Australian Standard®

AS 3580.9.10:2017

Methods for sampling and analysis of ambient air

Method 9.10: Determination of suspended particulate matter—$PM_{2.5}$ low volume sampler—Gravimetric method

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EV-007, Methods for Examination of Air, to supersede AS/NZS 3580.9.10:2006.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to provide regulatory and testing bodies with a standard method for determining suspended particulate matter with an equivalent aerodynamic diameter of less than 2.5 µm utilizing a low volume sampler and size selective inlet.

This Standard deals with the determination of suspended particulate matter with an equivalent aerodynamic diameter (EAD) of less than approximately 2.5 m ($PM_{2.5}$). This is one in a series of Standards for the determination of particulate matter in ambient air.

The procedure described in this Standard involves batch sampling and the gravimetric determination of $PM_{2.5}$, and is based on the United States Code of Federal Regulations, Title 40, Chapter 1, Part 50 Appendix L, Reference method for the determination of fine particulate matter as $PM_{2.5}$ in the atmosphere.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

FOREWORD

Suspended particulate matter measured by this method includes particles with an equivalent aerodynamic diameter (EAD) of less than 2.5 µm, as passed by a size selective inlet ($PM_{2.5}$). $PM_{2.5}$ has been statistically associated with certain human health end points, including daily mortality, hospital admissions and exacerbation of asthma. $PM_{2.5}$ emission sources include industrial processes, fuel combustion, burning of vegetation, incineration and natural causes such as wind blown dust and salt laden air. Combustion processes tend to contribute more $PM_{2.5}$ than non-combustion sources. Important anthropogenic sources include domestic wood heaters and motor vehicles (especially diesel fuelled vehicles).

METHOD

1 SCOPE

This Standard sets out a gravimetric method for determination of $PM_{2.5}$ in ambient air utilizing low volume sequential and non-sequential samplers equipped with size selective inlets. The method provides a measure of mean concentration of $PM_{2.5}$ in units of micrograms per cubic metre (µg/m^3), normally sampled over a 24 h period. This method may be used to collect particle samples for subsequent physical or chemical analysis.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS ISO/IEC
17025 General requirements for the competence of testing and calibration laboratories

AS/NZS
3580 Methods for sampling and analysis of ambient air
3580.1.1 Part 1.1: Guide to siting air monitoring equipment
3580.9.14 Part 9.14: Determination of suspended particulate matter—$PM_{2.5}$ high volume sampler with size selective inlet—Gravimetric method

3760 In-service safety inspection and testing of electrical equipment

ISO/IEC
Guide 98 Uncertainty of measurement
Guide 98-3 Part 3: Guide to the expression of uncertainty in measurement (GUM: 1995)

EN
12341 Ambient air—Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2.5}$ mass concentration of suspended particulate matter

ASTM
E563 Standard Practice for preparation and use of an ice point bath as a reference temperature

US EPA
US Code of Federal Regulations—Environmental Protection Agency 40 CFR, Chapter I, Part 50, Appendix L
US Code of Federal Regulations—Environment Protection Agency 40 CFR, Chapter I, Part 53

3 DEFINITIONS

For the purposes of this Standard the following definitions apply.

3.1 Equivalent aerodynamic diameter (EAD)

The diameter of a spherical particle of unit density (1 g/cm^3), which exhibits the same aerodynamic behaviour as the particle in question.

3.2 Field blank filter

A filter not used for sampling, which has been taken into the field. The filter is handled as a sample filter, including placing it in the sampler filter holder, and removing it, except the sampler is not in operation during this time. A field blank filter is used to assess the effect of field conditions, transport conditions and field operator technique on the weighing procedure.

3.3 Laboratory blank filter

A filter not used for sampling, which remains in the laboratory. A laboratory blank filter is used to assess the effect of laboratory conditions and balance operator technique on the weighing procedure.

3.4 Measurement uncertainty

A variable associated with the result of a measurement that characterizes the dispersion of the values that could be reasonably attributed to the measurand.

3.5 $PM_{2.5}$

Atmospheric suspended particulate matter having an EAD of less than approximately 2.5 µm, which is passed by a size selective inlet having performance characteristics as defined in United States Code of Federal Regulations: Title 40, Chapter I, Part 50, Appendix L, or equivalent.

NOTE: One of the performance characteristics is a 50% collection efficiency of particles of 2.5 ±0.2 µm EAD.

3.6 U_{95}

A measurement uncertainty at a confidence interval of 95% according to ISO/IEC Guide 98-3.

4 PRINCIPLE

Ambient air is drawn at a constant flow rate through a prepared filter via a $PM_{2.5}$ size-selective inlet. Size selective inlets designed for low volume air samplers require a specific volumetric flow rate usually between 3.0 and 16.7 L/min to achieve the correct aerodynamic particle size cut-point.

Each sample filter is weighed before and after sampling to determine the mass of the collected particles.

Sampling is normally of 24 h duration to average out the effect of diurnal variations in particle levels and to enable collection of sufficient mass of particulate matter. Provided that the mass of the filter is determined under carefully controlled laboratory conditions, mean concentrations of 5 $\mu g/m^3$ (3 L/min sample flow rate) or 1 $\mu g/m^3$ (16.7 L/min sample flow rate) and greater may be determined, based on a 24 h sampling period. It is possible that some particulate matter, depending upon its hygroscopicity or volatility may alter in mass from its initial as-sampled state because of the environmental conditions and filter equilibration procedure referred to in Clauses 7.1 and 7.4. The degree of mass change is largely due to the nature of sampled aerosol and may vary from day to day, site to site and seasonally.

The $PM_{2.5}$ concentration is determined by dividing the mass of collected particulate matter by the sample volume, which is calculated from the sample duration and either the average or totalized flow rate.

5 APPARATUS

5.1 $PM_{2.5}$ sampler

The $PM_{2.5}$ sampler shall consist of a $PM_{2.5}$ size-selective inlet fitted to a low volume sampler. The $PM_{2.5}$ sampler shall demonstrate a performance equivalent to a U.S. EPA reference $PM_{2.5}$ sampler, sited and tested under the conditions described in Appendix A. The manufacturer’s published performance specifications shall be deemed as acceptable evidence of conformance provided they have been carried out in accordance with Appendix A or U.S. EPA equivalency testing procedures described in the US Code of Federal Regulations 40 CFR, Part 53.

The $PM_{2.5}$ sampler shall consist of the following:

(a) Sample inlet (incorporating rain cap and insect screen).

(b) Sample tube.

(c) Size selective inlet (impaction plate(s), well impactor, sharp cut cyclone or very sharp cut cyclone).

The $PM_{2.5}$ size-selective inlet shall be a device designed to separate particles and permit only the $PM_{2.5}$ fraction to pass through to the filter. The $PM_{2.5}$ size-selective inlet shall be designed to collect particles of EAD 2.5 ±0.2 mm at a 50% efficiency, on a mass basis, at the designated low volume sampler volumetric flow rate.

(d) Filter holder.

(e) Low volume sampler (incorporating pump, flow rate control, flow rate measurement, timer and enclosure).

The sampler shall be designed such that the filter temperature does not exceed 5°C above ambient during pre-sampling, sampling and post-sampling periods.

5.2 Filters

The preferred filter is 37 mm or 47 mm diameter PTFE, with or without a support ring. The filter selected shall have a maximum pore size of 2 µm and a specified collection efficiency of at least 99.95% for particles of 0.3 µm EAD.

The filters shall be free from pinholes and other defects (see Clause 5.6).

NOTE: Where the collected sample is to be used for other determinant(s), the filter should be selected to ensure minimum interference to such determinant(s).

5.3 Microbalance

An analytical balance with a minimum resolution of 1 µg calibrated in accordance with Appendix B.

5.4 Static eliminator

An alpha particle source, e.g. Americium 241 of 4×10^5 Bq activity, or Polonium 210 of 2×10^7 Bq activity, or a high voltage static elimination unit, is required to neutralize any static charge on the filters prior to weighing. The alpha particle source shall be renewed when found to be ineffective (e.g. 1 to 2 years).

NOTE: A licence from the relevant radiation licensing authority may be required to operate and dispose of an alpha particle source.

5.5 Flow meter

A traceable transfer standard flow measuring device (e.g. electronic piston meter, electronic bubble meter or flow meter), with a U_{95} of ±2% at the sampler's operating flow rate, may be used for field applications. The transfer standard device shall be calibrated against a reference standard device on a two-yearly basis.

5.6 Light-table

A light-table to check filters for pinholes or other defects.

5.7 Temperature sensor

A temperature sensor with a U_{95} of ±0.5°C and a resolution of 0.1°C, calibrated in accordance with Appendix C.

5.8 Timing device

A stopwatch or other timing device, capable of measuring elapsed time (typically greater than or equal to a period of 15 seconds, with a U_{95} of ±1% and a resolution of 0.1 second. The timing device shall be checked against the recorded time signal, over a minimum period of one hour, initially and then at an interval not exceeding six months.

5.9 Barometer

A traceable barometer with a U_{95} of ±0.5 kPa calibrated in accordance with Appendix D.

5.10 Relative humidity and temperature measuring device

A device for measuring and recording the relative humidity (U_{95} of ±5%) and temperature (U_{95} of ±1°C) in the filter conditioning environment, at intervals not exceeding 15 minutes.

The relative humidity and temperature measuring device shall be checked initially, and then at an interval not exceeding six months, at one relative humidity point and one temperature point.

6 CALIBRATION

6.1 General requirements

Verification checks of the sampler's temperature and pressure measuring devices (if equipped) shall be conducted on an annual basis against transfer standard instruments (see Clauses 5.7 and 5.9). A full calibration of the temperature measuring device(s) shall be conducted if the verification check indicates a difference equal to or greater than 2°C. A full calibration of the pressure measuring device(s) shall be conducted if the verification check indicates a difference equal to or greater than 1.3 kPa.

Calibration of the sampler's flow control and measurement device is required (see Clause 5.5).

NOTE: Low volume air samplers use various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification and frequency of calibration will vary depending on the type of flow controller and flow indicator used. Calibration in terms of actual volumetric flow rate is generally recommended, but other measures of flow rate (e.g. mass flow controller) may be used providing the requirements in Clause 5.5 are met. Consult the manufacturer's operational manual for specific guidance on calibration.

6.2 Flow rate calibration

The procedure shall be as follows:

(a) Ensure that a clean filter has been installed.

(b) Perform a leak check.

NOTE: A leakage rate less than 1% of the sampler design flow rate, or 80 mL/min, whichever is the greater, at 75 cm water gauge, is acceptable.

(c) Select the design flow rate for the inlet according to the manufacturer's specifications.

(d) Connect the flow meter to the sample tube (an adaptor may be required).

(e) Accurately measure and record the sampler's flow rate through the filter.

NOTE: For a bubble meter, time the period for the bubble to sweep the calibrated volume, and calculate the flow rate. The volume of a manually timed bubble meter should be such that the measured time period is a minimum of 15 seconds.

(f) Record the ambient temperature and atmospheric pressure using the temperature sensor (see Clause 5.7) and barometer (see Clause 5.9).

