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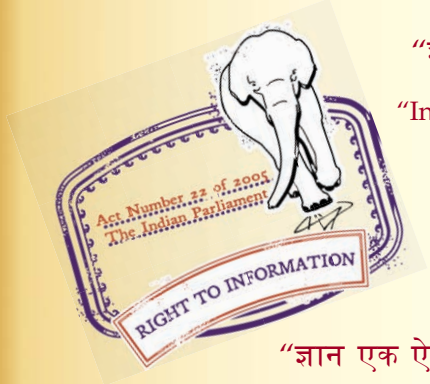
IS 5182-23 (2006): Methods for Measurement for air Pollution, Part 23: Respirable suspended particulate matter (PM 10), cyclonic flow technique [CHD 32: Environmental Protection and Waste Management]



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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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भारतीय मानक

वायु प्रदूषण मापन की पद्धतियाँ

भाग 23 श्वसनीय निलंबित विविक्त पदार्थ (पी एम$_{10}$), चक्रवाती प्रवाह तकनीक

Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART 23 RESPIRABLE SUSPENDED PARTICULATE MATTER (PM_{10}), CYCLONIC FLOW TECHNIQUE

ICS 13.040.01

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

March 2006

Price Group 3

FOREWORD

This Indian Standard (Part 23) was adopted by the Bureau of Indian Standards, after the draft finalized by the Environment Protection and Waste Management Sectional Committee had been approved by the Chemical Division Council.

Particulate matter (PM), is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Particles can be suspended in the air for long periods of time. Total suspended particulate (TSP) includes particles of various sizes. A significant fraction of TSP consists of particles too large to enter the human respiratory tract, Fig. 1 shows typical particulate penetration in the human respiratory system, therefore, TSP is not a good indicator of health-related exposure. There is now an increasing amount of scientific evidence which indicates that respirable suspended particulate matter (RSPM) or PM_{10} portion of the TSP is correlated to health impacts of particulate matter.

Almost all fine particulates are generated as a result of combustion processes, diesel fuelled engine combustion, and various industrial processes, including incineration. Emissions from these anthropogenic sources tend to be PM_{10} and/or $PM_{2.5}$. Their chemical and physical composition, vary depending on location, time of the year and meteorology. Health effects short-term exposure to PM_{10} can irritate the lungs and perhaps cause immune responses; lung constriction, producing shortness of breath and cough may result. The materials dissolving from the particles can also damage cells. Larger particles deposit in the upper respiratory tract, while smaller inhalable particulates travel deeper into the lungs and are retained for longer periods of time. Long-term, lower level PM_{10} exposure may cause cancer and premature deaths. Both PM_{10} and $PM_{2.5}$ can accumulate in the respiratory system and are associated with numerous health effects.

United States EPA's National Ambient Air Quality Standards (US NAAQS) has set an air quality standard of 50 $\mu g/m^3$ for long-term 1-year average concentrations of PM_{10}, short-term, 24 h PM_{10} concentrations should not exceed 150 $\mu g/m^3$ more than once a year. Long-term (annual) $PM_{2.5}$ concentrations should not exceed 15 $\mu g/m^3$ more than once a year and the short-term (daily) $PM_{2.5}$ concentrations should not exceed 65 $\mu g/m^3$ more than once a year. The WHO has a 50 $\mu g/m^3$ annual average guideline limit.

The sampling and analysis of any pollutant is of fundamental importance. There are large number of sampling system available for PM_{10} measurement each with its own advantages and disadvantages. Since the inlet determines which particles are excluded and which pass through the collection system, the inlet is actually defining the particle cut-off size and thus the species captured. The correct use of the inlet, the flow rate and the general operation of the system is vital to the accuracy of PM_{10} determination. Other methods for measurement of RSPM are in the consideration of the Committee for formulation as separate Indian Standard.

There is no ISO Standard on the subject. The standard is prepared based on the measuring techniques available and use in India.

The composition of the Committee responsible for formulation of this standard is given at Annex A.

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 23 RESPIRABLE SUSPENDED PARTICULATE MATTER (PM_{10}), CYCLONIC FLOW TECHNIQUE

1 SCOPE

This standard (Part 23) prescribes methods for measurement of respirable particulate matter PM_{10} in the ambient air with the help of an appropriate cyclonic particle fractionating device.

2 REFERENCE

The standard listed below contains provisions which, through reference in this text, constitutes provisions of this standard. At the time of publication, the editions indicated was valid. All standards are subject to revision and parties to agreements based on this standard is 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

3.1 For the purpose of this standard, the definitions given in IS 4167 and the following shall apply.

3.1.1 *Respirable Suspended Particulate Matter (PM_{10})*, PM_{10} size convention closely resembles the thoracic size distribution (*see* Fig. 1) and has a 50 percent penetration at 10 micron equivalent diameter/aerodynamic diameter. Figure 1 shows the size distribution of particulate penetration in different portions of the human respiratory tract and the PM_{10} size distribution adopted by the international community.

3.1.2 *Inhalable Particles (IPM)*, are particles that can be breathed through the nose or mouth — or all particles that enter the human respiratory tract.

3.1.3 *Thoracic Size Distribution (TPM)*, includes particles that travel past the Larynx and reach the gas exchange region of the Lungs.

4 PRINCIPLE

Air is drawn through a size-selective inlet and through a 20.3 cm × 25.4 cm filter at an flow rate of about 1 000 l/min. Particles with aerodynamic diameter less than the cut-point of the inlet are collected by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM_{10} in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

NOTE — The method of PM_{10} sampling is non-destructive and the sample is available further analysis of other components.

5 RANGE AND SENSITIVITY

5.1 Lower Quantifiable Limit

For a 24 h sample duration at about average 1 000 l/min, the lowest detection limit is determined by the reproducibility of the filter weight difference which shows a standard deviation (σ) of approximately ±2 mg. The three σ detection limit is then approximately 3.5 $\mu g/m^3$. The three σ lower quantifiable limit depends on the filter used and may be even 5 $\mu g/m^3$.

5.2 Upper Quantifiable Limit

For a 24 h sample duration at about average 1 000 l/min, the upper quantifiable limit is 1 000 $\mu g/m^3$. However, the exact value depends on the nature of the aerosol being sampled; very small particles will clog the filter at a relatively low mass loading while larger particles will bounce off during sample transport at high concentrations.

6 INTERFERENCES

6.1 Passive Deposition

Passive deposition occurs when windblown dust deposits on a filter both prior to and after sampling.

6.2 Re-circulation

Re-circulation occurs when the blower exhaust, which contains carbon and copper particles from the armature and brushes, is entrained in the sample air. Positive biases of 0.15 $\mu g/m^3$ have been measured, which are insignificant mass interference but which may affect carbon and copper measurements. Re-circulation can be minimized by assuring a tight seal between the blower and the sampler housing or by ducting blower exhaust away from the sampler. If the cyclone walls or the cup below are not cleaned and have accumulated too much particulate some of these may get re-entrained

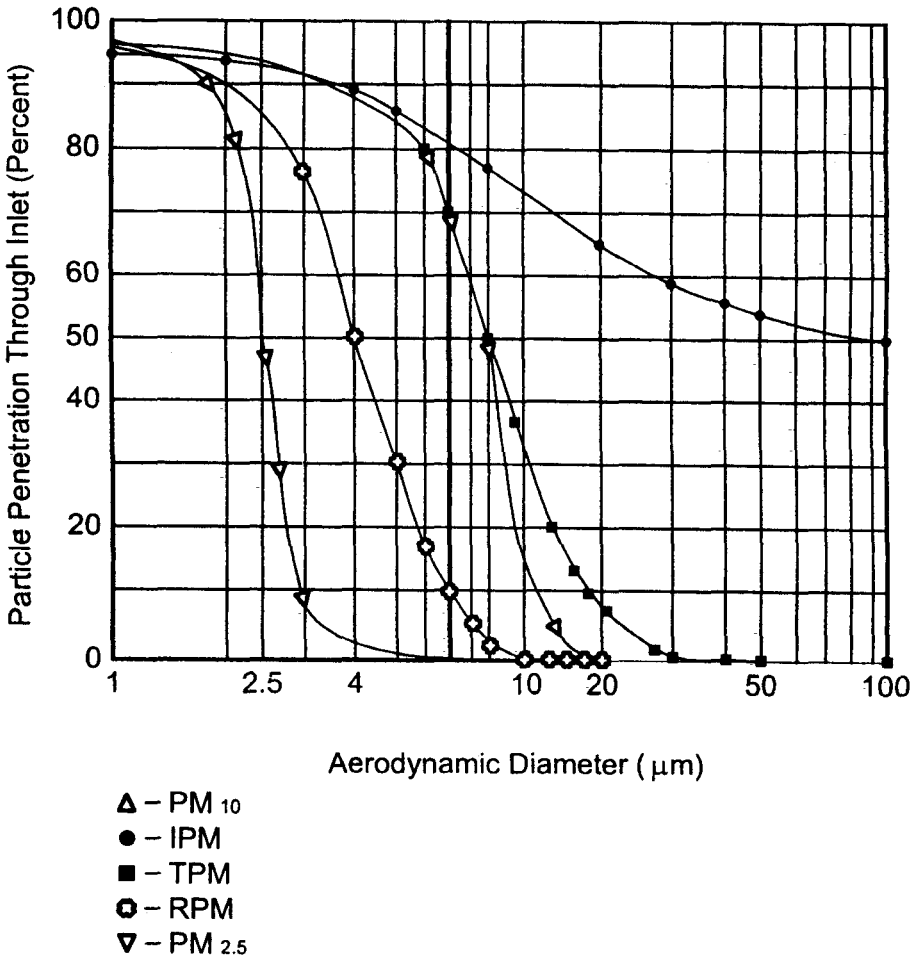

FIG. 1 SIZE DISTRIBUTION OF PARTICULATE PENETRATION IN DIFFERENT POSITIONS OF THE HUMAN RESPIRATORY TRACT

and reach the filter paper causing erroneously high PM_{10} values to be reported.

6.3 Filter Artifact Formation

Sulphur dioxide, nitrogen oxides, nitric acid and organic vapours can be absorbed on the filter medium along with the suspended particles thereby causing positive biases. Samples taken in the presence of high SO_2 concentrations have been shown to yield up to 10 $\mu g/m^3$ of excess sulphate on glass fibre filters.

6.4 Filter Conditioning

Filter conditioning environments can result in different mass measurements as a function of relative humidity (RH). Hygroscopic particles take on substantial quantities of water as RH increase, especially above the deliquescence point of approximately 70 percent RH. Increased mass deposits of 50 percent or more have been observed as RH increases to 100 percent. Twenty four hours at a constant temperature and RH is considered adequate for sample equilibration.

6.5 Shipping Losses

Particle loss during transport occurs when filters are heavily loaded with large dry aerosols. It is more prevalent on membrane than on glass fibre filters. Particle loss is minimized by shorter sample duration in heavily polluted environments, use of fibre as opposed to membrane filters, folding the filter prior to transport and careful shipping procedures.

7 APPARATUS

7.1 Sampler — The essential features of a typical cyclonic fractionating sampler for respirable particulate matter are those of a compact unit consisting of protective housing, blower, voltage stabilizer, time totalizer, rotameter and filter holder capable of supporting a 20.3 cm × 25.4 cm glass fibre filter. A typical schematic sampler is shown in Fig. 2.

7.2 Cyclonic Size Selective Inlet for PM_{10} Sampling

7.3 Volume Flow Controllers — For a PM_{10} Sampler flow rate is maintained within 15 percent of the

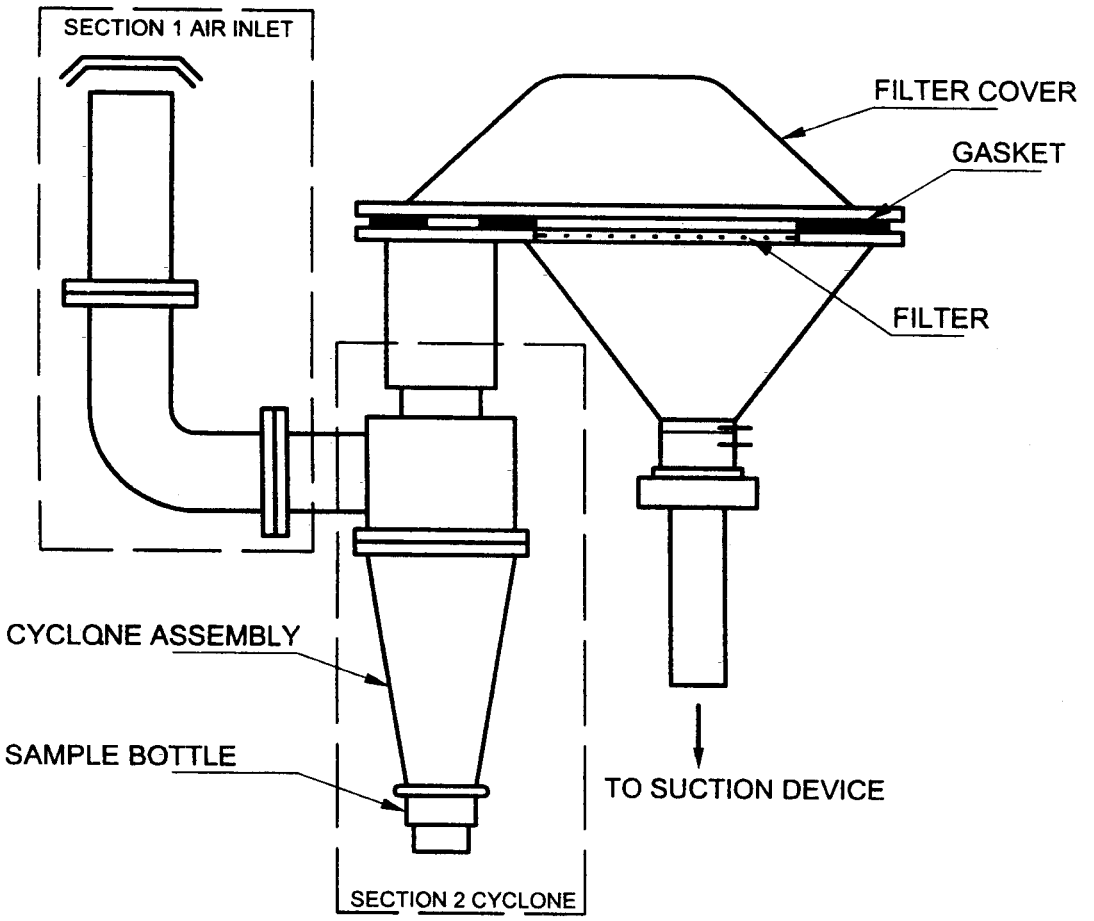

FIG. 2 A TYPICAL SCHEMATIC SAMPLER

designed flow rate (1 000 l/min) for the cyclone separating device. An automatic flow controller with flow sensing device and feedback should be provided to constantly monitor the flow rate and compensate for decrease in flow rate due to filter choking by dust load or flow rate changes on account of voltage fluctuation. A voltage stabilizer may be provided to compensate for voltage fluctuation.

NOTE — The flow rate decreases as the filter deposit increases. Sampling should be stopped and the filter paper should be replaced when the flow rate decreases to 850 litre/min.

7.4 Analytical Balance — having a sensitivity of 0.01 mg.

7.5 Elapsed Timer — accurate to ±1 min.

7.6 Flow Metering Device — accurate to ±5 percent.

7.7 Equilibration Rack — The rack to separate filters from one another so that the equilibration air can reach all parts of the filter surface.

NOTE — A photograph record rack serves this purpose well.

7.8 Numbering Machine — An incrementing numbering machine that prints 4 to 8 digit ID numbers.

7.9 Psychrometer

7.10 Filter Media — A 20.3 cm × 25.4 cm glass fibre filter.

NOTE — Glass fibre filters meet requirements in most categories with the exception of artifact formation and blank levels. Sampling efficiency is very high for all particle sizes. Blank levels for several elements of interest are high and variable. Glass fibre filters may exhibit organic carbon artifacts. Appropriate filter media should be used in case filters are subjected to chemical analysis.

7.11 Filter Jacket — A smooth, heavy paper folder or envelope is used to protect the filter between the lab and field and during storage. Filter and sampling data are often recorded on the outside of the jacket, but this should not be done while the filter is in the jacket to prevent damage.

8 PROCEDURE

8.1 Calibration of Sampler

The sampler shall be periodically calibrated at least once in six months or whenever a major repair/ replacement of blower takes place, by using top loading calibrator traceable to national standard.

8.2 Filter Inspection

Clean the light table surfaces. Filters should be handled with clean hands to prevent contamination. Clean lands each filter on the light table and examine it for pinholes, loose particles, tears, creases, limps or other defects. Loose particles may be removed with a soft brush. Filters not meeting the above visual criteria shall not be used.

If chemical analyses are to be performed, one or two filters from each lot shall be analyzed for blank levels.

8.3 Filter Identification

Apply an ID number to the upper right hand corner on the smoothest side of each filter with the incrementing number machine. Gentle pressure is to be used to avoid damaging the filter. Record this number in a chain of the custody log-book and on a filter jacket. The chain of custody log-book contains columns opposite every filter ID to record dates and technician initials for filter inspection. Equilibration, pre-weighing, shipment to field, receipt from field, re-equilibration, post-weighing and storage.

These records identify the disposition of each sample and prevent the creation of two samples with the same ID.

8.4 Filter Equilibration

Place blank or exposed filters in air tight desiccators having active desiccant in the control temperature 15 to 27°C and 0 to 50 percent relative humidity environment for 24 h prior to weighing. The rack should separate filters such that all surfaces are exposed to the equilibration environment. Measure the temperature and relative humidity of the controlled environment and record the values in the equilibration column of the chain of custody log-book.

8.5 Filter Weighing

Weigh filters in-groups of 10 to 50. Use clean hands for all filter handling. Stack filter jackets with data forms printed on them in the same order (in ascending order of filter ID number, if possible) as the order of filters in the equilibration rack. Adjust the balance tare to read zero with nothing in the weighing chamber and adjust the span to read (or verify that it read) 30 000 g ± 0.000 3 g with the 3 g standard weight on the weighing pan. Place a filter on the weighing pan and obtain a stable reading. Record the weight on the data form in the blank or exposed filter column. Verify the zero and span every ten filters. Place each filter in its filter jacket when weighing is complete, but do not seal the jacket opening. A separate technician randomly selects four filters or 10 percent of all filters in the batch (whichever is larger), re-weigh them and subtract this check-weight value from the corresponding routine weigh. If any check-weight differs by more than 4.0 mg from the routine weight, re-weigh all the filters. Seal filter jackets and ship blank filters to the field or place exposed filters into storage.

8.6 Field Sampling

Tilt back the filter house cover and secure it according to manufacturers instructions. Loosen the faceplate wing nuts and remove the faceplate. Remove the filter from its jacket and center it on the support screen with the rough side of the filter facing upwards. Replace the face-plate and tighten the wing-nut to secure the rubber gasket against the filter edge. Gently lower the inlet. Inertial jet and cyclonic inlets must have their seals in contact with the top of the faceplate. Look underneath the inlet just as it is coming into contact with the faceplate to assure that this contact is being made. It may be necessary to re-adjust the position of the filter/ motor assembly in the sampler housing to obtain such a seal. Excessively windy and wet conditions should be avoided when changing samples. Pre-loading in a filter cartridge assembly, temporary removal of the sampler to a protected area, or a wind or rain shield may be used if, the sample must be changed in inclement weather. Set the timer for the desired start and stop time. Replace the chart paper in the flow recorder, if there is one, set the proper time and mark the time and date on the chart. For a manually flow controlled sampler turn on the motor for 5 min and measure the exhaust pressure with a pressure gauge or rotameter. Read the flow rate corresponding to its exhaust pressure from the calibration curve and record it on the data sheet. Turn off the motor and assure that the timer is in its automatic mode. For automatically flow-controlled units, record the designed flow rate on the data sheet. Record the reading of the elapsed time meter. The specified length of sampling is commonly 8 h or 24 h. During this period several reading (hourly) of flow rate should be taken.

After sampling is complete, record the final flow rate and the elapsed time in the same manner. Subtract the initial elapsed time from the final elapsed time to determine the sample duration. Remove the faceplate by removing the wing nuts. Fold the filter in half lengthwise by handing it along its edge with the exposed side inward. Insert the filter in its jacket. Note the presence of insects on the deposit, loose particles, non-centered deposits, evidence of leaks, and unusual meteorological conditions on the data sheet. Mark the flow recorder chart, if any, and return it with the data sheet.

NOTE — In order to avoid the loss of weight due to potential loss of volatile particles, the sampled filter media should be weighed as early as possible after conditioning as mentioned in **8.5**.

9 CALCULATION

9.1 Calculation of volume of air sampled:

$$V = Qt$$

where

V = volume of air sampled, in m^3;

Q = average flow rate, in m^3/min; and

t = total sampling time, in min.

9.2 Calculation of PM_{10} in ambient air

$$PM_{10}\ (\text{as } \mu g/m^3) = \frac{(W_2 - W_1) \times 10^6}{V}$$

where

PM_{10} = mass concentration of particulate matter less than 10 micron diameter, in $\mu g/m^3$;

W_1 = initial of filter, in g;

W_2 = final weight of filter, in g;

V = volume of air sampled, in m^3; and

10^6 = conversion of g to µg.

10 PRECISION AND ACCURACY

Mass of the filter deposit, flow rate through the filter, and sampling time have typical precision of ±2 mg, ±5 percent and ±1 min, respectively, as determined from performance tests. The accuracy of those measurements can be well within these tolerances when determined with independent standards. These uncertainties combine to yield a propagated precision of approximately ±13 percent at 10 $\mu g/m^3$. The filter deposit mass, measurement precision dominates at low concentrations while the flow rate precision dominates at high concentrations.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

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This Indian Standard has been developed from Doc : No. CHD 32 (1217).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Prabhat Offset Press, New Delhi-2