequence



3.2.1 Synchronous Cycle Method

Synchronous timing cycles begin at the next hour mark (T = :00:00). The sample period must be less than the cycle time by ***at least*** the time required for counts and motor movement (approximately 9 minutes). Software automatically checks that the sample period is correct.

3.2.2 Normal Operation Mode

Every cycle of the normal operation mode consists of three main parts, automatic calibration, sampling, and counting and calculation. Logging of the data collected occurs after each calculation.

3.2.3 Automatic Calibration

The beta attenuation of plain filter tape is compared with that of the same piece of filter tape as seen through a "reference membrane" of standard material. The mass density **m** (mg/cm^2) of the reference membrane is calculated during this automatic calibration process. Statistical reporting on the value of **m** provides a method of internal diagnostics and for the compensation of external variables, such as temperature swings or pressure changes. During factory burn-in and calibration the average value of **m** is determined over at least 24 hours and saved as “ABS” for subsequent comparison with current values. The percentage of the latest value of **m** from ABS should be within the limits of known variability (+/-4%). The ABS value for the BAM-1020 can be found in Appendix B.

3.2.4 Sampling

During the "sampling period" incoming dust-laden air may be pumped through an optional external PM_{10} (or $PM_{2.5}$) inlet head to remove particles greater than 10 (or 2.5) µm in diameter. The air then goes through the filter tape, where particles less than or equal to 10 (2.5) µm in diameter are deposited. (Anything smaller than about 0.2 µm goes through to the exhaust.) First the filter tape is advanced 4 "windows" (50mm approximately) from the counting station to the sampling nozzle. Next the nozzle is lowered to the tape surface and the vacuum pump is turned on. At the end of the sampling period the pump is turned off, the nozzle is raised, and the tape is moved backward the same distance (4 windows) to the counting station.

3.2.5 Counting and Calculation

The final part of the normal operation mode is the counting of the beta particles through the dusty section of tape, and then the calculation and logging of the dust concentration. The tape is then advanced one more window (12.5mm approximately) to begin the next cycle. At the measurement cycle beginning at (or just after) midnight the tape is advanced an extra window to separate daily entries.

3.2.6 Logging

Data that is computed every sample period is logged in the local memory for the current day. Normal measurement mode starts immediately after the Operation Mode of the BAM-1020 is set ON by the operator, cycling indefinitely until the mode is set OFF.

3.3 Software Description – Setup Mode

The BAM-1020 saves various setup parameters needed to perform the desired calculations. These include date, time, ABS, BKGD, K, μ_{SW}, Cv, Q_0, and the sample period t_S. Once stored these numbers do not need to be reloaded, even if power is cycled.

ABS, BKGD, K, μ_{SW}, Cv and Q_0 are constants established at the factory by extensive burn-in test and calibration. They should not be altered without proper consideration being given to the consequential results. If these values are changed in error refer to Appendix B for the factory values. Note: match the serial number from the BAM1020 with the serial number in Appendix B.

The cycle method is always synchronous. The sample period t_S can be any duration from 1 to 200 minutes.

3.4 Calculations

The BAM-1020 uses the constants and input variables below to calculate the output data. The output data is used to calculate daily statistics. Factory set parameters for the BAM-1020 are given in Table 1.

Table 1: Factory Set Constants

Parameter	Factory Default Value
μ_{sw} – absorption coefficient	0.285 cm^2/mg
K – regression factor	0.9 to 1.1
ABS – Average reference membrane mass density	0.800 to 0.900 mg/cm^2
BKGD – Background concentration	-0.005 to –0.018 mg/m^3
S – Nozzle Orifice Area (cm^2)	1.0386891 cm^2
C_V – Pressure-flow Proportionality	1.000 mg/ m^3
Q_0 – Flow offset	0.000 lpm

The BAM-1020 measures for beta ray attenuation at several times during the sampling cycle. These are given in Table 2.

Table 2: Measured Beta Ray Intensities

Parameter	Description
I_0	Clean Filter Tape – Position X
I_1	Clean Filter Tape – Position X+4
I_2	Reference Membrane + Clean Filter Tape – Position X+4
$I_{1'}$	Clean Filter Tape Position X+4
I_3	Dust Laden Filter Tape Position X

The output data listed in Table 3 is output from the BAM-1020 every hour.

Table 3: BAM-1020 Outputs

Symbol	Meaning
M	Calibration reference membrane mass density – mg/cm^2
C	Concentration – mg/m^3
Q	Flow Rate – EPA Standard – liters/minute
Q_t	Total Flow – Average flow rate times sampling period

4 GETTING STARTED

4.1 General

The BAM-1020 is designed to operate on a minimum cycle of one hour and to yield an hourly average of the ambient dust concentration. Sequential hourly averages may be combined to yield longer averages. For example, twenty-four hourly averages may be combined to yield a daily average, which is the current PM_{10} requirement issued by the US-EPA.

Figure 5 shows the front panel of the BAM-1020.

Figure 5: Front Panel

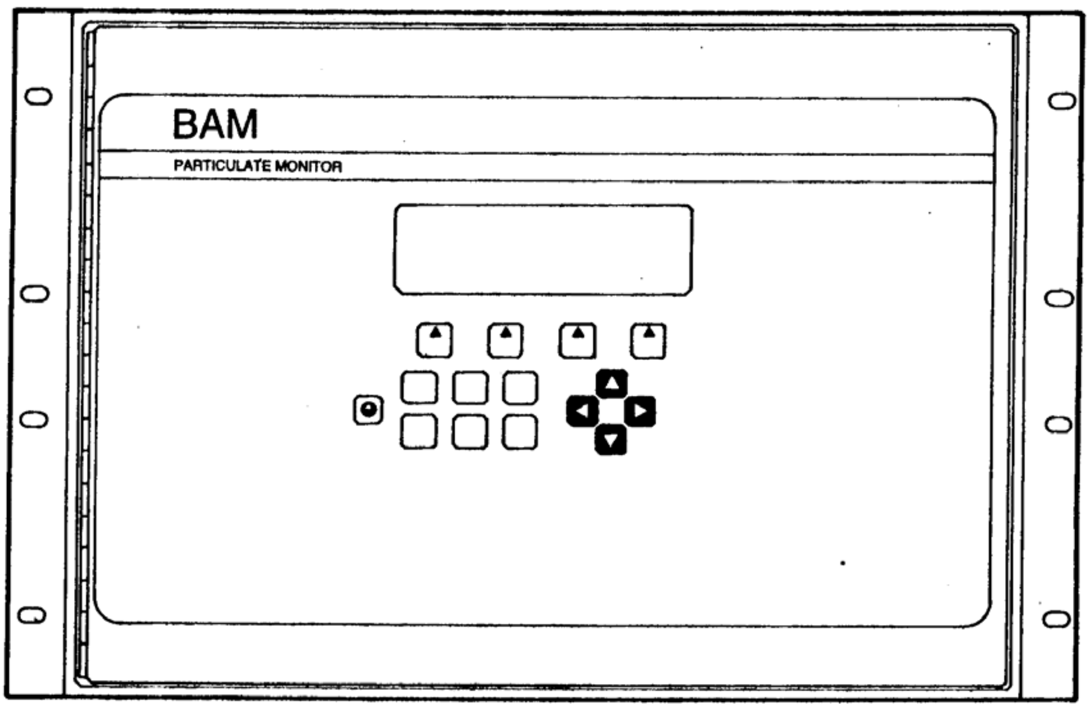
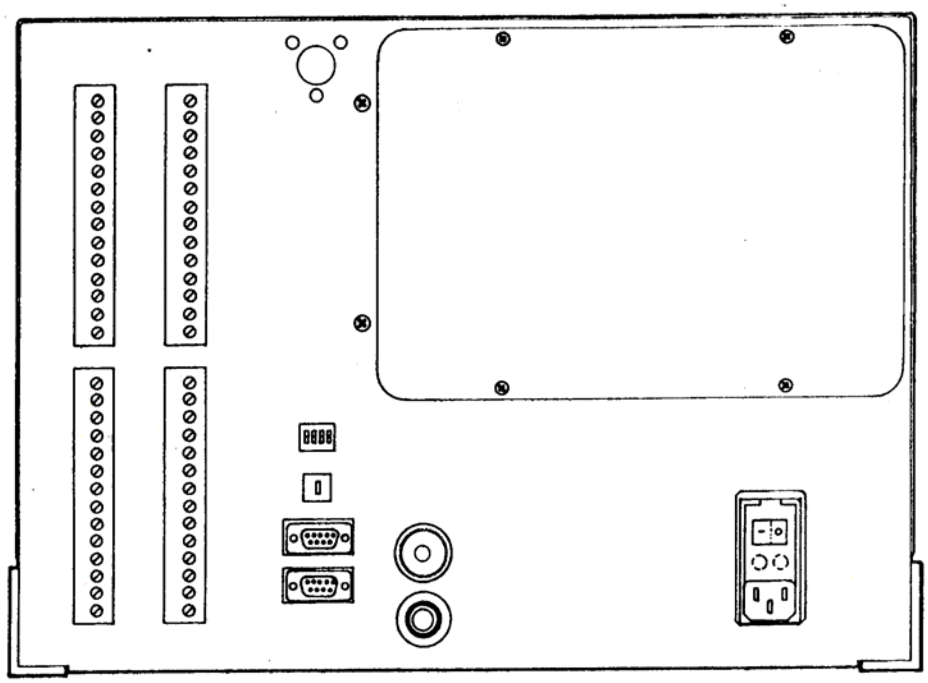


Figure 6 shows the rear panel of the BAM-1020.

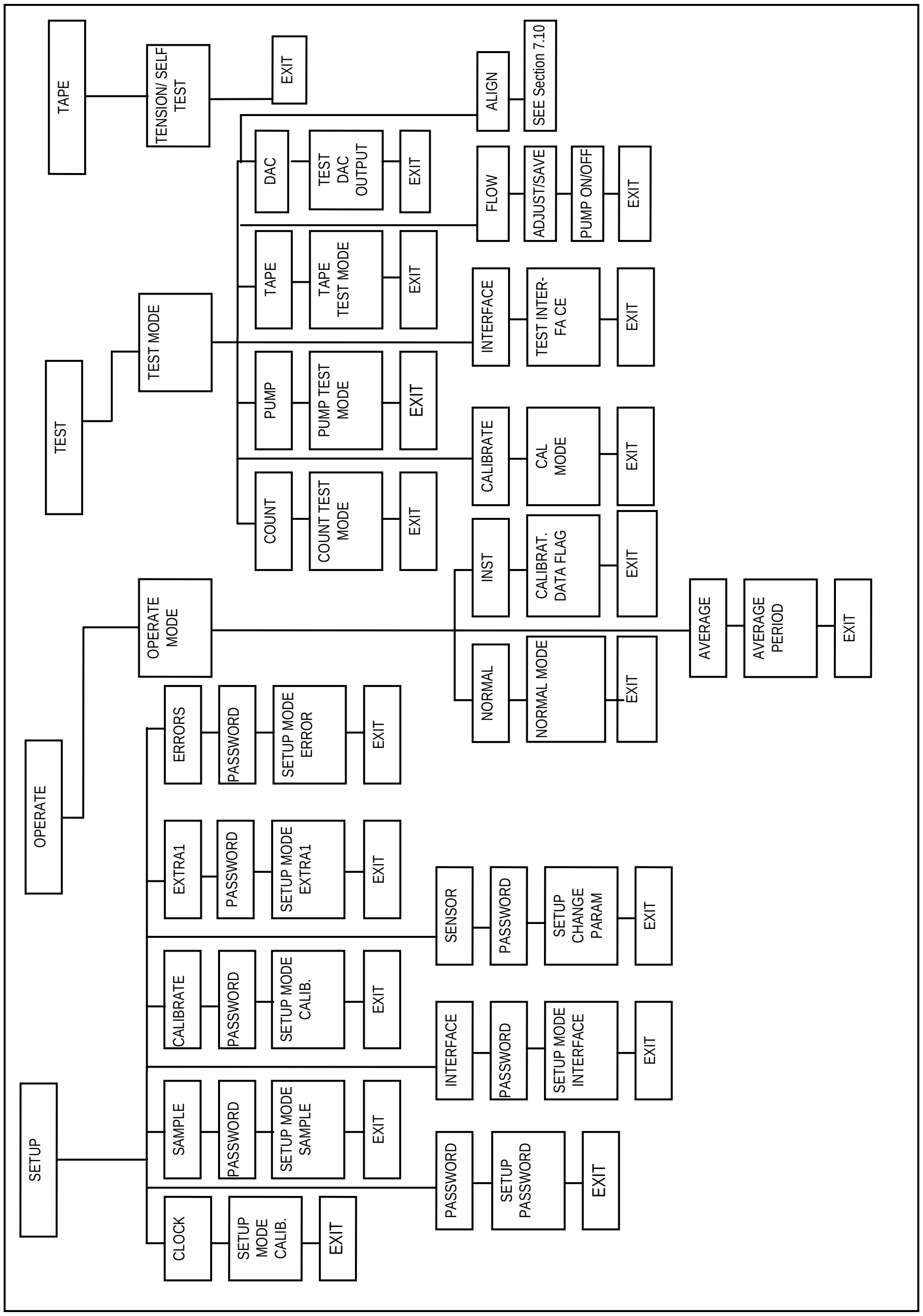
Figure 6: Rear Panel



4.2 Menu Hierarchy

Figure 7 shows the menu hierarchy for the BAM-1020.

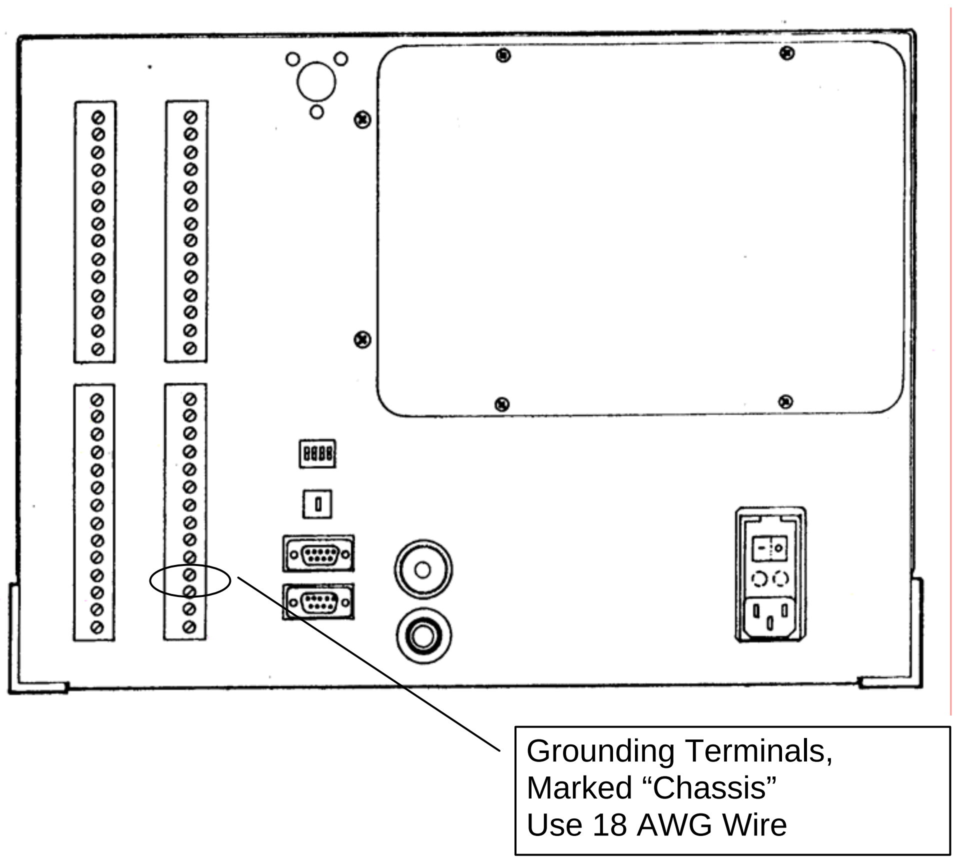
Figure 7: Menu Hierarchy



4.3 Instrument Grounding

Proper grounding will help eliminate background noise, and is required for safe and proper installation. Two grounding terminals are available on the rear panel of the BAM 1020 for connection to ground. Both terminals are tied to chassis ground, and electronic grounds on the instrument. Eighteen (18 AWG) gauge wire should be used to tie either of these terminals, marked “Chassis”, to the nearest ground point. Grounding location should be as close as possible to the instrument, and still meet local electrical codes. Proper clamping to grounding rods, or metal underground water pipes are possible examples. Please review local electrical codes, and use licensed contractors for electrical wiring and grounding.

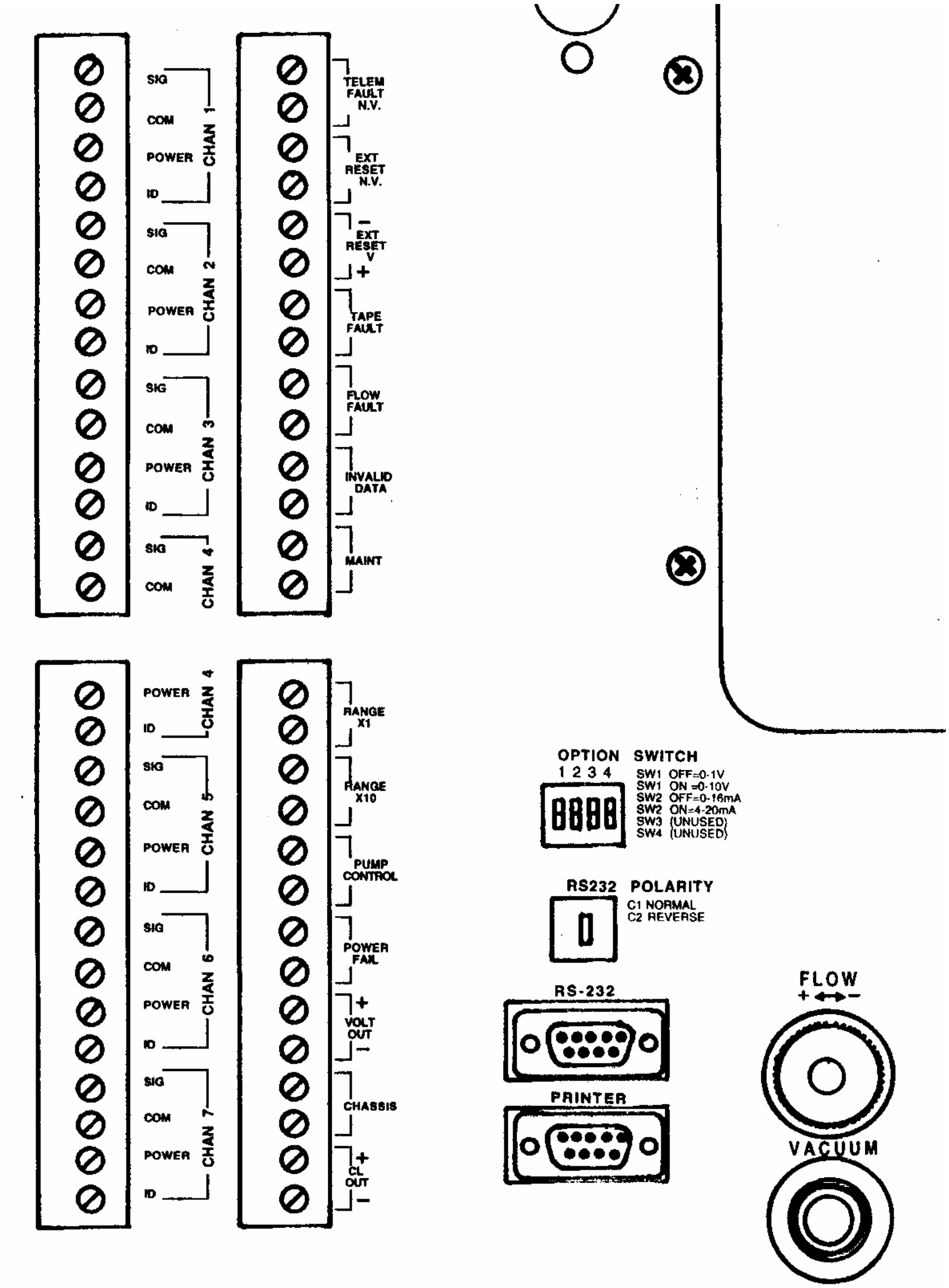
Figure 8: BAM-1020 Grounding Terminals



4.4 Connections to The BAM-1020

Refer to Figure 9 connections and in section 8 for details of control lines.

Figure 9: BAM-1020 External Connections



4.5 Power On and Warm Up

The BAM-1020 power up switch is located on the rear panel of the instrument as is shown in Figure 6. Do not power up the BAM-1020 until it is confirmed that the instrument has been properly sited and that all electrical and pneumatic connections have been correctly made. Please follow the procedures in Section 2 for further details.

After powering up the BAM-1020, the User Screen shown in Figure 10 will appear. ***The unit must be allowed to warm up for a period of at least one hour before any measurements are taken.***

Figure 10: User Screen

```
11/15/2001                          15:11:07

               > BAM – 1020 <
        BETA ATTENUATION MONITOR
                  Ver: 2.02
    Status:       ON

  SETUP    OPERATE      TEST      TAPE
```

4.6 Power

Before connecting power to the BAM-1020 verify that the voltage and frequency settings match the BAM-1020 requirements. If they do not match, contact the Met One Instruments Service Department. The power switch is located on the rear panel as is shown in Figure 6. After connecting the AC power cord to the proper source of power, turn on the unit. The front panel display will illuminate. The voltage and frequency settings to which the BAM-1020 was configured are shown on the back panel. Country specific wall plugs are supplied with every BAM-1020.

4.7 Filter Tape Loading Procedure

The filter tape is the only consumable item for the BAM-1020. One roll should last more than two months under normal operation. The filter tape must be loaded before the unit is operational. A good time to load the filter tape is during the warm up period. It is necessary to have power supplied to the BAM-1020 in order to load the filter paper.

To load the paper, go to the Tape menu. The Tape menu is shown in Figure 11.

Figure 11: Filter Tape Loading Menu

```
 11/15/2001                      15:29:30




Status:
TENSION   SELF TEST                  EXIT
```

Use the following procedure to load the filter tape.

A. From the Main menu, press <TAPE> and then <TENSION> to verify that nozzle is in the “UP” position.

B. Remove both of the clear plastic spool covers by unscrewing the captive knobs.

C. An empty core tube must be installed on the hub of the take-up spool, or filter tape edge damage will occur.

D. Lift the end of roller shaft to unload pinch rollers from capstan shaft. Latch in “UP” position.

NOTE: Special care should be taken when handling unused filter tape. Clean lint-free gloves should be worn to avoid contamination of sample material. Gentle handling during filter tape loading will reduce filter tape breakage.

E. Place full roll of filter tape on supply (right) spool, with tape feeding upward and counter-clockwise.

F. Pass filter tape clockwise over supply tension roller, then counter-clockwise over right end roller.

G. Thread filter tape through sampling/measuring area.

H. Feed filter tape counter-clockwise over left end roller.

I. Wrap it clockwise around take-up tension roller.

J. Feed end of filter tape so that it enters the take-up spool in a counter-clockwise direction. Using any available adhesive tape, attach the leading end of the filter tape to the core tube.

K. By hand, gently tension tape to initial point of slack removal.

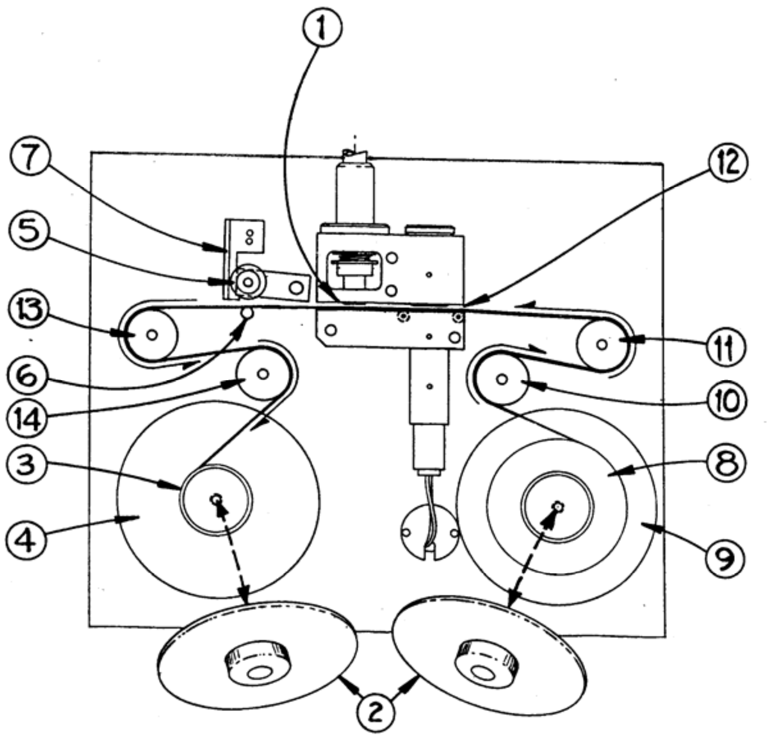
L. Install both spool covers. The clamping force of the covers prevents tape slippage on spool hubs.

M. Gently lower capstan pinch-rollers by releasing latch to left while supporting end of pinch roller shaft.

N. Tension the Tape by pressing <TAPE> and then <TENSION>, after the Tape is tensioned then press <EXIT>.

The filter tape loading procedure for the BAM-1020 is shown in Figure 12.

Figure 12: Filter Tape Loading Procedure



1----NOZZLE IN "UP" POSITION
2----CLEAR SPOOL COVER WITH KNOB
3----EMPTY CORE TUBE
4----TAKE-UP SPOOL
5----PINCH ROLLERS
6----CAPSTAN SHAFT
7----LATCH

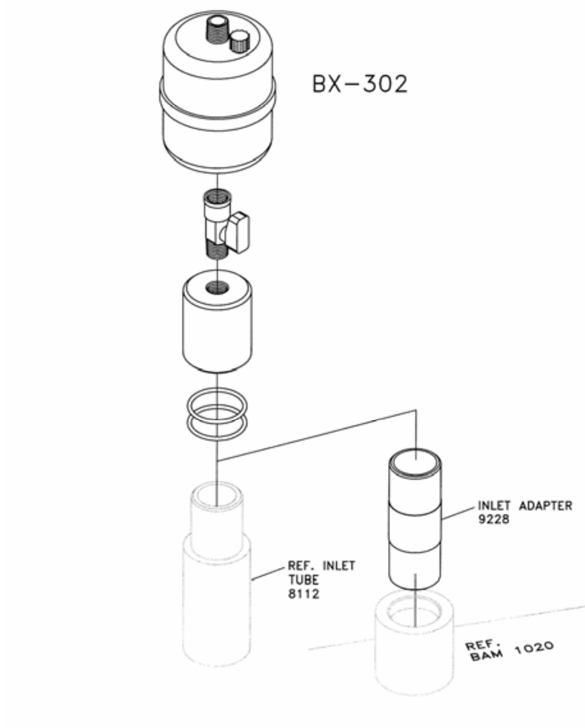
8----FILTER TAPE
9----SUPPLY SPOOL
10--SUPPLY TENSION ROLLER
11--RIGHT END ROLLER
12--SAMPLING/MEASURING AREA
13--LEFT END ROLLER
14--TAKE-UP TENSION ROLLER

4.8 Leak Check.

Tools Required: BX-305 or BX-302
Silicone Lube

Step 1. If the BAM102 is installed in a shelter remove the PM10 head (if necessary also the PM2.5 SCC). If the unit isn't installed insert the BAM inlet adapter from the BX-305/302 (Note: if you have a BX-305 you will not have the Zero filter) into the inlet of the BAM1020. See Figure 13:

Figure 13: BX-302/305 Installation



Step 2. Place the Inlet coupler onto the BAM1020 inlet. Press it firmly onto the inlet until it both O-rings are completely sealed to the inlet. This step may require a small amount of silicone lube on the inlet to allow proper sealing. Turn the stopcock valve to the off position. The lever will be at a 90-degree angle to the inlet tube.

Step 3. If the power to the BAM1020 is off turn it on now.

Step 4. In the main menu press TEST. In the TEST menu select TAPE and advance the tape one window.

Step 4. From the main menu press TEST. In the TEST menu select PUMP and turn the pump on.

Step 5. The indicated flow rate should be less than 1.5 LPM. If the flow is greater than 1.5 LPM see the Troubleshooting guide.
Note: the reason that there is a 1.5 LPM flow allowance is due to the nozzle filter paper interface. Under these test conditions the pressure differential across this interface is 21 inHg. This is an order of magnitude greater than the BAM1020 will encounter during sampling. If the flow is 1.5 LPM or less there will not be a leak during normal operation.

Step 6. Remove the Inlet coupler and replace the PM10 head and PM2.5 SCC.

Troubleshooting

Step 1. Check the Zero on the Flow meter.

a. Remove the pump tubing from the quick disconnect fitting on the back of the BAM.

b. From the main menu press TEST. In the TEST menu select PUMP and turn the pump on.
c. Flow should be less then 0.2 LPM. If the flow is greater than this value do a flow audit from page 56-57 from manual.
d. Retry the LEAK TEST PROCEDURE.

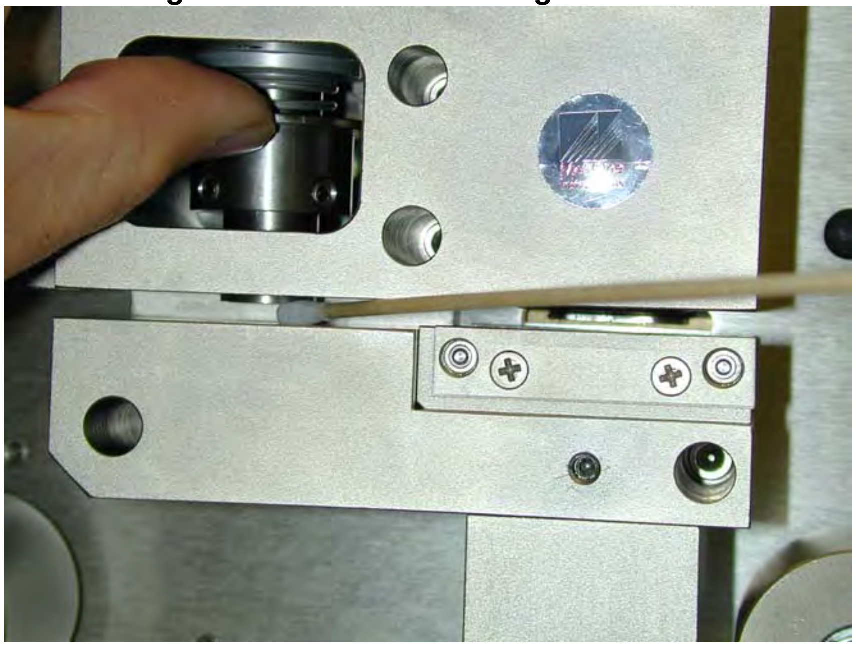
Step 2. Check all connections from the inlet adapter to the vacuum pump.

a. Remove the inlet adapter visually check for leaks and loose fittings and replace.
b. Remove the inlet tube from the BAM1020. Visually inspect for leaks or loose fittings and replace. Check the two orings in the BAM1020 inlet for wear or splits.
c. Open the front door on the BAM1020. Manually lift and lower the nozzle letting it slowly contact the filter paper. The nozzle should be free to move up and down. If the Nozzle sticks contact the factory and request a BX-803 kit.
d. Remove the tubing from the back of the BAM1020 and inspect for splits or loose connections. If the tube is split, cut out the bad portion and reinsert into the back of the BAM1020
e. Retry the LEAK TEST PROCEDURE.

Step 3. Clean the Nozzle.

a. Tools Required – Cotton Swabs and ISO Alcohol.
b. Remove the filter tape from the BAM1020 see section 4.7 of the manual.
c. Lower the Nozzle.
    a. In the BAM1020 main menu press TEST. In the TEST menu select PUMP and lower the nozzle.
d. Lift the Nozzle by pressing with your thumb on the spring tensioner above the nozzle lip. Place a Cotton swab with ISO alcohol under the nozzle and lower the nozzle onto the cotton swab. Slowly rotate the Nozzle assembly. Eight to ten rotations will clean the nozzle. The Vane (this is the cross piece that sits under the filter paper where the nozzle contacts the filter paper) also needs to be cleaned. In the TEST PUMP screen lift the nozzle. The Vane can be viewed by removing the inlet tube and looking down the inlet tube while shining a flashlight into the nozzle/vane area. Use a sharp tool (dental pick) to gently scrape the outside of the vane to remove any filter paper build up. Next scrape the cross hair piece to remove any accumulation of paper. See FIGURE 14:

Figure 14: Nozzle Cleaning Procedure

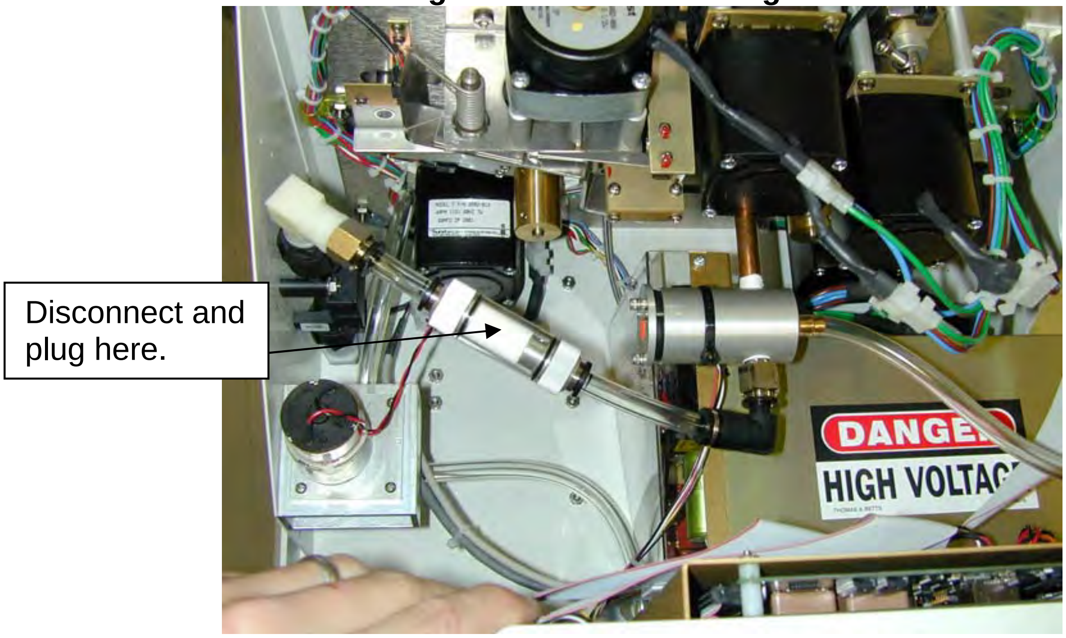


e. Retry the LEAK TEST PROCEDURES.

Step 4. Internal Check

a. Tools required – Screwdriver set, Pliers, and Adjustable Wrench.
b. Remove the Inlet tube from the BAM1020.
c. Plug the inlet and check the flow. If the leak test passes, the leak is in the inlet tube assembly.
d. Remove the BAM1020 cover by 10 Philips head screws and gently remove.
e. Disconnect the tubing at the inline filter and plug the opening (see Figure 15). Recheck the flow. If the unit passes the leak is in the nozzle assembly. Check all fittings from the inline filter to the BAM1020 inlet on the top of the BAM. Replace as needed. Note: Figure 15 shows a BAM with filter temperature and RH option (BX-962).

Figure 15 Internal Fitting Check



If the leak is below the inline filter then the flow meter has a leak or is faulty. Replace with a new flow sensor. MOI part number 970608.

4.9 Self Test

The BAM-1020 has a built-in self-test function. Press the TAPE key and then press the SELF TEST key. The Self-Test Menu is shown in Figure 16.

Figure 16: Self-Test Menu

```
02/08/1999              15:29:30
LATCH: OFF              TAPE BREAK: OK
CAPSTAN: OK             TAPE TENSION: OK
NOZZLE DN: OK           SHUTTLE: OK
NOZZLE UP: OK           REF EXTEND: OK
FLOW: OK                REF WITHDRAW: OK
Status:   SELF TEST PASSED
TENSION   SELF TEST                   EXIT
```

Upon depressing the SELF TEST key the will automatically go through a series of internal checks displaying, in sequence, the results of these checks. If the check passed, the user will see the word OK displayed, or if it does not operate correctly, the user will see the word FAIL displayed. With the large display it is not necessary to watch each segment being tested, as all of the results will be displayed upon completion of the test. The test will take approximately 4 minutes. The results of a properly operating unit are shown below.

Explanation of each of the above functions;

LATCH

Checks the position of the pinch roller latch, if the LATCH is OFF then the capstan will engage the pinch roller. If the LATCH is ON the capstan will not be able to shuttle the filter tape. If the LATCH is ON during normal operation the error message will be shown on the display. See Figure 12 number 1.

CAPSTAN

Capstan operation is tested by moving the paper forward and then back, this test is keyed by proper operation of photo-interrupters. See Figure 12 number 6.

NOZZLE DN (DOWN)

Checks the nozzle movement and reports the proper operation of the ‘nozzle down’ photo-interrupter sensor.

NOZZLE UP

Checks the nozzle movement and reports the proper operation of the ‘nozzle up’ photo-interrupter sensor.

FLOW

The pump is turned on and the flow is tested, to verify operation for operation between 10-20 LPM.

TAPE BREAK

Detects broken tape by looking at the operation of the feed and take up motors photo interrupters. The motors are un-tensioned and then tensioned and the change in the photo interrupters.

TAPE TENSION

Checks the condition of the IDLER rollers, verifies operation of the photo interrupters on the tension idlers.

SHUTTLE

Moves the shuttle left and right and verifies correct operation using the photo interrupters.

REF (REFERENCE) EXTEND

Checks the reference membrane operation and verifies proper extension.

REF (REFERENCE) WITHDRAW

Checks the reference membrane operation and verifies proper retraction.

4.10 Starting Measurement Cycles

1. Verify that power is on, tape is loaded, sample inlet is connected to outside air, and all setup parameters are correct.
2. Sample time parameter should be adjusted to match desired sampling interval. Factory default is set at 50 minutes. Refer to section 4.11.
3. Adjust displayed date and time to match locality. Refer to section 4.11.
4. Press OPERATE soft-key at Main menu to enter OPERATE Menu.
5. Verify that the Operation Mode is ON. The power-on default is ON. (Press UP cursor to change the Operation Mode to ON.)
6. If desired, enter Normal Mode screen to monitor operation by pressing NORMAL soft-key. This is not required, but allows the operator to view the automatic operation.
7. When complete, press EXIT soft-key.

NOTE: Press DOWN cursor to change the Operation Mode to OFF, thereby stopping normal measurement cycles.

4.11 Setup Selections

The BAM-1020 uses various setup parameters to perform the desired calculations and time the recording periods. Memory is set aside for the storage of these numbers. Once these values are saved they do not need to be reloaded, even if power is cycled.

The Setup Menu provides a choice of operations. Use the Up/Down/Right/Left keys to navigate to the operation desired. Press the SELECT key to execute the selection. The Setup screen is shown in Figure 17.

WARNING: Setup operations may not be selected without interrupting normal operations. If the system is in Operate mode, choosing the SETUP from the main menu will interrupt normal operations. It is advised to stop normal operations by letting the system complete the current sample and stop after the pump goes off and the latest concentration has been displayed.

Figure 17: Setup Screen

```
                     SETUP MODE SELECT

CLOCK    SAMPLE    CALIBRATE   EXTRA1
ERRORS   PASSWORD  INTERFACE   SENSOR
HEATER

SELECT                           EXIT
```

NOTE: The Setup menu may have selections that are left blank; this is normal.

Each of the selections are listed in Table 4 with functional descriptions.

Table 4: Setup Operations

Selection	Function
CLOCK	Date and Time Settings
SAMPLE	Range, Sample Time and RS-232 Communications
CALIBRATE	Factory Calibration Values
EXTRA1	Special Settings for Error Parameters (e1-e4)
ERRORS	Enable or disable analog errors and set range values for error limits
PASSWORD	Changing password
INTERFACE	Interface setup, used to configure alarm and control status lines
SENSOR	Setup selections when BAM-1020 is used with meteorological sensors
HEATER	Setup for RH and Delta T used by the heater. Note: This selection is not active unless HEATER CONTROL is set to AUTO in the Calibrate Setup Section4.14.

Some of the Setup operations relate to system calibration. ***Do not attempt any adjustment on these parameters.*** If they are changed in error, refer to Appendix B, for the factory calibration values.

4.12 CLOCK Screen

The CLOCK screen allows for the setting of the time and date. Time is a 24-hour clock only. After the time and date are entered press SAVE key and then EXIT. The CLOCK screen is shown in Figure 18.

Figure 18: CLOCK Screen

```
                      SETUP MODE CLOCK

DATE   11/15/2001   TIME 11:42:12


   SAVE                          EXIT
```

4.13 SAMPLE Screen

Use the SAMPLE screen to set BAM-1020 sampling periods. The SAMPLE screen is shown in Figure 19.

Figure 19: SAMPLE Screen

```
                      SETUP MODE SAMPLE

RS-232 9600 N 8 1   BAM SAMPLE 050 MIN

STATION # 01        MET SAMPLE 60 MIN
RANGE    1.000 mg   OFFSET    0.000 mg

   SAVE                          EXIT
```

RS-232

Range of baud rate settings: 300, 600, 1200, 2400, 4800, 9600.
For reference only these values can not be edited: No Parity, 8 data bits, 1 stop bit.

BAM SAMPLE

Sets the amount of time that the pump is on, the actual sample period. SAMPLE is set at 50 minutes for hourly recording periods. Note: 10 minutes is required to perform counting and to shuttle filter paper. The BAM-1020 SAMPLE has a maximum range of 0-200 minutes. If the BAM-1020 is set for shorter period, such as 15 minutes, the BAM-1020 will finish the sampling and then wait until the end of the hour before beginning a new cycle.

STATION #

This is a station identification number. This number has a range of 00-99. This number will be printed on the reports. When used in a network, every BAM-1020 should be given a different station number.

MET SAMPLE

This sets the MET data logger sample time. This logger is used for additional measurements. Use the up and down arrows to increment the data logger recording period 1,5,15, 60 minutes. If other measurements devices are not connected, always leave the MET SAMPLE at 60 minutes.

RANGE

Range setting sets the full-scale analog output at selected full-scale value. (0.1 mg, 0.2 mg, 0.25 mg, 0.5 mg, 1.0 mg, 2.0 mg, 5.0 mg, 10.0 mg)

OFFSET

The 'OFFSET" function is used to adjust/shift the analog output. Typically, a –0.005mg/m^3 "OFFSET" (also equal to –0.005vdc) is used to create an output range of –0.005vdc to 0.995vdc representing 0 to 1000mg/m^3. This shift in the DAC output allows 1.000vdc to ONLY represent an "Alarm" condition, and not true data. The factory default setting is –0.005mg/m^3**.**

4.14 CALIBRATE Screen

The CALIBRATE screen is used by the operator to modify the BAM-1020 calibration settings. These settings will not be changed without specific information from Met One Instruments. For example, information would accompany a replacement detector assembly and would require use of this screen.

The CALIBRATE screen is shown in Figure 20.

Figure 20: CALIBRATE Screen

```
                 SETUP MODE CALIBRATE
               Heater Control: Manual
FLOWRATE: 016.7    FLOW TYPE: Actual
Cv   1.0000        Qo    0.000
ABS  0.805         μsw   0.285
K    1.000         BKGD  0.000

   SAVE                        EXIT
```

CAUTION! Do not change any of these calibration values, such as ABS, BKGD, K, or μsw. These parameters are marked with an * character. If they are changed in error, refer to Appendix B, for the factory calibration values. Note: Cv and Qo can be changed with a flow calibration see section 6.

Cv *

Defines the flow rate constant (slope) and is used in conjunction with auditing procedures of section 6.3 to calibrate flow rate. The Cv range is from 0.0001 to 9.9999.

Qo *

Defines the flow rate offset and is used in auditing procedure section 6.3 to calibrate flow offset. The Qo range is from -9.999 to +9.999.

Heater Control – two selections are available which are the following:

Manual – If the BX-825 or BX-826 (coiled Heat Tape) option was purchased. If the Smart Heater (BX-827 or BX-830) is to remain on at all times.

Automatic – if the BX-827 or BX-830 (Smart Heater) option was purchased along with BX-962 (RH and Filter Temp sensors). This mode uses filter RH and Delta-T to control the RH of the filter tape. See section 4.20 for setup.

FLOWRATE

For a METERED type flow system (manually regulated) set the value to the desired flow rate.

For ACTUAL (VOLUMETRIC) or STD type flow system (computer regulated) set the value to the desired flow rate. The BAM-1020 computer will maintain this flow rate when the pump is on by controlling an electric valve. The unit must have the BX-961 option for automatic control.

The FLOWRATE range is from 10.0 to 20.0 liters/minute.

FLOW TYPE*

There are three flow type selections available to match your mode of operation. The FLOW TYPE selection determines how the flow is reported on the OPERATE NORMAL screen. Note: in older versions of the BAM1020 VOLUMETRIC is used for ACTUAL flow.

Flow Type	Description
METERED	Select METERED if your BAM is equipped with a manually regulated flow system. Flow is reported in EPA conditions (25 C and 760 mmHg).
ACTUAL	Select ACTUAL if your BAM is equipped with the BX-961 option, and a BX-592 temperature sensor. Flow (ACTUAL) is reported in ambient volumetric conditions (Temperature and Pressure). The concentration is reported in mg/m3 (ACTUAL conditions). Flow is controlled to ambient volumetric conditions.
STD	Select STD if your BAM is equipped with the BX-961 option. Flow (STD) is reported in EPA conditions (25 C and 760 mmHg). The concentration is reported in mg/m3 (EPA conditions). Flow can be controlled to ambient volumetric conditions with the BX-592 Temperature Sensor. Without this option flow is controlled to EPA conditions.

ABS*

This is the factory set value for the reference membrane calibration. The range is from 0.100 to 0.995.

µsw *

This is the factory set value for the mass absorption coefficient and is set in conjunction with factory tests of the reference membrane value. Typical values are about 0.285.

K*

This is the factory setting for the standard regression slope; this value has been determined by dynamic testing in the factory smoke and dust chamber. The typical range is 0.90 to 1.10.

BKGD*

This is a factory-calibrated setting for the zero concentration level. This value has been determined by dynamic testing using filtered input. All of the data stored, and displayed contains this adjustment. Typical range is –0.005 to –0.018 mg/m^3,

4.15 EXTRA1 Screen

The settings in the EXTRA1 screen are special settings that have been installed for special applications and generally would not be adjusted.

e1 Clamp lower limit for DISPLAY of concentration, range is -0.005 to +0.010.

e2 Not Used

e3 Hysteresis timer, range is 0.000 to 5.000 seconds.

e4 Membrane stuck timeout, range in seconds 10.00-20.00.

The EXTRA1 screen is shown in Figure 21.

Figure 21: EXTRA1 Screen

```
SETUP MODE EXTRA 1

e1: Low Concentration Limit    -0.005
e2: Not Used                    0.000
e3: Membrane OFF Delay (Sec)    0.000
e4: Membrane Time Out (Sec)     15.00

SAVE                         EXIT
```

4.16 ERRORS Screen

This screen sets up the error controls and conditions that are used to configure the error reporting. Additional settings allow the setting of the analog alarm errors. Errors are reported at the end of the cycle period and are reset at the beginning of the next cycle.

4.16.1 ERROR REPORTING, ANALOG OUTPUT

In some cases it is desirable to indicate instrument malfunction directly on the output channel. This type of error indication is used when the operator is limited to a single voltage channel for particulate information. When the analog errors are set, the normal analog concentration output will be put at maximum output when one of the selected errors occurs. Analog errors are set by selecting each error from the list below and enabling (1=ON) or disabling (0=OFF). When an error occurs the output signal goes to full scale, but the digital value is unchanged and may be recovered using either the display or RS-232 connection. See section 5.2 or Appendix C for error recall procedures.

The ERRORS screen is shown in Figure 22.

Figure 22: ERRORS Screen

```
                        SETUP MODE ERROR
   EUMILRNFPDCT AP  FRI FRh
   111111111111 150 10  20

1=ON,  0=OFF

   SAVE                               EXIT
```

In the above example all error lines have been selected, that means that any error will cause the analog output signal to go to full scale for sample period. Errors are reset at the end of each sample period.

E **EXTERNAL RESET—**Indicates that the system time was reset. This external reset maybe used to control operation for system synchronization. If external reset is successful then no error is logged.

U **TELEMETRY FAULT—**Indicates a fault with the remote telemetry operation.

M **METEOROLOGICAL CALIBRATION DATA FLAG—**This value indicates that calibration or testing was performed during this time period. See section 4.18.

I **INTERNAL CPU** – Errors in central processor.

L **POWER FAIL—**If the powered is cycled, a power fail error is logged.

R **REFERENCE MEMBRANE—**Indicates that the Reference Membrane was not operating correctly and forced a timeout of the membrane calibration. Often associated with the **D** error listed below.

N **NOZZLE STUCK TIMEOUT or Delta-T Setpoint Exceeded —** Nozzle movement occurs at the top of the hour or after a power failure. IF the time is at the top of the hour or after a power failure then the nozzle was not operating correctly and forced to timeout. At all other times the Delta-T Setpoint from Section 4.20 was exceeded.

F **FLOW OUT OF LIMITS** – These limits are set with FRl (low limit) and FRh (high limit).

P **PRESSURE DROP EXCESSIVE** – Limit is set with AP**.**

D **DEVIANT MEMBRANE DENSITY—**Indicates that the Reference Membrane was out of limits by more than ±5%.

C **COUNT—**Indicates that the counting cycle is not operating properly, and is activated by counts below 10,000 per 4 minutes.

T **TAPE BREAK—**Indicates broken tape.

The following are error parameters with associated ranges.

AP Pressure drop, range is 0-500 mm-Hg. If the pressure drop falls below the limit, then an alarm output will be generated.

FRl Flow Rate, lower limit, 0-30 lpm. This sets the lower flow limit. If the flow drops below this rate, then an "**F**" error will occur.

FRh Flow Rate, high limit, 1-38 lpm. This sets the high flow limit. If the flow goes above this rate, then an "**F**" error will occur.

4.17 PASSWORD Screen

Allows setting of password. Any of 6 different keys for the 4-key sequence. (6^4 combinations). The PASSWORD Screen is shown in Figure 23.

Figure 23: PASSWORD Screen

```
                   SETUP PASSWORD


          PASSWORD SEQUENCE
             F1 F2 F3 F4

    SAVE                             EXIT
```

4.18 INTERFACE Screen

The Interface Setup screen is shown in Figure 24.

Figure 24: INTERFACE Screen

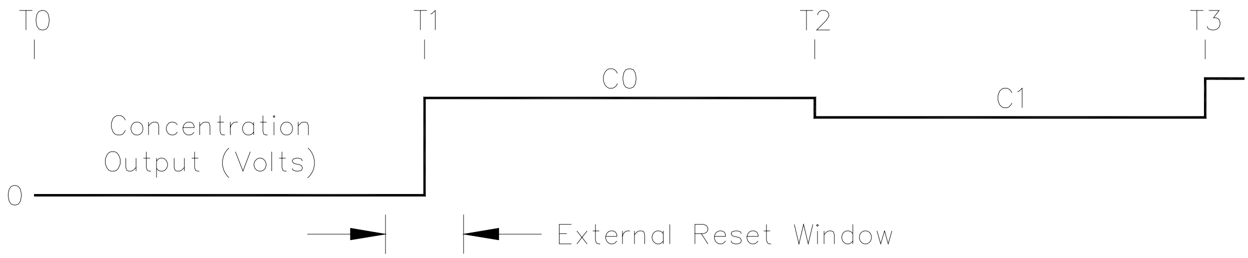
```
                         Interface Setup

Cycle Mode: STANDARD Force Maint: OFF
Fault Polarity: NORM Split DELTAP: 00300
Reset Polarity: NORM


   SAVE                           EXIT
```

Force Maint	Will toggle the maintenance relay to the ON or OFF position. This function is used when maintenance is performed and the Maintenance Relay can be used to signal data acquisition systems current status.
Fault Polarity	Sets the output polarity of the telemetry fault relay; NORM for normally open (NO) and INV for normally closed (NC).
Split DELTAP	Sets the split cycle point. Not required in BAM-1020.
Reset Polarity	Sets the input polarity of the external reset; NORM for normally open (NO) and INV for normally closed (NC).
Cycle Mode	The cycle mode setting determines the function of the external reset and format of the concentration voltage output. Description of the STANDARD and EARLY cycle modes follows.

STANDARD Cycle Mode

The concentration output voltage format for a standard cycle is shown below.

Figure 25: Standard Cycle Timing



The C0 output voltage represents the concentration measured from T0 to T1, where the T labels represent the top of the hour (i.e. zero minute and zero second).

An external reset maybe used to control operation for system synchronization. The reset signal must be present for a minimum of 2 seconds. The external reset window is plus and minus 5 minutes around the top of the hour.

Minute 0 to 5—The external reset signal changes the clock to the zero minute and second of the current hour. If a cycle has started, it will continue. No error occurs, since there is adequate time to complete the cycle.

Minute 5 to 55—The external reset signal has no effect. The error log will contain the date and time of the reset.

Minute 55 to 0—If an external reset occurs after a completed cycle, or idle condition, then no error occurs. At that instance the clock minute and second will be set to zero of the next hour and a new measurement cycle will start.

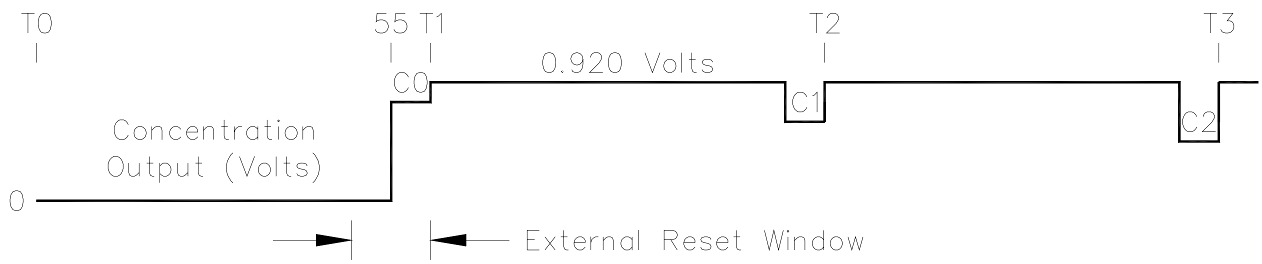
The clock is not reset if the cycle has not reached the I3 count. The error log will contain the date and time of the reset. Reset during this period is not recommended as the output data and error log will be reset at the same time.

If the I3 count is in progress, or the cycle is past the I3 count, then the measurement is canceled. The error log will contain the date and time of the reset (This means that the shuttle must be moved back to the right hand position to reset a cycle). A canceled cycle will also force the Voltage and Current Loop outputs to go to their full-scale values (i.e., 1.0 volt and 20 .0 mA).

EARLY Cycle Mode

The concentration output voltage format for an early cycle is shown below.

Figure 26: Early Cycle Timing



The C0 output voltage represents the concentration measured from T0 to T1, where the T labels represent the top of the hour (i.e. zero minute and zero second). The concentration output voltage for the end of the current hour is present for 5 minutes (minute 55 to 0). All other times the concentration output voltage is 0.920 volts.

An external reset maybe used to control operation for system synchronization. The reset signal must be present for a minimum of 2 seconds. The external reset window is plus and minus 5 minutes around minute 55.

Minute 55 to 0—The external reset signal changes the clock to minute 55 and second 0 of the current hour. A new measurement cycle will start at that moment. If a cycle has started, it will continue. No error occurs, since there is adequate time to complete the cycle.

Minute 0 to 50—The external reset signal has no effect. The error log will contain the date and time of the reset.

Minute 50 to 55—If an external reset occurs after a completed cycle, or idle condition, then no error occurs. At that instance the clock is set to minute 55 and second 0 of the current hour and a new measurement cycle will start.

The clock is not reset if the cycle has not reached the I3 count. The error log will contain the date and time of the reset. Reset during this period is not recommended as the output data and error log will be reset at the same time.

If the I3 count is in progress, or the cycle is past the I3 count, then the measurement is canceled. The error log will contain the date and time of the reset (This means that the shuttle must be moved back to the right hand position to reset a cycle). A canceled cycle will also force the Voltage output to 0.920 volts.

4.19 SENSOR Screen

The BAM-1020 provides six analog inputs for logging Meteorological (or air quality) sensor data. New sensors added must be setup before data can be acquired. Use the SENSOR screen to set the data collection parameters. The SENSOR Screen is shown in Figure 27.

Figure 27: SENSOR Screen

```
                      SETUP CHAN PARAMS

CH      TYPE  UNITS  PREC  MULT   OFFSET
I1      Conc  mg       3  01.000  -0.005
        SENSOR FS VOLT:   2.500
INV SLOPE:N VECT/SCALAR:S MODE:AUTO ID

  SAVE             ID MODE      EXIT
```

CH Channels are selected by using the up and down cursor keys in the CH (Channel) field.

NOTE: Channels I1 (Conc) and I2 (Qtot) are internal. They can be viewed, but cannot be changed.

TYPE This is the channel type name. If the MODE is set to AUTO ID then the name is pick based on the Met One auto ID sensors (500 series). If the MODE is set to MANUAL then enter your desired name by pressing the up, down, left, or right arrow keys.

UNITS This is the engineering units for this channel.

PREC Sets the decimal place for Multiplier and Offset parameter.

MULT Scale (multiply) the input value by this amount.

OFFSET Offset (add) the input value by this amount.

SENSOR FS VOLT The value of the input full scale value voltage.

INV SLOPE Use inverse slope for thermistor temperature sensors with resistance outputs only.

VECT/SCALAR Sets the averaging method; SCALAR is used for all measurements, except wind direction, then use vector.

MODE Press the ID MODE key to change mode type.

MANUAL—in this mode the operator can define the sensor parameters manually.
AUTO ID—In this mode the AUTOMET ID method is used to select the sensor parameters. Met One 500 series sensors support this mode.

NOTE: Manually set parameters are lost when changing to AUTO ID mode.

4.20 HEATER Screen

An option for the BAM1020 is the RH controlled heater. This option uses an RH sensor and a temperature sensor located below the filter paper. Testing has shown that if the RH on the filter paper increases above 55% the particulate can absorb water and the measured mass will increase. The RH controlled heater minimizes this effect. Met One suggests setting the RH value to 45%. This is the equilibration value for the FRM filters.

Secondly, the filter temperature and ambient temperature are measured and a Delta-Temperature is computed from the difference. Volatile organic compounds (VOCs) and Semi-VOCs can be vaporized and removed from the measured mass if the filter temperature is greater than the ambient temperature by more than 5 degrees C. Met One suggest setting the Delta-T set point to 5 degrees Celsius. Note: Delta-T is only available if an ambient temperature probe (BX-592) is connected to channel 6.

Heater is enabled if the BAM-1020 is on and the sample pump is on. The heater will turn off when RH is 1% below Setpoint or if the Delta-T Setpoint is reached.

Figure 28: HEATER Screen

```
Heater Setup
         RH Control: YES
        RH Setpoint:  45 %
         Datalog RH: YES (Chan 4)
    Delta-T Control: YES
   Delta-T Setpoint:   5 C
    Datalog Delta-T: YES (Chan 5)
   Save                         Cancel
```

RH Control Options are YES or NO. If YES is selected the sample heater will be turned on until the RH is within 1% of the RH Setpoint.

RH Setpoint The Setpoint can be a number from 1-99. This is the value of RH that will be maintained at the filter.

Datalog RH Options are YES or NO. If YES is selected the RH will be logged on channel 4 of the BAM1020 Datalogger. Note: if YES is selected external inputs on channel 4 are ignored.

Delta-T Control Options are YES or NO. If YES is selected the sample heater will be turned off if the Delta-T Setpoint is exceeded. If the Delta-T Setpoint is exceeded by 1 degree Celsius an error (N) will be logged. See Section 4.16.

Delta-T Setpoint The Setpoint can be a number from 1-99. This is the value that if it is exceeded the sample heater will be turned off. Note: this overrides the RH Setpoint. If RH is still above the RH Setpoint but the Delta-T is equal or greater than Delta-T Setpoint the sample heater will be turned off.

Datalog Delta-T Options are YES or NO. If YES is selected the Delta-T will be logged on channel 5 of the BAM1020 Datalogger. Note: if YES is selected external inputs on channel 5 are ignored.

5 OPERATION

5.1 Introduction

The BAM-1020 has a large 320-character display (8 lines by 40 characters) that acts as a powerful communication interface with the operator. The operator can obtain data records, set various communication protocols and test the operation of the system using the display and keypad.

5.2 Learning How to Use the Keypad

When the BAM-1020 is first powered up, it will display the top menu. This is the indication that the system is ready for operation. The screen displays the date, time, Firmware version model number, and four soft-keys for selecting menus of the BAM-1020. The soft-keys allow the operator to select menus for setup, operation, and testing. Each menu will have a keyword displayed above the soft-key, identifying its function. Each sub-menu will have an EXIT soft-key that will return the BAM-1020 to the top menu.

The left and right arrow keys move the cursor through the various data entry points in the sub-menus. Use the up and down arrows to increment or decrement the numeric value or selections made within a field. Modifications made within a menu are not saved unless the SAVE soft-key is pressed. A screen indicator is displayed when the modifications are saved.

The BAM-1020 start up screen is shown in Figure 29.

Figure 29: Start Up Screen

```
11/15/2001                       10:11:07

             > BAM – 1020 <
        BETA ATTENUATION MONITOR
              Ver: 2.03
    Status:    ON

  SETUP    OPERATE     TEST     TAPE
```

KEY DESCRIPTION

SOFT-KEYS
These 4 keys directly below the display are used with the corresponding four description fields being displayed in bottom row. The meaning of each soft-key is dependent on the current menu.

CURSOR KEYS
These 4 arrow-shaped keys point up, down, right, and left. They are normally used to move through a menu (right or left to change fields) and to vary a setup parameter (up or down).

CONTRAST ADJUSTMENT KEY
This single key is labeled with a starburst symbol. By pressing it, the display contrast can be adjusted up or down. Continuous pressure will change the contrast in only one direction (increasing or decreasing).

FUNCTION KEYS
These 6 keys are labeled F1 through F6. They serve to simplify keystrokes for certain frequently performed tasks.

NOTE: Function keys are only available from the top menu and for entering the password.

F1
This key is used to display the instantaneous values that are recorded by the BAM-1020. All the values including the last concentration value, current flow value, and current values of all other sensors that are connected to BAM-1020 are displayed. The Instantaneous value screen is shown in Figure 30.

Figure 30: Instantaneous Value (F1) Screen

```
2/14/1999 CAL DATA FLAG: OFF   11:27:54
          Eng Units           Eng Units
1 Conc    0.000 mg  2 Qtot    .807 m3
3 no      0.000     4 no      0.000
5 no      0.000     6 no      0.000
7 no      0.000     8 no      0.000

          TOGGLE FLG VOLT/ENG    EXIT
```

This screen is useful for monitoring any other channels that may be connected to the BAM-1020; all values except Conc (concentration) and Qtot (flow) are current. The Conc represents the concentration of the last period. Qtot represents total volumetric flow during the last period.

CAL DATA FLAG
The calibration data flag indicates the status of the calibration flag, when it is ON the data will be marked with M in the data array see example in Appendix E. This is useful when performing flow audits, tape changes and other routine maintenance.

TOGGLE FLG
Will set the MET calibration flag in the logged data. When set, the calibration data flag displays a reverse flashing "ON".

VOLT/ENG
Allows the operator to view the channels as engineering data (ENG), or raw input voltage (VOLT).

F2
This key is used to display the last average values that are recorded by the BAM-1020. The concentration and flow are presented as the last hour's values; the other measurements are shown as the last average period of the data logger. The last average value screen is shown in Figure 31.

Figure 31: Last Average Value (F2) Screen

```
11/15/2001                      13:13:07
60 Min Avg Period        Last Avg 00:00
  Conc    0.000 mg    Qtot    0.000 m3
1 no      0.000 V   2 no      0.000 V
3 no      0.000 V   4 no      0.000 V
5 no      0.000 V   5 AT       19.8 C

                               EXIT
```

F3
Error Recall key displays any errors logged by the BAM-1020. The error screen is shown in Figure 32.

Figure 32: Error Recall Screen

```
11/15/2001                      11:27:54

                  FLOW


NEXT      PREV      SELECT DAY   EXIT
```

F4
Data Recall key displays the last 10 days of data.

F5
Key is used to transfer memory contents to storage module, refer to section 8.7.

F6
Key is not assigned.

5.3 Operation Mode

When the BAM-1020 is placed in the Operation Mode (ON) it will continuously operate until it is commanded to stop. The command to stop may be generated by the operator selecting Operation Mode: OFF, by the operator attempting to use either SETUP or TEST while the BAM-1020 is in ON mode, or by the BAM-1020 after a non-correctable fault has been encountered (such as broken tape).

5.4 Operate Mode

Press OPERATE soft-key at top menu to enter OPERATE screen.

The OPERATE screen has four options, NORMAL is the standard monitoring mode, INST is used to view BAM-1020 channels and extra datalogger channels instantaneously, AVERAGE is used to look at the averages of the instantaneous values, and EXIT.

The power-on default operation mode is ON. To change operation mode press the UP button for ON and the DOWN button for OFF.

The Operate Mode Screen is shown in Figure 33.

Figure 33: OPERATE MODE Screen

```
11/15/2001   OPERATE MODE       14:13:07

       ↑ = ON
       ↓ = OFF
Operation Mode: ON
        Status: ON

  NORMAL     INST    AVERAGE     EXIT
```

5.5 *Normal Mode*

Enter Normal Mode screen to monitor operation by pressing NORMAL soft-key. This screen allows the operator to monitor unit operation.

Figure 34: Normal Mode Screen

```
11/15/2001    NORMAL MODE     11:27:54

LAST C: 0.060 mg/m3  Flow(STD) 16.7 LPM

LAST m: 0.806 mg/cm2  PRESS:  00780 mmHg
     STATUS: SAMPLING

                              EXIT
```

LAST C
This indicates the last concentration recorded, the value will hold until updated at the end of the cycle.

LAST m
This indicates the last calibration value; the value should be equal to the ABS value within ±5%. If the value differs more than ±5% a **D** error will be logged.

FLOW
The FLOW TYPE selection (Section 4.14 CALIBRATE Screen) determines how the flow is reported on this screen. LPM is the abbreviation for liters-per-minute.
Note: in older versions of the BAM1020 Volumetric flow is used for Actual flow. These terms are used synonymously.

Table 5 Flow Type

Flow Type	**Description**
METERED	Select METERED if your BAM is equipped with a manually regulated flow system. Flow is reported in EPA conditions (25 C and 760 mmHg).
ACTUAL	Select ACTUAL if your BAM is equipped with the BX-961 option, and a BX-592 temperature sensor. Flow (ACTUAL) is reported in ambient volumetric conditions (Temperature and Pressure). The concentration is reported in mg/m3 (ACTUAL conditions). Flow is controlled to ambient volumetric conditions.
STD	Select STD if your BAM is equipped with the BX-961 option.

	Flow (STD) is reported in EPA conditions (25 C and 760 mmHg). The concentration is reported in mg/m3 (EPA conditions). Flow can be controlled to ambient volumetric conditions with the BX-592 Temperature Sensor. Without this option flow is controlled to EPA conditions.

PRESS
Indicates the current pressure in mm-Hg.

5.6 *Instantaneous Mode (INST)*

This screen is useful for monitoring any other channels that may be connected to the BAM-1020, all values except Conc (concentration) and Qtot (flow) are current. The Conc represents the concentration of the last period. Qtot represents total volume of flow during the last period.

CAL DATA FLAG
Indicates the status of the calibration flag, when it is ON the data will be marked with M in the data array, see example in Appendix E. This is useful when performing flow audits, tape changes and other routine maintenance.

TOGGLE FLG
Will set the MET calibration flag in the logged data. When set, the cal data flag displays a reverse flashing "ON".

VOLT/ENG
Allows the operator to view the channels as engineering data, or raw input voltage.

The Instantaneous Mode Screen is shown in Figure 35.

Figure 35: Instantaneous Mode Screen

```
11/15/2001  CAL DATA FLAG: OFF   11:27:54
          Eng Units            Eng Units
1 Conc    0.000 mg  2 Qtot    .807 m3
3 no      0.000     4 no      0.000
5 no      0.000     6 no      0.000
7 no      0.000     8 no      0.000

          TOGGLE FLG VOLT/ENG    EXIT
```

5.7 Average Mode

This screen is useful for monitoring any other channels that may be connected to the BAM-1020; all values except Conc (concentration) and Qtot (flow) are current. The Conc represents the concentration of the last period. Qtot represents total volumetric flow. The average period is defined and the time period of the last average is shown on the second line of the display. To change the averaging period see Section 4.13. The Average Mode Screen is shown in Figure 36.

Figure 36: Average Mode Screen

```
11/15/2001                    11:27:54
60 Min Avg Period       Last Avg
1 Conc    0.000 mg  2 Qtot    .807 m3
3 no      0.000     4 no      0.000
5 no      0.000     6 no      0.000
7 no      0.000     8 no      0.000

                                 EXIT
```

6 CALIBRATION

6.1 Factory Calibration Method

Met One Instruments maintains a complete test facility for calibration of all particulate instrumentation. Each instrument is tested to traceable standards and then operated in a chamber with dust-laden atmosphere. The results of the testing provide data points that are used in the data regression and final calibration. The built-in membrane calibrator is tested to assure conformity during the test period.

Based on field experience, the user will need to service the pump every two years. Built in firmware performs hourly diagnostic tests on the unit, and tests for correct operation of all components. Field calibration of the flow system is performed on a seasonal basis.

6.2 Automatic Calibration Method

The BAM-1020 has a built-in Mass Membrane Calibrator. The membrane is automatically moved into the Beta pathway to determine the ‘mass’ of the membrane each hour or when the filter tape advances. Each membrane has a factory verified mass and that value is stored in the BAM-1020. When the hourly membrane calibration is made, the computed value is compared to the stored factory value to determine proper operation. The membrane must be withdrawn for normal measurements. Should the instrument fail to perform to specification an error is logged in memory and data is flagged.

Zero testing of blank filter paper is performed at the beginning and end of each sample period to insure the stability of the measurement system. Zero testing is based on the ability of the BAM-1020 to hold a constant output when measuring blank filter paper. If the difference between the two values exceeds a preset limit a data error message is logged in the error log and the digital data value is marked.

6.3 Field Calibration of Flow System

A BAM 1020 has three flow types—Metered Standard or Actual (Note: older versions use Volumetric in place of Actual). Metered flow measures the flow in EPA conditions (298 Kelvin and 760 mmHg) and does not have active flow control. Actual flow measures the volume of flow in ambient conditions and automatically regulates the flow to ambient conditions. Standard flow measures the volume of flow in EPA conditions (298 Kelvin and 760 mm-Hg) and automatically regulates the flow to EPA conditions. Each type requires a different set of test equipment and procedure.

To determine the flow type of the BAM under test navigate to the calibrate screen (SETUP>CALIBRATE). A password is required see Section 4.17. This screen displays the FLOW TYPE—METERED, STANDARD, or ACTUAL. Proceed to step **A** for METERED, and STANDARD and step **B** for ACTUAL.

A. Metered flow type calibration requires a reference flow meter with a flow audit cap. Met One suggests the BIOS® brand or purchasing the BX-307 option. A reference temperature device is also needed to measure ambient temperature.

1. With vacuum pump OFF record:

   $T_{ambient}$ (T_a)______________Kelvin. (Reference temperature device)

   $P_{ambient}$ (P_a)______________mm-Hg (BAM OPERATE>NORMAL screen)

2. In the SETUP>CALIBRATE screen set C_v and Q_0 to 1.000 and 0.000 respectively.

3. Cycle filter tape to a new spot. Disconnect the pump tubing from the back of the BAM-1020. In TEST>PUMP screen turn ON the pump.

   NOTE: There should not be air flowing through the BAM-1020. Record the indicated flow rate:

   Zero flow (Z_f)_____________LPM.

4. In the SETUP>CALIBRATE screen set the Q_0 value to equal the negative of Zero flow. Check the flow rate as described above and make sure the reading is zero $\pm$ 0.10 LPM.

5. Reconnect the pump vacuum line.

6. Remove PM_{10} inlet and set aside.

7. Place flow audit cap in place of inlet. Connect the reference flow meter exit tube to the hose barb on the top of the flow audit cap.

8. Using the reference flow meter measure and record actual flow after the pump has been running for 5 minutes. At the same time record the BAM-1020 indicated flow from the TEST>PUMP screen.

   Audit (Q_a)______________LPM (Recorded from the reference meter)

BAM (Q_b)_____________LPM (Recorded from the BAM screen)

9. Convert the reference flow to EPA flow:

   $Q_s = Q_a * (P_a / T_a) * (298 / 760)$

10. Compute C_v and Q_o:

    $C_v = Q_s / Q_b$

    $Q_o = -C_v * Z_f$

11. In the SETUP>CALIBRATE screen set C_v and Q_o value to the calculated C_v and Q_o from step 10.

12. Turn pump on and compare the values of Q_s and Q_b as described in steps 8—10. They should be within 1% of each other, otherwise return to step 1.

13. Using the flow adjustment knob on the rear of the BAM 1020, adjust the flow until the panel readout shows 17.5 L/minute. This level is within the specification of the PM-10 particle separation head, and will allow for filter loading in high concentration areas. In some cases, this flow can be set at a lower level. Factory consultation is advised if other settings are used.

B. ACTUAL flow type calibration requires a reference volumetric flow meter with a flow audit cap BX-305. For a complete list of BAM options see section 10.3.3. Met One suggests the BIOS® brand or purchasing the BX-307 option.
Note: This screen becomes available in the Test menu when the ACTUAL flow type has been selected from the SETUP>CALIBRATE screen. Note: in older versions of the BAM1020 VOLUMETRIC is used for ACTUAL flow. The BAM must also be equipped with the volumetric flow hardware—BX-961. A Model 592 temperature sensor must be connected to the BAM back panel channel 6. Refer to Figure 61 of APPENDIX F for sensor hookup.

Figure 37: Volumetric Flow Calibration Screen

```
       ACTUAL FLOW CALIBRATION MODE
F1=RESTORE DEFAULT
                     BAM       REFERENCE
AMBIENT TEMPERATURE: 21.8C     21.8C
BAROMETRIC PRESSURE: 737mmHg   737mmHg
VOLUMETRIC FLOWRATE:  0.0l/min 16.7l/min

ADJUST/SAVE  NEXT     PUMP ON    EXIT
```

To perform a volumetric flow audit you will need reference temperature, pressure and flow meter equipment. Then follow these steps.

1. First, correct the BAM ambient temperature reading. Using a reference temperature sensor measure the temperature at the PM10 head. Enter the externally measured reference temperature value in the REFERENCE field. Use the up and down arrows to edit the field. Press the ADJUST/SAVE button to correct the BAM ambient temperature reading. The BAM and REFERENCE values should now be the same.
2. Press the NEXT button and repeat the same steps for barometric pressure.
3. After the temperature and pressure readings are correct remove the PM10 head (and PM2.5 SCC if installed) and place the flow audit cap (BX-305) with the reference flow meter on the inlet. On the BAM 1020 LCD press the PUMP ON button hot key. After the flow rate has stabilized (minimum of 5 minutes) compare the BAM volumetric flow rate against a reference flow meter connected to the BAM 1020 inlet. Take the reference flow meter value and enter it into the REFERENCE field. If the BAM volumetric flow rate is not the same as the reference flow meter correct the BAM reading by pressing the ADJUST/SAVE button.
4. Repeat step three until the reference flow meter and BAM flow are within 1%.

6.4 Periodic Manual Flow Setting

This procedure is used for BAMs that do not have Automatic Flow Control (BX 961). These units have a manual flow adjust valve on the back of the BAM.

1. Measure the ambient temperature near the Pm_{10} head inlet at approximately 4:00 PM (outside the enclosure of the BAM 1020). Convert the temperature reading to Kelvin by the following: for Celsius add 273.15; for Fahrenheit use (Fahrenheit -32)*.556 + 273.15. Record as Temp.
2. Make sure the BAM 1020 is in Pump Test mode and the pump is off. The display will have a reading called *PRESSURE.* This reading will be equal to ambient pressure when the pump is off. Record as Press.
3. Now calculate a Volume correction term by the following:

$$V = (Temp / Press)*62.4$$

4. Divide V by 24.47 to determine the ratio of EPA flow to Ambient Flow and record as Calnum.
5. Lower the nozzle and turn the pump on and wait for at least 10 minutes. Then divide the displayed flow by Calnum.
6. Locate the flow valve v1 on the back of the BAM 1020. Set the displayed flow rate to equal 17.5/Calnum.

Example:

1. Temp. = 300 Kelvin
2. Pressure = 710 mmHg
3. V = (300/710) * 62.4
   = 26.4
4. Calnum = 26.4/24.47
   = 1.08
5. Adjusted flow = 17.5 / 1.08
   = 16.2 LPM
6. Adjust valve v1 until flow reading displayed by the BAM equals 16.2 LPM

Setting of the flow by this procedure should be done every time the filter paper is changed or a minimum of every two months.

7 INSTRUMENT DIAGNOSTICS

7.1 General

The BAM-1020 provides manual operation features designed to isolate subsystems and components for troubleshooting purposes.

WARNING: Test functions may not be selected without interrupting normal operations. If the Operation mode is ON, choosing the TEST key from the main menu will interrupt normal operations. It is advised to stop normal operations by letting the system complete the current sample and stop after the pump goes off and the latest concentration has been displayed.

7.2 Test Modes

This is the top menu of the test modes of operation. It provides the gateway to eight different individual tests, each of which performs an operation in a similar manner to what the system software does as it runs normally. The Test Menu is shown in Figure 38.

Figure 38: Test Menu

```
                     TEST MODE

COUNT     PUMP      TAPE      DAC
CALIBRATE INTERFACE FLOW      ALIGN
HEATER
```

7.3 Count Test Mode

Count test mode allows the operator to check the function of the detector and beta source separately from the rest of the mechanical tape movement or flow operations. Counting may be performed with or without the membrane in place. The operator can perform counts through filter paper alone or through paper plus the reference membrane. The counts are logged on the display for up to 6 counts before being overwritten. The Count test displays the beta detector counts every second for a standard period (typical period is 4 minutes). Data is not logged. The reference membrane may be fully extended or retracted between tests. The Count Test Menu is shown in Figure 39.

Figure 39: Count Test Screen

```
            COUNT TEST MODE
    <-
     TIME  COUNT M   TIME  COUNT M
    03:15  64736 N



 MEMBRN   NO MEMBRN    GO        EXIT
```

<- Indicates a withdrawn membrane, no membrane.

-> Indicates the membrane is in place.

TIME Indicates the time that the sample is started.

COUNT Indicates the total count during a four-minute period.

Y or **N** Indicates the membrane in place (Y) or the membrane not in place (N).

MEMBRN Use the associated key to put membrane in place, extended.

NO MEMBRN Use the associated key to remove membrane, withdrawn.

GO Starts the counting cycle, the counting will immediately begin. At the completion of the cycle the counting will stop and wait for the operator to initiate another cycle or EXIT.

7.4 Nozzle/Pump Test Mode

This test mode checks the components of the flow system. The Pump Test screen is shown in Figure 40.

Figure 40: Pump Test Screen

```
          NOZZLE/PUMP TEST MODE

NOZZLE:▼

FLOWRATE: 22.1 l/min  PUMP:  ON


MOVE NOZZLE  PUMP ON  PUMP OFF   EXIT
```

NOZZLE: Nozzle status; up (▲) or down (▼).

PUMP: Pump status; ON or OFF.

FLOWRATE: Flowrate value displayed in liters/minute.

MOVE NOZZLE This operation will move the nozzle up or down. The test allows for checking proper nozzle movement. Total elapsed time is about 5 seconds. If the pump is ON this operation is disabled.

PUMP ON This operation will move the nozzle to the down position and then turn ON the vacuum pump.

PUMP OFF This operation will turn the pump OFF.

7.5 Tape Test Mode

The Tape Movement tests allow semi-automatic control of the filter tape transport, either forward or backward in steps of 12.5 mm windows. The Tape Test screen is shown in Figure 41.

Figure 41: Tape Test Screen

```
          TAPE TEST MODE


X:       0 WINDOWS(S)
FEED:  10 MORE WINDOWS(S)


  FWD      BKWD                   EXIT
```

X: Displays the number of windows moved. The number of backward moves is displayed as a negative number (-).

FEED: An editable value for the number of windows to move. Use the up and down arrow keys to change this value the range is 1 to 10.

FWD This operation will move the filter tape forward the FEED number of windows.

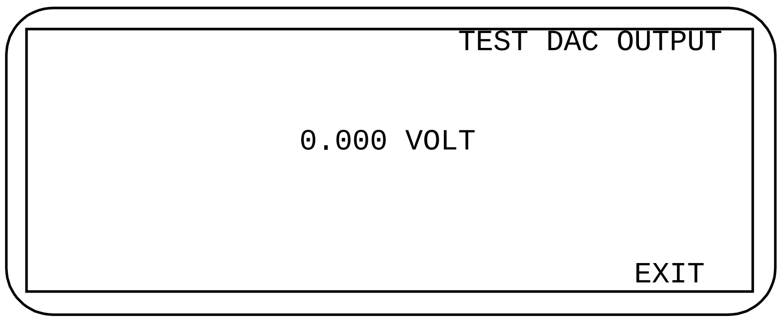
FWD This operation will move the filter tape backward the FEED number of windows.

7.6 Test DAC Output

The DAC test provides a simple way to verify the digital to analog conversion electronics and to verify correct data logger setup. The front panel display shows a keyboard-controllable voltage that the DAC is providing to the rear panel terminal strip.

Note: Use cursor keys to alter the values. Up/Dn steps the voltage in millivolt increments. Left cursor sets the output to zero. Right cursor sets the output to full scale. The DAC Output Test Menu is shown in Figure 42.

Figure 42: DAC Output Test Menu



7.7 Test Calibration Mode

The calibration test mode provides the operator the ability to perform a verification of the reference membrane calculation that occurs automatically every sample cycle. The same test could be performed in Count test mode, but without the mass density calculation. The Calibration test displays two beta counts, with and without the reference membrane. The reference membrane density m is then computed and displayed. Each BAM 1020 has an individually weighed membrane. This value is recorded in Appendix B as the ABS value. The calculated value from this procedure should be within 5% of the ABS value in Appendix B. Data is not logged. The total elapsed time is about 8.1 minutes. The Calibration Test Menu is shown in Figure 43.

Figure 43: Calibration Test Menu

```
          CALIBRATION MODE

REF MBRN: <
COUNT  (Io):        634000
COUNT  (I):         556234
CAL MASS M:         0.801 mg/m3

START     STOP                    EXIT
```

REF MBRN (Reference Membrane)

- <- Indicates a withdrawn membrane, no membrane in beta source path.
- -> Indicates the membrane is in the beta source path.

COUNT (I_0)

Indicates the total count during a four-minute period of filter paper.

COUNT (I)

Indicates the total count during a four-minute period of filter paper with the membrane installed.

CAL MASS M (Calibration Mass)

Calculated value of the membrane based on the preceding counts.

START

Starts the calibration cycle, the counting will immediately begin. After 4 minutes the counting of I_0 will stop the membrane will be installed and the count I will begin. At the completion of the cycle the counting will stop and the Calibration Mass of the membrane will be calculated.

7.8 Test Interface

The interface operations may be tested by scrolling the screen and toggle the highlighted functions. The Test Interface Menu is shown in Figure 44.

Figure 44: Test Interface Menu

```
                        TEST INTERFACE
          <---INPUTS--->
FAULT:    OFF       RESET:    OFF
          <---RELAYS--->
TAPE BREAK: OFF     FLOW ERROR:  OFF
DATA ERROR: OFF      MAINTENANCE: OFF
RANGE:      OFF
                                EXIT
```

FAULT

Indicates the condition of the TELEMETRY FAULT input, OFF is normal.

RESET

Indicates the condition of the EXTERNAL RESET, OFF is normal.

TAPE BREAK

Used to test the TAPE BREAK relay, activate the relay by pressing the up arrow key. When the operator exits from the screen the activated relay will be returned to the OFF position.

FLOW ERROR

Used to test the FLOW ERROR relay, activate the relay by pressing the up arrow key. When the operator EXITs from the screen the activated relay will be returned to the OFF position.

DATA ERROR

Used to test the DATA ERROR relay, activate the relay by pressing the up arrow key. When the operator EXITs from the screen the activated relay will be returned to the OFF position.

MAINTENANCE

Used to test the MAINTENANCE relay, activate the relay by pressing the up arrow key. When the operator EXITs from the screen the activated relay will be returned to the OFF position.

RANGE

Is not used in the BAM-1020.

7.9 Volumetric Flow Calibration

The screen is used for auditing and calibrating the volumetric flow system of the BAM 1020. The BAM can be calibrated to temperature, pressure and flow measurements from external auditing equipment. The Volumetric Flow Calibration screen is shown in Figure 45.

Note: This screen becomes available in the Test menu when the VOLUMETRIC flow type has been selected from the SETUP>CALIBRATE screen. The BAM must also be equipped with the volumetric flow hardware—BX-961. A Model 592 temperature sensor must be connected to back panel channel 6. Refer to Figure 61 of APPENDIX F for sensor hookup.

Figure 45: Volumetric Flow Calibration Screen

```
       ACTUAL FLOW CALIBRATION MODE
F1=RESTORE DEFAULT
                       BAM       REFERENCE
AMBIENT TEMPERATURE: 21.8C     21.8C
BAROMETRIC PRESSURE: 737mmHg   737mmHg
VOLUMETRIC FLOWRATE:  0.0l/min 16.7l/min

ADJUST/SAVE  NEXT     PUMP ON    EXIT
```

To perform a volumetric flow audit you will need reference temperature, pressure and flow meter equipment. Then follow these steps.

1. First, correct the BAM ambient temperature reading. Using a reference temperature sensor measure the temperature at the PM10 head. Enter the externally measured reference temperature value in the REFERENCE field. Use the up and down arrows to edit the field. Press the ADJUST/SAVE button to correct the BAM ambient temperature reading. The BAM and REFERENCE values should now be the same.
2. Press the NEXT button and repeat the same steps for barometric pressure.
3. After the temperature and pressure readings are correct remove the PM10 head (and PM2.5 SCC if installed) and place the flow audit cap (BX-305) with the reference flow meter on the inlet. On the BAM 1020 LCD press the PUMP ON button hot key. After the flow rate has stabilized (minimum of 5 minutes) compare the BAM volumetric flow rate against a reference flow meter connected to the BAM 1020 inlet. Take the reference flow meter value and enter it into the REFERENCE field. If the BAM volumetric flow rate is not the same as the reference flow meter correct the BAM reading by pressing the ADJUST/SAVE button.
4. Repeat step three until the reference flow meter and BAM flow are within 1%.

Is not used in the BAM-1020.

7.10 ALIGN SCREEN

This screen is used for auditing and checking the tape transport, reference membrane and nozzle mechanism of the BAM 1020.

The Alignment Test Mode Menu is shown in Figure 46.

Figure 46: Alignment Test Mode Menu

```
                     TEST MODE

NOZZLE    SHUTTLE    IDLER     CAPSTAN
LATCH     REF


SELECT                          EXIT
```

This is the top menu of the “Alignment” test modes of operation. It provides the gateway to six different individual tests, each of which highlights the operation BAM-1020 of one or two related photo interrupters. These tests are primarily used in factory setup of the mechanical portion of the BAM, but they are useful as troubleshooting aids as well.

NOTE: The tests in this section do not have motor timeouts or log errors. The tape should be removed to prevent breakage

TEST NOZZLE PHOTO SENSOR - FACTORY DIAGNOSTIC

The Test Nozzle Photo Sensor Factory Diagnostic Screen is shown in Figure 47.

Figure 47: Test Nozzle Photo Sensor Factory Diagnostic Screen

```
          TEST NOZZLE PHOTO SENSOR

          ON   S5 (Up)
          OFF  S4 (Down)



UP        DOWN      STOP          EXIT
```

This test allows the operator to check the ‘Up’ and ‘Down’ nozzle sensors by activating the nozzle motor under keyboard control.

TEST SHUTTLE PHOTO SENSOR - FACTORY DIAGNOSTIC

The Test Shuttle Photo Sensor Factory Diagnostic Screen is Figure 48.

Figure 48: Test Shuttle Photo Sensor Factory Diagnostic Screen

```
          TEST SHUTTLE PHOTO SENSOR

          ON   S7 (To Supply Side)



                                EXIT
```

This test allows the operator to check the tape transport "shuttle" sensors by displaying their outputs. No motor controls are provided, but the shuttle can be moved by hand for this test.

TEST SUPPLY IDLER PHOTO SENSOR - FACTORY DIAGNOSTIC

The Test Supply Idler Photo Sensor factory diagnostic screen is shown in Figure 49.

Figure 49: Test Supply Idler Photo Sensor Factory Diagnostic Screen

```
 TEST SUPPLY IDLER PHOTO SENSOR

  ON   S6 (Tensioned)
  OFF  S1 (Off = Tape Break)



                               EXIT
```

This test allows the operator to check the supply side idler under manual control.

TEST CAPSTAN PHOTO SENSOR - FACTORY DIAGNOSTIC

The Test Capstan Photo Sensor Factory Diagnostic Screen is shown in Figure 50.

Figure 50: Test Capstan Sensor Photo Diagnostic Screen

```
          TEST CAPSTAN PHOTO SENSOR

          ON S8 (At Window)



ADVANCE   BACKUP     STOP           EXIT
```

This test allows the operator to check the capstan motor movement of the tape without allowing the supply or take up motors to run. Keyboard control in both directions is provided.

TEST LATCH PHOTO SENSOR - FACTORY DIAGNOSTIC

The Test Latch Photo Sensor Factory Diagnostic Screen is shown in Figure 51.

Figure 51: Test Latch Photo Sensor Factory Diagnostic Screen

```
          TEST LATCH PHOTO SENSOR

          ON S9 (Latched)



                                EXIT
```

This test allows manual control of the tape latch to provide a front panel display of the corresponding photo interrupter.

TEST REFERENCE PHOTO SENSOR - FACTORY DIAGNOSTIC

The Test Reference Photo Sensor Factory Diagnostic Screen is shown in Figure 52

Figure 52: Test Reference Photo Sensor Factory Diagnostic Screen

```
          TEST REFERENCE PHOTO SENSOR

          ON   S3 (Withdrawn)
          OFF  S2 (Extended)


EXTEND    WITHDRAW    STOP       EXIT
```

This test allows the operator to check the 'Extended' and 'Withdrawn' membrane sensors by activating the reference membrane motor under keyboard control. EXTEND will attempt to move the reference membrane to the fully extended position. WITHDRAW will attempt to move the reference membrane to the fully withdrawn position. STOP turns off power to reference motor.

7.11 HEATER SCREEN

This screen is used for auditing and checking the Smart Heater Filter RH and Filter Temperature sensors.
The HEATER Menu is shown in Figure 53.

Figure 53: HEATER Menu RH

```
Heater Test

Calibration: RH
Pt  BAM    Ref    Save
1  xxx.x  xxx.x  xxx.x %        Save(F1)
2  xxx.x  xxx.x  xxx.x %        Save(F4)

Calibrate Heater ON    Default   Exit
```

This Screen is a Filter RH audit screen. Filter Temperature Audit screen is shown below.

Figure 54: HEATER Menu Temperature

```
Heater Test

Calibration: Temperature
Pt  BAM    Ref    Save
1  xxx.x  xxx.x  xxx.x C        Save(F1)
2  xxx.x  xxx.x  xxx.x C        Save(F4)

Calibrate Heater ON    Default   Exit
```

These screens are used to audit and calibrate the filter sensors.

Calibration: Select the sensor to calibrate either RH or Temperature.

PT: This is an abbreviation for point. Each sensor can be calibrated at two points.

BAM: This is the real time value for the selected sensor measured by the BAM-1020

Ref: This is the field to enter in the Reference measured value to calibrate the selected sensor.

Save: This saves the BAM real time value to the Ref entered value to recalculate a slope calibrated to the Ref value. Save command is executed by pressing the F1 or F4 Key.

Calibrate: When 1 or 2 points have been entered and saved this command recalibrates the sensor according to the Ref values entered by the user.

Heater ON: This command turns the Heater on to verify it is functioning correctly.

Default: This command restores the factory calibration for the selected sensor.

Audit - Remove the inlet from the top of the BAM-1020. Go to the TEST/PUMP screen and turn the PUMP on for 10 minutes. This will equalize the internal temperature and RH to the enclosure temperature and RH. Use a reference sensor to verify that the readings are within specifications. Temperature should be within 1 degree of reference. RH should be within 5% of the Reference.

Calibrate – The sensors will need to be removed from the flow stream. First, remove the BAM-1020 cover by removing the 12 screws on the top and sides of the BAM1020. Next, unplug the 3-pronged fitting in the flow system (it is connected directly into the back of the transport plate between two black motors) that holds the temperature and RH sensors. Pressing in on the retainer ring and sliding the tubing out unplugs the fittings in the flow system. See the fitting on the back of the BAM-1020 where the pump tube connects. Once the sensors are removed calibrate each one per the site SOP.

Met One suggests a single point calibration for the RH by comparing the BAM-1020 RH to a reference. Then enter the reference value into line 1 Ref value and press Save and then Calibrate. Met One suggests a two point calibration for the temperature sensor. Compare the reference sensor and the BAM-1020 sensor at room conditions. After an equilibration period enter the reference value in line1 under Ref and press Save. Place the reference sensor and the BAM-1020 in an ice bath. Enter the value for the reference in line 2 under Ref and press Save and then Calibrate.

8 COMMUNICATIONS

8.1 Analog

Analog outputs of the BAM-1020 are selectable and may be set for isolated voltage (0-1 Vdc or 0-10 Vdc) and isolated current (4-20 or 0-16 mA). Rear panel dipswitch is used to make selection, analog signal is located on rear panel. The full-scale value of both outputs is determined by the concentration range setting in the INTERFACE SETUP screen.

SW1 OFF	=	0-1 Vdc
SW1 ON	=	0-10 Vdc
SW2 OFF	=	0-16 mA
SW2 ON	=	4-20 mA

Note: SW3 and SW4 are not used.

ERROR REPORTING, ANALOG OUTPUT
In some cases it is desirable to indicate instrument malfunction directly on the output channel. This type of error indication is used when the operator is limited to a single voltage channel for particulate information. When the analog errors are set, the normal analog concentration output will be put at maximum output when one of the selected errors occurs. Analog errors are set by selecting each error from the list in section 4.16. When an error occurs the output signal goes to full scale, but the digital value is unchanged and may be recovered using either the display or RS-232 connection.

8.2 Telemetry and Error Relay

Connections are provided on rear panel to allow the full use of the BAM-1020 Telemetry Controls and Alarm Relays. The BAM-1020 may be used with external data logger in a synchronous mode of operation. Typically the data logger will provide a contact closure at the top of the hour to begin a new cycle. There are five relays that indicate error conditions.

1. TAPE FAULT
2. FLOW ERROR
3. DATA ERROR
4. MAINTENANCE ERROR
5. POWER FAIL

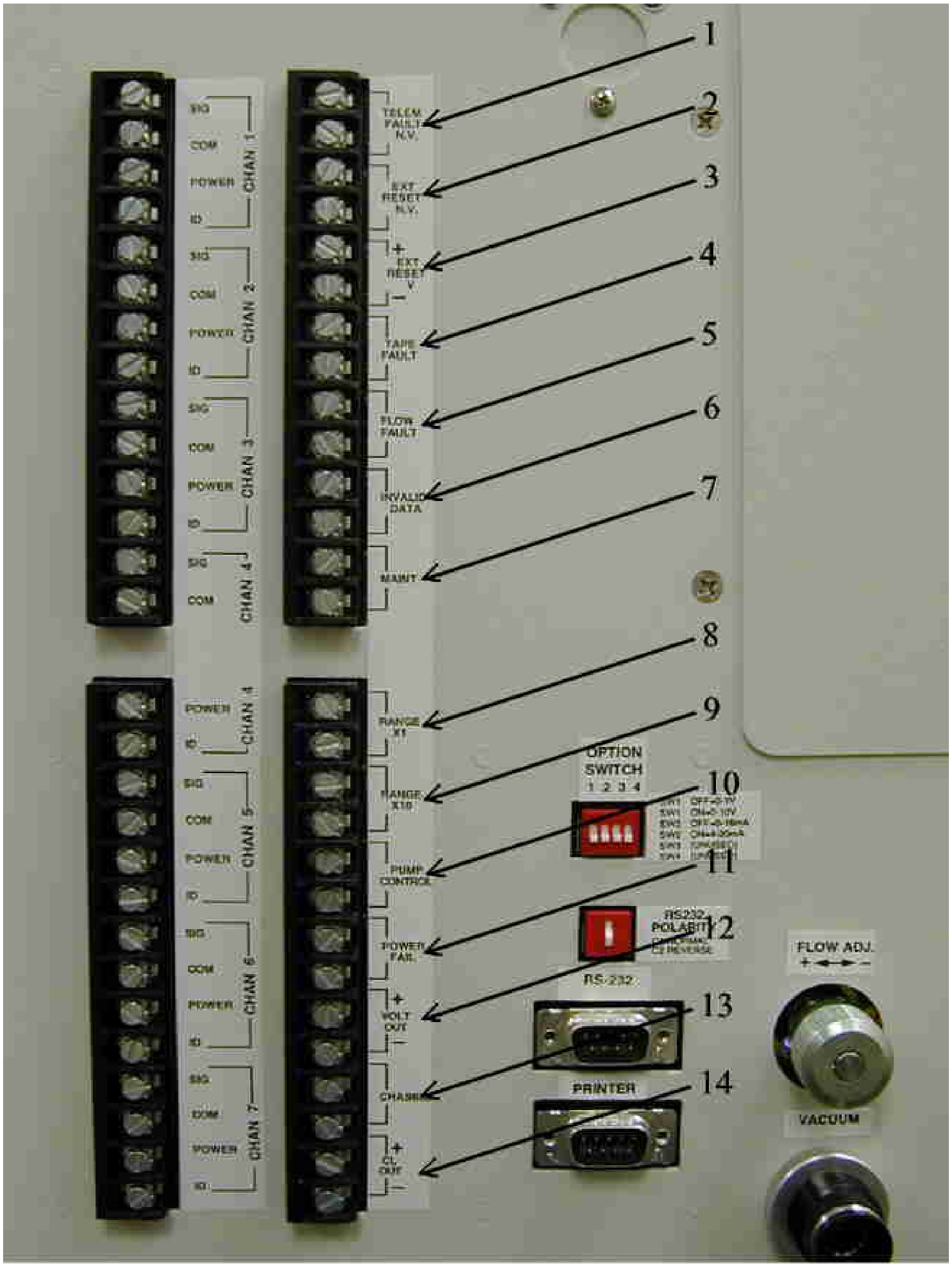
When an error condition occurs during a cycle, the following actions are taken:

1. Error Message is printed
2. Related error relay is activated (closed).
3. Error is flashed on the status line of the LCD display.

4. The analog output is forced to full scale (See section 4.16).

NOTE: Errors are reset at the top of the hour, or when the cycle is stopped.

Figure 55: Telemetry Connections



1. TELEM FAULT NV (Telemeter Fault Non Voltage, contact closure input)

The fault input signal indicates that the external telemeter system is not operational. The unit will continue to cycle. The input is a contact-closure type. Polarity of the signal can be selected in the SETUP>INTERFACE screen, section 4.18.

When a telemeter fault occurs, the unit will log an error message. Operation and data logging will continue. The status display will indicate a telemeter fault condition. As a result of the fault signal, the data error relay will be activated. The fault signal must be present for a minimum of 2 seconds.

2. EXT RESET NV (External Reset Non Voltage, contact closure input)
3. EXT RESET V (External Reset Voltage, voltage input)

The BAM-1020 accepts an external reset signal. There are two types of inputs available on the back panel: Voltage or contact closure input. The reset signal must be present for a minimum of 2 seconds. Polarity of the signal can be selected in the SETUP>INTERFACE screen, section 4.18. The operation of the reset signal is described in section 4.18.

4. TAPE FAULT (Normally Open)

Indicates a tape path error, such as broken tape, tape tension or capstan latch setting.

5. FLOW FAULT (Normally Open)

Indicates the flow is out of bound. Bound limits are set by the ERRORS screen of section 4.16.

6. INVALID DATA (Normally Open)

Activated on the following errors: Pressure loss is greater than 460 mm-Hg (300 Torr).

7. MAINT (Maintenance)

A normally open contact closure activated when the measurement cycle is off, or the unit is placed in a SETUP, TEST or TAPE screens. Relay will also be activated if the FORCE MAINT field is on. (See SETUP>INTERFACE screen, section 4.18).

8. RANGE X1

The Range Relay reflects the range setting of the unit as set in the SETUP>INTERFACE screen; this range relay is only capable of showing the normal 0-1.000-mg/m3 range. If the range switch is in any other position the X10 relay will be activated. The function of the Range Relay is to indicate proper operating range according to EPA approval.

9. RANGE X10

The Range X10 indicates operation in a range other than 0-1.000 mg/m^3. And when used in conjunction with two-range firmware will indicate operation in the 0-10.000 mg/m^3 range.

10. PUMP CONTROL

Connection to low voltage controller for pump control.

11. POWER FAIL (Power Failure, contact closure)
    Power failure is driven from internal +5 Volt power supply. This contact will open when the unit is first powered up. If the power fails the contacts are closed.

12. VOLT OUT
    See section 8 for options and details.

13. CHASSIS
    Grounding connections

14. CL OUT (CURRENT LOOP OUT)
    See section 8 for options and details.

8.3 RS-232 Communications

Printers, computers and modems may be connected to the RS-232 ports on the rear panel.

Serial interface #1 handles data transfer and instrument operation status. This interface is often used with modem for remote communications. For ease of operation this terminal is supplied with a switch to select ‘modem’ or ‘computer’ operation. The switch and connections are located on the rear panel. Recorded data may be retrieved using the RS-232 communications serial port when used with a PC (section 8.4), Data Transfer Module (section 8.7), or Modem (section 8.5).

Serial interface #2 is output only and may be used with serial printer or computer. Output may be set for date, time, data printout or may be set to one of three diagnostic modes (Refer to Appendix D, command a.).

Software packages include AutoMet Report, Air Plus and MicroMet Plus.

The BAM-1020 may also be used with simple terminal software to retrieve data and setup station parameters. Specific communications features include; setting of the Date, Time, erasing the BAM-1020 memory, binary downloading of data, and the ability to view the current BAM-1020 setups. Any simple PC communications or terminal program can also be used for monitoring of the system or collection of recorded data. Access to the BAM-1020 is a simple menu driven interface. The menus allow reports to be viewed directly in ASCII form. Refer to section 8.6 for details of the menu system. To verify the RS-232 connection to the BAM-1020 unit, press the <Enter> key until the command prompt appears; the asterisk character: *****. If not, verify the cabling and communications settings.

Note: The LCD screen of the BAM-1020 will not operate when communications over the RS-232 line are in process. If the operator is using the BAM-1020 locally and the display is in one of the sub-menus, the RS-232 data line is disabled. Therefore, the BAM-1020 should be left in the main menu when RS-232 communications are expected.

NOTE: Communications between the PC and the BAM-1020 will not occur until the display is in top menu position.

8.4 Direct PC Connection

The BAM-1020 can easily be connected to any standard PC that has an extra RS-232 port available for communications (COM1 to COM4). Simply connect the cable from the BAM-1020 to the 9-pin RS-232 COM port connector on the host computer. If the computer has the older style 25-pin connector, install a 9 to 25-pin adapter.

NOTE: The BAM-1020 communicates at 9600 Baud, 8 bit, no parity, one stop (9600 8N1).

CAUTION—Do not confuse the computer parallel printer port or video adapter connectors as RS-232 COM ports. Connecting to these will cause damage to your computer and/or the equipment being connected to it. If in doubt, consult the owner's manual of the computer, or check with your computer supplier before making any connections.

To verify the RS-232 connection to the BAM-1020 unit, press the <Enter> key until the command prompt appears; the asterisk character: *****. If not, verify the cabling and communications settings. If still unable to communicate, try changing the DIP SWITCH (located directly above the RS-232 connector) position.

8.5 Modem Option

Connect the Met One Instrument Modem to the serial port #1. Note: the polarity dipswitch must be in the correct position for communication. If communication is not possible reverse the position of the dipswitch. It is strongly recommended that the Met One Instrument Modem be used as it is designed to reliably communicate when other modems will not.

If you are using one of the Met One Instruments data acquisition programs such as MicroMet Plus or MicroMet AQ you need only enter the telephone number of the site in the system setup menu of the program. They provide a very easy to use graphical windows interface for communications and data collection from the BAM-1020. Multiple telephone numbers can be entered for connection to multiple remote sites.

If you are communicating with a terminal program such as the Windows 3.1X program TERMINAL or using the WIN95 program HYPERTERMINAL you will have already defined the modem configuration in the setup of the computer. It may be necessary to set the baud rate to 9600, with 8 data bits, no parity, and 1 stop bit. Use the terminal program or other communications package internal dialing command sequence to dial up the BAM-1020. To verify the RS-232 connection to the BAM-1020 unit, press the <Enter> key until the command prompt appears; the asterisk character: *****. If not, verify the cabling and communications settings. Once connected the access to the BAM-1020 is a simple menu driven interface. The menus allow reports to be viewed directly in ASCII form.

8.6 Menu System

To verify the RS-232 connection to the BAM-1020 unit, press the <Enter> key until the command prompt appears; the asterisk character: *****. If not, verify the cabling and communications settings. If still unable to communicate, try changing the DIP SWITCH (located directly above the RS-232 connector) position.

Display the System Menu by typing the “?” or "H" keys. The following menu should display:

```
* H
--------------------------------------
|   > BAM-1020 <     System Menu      |
--------------------------------------

Select One of the Following:

0 - None
1 - Display Current Day Data
2 - Display All Data
3 - Display New Data
4 - Display System Configuration
5 - Display Date / Time
6 - CSV File Output
        2 - All Data
        3 - New Data
7 - Display last 100 errors
8 - Display > BAM-1020 < Utility Commands
9 - Display Pointers

   Press <Enter> to Exit a Selection

*
```

By typing one of the number keys, the associated function will be performed.
See Appendix C for command details.

Utility commands for binary data transfers and maintenance are reached by typing “8”. See Appendix D for command details.

```
* 8
 > BAM-1020 < Utility Commands:

ASCII Commands:

c     - Clear Data Memory (Password required)
d     - Set Date (Password required)
e     - Display Hex EEPROM Setup Values
f     - Factory Calibration Tests
h,H,? - Display > BAM-1020 < System Menu
i     - Display ID Values
m     - Display Hex Data Memory Values
p     - Modify Modem Pointer
q     - Display Station ID
t     - Set Time (Password required)

BINARY Commands:

b     - XMODEM Download of Data
r     - XMODEM Download of Real Time Values
x     - XMODEM Download of EEprom Values

*
```

8.7 Transfer Module

Please refer to Universal Transfer Module Manual, P/N UX-961-9800

9 TROUBLESHOOTING

9.1 Problem Index

Most problems with the BAM-1020 can be determined with the simple five-step check below. These checks will direct the operator to the problem and then to the remedy. Please make yourself familiar with the SELF TEST in Section 4.9.

9.1.1 The Display is Not Operational

Make sure that the plug is connected to an operational electrical circuit. Verify that the rear panel switch is ON. Check the fuses inside of the power switch.

Contrast setting may not allow the display to be seen, press the contrast control key (Contrast control key is located on the BAM1020 front panel. It is on the left side and appears as a circle colored half white and half black) and watch the screen contrast change.

9.1.2 Does Not Appear to Operate

Once started the BAM-1020 will begin a cycle when the internal clock is at 00 minutes (top of the hour). No activity should be expected until the clock reaches the top of the hour (minutes = 00). Make sure that the unit is either in the top menu or in one of the OPERATE menus. Press EXIT and verify that “OPERATE; ON” is displayed, if not then go to Section 4.10 for STARTING.

9.1.3 Is Making “Beep” Sounds

The BAM-1020 wants to operate and if it cannot it will beep. Beeping will not occur if the unit is in the SETUP or TEST modes. Beeping will occur if the unit is any OPERATE screen or the top menu and the OPERATE mode is OFF, or if the OPERATE mode is ON and there is an error occurring.

9.1.4 Does Not Pass the Self Test

Note the error and correct using the error information in Appendix G.

9.1.5 Output is Always Reading Full Scale

The output is always full scale, settings of ERROR control the analog output and will force the analog output to full scale if an error occurs. Use the Recall Error function in Sections 4.16 and 5.2.

9.2 Troubleshooting

A basic troubleshooting guide is shown in Table 6.

Table 6: BAM-1020 Troubleshooting Guide

Symptom	Checkpoint	Probable Cause	Remedy
Will not operate	Power switch Line Cord/Plug Fuse F1 Power Source Power switch	Switch "OFF" Loose/Broken Fuse Blown Main Breaker No power	Switch "ON" Reinstall Replace Reset Breaker Replace
Vacuum pump will not operate	LCD (Main menu) Wiring	Not in Operation Mode Poor connection	Turn unit on Tighten Connection
Operation Mode ON, but no action	Circuit board at connector	Connector loose	Reinstall
No tape moving	Capstan	Pinch rollers up	Lower them onto paper
Torn paper edge	Capstan Take up spool Loading methods	Misalignment Missing core tube Improper handling	Reload paper Install core tube Proper handling
Torn tape and bunched paper	Shuttle photo interrupter on rear of transport	Blocking shuttle transport wiring harness	Free shuttle travel Replace interrupter
Motor not stopping at correct position	Capstan, nozzle, membrane	Defective photo interrupter	Replace
"Corona" around sample area collar	Sample spots Nozzle Nozzle tip	Clogged inlet or loose nozzle, debris on nozzle	Clean out sample line, lower and tighten Remove debris
Flow Error	PM_{10} inlet Sampling station Vacuum pump	Hose leak Vanes worn	Reinstall Replace vanes

No counting	LCD, Count test	Detector of HVDC Beta source position 3150-1 circuit board, HV Threshold	Replace Unblock it Replace Assembly
High concentration reading	Inlet tube, nozzle	Condensation	Heat inlet
High reference mass reading	Membrane holder	Travel impeded	Call Service
Time incorrect after power down	LCD, Top Menu	3230-4 CPU	Replace battery
Bad pressure	LCD, Operation Mode	3250-1 Interface	Correct jumps

10 MAINTENANCE AND CALIBRATION

10.1 Met One Suggested Periodic Maintenance

10.1.1 Periodic Function Checks

1. Data logger Verification. Review data logger current concentration value with the concentration displayed on the BAM 1020 LCD. These values should be within 2 ug/m3.
2. Error Check. Make sure the BAM 1020 is in the top menu (Press the exit Hot key until it is no longer available). Press F3 key. This will recall the last 10 errors recorded by the BAM 1020. Review the error and decide corrective action. See Sections 4.16, 5.2, and 9.2.

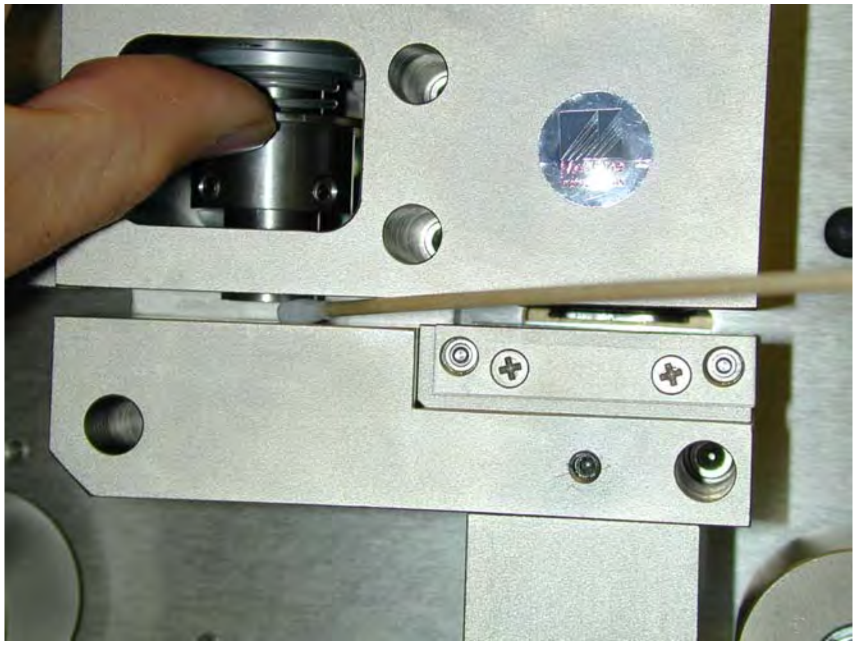
10.1.2 Monthly Intervals

1. Perform an inlet flow check to ensure sampler flow rate is correct. Flow should be measured with the PM10 head removed and flow audit cap in place of the PM10 head. If flow has an error greater than +/-3% recalibration is necessary. See Section 6 for flow calibration procedures.
2. Visual Inspection. Open the front cover of the BAM 1020. Check for sufficient filter tape. One roll will last for 2 months. Check for condensation near the sample/Tape interface. Clean any build up of dust inside the cover area and on the top of the BAM 1020.

10.1.3 Two (2) Month Intervals

1. Replace filter tape. See section 4.7 for filter tape replacement.
2. Clean the PM10 Head. BX-344 provides all the necessary items to clean the PM10 inlet. The PM10 inlet requires removal from the inlet tube, disassembly and cleaning. Disassemble the PM10 inlet and wipe clean with lint free cloth. Ensure that all Oring surfaces are in excellent shape and are re-installed correctly. If Orings are damaged see Appendix 10.3 for replacement parts.
3. Clean the PM2.5 SCC. The PM2.5 SCC inlet requires removal from the inlet tube, disassembly and cleaning. Disassemble the SCC and wipe clean with lint free cloth. Ensure that all ‘O’ ring surfaces are in excellent shape and are re-installed correctly. . If Orings are damaged see Appendix 10.3 for replacement parts.
4. Clean the inlet nozzle and nozzle area. The inlet nozzle on the BAM 1020 can have a build up of filter paper in one or more spots. This build up may eventually cause holes to be punched in the filter tape. Symptoms of punched tape can cause the BAM 1020 to have erroneous negative concentration values and flow readings that are incorrect. The nozzle and vane should be cleaned each time the filter tape is replaced. Figure 56 shows the procedure to clean the nozzle.

Figure 56: Nozzle Cleaning



Tools Required – Cotton Swabs, Flashlight and ISO Alcohol.
Remove the filter tape from the BAM1020 see page 30 of the manual. Lower the Nozzle. In the BAM1020 main menu press TEST. In the TEST menu select PUMP and lower the nozzle. Lift the Nozzle by pressing with your thumb on the spring tensioner above the nozzle lip. Place a Cotton swab with ISO alcohol under the nozzle and lower the nozzle onto the cotton swab. Slowly rotate the Nozzle assembly. Eight to ten rotations will clean the nozzle. The Vane (this is the cross piece that sits under the filter paper where the nozzle contacts the filter paper) also needs to be cleaned. In the TEST/PUMP screen lift the nozzle. The Vane can be viewed by removing the inlet tube and looking down the inlet tube while shining a flashlight into the nozzle/vane area. Use a sharp tool (dental pick) to gently scrape the outside circumference of the vane to remove any filter paper build up. Next scrape the cross hair piece to remove any accumulation of paper. Finally, clean the entire area with a cotton swab and alcohol.

10.1.4 Semiannual Interval

1. Replace the muffler on the Pump. This is very important to extend the life to the Low noise pump. Check the model of pump and find the replacement part in section 10.3 of the manual.
2. Complete Calibration of the flow system. Calibrate the Ambient Temperature sensor, pressure sensor and flow meter per section 6. Note: depending on the BAM 1020 configuration a temperature sensor may not be included.

10.1.5 Twelve to Twenty-Four (12-24) Month Intervals

1. Check and replace carbon vanes in pump. No maintenance is required for the Medo low noise pump.
2. Clean the inlet system. See BX-341 option.

10.2 Calibration Settings

Calibration is established at the factory, do not change the calibration information without information from the factory regarding new settings. The two flow variables Cv and Qo may be changed according to Section 6.

If it is determined that settings should be changed then the SETUP MODE, CALIB menu is used by the operator to modify the BAM-1020 calibration settings, repeat these settings should not be changed without specific information from the manufacturer. For example, information would accompany a replacement detector assembly and would require use of the Factory Calibration Screen shown in Figure 57.

Figure 57: Factory Calibration Screen

```
                 SETUP MODE
          CALIBRATE
Cv        1.000     Qo         0.021
FLOW TYPE: METERED  FLOW RATE 16.7
ABS       0.805     µsw        0.285
K         1.000     BKGD      -0.009

SAVE                             EXIT
```

10.3 Consumables, Replacement Parts and Accessories

10.3.1 Consumables

Description	Met One Part Number
Filter Paper	460130
Muffler for Medo Pump	580293
Muffler for Gast Pump	580293
Internal Pisco Filter	580291
Internal Pisco Filter – Element only	580292
Pump Rebuild Kit Gast	680820

10.3.2 Replacement Parts

Description		Met One Part Number
Pump Controller		BX-839
Power Supply		
	115 VAC 60 HZ	BX-115
	115 VAC 50 HZ	BX-116
	230 VAC 60 HZ	BX-230
	230 VAC 50 HZ	BX-231
	100 VAC 60 HZ	BX-100
	100 VAC 50 HZ	BX-101
Pump		
	100 VAC 60 HZ	BX-123
	115 VAC 50/60 HZ	BX-121
	115 VAC 50/60 HZ Low Noise	BX-126
	230 VAC 50 HZ	BX-122
	230 VAC 60 HZ	BX-124
	230 VAC 50/60 HZ Low Noise	BX-127
Flow Meter 0-20 LPM		970608
Flow Control Assembly		8776
PM10 Head Oring		
	Approx 1” dia for inlet tube connection	720084
	Approx 2.5” dia for PM10 head	760079
LCD Assembly		2823
Detector		3150-1
CPU Printed Circuit Board		3230-4
Interface Circuit Board		3250-1
Motor 4 RPM		8105
Motor 10 RPM		8106

10.3.3 Accessories

Description	Met One Part Number
Environmentally Enclosed Pump	
115 VAC 50/60 HZ	BX-131
230 VAC 60 HZ	BX-134
230 VAC 50 HZ	BX-132
Inlet System – Mounting Flanges, Inlet Tube Etc.	BX-801
PM10 Inlet Head (EPA – Style)	BX-802
PM10 Inlet Head (EU – Style)	BX-809
TSP Sampling Inlet	BX-803
PM2.5 Sharp Cut Cyclone	BX-807
PM2.5 WINS Impactor	BX-804
Inlet Extension 8 feet with coupler	BX-823
Inlet Extension (specify Length)	BX-801S
Automatic Flow Control	BX-961
Inlet Adapter for Flow Calibration	BX-305
Ambient Temperature Sensor	BX-592
Filter Temperature and RH sensor	BX-962
Inlet Heater Tape 115 VAC	BX-825
Inlet Heater Tape 230 VAC	BX-826
Smart Heater 115 VAC	BX-827
Smart Heater 230 VAC	BX-830
Inlet Tripod for Roof Mounting	BX-828
Low Range Calibration Kit	BX-306
Mid Range Calibration Kit	BX-301
Zero Calibration Kit	BX-302
Gravimetric Calibration Kit	BX-304
Mass Flow Calibration Kit	BX-303
Volumetric Flow Calibration Kit	BX-307
Real Time Module for BAM Inlet	BX-894
Inlet Tube Cleaning Kit	BX-341
PM10 Head Cleaning Kit	BX-344
Serial Printer	BX-601
Converter for Parallel Printers	BX-602
Exterior Enclosure	BX-902
Temperature Controlled Exterior Enclosure	BX-903
Service Tool Kit	BX-308
Diagnostic Kit	BX-342

APPENDIX A

Table 7: Measurement Specifications

Parameter	**Specification**
Principle	Relative concentration by Beta Attenuation
Reference Method	Gravimetric Method
Range:	0-0.100, 0.200, 0.250, 0.500, 1.000, 2.000, 5.000, 10.000 mg/m^3
Accuracy (24 hours)	± 2 µg with concentration range from 0.000 mg to 0.100 mg/m^3 (24 hour mode) 2 % with concentration range from 0.100 mg to 1.000 mg/m3
Accuracy (one hour)	± 8 µg with concentration range from 0.000 mg to 0.100 mg/m^3 (1 hour mode) ± 8% with concentration range from 0.100 mg to 1.000 mg/m^3
Resolution:	± 1 µg/m3
Span Stability (1 month)	± 1%, verified with built-in calibrator
Minimum Reading	± 1 µg/m3 (± 0.001 mg/m^3)
Calibration	Automatic Internal membrane calibration provides SPAN test. Membrane is activated automatically every hour, deviations from standard are logged.
Measurement Cycle	1 hour standard, or set by operator with range of 1 minute to 200 minutes. Special time cycles available.
Beta Measurement	C-14, 60 µCi (< 2.22×10^6 Bq) source, Half life of 5730 years
Detector:	Plastic Scintillation Probe
Filter Tape	Continuous glass fiber filter, 30mm wide by 21meters long, single roll will operate for 60 days @ 1 Hr Sample Period
Flow Rate:	16.7 liters/minute (standard), may be adjusted from 0-20 LPM
Flow system	Measured using mass flow meter.
Sample Pump	1/3 Hp Rotary Gast Pump (standard)
Heated Flow System	There are two optional Heater types available. These are the BX-825/BX-826 or BX-827/BX830 option (110V/230V).
Approvals	US EPA, United Kingdom, Korea, Japan, China

Table 8: BAM-1020 Human Interface Elements

Parameter	Specification
Display and Keypad	8 line by 40 character wide display, provides all operational, calibration, and setup parameters with menu prompts and cursor control. Keypad contains the four prompt keys, four cursor keys and six function keys.
Display Functions	LCD Screen with 8 X 40 characters, and controlled back lighting MENU DRIVEN screens for SETUP, OPERATE, TEST
Analog output	0-1 VDC or 0-10 Vdc, switch selectable, (isolated type) 4-20 or 0-16 mA output, switch selectable, (isolated type)
Serial Interface #1	Data transfer and instrument operation status. This interface is often used with modem for remote communications.
Serial Interface #2	Serial interface #2 is output only and may be used with printer or computer. Output may be set for date, time, data printout or may be set to one of two diagnostic modes. Used by technicians to service instruments.
Printer	Serial printer may be connected to Serial Interface #2, optional serial to parallel interface cable may be used with standard parallel printers.
Printer, external	80 column serial printer optionally available
Telemeter	External timer in (isolated) Telemeter fault in (isolated)
Alarm contact closure	Invalid data error Tape fault Flow error Power failure Maintenance
Software	May be used with any terminal program and most of Met One's software packages
Errors	Filter Tape Broken, Calibration Flow Rate, Pressure, Count. See Section 4.16 for complete listing.
Logged Data	Concentration (mg/m^3) at sample rate
Total Memory	30-200 days depending on sample period
Outputs	Read RS-232 Data (from BAM-1020 remote site)

Table 9: BAM-1020 Physical Parameters

Operating Temperature Range	0-40 °C (0-90% RH, non condensing) 5-40 °C tested in EU designation testing
Extended temperature range	-30° to +60 °C (0-90% RH, non condensing)
Power Supply Voltage/Frequency	100/115/230 VAC, power supply is changed with internal switch, 50 or 60 Hz, manually selected inside of unit
Weight:	21 Kg (46.3 pounds) approximate, excludes pump
Dimensions	(H)x(W)x(D) (14 3/8")x(19")x(18") (36.5) x (48.3) x (45.7) cm
Detector Control Unit Total System with Pump (Gast) and Heater Pump (Medo) and Heater	75 VA Approx. 780 VA Approx. 370 VA
Field Calibration	Is best performed with collocated reference samplers with subsequent gravimetric evaluation.

APPENDIX B

Factory calibration data.

Date: ________________

Serial Number: ________________

Flow Calibration

Cv: ________________ EPA SLPM per mm-Hg

Qo: ________________ EPA SLPM

Reference Membrane Calibration

μ_{sw}: ________________ cm^2/mg

ABS: ________________ mg/ cm^2

Concentration Calibration

K: ________________

BKGD: ________________ mg/ cm^3

E1: ________________ mg/ cm^3

APPENDIX C

RS-232 COMMAND SUMMARY

1 - Display Current Day Data
Display today's data only

2 - Display All Data
Display all the data stored in the memory

3 - Display New data
Display data that was not previously retrieved

4 - Display System Configuration
General information screen providing some of the Unit setup values, example shown below:

```
* 4
------------------------------------------------------
|     > BAM 1020 <  SETUPS   02/10/1996   06:43:05      |
------------------------------------------------------

BAM Sample Time: 015 Minute(s)
MET Sample Time: 05  Minute(s)
ABS: 0.805
mu: 0.285
K: 0.950
BKGD: -0.009
Cv Qo: 2.622 0.000
E1 E2 E3 E4: -0.005 0.500 0.000 15.000
DAC Mask: = 0x03ff
Ap FRl FRh: = 150.000 10 20
Cp Cm I% F%: = 50.000 -20.000 99 99
RS232: 9600 N 8 1
Firmware Ver: 2.03.03
Station ID: 01
Channel Identification:
Channel              01     02     03     04     05     06
Type     Conc   Qtot   no     no     no     no     no     AT
Units    mg     m3     V      V      V      V      V      C
Mult     1.000  3.000  1.000  1.000  1.000  1.000  1.000  080.0
Offset  -0.005  0.000  0.000  0.000  0.000  0.000  0.000 -030.0
```

5 - Display Date / Time
Current date and time of the unit.

6 - CSV DATA Output

    2 - All DATA
    3 - New DATA

7 - Display Last 100 Errors
Shows all errors and times of occurrences

8 - Display > < Utility Commands
Sub-Menu for down-loading data and setup of the unit.

9 - Display Pointers
This is a display of the current status of the data storage memory. The current pointer position and number of full memory locations is shown.

APPENDIX D

RS-232 UTILITY SUB-COMMANDS SUMMARY

ASCII Commands:

NOTE: The password used in the utility commands is equivalent to the numeric sequence of the function keys used for the password entered on the unit keyboard (i.e. sequence F1 F2 F3 F4 would be 1234).

a - RS-232 Port #2 Function Select (THIS IS NOT VISIBLE COMMAND!)

Sets the 2nd port to operate in diagnostics or printer mode

1 - Printer Port
2 - Standard Diagnostic
3 - Factory Diagnostic
4 – Comma Separated Data Output Port
5 - Cancel

c - Clear Data Memory (Password required)

This is a destructive command. Activation will erase all data stored in the memory. Password is required.

d - Set Date (Password required)

Set the Date of the Unit. The password is required.

e - Display Hex EEPROM Setup Values

Used for diagnostic purposes. Displays the special memory locations where the setups are stored.

f - Factory Calibration Tests

Used for factory calibration only - not recommended for field use

h,H,? - Display > < System Menu

Displays the main menu.

i - Display ID Values

Used for diagnostic purposes. Displays the ID (Identification) codes of the MET sensors.

m - Display Hex Data Memory Values

Used for diagnostic purposes. Displays the data memory locations.

p - Modify Modem Pointer

(Contact Met One Instruments for details)

q - Display Station ID

Shows preset station identification number.

t - Set Time (Password required)

Set the Time of the Unit. The password is required.

BINARY COMMANDS

b - XMODEM Download of Data

XMODEM is a standard binary data transfer protocol. The command allows binary transfer of the data stored in the AutoMet unit memory. AutoMet Report uses this command for data down-loading. (Note: This command requires software handshaking and is a not recommended for terminal software operation).

r - XMODEM Download of Real Time Values

Download Real Time allows quick scanning of the instantaneous values of the sensors, alarms, and other settings. AutoMet Report uses this command for the Logger Monitor screen. (Note: This command requires software handshaking and is not recommended for terminal software operation).

x -XMODEM Download of EEprom Value

Download EEPROM allows quick scanning of the non-volatile EEPROM memory (For diagnostic purposes).

APPENDIX E

DISPLAY CURRENT DAY DATA

TYPICAL REPORT

Report for 12/09/99 - Day 343 > < Station ID: 1

Channel				01	02	03	04	05	06
Sensor		Conc	Qtot	no	no	no	no	no	no
Units	<Errors>	mg/m3	m3	V	V	V	V	V	V
00:00	------------	0.011	0.800	000.0	000.0	000.0	000.0	000.0	000.0
01:00	------------	0.014	0.800	000.0	000.0	000.0	000.0	000.0	000.0
02:00	------------	0.013	0.800	000.0	000.0	000.0	000.0	000.0	000.0
03:00	------------	0.016	0.800	000.0	000.0	000.0	000.0	000.0	000.0
04:00	------------	0.013	0.800	000.0	000.0	000.0	000.0	000.0	000.0
05:00	------------	0.014	0.800	000.0	000.0	000.0	000.0	000.0	000.0
06:00	------------	0.016	0.800	000.0	000.0	000.0	000.0	000.0	000.0
07:00	------------	0.018	0.800	000.0	000.0	000.0	000.0	000.0	000.0
08:00	------------	0.019	0.800	000.0	000.0	000.0	000.0	000.0	000.0
09:00	------------	0.018	0.800	000.0	000.0	000.0	000.0	000.0	000.0
10:00	------------	0.016	0.800	000.0	000.0	000.0	000.0	000.0	000.0
11:00	------------	0.014	0.800	000.0	000.0	000.0	000.0	000.0	000.0
12:00	------------	0.011	0.800	000.0	000.0	000.0	000.0	000.0	000.0
13:00	------------	0.012	0.800	000.0	000.0	000.0	000.0	000.0	000.0
14:00	------------	0.014	0.800	000.0	000.0	000.0	000.0	000.0	000.0
15:00	------------	0.011	0.800	000.0	000.0	000.0	000.0	000.0	000.0
16:00	------------	0.014	0.800	000.0	000.0	000.0	000.0	000.0	000.0
17:00	------------	0.015	0.800	000.0	000.0	000.0	000.0	000.0	000.0
18:00	------------	0.018	0.800	000.0	000.0	000.0	000.0	000.0	000.0
19:00	------------	0.020	0.800	000.0	000.0	000.0	000.0	000.0	000.0
20:00	------------	0.016	0.800	000.0	000.0	000.0	000.0	000.0	000.0
21:00	------------	0.014	0.800	000.0	000.0	000.0	000.0	000.0	000.0
22:00	------------	0.011	0.800	000.0	000.0	000.0	000.0	000.0	000.0
23:00	------------	0.009	0.800	000.0	000.0	000.0	000.0	000.0	000.0
Savg		0.015	0.800	000.0	000.0	000.0	000.0	000.0	000.0
Vavg		0.000	0.000	000.0	000.0	000.0	000.0	000.0	000.0

Data Recovery 100.0 %

The BAM-1020 logs the data, as well as the error code conditions during the BAM-1020 cycle. The report format is as follows:

02:00 ------------ -0.000 0.000 000.0 0.000 0.000 0.000 0.000 020.1
03:00 EUMILRNFPDCT -0.000 0.000 000.2 0.001 0.001 0.001 0.003 020.2

Presence of a letter indicates that there is an error or flag for that parameter. Error letter codes are defined in section 4.16.

APPENDIX F

Series 500 Sensor Wiring Connections to the BAM-1020

The scaling and setups values as well as the wiring schemes of the series 500 Sensors are provided in this Section. The cable hookup to the BAM-1020 unit is on the rear external surface. Refer to the diagram in the BAM-1020 Operators Manual that shows the external connections to the BAM-1020. Follow the procedure below to hookup sensor(s) to any of the six available channels on the BAM-1020 (channels 3-8).

Enter the SETUP CHAN PARAMS screen and using the Up/Down arrow keys, select a channel not being used (channels 3-8).
Press ID Mode and change Auto ID to MANUAL
Refer to the table below to determine Multiplier, Offset, and Full Scale Voltages. Using the Up/Down arrow keys, you can convert the units from English to Metric and enter the new values.
Once these elements have been set in the BAM-1020 then press SAVE
Now you are ready to begin collecting information

Table 10 shows the BAM-1020 Scaling and Setup information.

Table 10: BAM-1020 Scaling and Setup Values

Sensor Parameters				Datalogger					MMP Software	
Type	**Model**	**Units**	**Range**	**Mult**	**Offset**	**FS VOLT**	**S/V**	**Inv Slope?**	**Mult**	**Offset**
WD	590	Deg	0 to 360	360	0	1.0	V	N	900	0
WS	591	mph	0 to 100	100	0	1.0	S	N	250	0
		m/s	0 to 44.704	44.70	0	1.0	S	N	111.76	0
AT	592	^{0}F	-22 to +122	144	-22	1.0	S	N	360	-22
		^{0}C	-30 to +50	80	-30	1.0	S	N	200	-30
RH	593	%	0 to 100	100	0	1.0	S	N	250	0
BP	594	inHg	26 to 32	6	26	1.0	S	N	15	26
		mm-Hg	660.4 to 812.8	152.40	660.40	1.0	S	N	381.00	660.40
		mbar	880.5 to 1083.7	203.19	880.46	1.0	S	N	507.98	880.46
SR	595	Ly/ min	0 to 2	2	0	1.0	S	N	5	0
		W/M2	0 to 2000	2000	0	1.0	S	N	5000	0

The following figures are the wiring connections for the 500 Series of Sensors that can be hooked up to the BAM-1020. The Sensors are options that can be purchased from Met One Instruments. Consult Met One Instruments for more information.

Figure 58: Analog Terminal Block

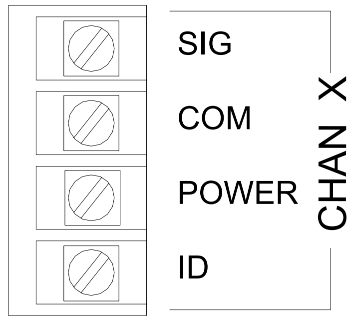


Figure 59: 590 Wind Direction Sensor Hookup

Terminal Block	Cable Wire Color
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

Figure 60: 591 Wind Speed Sensor Hookup

Terminal Block	Cable Wire Color
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

Figure 61: 592 Ambient Temperature Probe Hookup

Terminal Block	Cable Wire Color
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

Figure 62: 593 Relative Humidity Sensor Hookup

Terminal Block	Cable Wire Color
SIG	Yellow
COM	Green/Shield
POWER	White
ID	Red

Figure 63: 594 Barometric Pressure Sensor Hookup

Terminal Block	Cable Wire Color
SIG	White
COM	Black/Shield
POWER	Red
ID	Yellow

Figure 64: 595 Solar Radiation Sensor Hookup

Terminal Block	Cable Wire Color
SIG	Yellow
COM	Black/Shield
POWER	Red
ID	Green

APPENDIX G

ERROR HANDLING

ERRORS

The BAM-1020 provides continuous display of such variables as pressure and flow rate. Errors are logged in memory and are available with the RS-232 terminal port.

Motor Timeouts

Operation of the transport motors may take longer than a maximum amount of time if the motors stick or the filter tape breaks. This will abort the movement operation and assert the appropriate error bits (TAPE BREAK, NOZZLE STUCK, REFERENCE MEMBRANE STUCK). Timeout definitions are listed below. Tape movement is assumed to be one window only.

Motor	Function	Timeout (Sec)
M1	NOZZLE	10
M2	REF MEMBRN	15
M3	SUPPLY	10
M4	TAKE UP	10
M5	CAPSTAN	5

Error Logging

A 100-error log is maintained in the memory, showing the date and time of occurrence. The remote host can retrieve this error log.

Logged Error Definitions

COUNT ERROR: less than 10,000 COUNTS / 4 MINUTES

PRESSURE ERROR: Pressure drop > AP

FLOW RATE ERROR: |Q -16.7| Ž F% of 16.67

CALIBRATION ERROR: |m - ABS |Ž 0.05

(DEVIATION Ž 5%)

TAPE BREAK ERROR

Sensor S6 is continuously ON, regardless of drive commands to motors M3-M5.

NOZZLE STUCK ERROR

Sensors S4 and S5 never change state, regardless of drive commands to nozzle motor M2.

REFERENCE MEMBRANE STUCK ERROR

sensors S2 & S3 never change state, regardless of drive commands to reference motor M1.

POWER FAILURE ERROR

Power interruption, any time period.

Read This First!

BAM-1020-9800 Addendum

This addendum discusses the firmware revision 3.0.0 items not included in the BAM-1020-9800 Rev E manual.

Met One Instruments, Inc
1600 Washington Blvd.
Grants Pass, Oregon 97526
Telephone 541-471-7111
www.metone.com

1. Standard Conditions

This update supports three (3) standard conditions in which to report concentration.

1. 0 C, 760 mmHg
2. 20 C, 760 mmHg
3. 25 C, 760 mmHg

The standard condition selection is determined by the `Std Temp` setting located in the `SETUP/CALIBRATE` screen. The selections are `0 C`, `20 C`, or `25 C`.

For example, to report your concentration in standard conditions of 0 C, 760 mmHg, set the `Flow Type` to `STD` and the `Std Temp` to `0 C`.

```
Calibrate Setup
               Heater Control: AUTO
Flow Rate: 16.7     Flow Type: STD
       Cv:  1.000          Qo: 0.000
      ABS:  0.805         usw: 0.285
        K:  1.000        BKGD: 0.000
 Std Temp: 25 C
   SAVE                          EXIT
```

2. Ambient Pressure Readout

In previous revisions of firmware the pressure reading was reported as absolute pressure. This revision reports the pressure reading as ambient pressure. The ambient pressure reading is updated only when the pump is off. When the pump is on, the pressure reading displayed is the last reading before the pump was turned on. The ambient pressure reading, `Amb P`, is viewed from the `OPERATE/NORMAL` screen.

```
04/03/2006     Normal Mode      09:38:19
                     Flow(STD):  0.0 LPM

LAST C: 0.995 mg/m3      Amb P: 760 mmHg
LAST m: 0.000 mg/cm2        RH: 45%
                        Heater: OFF

Status: SAMPLING                 EXIT
```

3. Future Firmware Upgrades

This update supports provisions to upgrade future revisions of BAM-1020 firmware via the RS232 serial port of your personal computer. This means firmware upgrades can now be sent to you by email. The upgrade procedure will be made available at the next firmware upgrade.

Firmware Revision 3.1.0
Read This First!

BAM-1020-9800 Addendum

This addendum discusses the firmware revision 3.1.0 items not included in the BAM-1020-9800 Rev E manual.

Met One Instruments, Inc
1600 Washington Blvd.
Grants Pass, Oregon 97526
Telephone 541-471-7111
www.metone.com

Table of Contents

1. Flash Upgrade

When upgrading the firmware from 3.0.0 to 3.1.0 by either the Flash Update Utility program or by replacing the chip do the following.

Before the update process:

1. Download and save data and error logs before proceeding with the flash update process because the process will clear the data and error logs.
2. Record the `SETUP/SAMPLE OFFSET` setting value to be used later.

After the update process:

3. The RS232 baud rate will be set to 38400. Reset as appropriate.
4. Recalibrate the filter temperature (`TEST/FILTER-T`) and RH (`TEST/RH`) sensors.
5. Reset the `SETUP/SAMPLE OFFSET` setting value recorded earlier.
6. Set the `SETUP/SAMPLE CONC UNITS` setting value.
7. Set the `SETUP/CALIBRATE CONC TYPE` setting value.
8. Set the `SETUP/CALIBRATE FLOW TYPE` setting value.

2. Top Screen

This update changes the layout of the top screen.

```
05/18/2006      BAM 1020        09:21:18
             3236-02 3.1.0

    LAST CONC: 0.012 mg/m3
         FLOW:  16.7 LPM
       STATUS: ON

  SETUP    OPERATE     TEST      TAPE
```

Line 2, `3236-02 3.1.0`, displays the firmware part number and revision number.

Line 4, `LAST CONC`, displays the concentration measurement for the last hour. The concentration units are either `mg/m3` or `ug/m3`. The concentration units are selected in the `SETUP/SAMPLE` screen by changing the `CONC UNITS` field.

Line 5, `FLOW`, displays the real time sample flow. The flow units are either `LPM` or `SLPM`. The type of flow control selected determines the flow units. The flow control type is selected in the `SETUP/CALIBRATE` screen by changing the `FLOW TYPE` field.

Line 6, `STATUS`, displays the operational status and error conditions.

Line 7, if an ambient temperature probe is required but not connected then this message is displayed: `MISSING TEMP PROBE`.

3. CAUTION STOP SAMPLING

This screen is presented when attempting to go to the `SETUP`, `TEST`, and `TAPE` menu screens. Going to these screens requires the unit to stop sampling. Pressing the `YES` key will stop the unit from sampling and display the `SETUP`, `TEST`, or `TAPE` menu screen. Pressing the `NO` key will return to the Top screen. No key presses for 5 seconds will automatically return to the Top screen.

```

            >>> CAUTION <<<
     CONTINUING TO THE NEXT SCREEN
   REQUIRES THE BAM TO STOP SAMPLING.

       STOP SAMPLING: YES OR NO?

   YES                            NO
```

4. Concentration Units

The units of concentration may be displayed in either `ug/m3` or `mg/m3`. The concentration units are determined by the `CONC UNITS` setting on the `SETUP/SAMPLE` screen (Line 7).

```
                            SETUP SAMPLE

RS232 38400 8N1     BAM SAMPLE  050 MIN

STATION #  01       MET SAMPLE  01  MIN
RANGE   1.000 mg    OFFSET   -0.005 mg
CONC UNITS ug/m3
   SAVE                          EXIT
```

5. Concentration Resolution

The resolution of the concentration value now depends on the concentration units setting.

For a concentration units setting of `mg/m3` the display resolution is 3 (99.999) for all ranges.

For a concentration units setting of `ug/m3` the display resolution is 0 (99999) for all ranges.

6. WARNING RANGE/OFFSET Change

When either the `RANGE` or `OFFSET` setting parameter (Line 6) changes the concentration values stored in the data log are incorrect.

```
                            SETUP SAMPLE

RS232 38400 8N1     BAM SAMPLE  050 MIN

STATION #  01       MET SAMPLE  01  MIN
RANGE   1.000 mg    OFFSET   -0.005 mg
CONC UNITS ug/m3
   SAVE                          EXIT
```

When the SAVE key is pressed and either the RANGE or OFFSET parameters have changed the user will be prompted with this screen.

```
           >>> WARNING <<<
    CHANGING THE RANGE OR OFFSET
   SETTINGS REQUIRES THE DATA LOG
       MEMORY TO BE CLEARED!

    CLEAR THE DATA LOG: YES OR NO?

   YES                            NO
```

Press the YES key to save the changes and clear the data log.

Press the NO key to not save the changes and NOT clear the data log.

7. Baud Rate

The RS232 baud rate setting (Line 2) now supports 19200 and 38400 bps. The RS232 setting is located in the SETUP/SAMPLE screen.

```
                            SETUP SAMPLE

RS232 38400 8N1     BAM SAMPLE  050 MIN

STATION #  01       MET SAMPLE  01  MIN
RANGE   1.000 mg    OFFSET   -0.005 mg
CONC UNITS ug/m3
   SAVE                          EXIT
```

8. Set Time Command

The RS232 set time command (t) can now also set the time to the nearest second. Setting to the nearest minute is still supported.

```
* t

Enter Password (Function Key #'s): 1234
Time: 18:55  X4193: 16:55:12

Time: 16:55:12  X0843

*
```

9. Concentration Reporting

The `Conc Type` setting (Line 3) determines which type of air volume is used to calculate concentration. The two (2) settings are `STD` and `ACTUAL`.

The `Flow Type` setting (Line 3) determines which type of flow to regulate to. The three (3) settings are `METERED`, `STD` and `ACTUAL`. The `METERED` setting is used when no flow controller is present.

If the `Conc Type` or `Flow Type` is set to `ACTUAL` then it is required that the ambient temperature probe be connected to the unit.

When the `SAVE` button is pressed and the ambient temperature probe is required but not connected the `MISSING TEMP PROBE` message is displayed on the screen.

```
CALIBRATE SETUP       MISSING TEMP PROBE
                      FLOW RATE: 16.7
  CONC TYPE: STD      FLOW TYPE: ACTUAL
         Cv:  1.000          Qo: 0.000
        ABS:  0.805         usw: 0.285
          K:  1.000        BKGD: 0.000
   STD TEMP: 25 C        HEATER: AUTO
   SAVE                          EXIT
```

During operation when the operate mode is on and the pump is on and the `Conc Type` is `ACTUAL` or the `Flow Type` is `ACTUAL` then if a probe is not connected an error event is stored in the Error log. This error event sets the F bit.

10. Test Menu

Two (2) items have been added to the `TEST` menu—`FILTER-T` and `RH` (Line 5). These screens are use to calibrate the filter temperature and RH probes. The functions were previously located in the `HEATER` screen.

```
TEST MENU

COUNT     PUMP      TAPE      DAC
CALIBRATE INTERFACE FLOW      ALIGN
HEATER    FILTER-T  RH


 SELECT                          EXIT
```

11. Heater Test

Use the HEATER TEST screen to test the operation of the heater. This screen requires the password to enter.

```
HEATER TEST


HEATER STATUS: OFF




    ON                           EXIT
```

Press the ON hot key to turn on the heater. The ON key label will change to OFF.

```
HEATER TEST


HEATER STATUS: ON




    OFF                          EXIT
```

Press the OFF hot key to turn off the heater. The OFF key label will change to ON. On EXIT the heater is turned off.

12. Filter Temperature Calibration

The filter temperature sensor is calibrated from this screen. This screen requires password to enter.

When the screen is entered the nozzle is raised, the pump turned on and the REFERENCE is set to the BAM reading.

To calibrate enter your REFERENCE reading and press CALIBRATE.

To remove the calibration press RESET.

The pump is turned off on EXIT.

```
FILTER TEMPERATURE CALIBRATION


      BAM: -99.9 C
REFERENCE: -99.9 C


CALIBRATE    RESET               EXIT
```

The calibration equation is as follows.

Offset = Reference – Uncalibrated Temperature

Calibrated Temperature = Uncalibrated Temperature + Offset

13. RH Calibration

The filter RH sensor is calibrated from this screen. The calibration requires that the filter tape be removed.

This screen requires password to enter.

When the screen is entered the nozzle is raised, the pump turned on and the `REFERENCE` is set to the `BAM` reading.

To calibrate enter your `REFERENCE` reading and press `CALIBRATE`.

To remove the calibration press `RESET`.

The pump is turned off on `EXIT`.

```
RH CALIBRATION


      BAM: 100.0 %
REFERENCE: 100.0 %


CALIBRATE    RESET               EXIT
```

The calibration equation is as follows.

Offset = Reference – Uncalibrated RH

Calibrated RH = Uncalibrated RH + Offset

14. Settings Report

The setting report (RS232 command, `4 - Display System Configuration`) has been updated and reformatted. Following is the new settings report.

```
BAM 1020 Settings Report
06/07/2006  14:19:45

     Station ID, 1

       Firmware, 3236-02 3.1.0

              K, 01.000
           BKGD, 00.000
            usw, 00.285
            ABS, 00.805
          Range, 1.000
         Offset, -0.005
          Clamp, -0.005
     Conc Units, mg/m3
      Conc Type, STD

             Cv, 01.000
             Qo, 00.000
      Flow Type, METERED
     Flow Setpt, 0016.7
       Std Temp, 25
      Temp Mult, 1.0000
      Pres Mult, 1.0000
      Flow Mult, 1.0000
High Flow Alarm, 20
 Low Flow Alarm, 10

      Heat Mode, MANUAL
       Heat OFF, 20
        RH Ctrl, NO
       RH SetPt, 99
         RH Log, NO
        DT Ctrl, NO
       DT SetPt, 99
         DT Log, NO

     BAM Sample, 50
     MET Sample, 60
     Cycle Mode, STANDARD
 Fault Polarity, NORM
 Reset Polarity, NORM
    Maintenance, OFF

   EUMILRNFPDCT
   000000000000

             AP, 000150
      Baud Rate, 9600
 Printer Report, 2
             e3, 00.000
             e4, 15.000
```

```
      Channel,       1,       2,       3,       4,       5,       6,
    Sensor ID,     255,     255,     255,     255,     255,     255,
   Channel ID,     255,     255,     255,     255,     255,     255,
         Name,  XXXXX,   XXXXX,   XXXXX,   XXXXX,   XXXXX,   XXXXX,
        Units,     XXX,     XXX,     XXX,     XXX,     XXX,     XXX,
         Prec,       0,       0,       0,       0,       0,       0,
     FS Volts,  1.000,   1.000,   1.000,   1.000,   1.000,   1.000,
         Mult,  1.000,   1.000,   1.000,   1.000,   1.000,   1.000,
       Offset,  0.000,   0.000,   0.000,   0.000,   0.000,   0.000,
  Vect/Scalar,       S,       S,       S,       S,       S,       S,
    Inv Slope,       N,       N,       N,       N,       N,       N,

             ,  Offset,
       RH Cal,   0.000,
       FT Cal,   0.000,
```

Firmware Revision 3.2.0
Read This First!

BAM-1020-9800 Addendum

This addendum discusses the firmware revision 3.2.0 items not included in the BAM-1020-9800 Rev E manual.

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Table of Contents

1. Flash Upgrade

When upgrading the firmware from 3.x.0 to 3.2.0 by either the Flash Update Utility program or by replacing the chip do the following.

Before the update process:

1. Download and save data and error logs before proceeding with the flash update process because the process will clear the data and error logs.
2. Record the `SETUP/SAMPLE OFFSET` setting value to be used later.
3. Record the `SETUP/CALIBRATE BKGD` setting value to be used later.

After the update process:

4. The `RS232` baud rate will be set to `38400`. Reset as appropriate.
5. Recalibrate the filter temperature (`TEST/FILTER-T`) and RH (`TEST/RH`) sensors.
6. Reset the `SETUP/SAMPLE OFFSET` setting value recorded earlier.
7. Set the `SETUP/SAMPLE CONC UNITS` setting value.
8. Set the `SETUP/SAMPLE COUNT TIME` setting value.
9. Set the `SETUP/CALIBRATE CONC TYPE` setting value.
10. Set the `SETUP/CALIBRATE FLOW TYPE` setting value.
11. Reset the `SETUP/CALIBRATE BKGD` setting value recorded earlier.

2. Beta Count Time

The beta count time is now selectable.

The beta count time selection is located on the SETUP/SAMPLE screen.

The field name is COUNT TIME with selections of 4, 6, or 8 minutes.

```
                              SETUP SAMPLE

RS232 38400 8N1     BAM SAMPLE  050 MIN

STATION #  01       MET SAMPLE  01  MIN
RANGE   1.000 mg    OFFSET   -0.005 mg
CONC UNITS ug/m3    COUNT TIME   4  MIN
   SAVE                          EXIT
```

When the SAVE button is pressed and the recommended BAM SAMPLE time for a corresponding COUNT TIME does not match you will be prompted with a recommended BAM SAMPLE time. The recommended sample times are shown in the table below.

COUNT TIME	BAM SAMPLE
4	50
6	46
8	42

```
             >>> CAUTION <<<
     FOR A COUNT TIME OF 4 MINUTES
            THE RECOMMENDED
     BAM SAMPLE TIME IS 50 MINUTES.

   CHANGE THE BAM SAMPLE TIME TO 50?

   YES                            NO
```

Press YES to change the BAM SAMPLE time and save all SAMPLE screen changes. Press NO to not change the BAM SAMPLE time but save all other SAMPLE screen changes.

3. Sensor Failures

Sensor failure criteria are applied to the ambient temperature, beta temperature, and ambient pressure sensors.

3.1. Ambient Temperature Sensor Failure

The ambient temperature sensor is checked for failure if either the `CONC TYPE` or `FLOW TYPE` is set to `ACTUAL`. The failure is only checked during the sample period when the pump is on. The sensor has failed when the 1-minute average reading is less than minus 29.0 C or greater than plus 49.0 C. The failure event is logged once per sample cycle as a `FLOW` error (F).

3.2. Ambient Pressure Sensor Failure

The ambient pressure sensor is checked for failure at the end of the I0 and I3 count periods. The sensor has failed when the average reading for the beta count period is less than 487.5 mmHg (650 hPa) or greater than 774.2 mmHg (1032 hPa). The failure event is logged once per sample cycle as a `FLOW` error (F).

3.3. Beta Temperature Sensor Failure

The beta temperature sensor is checked for failure at the end of each beta count period (`I0`, `I1`, `I2`, `I1x` and `I3`). The sensor has failed when the average reading for the beta count period is less than 0 C or greater than 60 C. The failure event is logged once per sample cycle as a `BT FAILURE` error. This error will not flag the data in the data logger.

4. BKGD Edit Resolution

The BKGD resolution is increased from 3 to 4 places after the decimal point.

```
CALIBRATE SETUP
                      FLOW RATE: 16.7
  CONC TYPE: STD      FLOW TYPE: ACTUAL
         Cv:  1.000          Qo: 0.000
        ABS:  0.805         usw: 0.285
          K:  1.000        BKGD: 0.0000
   STD TEMP: 25 C        HEATER: AUTO
   SAVE                          EXIT
```

5. Concentration Report

A ‘z’ RS232 command was added to configure the PRINTER port to report the concentration at the end of a sample period. This report could be used to interface to data loggers using a serial port.

The report parameters are date, time, concentration, and sample air volume (Qtotal). The format is fixed width.

The format in mg/m3 is: `MM/DD/YY HH:mm:ss,+99.999,+9.999`
The format in ug/m3 is: `MM/DD/YY HH:mm:ss,+999999,+9.999`

Here is an example for each concentration units (mg/m3, ug/m3).

```
MM/DD/YY HH:mm:ss,+00.015,+0.835
MM/DD/YY HH:mm:ss,+000015,+0.835
```

or

```
MM/DD/YY HH:mm:ss,-00.001,+0.835
MM/DD/YY HH:mm:ss,-000001,+0.835
```

The time stamp for STANDARD cycle mode will be the top of the next hour. An example is if the concentration calculation occurs in hour 2 then the format is.

```
MM/DD/YY 03:00:00,+00.015,+0.835
```

The time stamp for EARLY cycle mode will be minute 55, second 00 for the current hour. An example is if the concentration calculation occurs in hour 2 then the format is.

```
MM/DD/YY 02:55:00,+00.015,+0.835
```

The ‘z’ command can be found in the Utility Commands menu (8 command) as shown below.

```
 > BAM 1020 < Utility Commands

ASCII Commands:

c      - Clear Data Memory (Password required)
d      - Set Date (Password required)
e      - Display Hex EEPROM Setup Values
f      - Factory Calibration Tests
h,H,? - Display > BAM 1020 < System Menu
i      - Display ID Values
m      - Display Hex Data Memory Values
p      - Modify Modem Pointer
q      - Display Station ID
t      - Set Time (Password required)
z      - Enable concentration report to PRINTER output
```

Firmware Revision 3.2.1b

Read This First!

BAM-1020-9800 Addendum

This addendum discusses the firmware revision 3.2.1b items not included in the BAM-1020-9800 Rev E manual and in pervious Addendums (3.0.0, 3.1.0, 3.2.0)

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Table of Contents

1. Overview

This specification outlines the scope of BAM 1020 firmware upgrade from 3.2.0 to 3.2.1b. Read this Addendum in conjunction with the BAM 1020-9800 Rev. E Operation manual and Addendum 3.0.0, 3.1.0 and 3.2.0.

2. Top Screen

This update changes the layout of the top screen.

```
05/18/2006      BAM 1020        09:21:18
             3236-02 3.2.1b

    LAST CONC: 0.012 mg/m3
         FLOW:  16.7 LPM
       STATUS: ON

  SETUP    OPERATE     TEST      TAPE
```

Line 2, `3236-02 3.2.1b`, displays the firmware part number and revision number.

Line 4, `LAST CONC`, displays the concentration measurement for the last hour. The concentration units are either `mg/m3` or `ug/m3`. The concentration units are selected in the `SETUP/SAMPLE` screen by changing the `CONC UNITS` field.

Line 5, `FLOW`, displays the real time sample flow. The flow units are either `LPM` or `SLPM`. The type of flow control selected determines the flow units. The flow control type is selected in the `SETUP/CALIBRATE` screen by changing the `FLOW TYPE` field.

Line 6, `STATUS`, displays the operational status and error conditions.

Line 7, if an ambient temperature probe is required but not connected then this message is displayed: `MISSING TEMP PROBE`.

3. Concentration Offset

Change the concentration offset low range from `-0.005` to `-0.015`.

The `OFFSET` parameter range is `-0.015` to `0.005`.

The `OFFSET` default is `-0.015`.

```
                           SETUP SAMPLE

RS232 38400 8N1      BAM SAMPLE  050 MIN

STATION #  01        MET SAMPLE  01  MIN
RANGE   1.000 mg     OFFSET   -0.015 mg
CONC UNITS ug/m3     COUNT TIME   4  MIN
   SAVE                           EXIT
```

Note: changing either the `RANGE` or `OFFSET` parameter will require that the data logger memory be cleared.

The following table shows the low and full scale data logger values. It also shows the ug resolution per storage bit. The data logger dynamic range is 4095 bits.

OFFSET (mg)	RANGE (mg)	Low Scale (mg)	Full Scale (mg)	ug / bit
-0.015	0.100	-0.015	0.085	0.02
-0.015	0.200	-0.015	0.185	0.05
-0.015	0.250	-0.015	0.235	0.06
-0.015	0.500	-0.015	0.485	0.12
-0.015	1.000	-0.015	0.985	0.24
-0.015	2.000	-0.015	1.985	0.49
-0.015	5.000	-0.015	4.985	1.22
-0.015	10.000	-0.015	9.985	2.44

3.1. Low Concentration Limit (e1)

Change the Low Concentration Limit (e1) low range from `-0.005` to `-0.015`.

The `Low Concentration Limit` parameter range is `-0.015` to `0.010`.

The `Low Concentration Limit` default is `-0.015`.

```
                      SETUP MODE EXTRA 1

e1: Low Concentration Limit      -0.015
e2: Not Used                      0.500
e3: Membrane OFF Delay (Sec)      0.000
e4: Membrane Time Out (Sec)       15.00

   SAVE                           EXIT
```

4. Daily Report

Changed the daily report (Command 1, 2, and 3) beginning and end report times to 00:00:01 – 24:00:00 (previously 00:00:00 – 23:59:59). This has been done to synchronize the report now with the actual daily values. Following is an example.

Report for 11/19/2006 - Day 323 > BAM 1020 < Station ID: 1

Channel			01	02	03	04	05	06
Sensor	Conc	Qtot	XXXXX	XXXXX	PRESS	RH	FT	AT
Units	ug/m3	m3	XXX	XXX	mmHg	%	C	C
01:00 ----L-------	00185	0.000	0.000	00000	738.3	016.9	046.1	016.8
02:00 ----L-------	00185	0.000	0.000	00000	738.4	016.1	045.6	016.0
03:00 ------------	00010	0.700	0.000	00000	738.4	015.3	045.1	015.8
04:00 ------------	00010	0.700	0.010	00000	738.6	018.0	044.9	016.4
05:00 ----L-------	00185	0.000	0.000	00000	738.9	017.0	045.0	016.1
06:00 ------------	00009	0.700	0.000	00000	739.2	015.9	044.9	015.4
07:00 ----L-------	00185	0.000	0.000	00000	739.6	017.1	044.5	014.5
08:00 ------------	00007	0.700	0.000	00000	740.1	018.0	044.3	015.7
09:00 ------------	00007	0.700	0.007	00000	740.5	018.6	044.7	017.9
10:00 ------------	00008	0.700	0.007	00000	740.7	016.0	046.0	022.5
11:00 ------------	00009	0.700	0.008	00000	740.5	016.1	048.0	024.4
12:00 ------------	00010	0.700	0.009	00000	740.5	014.3	050.2	026.5
13:00 ------------	00010	0.700	0.010	00000	740.4	012.7	051.9	025.9
14:00 ------------	00009	0.700	0.010	00000	740.0	012.5	052.2	025.4
15:00 ------------	00010	0.700	0.009	00000	739.6	014.0	052.2	025.4
16:00 ----L-------	00185	0.000	0.000	00000	739.3	013.6	052.1	024.6
17:00 ------------	00002	0.700	0.000	00000	738.9	013.8	052.2	027.5
18:00 ------------	00005	0.700	0.002	00000	738.7	013.5	052.8	027.7
19:00 ------------	00005	0.700	0.005	00000	738.7	013.3	053.1	026.4
20:00 ------------	00002	0.700	0.005	00000	739.0	014.3	051.3	021.7
21:00 ------------	00003	0.700	0.003	00000	739.1	015.2	049.9	019.2
22:00 ------------	00003	0.700	0.003	00000	739.4	015.4	048.8	018.3
23:00 ------------	00003	0.700	0.003	00000	739.9	015.5	047.3	016.9
00:00 ------------	00003	0.700	0.003	00000	739.5	017.9	045.5	015.9
Savg	00044	0.554	0.004	00000	739.4	015.5	048.3	020.5
Vavg	00000	0.000	0.000	00000	00000	00000	00000	00000

Data Recovery 100.0 %

In Line **Savg** you will find the calculated 24h averages for the day shown on top of the table. The Line **Vavg** is a vector average connected Sensors delivering vector information like for instance a wind direction sensor.

The Value **Data recovery** tells the availability of the instrument for that day. In columns 01-06 the average values for the connected Sensors are shown.

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TEMPERATURE SENSOR
MANUAL

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592-9800 Rev B

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Technical Support

Should you require support, please consult your printed documentation to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours—7:30 a.m. to 4:00 p.m. Pacific Standard Time, Monday through Friday.

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Table of Contents

1.0 Introduction

1.1 The Model 592 Temperature Sensor is mounted in a radiation shield; refer to Figure 1-1. Concentric enameled aluminum plates to reflect solar energy shield the temperature sensor. The shields are designed to greatly reduce errors due to direct solar radiation and reflected terrestrial radiation. The shield is naturally aspirated by normal wind conditions.

1.2 The radiation shield containing the temperature sensor mounts onto a Met One Instruments type 191 cross arm or other 1-in diameter horizontal boom such as the Met One Instruments type 193 universal boom.

1.3 The Model 592 is supplied with a standard 15-ft cable with 4-pin connector for direct input on the Automet Data Logger. For connection to other instruments the connector can be cut off or the sensor can be ordered without the connector. See Figure 3-1 for wire color and pin connections from the sensor. If supplied less connector, use the appropriate wire colors.

1.4 These sensors are very durable, and field proven devices;

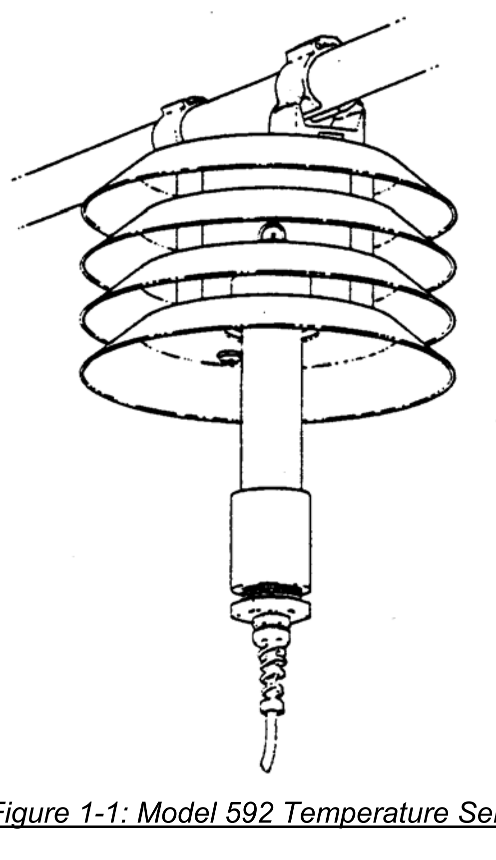

Figure 1-1: Model 592 Temperature Sensor

2.0 Specifications

Performance

Temperature Range: Standard	-30° to +50° C (-22° to +122° F)
Optional	-50° to +50° C (-58° to +122° F)
Accuracy: Standard	± 0.15° C
Optional	± 0.1° C
Linearity	± 0.15° C
Time Constant	10 seconds in still air

Electrical Characteristics

Input Power	12V DC at 4mA typical
Output	0-1 Volts for -30° to +50° C 0.5-1 Volts for -50° to +50° C
Output Impedance	100 Ohms maximum
Maximum Line Length	100-ft (consult factory if longer line is to be used)

3.0 Wiring Connections

3.1 The following connections are available for the 592 Temperature Probe. The Sensor requires 12 VDC power for operation. The output is typically 0 to 1 volt for input to data logger or other device. There is also an ID line, which is used by the various "Smart" data logger systems such as the Automet and the BAM-1020 Particulate Monitor. The output is used to automatically program the logger for the installed sensor, eliminating the need for the user to program the logger.

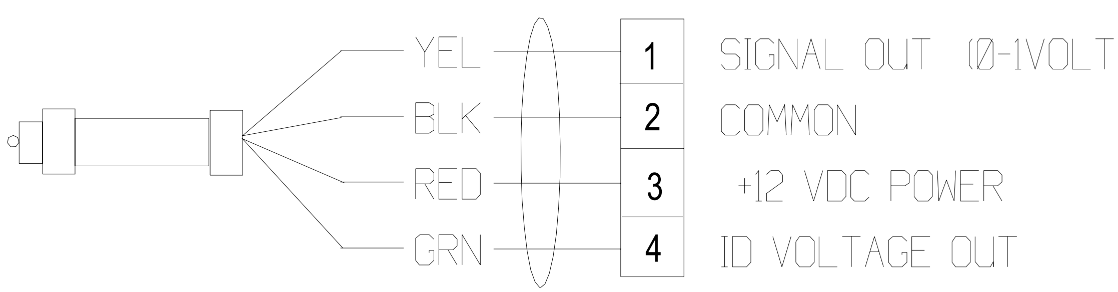

Figure 3-1:Temperature Probe and Connector Wiring

4.0 Calibration Check

4.1 A simple calibration check can be performed using an ice bath. The probe can be removed from the shield and tested in the ice bath. It may be necessary for the probe to be water proofed using a plastic or rubber cover over the section of the probe immersed in the water and ice mixture. At 0° C or 32° F the output of the sensor can be measured using the equipment that it is normally connected or by using a voltmeter. At ice point, the output of the sensor should be 0.375 volts. At a typical room temperature of 20° C, the output should be approximately 0.625 volts.

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BAROMETRIC PRESSURE SENSOR MANUAL

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Table of Contents

1.0 GENERAL INFORMATION

1.1 5904 Barometric Pressure Sensor uses an active solid-state device to sense barometric pressure. Self-contained electronics provide a regulated voltage to the solid-state sensor and amplification for the signal output.

2.0 Specifications

Performance

Calibrated Range:	26-32" (standard)*
Calibrated Operating Range:	-18°C to +50°C
Operating Temperature Range:	-40°C to +50°C
Resolution:	Infinite
Accuracy:	±0.04 in Hg (±1.35 mb) or
Accuracy:	±0.125% FS
Output:	0-1V DC (standard)*

*Range example: 5904 - 26/32 - 1

Basic Mod # Range ("Hg) Output Voltage

(In this example, the sensor output is 0-1v for a range of 26 to 32" Hg)

Electrical Characteristics

Power:	11 ma @ 12 VDC
Sensor Output:	0-1 VDC Standard 0-5 VDC Optional

Physical Characteristics

Weight:	8.8 oz (250 g)
Dimensions:	2.13" x 3.2" x 5" (5.4x8.3x13 cm)

3.0 INSTALLATION

3.1 Mounting the Sensor

A. Mount sensor on mast with pressure inlet port facing downward. Locate clamps on mast. Apply pressure forcing clamp jaws to close and lock. (To remove clamp from mast, pry clamp jaws apart at latch).

4.0 OPERATION

4.1 The Barometric Pressure Sensor has been calibrated at the factory, and will not change unless it is damaged. To check for proper operation of the sensor and module, it is advised that the module's output be checked against a local weather service facility. Exact correlation is not to be expected, due to geographical and meteorological variations. The sensor reads absolute barometric pressure, whereas local weather services readings are normalized to sea level values.

4.2 One should keep in mind that nominal pressure, at sea level, is 30 inches of mercury and that for every 1,000 feet of elevation, the pressure decreases approximately one inch of mercury. EXAMPLE: A weather station at sea level may use a barometer with a range of 26 to 32 inches of mercury to cover all possible weather conditions. However, a weather station, located 4,000 above sea level, would require a range of 22 to 28 inches of mercury.

Table 4-1: Barometric Pressure Sensor Range Selection Guide

ELEVATION	RANGE "Hg" (standard)*
0 to 1,500	26/32
1,501 to 3,500	24/30
3,501 to 5,500	22/28
5,501 to 8,000	20/26
8,001 to 10,000	18/24
10,001 to 12,500	16/22
12,501 to 15,500	14/20
15,501 to 19,000	12/18

*Consult factory for optional ranges

4.3 Each sensor is provided with a calibration data sheet showing transducer outputs at two or more pressure levels. It is important to record these values, as they are required, should it ever be necessary to recalibrate the pressure translator module in the field. If these values are lost, the sensor can be returned to the factory for recalibration.

5.0 MAINTENANCE AND TROUBLESHOOTING

5.1 General Maintenance Schedule:

A. Inspect pressure inlet port occasionally to insure it is free of obstruction. No other periodic maintenance or calibration is required.

B. Inspect sensor for proper operation per Section 4.1.

5.2 5904 Pressure Sensor Maintenance:

A. The pressure sensor is an inherently stable device that does not require periodic service or recalibration. Should service or recalibration become necessary, the sensor must be returned to the factory. Always inspect Model

5904 Pressure Sensor to make sure that inlet port is clean and free from obstructions.

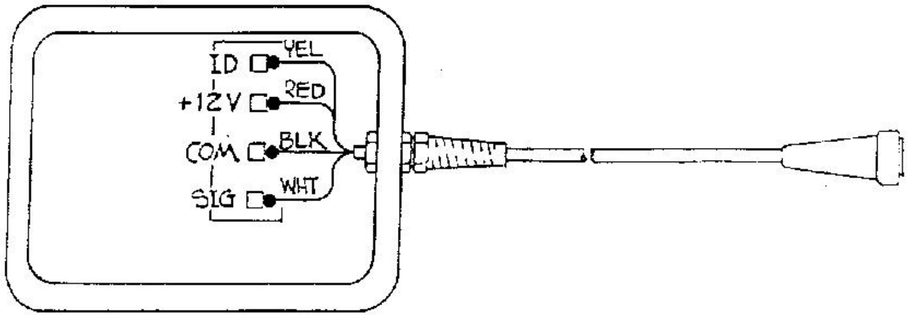

Figure 5.1-Barometric Pressure Sensor Cable Connection

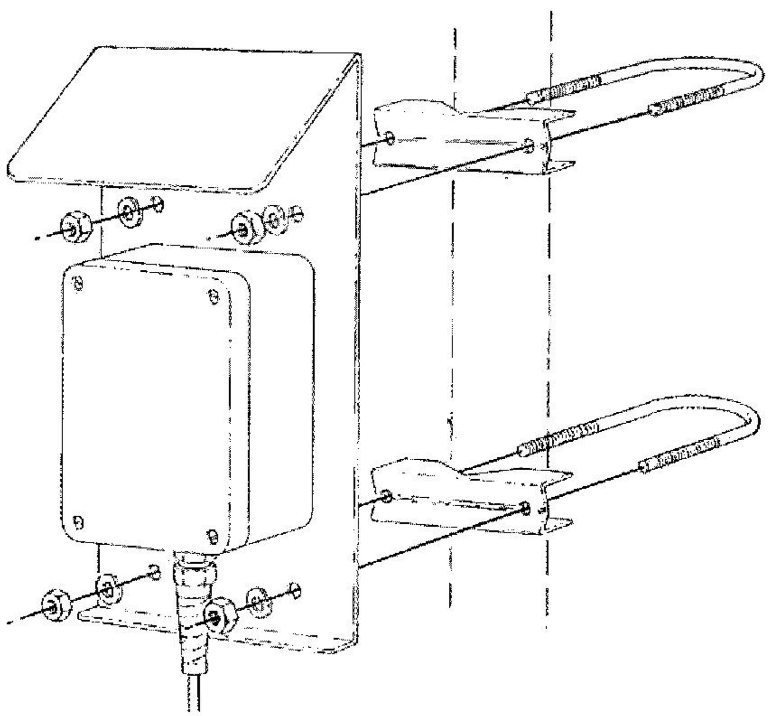

Figure 5.2-Barometric Pressure Sensor Mounting