IS 5182-4 (1999): Methods for Measurement of Air Pollution, Part 4: Suspended Particulate Matter [CHD 32: Environmental Protection and Waste Management]

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IS 5182 (Part 4) : 1999

(Reaffirmed 2005)

भारतीय मानक

वायु प्रदूषण मापन पद्धतियाँ

भाग 4 निलंबित सामग्री

(पहला पुनरीक्षण)

Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART 4 SUSPENDED PARTICULATE MATTER

(First Revision)

ICS 13.040.01

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 1999 **Price Group 3**

Air Environmental Protection Sectional Committee, CHD 32

FOREWORD

This Indian Standard (Part 4) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Air Environmental Protection Sectional Committee had been approved by the Chemical Division Council.

Serious damage may be caused by polluting substances discharged into the atmosphere from various sources. Such emissions can adversely affect agricultural land and crops, can soil clothing and building, can corrode metal installations and can have a harmful effect on the health of the community.

The pollutants emitted into the air may be arbitrarily classifed as follows:

a) Solid material, such as grit, coarse enough to settle out fairly rapidly. The quantity of such material may be assessed by the method described in IS 5182 (Part 1) : 1969 'Methods for measurement of air pollution:Part 1 Dustfall'.

b) Finer material which tends to remain suspended in the air, but can be collected by filtration. Heavy concentration of such materials can limit visibility or cause blackening of buildings and clothing. A method of quantitative assessment is given in this standard.

c) Gaseous impurities, which can be separated from the air by chemical means. An example of such impurities is sulphur dioxide, which causes corrosion and presents a health hazard. A method for the determination of this pollutant is given in IS : 5182 (Part 2) : 1969 'Methods for measurement of air pollution: Part 2 Sulphur dioxide (*under revision*)'.

Suspended matter means all particulate material which is too small in size to have an appreciable falling velocity and which, therefore, persists in the atmosphere for lengthy periods.

Suspended particulate matter consists of smoke, dust, fumes and droplets of viscous liquids. Suspended particulate matter varies in size from well below 1 micron to approximately 100 microns. These arise from many sources, such as incomplete combustion of solid, liquid or gaseous fuels; wastes from metallurgical, chemical and refining operations; incineration and numerous other processes. Besides, natural sources also contribute suspended materials like spores, salt water spray, pollens, etc.

Among the effects of particulate pollutants are reduction of visibility, soiling and deterioration of materials, plant damage, irritation of tissues, and possible damage to health.

The determination of composition of suspended particulate matter in the atmosphere sheds light on the nature of particulate pollution. A detailed chemical analysis of particulate samples from urban and rural areas provides basic data that is valuable in the overall assessment of air pollution. Such data may be useful in pin-pointing sources of pollution in predicting potential health effects.

This Indian Standard was published in 1973; however, in view of experience gained so far, the technical committee decided to revise this standard. In the revised version, correction factors for pressure and temperature, have been introduced.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART 4 SUSPENDED PARTICULATE MATTER

(First Revision)

1 SCOPE

1.1 This standard (Part 4) prescribes a method for the determination of concentration of suspended particulate matter in air.

1.1.1 This method gives a direct measure of the mass of the materials filtered out from the sample of air.

1.1.2 This method does not cover particle counting or sizing.

2 REFERENCE

The following Indian Standard contains provisions which through reference in this text, constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

IS No.	*Title*
4167 : 1980	Glossary of terms relating to air pollution (*first revision*)

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 4167 shall apply.

4 FIELD OF APPLICATION

4.1 Sampling flow rate shall not be less than 0.8 m^3/min. Average flow rates within 1.1 -1.4 m^3/min over 24 h sampling, shall give satisfactory results. If particulate levels are unusually high, a satisfactory sample may be obtained in 6-8 hours. For determination of average concentrations of suspended particulates in ambient air, a standard sampling period of 24 hours is recommended.

4.2 Mass is determined to the nearest 0.1 mg, air flow rates to the nearest 0.03 m^3/min, and time to the nearest 2 min and mass concentration reported to the nearest microgram per cubic metre.

5 INTERFERENCES

5.1 Particulate matter which is oily, such as photochemical smog or wood smoke, may block the filter and cause a rapid drop in air flow to a non-uniform rate. Dense fog or high humidity can cause the filter to become too wet and severely reduce the air flow through the filter.

5.2 Glass-fibre filters are comparatively insensitive to change in relative humidity, but collected pariculates can be hygroscopic.

5.3 Whenever the concentration of particulates is abnormally high, there may be loss of particulates because of the weak adhesion of the particles to the filter.

6 APPARATUS

6.1 Sampler

The sampler shall be composed of three main parts, namely:

a) the face plate gasket and retaining ring,
b) the filter adapter assembly, and
c) the motor fan unit.

The sampler shall be capable of drawing ambient air through a portion of a clean glass fibre filter of 8" × 10" size with an effective area of not less than 400 cm^2 at a flow rate of 1 m^3/min with a permissible variation of 0.3 m^2/min, over 24 hours. The motor shall be able to operate continuously for 24-hour period with input voltage unit through automatic voltage stabilizer giving an output voltage ranging from 190-230 V at 50 - 60 Hz and shall be properly earthed. The housing for the motor unit may be of any convenient construction as long as the assembly remains air-tight and leak-free.

NOTES

1 Replace brushes before they are worn out to the point where damage to the motor can occur.

2 Replace when the margins of samples are no longer sharp. The gasket may be sealed to the retaining plate with rubber cement or double-sided adhesive tape.

6.2 Sampler Shelters

It is important that the sampler shall be properly installed in a suitable shelter. The shelter is subjected to extremes of temperature, humidity, and all types of air pollutants. For these reasons, the materials of the shelter shall be chosen carefully. The sampler shall be mounted vertically in the shelter so that the glass-fibre filter is parallel with the ground. The shelter shall be provided with a roof so that the filter is protected from precipitation and debris. The internal arrangement and configuration of a suitable shelter with a gable roof are shown in Fig. 1.

The clearance area between the main housing and the roof at its closest point shall be 580 ± 195 cm^2. The main housing shall be rectangular, with dimensions of about 29 cm × 36 cm.

6.3 Flow Metering Device

This device is usually a rotameter or U-tube manometer or orifice meter and shall have an accuracy of 0.03 m^3/min in the flow range of 0.8-1.7 m^3/min when calibrated against a standard orifice meter. The calibration of the device shall be checked at least once in 3 months.

6.4 Orifice Calibration Unit

This consists of a metal tube of 7.6 cm internal diameter and 15.9 cm in length, provided with a static pressure tap 5.1 cm from one end. The tube end nearest to the pressure tap is flanged to about 10.8 cm in external diameter with a male thread of same size as the inlet end of the high volume sampler. A single metal plate, 9.2 cm in diameter and 0.24 cm thick, having a central orifice of 2.9 cm in diameter, is held in place at the air inlet end with a female threaded ring. The other end of the tube is flanged to hold a loose female threaded coupling which screws on the inlet of the sampler. A gasket and five multi-hole resistance plates (5, 7, 10, 13 and 18 holes) are positioned between the orifice and sampler. The 18 hole metal

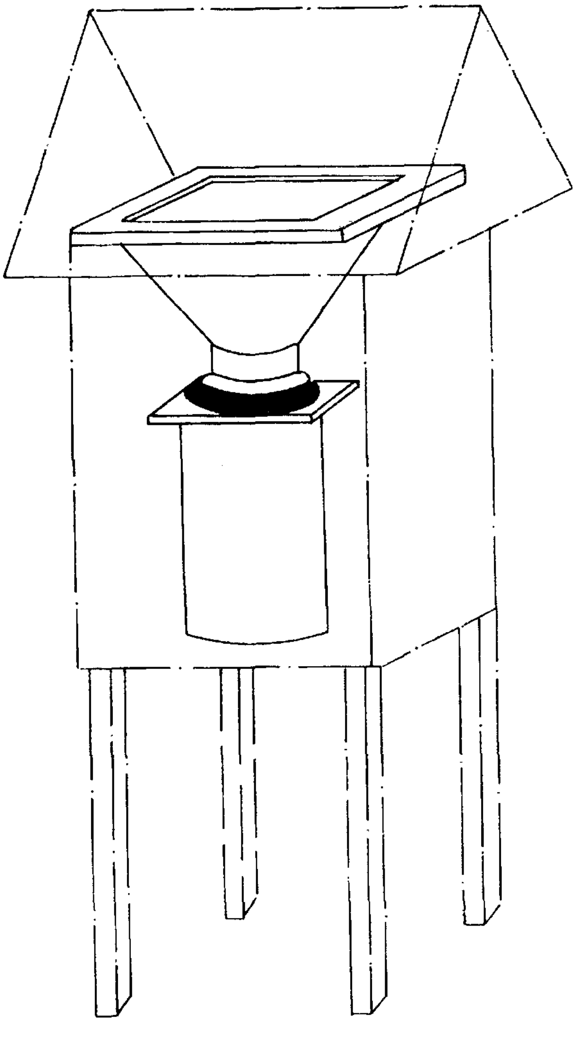

FIG. 1 SAMPLER AND SHELTER

plate simulates the resistance of a clean glass-fibre filter while other plates represent a filter with increasingly heavy dust loading. An orifice calibration unit is shown in Fig. 2.

6.5 Positive Displacement Meter

Calibrated in cubic meters to be used as a primary standard.

6.6 Barometer

Capable of measuring atmospheric pressure to the nearest millimetre of mercury.

6.7 Filter Conditioning Equipment

Balance room or desiccator maintained within 20-30°C with less than 50 percent relative humidity.

7 REAGENTS

7.1 Filter Media

Glass-fibre filters or equivalent having a collection efficiency of at least 99 percent for particles of 0.3 µm diameter shall be used for the quantitative measurement of concentrations of suspended particulates. If a more detailed analysis is contemplated, care shall be exercised to use filters that contain low background concentrations of the pollutant being measured. Careful quality control is required to determine background levels of these pollutants.

8 SAMPLING

8.1 Filter Preparation

Expose each filter to the light source and inspect for pinholes, particles or other imperfections. Filters having visible defects shall not be used. A small brush is useful for removing loose particles. Equilibrate the filters in the filter conditioning environment for 24 hours. Weigh the filters to the nearest one-tenth milligram and record the tare weight and filter identification number. Folding the filter before collection of the samples, as far as possible, shall be avoided.

8.2 Sample Collection

Open the shelter, loosen the wing nuts and remove the retaining ring from the filter holder. Install a weighed and numbered glass-fibre filter in position with the rough side up, replace the retaining ring without disturbing the filter and fasten secures. Undertightening will allow air leakage, overtightening will damage the sponge rubber gasket. During inclement weather, the sampler may be removed to a protected area for filter change.

8.2.1 Close the roof of the shelter, run the sampler for about 5 minutes, connect the flow-metering device to the nipple on the back of the sampler, and take the reading of the float fixed with the flow-metering device kept in a vertical position. Estimate the reading to the nearest whole number. If the ball is fluctuating too rapidly, tilt the flow-metering device and slowly straighten it until the float gives a constant reading. Disconnect the flow-metering device from the nipple and record the initial flow-metering device reading and the starting time and date, on the filter folder.

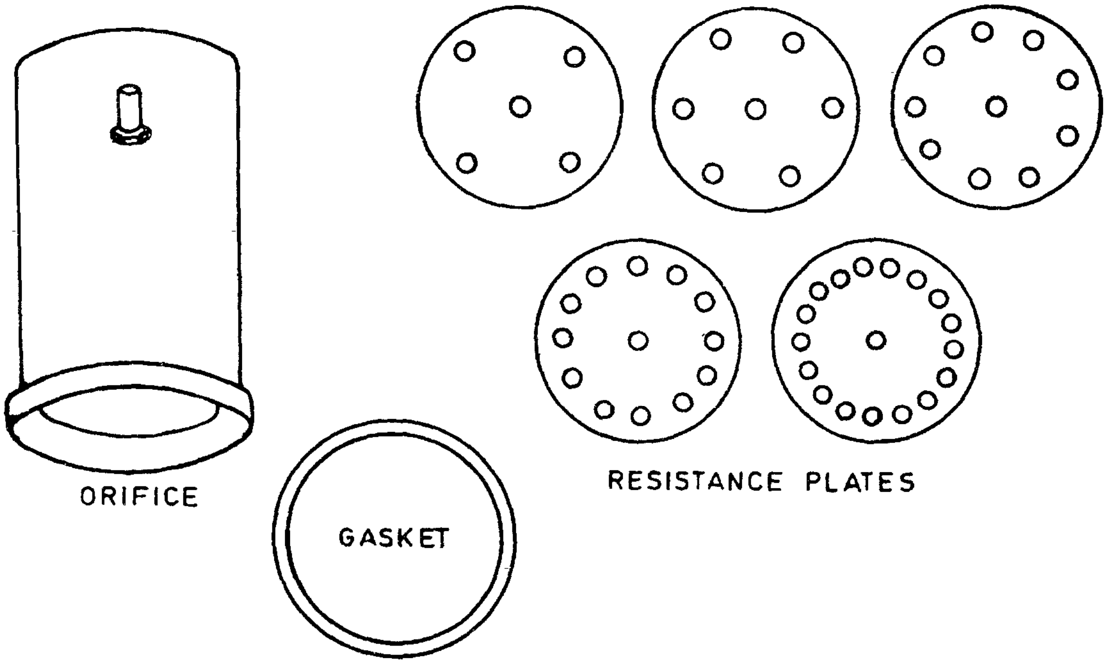

FIG. 2 ORIFICE CALIBRATION UNIT

8.2.2 Sample for 24 hours, and take a final flow-meter reading at the end of the sampling period. Record the final flow-meter reading, ending time and date on type filter holder. Remove the filter retainer as described above and carefully remove the filter from the holder, touching only the outer edges. Fold the filter length-wise so that only surfaces with collected particulates are in contact and place in an envelope. Record on the envelop, the filter number, location and any other factors such as meteorological conditions etc, that might affect the final results.

8.3 Analysis

Equilibrate the exposed filters for 24 hours in the filter conditioning environment and then weigh again. The weighed filters can be used later for detailed chemical analyses.

9 PROCEDURE

9.1 Calibration

Since only a small portion of the total air sampled passes through the flow-meter during measurement, the flow-meter must be calibrated against actual air flow with the orifice calibration unit. Before the orifice calibration unit can be used to calibrate the flowmeter, the orifice calibration unit itself must be calibrated against the positive displacement primary standard.

9.1.1 *Orifice Calibration Unit*

Attach the orifice calibration unit to the intake end of the positive displacement primary standard and attach a high volume blower unit to the exhaust end of the primary standard. Connect one end of a differential manometer to the differential pressure tap of the orifice calibration unit and leave the other end open to the atmosphere. Operate the high volume motor-blower unit so that a series of different, but constant airflows, usually six, are obtained for definite time periods. Record the reading of the different constant airflows, which are obtained by placing a series of loads, one at a time, between the calibration unit and the primary standard. Place the orifice, before the inlet reduces the pressure, at the inlet of the primary standard below atmosphere. A correction must be made, therefore, for the increase in volume caused by this decreased inlet pressure. Attach one end of a second differential manometer to the inlet pressure tap of the primary standard and leave the other end of the manometer open to the atmosphere. During each of the constant airflow measurements made above, measure the true inlet pressure of the primary standard with this second differential manometer. Measure the atmospheric pressure and temperature. Correct the measured air volume to true air volume as given in **10.1**, then obtain the true air flow rate, Q, as given in **10.1.2** Plot the graph for the differential manometer readings (of the orifice unit) against Q.

9.1.2 *High Volume Sampler*

Assemble a high volume sampler with a clean filter in place and run for at least 5 minutes. Attach a flow-metering device , read the float, adjust so that the float gives a reading of 65 and seal the adjusting mechanism so that it cannot be changed easily. Shut off the motor, remove the filter and attach the orifice calibration unit in its place. Operate the high volume sampler at a series of different but constant rate of air flows, usually six. Take the readings of the differential manometer from the orifice calibration unit and record the readings of the flowmeter for each flow-rate. Measure the pressure and temperature of the ambient atmosphere. Convert the differential manometer readings into m^3/min, that is Q; then plot a graph for flowmeter reading against Q.

A modification of the high volume sampler incorporating a method for recording the actual airflow over the entire sampling period is also acceptable for measuring the concentration of suspended particulates. This modification consists of an exhaust orifice meter assembly connected through a transducer to a system for continuously recording airflow on a circular chart. The volume of air sampled is calculated by the following equation:

$$V = Q \, . \, T$$

where

Q = average sampling rate, m^3/min; and
T = sampling time, in min.

The average sampling rate, Q, is determined from the recorder chart by estimation, if the flow-rate does not vary more than 0.11 m^3/min during sampling period. If the flow-rate does vary more than 0.11 m^3/min during the sampling period, read the flow rate from the chart at 2 hour intervals and take the average.

10 CALCULATIONS

10.1 True Air Volume

True volume of air at atmospheric temperature, in m^3 $\quad Va = \dfrac{(Pa - Pm)}{Pa} \times Vm$

Pa = barometric pressure, in mm of mercury;
Pm = drop in pressure at inlet to reference orifice, in mm, of mercury; and
Vm = volume measured using the standard orifice, in m^3.

10.1.1 *Convertion Factors*

Inches of mercury × 25.4 = millimetres of mercury;
Inches of water $\times 73.48 \times 10^{-3}$ = inches of mercury;
Cubic feet of air × 0.028 4 = cubic metres of air.

10.1.2 *True Air Flow Rate*

True air flow rate, Q, in m^3/min $= \dfrac{Va}{T}$

where

T = duration of sampling, in min.

10.2 Sample Volume Conversion

Convert the initial and final flow-meter readings to true air flow-rate, Q, using the calibration curve established in accordance with **9.1.1.**

10.3 Calculation of Volume of Air Sampled

Volume of air sampled, V, in $m^3 = \frac{(Q_1 + Q_2)}{2} \times T$

where

Q_1 = initial air flow rate in m^3/min,
Q_2 = final air flow rate in m^3/min, and
T = sampling time, in min.

10.4 Corrections for Pressure or Temperature

If the pressure or temperature during calibration of high volume sampler is substantially different from the pressure or temperature during orifice calibration, a correction of the flow rate, Q may be required. If the pressures differ by not more than 15 percent and the temperatures, in °C, differ by not more than 100 percent, the error in the uncorrected flow-rate will be not more than 15 percent. If necessary, obtain the corrected flow- rate as given below. This correction applies only to orifice meters having a constant overflow coefficient. This coefficient for the calibrating orifice described in **6.4**, has been shown experimentally to be constant over the normal operating range of the high volume sampler, of 0.6 to 2.2 m^3/min.

Calculate corrected flow rate according to the formula:

$$Q_2 = Q_1 \frac{T_2 \times P_1}{T_1 \times P_2}$$

where

Q_2 = corrected flow rate, m^3/min;
Q_1 = flow-rate during high volume calibration, m^3/min;
T_1 = absolute temperature during orifice unit calibration, K;
P_1 = barometric pressure during orifice unit calibration, in mm Hg;
T_2 = absolute temperature during high volume calibration, °K; and
P_2 = barometric pressure during high volume calibration, in mm Hg.

10.5 Calculation of Mass Concentration of Suspended Particulate Matter

$$SP = \frac{(M_2 - M_1) \times 10^6}{V}$$

where

SP = mass concentration of suspended particulates in $\mu g/m^3$.
M_1 = initial mass of filter, in g;
M_2 = final mass of filter, in g;
V = air volume sample, in m^3; and
10^6 = conversion factor from grams to micrograms.

Masses are determined to the nearest 0.1 mg; airflow rates are determined to the nearest 0.03 m^3/min; times are recorded to the nearest 2 min; and mass concentrations are reported to the nearest $\mu g/m^3$.

11 PRECISION, ACCURACY AND STABILITY

Based upon collaborative testing, the relative standard deviation for single analyst variation, or repeatability of the method, is 3.0 percent. The corresponding value for multilaboratory variation, or reproducibility of the method is 3.7 percent.

Bureau of Indian Standards

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc : No. CHD 32 (144).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at : Prabhat Offset Press. New Delhi-2