# PRODUCT CONFORMITY CERTIFICATE

This is to certify that the

***1. SWAM 5a 24 hour Dual Channel Monitor with both $PM_{10}$ and $PM_{2.5}$ pre-separators;***
***2. SWAM 5a 24 hour Single Channel Monitor with $PM_{10}$ pre-separator;***
***3. SWAM 5a 24 hour Single Channel Monitor with $PM_{2.5}$ pre-separator;***
***4. SWAM 5a 1 hour Dual Channel Monitor with both $PM_{10}$ and $PM_{2.5}$ pre-separators.***

manufactured by:

***FAI Instruments s.r.l.***
*Via Aurora,*
*15 - 00013 FONTE NUOVA,*
*Rome,*
*Italy*

has been assessed by Sira Certification Service
And for the conditions stated on this certificate complies with:

**MCERTS Performance Standards for Continuous Ambient Air Quality Monitoring Systems, Version 10 dated June 2016**
**MCERTS for UK Particulate Matter as set out in the 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, Version 1.1, dated 31 July 2012**

Certification ranges :

| | |
|---|---|
| $PM_{2.5}$ | 0 to 200 µg/m$^3$ |
| $PM_{10}$ | 0 to 200 µg/m$^3$ |

| | |
|---|---|
| Project number: | 16A30897/80054618 |
| Certificate number: | Sira MC150272/03 |
| Initial certification: | 27 February 2015 |
| This certificate issued: | 25 September 2020 |
| Renewal date: | 26 February 2025 |

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MCERTS is operated on behalf of the Environment Agency by

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UKAS PRODUCT CERTIFICATION 0011





Form 1335
Issue 9

## Certificate contents



## Approved site application

*Any potential user should ensure, in consultation with the manufacturer, that the monitoring system is suitable for the intended application. For general guidance on monitoring techniques refer to the Environment Agency technical guidance on monitoring, available at www.mcerts.net*

The field tests were conducted at one site in the UK, and five sites in Germany. The particulate loading at the test sites is representative of different types of areas including urban background, roadside, industrial and areas with a strong rural influence. The testing took place in both winter and summer months.

On the basis of these tests this certificate is valid when the instrument is used for urban, industrial and rural air quality monitoring and similar applications.

The requirements according to the Guide To The Demonstration Of Equivalence Of Ambient Air Monitoring Methods (GDE 2010) are fulfilled for $PM_{10}$ and for $PM_{2.5}$.

## Basis of certification

This certification is based on the following Test Report(s) and on Sira's assessment and ongoing surveillance of the product and the manufacturing process:

| | |
|---|---|
| MCERTS certification committee report | Certification Report and Checklist on the Evaluation of the Ambient Air Particulate Matter Monitor Test Reports for the FAI SWAM 5a 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, MCERTSPMT5SWAMPM10&PM2.5301214/V1, dated February 2015. |
| Bureau Veritas | UK Report on the Equivalence of the FAI SWAM 5a series of Instruments for $PM_{10}$ and $PM_{2.5}$.<br>Report ref AGGX8312756/BV/DH/2922 dated December 23 2014. |
| TÜV Rheinland | Report on suitability testing of the ambient air quality measurement system SWAM 5a Dual Channel Monitor with $PM_{10}$ and $PM_{2.5}$ pre-separators of the company FAI Instruments s.r.l. for the components of suspended particulate matter $PM_{10}$ and $PM_{2.5}$.<br>TÜV-Report: 936/21207522/A dated March 23, 2009.<br>Report published on www.qal1.de/en/hersteller/fai.htm |

Certificate number : Sira MC150272/03
This certificate issued : 25 September 2020

| | |
|---|---|
| TÜV Rheinland | Report on the qualification of the 1-hour sampling version of SWAM 5a Dual-Channel Monitor for $PM_{10}$ and $PM_{2.5}$ of the company FAI Instruments s. r. l. as a type-approved continuous ambient air monitor.<br>TÜV-Report: 936/21215783/A dated February 7, 2012 |
| TÜV Rheinland | Report on the qualification of the SWAM 5a Monitor for either $PM_{10}$ or $PM_{2.5}$ of the company FAI Instruments s. r. l. as a type-approved continuous ambient air monitor,<br>TÜV-Report: 936/21217516/A dated February 7, 2012 |

**Product certified**

Four different instruments are certified:

1. SWAM 5a 24 hour Dual Channel Monitor with both $PM_{10}$ and $PM_{2.5}$ pre-separators (herein referred to as SWAM 5a DC 24 Hour). Tested at four sites in Germany and one in the UK;
2. SWAM 5a 24 hour Single Channel Monitor with $PM_{10}$ pre-separator (herein referred to as $PM_{10}$ SWAM 5a 24 Hour). Tested at one site in Germany;
3. SWAM 5a 24 hour Single Channel Monitor with $PM_{2.5}$ pre-separator (herein referred to as $PM_{2.5}$ SWAM 5a 24 Hour). Tested at one site in Germany;
4. SWAM 5a 1 hour Dual Channel Monitor with both $PM_{10}$ and $PM_{2.5}$ pre-separators (herein referred to as SWAM 5a DC Hourly). Tested at one site in Germany;

Components of these instruments are:

- A $PM_{10}$ inlet produced to the design specified in the former CEN $PM_{10}$ standard EN12341:1998 (Instruments 1, 2 and 4 in the above list only).
- A $PM_{2.5}$ inlet produced to the design specified both in the former CEN $PM_{2.5}$ standard EN 14907 and the current CEN $PM_{10}$ and $PM_{2.5}$ standard EN12341:2014 (Instruments 1, 3 and 4 in the above list only).
- 47 mm Glass Fibre GF10 Filters manufactured by Whatman.
- Spot size spot area of 5.2 cm² for 24 hour measurements. Spot size spot area of 2.27 cm² for hourly measurements.

The operation of instruments in permutations other than the above are not covered by this report, and are not recommended for approval without further consideration by the UK certification committee for the implications of any variations.

## Certified performance

**Ambient temperature range:** **5ºC to 40ºC**

The SWAM 5a DC 24 Hour was operated in a total of six field tests. In all six of these tests, the candidate method was operated with an inlet corresponding to the design specified in EN12341:1998. In five of these tests, the reference method was operated with a $PM_{10}$ inlet corresponding to the design in EN12341:2014. At the field test located in Bruehl, the reference method was operated with a $PM_{10}$ inlet corresponding to the design in EN12341:1998. The differences between these inlets are considered in detail in this report. It is the opinion of the UK certification committee that the primary evidence should consist of only the five sites where the reference method was operated with a $PM_{10}$ inlet corresponding to the design in EN12341:2014, and as such, it is these data that are summarised in Table 1 and Table 2 below. Table 3 and Table 4 relate to the $PM_{10}$ and $PM_{2.5}$ SWAM 5a 24 Hour. Table 5 and Table 6 relate to the SWAM 5a DC Hourly.

### SWAM 5a DC 24 Hour:

*Table 1: Summary of the test results for the SWAM 5a DC 24 Hour. The data in this table relate to the instrument without correction for slope and/or intercept.*

| Test | Results | MCERTS Specification |
|---|---|---|
| Constancy of the sample volumetric flow | -2.8%<br>(SN131 at Cologne 2011) | To remain constant within ± 3% of the rated value |
| Tightness of the sampling system | 0.3%<br>(SN131 during Lab Test) | Leakage not to exceed 1% of the sampled volume |
| Maintenance Interval | Two Weeks | ≥Two weeks |
| Data Availability | 93.0% | ≥90% |
| Number of UK Tests | 1 | ≥1 |
| Number of Reference Methods | 2 | ≥1 |

*Table 1* Continued. *Summary of the test results for the SWAM 5a DC 24 Hour. The data in this table relate to the instrument without correction for slope and/or intercept.*

| | | |
|---|---|---|
| Between sampler/instrument uncertainty for the standard method **$PM_{10}$** | | |
| Full data set | 0.75 µg/m$^3$ | ≤2 µg/m$^3$ |
| <30 µg/m$^3$ | 0.74 µg/m$^3$ | Not specified |
| ≥30 µg/m$^3$ | 0.78 µg/m$^3$ | Not specified |
| Between sampler/instrument uncertainty for the candidate method **$PM_{10}$** | | |
| Full data set | 0.68 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| <30 µg/m$^3$ | 0.44 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| ≥30 µg/m$^3$ | 1.24 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN127** | | |
| Full data set | 16.4% | ≤25% |
| <30 µg/m$^3$ | 12.0% | Not specified |
| ≥30 µg/m$^3$ | 20.3% | ≤25% (Only required when ≥ 40 data pairs) |
| Individual sites | | |
| Cologne 2007 | 24.6% | ≤25% |
| Bonn | 22.6% | ≤25% |
| Cologne 2011 | 9.6% | ≤25% |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN131** | | |
| Full data set | 13.0% | ≤25% |
| <30 µg/m$^3$ | 10.8% | Not specified |
| ≥30 µg/m$^3$ | 17.4% | ≤25% (Only required when ≥ 40 data pairs) |
| Individual sites | | |
| Cologne 2007 | 17.2% | ≤25% |
| Bonn | 19.8% | ≤25% |
| Cologne 2011 | 11.0% | ≤25% |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN145** | | |
| Full data set (Teddington) | 5.8% | ≤25% |
| <30 µg/m$^3$ | 8.5% | Not specified |
| ≥30 µg/m$^3$ | 32.4% (Only 4 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN149** | | |
| Full data set (Teddington) | 6.2% | ≤25% |
| <30 µg/m$^3$ | 7.4% | Not specified |
| ≥30 µg/m$^3$ | 32.0% (Only 4 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN248** | | |
| Full data set (Bornheim) | 9.1% | ≤25% |
| <30 µg/m$^3$ | 11.1% | Not specified |
| ≥30 µg/m$^3$ | Only 2 data pairs | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN249** | | |
| Full data set (Bornheim) | 8.9% | ≤25% |
| <30 µg/m$^3$ | 10.3% | Not specified |
| ≥30 µg/m$^3$ | Only 2 data pairs | ≤25% (Only required when ≥ 40 data pairs) |

*Table 1* Continued. *Summary of the test results for the SWAM 5a DC 24 Hour. The data in this table relate to the instrument without correction for slope and/or intercept.*

| | | |
|---|---|---|
| Between sampler/instrument uncertainty for the standard method **$PM_{2.5}$** | | |
| Full data set | 0.53 µg/m³ | ≤2 µg/m³ |
| <18 µg/m³ | 0.49 µg/m³ | Not specified |
| ≥18 µg/m³ | 0.60 µg/m³ | Not specified |
| Between sampler/instrument uncertainty for the candidate method **$PM_{2.5}$** | | |
| Full data set | 0.72 µg/m³ | ≤2.5 µg/m³ |
| <18 µg/m³ | 0.43 µg/m³ | ≤2.5 µg/m³ |
| ≥18 µg/m³ | 0.78 µg/m³ | ≤2.5 µg/m³ |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN127** | | |
| Full data set | 12.3% | ≤25% |
| <18 µg/m³ | 9.9% | Not specified |
| ≥18 µg/m³ | 15.8% | ≤25% (Only required when ≥ 40 data pairs) |
| Individual sites | | |
| Cologne 2007 | 6.6% | ≤25% |
| Bonn | 11.5% | ≤25% |
| Cologne 2011 | 15.9% | ≤25% |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN131** | | |
| Full data set | 14.2% | ≤25% |
| <18 µg/m³ | 12.1% | Not specified |
| ≥18 µg/m³ | 17.3% | ≤25% (Only required when ≥ 40 data pairs) |
| Individual sites | | |
| Cologne 2007 | 9.2% | ≤25% |
| Bonn | 12.1% | ≤25% |
| Cologne 2011 | 18.4% | ≤25% |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN145** | | |
| Full data set (Teddington) | 10.0% | ≤25% |
| <18 µg/m³ | 8.0% | Not specified |
| ≥18 µg/m³ | 26.4% (Only 12 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN149** | | |
| Full data set (Teddington) | 9.4% | ≤25% |
| <18 µg/m³ | 8.3% | Not specified |
| ≥18 µg/m³ | 18.7% (Only 12 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN248** | | |
| Full data set (Bornheim) | 15.2% | ≤25% |
| <18 µg/m³ | 24.8% | Not specified |
| ≥18 µg/m³ | 23.8% (Only 4 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN249** | | |
| Full data set (Bornheim) | 16.4% | ≤25% |
| <18 µg/m³ | 27.0% | Not specified |
| ≥18 µg/m³ | 19.8% (Only 4 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |

Certificate number : Sira MC150272/03
This certificate issued : 25 September 2020

Note 1: While some of the critical expanded uncertainties were greater than 25%, GDE 2010 makes an allowance that the greater than and equal to 18 µg/m³ or 30 µg/m³ subsets are only required to fulfil the 25 % criterion if there are at least 40 data pairs. As not all of expanded uncertainties were below 25 %, and some of the slopes and intercepts were statistically significant, it was necessary to test correction for slope, intercept, and both slope and intercept. The results are shown in Table 2 below. It is shown that there is no significant reduction in the range of critical expanded uncertainties, **and it is therefore not required to correct the SWAM 5a DC 24 Hour for slope, intercept, or both slope and intercept**. The CM fulfils the relevant Data Quality Objective of EU Directive 2008/50/EC when used without correction, It is essential that thorough and frequent on-going QA/QC procedures are employed (as prescribed in EN12341:2014 and CEN/TS16450:2013) including to precisely quantify analyser baseline performance.

*Table 2: Summary of the slope, intercept and expanded uncertainties with and without slope and/or intercept correction for the SWAM 5a DC 24 Hour.*

| **$PM_{10}$ SWAM 5a DC 24 Hour** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m³)** | **Expanded uncertainty of all paired data** | **Range of individual expanded uncertainties** |
|---|---|---|---|---|
| Uncorrected data | 1.049 | 0.020 | 13.4% | 5.8% to 24.6 % (For datasets with at least 40 data pairs) |
| Data corrected for slope by dividing by 1.049 | 0.999 | 0.035 | 8.7% | 7.7% to 15.2 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.020 | 1.049 | 0.000 | 13.4% | 5.9% to 24.5 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.020 and then dividing by 1.049 | 0.999 | 0.016 | 8.8% | 7.8% to 15.3 % (For datasets with at least 40 data pairs) |
| **$PM_{2.5}$ SWAM 5a DC 24 Hour** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m³)** | **Expanded uncertainty of all paired data** | **Range of individual expanded uncertainties** |
| Uncorrected data | 0.970 | 0.586 | 11.7% | 6.6% to 18.4 % (For datasets with at least 40 data pairs) |
| Data corrected for slope by dividing by 0.970 | 1.001 | 0.597 | 12.8% | 6.6% to 21.2 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.586 | 0.970 | 0.000 | 13.1% | 8.6% to 19.2 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.586 and then dividing by 0.970 | 1.001 | -0.008 | 12.2% | 7.2% to 19.2 % (For datasets with at least 40 data pairs) |

Note 2: Due to discontinuation of the microcontrollers by the manufacturers in 2008, FAI was forced to change the microcontrollers used in the SWAM 5a DC 24 Hour. For instruments equipped with the old microcontrollers, the earliest approved Firmware version is 04-08.01.65-30.02.00, and the most recent approved version is 04-09.01.85-30.02.00. For instruments equipped with the new microcontrollers, the earliest approved Firmware version is 04-08.01.65-30.03.00, and the most recent approved version is 04-09.01.85-30.03.00. It is recommended that operators install the latest approved versions of the Firmware approved for the instrument. Future versions could be accepted if they are approved comprehensively during the annual audit of the manufacturing facility.

Note 3: A comprehensive set of laboratory tests were undertaken by TÜV Rheinland and are discussed in the TÜV Rheinland report. It is not necessary to review the results of these tests under the MCERTS for UK Particulate Matter certification scheme.

**$PM_{10}$ and $PM_{2.5}$ SWAM 5a 24 Hour:**

*Table 3: Summary of the test results for the $PM_{10}$ and $PM_{2.5}$ SWAM 5a 24 Hour. The data in this table relate to the instrument without correction for slope and/or intercept.*

| Test | Results | MCERTS Specification |
|---|---|---|
| Constancy of the sample volumetric flow | Not Tested | Requirement to test waived as instrument is a variation on a theme of the SWAM 5a DC 24 Hr. |
| Tightness of the sampling system | Not Tested | Requirement to test waived as instrument is a variation on a theme of the SWAM 5a DC 24 Hr. |
| Maintenance Interval | Two Weeks | ≥Two weeks |
| Data Availability | 100% ($PM_{10}$) 94.6% ($PM_{2.5}$) | ≥90% |
| Number of UK Tests | 0 | ≥1 Criterion waived as instrument is a variation on a theme of the SWAM 5a DC 24 Hr. |
| Number of Reference Methods | 2 | ≥1 |
| Between sampler/instrument uncertainty for the standard method **$PM_{10}$** | | |
| Full data set | 0.63 µg/m$^3$ | ≤2 µg/m$^3$ |
| <30 µg/m$^3$ | 0.63 µg/m$^3$ | Not specified |
| ≥30 µg/m$^3$ | 0.74 µg/m$^3$ | Not specified |
| Between sampler/instrument uncertainty for the candidate method **$PM_{10}$** | | |
| Full data set | 0.63 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| <30 µg/m$^3$ | 0.60 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| ≥30 µg/m$^3$ | 1.22 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN329** | | |
| Full data set (Bornheim) | 8.1% | ≤25% |
| <30 µg/m$^3$ | 8.1% | Not specified |
| ≥30 µg/m$^3$ | Only 2 data pairs | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 50 µg/m$^3$ for **Instrument SN330** | | |
| Full data set (Bornheim) | 7.9% | ≤25% |
| <30 µg/m$^3$ | 8.3% | Not specified |
| ≥30 µg/m$^3$ | Only 2 data pairs | ≤25% (Only required when ≥ 40 data pairs) |
| Between sampler/instrument uncertainty for the standard method **$PM_{2.5}$** | | |
| Full data set | 0.65 µg/m$^3$ | ≤2 µg/m$^3$ |
| <18 µg/m$^3$ | 0.65 µg/m$^3$ | Not specified |
| ≥18 µg/m$^3$ | 0.55 µg/m$^3$ | Not specified |
| Between sampler/instrument uncertainty for the candidate method **$PM_{2.5}$** | | |
| Full data set | 0.56 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| <18 µg/m$^3$ | 0.46 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| ≥18 µg/m$^3$ | 1.51 µg/m$^3$ | ≤2.5 µg/m$^3$ |
| Expanded uncertainty calculated at 30 µg/m$^3$ for **Instrument SN331** | | |
| Full data set (Bornheim) | 8.5% | ≤25% |
| <18 µg/m$^3$ | 9.3% | Not specified |
| ≥18 µg/m$^3$ | 5.3% (Only 3 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 30 µg/m$^3$ for **Instrument SN333** | | |
| Full data set (Bornheim) | 13.3% | ≤25% |
| <18 µg/m$^3$ | 22.1% | Not specified |
| ≥18 µg/m$^3$ | 225.8% (Only 4 data pairs) | ≤25% (Only required when ≥ 40 data pairs) |

Certificate number : Sira MC150272/03
This certificate issued : 25 September 2020

Note 4: While some of the critical expanded uncertainties were greater than 25%, GDE 2010 makes an allowance that the greater than and equal to 18 µg/m³ or 30 µg/m³ subsets are only required to fulfil the 25 % criterion if there are at least 40 data pairs. As not all of expanded uncertainties were below 25 %, and some of the slopes and intercepts were statistically significant, it was necessary to test correction for slope, intercept, and both slope and intercept. The results are shown in Table 4 below. It is shown that there is no significant reduction in the range of critical expanded uncertainties, **and it is therefore not required to correct the $PM_{10}$ and $PM_{2.5}$ SWAM 5a 24 Hour for slope, intercept, or both slope and intercept**. The CM fulfils the relevant Data Quality Objective of EU Directive 2008/50/EC when used without correction, It is essential that thorough and frequent on-going QA/QC procedures are employed (as prescribed in EN12341:2014 and CEN/TS16450:2013) including to precisely quantify analyser baseline performance.

*Table 4: Summary of the slope, intercept and expanded uncertainties with and without slope and/or intercept correction for the $PM_{10}$ and $PM_{2.5}$ SWAM 5a 24 Hour.*

| **$PM_{10}$ SWAM 5a 24 Hour** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m³)** | **Expanded uncertainty of all paired data** | **Range of individual expanded uncertainties** |
|---|---|---|---|---|
| Uncorrected data | 1.007 | -0.900 | 7.8% | 7.9% to 8.1% |
| Data corrected for slope by dividing by 1.007 | 1.000 | -0.889 | 10.9% | 10.9% to 11.1% |
| Data corrected for intercept by adding 0.900 | 1.007 | 0.000 | 8.1% | 8.3% to 8.3% |
| Data corrected for intercept by adding 0.900 and then dividing by 1.007 | 1.000 | 0.004 | 10.6% | 10.7% to 10.8% |
| **$PM_{2.5}$ SWAM 5a 24 Hour** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m³)** | **Expanded uncertainty of all paired data** | **Range of individual expanded uncertainties** |
| Uncorrected data | 0.971 | 0.235 | 9.5% | 5.3% to 13.3 % (For datasets with at least 40 data pairs) |
| Data corrected for slope by dividing by 0.971 | 1.001 | 0.232 | 12.2% | 11.6% to 19.3 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.235 | 0.971 | 0.000 | 10.8% | 5.7% to 13.0 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.235 and then dividing by 0.971 | 1.001 | -0.010 | 12.4% | 11.8% to 18.6 % (For datasets with at least 40 data pairs) |

Note 5: The earliest approved Firmware version is 01-05.04.04-30.03.00, and the most recent approved version is 01-05.05.13-30.03.00. It is recommended that operators install the latest approved versions of the Firmware approved for the instrument. Future versions could be accepted if they are approved comprehensively during the annual audit of the manufacturing facility.

**SWAM 5a DC Hourly:**

*Table 5: Summary of the test results for the $PM_{10}$ and $PM_{2.5}$ SWAM 5a DC Hourly. The data in this table relate to the instrument without correction for slope and/or intercept.*

| Test | Results | MCERTS Specification |
|---|---|---|
| Constancy of the sample volumetric flow | Not Tested | Requirement to test waived as instrument is a variation on a theme of the SWAM 5a DC 24 Hr. |
| Tightness of the sampling system | Not Tested | Requirement to test waived as instrument is a variation on a theme of the SWAM 5a DC 24 Hr. |
| Maintenance Interval | Two Weeks | ≥Two weeks |
| Data Availability | 96.4% | ≥90% |
| Number of UK Tests | 0 | ≥1 Criterion waived as instrument is a variation on a theme of the SWAM 5a DC 24 Hr. |
| Number of Reference Methods | 2 | ≥1 |
| Between sampler/instrument uncertainty for the standard method **$PM_{10}$** | | |
| Full data set | 0.59 µg/m³ | ≤2 µg/m³ |
| <30 µg/m³ | 0.62 µg/m³ | Not specified |
| ≥30 µg/m³ | 0.57 µg/m³ | Not specified |
| Between sampler/instrument uncertainty for the candidate method **$PM_{10}$** | | |
| Full data set | 0.73 µg/m³ | ≤2.5 µg/m³ |
| <30 µg/m³ | 0.54 µg/m³ | ≤2.5 µg/m³ |
| ≥30 µg/m³ | 0.88 µg/m³ | ≤2.5 µg/m³ |
| Expanded uncertainty calculated at 50 µg/m³ for **Instrument SN111** | | |
| Full data set (Cologne 2011) | 8.8% | ≤25% |
| <30 µg/m³ | 12.7% | Not specified |
| ≥30 µg/m³ | 9.3% | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 50 µg/m³ for **Instrument SN112** | | |
| Full data set (Cologne 2011) | 10.4% | ≤25% |
| <30 µg/m³ | 11.5% | Not specified |
| ≥30 µg/m³ | 10.9% | ≤25% (Only required when ≥ 40 data pairs) |
| Between sampler/instrument uncertainty for the standard method **$PM_{2.5}$** | | |
| Full data set | 0.52 µg/m³ | ≤2 µg/m³ |
| <18 µg/m³ | 0.45 µg/m³ | Not specified |
| ≥18 µg/m³ | 0.58 µg/m³ | Not specified |
| Between sampler/instrument uncertainty for the candidate method **$PM_{2.5}$** | | |
| Full data set | 0.74 µg/m³ | ≤2.5 µg/m³ |
| <18 µg/m³ | 0.49 µg/m³ | ≤2.5 µg/m³ |
| ≥18 µg/m³ | 0.80 µg/m³ | ≤2.5 µg/m³ |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN111** | | |
| Full data set (Cologne 2011) | 12.0% | ≤25% |
| <18 µg/m³ | 40.2% | Not specified |
| ≥18 µg/m³ | 12.0% | ≤25% (Only required when ≥ 40 data pairs) |
| Expanded uncertainty calculated at 30 µg/m³ for **Instrument SN112** | | |
| Full data set (Cologne 2011) | 11.3% | ≤25% |
| <18 µg/m³ | 32.3% | Not specified |
| ≥18 µg/m³ | 12.5% | ≤25% (Only required when ≥ 40 data pairs) |

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Note 6: While some of the critical expanded uncertainties were greater than 25%, GDE 2010 makes an allowance that the greater than and equal to 18 µg/m³ or 30 µg/m³ subsets are only required to fulfil the 25 % criterion if there are at least 40 data pairs. As not all of expanded uncertainties were below 25 %, and some of the slopes and intercepts were statistically significant, it was necessary to test correction for slope, intercept, and both slope and intercept. The results are shown in Table 6 below. It is shown that there is no significant reduction in the range of critical expanded uncertainties, **and it is therefore not required to correct the SWAM 5a 24 Hour for slope, intercept, or both slope and intercept**. The CM fulfils the relevant Data Quality Objective of EU Directive 2008/50/EC when used without correction, It is essential that thorough and frequent on-going QA/QC procedures are employed (as prescribed in EN12341:2014 and CEN/TS16450:2013) including to precisely quantify analyser baseline performance.

*Table 6: Summary of the slope, intercept and expanded uncertainties with and without slope and/or intercept correction for the $PM_{10}$ and $PM_{2.5}$ SWAM 5a DC Hourly.*

| **$PM_{10}$ SWAM 5a DC Hourly** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m³)** | **Expanded uncertainty of all paired data** | **Range of individual expanded uncertainties** |
|---|---|---|---|---|
| Uncorrected data | 0.972 | -0.305 | 9.3% | 8.8% to 10.4 % (For datasets with at least 40 data pairs) |
| Data corrected for slope by dividing by 0.972 | 1.000 | -0.321 | 7.4% | 7.7% to 8.9 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by adding 0.305 | 0.972 | 0.000 | 8.8% | 8.6% to 9.7 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by adding 0.305 and then dividing by 0.972 | 1.000 | -0.007 | 7.7% | 7.7% to 9.5 % (For datasets with at least 40 data pairs) |
| **$PM_{2.5}$ SWAM 5a DC Hourly** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m³)** | **Expanded uncertainty of all paired data** | **Range of individual expanded uncertainties** |
| Uncorrected data | 0.998 | 0.686 | 10.4% | 11.3% to 12.0 % (For datasets with at least 40 data pairs) |
| Data corrected for slope by dividing by 0.998 | 1.000 | 0.687 | 11.0% | 11.9% to 12.6 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.686 | 0.998 | 0.000 | 9.9% | 10.8% to 11.1 % (For datasets with at least 40 data pairs) |
| Data corrected for intercept by subtracting 0.686 and then dividing by 0.998 | 1.000 | 0.000 | 10.4% | 11.3% to 11.6 % (For datasets with at least 40 data pairs) |

Note 7: The earliest approved Firmware version is 05-01.07.14-30.03.00, and the most recent approved version is 05-02.08.56-30.03.00. It is recommended that operators install the latest

approved versions of the Firmware approved for the instrument. Future versions could be accepted if they are approved comprehensively during the annual audit of the manufacturing facility.

**General Requirements:**

Note 8: A study of pollution climate relevant to sites in the UK and Germany has demonstrated that in all cases the particulate geometric mean criteria are met. For the SWAM 5a DC 24 Hour, at least one site meets the lower threshold and higher threshold criterion for wind speed, ambient temperature, ambient dew point and semi volatile nitrate content. As the other SWAM 5a variants are considered a variation on a theme of the SWAM 5a DC 24 Hour, they were tested at only one field site each, and the requirement to meet the wind speed, ambient temperature, ambient dew point, and semi volatile nitrate content criteria cannot be tested. The pollution climate criteria are satisfied for all the equivalence tests.

Note 9: The field test sites utilised cover urban background, industrial and traffic locations. The data from the industrial location indicate that the choice of $PM_{10}$ head design is critical for sites with a high proportion of particles close to 10 micrometres in diameter. No data were collected for rural sites, though Bornheim is in a rural location with a Motorway influence. At many of the sites there are low concentrations and the instrument performs well. It is not expected that there will be a high PM coarse fraction at rural sites. As such, there are no problems anticipated with operating the SWAM 5a series of instruments in rural locations.
We propose, therefore, that this instrument is suitable for use at urban background (including suburban), rural, industrial and traffic locations within the UK. The SWAM 5a is supplied with a $PM_{10}$ head that corresponds to the design published in EN12341:1998. The Reference Method is most typically supplied with a head that corresponds to the design published in EN12341:2014; though within the 2014 standard, allowance is made for the use of the 1998 head design, so long as this is accounted for in the uncertainty budget. Extensive testing by CEN Technical Committee 264 Working Group 15 has shown that the difference between the two head designs has minimal impact upon measured concentrations; however, in areas with a very high coarse PM fraction (such as certain industrial sites), the SWAM 5a instrument with 1998 design heads may display higher $PM_{10}$ levels than the reference method operated with 2014 design heads. $PM_{2.5}$ is unaffected by the difference in $PM_{10}$ head design.

## Description

The SWAM 5a series of instruments determine the mass of separated particles based on the principle of beta attenuation. The relation between the attenuation of beta radiation after passing a layer of thin material and the mass thickness of the material can be described with the help of an equation.

The estimation of the mass thickness xp of a particulate matter film accumulated on a filter medium with xf mass thickness using the beta attenuation method is based on the correct quantification of the relative variation sustained by a flux of beta electrons achieving an appropriate detector, this film being present or absent.

Highly simplified, the following relation is given: $m_p=S*x_p$ with:

$$x_p = k(z) \cdot \ln \frac{Flux_{blank}}{Flux_{collect}}$$

Where:

| | |
|---|---|
| $m_p$ | mass of the dust particles |
| S | loaded surface |
| $X_p$ | mass thickness of the dust particles |
| k(z) | mass absorption coefficient function |
| $Flux_{blank}$ | beta radiation flux before sampling |
| $Flux_{collect}$ | beta radiation flux after sampling |

The measured beta radiation fluxes may include systematic fluctuations which cannot be attributed to the particulate mass on the filter. Those contributions to uncertainty primarily result from:

- Mass thickness changes of the filter medium (e.g. humidity effects)
- Air density fluctuations
- Detector sensitivity variations
-

In order to quantify and consider these influences for calculation the system is equipped with so-called spy-filters, which consist of the same material as the operative filters and which constantly remain in the system. The spy filters are measured in turns with the operative filters. Hence, possible influences as mentioned above can be considered on the basis of the beta fluxes obtained during spy filter measurement.
This results in the equation

$$m_P = S \cdot x_p = S \cdot \bar{k}(z) \cdot Z_{r1}^{*} \cong S \cdot k_{sh} \cdot \left[ \bar{k}(z) \cdot \ln \left( \frac{\bar{\Phi}^i(x_{Fr})}{\bar{\Phi}^j(x_{Fr}+x_p)} \frac{\bar{\Phi}^j(x_{Fs})}{\bar{\Phi}^i(x_{Fs})} \right) + offset \right],$$

where p = particles; $F_r$ = operative filters; $F_s$ = spy filters; $x_{Fr}$ = blank; and $x_{Fr}+X_p$ = collect. In the ideal conditions the parameter $k_{sh}$ assumes a value 1. From the gained experience on the mass measurement performance, a better value for this parameter has been estimated to be 1.04 to 1.06. A value of $k_{sh}$ = 1.05 is used as standard setting in the FAI standard factory calibration procedure. An offset of zero is also applied to all instruments.

Function k(z) is determined by the manufacturer with the help of six reference aluminium foils and programmed to the system. This calibration can be verified after each system restart (or else triggered manually) with the help of two reference aluminium foils of known mass thickness which are integrated in the system. The obtained results are compared with the respective default values and indicated as deviations in %. The result of the latest “beta span test” can be accessed at any time.

**General notes**

1. This certificate is based upon the equipment tested. The manufacturer is responsible for ensuring that on-going production complies with the standard(s) and performance criteria defined in this certificate. The manufacturer is required to maintain an approved quality management system controlling the manufacture of the certified product. Both the product and the quality management system shall be subject to regular surveillance according to 'Regulations applicable to the holders of Sira certificates'.

2. The design of the product certified is held and maintained by TUV Rheinland for certificate No. Sira MC150272.

3. If a certified product is found not to comply, Sira should be notified immediately at the address shown on this certificate.

4. The certification marks that can be applied to the product or used in publicity material are defined in 'Regulations applicable to the holders of Sira certificates'.

5. This document remains the property of Sira and shall be returned if requested by Sira.