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METHOD FOR MEASUREMENT OF AIR POLLUTION

PART III RADIOACTIVITY (PARTICULATE) IN AIR

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

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Indian Standard

METHOD FOR MEASUREMENT OF AIR POLLUTION

PART III RADIOACTIVITY (PARTICULATE) IN AIR

0. FOREWORD

0.1 This Indian Standard (Part III) was adopted by the Indian Standards Institution on 12 March 1970, after the draft finalized by the Chemical Hazards Sectional Committee had been approved by the Chemical Division Council.

0.2 Radioactivity in air arises out of natural processes and man's activities in the field of nuclear energy. It can be present either as particulates or in the form of gases and vapours.

0.2.1 Natural radioactivity in the atmosphere is due principally to radon and thoron, which are inert gases, and their daughter products which are particulate and hence get attached readily to minute dust particles present in the atmosphere. As radon-222 and thoron (radon-220) diffuse into the atmosphere from the earth's crust where they are formed by decay from the naturally occurring radioactive ores, the concentrations of these gases and their daughter products vary quite widely with place, time and meteorological conditions. Certain radionuclides (such as C-14 and H-3) are produced in small quantities in the upper layers of the atmosphere by the action of cosmic rays.

0.2.2 Among the contributions from man's activities to the radioactivity in air, fallout from nuclear weapon tests and releases from mining and processing of radioactive minerals, radiochemical laboratories and from operation of nuclear facilities, may be mentioned.

0.3 Measurement of airborne radioactivity in the environment is required when it is necessary to obtain its value at a given place, to know how it changes from time to time or to determine how it is affected by different known parameters.

0.4 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*).

1. SCOPE

1.1 This standard prescribes the method for the collection and measurement of particulate radioactivity in air. It describes methods of calculation to obtain the gross and the long-lived beta radioactivity in the atmosphere.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 4167-1966* shall apply.

3. SAMPLING

3.0 General — The most easily available and convenient method for sampling of particulates from air is the filtration technique. It consists of collecting the radioactive material from a measured volume of air on a filter paper or mat.

3.1 Filtration Assembly — The assembly illustrated in Fig. 1 consists essentially of a sampling head, flowmeter for reading the rate of flow of air through the system and a suction device. A means of regulating the flow may also be incorporated.

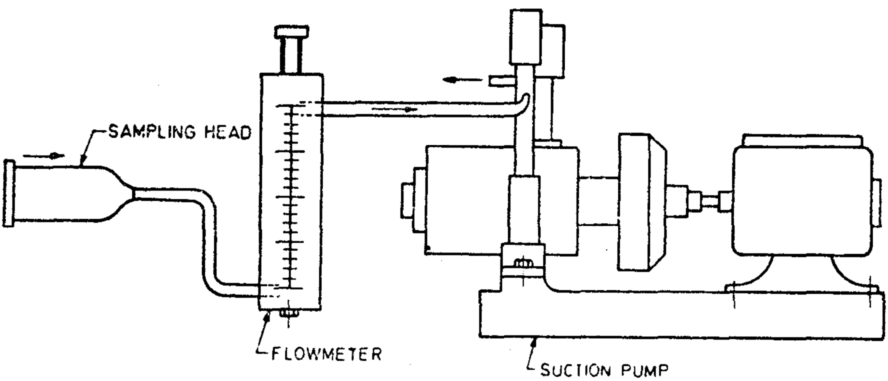
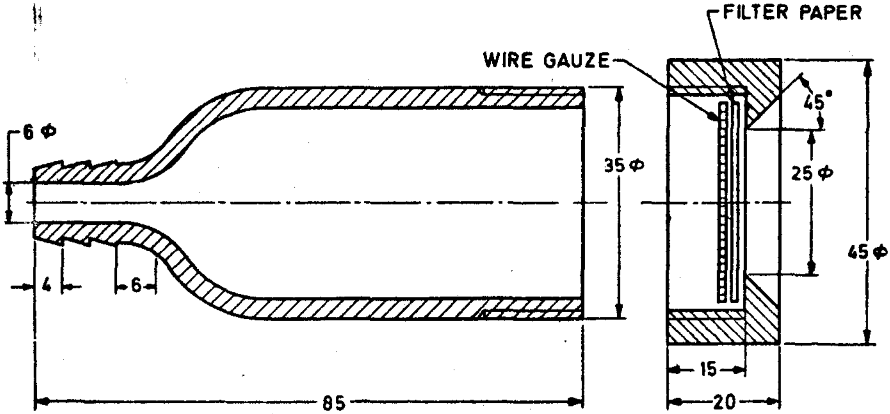


FIG. 1 ASSEMBLY OF FILTRATION APPARATUS

3.1.1 *Sampling Head* — The sampling head or a filter holder should be so designed as to provide uniform air velocity (known as face velocity) across the entire face of the sampling area of the filter. A typical sampling head is shown in Fig. 2.

*Glossary of terms relating to air pollution.



All dimensions in millimetres.

FIG. 2 SAMPLING HEAD

It provides an effective filter area of 25 mm diameter. When the size of the filter to be accommodated is smaller than that represented in the figure, a smaller filter head has to be used. A mechanical support such as a wire gauze, sometimes with a ' O ' ring, is provided to hold the filter paper air-tight at the edges and to prevent displacement or rupture of the filter during sampling. The back-up screen or the support used is normally firmly fixed on the main piece when required to hold brittle filters (such as the membrane type) or soft filters such as of the glass fibre type.

3.1.2 *Filter* — The filter paper for any specific sampling work is selected after considering many factors : cost, availability, resistance to flow that may be permitted, efficiency of collection desired, etc. It may be noted here that papers of high filter efficiency are usually those of high resistance also.

3.1.2.1 The all-cellulose filter papers such as Whatman-41 offer high mechanical strength and are widely used for air sampling mainly because of low cost. However, being not very uniform, the resistance to air flow and consequently the collection efficiency vary from sample to sample.

3.1.2.2 Where almost 100 percent efficiency is required, mixed filter papers such as of the cellulose-asbestos type are much in use. Glass fibre filters also offer very high efficiency.

3.1.2.3 Membrane filters (millipore filters) which combine high collection efficiency even for submicron particles with relatively low resistance are among the most efficient filter media available. Millipore filters consist of thin membranes of cellulose esters perforated with tiny uniform conical holes. Being fragile they require special sampling heads for use.

3.1.3 *Flow-Measuring Device* — Dry or wet gas metres may be employed to record the total volume of air passed directly. Rotameters or float-type gauges may be used to give rates of flow of air.

3.1.4 *Suction Device (or a Source of Vacuum)* — This may be a pump or an ejector which uses steam or compressed air, having the capacity for sampling rate varying between 20 to 200 litres per minute.

3.2 Period of Sampling — When the long-lived radioactivity in air is required, it is sometimes necessary to choose a high rate of sampling and the sampling may be performed for a long time such as a few hours, whereas if the gross activity is required, the sample need be taken from a relatively small volume of air and hence a low flow rate would be adequate.

4. MEASUREMENT OF RADIOACTIVITY

4.1 General — After the sampling is over, the radioactivity of the filter paper with the collected material on it is measured. Knowing the total volume of air sampled, the specific radioactivity of the atmosphere may be calculated.

4.2 Counting

4.2.1 A typical arrangement used for counting the beta radioactivity of filter paper air samples is shown in Fig. 3. It consists of an end-window Geiger-Muller counter. A lead housing for the counter is used in practice (not shown in figure) in order to keep the background count rate low. The filter paper sample is kept below the counter soon after the sampling is over. When the location of sampling is not near the counting laboratory, however, some delay is involved between the end of sampling and the start of counting, and this should be reported.

4.2.1.1 Instead of a Geiger-Muller counter as th deetector, beto sensitive thin plastic scintillator may also be used.

4.2.1.2 By using electronic counting set-up the total counts registered in any given time may be obtained and hence the count rate in counts per minute.

4.2.2 When the count rate is high, as in the initial stages, the counting time may be 6 to 10 minutes. But when the activity falls down, larger counting periods (say 20 to 60 minutes) may have to be employed.

4.2.3 By subtracting the background count rate of the counter obtained without using any sample, the net count rates due to the sample may be calculated.

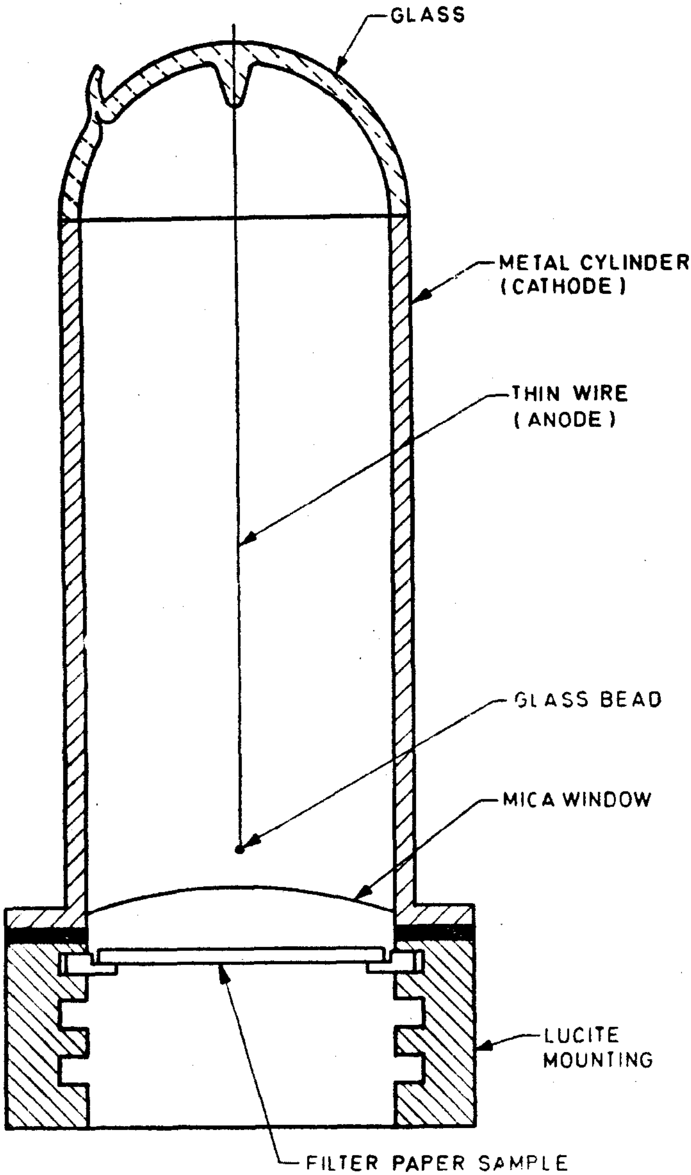


FIG 3. END WINDOW GEIGER-MULLER COUNTER FOR COUNTING FILTER PAPER SAMPLE

4.3 Counter Efficiency — The efficiency factor of the counting set-up (the fraction of the total disintegrations in the sample that is actually counted) should be first obtained by using a standard source of beta radiation. This factor, f, should be used to convert the net counts per minute (cpm) into disintegrations per minute (dpm).

4.4 Calculation — Let the period of collection of sample be equal to t min and the average rate of sampling be v litres per minute. Then total volume of air sampled $V = vt$ litres.

4.4.1 *Gross Activity* — Let the net activity of the filter sample (after subtracting the background of the counter) be C counts per minute at a delay time of about 10 to 15 minutes after the sample collection is over. The air activity may then be expressed as $10^3\ C/Vf$ disintegrations per minute per cubic metre.

4.4.2 *Long-Lived Activity*

4.4.2.1 By counting the filter paper sometime after the collection of the sample is over, thus allowing the natural activity to decay out, it is possible to evaluate the long-lived component of the activity in air.

4.4.2.2 The natural activity of the air is largely a mixture of radium-B and thorium-B. The former has a half-life of 26·8 min and accounts usually for about 90 percent of the natural air activity. Thorium-B has a half-life of 10·6 hours.

4.4.2.3 A period of about 4 hours which is more than 8 half-lives of radium-B is permitted to elapse before the sample is counted for the first time. This ensures that more than 99·5 percent of the radium-B component will have decayed. If one has to wait till almost all thorium-B disintegrates it would delay obtaining the results for three days. Instead, a calculation based upon two counts separated by approximately 24 hours is applied as follows to remove the fraction of the total count due to thorium-B:

Let c_1 be the net count rate obtained at a delay time of t_1 hours and c_2 the net count rate at a delay time, t_2 hours after the end of sampling, the second counting being done after 24 hours of the first counting.

The count rate due to the long-lived beta activity is then given by

$$c = \frac{c_2 - c_1 e^{-\lambda t}}{1 - e^{-\lambda t}}$$

where t is the time interval between the counts, ($t_2 - t_1$) and λ the decay constant of thorium-B (0·065 4 hour^{-1}).

Then the long-lived beta activity

$$= \frac{c/Vf}{2{\cdot}22 \times 10^{9}} = 4{\cdot}5 \times 10^{-10} \times c/Vf \text{ microcuries per millilitre}$$

4.5 Correction for Efficiency of Filter Paper

4.5.1 The calculations in **4.4** assume that the efficiency of the filter paper is 100 percent for retention of particulates carrying the radioactivity. When this assumption is not correct, the values are to be corrected after evaluating efficiency of the filter paper.

4.5.2 Efficiency for retention of the particles on the filter paper used may be experimentally obtained if an absolute filter paper (such as the millipore filter) is kept behind the routine filter while collecting the sample. By obtaining the gross count rates for the two filter papers for the same delay time (time elapsed after the end of sampling), the efficiency of the routine filter paper may be calculated.

5. REPORTING THE RESULTS

5.1 The results of measurement of the radioactivity in air may be reported in a suitable form, such as the proforma given below:

MEASUREMENT OF RADIOACTIVITY IN AIR

a) Location:

b) Date of collection :...........

c) Period of collection :........h to........h = t minutes

d) Average rate of sampling, v = ...litres/minute

e) Total volume of air sampled $V = v.t$ = ...litres

f) Background of the counting set-up = ...counts per minute, cpm

g) Efficiency factor of the counter, f =

$$\frac{\text{observed count rate with the standard source}}{\text{theoretical count rate of the standard source}}$$

h) Count rate of the filter paper sample between......min and........ min after collection = ...cpm

j) Net count rate, C = (h) − (f) = ...cpm

k) Gross beta activity in air = $10^3\ C/V\,f$
= ....dpm/m³

m) Count rate of the filter paper sample after a delay of t_1 hours = ...cpm

n) Net count rate at delay of t_1 hours, c_1 =.........cpm

p) Count rate of the filter paper sample after a delay of t_2 hours = ...cpm

q) Net count rate at delay of t_2 hours, c_2 = ...cpm

r) Count rate due to long-lived activity, $c = \dfrac{c_2 - c_1 e^{-\lambda t}}{1 - e^{-\lambda t}}$ = ...cpm

where $\lambda = 0.065\,4\ h^{-1}$, $t = t_2 - t_1$

s) Long-lived beta activity in air = $4.5 \times 10^{-10}\ c/Vf$ =.........μCi/cm^3

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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