Certification Report and Checklist on the Evaluation of the Ambient Air Particulate Matter Test Reports Submitted for Approval and Certification within the MCERTS Scheme for UK Particulate Matter

Evaluation with Respect to:
MCERTS Performance Standards for Ambient Air Quality Monitoring Systems and its Annex:

Requirements of the UK Competent Authority for the Equivalence Testing and Certification of Automated Continuous Methods and Manual Discontinuous Methods that Monitor Particulate Matter in Ambient Air

Instrument Manufacturer:	PALAS GmbH Greschbachstrasse 3b, 76229 Kahlsruhe Germany
Type of Instrument Evaluated:	PALAS Fidas 200 Particulate Measuring System for Particulate Matter Components PM_{10} and $PM_{2.5}$ of Total Suspended Particulate Matter, using Method 11
Report prepared by:	Certification Committee for MCERTS Performance Standard for Automated Continuous Methods and Manual Discontinuous Methods that Monitor Particulate Matter in Ambient Air
Report number:	MCERTSCCPMT6PALASPM10&PM2.5260416/10.4
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Executive Summary

This Report provides the MCERTS certification committee's evidence to support the recommendations for certification under the Environment Agency's MCERTS Performance Standards for Continuous Ambient Air Monitoring Systems [Ref.3[1]], and it's Annex regarding MCERTS for UK Particulate Matter [Ref.5[1]].

The manufacturer of this continuous automated particulate monitoring method for ambient air suspended particulate matter PM_{10} and for $PM_{2.5}$ is:

PALAS GmbH
Greschbachstrasse 3b,
72229 Kahlsruhe, Germany

E1 Description of the Particulate Monitoring Candidate Method

This Evaluation Report prepared by the MCERTS certification committee covers the following automated particulate PM_{10} or $PM_{2.5}$ measurement method:

(a) Hardware

Ambient air-quality monitoring system PALAS Fidas 200 Method 11 multi-channel particulate continuous monitor using an optical particulate monitoring spectrometer, which determines particle size by means of the scattered Lorentz-Mie optical radiation, using a polychromatic (white) light source with scattered light detection;

(i) Instrument stores high frequency measurement data of particulate in size range of 0.18 µm – 18 µm, with a spectral resolution of 32 channels per decade.

(ii) No PM_{10} or $PM_{2.5}$ heads, but a total suspended particulate head Sigma-2 with a flow rate of 4.8l/min measured at 25^{o}C and 1013mb. It should be noted that this is NOT compliant with the requirements of EN 12341 but its equivalence evaluation is the subject of this Report.

(iii) PM_{10} and $PM_{2.5}$ concentrations are calculated by applying a density distribution to the measured size fraction data.

(iv) Heated sample drying system following the sample head, consisting of the IADS moisture compensation module, operated at a temperature of UP TO 24 ^{O}C above the ambient temperature. This method is adaptive starting at 23 ^{O}C up to the 24 ^{O}C above ambient [ref.6 p46]

(v) A method of carrying out calibrations or calibration checks of the spectral settings of the monitor uses mono-disperse aerosols provided with the monitor. The objective and frequency of this calibration check are summarised in Section 2.1 of this Report.

(vi) An external zero air filter shall be attached to the inlet of the instrument to provide air free of suspended particulate matter to carry out zero point checks.

(vii) The instrument is available in the versions Fidas 200 S for outdoor use including weatherproof housing used in the field test and laboratory test programme discussed here, and the Fidas 200 without this housing for indoor applications.

(viii) In the field tests and the initial laboratory tests, the instrument was operated with the IP65 case which is heated and ventilated, but not air conditioned. A laboratory test was subsequently conducted on the Fidas 200 (*i.e.* the instrument without the bespoke case), and these results are also presented in this report.

[1]*References in this Executive Summary are not in numerical order. They are in numerical order in the main body of this Report*

(ix) The operations of the Fidas 200 and Fidas 200 S were both evaluated and the results are discussed in Section 2 of this Report.

(x) Algorithms have been developed by the manufacturer, and ONE OF THESE is specific to this Evaluation Report:

- data have been processed *via* an algorithm known as PM_ENVIRO_0011, ***known in this Report as Method 11;***
- Data have been processed as 15 minute averages which are then averaged to form 24 hour averages.

A summary explanation of the operating principles of this type of monitor are given in Section 2.1 of this Report and in [Refs.6&7[1]]

NOTE: It is also important to recognise that operation of this type of instrument by utilising components in combinations and permutations other than the above, is not covered by this Report. As such no other combinations and permutations are recommended for approval without further consideration by the UK MCERTS certification committee. They must assess the implications of such variations.

(b) Serial Numbers of the Candidate Method Tested

Table E1: The candidate instruments

Serial numbers assigned by Manufacturer	Model	Dates of tests	Firmware/software version	Reports of the test programme
0111 & 0112 Used for the 4 sites in Germany and 2 sites in the UK	See above – sample channels for PM_{10} & $PM_{2.5}$	April 2012 – September 2013 (Germany); February – June 2014 (UK)	Firmware: 100327.0007. 0001.0011 Implemented evaluation algorithm: PM_ENVIRO_0011[2]; & For external PC 1.01	Ref. 6 (September 2013) for the 4 German tests; Ref.7 includes the 2 UK tests

(c) **Firmware/Software of the Candidate Method**

The stated firmware version noted above in the Table (100327) is used for the operation of the integral panel PC.

The implemented data evaluation algorithm used in this Report and in [Ref.7] is PM_ENVIRO_0011 which is known in this Report and in [Ref.7] as ***Method 11.*** *No other data processing software other than Method 11 is covered directly by this certification*

There is a more detailed description of the firmware used in the equivalence testing programme given in [Ref.7] Section 1.5. It is noted that it has also been confirmed that this firmware has been updated and approved by the appropriate German assessment group, and should be reviewed by the annual audits carried out within the requirements of EN15267-Part 2 by TÜV and/or by Sira. *Annual audit reports shall contain specific references to the issue of software and its validation, to ensure continued compliance.*

[1]*References in this Executive Summary are not in numerical order. They are in numerical order in the main body of this Report*

It should be noted that whilst it may in principle be considered appropriate to retain this firmware/software version because this is what is certified, it is recommended that efforts should be made by operators of the instruments to install ***the latest approved version*** *of the instrument firmware/software suitable for the particular model being operated.*

E2 Reports and other Documents Reviewed during this MCERTS Evaluation

The reports concerning this Candidate Method have been reviewed by the MCERTS certification committee are:

1. **Test report on Palas Fidas 200 prepared by TUV Rheinland Energie und Umwelt GmbH:** *Report on supplementary testing of the Fidas® 200 S respectively Fidas® 200 measuring systems manufactured by PALAS GmbH for the components suspended particulate matter PM_{10} and $PM_{2.5}$, Report number 936/21227195/A, dated 9th March 2015 [Ref.6]*

This TÜV report, published in 2015, provides the results obtained at the test sites in Germany (Two at Cologne, one at Bonn, and one at Bornheim) and the two additional tests in the UK (Teddington) Further information on these tests and on the two UK tests are given in Ref.7 and Section 2.2 of this Report. The ranges of the ambient environmental conditions that occurred during each of the six sets of tests are also shown in Section 2.2

The results of the sets of field tests and the laboratory tests produced in the TUV report were subsequently evaluated and approved in Germany. This is discussed in the BV report [Ref. 7], and in the main body of this Evaluation Report.

The six sets of data were, however, also evaluated in the UK, and the processed results were also reviewed with respect to the ***field test requirements*** of the EC "Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods [Ref.2]. *The results obtained in this TÜV report have been re-calculated [Ref.7] in order to confirm their complete conformance with all the modern GDE requirements (e.g. the "outlier" test carried out by TÜV very slightly different from that required by the GDE).* The MCERTS Performance Standard [Ref.3] and the MCERTS Annex document [Ref. 5] have the same requirements as the GDE. *All of the results have been re-processed by BV [Ref.7], and these were shown to conform to the requirements of the GDE, MCERTS Standard and MCERTS Annex documents referred to above, as discussed in the main body of this Report.*

4. Report prepared by Bureau Veritas, UK:

UK Report on the Equivalence of the PALAS Fidas Method 11 for PM_{10} and $PM_{2.5}$, Number AGGX8316719/BV/DH/2972, *Bureau Veritas Air Quality, dated March 2016 [Ref.7];*

This is a UK report presented in the format required by the Defra Annex report [Ref.5] to fulfil Defra requirements. All candidate methods were tested against the PM_{10} and/or $PM_{2.5}$ Sven Leckel LVS3 or SEQ47/50 European Reference Methods (RM). The operation of the instruments was undertaken by TÜV Rheinland in Germany, and the National Physical Laboratory (NPL) in the UK. Both organisations have appropriate ISO17025[1] accreditations, which are included in [Ref.7].

Calculations of the between sampler uncertainties and the expanded uncertainties relative to the reference method were undertaken by Bureau Veritas (BV).

A series of intensive laboratory tests were undertaken by TÜV Rheinland that go beyond the laboratory test requirements set out in MCERTS for UK Particulate Matter. The instruments

[1] *ISO Standard 17025:2005 General requirements for the competence of testing and calibration laboratories*

were also leak tested and flow tested by NPL and TÜV Rheinland throughout the field campaigns (Section 3.3).

The Maintenance Interval is discussed in [Ref.7 & Section 2.4], and summarized in this Report. To achieve this it is necessary to use periodic calibration/testing with CalDust 1100 [Ref.7]. Data Capture has been calculated in accordance with MCERTS for UK Particulate Matter [Ref.7 Section 11]. This also demonstrated that there are no significant differences between the Palas Fidas 200 S and Palas Fidas 200;

The correct method of downloading data should be used (Ref.7].

It is also necessary to consider the sensitivity of these two forms of the instrument to surrounding temperature (Ref.7 Section 6).

Calculations of the suitability of the data with respect to the pollution climate within the UK were undertaken by BV (Ref.7 Section15).

This Report summarizes the findings of the field campaigns, laboratory testing and pollution climate calculations. This and Ref. 7, are compatible with all the requirements of MCERTS for UK Particulate Matter [ref.5], including its reporting structure. It has been used to provide the MCERTS Certification Body, and its certification committee, with the evidence required to assess whether all the testing carried out is compliant with all the requirements of MCERTS for UK Particulate Matter {ref.5}.

In Germany, the instrument was referred to as Palas Fidas 200®, where ® denotes a registered trade mark. In this report, for UK purposes, the ® is excluded from the name of the instrument. The instrument is therefore herein referred to as the Palas Fidas 200 S Method 11 when used with the IP65 case. The instrument is also herein referred to as the Palas Fidas 200 Method 11 when used without the IP65 case, and when referring to the name of the instrument to be certified. When referring to those laboratory tests where the algorithm to calculate concentrations was not used, the instruments are referred to as Palas Fidas 200 S or Palas Fidas 200.

These reports are discussed further in the main body of this MCERTS Evaluation Report.

E3 Summary of the Scope of Equivalence Testing Evaluated in this Report

The scope of the equivalence testing is summarised here, and is discussed in more detail in Section 2.3 of the report. As noted above, four of the test sets were obtained at different sites in Germany, and two in the UK, carried out from May 2012 – June 2014 [Ref.7], and Table E2 below

The list of the field test sites considered in this Evaluation Report are given in Table E2 below:

Table E2: Field Test Sites Employed in Germany and the UK for Equivalence Testing

Measurement Site	Period	Characterisation
Cologne Summer	05/2012 to 09/2012	Urban background
Cologne Winter	11/2012 to 02/2013	Urban background
Bonn Winter	02/2013 to 05/2013	Traffic
Bornheim Summer	05/2013 to 07/2013	Rural with influence of traffic
Teddington Winter	02/2014 to 04/2014	Urban background
Teddington Summer	04/2014 to 06/2014	Urban background

The MCERTS certification committee has carried out discussions with technical experts in this field in order to decide the tests that should be considered as the primary evidence in this Evaluation, and which could be used as supporting evidence. It has been concluded that:

(a) The results of the four field tests carried out in Germany and the two sets in the UK (Cologne, Bonn, and Teddington [Ref.7]), are listed in Table E2 above. Application of the results is summarised below.

(b) The EC GDE [Ref.2] and the MCERTS Annex [Ref.5] require the determination of the measurement uncertainty of the CMs with respect to the paired datasets obtained by the RMs, and this procedure requires separate evaluations of these datasets with:

- The full dataset;
- Datasets representing PM concentrations greater than or equal to 30 µg m^{-3} for PM_{10}, and concentrations greater than equal to 18 µg m^{-3} for $PM_{2.5}$, ***provided that the subset contains 40 or more valid data pairs;***
- Datasets for each individual site.

The EC DGE and MCERTS requirements for these datasets have all now been calculated according to these and presented in this Evaluation Report (Section 5). These results are all also presented in the BV report [Ref.7].

Taking account of the scientific discussions - the utilisation of some of the above datasets for the evaluation of equivalence of this type of monitor for this Report may be summarised:

(1) The results of the four field tests in Germany listed in (a) above and in [Ref.7] are considered to be acceptable for use as part of the ***evidence for the determination of equivalence*** in this Evaluation Report for both the PM_{10} and $PM_{2.5}$ monitors.

(2) The results of the two sets of UK field tests listed in (a) above and in [Ref.7] are considered to be acceptable for use as the other part of the ***evidence for the determination of equivalence*** in this Evaluation Report for the PM_{10} and $PM_{2.5}$ monitors.

It is also important to recognise that none of the field tests were carried before the document on "MCERTS Certification for UK Particulate Matter" [Ref.5] was published, as discussed in Section 3.1 of this Evaluation Report. There were transitional arrangements in the MCERTS Annex [Ref.5] allowed ***but these are not relevant here. The most relevant of the requirements for these tests now are:***

- The determination of the UK Particulate Matter (PM) Pollution Climate is required for ALL these tests carried out. This determination was carried out and is presented in the BV report [Ref.7 Section 15]. (In addition, it should be noted that some of these sites in Germany had previously been assessed for their applicability to the UK Particulate Matter Pollution Climate during a UK study on this [Ref.13]
- There is a requirement for two sets of tests to be carried out in the UK for tests that were completed ***after*** the publication of the MCERTS Annex report [Ref.5]. Two sets of tests were carried out in the UK, and included in this Evaluation.
- The requirements for the specified variations in wind speed, and the other variables in [Ref.5] over the duration of the field trials are essential for these tests. For all the tests there were sufficiently large variations in wind speed during the selected field trials. There were also a range of atmospheric temperatures present during the complete set of field trials as shown in Table 40 of the BV report [Ref.7]. (However, it should be noted that the Palas Fidas 200S monitors tested in the field during this programme were in individual IP65 temperature enclosures, and thus the issue of a large variability in the outside ambient temperatures is not so significant.)
- The requirements to have two reference methods with simultaneous data over the duration of the field trials is essential for tests since they were completed after publication of the MCERTS Annex document [Ref.5]. All the field trials used for this evaluation employed two reference methods [Refs.6&7]. These were also all implemented consistently within the requirements of the GDE [Ref.2].

In addition to the scope of tests that are evaluated in this Report, it may be summarised:

a) The UK Particulate Matter Pollution (PM) Climate calculations are presented [Ref.7 Section 15], and are also summarised in the checklist in this Report. These show that the sites where the selected sets of tests were carried out, all of a similar PM pollution climate to the UK during the tests. There were no field test sites within those evaluated for UK Particulate Matter Pollution Climate that did not conform to the requirements of this UK Particulate Matter Pollution Climate, and hence none are excluded from this Evaluation Report on these grounds.

b) It is accepted that the Palas Fidas monitoring particulate PM10 and PM2.5 is the measuring range is effectively 0-10,000 ug m^{-3}, but this is based on a setting of the instrument, rather than its maximum response. The instrument has no ability to set a measuring range. The instrument can measure up to 4000 particles/cm³ before interference between more than one particle in the optical scattering range occurs, which corresponds to a maximum concentration of 0-10,000 µg/m³ for instantaneous measurements.

c) The data availability for the field test sites reviewed in this Report, averaged over the total period of these field tests, were in excess of 200 days during which the CMs and the RMs were operating in parallel. Based on these daily data results, the data availability is >99% form the test site results [Refs. 6&7], *The European Directive 2008/50/EC [Ref.1] requires a data capture of ≥ 90 % per calendar year, and this requirement is therefore considered to be fulfilled.*

d) The results from the field test sites that were used as the primary evidence in this Report were at urban background, traffic, and rural locations. Also the Bornheim site is rural with traffic influence characteristics. *It is recommended, therefore, in this Evaluation that*

this type of instrument is suitable for use at urban background (including suburban), rural, and traffic locations within the UK.

e) Laboratory tests were carried out and reported [Ref.6]. These are considered as meeting the requirements of the MCERTS Performance Standard [Ref.3} and its MCERTS Annex document [Ref.5], as well as more comprehensive requirements in Germany

f) The measurement uncertainty results for the candidate methods were calculated in the TÜV Report listed below using the limit values for PM_{10} or $PM_{2.5}$ as applicable. These were consistent with *the current requirements of the GDE [Ref.2], and of the MCERTS Annex document [Ref.5]. The currently required calculations have therefore been checked for this MCERTS Evaluation Report, reported in the UK BV report, with the results in [Ref.7], and summarised in Section 5 of this Report.*

E4 Tabulated Summary of the Results Obtained

The results of the test programme that was carried out on the PALAS Fidas 200 using both the PM_{10} and $PM_{2.5}$ results, with 24-hour sampling, at the six selected field test sites listed above. These are summarised below.

Table E3: Summary of the test results for the PALAS Fidas 200 S

Test	Results	MCERTS Specification
Constancy of the sample volumetric flow	2.3%	To remain constant within ± 3% of the rated value
Tightness of the sampling system	0.8%	Leakage not to exceed 1% of the sampled volume
Maintenance Interval	Four Weeks	≥Two weeks
Data Availability	99.2%	≥90%
Number of UK Tests	2	≥2
Number of Reference Methods	2	2
Between sampler/instrument uncertainty for the standard method **PM_{10}**		
Full data set	0.57 µg/m^3	≤2 µg/m^3
<30 µg/m^3	0.56 µg/m^3	Not specified
≥30 µg/m^3	0.60 µg/m^3	Not specified
Between sampler/instrument uncertainty for the candidate method **PM_{10}**		
Full data set	0.67 µg/m^3	≤2.5 µg/m^3
<30 µg/m^3	0.57 µg/m^3	≤2.5 µg/m^3
≥30 µg/m^3	1.17 µg/m^3	≤2.5 µg/m^3
Between sampler/instrument uncertainty for the standard method **$PM_{2.5}$**		
Full data set	0.53 µg/m^3	≤2 µg/m^3
<18 µg/m^3	0.51 µg/m^3	Not specified
≥18 µg/m^3	0.60 µg/m^3	Not specified
Between sampler/instrument uncertainty for the candidate method **$PM_{2.5}$ without slope correction**		
Full data set	0.48 µg/m^3	≤2.5 µg/m^3
<18 µg/m^3	0.32 µg/m^3	≤2.5 µg/m^3
≥18 µg/m^3	0.85 µg/m^3	≤2.5 µg/m^3

A tabulated list of the field test results from the six individual test sites is given below in Tables E4 to E7 for the PM_{10} tests and the $PM_{2.5}$ tests respectively.

The corrections for these are summarised in Table E8, and discussed in in more detail in Section 5.

E5: Summary of the test results for the Palas Fidas 200 S and Palas Fidas 200 using Method 11

Certification Range:

PM_{10}: 0 to 10,000 µg/m^3 ; The measuring range is effectively 0-10000 ug/m^3; However, it isn't based on a setting of the instrument – **rather this is its maximum response**. T**he instrument has no ability to set a measuring range. The instrument can measure up to 4000 particles/cm³.This corresponds to a maximum concentration of 0-10000 µg/m³ for instantaneous measurements. "**

$PM_{2.5}$ 0 to 10,000 µg/m^3 The measuring range is effectively 0-10000 ug/m^3; However, but it isn't based on a setting of the instrument - **rather this is its maximum response. The instrument has no ability to set a measuring range. The instrument can measure up to 4000 particles/cm³.This corresponds to a maximum concentration of 0-10000 µg/m³ for instantaneous measurements**

Ambient temperature range:
Palas Fidas 200 Method 11 (Indoor Version) +5°C to +40 ºC
Palas Fidas 200 S Method 11 (Outdoor Version) -20°C to +50 ºC

Table E4: Summary of the test results for the Palas Fidas 200 Method 11 from the six test sites. No corrections are required for PM_{10}.

Test	Uncorrected	MCERTS Specification
Expanded uncertainty calculated at 50 µg/m^3 for **Instrument SN 0111**		
Full data set	9.0%	≤25%
<30 µg/m^3	9.4%	Not specified
≥30 µg/m^3	11.9%	≤25%
Individual sites		
Cologne Summer	7.0%	≤25%
Cologne Winter	9.2%	≤25%
Bonn Winter	12.0%	≤25%
Bornheim Summer	19.1%	≤25%
Teddington Winter	9.2%	≤25%
Teddington Summer	12.3%	≤25%
Expanded uncertainty calculated at 50 µg/m^3 for **Instrument SN 0112**		
Full data set	7.5%	≤25%
<30 µg/m^3	6.5%	Not specified
≥30 µg/m^3	11.4%	≤25%
Individual sites		
Cologne Summer	6.6%	≤25%
Cologne Winter	5.7%	≤25%
Bonn Winter	9.3%	≤25%
Bornheim Summer	10.6%	≤25%
Teddington Winter	13.9%	≤25%
Teddington Summer	14.3%	≤25%

Table E5: Processed Results for the Palas Fidas 200 Using Method 11. Slope correction is required for $PM_{2.5}$ (by dividing by 1.06)

Test	Uncorrected	Slope Corrected	MCERTS Specification
Expanded uncertainty calculated at 30 µg/m^3 for **Instrument SN 0111**			
Full data set	16.7%	9.5%	≤25%
<18 µg/m^3	25.8%	13.8%	Not specified
≥18 µg/m^3	18.5%	12.7%	≤25%
Individual sites			
Cologne Summer	20.1%	10.4%	≤25%
Cologne Winter	17.1%	8.5%	≤25%
Bonn Winter	21.2%	12.3%	≤25%
Bornheim Summer	35.0%	22.4%	≤25%
Teddington Winter	7.7%	9.5%	≤25%
Teddington Summer	5.9%	11.5%	≤25%
Expanded uncertainty calculated at 30 µg/m^3 for **Instrument SN 0112**			
Full data set	12.8%	10.2%	≤25%
<18 µg/m^3	20.3%	10.0%	Not specified
≥18 µg/m^3	15.5%	13.4%	≤25%
Individual sites			
Cologne Summer	20.1%	10.8%	≤25%
Cologne Winter	11.4%	9.4%	≤25%
Bonn Winter	16.6%	12.3%	≤25%
Bornheim Summer	29.1%	17.5%	≤25%
Teddington Winter	6.7%	10.0%	≤25%
Teddington Summer	5.7%	13.4%	≤25%

Table E6: Equivalence Correction for the PM_{10} Palas Fidas 200 with Method 11 – No corrections for PM_{10} required

PM10 PALAS Fidas200 Method 11	17.5% ≥ 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 Data	7.5	315	0.973	1.035 +/- 0.010	-1.360 +/- 0.218	0.57	0.67
< 30 µg m-3	7.1	272	0.918	1.045 +/- 0.018	-1.543 +/- 0.311	0.56	0.57
≥ 30 µg m-3	11.0	43	0.944	0.984 +/- 0.036	0.974 +/- 1.569	0.60	1.17

SN0111	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 Summer	81	0.944	1.045 +/- 0.028	-1.637 +/- 0.490	6.98	9.9
	Cologne Winter	50	0.989	1.059 +/- 0.016	-1.171 +/- 0.413	9.22	22.0
	Bonn Winter	50	0.967	1.043 +/- 0.027	-0.082 +/- 0.821	11.98	46.0
	Bornheim Summer	47	0.944	1.128 +/- 0.040	-1.986 +/- 0.733	19.05	6.4
	Teddington Winter	44	0.987	0.999 +/- 0.017	-1.598 +/- 0.441	9.16	20.5
	Teddington Summer	45	0.961	0.946 +/- 0.029	-0.090 +/- 0.474	12.26	2.2
Combined Datasets	< 30 µg m-3	274	0.915	1.064 +/- 0.019	-1.597 +/- 0.320	9.38	4.4
	≥ 30 µg m-3	43	0.946	1.013 +/- 0.037	0.381 +/- 1.597	11.86	100.0
	All Data	317	0.972	1.052 +/- 0.010	-1.386 +/- 0.222	8.99	17.4

SN0112	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 Summer	82	0.943	1.028 +/- 0.028	-1.524 +/- 0.489	6.56	9.8
	Cologne Winter	49	0.989	1.023 +/- 0.016	-1.215 +/- 0.413	5.69	22.4
	Bonn Winter	50	0.961	1.004 +/- 0.029	0.061 +/- 0.865	9.29	46.0
	Bornheim Summer	47	0.942	1.083 +/- 0.039	-2.169 +/- 0.720	10.63	6.4
	Teddington Winter	44	0.988	0.969 +/- 0.016	-1.580 +/- 0.420	13.91	20.5
	Teddington Summer	45	0.955	0.944 +/- 0.031	-0.502 +/- 0.507	14.26	2.2
Combined Datasets	< 30 µg m-3	274	0.917	1.028 +/- 0.018	-1.522 +/- 0.308	6.49	4.4
	≥ 30 µg m-3	43	0.940	0.956 +/- 0.037	1.504 +/- 1.584	11.39	100.0
	All Data	317	0.971	1.019 +/- 0.010	-1.331 +/- 0.219	7.53	17.4

Table E7: Equivalence Correction for the $PM_{2.5}$ Palas Fidas 200 with Method 11 – Slope correction for $PM_{2.5}$ Applied

PM2.5 PALAS Fidas200 Method 11 Slope Corrected	24.3% ≥ 17 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 Data	9.3	313	0.980	0.999 +/- 0.008	-0.190 +/- 0.136	0.53	0.45
< 18 µg m-3	11.3	246	0.890	1.065 +/- 0.023	-0.782 +/- 0.224	0.51	0.31
≥ 18 µg m-3	12.5	67	0.973	0.981 +/- 0.020	0.306 +/- 0.630	0.60	0.80

SN0111	Dataset	Orthogonal Regression				Limit Value of 30 µg m-3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% ≥ 17 µg m-3
Individual Datasets	Cologne Summer	81	0.927	1.053 +/- 0.032	-0.850 +/- 0.342	10.46	9.9
	Cologne Winter	51	0.992	0.991 +/- 0.013	0.656 +/- 0.296	8.50	39.2
	Bonn Winter	50	0.976	1.050 +/- 0.024	-0.723 +/- 0.539	12.32	60.0
	Bornheim Summer	45	0.915	1.142 +/- 0.051	-1.370 +/- 0.607	22.40	6.7
	Teddington Winter	44	0.994	0.964 +/- 0.012	-0.004 +/- 0.223	9.46	20.5
	Teddington Summer	44	0.981	0.934 +/- 0.020	0.461 +/- 0.232	11.50	13.6
Combined Datasets	< 18 µg m-3	248	0.889	1.083 +/- 0.023	-0.841 +/- 0.227	13.84	3.6
	≥ 18 µg m-3	67	0.973	0.999 +/- 0.020	0.134 +/- 0.642	12.67	100.0
	All Data	315	0.980	1.014 +/- 0.008	-0.225 +/- 0.137	9.50	24.1

SN0112	Dataset	Orthogonal Regression				Limit Value of 30 µg m-3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% ≥ 17 µg m-3
Individual Datasets	Cologne Summer	82	0.919	1.050 +/- 0.033	-0.810 +/- 0.357	10.77	9.8
	Cologne Winter	50	0.991	0.956 +/- 0.013	0.645 +/- 0.307	9.43	40.0
	Bonn Winter	50	0.969	1.008 +/- 0.026	-0.471 +/- 0.584	12.33	60.0
	Bornheim Summer	45	0.911	1.115 +/- 0.050	-1.482 +/- 0.607	17.49	6.7
	Teddington Winter	44	0.995	0.963 +/- 0.011	-0.143 +/- 0.207	10.01	20.5
	Teddington Summer	44	0.981	0.926 +/- 0.020	0.399 +/- 0.229	13.40	13.6
Combined Datasets	< 18 µg m-3	248	0.885	1.052 +/- 0.023	-0.744 +/- 0.226	9.97	3.6
	≥ 18 µg m-3	67	0.970	0.965 +/- 0.021	0.443 +/- 0.646	13.39	100.0
	All Data	315	0.979	0.985 +/- 0.008	-0.137 +/- 0.137	10.17	24.1

During the laboratory and field testing, the full unprocessed data files have been downloaded by the manufacturer or TÜV Rheinland and subsequently processed as 15 minute averages *via* an algorithm known as PM_ENVIRO_0011, or more commonly known as Method 11. The 15 minute data have then been averaged to form 24 hour averages. **The certificate only covers data processed using the Method 11 algorithm and does not cover data processed using any other algorithm.** Further information is given in Section 2.3 of this Report and [Ref.7 p20]

Table E8: Summary of the slope, intercept and expanded uncertainties, with and without slope corrections where required - processed PM_{10} and $PM_{2.5}$ results

PM_{10} Palas Fidas 200	Calculated slope of all paired data	Calculated intercept of all paired data ($\mu g/m^3$)	Expanded uncertainty of all paired data	Range of individual expanded uncertainties
Uncorrected data	1.035	-1.360	7.5%	5.7% to 19.1%
Data corrected for slope by dividing by 1.035	1.000	-1.305	9.0%	5.9% to 20.3 %
Data corrected for intercept by adding 1.360	1.035	0.000	10.2%	6.5% to 24.2%
Data corrected for slope and intercept by adding 1.360 then dividing by 1.035	1.000	0.009	7.4%	6.1% to 17.0%
$PM_{2.5}$ Palas Fidas 200	Calculated slope of all paired data	Calculated intercept of all paired data ($\mu g/m^3$)	Expanded uncertainty of all paired data	Range of individual expanded uncertainties
Uncorrected data	1.060	-0.210	14.4%	5.7% to 35.0%
Data corrected for slope by dividing by 1.060	0.999	-0.190	9.3%	8.5% to 22.4%
Data corrected for intercept by adding 0.210	1.060	0.000	15.5%	5.7% to 36.4%
Data corrected for slope and intercept by adding 0.210, then dividing by 1.060	0.999	0.008	9.3%	8.6% to 23.6%

E5 Main Conclusions of the MCERTS Certification Committee

All of the processed results from the primary datasets are compliant with the requirements of [Refs.2 & 5]. Supplementary results reported [Refs.6&7] are also shown to be compliant with these requirements

In particular, the MCERTS certification committee has reviewed rigorously the results obtained with all the valid paired datasets noted above, and discussed further in Section 2.3 in the main body of this Evaluation Report. The certification committee has concluded that the evidence provided by these datasets and by the related TUV report [Ref.6], demonstrate that the minimum requirements of the MCERTS Performance Standard for Continuous Ambient Air Monitors, July 2012 [Ref.3] are fulfilled, *without requirements for corrections for the slope of the calibration line, or the intercept, or the slope and intercept together*. For PM_{10} results, BUT require a slope correction for $PM_{2.5}$ results. The requirements of the relevant VDI/DIN Guidelines [Refs.10&11] are also fulfilled.

The MCERTS certification committee has also concluded that all the minimum requirements specified in the *document:*

Annex to the MCERTS Performance Standards for Ambient Air Quality Monitoring Systems: Requirements of the UK Competent Authority for the Equivalence Testing and Certification of Automated Continuous and Manual Discontinuous Methods that Monitor Particulate Matter in Ambient Air [Ref.5]. **This is important to the requirements of the UK and Defra and these are also fulfilled,**

Therefore, it is recommended that the type of ambient air particulate monitor for PM_{10} and or $PM_{2.5}$ listed, with a correction for SLOPE for PM2.5 as also described in Section 2.1, and discussed in this Evaluation Report, are accepted as conforming to the requirements of the above MCERTS Performance Standard, **and** that this type of ambient air particulate monitor for PM_{10} and or $PM_{2.5}$ is also in conformance with the Annex to this MCERTS Performance Standard covering the requirements of MCERTS for UK Particulate Matter, without corrections for slope, intercept or corrections for slope and intercept.

It is also recommended that *instead of applying intercept correction and/or slope correction factors,* that thorough and sufficiently-frequent quality assurance/quality control procedures are employed as prescribed in [Ref. 2&5]. This should include those measures that are related to quantifying the baseline of this type of instrument accurately, and ensuring that instrument-specific baseline corrections are programmed into the instruments. In addition, procedures should be employed to check the calibration of these PM_{10} and/or $PM_{2.5}$ monitors at a test site in the field (as prescribed in EN12341:2014 [Ref.9] and CEN/TS16450:2013 [Ref.12]).

There are a number of restrictions and conclusions that apply that are given in the Summary and Recommendations Section of this Report (Section 5).

1. Introduction to the MCERTS Evaluation Report

1.1 About this Report

This Evaluation Report has been prepared by the MCERTS certification committee that has been appointed to review the equivalence testing, approval, and certification of automated continuous methods and manual discontinuous methods to be used to monitor particulate matter concentrations in ambient air – generally for UK and EU regulatory compliance purposes.

The evaluation by the certification committee that is presented in this Report has assessed whether all the testing that was carried out on the candidate particulate measurement methods listed fulfils comprehensively and rigorously the requirements that are specified in the set of published documents described below. This MCERTS Evaluation Report must be considered together with the published MCERTS certificates for these automated methods for monitoring ambient particulate matter, and together with the associated technical reports listed on their certificates.

This Evaluation Report, with its checklist, has been completed following a review of the reports that were submitted to Sira Certification Ltd. (see Section 2.2 of this Report for the reports submitted). They were submitted for consideration as to the suitability of the monitoring method in conforming to all the requirements of the documents outlined in Sections 1.2 & 1.3 below.

The checklist is presented in Section 4 of this Report and was completed by the MCERTS certification committee.

Additional comments are also included in this Evaluation Report in order to address the laboratory test requirements and other test aspects that are given in the TÜV test report, when these were used for this evaluation, particularly where these *differ in some manner* from the specifications of the Environment Agency's MCERTS Performance Standards for Continuous Ambient Air Monitoring Systems and it's Annex. These are discussed in Section 3.

A list of specialised terms that are referred to in this Report, together with their definitions, is presented in Annex 1. A list of the abbreviations used is given in Annex 2. The references used in this Evaluation Report and its Annexes are listed in Annex 3.

1.2 Background to the Requirements for Equivalence Testing

Initial requirements for the testing of ambient air monitoring methods for their equivalence with the EU specified reference methods were given in the *EU Directive 2008/50/EC* [Ref.1, Annex VI].

Methods for demonstrating this equivalence with the reference methods specified in the above Directive are given in a guidance document prepared for the European Commission, which is entitled *"Guide to the Demonstration of Ambient Air Monitoring Methods", January 2010* [Ref.2]. It should be noted that this Guidance was prepared as a document for the competent authorities and other relevant bodies within the EU Member States - with no mandatory provisions.

Subsequently, this EC guidance on demonstrating the equivalence of any alternative methods to the specified reference methods was incorporated into the Environment Agency's MCERTS Performance Standard entitled:

MCERTS Performance Standards for Ambient Air Quality Monitoring Systems, Environment Agency, Version 8, June 2012 [Ref.3].
The above document describes the MCERTS Performance Standards that must be achieved for certain categories of ambient air quality monitoring systems (CAMs) to allow these to be granted certification by the MCERTS scheme [Ref.4]. The ambient air pollutants that are covered by this are nitrogen dioxide (NO_2), nitrogen oxides (as nitrogen monoxide (NO) and nitrogen dioxide (NO_2)), sulphur dioxide (SO_2) carbon monoxide (CO), benzene and benzene-like volatile organic compounds, and particulate matter (PM_{10} and $PM_{2.5}$). These CAMs are generally those that are to be applied to regulatory compliance monitoring applications. The requirements for particulate matter CAMs in this MCERTS performance standards document are given in Sections 6.4 to 6.8 of Ref.3, and are fully consistent with the EC Guidance document on equivalence [GDE - Ref.2].

1.3 Background to MCERTS Certification for UK Particulate Matter.

Following the publication of this MCERTS Performance Standard [Ref.3], the Department of Environment Food and Rural Affairs (Defra), in conjunction with the Environment Agency and its MCERTS scheme, published a further document in order to specify comprehensively and rigorously the requirements for "equivalence testing" (product conformity and certification) in the United Kingdom, of some specific monitoring methods for particulate matter in ambient air, so as to be in alignment with the Guidance from the European Commission, in a manner that is fully acceptable to the UK's Competent Authority. This document, which is prepared as a separate *Annex* to the above MCERTS Performance standards document, is entitled:
Annex to the MCERTS Performance Standards for Ambient Air Quality Monitoring Systems: Requirements of the UK Competent Authority for the Equivalence Testing and Certification of Automated Continuous and Manual Discontinuous Methods that Monitor Particulate Matter in Ambient Air [Ref.5].
The MCERTS Annex document contains the background information and the requirements for equivalence testing that must be carried out *in order to achieve approval and certification that the Candidate Method conforms to the MCERTS Performance Standard for the Pollution Climate for UK Particulate Matter*.

This is a new type of certification that has been brought in during July 2012 to provide the formal recognition that Defra and the Devolved Administrations of Scotland, Wales and Northern Ireland, as the Competent Authority for the UK, have provided approval of specific types of PM monitoring methods for use in the UK, where they are found to be "equivalent" to the requirements in the relevant CEN Standard, and also they meet the requirements of the MCERTS Annex document [Ref.5]. The type of certification is known as "MCERTS for UK Particulate Matter". The procedures are based on those required for MCERTS approval and certification in accordance with the MCERTS Performance Standard for Continuous Ambient Air Quality Monitoring Systems. There are, however, additional requirements that include a specification for full conformance with the Particulate Matter Pollution Climate in the UK. The summary of the scientific background to this requirement is given in [Ref.13] of the Evaluation Report.

It should also be noted, however, that the Competent Authority for the UK has already approved as "equivalent" a number of measurement methods for monitoring particulate

matter, and this new certification process and its requirements do not apply to those methods already approved.
In addition, a number of transitional arrangements are specified by the MCERTS Annex document [Ref.5] (and identically applied by the MCERTS certification committee) for methods for which certification is sought, but which were tested before, or were already being tested, at the time at which the MCERTS document for UK Particulate Matter was published. These are detailed in Section 3.3 of the MCERTS for UK Particulate Matter Annex [Ref.5].
The MCERTS for UK Particulate Matter Annex also contains a checklist that has been used in this Evaluation Report for the review of the reports that were submitted for approval - within the process that is specified in that document, and this is included in this Evaluation.

2 Type of Monitoring Method, Reports Evaluated, and Scope of Equivalence Testing

2.1 Type of Ambient Air Particulate Matter (PM) Monitoring Method

The type of continuous ambient air PM monitoring method that has been submitted to be approved for certification under the MCERTS scheme within the context of this MCERTS Evaluation report is:

(a) Hardware

Ambient air-quality monitoring system Palas Fidas 200 Method 11 multi-size channel continuous monitor for an optical particulate monitoring spectrometer, which determines particle size by means of scattered Lorentz-Mie optical radiation, using a polychromatic (white light) light source with scattered light detection;

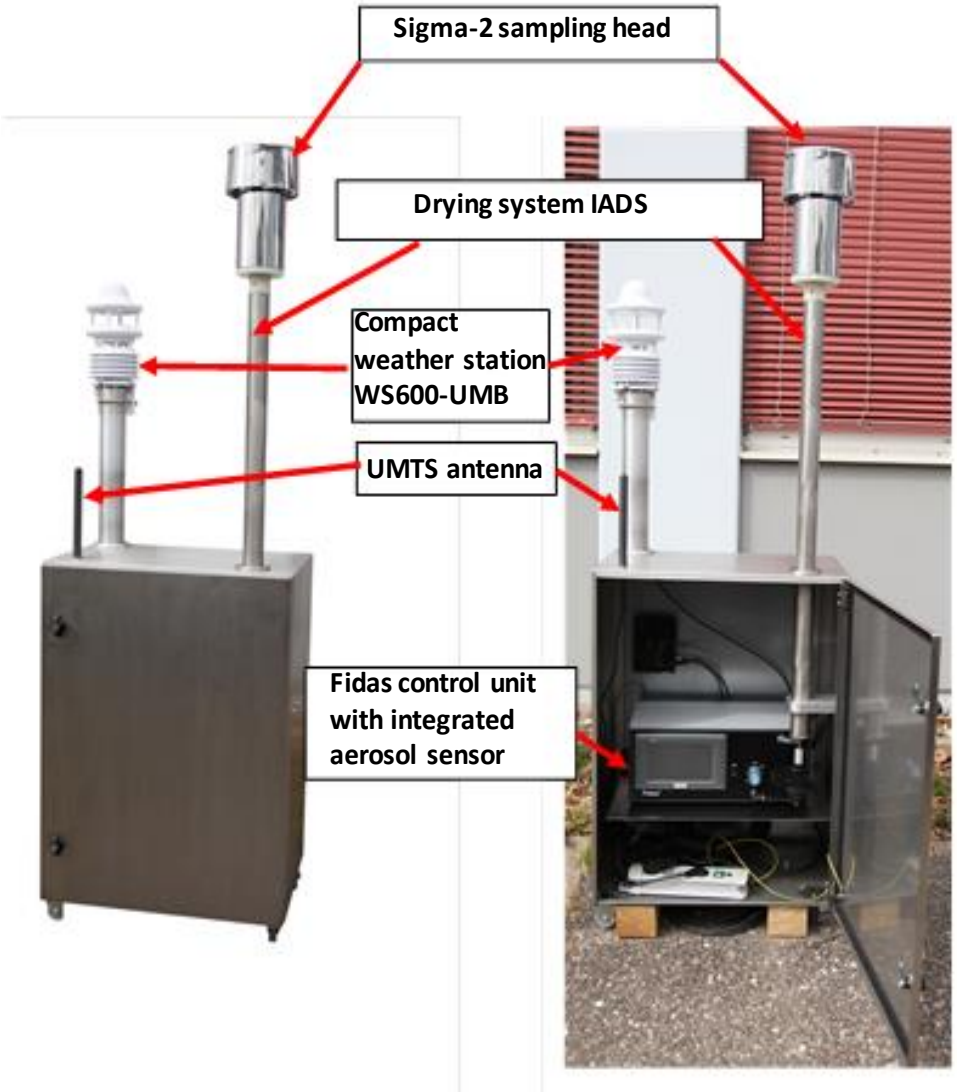
(a) Instrument stores high frequency measurement data of particulate in size range of 0.18 µm – 18 µm, with a spectral resolution of 32 channels per decade.
(b) No PM_{10} or $PM_{2.5}$ heads are used; instead a total suspended particulate head Sigma-2 which has a flow rate of 4.8l/min measured at 25^{o}C and 1013mb. It should be noted that this is NOT compliant with the requirements of EN 12341 - but its equivalence evaluation is part of this Report.
(c) PM_{10} and $PM_{2.5}$ concentrations are calculated by applying a density distribution to the measured size fraction data.
(d) Heated sample drying system following the sample head, consisting of the IADS moisture compensation module, operated at a temperature of 24 ^{O}C above the ambient temperature. This is an adaptive drying system, which is adjusted depending on the relative humidity of the input ambient air [Ref.6 p46].
(e) A method of carrying out calibrations or calibration checks of the spectral settings of the monitor using mono-disperse aerosols provided with the monitor. The objective and frequency of this calibration check are summarised in Section 2.1 of this Report.
(f) An external zero air filter shall be attached to the inlet of the instrument to provide air free of suspended particulate matter to carry out zero point checks.
(g) The instrument is available in the versions Palas Fidas 200S for outdoor use including weatherproof housing used in the field test and laboratory test programme discussed here, and the Palas Fidas 200 without this housing for indoor applications.
(h) During the field tests and during the initial laboratory tests, the instrument was operated with the IP65 case which is heated and ventilated, but not air conditioned. A laboratory test was subsequently conducted on the Fidas 200 (*i.e.* the instrument without the bespoke case), and

these results are also presented in this report. The operation of the Fidas 200 and Fidas 200S were evaluated and the results are discussed in Section 2.3 of this Report.

(b) Operating principles

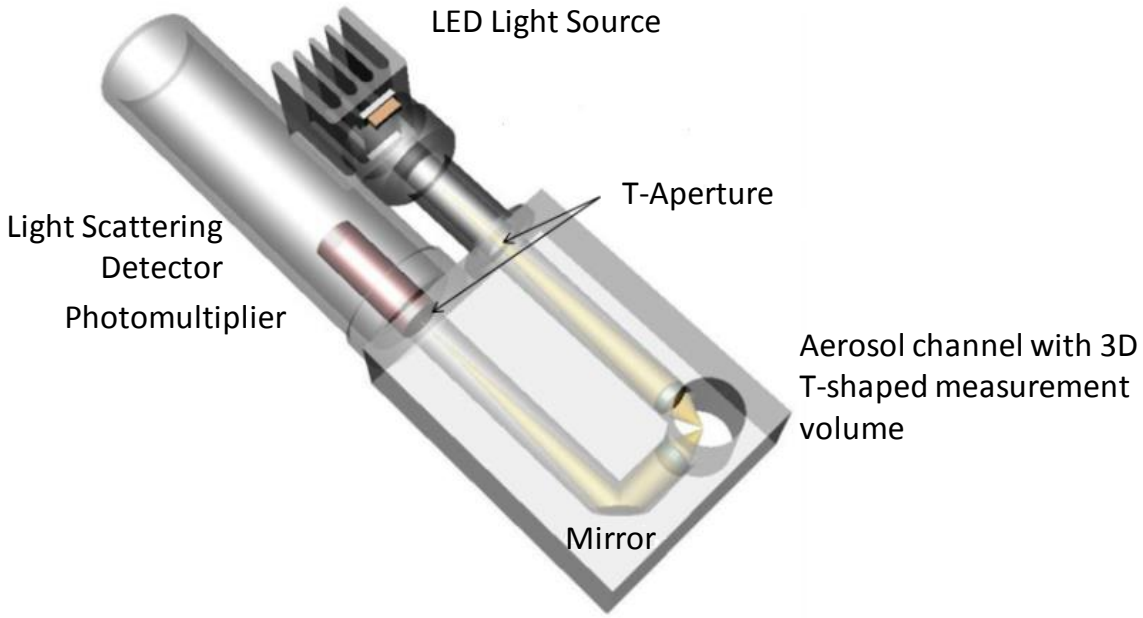
The Palas Fidas 200 is based upon the measurement principle of scattered light analysis.
The instrument is available in the versions Fidas 200 S (for outdoor application, including weatherproof housing, tested in type approval test) and Fidas 200 (for indoor application)
The tested measuring system consists of a Sigma-2 sampling head, a sampling line with the IADS moisture compensation module, the Fidas control unit with integrated aerosol sensor, the compact weather station WS600-UMB, a UMTS-antenna, a weatherproof housing (IP65 only for PalaS Fidas 200 S), corresponding connection lines and cables, one bottle of CalDust 1100 or Mono Dust 1500), and manuals in German and English.

Figure 1a: Overview of the complete Fidas 200 S System



The spectrometer determines particle size by means of light analysis according to Lorenz-Mie scattering measured at 90 degrees.

Figure 1b: Design of the Fidas Optical Sensor



The particles move separately through an optically differentiated measurement volume that is homogeneously illuminated with white light. The use of white light enable a MONOTONIC scattered response from the detector of the scattered light as a function of particle size. This is discussed further in [Ref.7 Section 1.1].

The particle sample passes through the Sigma-2 sampling head (a TSP head without an impaction surface or cyclone) at a flow rate of 4.8 l/min (at 25 °C and 1013 hPa) and is led into the sampling line which connects the sampling head to the Fidas control unit. The IADS (Intelligent Aerosol Drying System) moisture compensation module is used in order to avoid the possible effects of condensation, especially when the ambient air humidity is high. The temperature of the IADS is regulated with regard to relative humidity and ambient temperature (measured with weather station WS600-UMB –see below). The minimum temperature is 23°C. The moisture compensation is carried out by a dynamic adjustment of the IADS temperature up to a maximum heating output of 90 watts. The IADS module is controlled *via* the Fidas Firmware. After passing through the IADS module the particle sample is led to the aerosol sensor where the actual measurement is performed. From the aerosol sensor the sample is then led through an absolute filter which can be used, for instance, to further analyse the collected aerosol. The Fidas 200 measurement system has an integrated weather station (WS600-UMB) to capture the measured quantities wind velocity, wind direction, amount of precipitation, type of precipitation, temperature, humidity, and pressure. The Fidas 200 control unit contains the necessary electronics for operating the measuring system as well as the 2 parallel-connected sample pumps. Should one pump fail, proper operation is secured by the remaining pump.

There is a requirement to re-calibrate or check the calibration of the instrument using mono-disperse aerosols every 4 weeks [Ref.7 Figure 16]. This is clearly necessary given the operating method and the instrument

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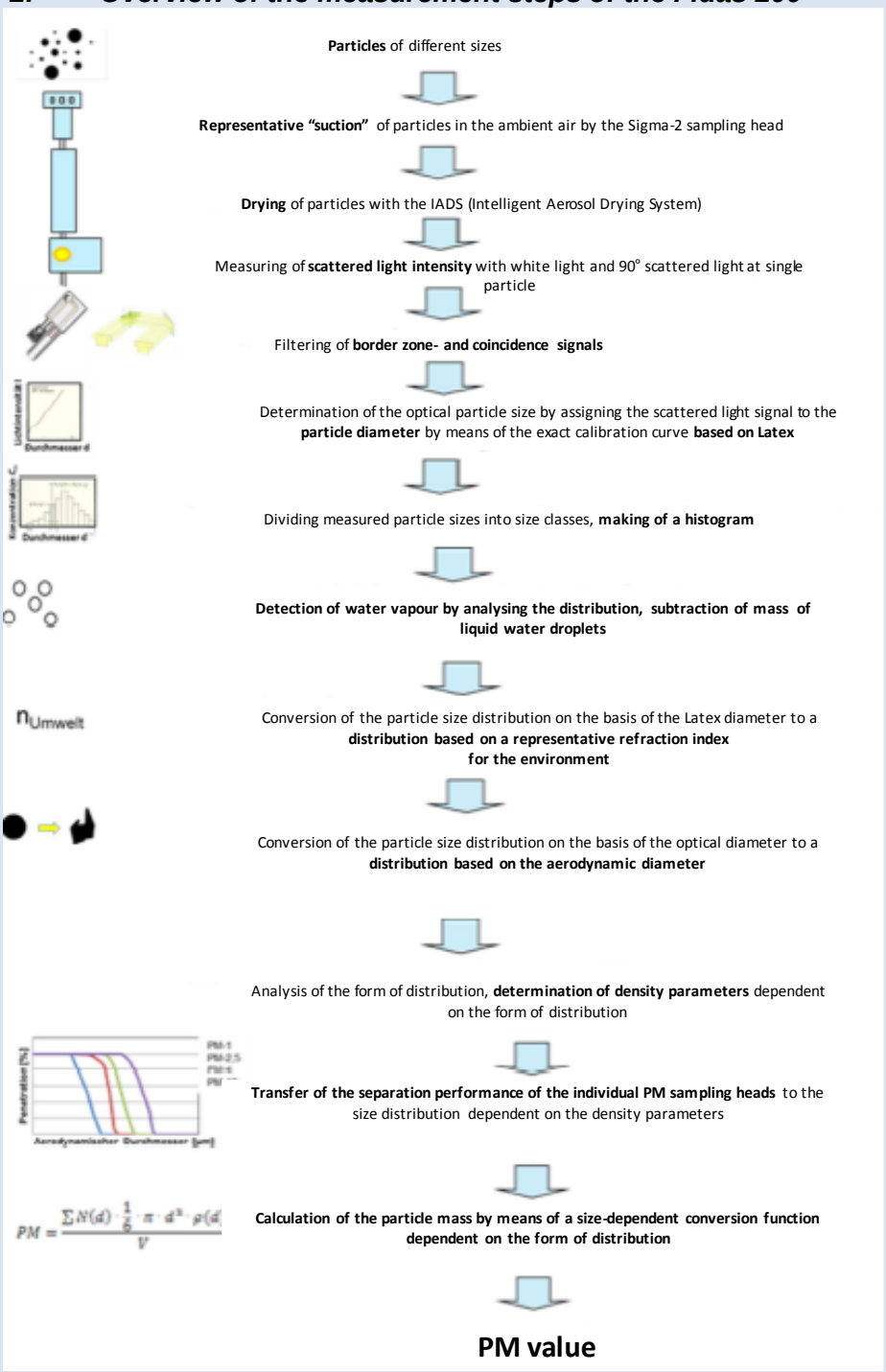
There is also a requirement to check the instrument zero using a supplied zero PM artefact [Ref.7 Figure 15].

In addition, the overall data collection and processing system that covers this instrument that uses Method 11 is given in the figure below:

Figure 2: Overview of the measurement steps of the Fidas 200



The Fidas 200 measurement system saves data in its raw format. Then, in order to determine the mass concentration values, the stored raw data have to be converted by means of an evaluation algorithm. A size-dependent and weighted algorithm is used to convert particle size and number to mass concentrations. During type approval testing, conversion was performed using the evaluation algorithm PM_ENVIRO_0011. This is explained in more detail in Ref.7 Section 1.2]

(c)Serial Numbers of the Candidate Method Tested

Serial numbers assigned by Manufacturer	Model	Dates of tests	Firmware/software version	Reports of the test programme
0111 & 0112 Both for all the six tests in Germany and the UK	See above – sample channels for PM_{10} & $PM_{2.5}$	April 2012 to September 2013 (Germany); February to June 2014 (UK)	Firmware: 100327.0007. 0001.0011 Implemented evaluation algorithm: PM_ENVIRO_0011; & For external PC 1.01	Ref. 6 (September 2013) for the 4 German tests; Ref.7 includes the 2 UK tests

The same instruments were used for the laboratory tests

(h) Firmware/software of the Method

The stated firmware version noted above in the Table (100327) is used for the operation of the integral panel PC.

The implemented data evaluation algorithm used in this CM and in [Ref.7] is PM_ENVIRO_0011 which is known in this Report and in [Ref.7] as ***Method 11.*** *No other data processing software* ***other than Method 11*** *is covered directly by this certification*

(i)

There is a more detailed description of the firmware used in the equivalence testing programme in [Ref.7] Section 1.5. It is noted that it has also been confirmed that this firmware has been updated and approved by the appropriate German assessment group, and it also should be reviewed by the annual audits carried out within the requirements of EN15267-Part 2 by TÜV and/or by Sira. *Annual audit reports should contain specific references to the issue of software and its validation, to ensure continued compliance.*

It should be noted that whilst it may in principle be considered appropriate to retain this firmware/software version because this is what is certified, it is recommended that efforts should be made by operators of the instruments to install ***the latest approved version*** *of the instrument firmware/software suitable for the particular model being operated.*

2.2 Reports Evaluated by the MCERTS Certification Committee for the Palas Fidas 200 using Method 11 for PM_{10} and $PM_{2.5}$ Particulates

Reports concerning this Candidate Method have been reviewed by the MCERTS certification committee. These are:

2.2.1 Test report on Palas 200 prepared by TUV Rheinland Energie und Umwelt GmbH:

Report on testing of the Fidas® 200 S and respectively Fidas® 200 measuring systems manufactured by Palas GmbH for the components of suspended particulate matter PM_{10} and $PM_{2.5}$, Report number 936/21227195/A, dated 9th March 2015 [Ref.6]

This TÜV report, published in 2015, provides the results obtained at four test sites in Germany (Two at Cologne, one at Bonn, and one at Bornheim) and two in the UK (Teddington). This recent Report replaces a previous TUV report that covered the four German tests only. Further information on these tests and on the two UK tests are given in Ref.7 and Section 2.2 of this Report. The ranges of the ambient environmental conditions that occurred during each of the six sets of tests are also shown in Section 2.2 below [see also Ref.6 Table 4 and [Ref.7], and these are considered to be adequately broad.
The results of the sets of field tests and the laboratory tests produced in the TUV report were subsequently evaluated and approved by the certification committee in Germany. This is discussed in the BV report [Ref. 7], and in the main body of this Evaluation Report.

The six sets of data were also evaluated, and the processed results were also reviewed with respect to the ***field test requirements*** of the EC "Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods [Ref.2]. *The results obtained in this TÜV report have also been re-calculated [Ref.7] in order to confirm their complete conformance with all the modern GDE requirements (e.g. the "outlier" test carried out by TÜV was very slightly different from that required by the GDE).* The MCERTS Performance Standard [Ref.3] and the MCERTS Annex document [Ref. 5] have the same requirements as the GDE. *All of the results have been re-processed by BV [Ref.7], and these were shown to conform to the requirements of the GDE, MCERTS Standard and MCERTS Annex documents referred to above, as discussed in the main body of this Report.*

Note 1: The numbers of paired datasets given in the Table in Ref.7 are slightly different than those given in [Ref.6]. This is because [Ref.6] carried out the calculations on outlier rejection according to earlier rules of the GDE. These calculations have now been performed [Ref.7 Section 10] according to the GDE 2010 [Ref.2] in which the data rejection rules are slightly different

2.2.2 Report prepared by Bureau Veritas, UK: *UK Report on the Equivalence of the Palas Fidas Method 11 for PM_{10} and $PM_{2.5}$, BV Number AGGX8316719/BV/DH/2972,* *Bureau Veritas Air Quality, dated March 2016 [Ref.7];*

This is a UK report presented in the format required by the Defra Annex Report [Ref.5], to fulfil Defra requirements. All candidate methods were tested against the PM_{10} and/or $PM_{2.5}$ Sven Leckel LVS3 or SEQ47/50 European Reference Methods (RM). The operation of the instruments was undertaken by TÜV Rheinland in Germany, and the National Physical Laboratory (NPL) in the UK. Both organisations have appropriate ISO17025[2] accreditations, which are including in [Ref.7 Section 5]. Calculations of the between sampler uncertainties and the expanded uncertainties relative to the reference method were undertaken by Bureau Veritas (BV). BV has provided overall project management to the delivery of the programme in the UK.
A series of intensive laboratory tests were undertaken by TÜV that go beyond the laboratory test requirements set out in MCERTS for UK Particulate Matter. The instruments were ALSO leak tested and flow tested by NPL and TÜV Rheinland throughout the field campaigns (Section 3.3) in a manner that is similar to the MCERTS requirements.
The Maintenance Interval is discussed (Ref.7 & Section 2.4). It is also necessary to consider the periodic testing with CalDust 1100 (Ref.7 Section P31] and methods of downloading data (Ref.7 Section 1.2). Data Capture has been calculated in accordance with MCERTS for UK Particulate Matter [Ref.7 Section 11].

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[2] *ISO Standard 17025:2005 General requirements for the competence of testing and calibration laboratories*

Certification Report and Checklist on the Evaluation of the Ambient Air Particulate Matter Monitor Test Reports for the PALAS Fidas 200 and 200s Monitors Submitted for Approval and Certification within the MCERTS Scheme for UK Particulate Matter: Requirements of the UK Competent Authority for the Equivalence Testing of Methods that Monitor Particulate Matter in Ambient Air, MCERTSPMT6PALASPM10&PM2.5260416/10.4

Further, as it is necessary to demonstrate that there is no significant differences between the Fidas 200 S and Fidas 200, and it is necessary to consider the sensitivity of these two forms of the instrument to surrounding temperature [Ref.7 Section 6).
In addition, due to discontinuation of the LED used in the instrument, the manufacturer was required to change the LED for a different type, and a series of laboratory tests were undertaken to test the effect of this [Ref.7 Section 7]. Calculations of the suitability of the data with respect to the pollution climate within the UK were undertaken by BV (Ref.7 Section 15).
This Report sets out the findings of the field campaigns, laboratory testing and pollution climate calculations. This Report, and that of Ref.7, are fully compatible with all the requirements of MCERTS for UK Particulate Matter [Ref.5], including its reporting structure. It has been used to provide the MCERTS Certification Body, and its certification committee, with the evidence required to assess whether all the testing carried out is compliant with all the requirements of MCERTS for UK Particulate Matter {ref.5}.

In the field tests and the initial laboratory tests, the instruments were operated with the IP65 case, which is heated and ventilated but not air conditioned. In this configuration, and the instrument is known by the manufacturer as the Fidas 200 S. A laboratory test was subsequently conducted on the Fidas 200 (*i.e.* the instrument without the bespoke case), and the results are presented in this Report. The operation of the Fidas 200 and Fidas 200 S were both shown to be unaffected by the temperature of their surroundings, *within their respective specifications,* and it is therefore recommended that the certification covers the Palas Fidas 200, and that the instrument can either be installed in the IP65 case, or any other enclosure. The MCERTS certificate should however cover different temperature ranges for both instruments that correspond to the temperatures over which they were tested.

In Germany, the instrument was referred to as Palas Fidas 200®, where denotes ® registered trade mark. In this report, for UK purposes, the ® is excluded from the name of the instrument. The instrument is therefore herein referred to as the Palas Fidas 200 S Method 11 when used with the IP65 case. The instrument is also herein referred to as the Palas Fidas 200 Method 11 when used without the IP65 case, and when referring to the specific name of the instrument to be certified. When referring to those laboratory tests where the algorithm to calculate concentrations was not used, the instruments are referred to as Palas Fidas 200 S or Palas Fidas 200. The results in this TÜV report were evaluated with respect to the daily average limit value for PM_{10} and $PM_{2.5}$ as required by the GDE, and also with respect to data that was ≥ 50% of the daily limit value *but not required by the GDE.*
The results of the six sets of field tests and the laboratory tests were subsequently evaluated and approved by the certification committee in Germany. This is discussed in the BV report [Ref.7], and in the conclusions of this Evaluation Report.

The results obtained in this TÜV report have been re-calculated in the BV report [Ref.7] to evaluate their conformance with all the GDE requirements. (The MCERTS Performance Standard [Ref.3] and the MCERTS Annex document [Ref. 5] have the same requirements as the GDE).

2.3 Scope of Equivalence Testing for this Evaluation

The Reference Method takes 24-hour samples on to filters that are weighed on a balance before and after sampling. However, as noted previously, the Fidas 200 takes many samples that are processed into 15 minute averages that are then averaged to give 24 hour results.

As such, there is a significant difference between the Candidate and Reference Methods, necessitating that a complete set of test procedures are undertaken as discussed in MCERTS for UK Particulate Matter at different locations. The field tests were carried out at the following test sites:

Table 1: Field Test Sites and their Characterisation

Measurement Site	Period	Characterisation
Cologne Summer	05/2012 to 09/2012	Urban background
Cologne Winter	11/2012 to 02/2013	Urban background
Bonn Winter	02/2013 to 05/2013	Traffic
Bornheim Summer	05/2013 to 07/2013	Rural with influence of traffic
Teddington Winter	02/2014 to 04/2014	Urban background
Teddington Summer	04/2014 to 06/2014	Urban background

It should be noted that:

(a) The EC GDE [Ref.2] and the MCERTS Annex [Ref.5] require the determination of the measurement uncertainty of the CMs with respect to the paired datasets obtained by the RMs, and this procedure requires separate evaluations of these datasets with:

- The full dataset;
- Datasets representing PM concentrations greater than or equal to 30 µg m^{-3} for PM_{10}, and concentrations greater than equal to 18 µg m^{-3} for $PM_{2.5}$ provided that each subset contains 40 or more valid data pairs;
- Datasets for each individual site.

(b) It is necessary that all the field test sites had a similar particulate pollution climate to that of the UK. The data obtained during all the field trials was determined to be suitable for assessing the applicability of the test sites to the UK Particulate Matter Pollution Climate. The determination was carried out and presented in the BV report [Ref.7]. There were *no* field test sites that did not conform to the requirements for the UK PM Pollution Climate, and hence *none* were excluded from this Report *on these grounds*. (This includes the German test sites).

(c) There is a requirement for there to be at least one UK field test with a valid set of results in this evaluation. Two sets of UK tests were carried out as above and these are included in this Evaluation.

(d) There is a requirement in this test programme that two collocated reference methods are used for each field test. These were reviewed for their suitability [Ref.9 Section 4] and these were the same type as that specified in the standard EN 12341 [Ref.8];

(e) There is a requirement for there to be at least 90% data availability. The calculation of this is presented in [Ref. 7]. This exceeds 90%, and is summarised below in Section 2.4.5 of this MCERTS Report.

2.4 Range of Conditions over which Equivalence is supported

2.4.1 Measurement/Certification Range

There are currently no European standard measurement ranges or certification ranges for these types of automated particulate measuring instruments, either for PM_{10} or for $PM_{2.5}$ particulate monitoring, because the CEN standard for this is still under development, including a requirement to complete a linked validation programme. The GDE [Ref.2] gives no suitable recommendation on this. There is however, a precursor to the above CEN standard being developed that has been published recently - CEN/TS16450:2013 [Ref.12]. The requirements of this for PM_{10} monitoring currently are that measurement ranges, or certification ranges, are defined as:

- 0 µg/m^3 to 1000 µg/m^3 as a 24-hour average value; and
- 0 µg/m^3 to 10000 µg/m^3 as a 1-hour average value, if applicable.

During the field tests, the measuring range was apparently set to much less than this, for the 24-hour averaged values, although it is not completely clear to the certification committee. The concentrations observed in the six field campaigns were also generally lower than the 1000ug/m3 measurement range, since all of the concentrations are expressed with respect to the 24-hour sampling period of the reference method. The hourly concentration values determined by the instrument are higher and these feed into the 24-hour reference values. It is therefore recommended that the Palas Fidas 200S Monitor is certified for the measurement range:

- **0 µg/m^3 to 10,000 µg/m^3 over a 24-hour averaged sampling period;**
- **This range is applicable to both PM_{10} and $PM_{2.5}$ channels;**
- **The measuring range may be considered as effectively 0-10000 ug/m^3, but this isn't based on a setting of the instrument, rather this is its maximum response.**

2.4.2 Range of Ambient Temperatures

As noted above, there are currently no European standard test conditions for these types of automated particulate measuring instruments - either for PM_{10} or for $PM_{2.5}$ particulate monitoring - because the CEN standard for this is still under development, and this includes a linked validation programme. The GDE [Ref.2] also gives no suitable recommendation on this. There is, however, a precursor to the CEN standard that has been published - CEN/TS16450:2013 [Ref.12]. The requirements of this CEN/TS for ambient temperature tests on PM_{10} monitors are that:

The dependence of the zero reading, and the measured value obtained by applying a calibration artefact, on the surrounding temperature should be 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 temperature range of these tests is selected for PM_{10} instruments that are to be used in indoor enclosures.
These tests require the use of zero and span calibration devices. *The tested instruments passed the tests:*

- A maximum deviation was determined over the temperature range of +5 °C to +40 °C of very small, and effectively zero concentration, where the performance criterion is ≤ 2.0 µg/m^3; it should be recognised that this should be maintained by the use of the Caldust 1100 or Monodust 1500 calibration particulates - preferably every one month, but at least every three months [Ref.7 Section 8.3, and Restrictions in this report Section 5.3.

It should also be noted that the 24 hour average ambient (outside) temperature range that occurred during the first four field test data sets (Table 2) varied from -3.4 °C to 16.4 °C. However, the instruments are usually housed in controlled-temperature containers [Ref.6 Section 9]

It is therefore considered that

The acceptable temperature range for this type of *indoor* monitor shall be +5 °C to +40 °C;

The acceptable temperature range for this type of *outdoor* monitor with its defined enclosure is -20°C to +50°C

2.4.3 Requirements to Fulfil the UK Particulate Climate Conditions

The UK Particulate Pollution Climate calculations are presented in [Ref.7 Section 15], and summarised in the checklist of this Evaluation Report (Section 4 (v)). These calculations show the sites in Germany are of a similar Particulate Matter Pollution Climate to that of the UK [Ref.13], and for there to be suitable ranges of wind speed, temperature, dew point and semi-volatile components. These requirements are all met for the field test sites reviewed in this Report.

2.4.4 Types of Monitoring site covered by this Type of Instrument in the UK

The results from the field test sites that were used as the primary evidence in this Report were at urban background, and traffic locations. Bornheim represents a semi-rural environment with impact from traffic. *It is recommended, therefore, in this Evaluation that this type of instrument is suitable for use at urban background (including suburban), rural, and traffic locations within the UK.*

2.4.5 Firmware/software

A discussion and recommendations for the versions of firmware/software to be used is given in Section 5.5 of this Evaluation Report.

2.4.5 Data availability of the candidate method

The Annex document MCERTS for UK Particulate Matter [Ref.5] lists the following requirement for the Availability of the measuring system:

"The fraction of the total and consecutive monitoring time during all the field trials involved in the equivalence testing programme for which data of acceptable quality are collected. The times required for scheduled calibrations and maintenance shall not be included. The method for calculating this fractional time is given in Section 5.2 Eq.2. Availability defined here is the same as the minimum data capture requirements given in the data quality objectives in Directive 2008/50/EC for the relevant pollutant."

The data availability of these candidate methods can be determined from the available data, as outlined in [Ref.7 Section 11]:

- The TÜV Report [Ref.6] summarises this availability for the first four tests. The BV report [Ref.7 Section 11] summarises this for all the six test sites used, taking account of losses of data attributed to the instruments themselves, and this information should be included on the MCERTS certificate.
- The average data availability for the field test sites reviewed in this Report, taken over the total period of the field tests and based on the daily data results, is in excess of 99% [Ref.7 Section11]
- The related maintenance interval is also discussed in [Ref. 7 Section 11], and the data capture has been calculated in accordance with MCERTS for UK Particulate Matter [Ref.5 Section 5.2]. It is presented in the checklist of this Report, and in its Summary and Recommendations – Section 5.

The European Directive 2008/50/EC [Ref.1] requires a data capture of ≥ 90 %. This requirement is therefore fulfilled using all of the processing methods that are outlined here.

2.5 Summary of Equivalence Scope and Conditions

The BV report [Ref.7] sets out all the findings of the field campaigns, laboratory testing, and particulate pollution climate calculations, and this report is structured to include the 17 numbered sections specified in the MCERTS for UK Particulate Matter document [Ref. 5 Section 6]. Thus, this BV report is fully compatible with all the requirements of MCERTS in the UK [Refs.3 & 5], including its reporting structure. It has been evaluated by the MCERTS Certification Body, and by the MCERTS certification committee, as the evidence that is required to assess whether all the testing carried out is compliant with all the requirements of the MCERTS for UK Particulate Matter Document [Ref.5], and the summary and conclusions of this evaluation are given in Section 5.

A series of *laboratory tests* were also undertaken by TÜV [Ref.6 Section 6, Ref.7 Section 8], and these are summarised in the next Section of this Evaluation Report.

3. Requirements and Options for the Laboratory Test Programme

3.1 Requirements of the MCERTS Annex Document

The Annex to the MCERTS Performance Standards Document [Ref.5 Section 4.2] provides the scope of the laboratory test programme that is specified in the GDE, and that which is also specified in the MCERTS Performance Standard [Ref.3].

This Section of the Evaluation Report also lists below in summary the additional testing requirements that are were specified in German VDI/DIN Guidelines [Refs.12&13]. These VDI/DIN Guidelines are required to be carried out for suitability testing/type approvals for

automated continuous methods to be accepted for use in Germany. There are similar, but not identical to, additional requirements that are in a draft European standard being prepared by CEN. A precursor of this is currently published as a CEN Technical Specification [Ref.12], although this is not mandatory.

The somewhat *different* test requirements of the GDE [Ref 2], of the MCERTS Performance Standard [Ref 3], of the MCERTS Annex Document [Ref 5], and of the German VDI/DIN Guidelines, are discussed below - as applied to the TÜV test report [Ref.6] that has been submitted for MCERTS Certification.

The evaluations and the conclusions that have arisen from the MCERTS certification committee's review of this TÜV test report that relate to the ***laboratory tests*** are given below in this Section - in each case under the heading "Evaluation and Findings" in ***italic text below.***

The laboratory test programme was all carried out using the same two Palas Fidas 200 S instruments that were deployed in the field test programme

3.2 The laboratory test programme required by the Guide to Demonstration of Equivalence

3.2.1 Requirements

Section 9.3 of the GDE [Ref.2], covers *only two applications* that relate to certain limited modifications of the manual CEN standard method (PM_{10} or $PM_{2.5}$), which the AQD has specified as a reference method. These are:

1a. Application of automated filter changers leading to filter storage conditions deviating from those prescribed in the EN standards;

1b. Use of different weighing conditions, e.g., conditions deviating from the requirements set in the EN standards.

In either of the above circumstances the GDE requires a set of laboratory tests that are given in [Ref.2] Sections 9.3.2 and 9.3.3 respectively. ***There are no laboratory tests prescribed in the GDE for candidate methods that are different to these.***

3.2.2 Evaluation and Findings for 3.2.1 above

The candidate methods discussed in the TÜV test report [Ref.6] do not relate to the limited modifications of the manual CEN standard method that are stated in the GDE, and as also listed in 1a and 1b above. Thus the TÜV report, as well as this MCERTS Evaluation Report, does not need to discuss such tests as they are not required.

3.3 The laboratory test programme required by the MCERTS Performance Standard

3.3.1 Requirements

The MCERTS Performance Standard [Ref.3] specifies further tests compared to those in the GDE listed in Section 3.2 above, two of which are related to the stability of the atmospheric

sample flow through the sample filter or the measurement cell, and the provision of a representative sample. These are:

a. Constancy of the sample volume flow, is tested as specified in the MCERTS Standard [Ref.3 paragraph 6.5.2], using selective filters loaded with particulates at 80%, 50% and 0% of the maximum permissible filter loading specified. The constancy of the sample volumetric flow was recorded as a 3-minute average every 30 minutes for at least 24 hours – to achieve the performance criteria given in Table 6.2 of the MCERTS Performance Standard [Ref.3].

b. The leak tightness of the sampling system is carried out using atmospheric sample flow and atmospheric pressure monitoring equipment to determine the leak rate of the entire instrument where feasible, or by evaluating the leaks of different parts separately. The tests can be made by measuring the sample volume flow at the inlet and outlet of the system, or by determining the pressure drop – to achieve the performance criterion as given in [Ref.3 Table 6.2].

c. In addition, the same tests are required in The MCERTS Performance Standard [Ref.3] *where relevant* as in the two applications in the GDE [Ref.2]. These relate to certain limited modifications of the manual CEN standard method, which the AQD [Ref.1] defines as the reference method. The test procedures in the two documents are identical and are:
   - Application of automated filter changers leading to filter storage conditions deviating from those prescribed in the CEN standards;
   - Use of different weighing conditions, e.g., conditions deviating from the requirements set in the CEN standards.

   In either of the above circumstances the MCERTS Performance Standard [Ref.3] requires a set of laboratory tests that are as given in that document Sections 6.6.2 and 6.6.3 respectively.

The laboratory tests that are specified in the MCERTS Performance Standard [Ref.3] shall be the minimum laboratory tests that are carried out to show conformance with the requirements of this Evaluation Report.

3.3.2 Evaluation and Findings for Paragraph 3.3.1a above – Constancy of the sample volume flow

The laboratory test to be carried out to fulfil Paragraph (a) above from the MCERTS Performance Standard [Ref.3] states:

Constancy of sample volumetric flow: The testing shall be carried out by providing loaded filters, a volumetric flow measuring device such as a mass flow meter, and a pressure measuring device. Three pre-loaded filters shall be provided with the particulate load of approximately 0%, 50%, and 80% of the maximum permissible filter loading. For each filter the constancy of the sample volumetric flow shall be recorded every 30 minutes as a 3 minute average over a time period of at least 24 hours. The criteria required in Table 6.2 of the MCERTS standard [Ref.3] are:

Table 2: Specific performance criteria for laboratory volume flow, and leakage of the PM sampling system, given in the MCERTS Performance Standard

Parameter	Performance requirement
Constancy of sample volumetric flow	Sample volumetric flow averaged over the sampling time to remain constant within ± 3% of the rated value. All instantaneous values to remain within ± 5% of the rated value.
Tightness of the sampling system	Leakage not to exceed 1 % of the sampled volume.

The TÜV testing was carried out using different procedures, which were implemented during the field tests – by using results taken at the beginning of each of the field tests after calibrations at the first of the sites adjusted where required. The flows were monitored every five seconds and then averaged for six hourly measurements covering six cycles. The results obtained at the beginning of each field test were checked for correctness at the end of each field test - [Ref.6 Section 6.1, 5.3.6]. This data was therefore obtained over the different ambient particulate loadings that were encountered during the complete durations of the field trials in Germany, but were not carried out in the manner described above from [Ref.3]. The results were obtained with the flows monitored by a dry gas meter, and the CM total flows were provided by the CMs' data outputs. The data of the measured results are presented but the PM loadings are not presented in the TÜV report [Ref.6]. The results are also summarised in [Ref.7 Section 8.1]. Tables 5 and 6 below give a summary of the results.

The German performance criteria [Refs.12&13] are the same as given above for the MCERTS Performance Standard [Ref.3]. This was fulfilled within the TÜV test report [Ref.6 & Ref.7 P40], with a maximum deviation of +2.3% obtained, as compared with the criterion of ±3%. There was no instantaneous value outside of the 5% criterion. The filter loadings of 0%, 50% and 80% ***cannot*** be implemented systematically*, clearly because there is no filter to load by these amounts*

The results of the flow rate checks carried out at five on the field test sites are given [Ref.6 & 7] and Table 3 below. A flow check was conducted before the Teddington winter field test, and it is known that both SN 0111 and SN 0112 passed the test, but the results have not been recorded.

Table 3: Summary of Results of the Volume Flow Tests for Instruments SN 0111 & 0112.

Flow rate check before testing at Test site:	SN 0111		SN 0112	
	[l/min]	Deviation from nominal value [%]	[l/min]	Deviation from nominal value [%]
Cologne Summer	4.87	1.5	4.88	1.7
Cologne Winter	4.78	-0.4	4.80	0.0
Bonn Winter	4.77	-0.6	4.77	-0.6
Bornheim Summer	4.91	2.3	4.89	1.9
Teddington Summer	4.85	1.0	4.83	0.6

Graphical representations of flow rate constancy [Ref.7 Section 8.1] show that none of the values obtained during sampling deviates from the respective nominal value by more than ±5 %. The 24 hour mean values for the total flow rate of 4.8 ± 0.15 l/min at 25 °C and 1013 hPa also deviate significantly less than the permissible ±3 % from the nominal value.

All determined daily mean values deviate less than ±3% from the rated value and all instantaneous values deviate less than ± 5 %.

The German performance criteria [Refs.12&13] are the same as given above for the MCERTS Performance Standard [Ref.3]. This was reported in detail and fulfilled within the TÜV test report [Ref.6], with a maximum deviation of +2.3% obtained, as compared with the criterion of ±3%. There was no instantaneous values outside of the 5% criterion [Ref.7 Section 8.1].
These TÜV results represent a different evaluation procedure carried out in practice in the field, compared to the requirements of the MCERTS Performance Standard (although this TÜV report did not present the PM loadings present). The highest deviation from the nominal values for flow is +2.3% and is less than the performance criterion of ±3%. The flow rate tests were carried out under the filter loadings encountered in the field tests and not at the 0%, 50% and 80% of the mass loading as prescribed in the MCERTS for UK Particulate Matter [Ref.5]
The requirements for constancy of the sample volume flow are therefore considered to be fulfilled.

3.3.3 Evaluation and Findings for Paragraph 3.3.1b above – Leak tightness of the sampling system

The laboratory test to be carried out fulfil paragraph (b) above of the MCERTS Performance Standard [Ref.3] states:
Tightness of the sampling system: The testing is normally carried out with the aid of a pressure measuring device and a volumetric flow measuring system. The leak rate of the entire instrument shall be determined if this is feasible. This includes the inlet as well as the whole sampling system and the measuring system. If because of the instrument design the complete system tightness cannot be measured the leak rate can be determined separately for the sampling part and the measuring part. The leak rate can be measured by the determination of volume flow at the inlet and outlet of the system, or by the pressure drop method. In the latter case the system is sealed at the inlet and evacuated by a built-in or separate pump and the pressure increase due to leaks is measured over a period of 5 minutes. The leak rate V_L determination shall be repeated three times. It is calculated from the following formula:

$$V = \frac{\Delta P . V_g}{P_0 . \Delta t}$$

Where: ΔP – pressure drop determined over the time interval Δt
P_0 - pressure at time t_0
V_g - estimated total volume of the system

The performance criterion to meet the requirements of Table 2 of the MCERTS standard [Ref.3] is given in the table above.
*The TÜV tests followed a procedure similar to that given above b**ut not the same**:*

The flow meter of the Fidas 200 S measuring system is located directly upstream of the pump. To determine the leak rate of the AMS, the measuring system is switched to calibration mode and the instrument inlet is sealed (with a plug) according to chapter 3.1 of the operator's manual. As specified by the manufacturer, the flow rate measured by the instrument shall then drop to 0 ± 0.1 l/min. This procedure was carried out every time the

AMS was installed at a new field test site. It is recommended to check the tightness of the measuring system by means of the aforementioned procedure every three months.

Leakage testing was performed after the AMS was installed at a new field test site. The criterion for passing the leak test, which has been proposed by the manufacturer (maximum flow at blocked inlet 0 ± 0.1 l/min) proved to be an appropriate parameter for monitoring instrument tightness. The detected maximum leak rate was 0.83%, which is less than 1 % of the nominal flow rate.

It can also be seen from these tables that the leak rate is ≤ 0.04% for SN 0111 and ≤ 0.04 % for SN 0112) at an atmospheric pressure of 1028 hPa. The determined values are less than the requirement of ±1%.

Thus these test results were in conformance with requirements, and the requirements for this test may therefore be deemed to be fulfilled.

3.3.4 Evaluation and Findings for Paragraph 3.3.1c above – limited modifications to the CEN manual reference method

The laboratory test that should be carried out to fulfil paragraph (c) in Section 5.3 of the MCERTS Performance Standard [Ref.3] is not relevant to the test report [Ref.6] since the tested CMs do not relate to limited modifications of the manual CEN standard method specified in the GDE [Ref.2]. Thus the test report does not describe any such tests, as they are unnecessary.

3.4 Tests Carried Out as an *Option Additionally* to the Requirements of the MCERTS Performance Standard and of the MCERTS Annex Document

3.4.1 Requirements

In Germany, there are minimum requirements and test procedures *for laboratory tests* for automated continuous methods defined in VDI 4202- Part 1 and VDI 4203-Part 3 [Refs.12&13] that are *additional* to those of the GDE [Ref 2], and to those of the MCERTS Performance Standard [Ref 3], and to those of the MCERTS Annex Document [Ref 5]. These requirements and procedures would need to be met and followed in addition for automated continuous PM methods that are to be used in Germany for regulatory purposes. These standards include references to EN 12341 (in terms of equivalence testing for PM_{10}) and to the GDE [Ref 2] (in terms of equivalence testing for PM_{10} and $PM_{2.5}$). The additional laboratory tests include:

- Measured value display;
- Easy maintenance;
- Functional check test;
- Set-up and warm-up times;
- Instrument design;
- Unintended adjustment;
- Data output;
- Measuring range;
- Negative output signals;
- Certification range(s)
- Analytical function;
- Linearity;
- Detection limit/repeatability at zero point

- Repeatability at the reference point
- Response time;
- Dependence of the zero point on ambient temperature;
- Dependence of the measured value on ambient temperature;
- Long-tem/short term drift of the zero point;
- Drift of measured value;
- Reproducibility RD;
- Daily averages.
- Cross sensitivity
- Averaging effects

These tests were carried out as described in the TÜV report [Ref.6], according to the VDI/DIN Guidelines [Refs.12&13], together with certain clarifications from the Competent Authority in Germany where required. These test procedures were employed to produce the test results that are listed in the TÜV test report [Ref.6 Sections 4.1 and 6.1]. (The methodology for the equivalence checks in the field is covered in [Ref.6 Section 7.1].)

1.4.2 Evaluation and Findings

The additional laboratory tests referred to in the above are outside of the scope of the requirements of the MCERTS Performance Standard for Continuous Ambient Air Monitoring Systems [Ref.3] and its Annex [Ref.5]. Therefore, the test results do not need to be evaluated within the MCERTS procedures. They have been recognised and accepted by the relevant Competent Authority in Germany. It is proposed that summary comments concerning these additional tests, NOT required by the UK Competent Authority, are included in the MCERTS Certificate for the type of monitoring system discussed in this Report.

4. Checklist for Assessing the Acceptability of the Equivalence-testing Programme

This Section covers the MCERTS certification committee's checklist for the assessment of conformance with the requirements of the MCERTS Standard for the UK Particulate Matter. ***It is important to recognise that this UK checklist is almost identical with the checklist developed recently (after 2012 [Ref.5]) by the EU AQUILA Network for similar applications - particularly those covering ambient particulate PM_{10} and $PM_{2.5}$ monitors.***

(i) Manufacturer and Monitoring Method

Manufacturer of the automated particulate monitoring method (including name and address)	Palas GmbH Greschbachstrasse 3b, 76229 Kahlsruhe, Germany
Is the above manufacturer requiring the equivalence testing or does the manufacturer have an agent?	Manufacturer requires equivalence testing;
Contact name at manufacturer and manufacturer's agent	Karsten Pletcher, Palas GmbH
Telephone numbers of contact names	+49 (0)721 96213-0
Description of automated PM method (model, serial numbers, software details etc.)	Software version: 100327.0007.0001.0011 (***BUT see Section 5.1c)***
All the initial stages of the MCERTS Certification process shall be completed (Ref.4].	Yes – processed through the MCERTS Certification Body

(ii) Details of the Test Laboratories and Other Laboratories Involved

Name of Company	1. TÜV Rheinland Energie und Umwelt GmbH, Germany 2. National Physical Laboratory, United Kingdom 3. Bureau Veritas UK Ltd. – preparation of the UK report – see Section 2.2 of this MCERTS certification committee Evaluation Report
Address	1. Am Grauen Stein, Köln, D-51105, Germany 2. Hampton Rd. Teddington, Middlesex, TW11 0LW,UK 3. 5th Floor, 66 Prescott St, London, E18HG, UK
Contact Name	1. Dipl.-Ing. Karsten Pletscher (report author) 2. Mr. David Butterfield/Dr. Peter Woods 3. Dr. Richard Maggs, Dr. David Harrison
Telephone number of Contact	1. +49-221-806-2592 2. +44-208-943-6391 3. +44-845-600-1828
Email address of Contact	1. Guido.baum@de.tuv.com/ Stefan.heift@de.tuv.com 2.David.butterfield@npl.co.uk/peter.woods@npl.co.uk 3.Richard.maggs@uk.bureauveritas.com
Dates tests were carried out	Germany: 05/2012 to 07/2013 United Kingdom: 02/2014 to 06/2014
Test Laboratory Report number and date	Report numbers: For details see Section 2 of this Evaluation Report of the MCERTS certification committee, and also Refs.6, 7;
Laboratory tests shall be carried out - where the tests have been made: ○ According to MCERTS Standard [Ref.3] Sections 6.5–6.6 ○ And to VDI/DIN Germany Guidelines VDI 4201-1 and VDI 4203 [Refs.12&13] requirements.	Yes - MCERTS Performance Standard and the VDI/DIN Guidelines – see Sections 3 .3 and 3.4 of this Evaluation Report of the MCERTS certification committee, and [Refs.6 & 7];

(iii) General Requirements of the Equivalence Testing

Relevant clause of the MCERTS Annex document [Ref.5] (& GDE Ref.2)	Requirement	Comments: including location of the relevant information in the Equivalence test report, or the FINAL test report, and its acceptability
Ref.5 Section 4.3(i)	All decisions by the Competent Authority with regards to the declaration of equivalence after June 2012 shall meet all the requirements of this document, with transitional arrangements as set out in Ref 5.	*Accepted:* All six of the field tests in Germany and the United Kingdom for this type of CM were carried out AFTER publication of the MCERTS Annex requirements document in July 2012; Two sets of field tests were carried out in the United Kingdom as required in Ref.5. There are no requirements for transitional arrangements - discussed in this Report
Ref.5 4.3(ii) (& GDE 9.4.1)	Where the CM is a limited modification of an existing CEN reference method the appropriate sub-set of tests shall be carried out completely and satisfactorily.	*Not applicable :* APPLICABLE only to a limited modification of an existing CEN reference method
Ref.5 4.3(iii)	Where the CM is a modification of an existing equivalent method, the test requirements shall have been specified and agreed with the UK Competent Authority. The tests shall been carried out satisfactorily in conformance with all the specifications, by a laboratory accredited to ISO/IEC EN 17025.	*Not applicable:* NOT a modification of an existing equivalent method.
Ref.5 4.3(iv) (& GDE 9.3)	Two RMs shall be used at all test sites – see 4.2 (iv), 4.2 (v), & 4.3(iii).	*Accepted:* All the sets of valid field tests in Germany and the United Kingdom used two reference methods [Ref.6 & 7];
Ref.5 4.3(v)	The RMs shall be of the specified type given in the relevant CEN standard. The gravimetric analyses of the samples in the laboratory shall be applied completely as specified in that standard.	*Accepted: these conformed to the then published CEN reference method*
Ref.5 4.3(vi)	Two complete CMs of the same type shall be used, and they shall be clearly and uniquely identified as such;	*Accepted*: Unique identifiers given;
Ref.5 4.3(vi) (& GDE 9.2)	The sample head of the CM shall be as specified in the relevant CEN standard. If not, the complete details of the CM's sample head shall be documented as specified in Ref.5 Section 4.2 and GDE [Ref.2] Section 9	The CEN standard has recently been revised [Ref.9] and different designs of sample head for the ***reference method*** are now required. **However, the sample head of this Palas Fidas type of CM is NOT of CEN design for either PM_{10} or for $PM_{2.5}$ because the**

		analytical system monitors ALL size fractions of TSP from 0.18 µm – 18 µm using a large number of size selective channels - produced by data from optical scattering – See Section 2.1 of this Report. This is the CM that is evaluated in this Report. *However, it is emphasized that there must be a regular calibration check using mono-dispersed aerosols to ensure that the size selective fractions in the detection channels have not drifted during use. The equivalence test programme demonstrates that this is satisfactory* ***despite this non-conformance with the CEN specified head*** *The requirement is considered suitable and thus fulfilled*
Ref.5 4.3(vii)	The two (local) CMs shall be co-located satisfactorily with respect to each other and with respect to the adjacent RMs to sample the ambient air homogeneously	*Accepted:* The CMs are located in transportable containers of the same type at the three German test sites (Cologne summer and winter, Bonn winter, and Bornheim winter, and in the UK Teddington, each with an enclosure, adjacent to each other. The sites were selected to have NO inhomogeneous significant or local emission sources. [Ref.6 Section 4 & Ref.7]
Ref.5 4.3(viii) (& GDE 9.1, & 9.4)	Where a "regional" instrument is used with two local CMs in the test programme, their results shall be applied correctly, and their measurement uncertainties calculated correctly.	*Not directly applicable*: The results of regional instruments were not used directly. However, the requirements for > 6 months of measurements at two of the German test sites are underpinned by the presence of the dataset at the Cologne site, which uses the requisite reference method data, and is <130 km distant [Ref.9 Section 15]. The requirements for >6months at the two UK sites are supported by > 6 months data with underpinning PM speciated measurements. *The requirement is fulfilled*
Ref.5 4.3(ix) & 4.6 (GDE 9.4.3)	Acceptable QA/QC checks shall be carried out during the test programme as specified in GDE Annex D for CMs[Ref. 2], and in EN 12341 (EN 14907 where applicable) for RMs.	*Accepted:* Within the TÜV report [Ref. 6], there is some information on the maintenance of the reference methods used during the trials and reference is made to the use of the appropriate CEN standard. However, there is no detailed and specific description of the QA/QC that was performed by the test laboratories according to the GDE [Ref 2]. Additional information has been made available in the UK BV report [Ref.7 Annex D]. There is therefore in our judgement in total, sufficient information to make the judgement that the quality assurance and quality control regime carried

		out is satisfactory and fit for purpose. *This requirement is considered fulfilled*
Ref.5 4.3(x) & 5.5.1	All the test results for the 2 RMs and the 2 CMs shall be documented completely - including all results that are rejected as outliers by Grubbs test or other means- or otherwise discarded.	*Accepted:* The allowed number of outlier rejections of the RM were carried out [Ref.7 Section 10 & Ref.6]. *The requirement is fulfilled*
Ref.5 4.3(xi) & 5.2	Both CMs shall have a minimum data capture and availability of greater or equal to 90%, as determined in Ref.5 Section 5.2, where tests have begun after Ref.5 entered into force.	*Accepted:* The averaged data capture of all the types of CMs in all the test programmes were all >90%, with the minimum value being 99% (see Ref.7 Section 11) including field test related downtime. The tests were carried out AFTER the MCERTS Annex document [Ref.5] was published, and thus this requirement is necessary.
Ref.5 4.3(xiii), &(xiv)	Where a test laboratory within a European Member State other than the UK produces the test report, at least two sets of valid (≥40) tests shall be carried out in that Member State at suitable sites. Where only one set of valid (40) equivalence field tests are to be carried out in the UK, there shall be at least three equivalence tests carried out in the other Member State. Where tests are begun before the date of publication of this document there shall be one or more tests carried out in the UK. Where tests are carried out that begin after the date of publication of this document, there shall be at least two tests carried out in the UK. The UK tests shall be carried out at one or more locations in the UK - selected with respect to the UK pollution climate evaluation, and at different seasons - The test laboratories shall be accredited to the ISO/IEC 17025 standard for all the MCERTS tests;	There are six test sets in total, four in Germany and two in the UK. In all six of these tests, the CMs were operated with an inlet that did not conform to the specifications of the published CEN standards – see Section 2.1 of this Report, but the results demonstrate equivalence. The test laboratories were accredited to EN ISO 17025 for these field tests. *There are more than four sites with ≥ 40 pairs of valid data points each, and therefore the requirements are fulfilled (Section 5 of this Report).*

(iv) Laboratory Tests to Fulfil the Requirements of the MCERTS Performance Standard and/or VDI/DIN

Section 4.2	The laboratory test to be carried out to fulfil Paragraph 6.5.2 of	The TÜV testing was carried out using a different procedure, which was implemented during the field	is

of Ref.5 & this Evaluation Report Section 3.3	the MCERTS Performance Standard [Ref.3] states: *Constancy of sample volumetric flow:* The testing shall be carried out providing loaded filters, volumetric flow measuring device such as, for example, a mass flow meter and a pressure measuring device. Three pre-loaded filters with the particulate load of approximately 0%, 50%, and 80% of the maximum permissible filter loading shall be used. For each filter the constancy of the sample volumetric flow shall be recorded every 30 minutes as a 3 minute average over the time period of at least 24 hours.	tests - using results obtained from the test sites. This data was therefore obtained over the different ambient particulate loadings that were encountered during the complete durations of all the field trials in Germany (see TÜV test report [Ref.6, Sections 4, 5.4.7 & 5.4.8] and results therein, and the BV report [Ref.7 Section 8). These utilised the continuously recorded daily averaged PM flows and the CM total flows provided by the CMs' data outputs. These data of the measured results are presented. The TÜV results represent a different, and possibly a more comprehensive, evaluation procedure carried out in practice in the field, compared to the requirements of the MCERTS Performance Standard [Ref.5]. The highest deviation from the nominal value observed was 2.3% of value (for SN0111 in Bornheim), within the criterion of 3% of the rated value (see Section 3.3 of this Report). There were no instantaneous values of 5% or more The performance criteria are the same as given in the MCERTS standard, and this was fulfilled within the TÜV test report. *The requirement for constancy of the sample volume flow is therefore considered to be fulfilled.*	
Section 4.2 of Ref.5 and this Report Section 3.3	The laboratory test to be carried out to fulfil paragraph 6.5.3 of the MCERTS Performance Standard [Ref.3] states: *Tightness of the sampling system:* The testing is normally carried out with the aid of a pressure measuring device and a volumetric flow measuring system. The leak rate of the entire instrument shall be determined if it is feasible. This includes the inlet as well as the whole sampling system and the measuring system. If because of the instrument design the complete system tightness cannot be measured the leak rate can be determined separately for the sampling part and the measuring part. The leak rate can be measured by the determination of volume flow at the inlet and outlet of the system or by the pressure drop method. In the latter case	This test was carried out by TÜV as described in Section 6.1, 5.3.7 of [Ref.6] and in [Ref.7]. The results obtained gave maximum leak rates during the tests of 0.04l/min for both of the CMs, compared with the performance criterion corresponding to <1% at the nominal flow of 4.8 l/min The performance criterion is the same as given in the MCERTS standard, and this was fulfilled within the TÜV test report. *The requirement for this test of tightness of the sampling system is therefore considered to be fulfilled.*	

	the system is sealed at the inlet and evacuated by a built in or separate pump and the pressure increase due to leaks is measured over the period of 5 minutes. The leak rate V_L determination shall be repeated three times. The criterion of both the UK and the German requirements are ±1% of the sample volume		
Section 4.2 of Ref.5 & this Evaluation Report Sections 3.2.2 & 3.3.4	Laboratory tests are required where relevant, on two applications that relate to certain limited modifications of the manual CEN standard method (PM_{10} or $PM_{2.5}$) specified in the GDE tests, where the AQD defines it as a reference method. These are: ○ Application of automated filter changers leading to filter storage conditions deviating from those prescribed in the CEN standards; ○ Use of different weighing conditions, e.g., conditions deviating from the requirements set in the CEN standards. ○ In either of the above circumstances the MCERTS Performance Standard [Ref.3] requires a set of laboratory tests that are as given in its Sections 6.6.2 and 6.6.3 respectively.	*Not applicable:* The laboratory test that should be carried out to fulfil paragraph (c) in Section 5.3 of the MCERTS Performance Standard [Ref.3] and section 4.2 2c of the MCERTS Annex document [Ref.5] is not relevant to this test report. This is because these CMs do not relate to limited modifications of the manual CEN standard method. Thus the test report does not report such tests, as they are unnecessary.	
Section 4.2 of Ref.5 & this Evaluation Report Section 3.4	There are minimum requirements and test procedures in Germany for automated continuous methods defined in VDI 4202- Part 1 and VDI 4203-Part 3 (both updated and re-published in 2010) [Refs.12&13] that are additional to those of the GDE [Ref 2] the MCERTS Performance Standard [Ref 3], and the MCERTS Annex Document [Ref 5]. These requirements and procedures would need to be achieved and	The additional tests referred to in Section 3.4 of this MCERTS Evaluation Report, are outside of the current scope of the requirements of the MCERTS Performance Standard for Continuous Ambient Air Monitoring Systems [Ref.3], and its Annex [Ref.5] As such do not need to be evaluated within the MCERTS procedures. *They have been recognised and accepted by the relevant Competent Authority in Germany*. *It is proposed that limited comments concerning these additional tests are included in the MCERTS Certificate for the type of monitoring systems discussed here.*	

	followed in addition for automated continuous PM methods that are used in Germany for regulatory purposes. These include references to EN 12341 (in terms of equivalence testing for PM_{10}) and to the GDE (in terms of equivalence testing for PM_{10} and $PM_{2.5}$).		

(v) Requirements of the Field Test Conditions

Ref.5 Section 4.4(i)	The equivalence test sites shall be demonstrated to be representative of the UK's PM pollution climate. This shall be done using at least six months, and preferably twelve months from the reference method or equivalent method of PM measurement data. This should ideally be done in a period of time that encompasses the field test period and be co-located with the field test. If either of these is not available, then data from another time period, preferably within the two years previous to the field trial and/or data from an alternative monitoring location, similar in type to the field test site (e.g. urban background, traffic, rural) and in the close proximity to the field test site may be used as the basis for the assessment ([Ref.5 section 3.2]. The individual atmospheric components that make up the successful demonstration of the pollution climate are *listed below*:	The determination of the UK pollution climate has been carried out in the BV UK report [Ref.7 Section 15] and is appropriate; Two of the sites in Germany do not have > 6 months of calendar data for PM_{10}. Thus, to support this limitation, results from a North-Rhine Westphalia (Cologne-Chorweiler) site (where there were 3 years of PM_{10} reference data, and which is within 130 km of the sites) were employed. This has been demonstrated to be within the same PM climate as the UK requirements [Ref.7 Section 15]. This is also supported by the results of Ref. 16. *The requirements are fulfilled*
Ref.5 Section 4.4(ii)	The geometric mean(s) of the PM data (PM_{10} and/or $PM_{2.5}$) obtained from a minimum of six months of monitoring, shall conform to the requirements of Section 4.4(ii) of Ref.5	*Accepted: T*aking account of the site in Cologne outlined above;
Ref.5 Section 4.4(iii)	The collocations of the RMs and the CMs shall be acceptable in terms of minimising the spatial inhomogeneity and differences in the PM content of the air sampled by all the methods.	*Accepted;*
Ref.5 Section 4.4(iv)	There shall be a minimum of four valid comparisons at a minimum of two sites if all the tests are all carried out in the UK.	There are two valid UK tests in Teddington, and four valid tests in Germany. These were all completed AFTER the MCERTS Annex document was published. *This is a requirement for these tests, and the requirements are fulfilled*
Ref.5 Section 4.4(iv)	There shall be evidence that the sampled PM fractions have both high and low fractions of semi-volatiles during specified periods of the test programme	*Accepted:* see Ref. 7 Section 15, and MCERTS Annex document [Ref 5] Table 3
Ref.5 Section 4.4(iv)	There shall be evidence that the measurements were taken at both high and low ambient atmospheric temperatures and high and low relative humidity during specified times of the complete test programme.	*Accepted:* see Ref.7 Section 15, and MCERTS Annex document [Ref 5] Table 3;
Ref.5 Section	There shall be evidence that the measurements were taken at both high and low wind-speed conditions during specified times of the complete	*Accepted*: see Ref.7 Section 15, and MCERTS Annex document [Ref 5] Table 3

4.4(iv)	test programme.	
Ref.5 Section 4.4(iv)	The comparisons should be carried out during different UK climatic conditions;	*Accepted :* see Ref.7 Section 15, and MCERTS Annex document [Ref 5] Table 3
Ref.5 Section 4.4(iv)	The individual comparative results from both the RMs and CMs shall be taken at regular intervals during all the comparisons;	*Accepted:* see Ref. 7
Ref.5 Section 4.4(v)	There shall be a comprehensive and valid evaluation of the UK "PM pollution climate" carried out as summarised in Ref.5 Section 3.2 and given in Ref.5 section 4.4(v), utilising all the variable atmospheric components given in that Section of Ref.5.	*Accepted:* see Ref.7 Section 15
Ref.5 Section 4.4(vi)	From the above and other indicators the selected equivalence test sites shall be "representative of the field conditions under which the CMs are likely to operate"	*Accepted:* see Ref.7 Section 15,
Ref.5 Section 4.4(vii)	The scope of the equivalence claim shall be defined satisfactorily with respect to the evaluation of the PM climate and with respect to the type of the selected test sites (national, regional, station type, etc.)	*Accepted*: see Ref.7 Section 17,

(vi) Requirements of the Candidate Method in the Field Tests

Ref.5 Section 4.5	The complete type and model number of the CM and type of sampling head, including all its functional parts, its sensors, its software version etc., shall be documented comprehensively so that the two CMs are uniquely identified. The type and all the characteristics of the CM shall be listed on the MCERTS certificate.	*Accepted:* see TÜV report [Refs.6] BV report [Ref.7], and this Report Section 2.
Ref.5 Section 4.6	There shall be a complete and comprehensive QA/QC programme for the CMs and the RMs throughout the field test programme (see also Checklist (vii)below)	*Accepted:* The QA/QC programme is summarised suitably in Appendix D of the BV UK report [Ref.7].
Ref.5 Section 4.7 & 5.1	All the results of the field test programme shall be documented and reported in units of mass of particulate per unit volume of air sampled at ambient conditions. The results of the CMs shall be averaged correctly over each 24 hour period, to provide at least 40 data set pairs of RM and concurrent CM data for the two RMs and the two CMs, as specified in Ref.5 Section 4.7. Where the CM results are based on aggregated results of smaller averaging times the percentage of these values available for calculating the 24-hour average shall be at least 75%.	*Accepted:* All the results are documented on an average daily basis. Within the TÜV report [Ref.6] it is not explicit whether there are any partial day's results that have been removed. Further information is provided in Section 10 of the BV UK report [Ref.7];
Ref.5 Section 5.1	In the case of filter changes that form part of the operations of a *manual* CM, The times of these changes shall be logged permanently by the CM. The time during which the filter is changed shall be limited to less than 1% of each 24 hour period (This 1% criterion is specified currently in the CEN automatic standard that is now a draft. If the final published CEN document specifies a different percentage to this then this criterion should be changed.)	*Not applicable*: This is not required for this test programme;
5. Ref.5 Section 2	The availability (data capture) of the CMs shall be separately evaluated as given by Ref.5 Section 5.2, equation 2, for all tests that are carried out in or after 2012. This shall be included in the test report and in the MCERTS test certificate, with the acceptance criterion of 90%.	*Accepted:* The data capture has been reported and is above requirements – see the BV report [Ref.7 Section 11] as required in [Ref.5 Section 3]
Ref.5 Section 5.3	The between-candidate method standard uncertainty defined in Ref 5 Section 5.3 shall be determined (after all the results have been evaluated and any removed or discarded as specified in Ref 5 Section 5.5.1), in order to define the complete set of *valid* results. These shall be ≥ 40 valid results per comparison trial or the data is unsuitable.) - For all the *valid* results of the (minimum) four comparisons in the total dataset together;	The TÜV report [Ref.6] Section 7.5 gives the uncertainty of all the results for $PM_{10}$and $PM_{2.5}$, before and after corrections. Different expanded uncertainties are obtained when considering slope, or slope and intercept, corrected data; The corrected results for $PM_{2.5}$ slope are less than the performance criterion.

	- Separately for the two datasets obtained by splitting the full dataset according to their concentrations as given in section 5.3.3;	All the results from [Refs. 6] and from the UK tests are re-calculated as discussed in Section 2.2 of this report. [Ref.7] Section 12 has all the results for all 6 sites. *The requirement is fulfilled*
Ref.5 Section 5.3	The between-CM uncertainty of ≤ 2.5 μg m^{-3} shall be satisfied for both instruments and for all the datasets.	*Accepted:* the results are re-calculated In the BV Report [Ref.9] Table 5. *The requirement is fulfilled*

(vii) Requirements of the Reference Method in the Field Tests

Ref.5 Section 4.3(iv) & 5.4	The complete type and model number of the RM and the type of sampling head, including all its functional parts, its sensors, its software version etc. (where relevant), shall be documented comprehensively so that the two RMs are uniquely identified. The type of subsequent laboratory analyses of the gravimetric filters shall be documented and shall comply with all the requirements of the relevant CEN standard – to be quoted;	BV Report [Ref.7] Section 4 and Appendix B; *The requirement is fulfilled*
Ref.5 Section 5.4 & 4.3(iv)	Two RMs shall generally be used throughout the complete test programme. If not the reason for this shall be justified comprehensively. Where only one RM is used this shall be accounted for in the evaluation of the uncertainty of the CM – see Ref.5 Section 5.5.3.1	At all six of the test sites there were two reference methods [Ref.7 section 4]. *The requirement is fulfilled*
Ref.5 Section 5.1	In the case of filter changes that form part of the operations of the RM, the times of these changes shall be logged by the RM.	*Accepted:* [Ref.7 Section 4]
Ref.5 Section 5.4	The between RM standard uncertainty defined in Ref.5 Section 5.4 equation 3 shall be determined: - After all the results have been evaluated and removed or discarded as specified in Ref.5 Section 5.5.1 to define the complete set of remaining *valid* results – This shall be ≥ 40 valid results per comparison trial or the data is unsuitable. - For all the *valid* results of the (minimum 4 comparisons) in the total dataset together, then:	These results have been recalculated and are discussed in [Ref.7 Section 12]. *The requirement is fulfilled*;
Ref.5 Section 5.4	The between RM uncertainty of ≤ 2.0 μg.m^{-3} shall be satisfied for both RMs, across the complete data set [Ref.5].	These results are all shown to be ≤ 2.0 μg.m^{-3} in [Ref.7 Section 12] including for the German and UK test site results in this UK evaluation. *The requirement is fulfilled*

(viii) Requirements of the QA/QC Programme in the Field Tests

Ref.5 Section 4.6	The requirements of the GDE [Ref 2] Annex D for calibrations and quality control checks shall be met during the complete filed test programme	*Accepted:* Requirements are met;
Ref.5 Section 4.6	The requirements for, and the frequency of, QA/QC checks shall in addition be the same as those intended for operational field conditions to the extent that it is demonstrated that no additional significant uncertainty terms would arise during those subsequent field operations. Otherwise an additional uncertainty term shall be added.	*Accepted:* Requirements SHOULD BE met during field tests when these are deployed for EU reporting;
Ref.5 Section 4.6	All the information listed in Reference 5 Section 4.6 shall be recorded during the entire field test programme and shall be made available for assessment within the MCERTS certification process, in a report in a format given in Reference 5 Section 6.	*Accepted:* the information is in different sections of the TÜV reports. Within the BV UK Report [Ref.7] the information is collated into Appendix D.

(ix) Assessment of the Suitability of the Results Obtained in the Field Tests

Ref.5 Section 5.5.1	There shall be a minimum of four sets of data from comparisons between the RMs and both the CMs at a minimum of two sites, each containing a minimum of 40 paired results – If not the datasets are unacceptable;	There are greater than the minimum required - valid results at the six sites. *The requirement is fulfilled*
Ref.5 Section 5.5.1	Paired results may be removed from the complete data set. If so, the removed results shall be tabulated and the removals shall be justified on sound technical grounds.	No paired results of the CMs have been removed, except where the results from the RMs were shown to be outliers. *The requirement is fulfilled*
Ref.5 Section 5.5.1	Further results may be removed as statistical outliers. – if so, they shall be removed using only one Grubb's test with an outlier test at the 99% level; This shall not remove more than 2.5% of the data pairs – If more, the results are invalid;	RM outliers have been removed as per the GDE requirements; *The requirement is fulfilled*
Ref.5 Section 5.5.1	There shall be 40 (valid) measurement paired results *remaining* in each comparison for both CMs – after removal of the paired data by Grubb's tests etc.	*The requirement is fulfilled*
Ref.5 Section 5.5.1	≥20% of the remaining paired results of the full dataset shall have greater than the prescribed PM concentrations of 28µg m^{-3}, as determined by the collocated RM.	[Ref.7 Section 12] More than 20% of the paired reference method results are greater than 28µg m^{-3} for PM_{10} at the six sites, and as such the greater than 20% criterion has been achieved; For $PM_{2.5}$ more than 20% of the RM results are greater than 17ug m^{-3} - BOTH compared to the 20% criterion. *The requirements are fulfilled*

(x) Assessment of the Procedure used to Evaluate the Resultant Final Data Sets of the Field Tests

Ref.5 Section 5.5.1	The results of all the paired data obtained, after carrying out the procedure in Ref.5 Section 5.5.1, shall be processed assuming a linear relationship between CM and RM of the form given in Ref.5 equation.4, using a regression technique that leads to a symmetrical treatment of both the variables (e.g. generalised least squares or orthogonal regression), which shall be derived from a recognised and validated source of the regression technique	[ref. 6] states that orthogonal regression was applied. Further clarifying information is given in the BV UK report [Ref.7]. As part of this MCERTS certification committee's evaluation, the calculations and the formulae were re-calculated. This included using the EU accepted and verified RIVM_PM_ spreadsheet (10th April 2014) [Ref.14]). *The requirement is fulfilled*
Ref.5 Section 5.5.2	The results above shall be processed using the average results of the two RMs, and regressions shall be established for each of the CMs individually;	Correctly processed; *The requirements are fulfilled*
Ref.5 Section 5.5.2	The above results shall be processed: (i) all together and (ii) in datasets with concentrations greater than or equal to 30 µg m^{-3} for PM_{10} or equal to or greater than 18 µg m^{-3} for $PM_{2.5}$, and (iii) datasets at each individual site where testing was performed to produce valid datasets and (iv) separately for each individual site type if applicable.	Correctly processed: *The requirements are fulfilled*
Ref.5 Section 5.5.2	For each of the datasets, for each CM, the criteria for the acceptance of the calibration function between the average of the RM results and the CM results shall conform to the requirements of Ref.5 equations 5 and 6. If these criteria are met the calculations in Ref.5 Sections 5.5.3.1 and 5.5.3.5 shall be applied. If these criteria are not met, the CM may be calibrated as in Ref.5 Section 5.5.3, and as indicated below in this checklist.	The $PM_{2.5}$ data without any corrections has two sets of results with the expanded uncertainties that are greater than 25% [ref.7 Sections 12.3]. The criteria for acceptance of the $PM_{2.5}$ CMs are not therefore achieved without the application of calibration functions [Ref.7 section 12]. The $PM_{2.5}$ slope has a significant offset. However, correction for the intercept did not result in a situation where all of the expanded uncertainties are below 25 %. Correction for slope and for slope and intercept resulted in a situation where all of the expanded uncertainties were below 25 % for $PM_{2.5}$. This Evaluation therefore proposes that a slope correction be applied to accept the $PM_{2.5}$ results The PM_{10} results have NO need to for corrections, ***apart*** from the fact that all the data processed together shows a slope and intercept that are significantly statistically different from requirements. [Ref. 7 Table 22] shows the results for corrections for slope, intercept and for both together [Ref.7 Section 12.2]. This brings about small improvements, and the corrections for both slope and intercept mean that these small offsets

		are eliminated. However, the MCERTS certification committee recommends that corrections for slope or intercept are NOT applied FOR PM_{10}, since the results conform with the measurement uncertainty requirements of the GDE *The requirement is fulfilled; All sets of results for the six selected sites should be included on the certificate.*

(xi) Evaluation of the Method Used to Determine the Uncertainty of the Results of the CM in the field Tests

Ref.5 Section 5.5.3.1	No correction for the slope or intercept has been applied for PM_{10} but for $PM_{2.5}$ it must be applied. Eq. 8 shall be applied for the evaluation of the uncertainty of the results of both the CMs for $PM_{2.5}$ but NOT for PM_{10}.	In the final results slope corrections for $PM_{2.5}$ were applied in [Ref.7], since a few of the individual site results without corrections have uncertainties > 25%. These corrections made these measurement uncertainties < 25%. *The requirements are fulfilled without any uncertainty for slope corrections for PM_{10} but an uncertainty for slope correction is applied for $PM_{2.5}$.*
Ref.5 Section 5.5.3.2	A valid correction for the intercept has been applied as given in Table ix above, and Ref.5 Eq.12 shall be applied for the evaluation of the uncertainty of the results of both the CMs.	*The requirements are fulfilled without intercept correction. The combined datasets met the GDE requirements without intercept corrections*
Ref.5 Section 5.5.3.3	A valid correction for the slope has been applied as given in Table ix above, and Ref.5 equation.16 shall be applied for the evaluation of the uncertainty of the results of both the CMs.	Slope corrections were applied in [Ref.7] for $PM_{2.5}$ since a few of the individual site results have uncertainties > 25%. There is no requirement for an uncertainty requirement for corrections for the PM_{10} results *The requirements are fulfilled. The combined datasets met the GDE requirements*.
Ref.5 Section.5.3.4	Corrections for both the slope and intercept has been applied as given in Table ix above, and Ref.5 equation 21 shall be applied for the evaluation of the uncertainty of the results of both the CMs.	. *The requirements are fulfilled without BOTH slope and intercept corrections. The combined datasets met the GDE requirements*
Ref.5 Section 5.5.3.5	In all the above cases the correct values for the uncertainty of the RM, $u(x_i)$ shall be used as specified in Ref.5 Section 5.5.3.1 as $\mathbf{u_{bs,RM}/\sqrt{2}}$ (Eq.3)	*Not applicable*

(xii) The Overall Relative Measurement Uncertainty Assigned to the CM

Ref.5 Section 5.5.3.5	The relative standard measurement uncertainty of both the CMs shall be calculated using Ref.5.	*The requirement is fulfilled;*
Ref.5 Section 5.5.3.5	The calculation of Ref.5 equation.22 shall be carried out using the full dataset.	*The requirement is fulfilled;*
Ref.5 Section 5.5.3.5	The $u_{CR}(y_i)$ or $u_{CR}(y_{i,cal})$ values as appropriate used in the equation shall be those at the limit value – where this limit value is 50 µg m^{-3} for PM_{10}, and 30 µg m^{-3} for $PM_{2.5}$ (unless the Competent Authority specified a different value for $PM_{2.5}$).	These "limit" values have been applied correctly; *The requirement is fulfilled;*
Ref.5 Section 5.5.3.5	The $u_{CR}(y_i)$ or $u_{CR}(y_{i,cal})$ values as appropriate used in the equation shall be those that are derived using the calculation procedure in *one* of the Ref.5 Sections 5.5.3.1 –5.5.3.4, where either no corrections, correction to slope or intercept, or corrections to slope and intercept corrections, have been applied to this full dataset.	An additional uncertainty term has been added to allow for the $PM_{2.5}$slope correction. *The requirement is fulfilled;*
Ref.5 Section 5.5.3.5	One or more additional terms for measurement uncertainty shall be applied if the QA/QC activities carried out during the equivalence field tests are more stringent than those than will be applied when the method is operated in a network (GDE [Ref 2] Section 9.5.4)	No additional term has been applied, or needs to be applied, as there is evidence that the QA/QC procedures used were satisfactory; It should be noted that this has implications for QA/QC of these type of monitors when they are used in the field for reporting to the EU. *The requirement is fulfilled;*
Ref.5 Section 5.5.3.5	All the values obtained for $u_{CR}(y_i)$ or $u_{CR}(y_{i,cal})$ **whichever is applicable,** shall be multiplied by an appropriate coverage factor (k) to provide values for the expanded uncertainty, $\mathbf{W_{CM}}$, of the CM results, expressed at a 95% confidence level;	Accepted; *The requirement is fulfilled;*

(xiii) The Overall Measurement Uncertainty Calculated for the CM with Respect to the Requirements of the Directive

Ref.5 Section 5.6	The highest of the expanded uncertainty estimates $\mathbf{W_{CM}}$ arising from both CMs shall be compared with the expanded relative uncertainty stated as the data quality objective, $\mathbf{W_{dqo}}$, in Directive 2008/50/EC [Ref 1];	This comparison has been done correctly both before and after the intercept, slope, and both slope and intercept correction factors have been carried out. *The requirement is fulfilled;*
Ref.5 Section 5.6	One of two cases shall be determined: (i) $\mathbf{W_{CM} \leq W_{dqo}}$ then the CM is accepted as equivalent to the RM; (ii) $\mathbf{W_{CM} > W_{dqo}}$ then the CM is not accepted as equivalent to the RM;	It is not necessary to apply any slope and intercept correction of the results that has > 40 valid data points in order to fulfil this requirement for the PM_{10} data. *For the $PM_{2.5}$ results it is necessary to apply a slope correction to conform with requirements.* These should be noted on the certificate. *The requirements are fulfilled;*

5. Summary and Recommendations

This Evaluation Report is produced by the MCERTS certification committee. It reviews and provides evidence to support the recommendations for certification under the Environment Agency's MCERTS Performance Standards for Continuous Ambient Air Monitoring Systems [Ref.3], and it's Annex regarding MCERTS for UK Particulate Matter [Ref.5].

The manufacturer of this automated particulate monitoring method is:

PALAS GmbH
Greschbachstrasse 3b
76229 Kahlsruhe, Germany

5.1 Type of Particulate Method Evaluated

This Evaluation Report prepared by the MCERTS certification committee covers the following automated particulate PM_{10} or $PM_{2.5}$ measurement method:

(a) Hardware

Ambient air-quality monitoring system Fidas 200 Method 11 multi-channel particulate continuous monitor using an optical particulate monitoring spectrometer, which determines particle size by means of the scattered Lorentz-Mie optical radiation, using a polychromatic (white) light source with scattered light detection;

There is a more detailed description of this type of PM_{10} and $PM_{2.5}$ monitoring system in Section 2.1 of this Report and in [Refs.6 & 7}

Some of the critical components of these monitors are considered to be:

- The use of Method 11 data processing software as summarised in Section 2.1 of this Report and in [Ref.7];
- No PM_{10} or $PM_{2.5}$ heads, but a total suspended particulate head Sigma-2 with a flow rate of 4.8l/min when the CM is operated at 25^{o}C and 1013 mB; PM_{10} and $PM_{2.5}$ concentrations are calculated by applying a density distribution to the measured size fraction data.

(x) Heated sample drying system following the sample head, consisting of the IADS moisture compensation module, operated at a temperature of 24 ^{O}C above the ambient temperature. This method is adaptive starting at a temperature of 23 ^{O}C and then up to 24 ^{O}C above ambient [ref.6 p46]

- A method of carrying out calibrations or calibration checks of the spectral settings of the monitor using mono-disperse aerosols provided with the monitor. The objective and frequency of this calibration check are summarised in Section 2.1 of this Report.
- An external zero air filter shall be attached to the inlet of the instrument to provide air free of suspended particulate matter to carry out zero point checks.
- The instrument is available in the versions Fidas 200 S for outdoor use including weatherproof housing used in the field test and laboratory test programme discussed here, and the Fidas 200 without this housing for indoor applications. In the field tests the instrument was operated with the IP65 case which is heated and ventilated, but not air conditioned.

(b) Serial Numbers of the Tested Method: The serial numbers of the CMs used during test programme are given in Section 2.1 of this Evaluation Report and in [Ref.7].

Serial numbers 0111 & 0112 were *also* used during the laboratory tests

(b) Firmware/software of the Method

Firmware/software version that was tested at the sites is summarised above Table 1 of this Report. It should be noted that whilst it may in principle be considered appropriate to retain this firmware/software version because this is certified, it is recommended that efforts should be made by operators of the instruments to install the latest ***approved version*** *of the instrument firmware/software suitable for the particular model being operated*

5.2 Scope of Equivalence Testing Evaluated

There are six datasets that were reviewed and utilised in this Evaluation Report, as given in Table E2 in Section E2, for the evaluation of equivalence of this type of monitor for this Report:

1. The four sets of field tests in Germany listed in the Table E2 above and in [Ref.6] are considered to be acceptable as part of the *primary evidence for the determination of equivalence* in this Evaluation Report for both the PM_{10} and $PM_{2.5}$ monitors.
2, The two sets of UK field tests listed in the Table E2 above and in [Ref.7] are considered to be acceptable are the other part of the *primary evidence for the determination of equivalence* in this Evaluation Report for both the PM_{10} and $PM_{2.5}$ monitors.
3. This Evaluation has therefore utilised six *datasets for its evidence* of this type of monitor for PM_{10} & $PM_{2.5}$ monitoring.

5.3 Findings of the Equivalence Testing Carried Out

The following results, and the associated tables, summarise the findings of this evaluation with respect to the MCERTS Requirements for UK Particulate matter concerning the equivalence of the type of candidate method listed in Section 5.1:

5.3.1 Certification Range: 0 µg/m^3 to 10,000 µg/m^3 over the averaged 24-hour sampling and analysis period, for all models of this monitor, for PM_{10} and for $PM_{2.5}$ (WITH A SLOPE CORRECTION REQUIRED FOR $PM_{2.5}$); **However, it is essential to note that the measuring range isn't based on a setting of the instrument - rather this is its maximum response, DUE TO OVERLAP WITH MORE THAN ONE PARTICLE IN THE OPTICAL MONITORING VOLUME.**

5.3.2 Ambient temperature range: the acceptable temperature range for this type of instrument **for indoor monitoring applications** shall be **+ 5 °C to + 40 °C,** as was tested in the laboratory according to the requirements of CEN TS 16450 [Ref.12]. It should be noted, however, that the instruments used in the six test sites, subjected to different and more extreme ambient temperature conditions than the above range (**validity -20 °C to +50 °C)**, but they were all housed in temperature controlled enclosures, and these functioned correctly.

5.3.3 UK Particulate Pollution Climate: *The geometric mean calculations for particulate PM_{10} concentrations are consistent with the requirements of [Ref.5] as determined in [Ref.7 Section 15].* Also as discussed in [Ref.5 and Ref.7] there is the requirement that for each instrument type, that at least one site of at least 40 data pairs must meet the high threshold for each criterion, and at least one site of at least 40 data pairs must meet the low threshold for each criterion. For these Palas 200 monitors, at least one site of at least 40 data pairs meets the lower threshold and at least one site of at least 40 data pairs meets the higher threshold for each of Wind Speed, Ambient Temperature, Ambient Dew Point and Semi Volatile. As such, *the ranges in wind speed, ambient temperature, ambient dew point, and semi volatiles for the Palas 200 PM_{10}, and also $PM_{2.5}$* ***with slope correction*** *cover the requirements of the UK's Particulate Matter Pollution Climate.*

5.3.4 Types of monitoring sites in the UK: The results from the six field test sites that are used as the evidence in this Report were at urban background, and traffic locations. However, the results at the Bornheim site although close to a motorway can be classified as rural with an influence from traffic, and the relationship with the reference method determined at that site was good and similar to the others, although this site has low concentration PM data related to a rural site. *It is recommended, therefore, in this evaluation that this type of instrument is suitable for use at urban background (including suburban (if applicable), rural and traffic locations within the UK.*

5.3.5 Laboratory test programme: The MCERTS Performance Standard [Ref.3] and it's Annex [Ref.5] state requirements for tests for constancy of sample flow, and for leak tightness of the sampling system. These were carried out by TÜV. The results are described in [Refs.6&7], and in Section 3.3 of this Report: The test for constancy of sample flow was not carried out as specified in the MCERTS Performance Standard but an acceptable alternative was carried out, and the results fulfilled the performance criterion of ± 3% of the rated value, with no instantaneous value to be ≥ ± 5%. The test for leak tightness of the sample system fulfilled the performance criterion of ≤ 1% of the sampled volume. *It is considered that these two MCERTS requirements are met.*

A series of intensive laboratory tests was undertaken by TÜV Rheinland that go beyond the requirements set out in MCERTS for UK Particulate Matter. It is not required to report the results of these tests on the MCERTS certificate.

5.3.6 Between instrument uncertainty for the candidate method and the reference method in the field: The re-calculations were carried out by BV as shown in [Ref.7] for the six selected test sites. The maximum results at all test sites ***for the full data sets*** (Table E2) for the CM are 0.67 µg/m^3 for PM_{10}, and 0.53 ug/m^3 for $PM_{2.5}$, with correction for slope. For the RMs ***for the full data sets*** these are 0.57 µg/m^3 for PM_{10}, and 0.48 µg/m^3. These should be compared to the performance criteria of 2.5 µg/m^3, and 2.0 µg/m^3 respectively. These results are also shown in the Tables below in this Section as well as Table E2 above. *These MCERTS requirements are fulfilled.*

5.3.7 Data capture/ availability/Maintenance Interval of the measuring system: The Annex document MCERTS for UK Particulate Matter [Ref.5] lists the following requirement for the Availability of the measuring system: *"The fraction of the total and consecutive monitoring time during all the field trials involved in the equivalence testing programme for which data of acceptable quality are collected. The method for calculating this fractional time is given in Section 5.2 Eq.2. Availability defined here is the same as the minimum data capture requirements given in the data quality objectives in Directive 2008/50/EC for the relevant pollutant."* The data availability of these candidate methods has been determined from the available data [Ref. Section 11] summarised below:

Table 4 Availability

	System 1 (SN 0111)	System 2 (SN 0112)
Operating time / days	380	379
Downtime / days	1	3
Actual operating time / days	379	376
Availability / %	99.7	99.2

The maintenance interval is discussed above, and in [Ref.7 Section **Error! Reference source ot found.**.3]. A maintenance interval of 4 weeks should be transferred to the MCERTS certificate ***and is defined by the need for regular checks of the particle sensor with CalDust 1100 or MonoDust 1500***. This is less frequent than the required ≥ 2 weeks, and as such the MCERTS requirement is exceeded.

The European Directive 2008/50/EC [Ref.1] requires an ***annual*** data capture of ≥ 90 %. This requirement is therefore effectively fulfilled for all of the processing methods, *although this requirement is not needed for tests that were completed before the MCERTS Annex [Ref.5] was published.*

5.3.8 Comparisons between the Fidas 200 S Method 11 and Fidas 200 Method 11

A comparison of the Palas Fidas 200 S Method 11 and Palas Fidas 200 Method 11 (*i.e.* with and without an IP65 case which is heated and ventilated, but not air conditioned) was discussed in Section **Error! Reference source not found.**.6.

It is recommended that certification is given both for the Palas Fidas 200 S Method 11 and PALAS Fidas 200 Method 11, and due to the different temperature ranges over which the instrument was tested, it is specifically recommended that the Palas Fidas 200 Method 11 is certified between +5 and +40 ºC, whereas the Palas Fidas 200 S Method 11 is certified between -20 and +50 ºC. When operating a Palas Fidas 200 Method 11 in an enclosure, it is recommended that the user makes sure that an air unit in the enclosure does not point directly at the instrument, and also insulates the 1.5 cm section between the IADS and the measurement volume. During the winter it may be required to add extra heating to a measurement site, though this will be dependent on the specific site.

5.3.9 Replacement of LED

Since the field tests were conducted by TUV, the LED (Osram Ostar Projektion Art.-Nr. LE B H3W) in the Fidas 200 sensor was discontinued, and a new LED (Osram Ostar Stage Art.-Nr. LE ATB S2W) was identified. In {Ref. 6 & Re.7 Section **Error! Reference source not found.**.7] t has been demonstrated that there is no significant difference in the determination of measured PM between the old LED and the new LED.

5.4 Field Equivalence Test Results

These results of the laboratory and tests, other than the equivalence testing, that have been carried out are summarised in the Table below for the 24-hour averages

Table 5: Summary of the results obtained for the 24-hour averaged results of the PM_{10}, & of the $PM_{2.5}$ monitor corrected for slope of 1.06

Test	Results	MCERTS Specification
Constancy of the sample volumetric flow	2.3%	To remain constant within ± 3% of the rated value
Tightness of the sampling system	0.8%	Leakage not to exceed 1% of the sampled volume
Maintenance Interval	Four Weeks	≥Two weeks
Data Availability	99.2%	≥90%
Number of UK Tests	2	≥2
Number of Reference Methods	2	2
Between sampler/instrument uncertainty for the standard method **PM_{10}**		
Full data set	0.57 µg/m^3	≤2 µg/m^3
<30 µg/m^3	0.56 µg/m^3	Not specified
≥30 µg/m^3	0.60 µg/m^3	Not specified
Between sampler/instrument uncertainty for the candidate method **PM_{10}**		
Full data set	0.67 µg/m^3	≤2.5 µg/m^3
<30 µg/m^3	0.57 µg/m^3	≤2.5 µg/m^3
≥30 µg/m^3	1.17 µg/m^3	≤2.5 µg/m^3
Between sampler/instrument uncertainty for the standard method **$PM_{2.5}$**		
Full data set	0.53 µg/m^3	≤2 µg/m^3
<18 µg/m^3	0.51 µg/m^3	Not specified
≥18 µg/m^3	0.60 µg/m^3	Not specified
Between sampler/instrument uncertainty for the candidate method **$PM_{2.5}$ without slope correction**		
Full data set	0.48 µg/m^3	≤2.5 µg/m^3
<18 µg/m^3	0.32 µg/m^3	≤2.5 µg/m^3
≥18 µg/m^3	0.85 µg/m^3	≤2.5 µg/m^3

Summaries of the results of the six individual field test results for this evaluation are given below.

5.3.8 Summary of the Field Test Results for this Specified TYPE Monitor

Table 6: Equivalence calculations and results for the Palas 200 Monitor - for PM_{10} Particulates Using Method 11 – NO CORRECTION APPLIED

PM10 PALAS Fidas200 Method 11	17.5% ≥ 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 Data	7.5	315	0.973	1.035 +/- 0.010	-1.360 +/- 0.218	0.57	0.67
< 30 µg m-3	7.1	272	0.918	1.045 +/- 0.018	-1.543 +/- 0.311	0.56	0.57
≥ 30 µg m-3	11.0	43	0.944	0.984 +/- 0.036	0.974 +/- 1.569	0.60	1.17

SN0111	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 Summer	81	0.944	1.045 +/- 0.028	-1.637 +/- 0.490	6.98	9.9
	Cologne Winter	50	0.989	1.059 +/- 0.016	-1.171 +/- 0.413	9.22	22.0
	Bonn Winter	50	0.967	1.043 +/- 0.027	-0.082 +/- 0.821	11.98	46.0
	Bornheim Summer	47	0.944	1.128 +/- 0.040	-1.986 +/- 0.733	19.05	6.4
	Teddington Winter	44	0.987	0.999 +/- 0.017	-1.598 +/- 0.441	9.16	20.5
	Teddington Summer	45	0.961	0.946 +/- 0.029	-0.090 +/- 0.474	12.26	2.2
Combined Datasets	< 30 µg m-3	274	0.915	1.064 +/- 0.019	-1.597 +/- 0.320	9.38	4.4
	≥ 30 µg m-3	43	0.946	1.013 +/- 0.037	0.381 +/- 1.597	11.86	100.0
	All Data	317	0.972	1.052 +/- 0.010	-1.386 +/- 0.222	8.99	17.4

SN0112	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 Summer	82	0.943	1.028 +/- 0.028	-1.524 +/- 0.489	6.56	9.8
	Cologne Winter	49	0.989	1.023 +/- 0.016	-1.215 +/- 0.413	5.69	22.4
	Bonn Winter	50	0.961	1.004 +/- 0.029	0.061 +/- 0.865	9.29	46.0
	Bornheim Summer	47	0.942	1.083 +/- 0.039	-2.169 +/- 0.720	10.63	6.4
	Teddington Winter	44	0.988	0.969 +/- 0.016	-1.580 +/- 0.420	13.91	20.5
	Teddington Summer	45	0.955	0.944 +/- 0.031	-0.502 +/- 0.507	14.26	2.2
Combined Datasets	< 30 µg m-3	274	0.917	1.028 +/- 0.018	-1.522 +/- 0.308	6.49	4.4
	≥ 30 µg m-3	43	0.940	0.956 +/- 0.037	1.504 +/- 1.584	11.39	100.0
	All Data	317	0.971	1.019 +/- 0.010	-1.331 +/- 0.219	7.53	17.4

It can be seen that *all the measurement uncertainties are within requirements.* It is also seen that there are SMALL but significant measurement uncertainties associated with the slope and intercepts **for all the data together.**

[Ref.7 Tables 23 & 24] show the results of slope correction alone and intercept correction alone that still leave significant measurement uncertainties. These can be removed by corrections for slope and intercept together as given in the next Table [Ref.7 Table 25].

Table 7: Equivalence calculations and results for the Palas 200 Monitor for PM_{10} Particulates Using Method 11– SLOPE AND INTERCEPT CORRECTIONS APPLIED

PM10 PALAS Fidas200 Method 11 Slope and Intercept Corrected	17.5% ≥ 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 Data	7.4	315	0.973	1.000 +/- 0.009	0.009 +/- 0.211	0.57	0.65
< 30 µg m-3	6.7	272	0.918	1.008 +/- 0.018	-0.152 +/- 0.301	0.56	0.55
≥ 30 µg m-3	10.8	43	0.944	0.949 +/- 0.035	2.295 +/- 1.516	0.60	1.13

SN0111	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 Summer	81	0.944	1.009 +/- 0.027	-0.251 +/- 0.473	6.64	9.9
	Cologne Winter	50	0.989	1.023 +/- 0.015	0.188 +/- 0.399	8.03	22.0
	Bonn Winter	50	0.967	1.007 +/- 0.026	1.252 +/- 0.793	10.76	46.0
	Bornheim Summer	47	0.944	1.088 +/- 0.038	-0.586 +/- 0.708	16.98	6.4
	Teddington Winter	44	0.987	0.965 +/- 0.017	-0.225 +/- 0.426	10.25	20.5
	Teddington Summer	45	0.961	0.913 +/- 0.028	1.237 +/- 0.457	13.50	2.2
Combined Datasets	< 30 µg m-3	274	0.915	1.027 +/- 0.018	-0.203 +/- 0.309	8.20	4.4
	≥ 30 µg m-3	43	0.946	0.977 +/- 0.036	1.723 +/- 1.543	11.20	100.0
	All Data	317	0.972	1.016 +/- 0.010	-0.015 +/- 0.215	8.18	17.4

SN0112	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 Summer	82	0.943	0.992 +/- 0.027	-0.141 +/- 0.472	6.95	9.8
	Cologne Winter	49	0.989	0.988 +/- 0.015	0.145 +/- 0.399	6.13	22.4
	Bonn Winter	50	0.961	0.970 +/- 0.028	1.392 +/- 0.835	9.16	46.0
	Bornheim Summer	47	0.942	1.045 +/- 0.038	-0.762 +/- 0.696	9.32	6.4
	Teddington Winter	44	0.988	0.936 +/- 0.016	-0.208 +/- 0.405	15.00	20.5
	Teddington Summer	45	0.955	0.912 +/- 0.030	0.841 +/- 0.490	15.44	2.2
Combined Datasets	< 30 µg m-3	274	0.917	0.992 +/- 0.017	-0.132 +/- 0.297	6.94	4.4
	≥ 30 µg m-3	43	0.940	0.923 +/- 0.035	2.809 +/- 1.530	11.65	100.0
	All Data	317	0.971	0.983 +/- 0.009	0.038 +/- 0.211	8.04	17.4

It is noted that the significant uncertainties in the overall slope and intercepts are removed by these corrections. However, it is considered by the MCERTS certification committee that these small significant measurement uncertainties are partially present as a consequence of the high precision of the results. **Thus it is proposed that the results of the uncorrected data for PM_{10} monitoring be accepted for certification.** ***The results of the corrections for slope and intercept together should ALSO be included on the certificate.***

Table 8: Equivalence calculations and results for the Palas 200 Monitor for $PM_{2.5}$ Particulates – NO CORRECTION APPLIED

PM2.5 PALAS Fidas200 Method 11	24.3% ≥ 17 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 Data	14.4	313	0.980	1.060 +/- 0.008	-0.210 +/- 0.144	0.53	0.48
< 18 µg m-3	22.5	246	0.890	1.133 +/- 0.024	-0.866 +/- 0.237	0.51	0.32
≥ 18 µg m-3	16.6	67	0.973	1.041 +/- 0.021	0.300 +/- 0.668	0.60	0.85

SN0111	Dataset	Orthogonal Regression				Limit Value of 30 µg m-3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% ≥ 17 µg m-3
Individual Datasets	Cologne Summer	81	0.927	1.119 +/- 0.034	-0.925 +/- 0.363	20.11	9.9
	Cologne Winter	51	0.992	1.051 +/- 0.014	0.691 +/- 0.313	17.05	39.2
	Bonn Winter	50	0.976	1.114 +/- 0.025	-0.783 +/- 0.571	21.21	60.0
	Bornheim Summer	45	0.915	1.214 +/- 0.054	-1.487 +/- 0.644	35.02	6.7
	Teddington Winter	44	0.994	1.022 +/- 0.012	-0.007 +/- 0.237	7.71	20.5
	Teddington Summer	44	0.981	0.991 +/- 0.021	0.483 +/- 0.246	5.89	13.6
Combined Datasets	< 18 µg m-3	248	0.889	1.152 +/- 0.024	-0.929 +/- 0.241	25.80	3.6
	≥ 18 µg m-3	67	0.973	1.060 +/- 0.022	0.117 +/- 0.681	18.51	100.0
	All Data	315	0.980	1.075 +/- 0.009	-0.247 +/- 0.146	16.71	24.1

SN0112	Dataset	Orthogonal Regression				Limit Value of 30 µg m-3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% ≥ 17 µg m-3
Individual Datasets	Cologne Summer	82	0.919	1.116 +/- 0.035	-0.885 +/- 0.378	20.13	9.8
	Cologne Winter	50	0.991	1.014 +/- 0.014	0.679 +/- 0.326	11.42	40.0
	Bonn Winter	50	0.969	1.070 +/- 0.027	-0.519 +/- 0.619	16.63	60.0
	Bornheim Summer	45	0.911	1.186 +/- 0.054	-1.606 +/- 0.643	29.11	6.7
	Teddington Winter	44	0.995	1.022 +/- 0.012	-0.154 +/- 0.220	6.65	20.5
	Teddington Summer	44	0.981	0.982 +/- 0.021	0.418 +/- 0.243	5.68	13.6
Combined Datasets	< 18 µg m-3	248	0.885	1.119 +/- 0.024	-0.827 +/- 0.239	20.34	3.6
	≥ 18 µg m-3	67	0.970	1.024 +/- 0.022	0.443 +/- 0.685	15.51	100.0
	All Data	315	0.979	1.045 +/- 0.009	-0.154 +/- 0.146	12.75	24.1

It can be seen that *the measurement uncertainties are within requirements except for both instrument tests at Bornheim summer.* It is also seen that there are SMALL but significant measurement uncertainty associated with the slope **for all the data together. There is therefore a requirement to apply corrections of slope and/or intercept to these data sets to establish if there are improvements from these**

The next Table presented below [ref.7 Table 27] shows the correction for slope alone

Table 9: Equivalence calculations and results for the Palas 200 Monitor for $PM_{2.5}$ Particulates – SLOPE ONLY CORRECTION APPLIED

PM2.5 PALAS Fidas200 Method 11 Slope Corrected	24.3% ≥ 17 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 Data	9.3	313	0.980	0.999 +/- 0.008	-0.190 +/- 0.136	0.53	0.45
< 18 µg m-3	11.3	246	0.890	1.065 +/- 0.023	-0.782 +/- 0.224	0.51	0.31
≥ 18 µg m-3	12.5	67	0.973	0.981 +/- 0.020	0.306 +/- 0.630	0.60	0.80

SN0111	Dataset	Orthogonal Regression				Limit Value of 30 µg m-3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% ≥ 17 µg m-3
Individual Datasets	Cologne Summer	81	0.927	1.053 +/- 0.032	-0.850 +/- 0.342	10.46	9.9
	Cologne Winter	51	0.992	0.991 +/- 0.013	0.656 +/- 0.296	8.50	39.2
	Bonn Winter	50	0.976	1.050 +/- 0.024	-0.723 +/- 0.539	12.32	60.0
	Bornheim Summer	45	0.915	1.142 +/- 0.051	-1.370 +/- 0.607	22.40	6.7
	Teddington Winter	44	0.994	0.964 +/- 0.012	-0.004 +/- 0.223	9.46	20.5
	Teddington Summer	44	0.981	0.934 +/- 0.020	0.461 +/- 0.232	11.50	13.6
Combined Datasets	< 18 µg m-3	248	0.889	1.083 +/- 0.023	-0.841 +/- 0.227	13.84	3.6
	≥ 18 µg m-3	67	0.973	0.999 +/- 0.020	0.134 +/- 0.642	12.67	100.0
	All Data	315	0.980	1.014 +/- 0.008	-0.225 +/- 0.137	9.50	24.1

SN0112	Dataset	Orthogonal Regression				Limit Value of 30 µg m-3	
		n_{c-s}	r^2	Slope (b) +/- u_b	Intercept (a) +/- u_a	W_{CM} / %	% ≥ 17 µg m-3
Individual Datasets	Cologne Summer	82	0.919	1.050 +/- 0.033	-0.810 +/- 0.357	10.77	9.8
	Cologne Winter	50	0.991	0.956 +/- 0.013	0.645 +/- 0.307	9.43	40.0
	Bonn Winter	50	0.969	1.008 +/- 0.026	-0.471 +/- 0.584	12.33	60.0
	Bornheim Summer	45	0.911	1.115 +/- 0.050	-1.482 +/- 0.607	17.49	6.7
	Teddington Winter	44	0.995	0.963 +/- 0.011	-0.143 +/- 0.207	10.01	20.5
	Teddington Summer	44	0.981	0.926 +/- 0.020	0.399 +/- 0.229	13.40	13.6
Combined Datasets	< 18 µg m-3	248	0.885	1.052 +/- 0.023	-0.744 +/- 0.226	9.97	3.6
	≥ 18 µg m-3	67	0.970	0.965 +/- 0.021	0.443 +/- 0.646	13.39	100.0
	All Data	315	0.979	0.985 +/- 0.008	-0.137 +/- 0.137	10.17	24.1

It can be seen that a slope correction (of 1.06 – see later) is satisfactory to allow that all the measurement uncertainties at all the sites are within requirements of the GDE [Ref.3] and MCERTS Annex [Ref.5] and the measurement uncertainties of all the data for both slope and intercept corrections are now not significant. [Ref. 7 Table 29 shows similar results using both slope and intercept corrections together. [Ref.7 Table 28] show the results for intercept correction alone that still leave significant measurement uncertainties. These results are summarised below:

Table 10: Summary of all the corrections of the Test Results for the Palas 200 using Method 11: No correction is required for PM_{10}, but slope correction is required by dividing by 1.06 for $PM_{2.5}$

PM_{10} Palas Fidas 200	Calculated slope of all paired data	Calculated intercept of all paired data (µg/m^3)	Expanded uncertainty of all paired data	Range of individual expanded uncertainties
Uncorrected data	1.035	-1.360	7.5%	5.7% to 19.1%
Data corrected for slope by dividing by 1.035	1.000	-1.305	9.0%	5.9% to 20.3 %
Data corrected for intercept by adding 1.360	1.035	0.000	10.2%	6.5% to 24.2%
Data corrected for slope and intercept by adding 1.360 then dividing by 1.035	1.000	0.009	7.4%	6.1% to 17.0%
$PM_{2.5}$ Palas Fidas 200	**Calculated slope of all paired data**	**Calculated intercept of all paired data (µg/m^3)**	**Expanded uncertainty of all paired data**	**Range of individual expanded uncertainties**
Uncorrected data	1.060	-0.210	14.4%	5.7% to 35.0%
Data corrected for slope by dividing by 1.060	0.999	-0.190	9.3%	8.5% to 22.4%
Data corrected for intercept by adding 0.210	1.060	0.000	15.5%	5.7% to 36.4%
Data corrected for slope and intercept by adding 0.210, then dividing by 1.060	0.999	0.008	9.3%	8.6% to 23.6%

The results from the six selected field test sites for PM_{10} monitoring (Tables 6 &7), and for the same selected test sites for $PM_{2.5}$ monitoring (Tables 8 & 9) in this Evaluation, may therefore be summarised:

1. The uncorrected data has expanded uncertainties **for PM_{10}** from these six test sites and for all the individual field test sites have ALL measurement uncertainties that are less than the required 25%, but the slope uncertainty and the intercept uncertainty for all the data together has significant BUT SMALL measurement uncertainties;
2. Intercept or slope corrections **for PM_{10}** are **s**hown to have little effect on these expanded uncertainties of < 25%, and do not remove the significant uncertainties of slope and intercept for all the data. Correction for both slope and intercept make these latter significant uncertainties satisfactory
3. The uncorrected data has expanded uncertainties **for $PM_{2.5}$** for one of the individual field test sites is greater than the required 25% and therefore corrections need to be investigated;
4. Slope correction **for $PM_{2.5}$** is shown to be beneficial and reduces all the expanded uncertainties to < 25% [Ref.7 Table 27].with a correction applied that divides by 1.06.

5. Intercept correction alone, **for $PM_{2.5}$** is not beneficial as it does not reduce all the expanded uncertainty results to < 25% [Ref.7 Table 28]. Intercept and slope correction together ensure that the $PM_{2.5}$ results are all compliant with requirements.

6. It is considered that ***for the PM_{10} monitor, instead of applying any intercept and/or slope correction factors, that thorough and sufficiently-frequent quality assurance and quality control procedures are employed*** as prescribed in [Refs. 10 & 11]. This should be c***alibrated using the latex spheres provided correctly, and the zero baseline of this type of instrument should be defined accurately, These are an essential part of this calibration process.***

7. In addition, rigorous procedures should be employed intermittently to calibrate or check the calibration of these PM_{10} and/or $PM_{2.5}$ monitors against the CEN reference method [Ref.9], at a test site in the field (as prescribed in EN12341:2014 and CEN/TS16450:2013 [Ref.12]).

5.4 Other Requirements of the MCERTS Performance Standard and its MCERTS Annex:

There are a number of other requirements that have been covered in the Checklist or are discussed in the data tables. These cover requirements for:

- two identical CMs throughout the sets of field trials;
- two reference methods at the sites (not needed for test data sets produced before July 2012)*;*
- at least one UK test site out of the minimum of four;

These requirements are all fulfilled, as discussed in Section 2 of this Report.

5.5 Conclusions of this Evaluation Report of the MCERTS Certification Committee

The MCERTS certification committee has concluded that the evidence provided by the BV and the TÜV reports, together with the considerations discussed above in this Evaluation Report, demonstrate that all the minimum requirements of *the MCERTS Performance Standard for Continuous Ambient Air Monitors Version 8 July 2012 [Ref.3]* are fulfilled.

It is also concluded that the software/firmware versions discussed in Section 2.1 of this report are applicable to this approval, with restrictions below. Future software versions must be approved by means of annual audits that should be carried out to fully fulfil the requirements of EN standard 15267-Part 2. ***This should be a specific and focussed part of all the EN 15267-Part 2 audits, and with specific conclusions stated in each audit report***

The MCERTS certification committee further concludes that all the minimum requirements specified in the document: *Annex to the MCERTS Performance Standards for Ambient Air Quality Monitoring Systems: Requirements of the UK Competent Authority for the Equivalence Testing and Certification of Automated Continuous and Manual Discontinuous Methods that Monitor Particulate Matter in Ambient Air [Ref.5],* including the requirements for conformance with the UK Particulate Pollution Climate, are also fulfilled for the type of PM_{10} & $PM_{2.5}$ continuous monitors listed in Section 5.1 above.

Therefore, it is recommended that this type of ambient air PM_{10} & $PM_{2.5}$ particulate mass monitor is accepted as conforming to the requirements of the above MCERTS Performance Standard, and that it is also in conformance with the requirements of the Annex to this MCERTS Performance Standard for the requirements of MCERTS for UK Particulate Matter. ***This proposal for acceptance covers the hardware listed and described 2.1 of this Evaluation Report, together with the Method 11 data collection and analysis software, listed also.***
The restrictions below apply.

Restrictions:

1. The permitted range of surrounding temperature in the installation at the field measurement site is considered to be +5^{o}C to +40^{o}C for Palas Fidas 200 instruments without an enclosure. However, these monitors are normally supplied in enclosures (IP65), and then the allowed ambient atmospheric temperature range should be much larger (-20^{o}C to + 50^{o}c) - providing the enclosure is functioning correctly.
2. The allowed certification range is 0 ug/m^3 to 10,000 ug/m^3, **based on the possibility of interference between two particles in the same optical measurement volume.** This range is applicable to both PM_{10} and $PM_{2.5}$ monitors, of the models discussed and tested in this MCERTS Evaluation.
3. During the laboratory and field testing, unprocessed data files have been downloaded by the manufacturer or TÜV Rheinland and subsequently processed as 15 minute averages *via* an algorithm known as PM_ENVIRO_0011, or more commonly known as Method 11. The 15 minute data have then been averaged to form 24 hour averages. **The certificate only covers data processed using the Method 11 algorithm and does not cover data processed using any other algorithm.** This certificate covers the post processing of data sets using Method 11.
4. For the Cologne Winter PM_{10} dataset, TÜV Rheinland chose not to delete the single outlier as this would result in too few data points when PM_{10} was greater than 28 µg/ m^3. This outlier has been deleted for UK purposes, and as such, the PM_{10} equivalence calculations on the certificate are different to those in the Palas Fidas 200 S Method 11 TÜV Rheinland Report.
5. The maintenance interval is specified as 4 weeks and this is defined by the requirement to calibrate with MonoDust 1500 or CalDust 1100. The calibration peak should be within ± 1.5 of the value assigned to the calibration dust by the manufacturer. Should the peak lie outside of the specified range, then the user should recalibrate the instrument to the specified peak value.
6. When operating a Palas Fidas 200 Method 11 in an air conditioned enclosure, it is recommended that the user makes sure that the air conditioning unit does not point directly at the instrument, and also insulates the 1.5 cm section between the IADS and the measurement volume. During the winter it may be required to add extra heating to a measurement site, though this will be dependent on the specific site.
7. Due to discontinuation of the LED white light sources that were used in these tests, the manufacturer changed these to a new LED type with virtually the same characteristics. This has been tested by the manufacturers and the results are given in [refs.6 & 7] successfully.
8. The version of the firmware software used in these tests is given in Table E1 of the Evaluation Report, and discussed in [ref.7 Section 1.5]. Attention is however, drawn to the evolving nature of the firmware/software over time (which should not be discouraged), but the MCERTS requirement must be recognised that any *in-place firmware/software should be suitably approved.*

9. The field test sites utilised cover urban background, rural and traffic locations, with Bornheim being a rural site with traffic influences. At many of the sites there are low concentrations and the instrument performed well. As such, there are no problems anticipated with operating the Palas 200 instruments in rural locations.
10. It is proposed, therefore, that this instrument is suitable for use at urban background (including suburban), rural, and traffic locations within the UK.
11. Operations of instruments in permutations other than with the components listed in Section 2.1 and in [Ref.7], are not covered by this Report, and these permutations are not recommended for approval without further review by the UK MCERTS certification committee. They must assess the implications of any variations.

Notes:

1. The requirements of the EC Guidance on "Demonstration of Equivalence of Ambient Air Monitoring Methods" (GDE [Ref.2]) were fulfilled for the type of PM_{10} and $PM_{2.5}$ monitor and the two variants of the type of monitor described in this Report.
2. The TÜV laboratory test on constancy of sample flow was carried out using a somewhat different procedure to that given in the currently published MCERTS standard [Ref.3] – by using results taken at the beginning of each of the tests after calibrations at the first of the sites. The maximum deviation from the nominal values for flow is less than the performance criterion of ±3%. The test is considered to be a satisfactory implementation of the requirements, and the requirements for this test may therefore be deemed to be fulfilled
3. The TÜV test for sample leakage followed the procedure given in the MCERTS Performance Standard [Ref.3], and this procedure is given in Section 6.1, 5.3.7, of the TÜV report [Ref.6], with the results obtained also therein. The maximum leak rates did not exceed the requirements (expressed at an atmospheric pressure of 1028 hPa) as the determined values are less than the requirement of ±1%. The test is considered to be a valid implementation of the requirements, and the requirements for this test may therefore be deemed to be fulfilled
4. The requirements of the laboratory tests specified in the MCERTS Performance Standard [Ref.3] are considered to be fulfilled;
5. The larger range of laboratory tests required to meet the VDI/DIN Guidelines in Germany were carried out successfully, and have been demonstrated to meet those German requirements [Ref.6];
6. For the purposes of quality assurance and quality control of these monitors in the field, this type of automated monitor should be calibrated on a test site at intervals by use of the gravimetric (reference) method EN 12341:2014, and as given in the recommendations of the GDE [Ref.2].
7. The UK reports related to this evaluation are published on the MCERTS website: http://www.csagroupuk.org/services/mcerts/mcerts-product-certification/mcerts-certified-products/
8. The TÜV test reports on the suitability tests and the associated documentation are available on the internet at www.qal1.de

Annex 1 Terms and Definitions

For the purposes of this Report, its associated checklist, and for the purposes of the MCERTS Annex document [Ref.5], the following terms and definitions apply. The origins of these terms and definitions are indicated where appropriate by square brackets [Ref.] after the definition, taken from the list of references given in Section (i) P7 of this MCERTS Annex document. These references are also specified below in Annex 3 for convenience.

Ambient air

Outdoor air in the troposphere (excluding workplaces defined by Directive 89/654/EEC, where provisions concerning health and safety at work apply, and to which members of the public do not have regular access) [Ref.1].

Automated (measurement) method

A measurement method or system performing measurements or samplings of a specified pollutant in an automated way, generally directly in the field [Ref.2].

Availability (of the candidate method)

The fraction of the total and consecutive monitoring time during all the field trials involved in the equivalence testing programme for which data of acceptable quality are collected. The times required for scheduled calibrations and maintenance shall not be included. The method for calculating this fractional time is given in reference 5, Section 5.2 Equation 2. Availability defined here is the same as the minimum data capture requirements given in the data quality objectives in Directive 2008/50/EC for the relevant pollutant.

The MCERTS Performance Standard [Ref.3] also has a requirement that both of the candidate methods shall have an availability of greater than or equal to 90% during the entire set of field tests, and this shall be reported on the MCERTS certificate.

Calibration (of a candidate method)

Determination of the function between the concentrations of a specific pollutant in the ambient air as determined with respect to the reference method, and the responses of the candidate method to those same concentrations. This is applicable to the candidate method with time-limited validity [Ref.2].

Candidate method

A measurement method proposed as an alternative to the relevant reference method - for which equivalence is sought to be demonstrated [Ref.2].

CEN standard

International standard for normalization (norm) developed by the organisation the European Committee for Standardisation (CEN) for the objective of removing trade barriers for European industry and consumers [Ref.15].

Combined standard uncertainty

Standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of these terms, the terms being the variances or co-variances of these other quantities weighted according to how the measurement result varies with changes in these [Ref.17]. This may be expressed either as a relative (percentage) uncertainty, or as an absolute uncertainty, of the result.

Competent Authority

Organisation within the Member State that is designated by its national government to have overall responsibility for enacting all provisions of a set of European directives and/or other European regulations that are implemented into national regulations [Ref.16].

This is the organisation in the Member State that has national and legal responsibility for the provisions and requirements of Directive 2008/50/EC [Ref.1], and it is generally a national government ministry or an agency of national government, with political and administrative responsibilities for the relevant field of the legislation [Ref.16].

Competent body

Organisation designated by the Competent Authority in the Member State to carry out one or more technical or administrative functions at a national level, that in this document are those required by Directive 2008/50/EC [Ref.1], particularly those functional responsibilities that are specified in Article 3 of that Directive [Ref.16].

This is generally a designated scientific and technical organisation, rather than a government ministry, that enables all the functional responsibilities defined in Article 3 of the Directive 2008/50/EC[Ref.1] to be carried out. These responsibilities are applicable to all of the ambient air pollutants that are regulated across the EU, including those covered by Directive 2004/107/EC. One organisation in a given Member State is not generally capable of carrying out all of these, and there are therefore usually several competent bodies within a Member State [Ref.16]

Coverage factor

Numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty [Ref.17].

Designated body

Particular organisation that is designated for a specific task (type approval tests, equivalence tests, and/or Quality Assurance/Quality Control activities in the field) by the Competent Authority in that Member State.

This is a competent body that has been designated to carry out a particular scope of activities. It is required that a designated body that is appointed at a national level be accredited for the specified task(s) according to the EN ISO/IEC 17025 standard.

Environmental conditions

The specified range of meteorological conditions, the range of PM mass concentrations, and the range of semi-volatile components present in the sampled PM mass, that shall be present during one or more of the comparison tests carried out to demonstrate conformance with the “equivalence” requirements specified in this document.

Equivalent method

A measurement method other than the reference method for the measurement of a specified regulated air pollutant, capable of meeting the Data Quality Objectives given in Ref.1, for which equivalence has been demonstrated [Ref.1 Annex IV B & Ref.2 Section 4].

Expanded uncertainty

Quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand [Ref.17]. The fraction may be viewed as the coverage probability or level of confidence of the interval. (A specific level of confidence associated with this interval defined by the expanded uncertainty requires assumptions about the probability distribution characterised by the measurement result and its combined standard uncertainty.)

Field (equivalence) test or comparison

Experimental programme carried out by a test laboratory at a selected location in the field to compare the results obtained by the particulate matter reference method with those obtained by a particulate matter candidate method, during the course of establishing whether the candidate method conforms to the requirements for an equivalent method for monitoring particulate matter. This individual experimental field test or comparison forms part of a complete experimental test programme, together with a laboratory test programme where required, for demonstrating whether the candidate method may be deemed to be an equivalent method.

Laboratory (equivalence) test

Experimental programme carried out by a test laboratory in the environment of its laboratory to determine whether a particulate matter candidate method conforms to the requirements for an equivalent method for monitoring particulate matter. This laboratory test programme, where required, forms part of a complete experimental programme, together with the field test programme, for demonstrating whether the candidate method may be deemed to be an equivalent method. There are very limited requirements for laboratory tests in the MCERTS standard (and in the Guide to Demonstration of Equivalence [Ref 2]), but German test laboratories are required to carry out a greater and more comprehensive range of tests, many of which are being incorporated into a new CEN standard. These are discussed in MCERTS Annex document (Reference 5 Section 4.2).

Limit value

A concentration level of a pollutant in the ambient air that is fixed on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained [Ref.1].

Manual (measurement) method

A measurement method by which sampling is performed on site, generally for fixed short time intervals, with sample analysis performed subsequently in a laboratory [Ref.2].

Manufacturer (of the equipment)

The manufacturer of the hardware and associated software that makes up part of the *measurement method/candidate method* and is responsible for designing and/or manufacturing a product with a view to placing it on the market under its name. The manufacturer becomes the MCERTS certificate holder and is listed on the certificate, and has responsibility for compliance with the relevant MCERTS performance standards and regulations.

A manufacturer may also be an organisation that assembles, packs, processes, imports or labels ready-made products with a view to them being placed on the market under its name. The manufacturer may also be the manufacturer's agent or the equipment supplier of the automated or manual PM method when it has been MCERTS certified [Ref.4].

The term "manufacturer" is thus used to mean the equipment manufacturer, the manufacturer's commercial agent, or their equipment supplier, whichever is relevant as the customer in the MCERTS certification procedure.

Manufacturer's site audit

Initial and annual visits to the equipment manufacturer's plant by trained technical personnel as agreed by the MCERTS Certification Body to establish that equipment being

manufactured is of the same type as that submitted as a candidate method for the equivalence tests [Ref.4].

MCERTS certification

The approval of a candidate particulate matter monitoring method that meets all the MCERTS ***technical requirements*** but it has not necessarily been demonstrated for, or assessed for, use in the UK with its specific pollution climate for ambient PM monitoring [Ref.5]. This is a decision taken within the MCERTS certification procedure, and does not by itself involve, or denote approval by, the UK Competent Authority. This definition is restricted to the scope of this document, and is not intended to define all systems covered by MCERTS certification.

MCERTS certification for UK Particulate Matter

A candidate particulate matter monitoring method that has achieved all the MCERTS technical requirements, and is also demonstrated as equivalent for use in the UK with its Particulate Matter Pollution Climate for ambient monitoring, by means of additional investigations. This constitutes approval from the UK Competent Authority that the method has been tested satisfactorily for equivalence, and can be used in the UK for undertaking assessment in line with the requirements of Directive 2008/50/EC. Directive 2004/107/EC covers the requirements to monitor certain heavy metals and polycyclic aromatic hydrocarbons using the sample heads that are within the scope of this document, and in certain cases these may be considered as equivalent methods [Ref.5 Section 2.6, and [Ref.13]. This MCERTS classification may also be used for other monitoring activities, if required, including those carried out by Local Authorities – where appropriate.

This definition is restricted to and only relevant to the scope of the MCERTS Annex document [Ref.5], and to related reports of the MCERTS certification committee, and the definition is not intended for other systems covered by MCERTS certification.

MCERTS (Performance) Standard

Standard developed by The Environment Agency of England and Wales to prescribe the performance of monitoring instrumentation, equipment, or personnel, that has to be achieved for MCERTS certification to take place [Ref.3].

Measurement method

A complete description of the total operation of all aspects of the specific equipment, its operating procedures, data collection and storage, and data analysis, initial and on-going quality control and maintenance, that together make up the method, and that produce specific measurement results of defined quality [Ref.18].

The measurement method comprises: all parts of the hardware (such as the sample head, the analytical equipment, and data processing hardware) and all the software used, all

documented procedures for its use, all aspects of the associated control and analysis software, and all other procedures specified for use to enable valid measurement results to be produced.

Particulate Matter Pollution Climate

Characterisation of ambient particulate matter concentrations and certain compositional properties as representative in terms of its concentration range, its geometrical properties, its compositional range at the selected locations, together with selected meteorological conditions (wind speed, atmospheric temperature and ambient humidity) that are also representative.

PM_X

Particulate matter that is suspended in ambient air, and which passes through a size-selective sample inlet with a 50% efficiency cut-off at an aerodynamic diameter of x µm (usually PM_{10} or $PM_{2.5}$).

Pollutant

Any substance present in ambient air and likely to have harmful effects on human health and/or the environment as a whole [Ref.1].

Reference (measurement) method or reference method

European standard method developed by CEN, referred to in Directive 2008/50/EC Annex VI, and/or in Directive 2004/107/EC, and specified in that Directive as the reference method for the measurement of a specific ambient air pollutant. This measurement method produces, by convention, the accepted reference value of the measurand, with only a random uncertainty applicable to that value. (For the case of PM_{10} and $PM_{2.5}$ mass monitoring, these reference methods are specified as manual methods in [Ref.1].)

Regional, national, and local locations (for the equivalence tests)

Types of locations that have a similar PM pollution climate where the Competent Authority may choose to carry out equivalence tests and may install methods that have been deemed equivalent at these locations.

Sampled air

Ambient air that has been sampled through the sampling inlet and sampling system of the measurement method.

Semi-volatile fraction of particulate matter

The fraction of semi-volatile component within a sampled PM_{10} or $PM_{2.5}$ mass measurement result that shall be analysed from a sample obtained by a reference method or a candidate method during the equivalence test programme. (The semi-volatile channel of an automated PM mass analyser will usually indicate this fraction during the tests in the field – requirements for this fraction are given in Reference 5 Section 3.)

Standard uncertainty

Uncertainty of the result of a measurement expressed as a standard deviation [Ref.17].

Test laboratory

Organisation that is capable of carrying out all or part of the laboratory tests and/or the field tests specified in this document; that is contracted by the manufacturer for these; that has the agreement of the MCERTS certification body to perform these; and that is accredited to the EN ISO/IEC 17025 standard (latest published version) for these.

Uncertainty (of measurement)

Parameter, associated with the result of a measurement that characterises the dispersion (variability) of the values that could reasonably be attributed to the measurand [Ref.17].

Annex 2 Abbreviations used

AQD	Air Quality Directive 2008/50/EC
BV	Bureau Veritas – the organisation that prepared the UK versions of reports provided by TÜV in order that they conform to all the requirements of Ref.5
CAM	Ambient Air Quality Monitoring System (generally means "Continuous" - but this is not restricted to "continuous" in this Document and thus allows certain discontinuous PM samplers to be tested for equivalence)
CEN	European Committee for Standardisation [Ref.15]
CM	Candidate method
EC	European Commission
EU	European Union
GDE	EC Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods, January 2010 [Ref.2]
GM	Geometric mean (of particulate mass concentrations)
MCERTS	The Environment Agency's Monitoring Certification Scheme [Refs.3 & 4]
PM	Particulate matter
RM	Reference method
QA	Quality assurance
QC	Quality control
UKAS	United Kingdom Accreditation Service
VDI/DIN	Verein Deutscher Ingenieure / Deutsches Institut fur Normung e.V [see Refs.10 & 11]

Annex 3 References

Reference 1: Directive 2008/50/EC of the European Council and Parliament of 21 May 2008 on ambient air quality and cleaner air for Europe, Official Journal of the European Union L152/1, 11.6.2008

Reference 2: Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods, Report by an EC Working Group on Guidance for the Demonstration of Equivalence, January 2010 http://ec.europa.eu/environment/air/quality/legislation/assessment.htm

Reference 3: MCERTS Performance Standards for Ambient Air Quality Monitoring Systems, Environment Agency, Version 9.1, February 2016

Reference 4: A Guide to the Certification of Products under the Environment Agency's MCERTS Scheme, Form 1177, July 2006 http://www.csagroupuk.org/wp-content/uploads/2015/05/FORM1177-Guide-to-MCERTS-Product-Certification.pdf

Reference 5: Annex to the MCERTS Performance Standards for Ambient Air Quality Monitoring Systems: Requirements of the UK Competent Authority for the Equivalence Testing and Certification of Automated Methods and Manual Discontinuous Methods that Monitor Particulate Matter in Ambient Air, Department of the Environment, Food and Rural Affairs, Version 1, July 2012.

Reference 6: Report on supplementary suitability testing of the Fidas 200 S and respectively Fidas 200 measurement system manufactured by PALAS GmbH for the components suspended particulate matter PM10 and PM2.5. Report number 936/21227195/A dated 9th March 2015. http://www.gal1.de/en/hersteller/fai.htm

Reference 7: Palas GmbH: UK Report on the Equivalence of the Palas Fidas 200 Method 11 for PM_{10} and $PM_{2.5}$., BV Report AGGX8316719/BV/DH/2972, March 2016.

Reference 8: CEN Standard EN 12341:1998. Air Quality – Determination of the PM10 fraction of suspended particulate matter – Reference method and field test procedure to demonstrate reference equivalence of measurement

Reference 9: CEN Standard EN 12341:2014 Ambient air - Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2.5}$ mass concentration of suspended particulate matter.

Reference 10: Performance criteria for performance tests of automated ambient air measuring systems - Point-related measurement methods for gaseous and particulate air pollutants, Verein Deutscher Ingenieure, VDI RichtLinien VDI 4202-Part 1, September 2010

Reference 11: Testing of automated measuring systems: Test procedures for point-related ambient air quality measuring systems of gaseous and particulate pollutants, Verein Deutscher Ingenieure, VDI RichtLinien VDI 4203 Part 3, 2008

Reference 12: Ambient air quality – Automated continuous measuring systems for the measurement of the concentration of particulate matter (PM_{10}, $PM_{2.5}$), CEN Technical Committee 264 Technical Specification, CEN/TS 16450:2013.

Reference 13: Characterising the PM climate in the UK for Equivalence Testing, D Green & G Fuller, King's College London, Environmental Research Group, June 2012; ukair.defra.gov.uk/reports/cat13/1207190952_DefraCharacterisingThePMClimateInTheUKForEquivalenceTestingV3.pdf

Reference 14: EC DG Environment website covering "equivalence" – spread-sheet "test the equivalence (xls)"- developed by RIVM the Netherland, revised 2014; http://ec.europa.eu/environment/air/quality/legislation/assessment.htm

Reference 15: European Committee for Standardisation http://www.cen.eu/cen/products/en/pages/default.aspx

Reference 16: National Air Quality Reference Laboratories and the European Network – AQUILA: Roles and Requirements for Traceability, Accreditation, Quality Assurance/Quality Control, and Measurement Comparisons, at National and European Levels, December 2009; http://ec.europa.eu/environment/air/quality/legislation/pdf/aquila.pdf

Reference 17: Guide to the Expression of Uncertainty of Measurement (GUM): International Standardisation Organisation 1993

Reference 18: International vocabulary of metrology – basic and general concept and associated terms (international vocabulary of basic and general terms VIM) - Joint Committee for Guides in Metrology, JCGM 200:2008 (E/F)