GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 19.120
A 28

GB/T 39193-2020

Ambient air - Determination of particulate matter mass concentration - Gravimetric method

环境空气 颗粒物质量浓度测定

重量法

Issued on: October 11, 2020 **Implemented on: May 01, 2021**

Issued by: State Administration for Market Regulation;

Standardization Administration of the PRC.

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1 Scope

This Standard specifies the method of filter membrane sampling and weighing for the determination of particulate matter in ambient air, including principle and method, instruments and equipment, sampling and weighing, calculation and presentation of results, uncertainty evaluation of measurement results, quality control and quality assurance.

This Standard applies to the use of filter membrane weighing method to measure the particulate matter mass concentration in ambient air.

2 Normative references

The following documents are indispensable for the application of this document. For the dated references, only the editions with the dates indicated are applicable to this document. For the undated references, the latest edition (including all the amendments) are applicable to this document.

GB/T 4883 Statistical interpretation of data - Detection and treatment of outliers in the normal sample

GB/T 8170 Rules of rounding off for numerical values and expression and judgement of limiting values

GB/T 26497 Electronic balance

JJF 1059.1 Evaluation and Expression of Uncertainty in Measurement

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

Particulate matter; PM

The particulate matter in ambient air.

Medium-flow flowmeter: Range is 50 L/min~800 L/min; maximum allowable error: ±2%;

Small-flow flowmeter: less than 50 L/min; maximum allowable error: ±2%.

5.4 Standard thermometer

It is used to measure the ambient temperature and calibrate the temperature measurement parts of the sampler and constant-temperature and -humidity equipment. The measurement range is -30 °C~50 °C. The maximum allowable error is ±0.5 °C.

5.5 Standard hygrometer

It is used to measure the ambient humidity and calibrate the humidity measurement parts of the constant-temperature and -humidity equipment. Measurement range: relative humidity 40%~60%; maximum allowable error: ±2%.

5.6 Standard barometer

It is used to measure the atmospheric pressure of the environment and calibrate the atmospheric pressure measurement parts of the sampler. Measurement range: 50 kPa~107 kPa; maximum allowable error: ±0.25 kPa.

5.7 Standard stopwatch

It is used to check the timing parts of the sampler. Division value: 0.01 s.

5.8 Electronic balance

It is used for filter membrane weighing. According to the sampling volume and filter membrane mass, an electronic balance with an appropriate weighing range and division value shall be selected. Generally, the sampling mass shall be greater than 100 times the division value of the electronic balance. The division value of the electronic balance shall not be greater than 0.01 mg. The technical performance shall meet the requirements of GB/T 26497.

The electronic balance shall be placed in an environment with the same temperature and humidity control conditions as the constant-temperature and -humidity equipment.

5.9 Constant-temperature and -humidity equipment

It is used to balance the temperature and humidity of the filter membrane before and after sampling. Temperature control range: 15 °C~30 °C; temperature fluctuation: ±1 °C. Relative humidity control range: relative humidity 45%~55%.

temperature indication error exceeds this range, the sampler shall be calibrated for temperature.

6.1.6 Sampler atmospheric pressure measurement check and calibration

The standard barometer shall be used regularly to check the atmospheric pressure indication error of the sampler. The maximum allowable error is ±1 kPa. If the indication error exceeds this range, pressure calibration shall be performed on the sampler.

6.1.7 Temperature and humidity control check of constant-temperature and -humidity equipment

Standard thermometers and standard hygrometers shall be used regularly, to check the temperature and humidity indication errors and the temperature and humidity fluctuation ranges of the constant-temperature and -humidity equipment, to ensure that the constant-temperature and -humidity conditions meet the requirements in 5.9.

6.1.8 Filter membrane check

The filter membrane shall have flat edges, uniform thickness, no burrs, no pollution on the surface, no pinholes or damage.

6.2 Filter membrane balance and weighing before sampling

PLACE the uniquely-identified filter membrane in a constant-temperature and -humidity equipment to balance for at least 24 h. RECORD the equilibrium temperature and humidity of the filter membrane. USE a balance to weigh the filter membrane and record the mass and number of the filter membrane.

After the first weighing, place it under the same equilibrium conditions for at least 1 h before weighing again. The difference between the two weighed masses of the same filter membrane shall not exceed ±40 μg (for medium-flow or small-flow samplers) or ±0.4 mg (for large-flow samplers). If it exceeds this range, the filter membrane is invalid. TAKE the average of the two weighing results as the mass of the filter membrane.

6.3 Sampling operation

In a clean environment, use tweezers to put the weighed filter membrane into the filter membrane holder. The rough surface of the filter membrane shall face the direction of air intake. PUT the filter membrane holder into the sampler; SET the parameters such as sampling time; START the sampler for sampling.

After sampling, put the filter membrane in a sealed, independent storage box;

8.3 Expanded uncertainty

The expanded uncertainty of the measurement result is calculated according to formula (3).

$$U = k \cdot u_c \quad \cdots\cdots\cdots\cdots\cdots\cdots (3)$$

Where:

U - The expanded uncertainty, in micrograms per cubic meter (μg/m^3);

k - Coverage factor, generally k=2;

u_c - The combined standard uncertainty, in micrograms per cubic meter (μg/m^3).

9 Quality control and quality assurance

9.1 Management of instruments and equipment

It shall establish an instrument and equipment management system. The instruments and equipment used in the operation shall be verified, calibrated and maintained in accordance with the specified cycle.

9.2 Sampling process quality control

The sampler shall be placed and installed in accordance with relevant regulations. Multiple samplers, installed at the same sampling point, shall meet the corresponding spacing requirements. The exhaust of the sampler shall not affect the measurement of the particulate matter mass concentration.

When installing and removing the filter membrane, it shall wear special laboratory gloves and use non-serrated tweezers.

In order to monitor the impact of operation processes such as filter membrane installation and transfer on the mass of the filter membrane, during the same batch of sampling, standard blank filter membranes shall be used for quality control. The standard blank filter membrane shall be balanced and weighed before sampling together with the filter membrane for sampling; transported to the sampling location; placed at the sampling location for the same time as the filter membrane for sampling; and transported back to the laboratory together for balance and weighing after sampling. The difference between the mass of the standard blank filter membrane before and after sampling shall be much smaller than the mass of particulate matter loaded on the filter membrane for sampling in the same batch. Otherwise, the sampling data of this batch will be invalid.

During the sampling process, if the cumulative sampling time does not meet the requirements due to the sampler itself or external reasons, the sample is invalid.

During the sampling process, all factors, which affect the effectiveness and representativeness of the sampling, shall be recorded in detail. And based on the quality control data, perform a review and judge the effectiveness of the sampling process.

9.3 Weighing process quality control

9.3.1 Electronic balance quality control

The electronic balance shall be kept energized for a long time as much as possible; or it shall be warmed up and stabilized according to regulations after energizing. Before weighing, it shall check the reference level of the electronic balance and adjust it as needed.

The electronic balance shall be calibrated regularly. Or a standard weight or quality control material similar to the mass of the filter membrane is used to periodically check the performance of the electronic balance. If the results of the period check show that, the performance of the electronic balance has changed and the filter membrane weighing requirements have not been met, calibration shall be carried out immediately.

9.3.2 Filter membrane weighing quality control

The number of the filter membrane shall be unique. The number shall not be directly marked on the filter membrane (except for the filter membranes that have been pre-marked with numbers when leaving the factory).

Before weighing the filter membrane, destaticizing treatment shall be carried out.

The filter membrane before and after sampling shall be weighed using the same electronic balance. Dust-free and anti-static gloves shall be worn during operation.

For filter membrane samples with a small sampling volume, standard filter membranes can be used to monitor the impact of weighing environmental conditions on membrane weighing. The standard filter membrane shall be the same blank filter membrane as the sampling filter membrane, which is obtained by weighing and screening according to 6.2. WEIGH the standard filter membrane more than 10 times discontinuously; calculate the average of the weighing results as the original mass of the standard filter membrane. When weighing each batch of sampling filter membranes, weigh at least 1 standard filter membrane. If the difference between the weighing result of the standard

Appendix A

(Normative)

Method for checking air tightness of sampler

A.1 Overview

The air tightness of the sampler can be checked by the low-pressure method or the flow method. The flow method has a higher uncertainty than the low-pressure method; so, it is suitable for applications where low-pressure testing is technically impossible. It can be checked by measuring the flow difference between the inlet and outlet of the sampler pipeline, or the flow difference under different load pressures, or the flow after the sampling port is sealed.

If the condition of the sampler permits, the low-pressure method shall be preferred for check.

A.2 Low-pressure method

Connect the pressure gauge to the sampler air circuit system; CLOSE the sampler's inlet; PUMP air through the built-in or independent pump, to reduce the pressure in the air circuit to 75% of the maximum negative pressure that the sampler can withstand, and at least reduce by 40 kPa. STOP pumping and record the air pressure p_0 and time t_0; then after keeping for at least 1 min, record the air pressure p and time t again; according to formula (A.1), calculate the leakage rate of the sampler air circuit.

$$\phi_L = \frac{p - p_0}{\Delta t} \quad \cdots\cdots\cdots\cdots (A.1)$$

Where:

ϕ_L - Leakage rate, in kilopascals per second (kPa/s);

p - The pressure of air circuit at the end of the check, in kilopascals (kPa);

p_0 - The pressure of air circuit at the beginning of the check, in kilopascals (kPa);

Δt - The time from the start of the check to the end of the check, in seconds (s).

REPEAT the measurement 3 times and take the maximum as the leakage rate of the sampler.

A.3 Flow method

C.3 Sources of uncertainty

According to formula (C.1), the measurement results of the mass concentration of fine particulate matter are affected by factors, such as filter membrane treatment, filter membrane weighing, flow rate measurement, sampling timing, and fine particulate matter cutter. In the process of filter membrane treatment, humidity changes can cause changes in the mass of the particulate matter carried by the filter membrane. The equilibrium state of the filter membrane can also lead to changes in the mass of the filter membrane. In the process of filter membrane weighing, the main influencing factor comes from the weighing uncertainty of the electronic balance. Since the same electronic balance is used for weighing, the correlation of the measurement uncertainty shall be considered. In the process of flow rate measurement, the main influencing factor comes from the measurement uncertainty of the flowmeter. The uncertainty introduced by the sampling time is usually negligible. The cutter of fine particulate matter is a particulate matter screening component, which can screen the particle size according to the principle of aerodynamics. The error in its structure size can cause the cutting characteristics to change, thereby affecting the particle size of the collected samples.

C.4 Uncertainty evaluation

C.4.1 Filter membrane treatment

According to 6.2, in the pre-sampling balance process, when the mass difference between the two weighings of the filter membrane does not exceed 40 μg, it is considered to be in equilibrium. Assuming that the measurement results are distributed in a rectangle, the uncertainty introduced is:

$$u_{\mathrm{mm1}} = \frac{40}{2\sqrt{3}} \mu\mathrm{g}$$

In the post-sampling balance process, the mass difference between the two weighings of the filter membrane includes the balance state of the filter membrane and the mass change of the loaded particulate matter on its surface. Assuming that the measurement results are distributed in a rectangle, the uncertainty introduced is:

$$u_{\mathrm{mm2}} = \frac{40}{2\sqrt{3}} \mu\mathrm{g}$$

C.4.2 Filter membrane weighing

The error of any single measurement result does not exceed the maximum

------ The End ------