Clarity Node-S

Test of the Clarity Node-S Sensor Systems

for use as an Indicative Monitor for PM_{10} and $PM_{2.5}$

July 2023

Move Forward with Confidence

BUREAU VERITAS

This page is left blank intentionally

DOCUMENT CONTROL SHEET

Issue/Revision	Draft for Comment	Final
Date	30/06/2023	05/07/2023
Submitted to	Clarity Node-S	Clarity Node-S
Prepared by	Bethan Lloyd	Bethan Lloyd
Signature		
Approved by	Dr David Harrison	Dr David Harrison
Signature		
Project number	AIR19404466	AIR19404466

Disclaimer

This Report was completed by Bureau Veritas on the basis of a defined programme of work and terms and conditions agreed with the Client. Bureau Veritas' confirms that in preparing this Report it has exercised all reasonable skill and care taking into account the project objectives, the agreed scope of works, prevailing site conditions and the degree of manpower and resources allocated to the project.

Bureau Veritas accepts no responsibility to any parties whatsoever, following the issue of the Report, for any matters arising outside the agreed scope of the works.

This Report is issued in confidence to the Client and Bureau Veritas has no responsibility to any third parties to whom this Report may be circulated, in part or in full, and any such parties rely on the contents of the report solely at their own risk.

Unless specifically assigned or transferred within the terms of the agreement, the consultant asserts and retains all Copyright, and other Intellectual Property Rights, in and over the Report and its contents.

Any questions or matters arising from this Report should be addressed in the first instance to the Project Manager.

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

Two Clarity Node-S Sensor Systems were operated alongside a Palas Fidas 200, both of which monitor PM_{10} and $PM_{2.5}$. A comparison was made in line with the Performance Standards for Indicative Ambient Particulate Monitors, Version 4, dated August 2017[1]. In accordance with the criteria described therein, a summary of the performance of the instrument is given in the overleaf Table and summarised below.

The Clarity Node-S Sensor System passes all criteria set out in the Performance Standard for Indicative instruments for collecting PM_{10} and $PM_{2.5}$ data.

In order to be used for indicative purposes the Clarity Node-S Sensor System must be set up in the same configuration as which it was tested, namely the following must be installed:

- Sensor Type and Firmware Version: Plantower PMS6003, Firmware Version 146 (0x92). Modifications to the sensor firmware version would require verification by the certification committee. Modifications to the sensor itself may require repeating the field test or comparing systems operating different versions of the sensor to show that there are no differences to the measurements.

- Firmware and Algorithm Version of Sensor System: Firmware version 2.4.1.01, Algorithm version 1.04408. Modifications to the algorithm will need approval by the certification committee and if modifications are made to the PM mass calculation, then this would potentially require the field test to be repeated.

The Clarity Node-S is available as PM and PM+NO_2 variants. However, both have the same Sensor Type and Sensor System. As there are no significant differences in PM_{10} and $PM_{2.5}$ sampling between the two variants, it is assumed that the indicative test results would not be impacted by whether the device has additional gas monitoring capabilities or not.

All users must slope correct PM_{10} data by dividing by 1.681. All users must slope correct $PM_{2.5}$ data by dividing by 1.998. Alternatively, site specific calibration can be applied using the Clarity recommended procedure. Clarity recommends that co-location is carried out prior to each sensor being deployed for a minimum of 30 days. If more than 3 sensor systems are being deployed in the region, then collocation needs to be done with a minimum of 3 sensor systems (triplicate) and then any resulting calibration factor should be remotely applied to all other sensors in the network. Use of the systems without any calibration factor would not be covered by the certification process.

Certification Range:

PM_{10}	To be decided by the certification committee
$PM_{2.5}$	To be decided by the certification committee

[1] Performance Standards for Indicative Ambient Particulate Monitors, Version 4, Environment Agency, August 2017. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/642895/LIT_7070.pdf

Test	**Results**	**MCERTS Specification**
Constancy of the sample volumetric flow	Prior permission was sought and received not to perform this test as the instrument utilises a fan not a pump.	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	1.18 %	Leakage not to exceed 2 % of sampled volume.
Maintenance interval	No regular or periodic maintenance required for the entirety of the Node-S lifetime on the field. A system raises alarms when the Node-S operational status is degraded, including sensor faults. To clear alarms, customers are instructed to attempt troubleshooting. If troubleshooting fails, then the entire Node-S is replaced.	Greater than or equal to two weeks.

Performance characteristics when monitoring PM_{10}		
Test	**Results**	**MCERTS Specification**
Intra-instrument uncertainty for the reference method	Only one Palas Fidas 200 was used during the testing of the Clarity Node-S Sensor Systems. 0.33 µg m^{-3} was calculated during operation of two Palas Fidas 200s at a similar site during 2014.	≤ 2.5 µg m^{-3}. If only a single reference method instrument is available, then values from previous tests performed by the same laboratory/network using identical pattern of samplers can be used. If those are not available a default value of 0.67 µg m^{-3} can be assumed.
Intra-instrument uncertainty for the candidate method	After slope correcting by dividing by 1.681: 0.91 µg m^{-3} (All data, n = 460) 0.90 µg m^{-3} (< 30 µg m^{-3}, n = 456) 1.29 µg m^{-3} (≥ 30 µg m^{-3}, n = 4)	≤ 5 µg m^{-3} for all data as well as for the subsets: less than and greater than or equal to 30 µg m^{-3} for PM_{10}. The “greater than” data subset shall contain at least 8 data pairs. If 80 data pairs are produced still without generating the required 8 data pairs in the “greater than” subset then this is considered sufficient and the testing may be terminated.
Highest resulting uncertainty estimate comparison against data quality objective (measurement uncertainty)	After slope correcting by dividing by 1.681: All Data: W_{CM} = 19.1 % (n = 460) PM_{10} ≥ 30 µg m^{-3} : W_{CM} = 21.2 % (n = 4)	W_{CM} ≤ 50 %. The resultant expanded uncertainty is assessed for the full dataset, and the subset of data greater than or equal to 30 µg m^{-3}.

Performance characteristics when monitoring $PM_{2.5}$		
Test	**Results**	**MCERTS Specification**
Intra-instrument uncertainty for the reference or equivalent method	Only one Palas Fidas 200 was used during the testing of the Clarity Node-S Sensor Systems. 0.25 µg m^{-3} was calculated during operation of two Palas Fidas 200s at a similar site during 2014.	≤ 2.5 µg m^{-3}. If only a single reference method instrument is available, then values from previous tests performed by the same laboratory/network using identical pattern of samplers can be used. If those are not available a default value of 0.67 µg m^{-3} can be assumed.
Intra-instrument uncertainty for the candidate method	After slope correcting by dividing by 1.998: 0.94 µg m^{-3} (All data, n = 460) 0.93 µg m^{-3} (<18 µg m^{-3}, n = 450) 1.24 µg m^{-3} (≥18 µg m^{-3}, n = 10)	≤ 5 µg m^{-3} for all data as well as for the subset: less than and greater than or equal to 18 µg m^{-3} for $PM_{2.5}$. The “greater than” data subset shall contain at least 8 data pairs. If 80 data pairs are produced still without generating the required 8 data pairs in the “greater than” subset then this is considered sufficient and the testing may be terminated.
Highest resulting uncertainty estimate comparison against data quality objective (measurement uncertainty).	After slope correcting by dividing by 1.998: All Data: W_{CM} = 14.8 % (n = 460) $PM_{2.5}$ ≥ 18 µg m^{-3} : W_{CM} = 28.2 % (n = 10)	W_{CM} ≤ 50 %. The resultant expanded uncertainty is assessed for the full dataset, and the subset of data greater than or equal to 18 µg m^{-3}.

1. Legislative Background

The European Commission (EC) Directive 2008/50/EC[2] was accepted into UK law in June 2010. Member States of the European Union (EU) are required to measure the mass of particulate matter (PM) below 10 microns diameter (PM_{10}) and below 2.5 microns diameter ($PM_{2.5}$). Concentrations are reported as 24-hour averages, and for PM_{10} it is a requirement that there are fewer than 35 exceedances of 50 µg m^{-3} per year, and that the annual average is below 40 µg m^{-3}. For $PM_{2.5}$ there is no daily limit, though there is an annual average target of 10 µg m^{-3}. The European reference methods for quantifying PM_{10} and $PM_{2.5}$ are set out in the standard EN12341[3]. The reference instruments sample one filter every 24 hours (as per the reporting requirements), and there is a potential delay of several weeks before the filters are weighed, and the concentrations calculated.

While there is no legal mandate, there is often a need to have real-time data at a frequency of at least hourly. In light of this, the EC allows Member States to use instruments that can be proven equivalent to the European Reference Methods[4]. Many instruments are available that use a variety of methods to quantify PM. Candidate instruments are tested in duplicate against the reference methods for a minimum of 40 days at each of a minimum of four tests that cover a range of test locations and seasons. A mathematical analysis is undertaken to show that the slope and intercept are not significantly different from 1 and 0 respectively, and that the expanded uncertainty at the limit value is less than 25%. It is possible for a slope and/or intercept correction factor to be introduced; however, it is a requirement that the same correction factors are used for all the datasets.

Within the United Kingdom (UK), the Environment Agency (in collaboration with CSA) runs a Monitoring Certification Scheme (MCERTS) for Continuous Ambient Mass Monitoring Systems (CAMS) and this has been used successfully for several years to certify instruments that are proven equivalent to the European Reference methods[5]. Such certified instruments tend to be relatively large and expensive and often require air-conditioned enclosures in which to operate effectively.

Within the UK, there is often a requirement to monitor PM using cost-effective weatherproof methods that provide real-time data at a high frequency of 15 minutes or lower. Such equipment needs to be able to accurately identify that there has been a significant spike in PM concentrations, but it is not necessarily a requirement to accurately know the magnitude of this spike. As such, these instruments could be described as giving an “indication” of PM but are not intended to be equivalent to the European Reference Methods, and therefore are not suitable for compliance reporting. Typically, “indicative” methods can be used as a first approximation to compliance and then followed with more accurate methods that conform to the European reference methods for compliance measurement purposes. Indicative instruments are often situated at industrial processes that are regulated by the EA or Local Authorities (LAs).

The EA have developed a certification scheme for indicative instruments[1]. As with the equivalent tests, candidate instruments are tested in duplicate against the reference or equivalent method for a minimum of 40 days; however, it is just a requirement that there is a single test rather than at least four. Further, the mathematical analysis requires that the expanded uncertainty at the limit value is less than 50%, rather than 25% as is required for equivalent instruments.

---

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

[3] Standard EN12341:2014 Ambient air - Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2,5}$ mass concentration of suspended particulate matter

[4] European Standard EN16450:2017 Ambient air - Automated measuring systems for the measurement of the concentration of particulate matter (PM_{10}; $PM_{2,5}$)

[5] https://www.csagroup.org/en-gb/services/mcerts/mcerts-product-certification/mcerts-certified-products/mcertscertified-productscontinuous-ambient-air-monitoring-system-mcerts-for-uk-particulate-matter/

2. Methodology

From the 10th July 2021 to the 29th October 2022, two candidate Clarity Node-S Sensor Systems were collocated with a Palas Fidas 200. The Palas Fidas has previously been shown to be equivalent to the European Reference Method. The location of the tests was Manchester Fallowfield. The zero leak tests were supervised by the National Physical Laboratory (NPL) which has ISO17025 accreditation for these tasks.

The serial numbers for the two Clarity Node-S Sensor Systems tested were A50LXXPZ and ADBJW6TG.

The Sensor Type and Firmware Version were Plantower PMS6003, Firmware Version 146 (0x92).

The Sensor System was Firmware version 2.4.1.01, Algorithm Version 1.04408

The instruments produced readings every 3 seconds, and this data was then used to calculate hourly average concentrations which were averaged to 24 hour average concentrations. A 24 hour average was only valid when there was at least 75% data capture (18 hourly average concentration data values) for that day.

The Clarity Node-S Sensors performed well throughout tests. Over the 508-day period, only 3 days had 24 hour average concentrations that were considered invalid due to the daily data capture being below 75%.

Only around 0.6% of hourly average concentration data were deleted for both Clarity Node-S Sensors. The performance standard states “Data may be removed from the data set when there are sound technical reasons for doing so. This data ratification process applies in particular to spikes that can be considered unrealistic for a particular data set. The data ratification process cannot deplete the data set below the data capture level of 90%.”. It is believed that the use of the algorithm is within these criteria.

The following Sections discuss the results in the order that they are discussed in the performance standard.

3. Certification Range

The instrument is designed to operate over a measurement range of 0 µg m^{-3} to 1000 µg m^{-3}.

As with all certification projects, it is not always possible to achieve these high concentrations over the course of the test. The highest concentrations observed during the Manchester Fallowfield test were:

- Maximum Hourly PM_{10} 63.4 µg m^{-3};
- Maximum Hourly $PM_{2.5}$ 52.4 µg m^{-3};
- Maximum 24 hour PM_{10} 44.9 µg m^{-3};
- Maximum 24 hour $PM_{2.5}$ 32.9 µg m^{-3}.

The decision as to the appropriate certification range is left to the Certification Committee.

4. Constancy of Sample Volumetric Flow

Prior permission was sought and received not to perform this test as the instrument utilises a fan not a pump.

5. Tightness of the Sampling System

The performance standard states that "the tightness of the sampling system shall not exceed 2% of sampled volume". After consultation with NPL, these tests were performed on different systems to those employed in the Manchester Fallowfield field study. The serial numbers of the instruments used in the leak tests were A464RG7H and A52XH4WT.

Leak tests were performed by placing a HEPA filter on the inlet to the instruments on June 23rd 2023 at 2045 Filbert Street, San Francisco. For A464RG7H, PM_{10} and $PM_{2.5}$ were 39.3 µg m^{-3} and 33.2 µg m^{-3} before the HEPA test and decreased to 0.47 µg m^{-3} and 0.00 µg m^{-3} respectively after application of the HEPA filters. This corresponds to a leak rate of 1.18 % for PM_{10} and 0.00 % for $PM_{2.5}$.

For A52XH4WT, PM_{10} and $PM_{2.5}$ were 40.2 µg m^{-3} and 34.9 µg m^{-3} respectively before the HEPA test, with both decreasing to 0.192 µg m^{-3} following filter placement. This corresponds to a leak rate of 0.48 % for PM_{10} and 0.55 % for $PM_{2.5}$. All leak rates are below the required 2 %, but the highest of these (1.18 %) shall go on the certificate.

6. Intra Instrument Uncertainty of the Reference or Equivalent Method

Whilst only a single Palas Fidas 200 was operated during the testing of the Clarity Node-S, two identical instruments were operated in parallel between 27th February and 2nd June 2014 at a similar site. Calculations of the intra instrument uncertainty were undertaken using the methodology described in Technical Specification 16450[4].

For PM_{10}, the 24 hour intra instrument uncertainty was shown to be 0.33 µg m^{-3} and this value is therefore used in the calculation of the PM_{10} expanded uncertainty of the Clarity Node-S. As such, the instrument meets the intra instrument uncertainty for the reference or equivalent method specification for PM_{10}.

For $PM_{2.5}$, the 24 hour intra instrument uncertainty was shown to be 0.25 µg m^{-3} and this value is therefore used in the calculation of the Clarity Node-S $PM_{2.5}$ expanded uncertainty. As such, the instrument meets the intra instrument uncertainty for the reference or equivalent method specification for $PM_{2.5}$.

7. Intra Instrument Uncertainty of the Candidate Method

The performance standard states that the "Intra instrument uncertainty for the candidate method should be ≤5 µg m^{-3} for all data as well as for the subsets: less than and greater than or equal to 30 µg m^{-3} for PM_{10} and 18 µg m^{-3} for $PM_{2.5}$. Each "greater than" data subset shall contain at least 8 data pairs. If 80 data pairs are produced still without generating the required 8 data pairs in the "greater than" subset then this is considered sufficient and the testing may be terminated".

Calculations of the intra instrument uncertainty were undertaken using the methodology described in EN16450[4], and the results are shown for PM_{10} in Table 7.1. Calculations were performed using the 24 hour average data. The regression was forced through the origin and then slope corrected by dividing by 1.681 (as detailed in Section **Error! Reference source not found.**), which is permitted by the performance standard.

For all three categories, the intra instrument uncertainty (u_{bs}) was lower than the required 5 µg m^{-3}, and as such, the instrument meets the intra instrument uncertainty for the candidate method specification for PM_{10}. Note that as after 508 days there were only 4 days where PM_{10} was ≥ 30 µg m^{-3}, and so the decision was taken to stop the test in accordance with the requirements of the performance standard. Of these 508 days, 48 were excluded due to low data capture on either the Fidas (46 days) or the Clarity Node-S (4 days of which 2 were coincident with the Fidas being non-operational).

Table 7.1 Intra instrument uncertainties for the Clarity Node-S for PM_{10}.

All Data		< 30 µg m^{-3}		≥ 30 µg m^{-3}	
n	**u_{bs} / µg m^{-3}**	**n**	**u_{bs} / µg m^{-3}**	**n**	**u_{bs} / µg m^{-3}**
460	0.91	456	0.90	4	1.29

The results for $PM_{2.5}$ are shown in Table 7.2. Calculations were performed on the 24 hour average data and the regression was forced through the origin. For all three categories, the intra instrument uncertainty (u_{bs}) was lower than the required 5 µg m^{-3}, and as such, the instrument meets the Intra instrument uncertainty for the candidate method specification for $PM_{2.5}$. Note that after 508 days, there were 10 days where $PM_{2.5}$ was ≥ 18 µg m^{-3}, and so the dataset met the requirement of the performance standard for 8 data pairs in the "greater than" subset. Of these 508 days, 48 were excluded due to low data capture on either the Fidas (46 days) or the Clarity Node-S (4 days of which 2 were coincident with the Fidas being non-operational).

Table 7.2 Intra instrument uncertainties for the Clarity Node-S for $PM_{2.5}$.

All Data		< 18 µg m^{-3}		≥ 18 µg m^{-3}	
n	**u_{bs} / µg m^{-3}**	**n**	**u_{bs} / µg m^{-3}**	**n**	**u_{bs} / µg m^{-3}**
460	0.94	450	0.93	10	1.24

8. Expanded Uncertainty of the Candidate Method for PM_{10}

The performance standard states that the highest expanded uncertainty estimate (W_{CM}) should be below 50 %. For PM_{10}, the expanded uncertainty is assessed for the full dataset, and the dataset split to be greater than 30 µg m^{-3}. Of the full dataset at least 8 pairs of the results obtained by employing the standard method must be greater than 30 µg m^{-3}. If 80 data pairs are produced still without generating the required 8 data pairs in the "greater than" subset then this is considered sufficient and the testing may be terminated. In accordance with the performance standard, the expanded uncertainties were calculated at 50 µg m^{-3} using the methodology described in EN16450[4].

The 24 hour average concentrations of PM_{10} recorded by A50LXXPZ and ADBJW6TG were calculated from their respective 1 hour average concentration data. PM_{10} 24 hour averages were then calculated by averaging the 24 hour concentration data from both instruments. These were plotted against the PM_{10} Palas Fidas 200 Equivalent Method data (Figure 8.1). It was decided to force the orthogonal regression through the origin, which is permitted according to the performance standard. Of the 508 days, 48 were excluded due to low data capture/ratification, leaving 460 days of data to be plotted.

The figure gives the slope (b); intercept (a); number of data points (n); R^2; the expanded uncertainty (W_{CM}); and the between candidate and reference method uncertainties discussed in the previous two sections. The expanded uncertainty is 139.4 %, which is above the required 50 %. Therefore, it was decided to apply slope correction to the regression by dividing by 1.681. Figure 8.2 and **Error! Reference source not found.**Figure 8.3 Comparison of 24 hour averages of PM_{10} Clarity Node-S against the PM_{10} Palas Fidas 200 following slope correction by dividing by 1.681 (PM_{10} ≥ 30 µg m^{-3}).show the comparison plots following slope correction for All data and PM_{10} ≥ 30 µg m^{-3} respectively. The expanded uncertainty is reduced to 19.1 % for All Data, and 21.2 % for the 'greater than' subset. As both expanded uncertainties are now lower than the required 50 %, the Clarity Node-S) sensor system meets the performance standard for PM_{10} following slope correction by dividing by 1.681.

Figure 8.1 Comparison of 24 hour averages of PM_{10} Clarity Node-S against the Palas Fidas 200 PM_{10} (All data).

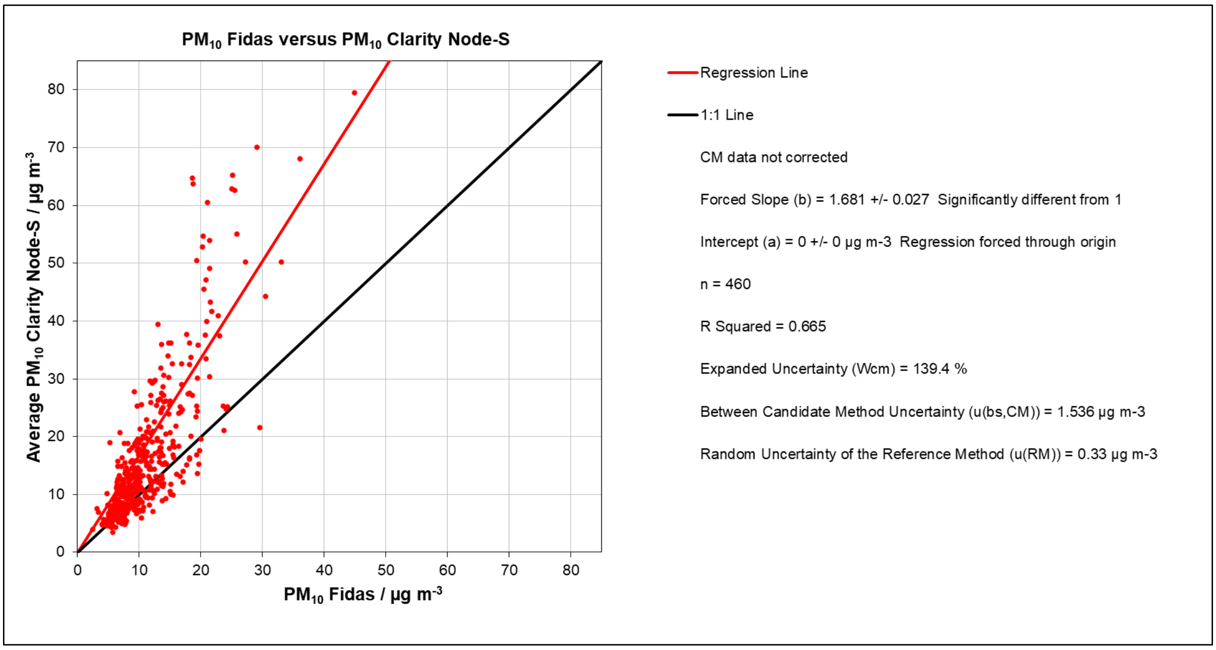


Figure 8.2 Comparison of 24 hour averages of PM_{10} Clarity Node-S against the PM_{10} Palas Fidas 200 following slope correction by dividing by 1.681 (All Data).

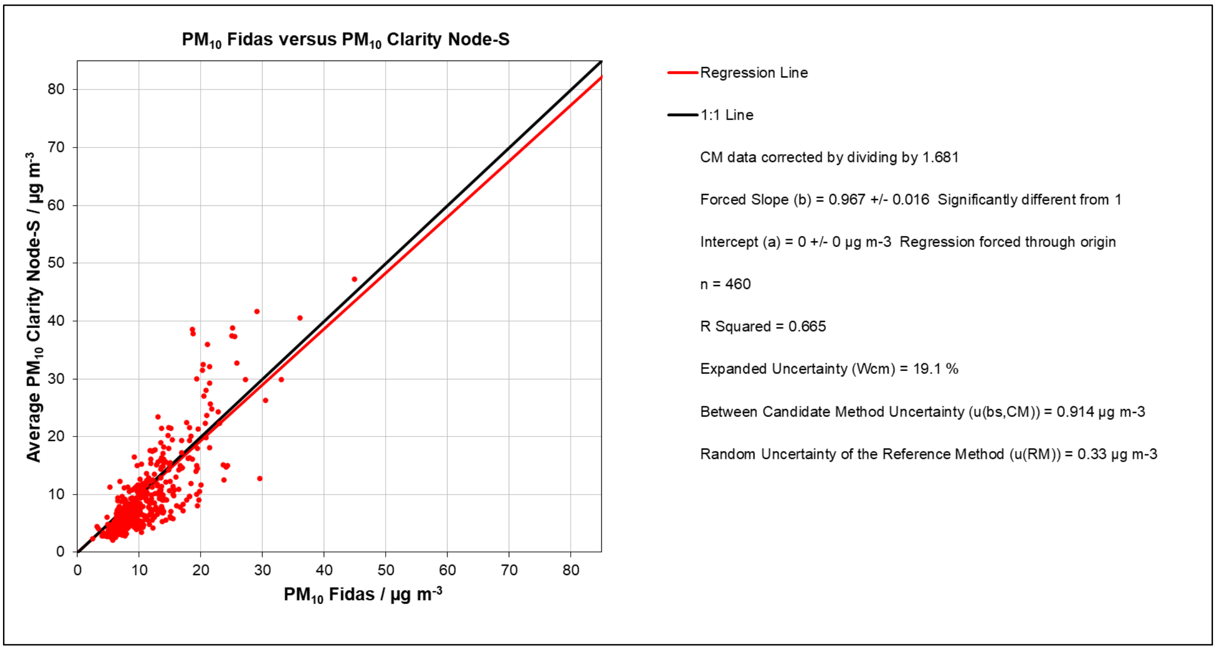
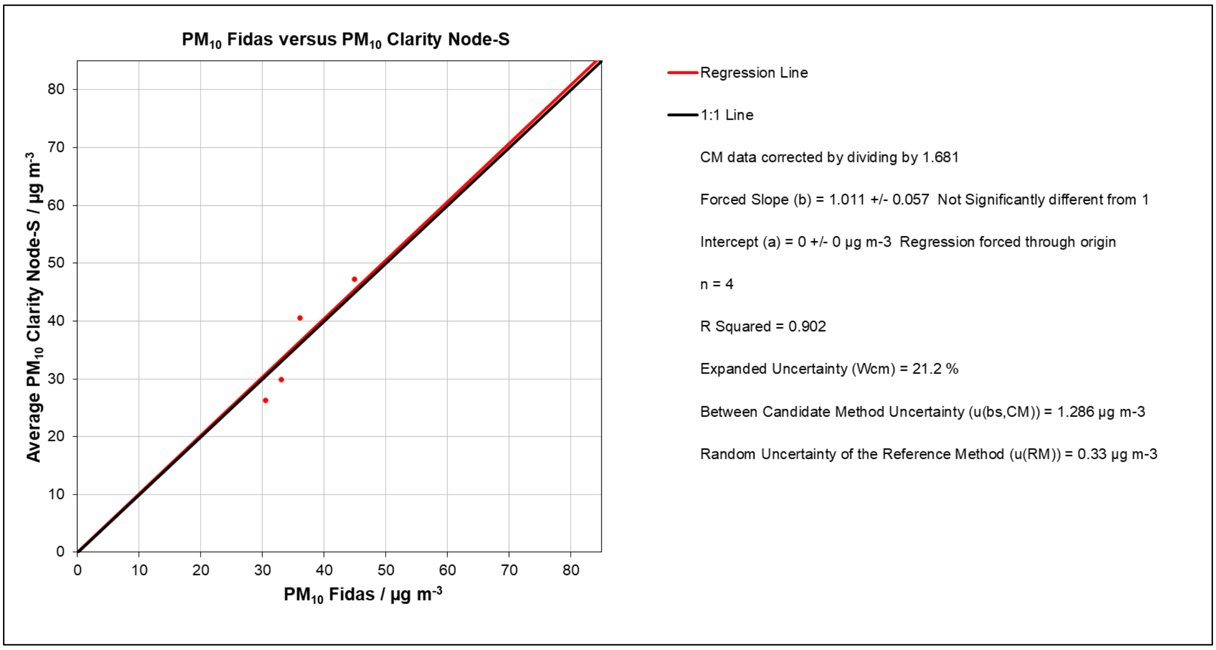


Figure 8.3 Comparison of 24 hour averages of PM_{10} Clarity Node-S against the PM_{10} Palas Fidas 200 following slope correction by dividing by 1.681 ($PM_{10} \geq 30$ µg m^{-3}).



9. Expanded Uncertainty of the Candidate Method for $PM_{2.5}$

The performance standard states that the highest expanded uncertainty estimate (W_{CM}) should be below 50 %. For $PM_{2.5}$, the expanded uncertainty is assessed for the full dataset, and the dataset split to be greater than 18 µg m^{-3}. Of the full dataset at least 8 pairs of the results obtained by employing the standard method must be greater than 18 µg m^{-3}. If 80 data pairs are produced still without generating the required 8 data pairs in the "greater than" subset then this is considered sufficient and the testing may be terminated. In accordance with the performance standard, the expanded uncertainties were calculated at 30 µg m^{-3} using the methodology described in EN16450[4].

The 24 hour average concentrations of $PM_{2.5}$ recorded by A50LXXPZ and ADBJW6TG were calculated from their respective 1 hour average concentration data. PM_{10} 24 hour averages were then calculated by averaging the 24 hour concentration data from both instruments. Of the 508 days, 48 were excluded due to low data capture/ratification, leaving 460 days of data to be plotted. The $PM_{2.5}$ Palas Fidas 200 Equivalent Method data have been divided by 1.06 as is required as a result of the initial equivalence test of the instrument. In accordance with EN16450:2017. It was decided to force the orthogonal regression through the origin, which is permitted according to the performance standard. The comparison plot is shown in Figure 9.1 and the expanded uncertainty is 201.4 %, which is above the required 50 %.

Therefore, it was decided to apply slope correction to the regression by dividing by 1.998. Figure 9.2 and Figure 9.3 show the comparison plots following slope correction for All data and $PM_{10} \geq 30$ µg m^{-3} respectively. The expanded uncertainty is reduced to 14.8 % for All Data, and 28.2 % for the 'greater than' subset. As both expanded uncertainties are now lower than the required 50 %, the Clarity Node-S) sensor system meets the performance standard for PM_{10} following slope correction by dividing by 1.998.

Figure 9.1 Comparison of 24 hour averages of $PM_{2.5}$ Clarity Node-S against the $PM_{2.5}$ Palas Fidas 200 (All data).

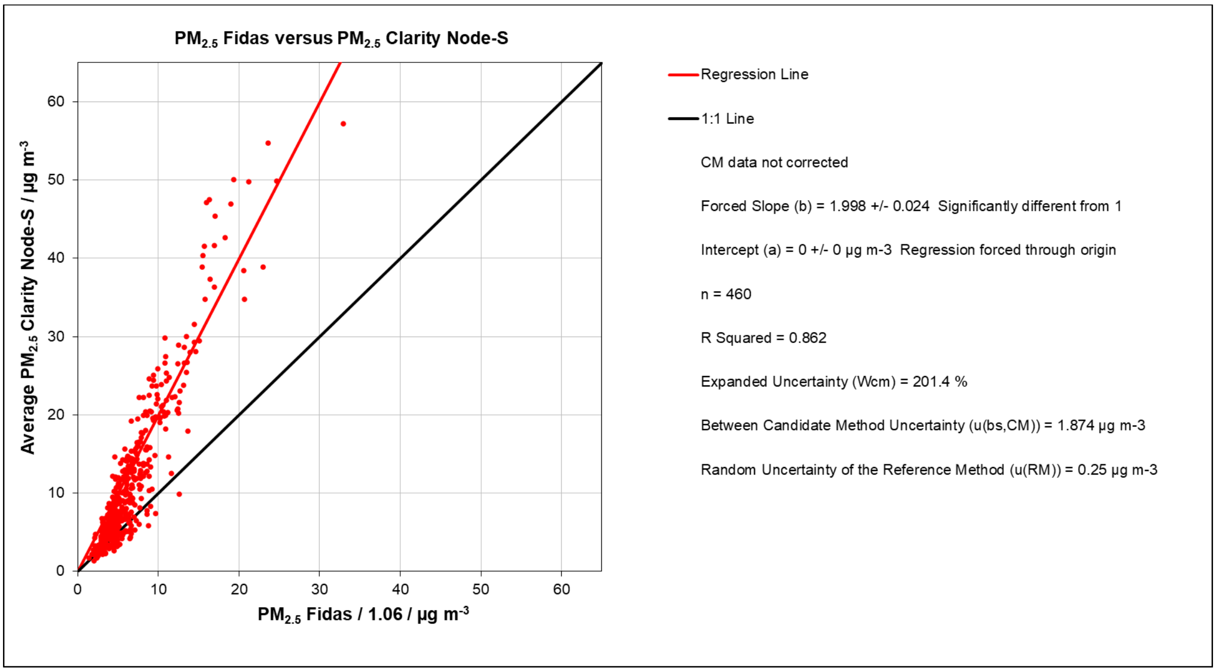


Figure 9.2 Comparison of 24 hour averages of $PM_{2.5}$ Clarity Node-S against the $PM_{2.5}$ Palas Fidas 200 (All Data) after slope correction by dividing by 1.998.

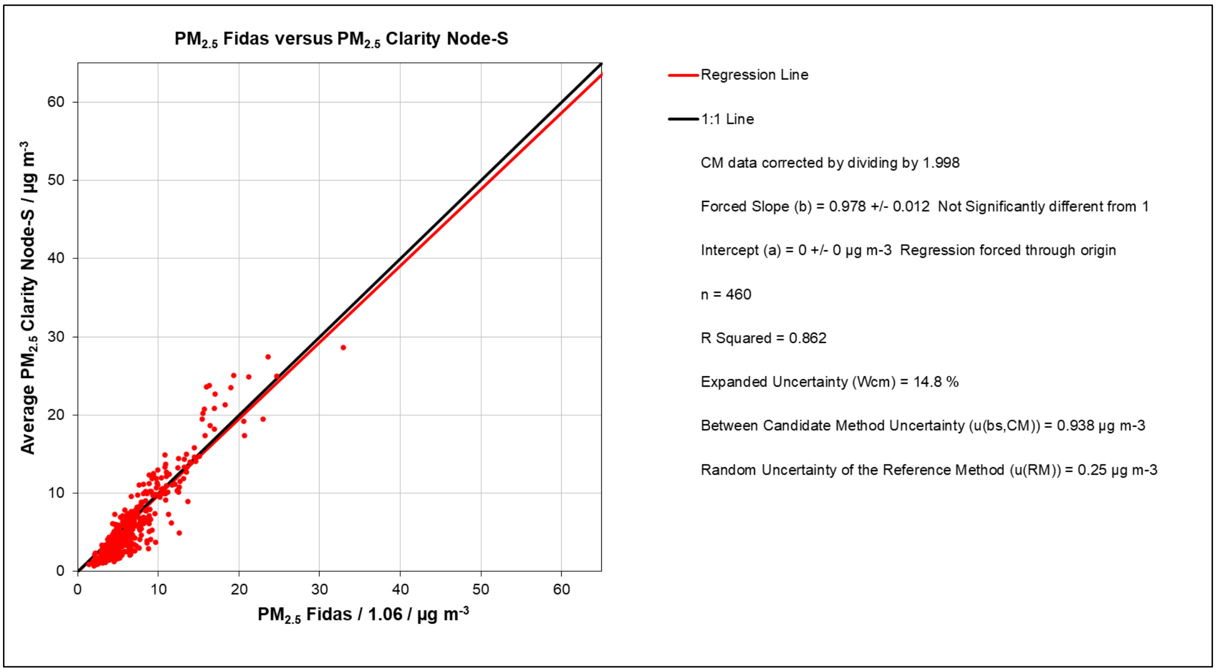
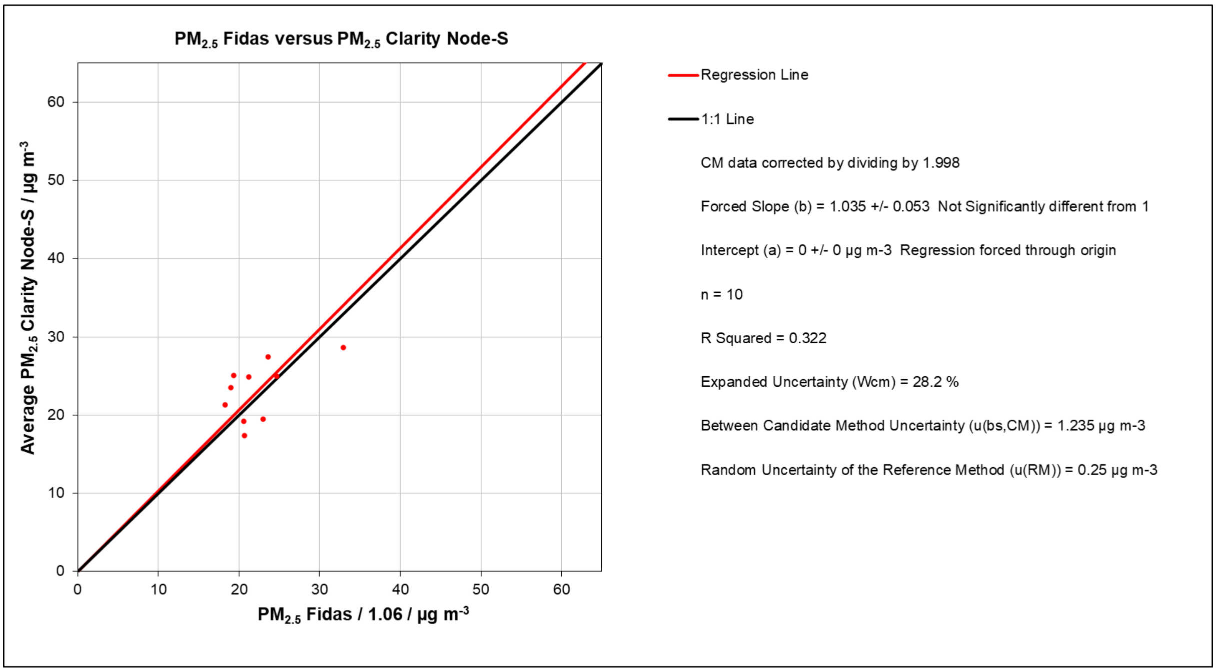


Figure 9.3 Comparison of 24 hour averages of $PM_{2.5}$ Clarity Node-S against the $PM_{2.5}$ Palas Fidas 200 ($PM_{2.5}$ ≥18 µg m^{-3}) after slope correction by dividing by 1.998.



10. Maintenance Interval

The performance standard states that the maintenance interval should be a minimum of 2 weeks. During the 72 weeks that the instruments were operational at Manchester Fallowfield, no maintenance was required. The manufacturer states that no regular or periodic maintenance is required for the entirety of the Node-S lifetime on the field. A system raises alarms when the Node-S operational status is degraded, including sensor faults. To clear alarms, customers are instructed to attempt troubleshooting. If troubleshooting fails, then the entire Node-S is replaced. As there is no time frame requirement for the user given in the maintenance procedure, the instrument meets the criterion of a greater than or equal to 2 weeks maintenance interval.

11. Conclusions

The Clarity Node-S Sensor Systems pass all the criteria set out in the Performance Standard for indicative instruments Version 2.4.1.01 for collecting PM_{10} and $PM_{2.5}$ data when operated with algorithm version 1.04408.

All users must slope correct PM_{10} data by dividing by 1.681. All users must slope correct $PM_{2.5}$ data by dividing by 1.998. Alternatively, site specific calibration can be applied using the Clarity recommended procedure. Clarity recommends that co-location is carried out prior to each sensor being deployed for a minimum of 30 days. If more than 3 sensor systems are being deployed in the region, then collocation needs to be done with a minimum of 3 sensor systems (triplicate) and then any resulting calibration factor should be remotely applied to all other sensors in the network. Use of the systems without any calibration factor would not be covered by the certification process.