

G.N. 964

FACTORIES AND INDUSTRIAL UNDERTAKINGS ORDINANCE (Chapter 59)

FACTORIES AND INDUSTRIAL UNDERTAKINGS (ASBESTOS) REGULATION

In exercise of the powers conferred on me by section 4(3) of the Factories and Industrial Undertakings (Asbestos) Regulation and section 32 of the Interpretation and General Clauses Ordinance (Chapter 1), I hereby approve, for the purposes of the said Regulation, the method for measuring exposure to asbestos as set out in the Schedule below. This approval is to come into effect on the day when the said Regulation comes into operation.

SCHEDULE

Approved Method for Measuring Exposure to Asbestos in Air

For the purpose of Section 15(1)(a) of the Factories and Industrial Undertakings (Asbestos) Regulation

Approved Method for Measuring Exposure to Asbestos in Air

1. *Introduction*

- 1.1 In pursuance of section 15(1)(a) of the Factories and Industrial Undertakings (Asbestos) Regulation, a proprietor shall ensure that the exposure of any workman in an industrial undertaking to asbestos in the air is monitored by means of an approved method where such monitoring is appropriate for the protection of the health of the workman and whenever there is a substantial change in the working conditions rendering the findings of the previous air monitoring no longer valid. For the purpose of the Regulation, the Commissioner for Labour set out the following method of measurement and calculation as the approved method for the exposure monitoring. This approved method applies when it is necessary to determine whether the concentrations and cumulative exposure of asbestos in the air respectively exceed the control limit and action level specified in the Regulation.
- 1.2 The measurement method is based on personal sampling. It is carried out by drawing a measured volume of air through a membrane filter which is subsequently rendered transparent and mounted on a microscope slide. The fibres collected in the sample are then counted under a phase contrast microscope to evaluate the asbestos fibre concentration in the air.
- 1.3 Exposure measurement should only be performed by persons who have the necessary knowledge and experience in asbestos air sampling. Moreover, they should have been given adequate information and instruction on the work undertaken.
- 1.4 The laboratory testing of asbestos samples needs its own special equipment, skills and a high standard quality control system. Therefore, the test required in the Regulation shall be carried out by a laboratory that is accredited for the relevant asbestos test by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) managed by the Industry Department or by a scheme with which HOKLAS has a mutual recognition agreement.

2. *Scope and Limitation*

- 2.1 The method measures the concentration of fibres in the air using a phase contrast microscopy with the rules specified in paragraph 8.3.
- 2.2 The method only counts a portion of the fibres present in the sample and therefore it does not give the absolute total number of fibres present. However, the counting result can be regarded as an index of the numerical concentration of fibres.
- 2.3 The method cannot distinguish whether a fibre is asbestos or not. It counts fibres regardless of the nature of them.
- 2.4 The uncertainty of the method depends very much on the quality control system of the analytical laboratory and the proficiency of the individual microscopist. It is necessary for the analytical laboratory to have its own intra-laboratory comparative testing supported by participation in inter-laboratory programs to establish the uncertainty.

3. *Lower Detection Limit*

The lower detection limit of the method for a 480 litre sample is 0.010 f/ml.

4. *Equipment*

- 4.1 Membrane filter—must be of cellulose ester or cellulose nitrate type of pore size 0.8 to 1.2 μm , and 25 mm in diameter with a printed grid. Flat tipped metal tweezers of good quality are required for its handling.
- 4.2 Filter holder—an open-faced filter holder fitted with an electrically conducting cylindrical cowl extending between 33 mm and 44 mm in front of the filter, and exposing a circular area of filter at least 20 mm in diameter.
- 4.3 Air sampling pump—a battery operated pump which draws air at a smooth flow maintained within $\pm 10\%$ of the initial rate during the sampling period. The pump shall be light and portable.
- 4.4 Flowmeter—able to measure the flowrate of the air sampling pump to within $\pm 5\%$. The flowmeter itself shall have been calibrated against a soap bubble flowmeter with accuracy traceable to international standards.
- 4.5 Microscope—A binocular phase contrast microscope shall be used for counting the fibre of the sample. It shall have the following features:—
 - (a) Koehler or Koehler-type illumination;
 - (b) a substage Abbe or achromatic phase contrast condenser in a centring focusing mount, with a phase contrast centring adjustment independent of the condenser centring mechanism;
 - (c) a 40x positive phase contrast achromatic objective, numerical aperture 0.65 to 0.70 and phase ring absorption between 65–80%;
 - (d) eyepieces with a magnification of at least 12.5x; one of the eyepieces shall be inserted with a Walton-Beckett graticule and be of focusing type;
 - (e) the graticule with the object-plane diameter measured within $100 \pm 2 \mu\text{m}$ by a stage micrometer using the specified objective and eyepieces;
 - (f) other accessories—a phase telescope to ensure alignment of the phase rings and phase annuli; a green filter to assist viewing; a low power objective to check fibre distribution.
- 4.6 Microscope slides and cover slips—clean glass slides of dimensions about 76 mm \times 25 mm and 0.8–1.0 mm thick. Slides and cover slips shall be clean and manufactured to British Standards BS 7011 Consumable accessories for light microscopes Part 2 Slides and Part 3 Cover glasses: specifications for dimensions and optical properties.

5. *Sampling Procedures*

- 5.1 In an area free from asbestos contamination, the membrane filter shall be placed into the clean filter holder with the grids facing the open end. The filter holder shall be sealed by a protective cap or bung during transport to avoid contamination.
- 5.2 Before sampling, the sampling pump shall be attached to a loaded filter holder with a flexible tubing. The pump shall be running within $\pm 10\%$ of the initial selected flowrate throughout the sampling period. The filter holder shall be attached to the worker's clothing or a harness as close to the nose and mouth as possible and shall be within 20 cm of them. The cowl shall always be pointing downwards. The sampling time shall be measured to within 2%.
- 5.3 After sampling, the filter holder shall be covered by the protective cap or bung. A control should be provided for each sampling exercise. Its purpose is to counter-check any possible sample contamination. A clean filter fitted into a filter holder is subjected to the same treatment of handling and transport as for normal samples. No air shall however be drawn through it nor it should be attached to the pump or the worker. This filter is known as 'field blank'.

6. *Sampling Period and flowrate*

- 6.1 The time to take samples should be carefully chosen so as to collect representative samples within the working period to indicate the actual exposure of the workman.

- 6.2 In measuring asbestos concentration in relation to the 4 hour control limit, the flow-rate of the sampling pump shall be set at 1 litre/min $\pm 5\%$. The sampling period shall be a continuous period of 4 hours. Shorter period is allowed if the following criteria are met:—
- (a) the sampling period is representative of the 4 hour exposure period for which the time weighted average concentration is to be calculated; and
 - (b) the expected fibre density of the filter sample is within or as close as possible to the range 100–400 fibres/mm².
- 6.3 In measuring asbestos concentration in relation to the 10 minute control limit, the flow-rate of the sampling pump shall be set between 1 and 8 litres/min such that the expected fibre density of the filter sample is within or as close as possible to the range 100–400 fibres/mm². In general, a flowrate of 4 litres/min is recommended when the proposed sampling period is 10 minutes.
- 6.4 In measuring asbestos concentration to evaluate the cumulative exposure compared with the action level, the flow-rate of the sampling pump shall be set between 1 and 8 litres/min with the appropriate sampling period such that the expected fibre density of the filter sample is within or as close as possible to the range 100–400 fibres/mm². The sampling period need not be longer than 4 hours.

7. *Filter Clearing and Mounting Method*

- 7.1 When the filter sample is transported to the laboratory after sampling, it shall be cut into halves. One of the halves will be kept for future reference. The other one shall be placed on a microscope slide and cleared by acetone vapour. The sample shall be treated with triacetin and covered with a glass cover slip, using sufficient triacetin to cover the whole filter when the cover slip is in place. Any air bubble trapped beneath the surface of the cover slip may be removed by gentle pressure.
- 7.2 Allow a period of time for the filter to clear completely before counting.

8. *Counting Procedure*

- 8.1 The microscope shall be set up according to the manufacturer's instruction. The microscopist shall use a HSE/NPL phase contrast test slide mark 2 to check the detection limit. He shall be able to see group 5 on the slide when the microscope is used as specified by the manufacturer. The object-plane diameter of the Walton-Beckett graticule shall be checked at suitable intervals using a stage micrometer. The measured diameter shall be used in the later calculations.
- 8.2 The cleared filter sample is examined by transmitted light under phase contrast conditions. The deposit should be first scanned using the low power objective to check the distribution and its uniformity. The sample shall be discarded if the uniformity is poor.
- 8.3 Fibres on the filter are then counted using the 40x objective and the eyepieces in accordance with the following rules:—
- (a) a countable fibre is defined as any object which has a length greater than 5 μm and a width less than 3 μm and the length/width ratio of at least 3:1; and it does not touch or appear to touch a particle with a maximum dimension greater than 3 μm ;
 - (b) a countable fibre with both ends within the graticule area shall be counted as one fibre, a countable fibre with only one end in the graticule area is counted as 1/2 fibre, a fibre passing through the graticule area and having no ends within the area shall not be counted;
 - (c) a split fibre shall be counted as a single fibre if it conforms to the fibre definition in paragraph 8.3(a); the width measured being that of the undivided part, not that of the split part;
 - (d) for fibres in a bundle, they should be counted individually if they can be distinguished and conformed to the fibre definition in paragraph 8.3(a); if no individual fibre meet the criteria, the bundle shall be considered to be a fibre if, taken as a whole, it conforms to the fibre definition in paragraph 8.3(a);
 - (e) if more than one eighth of a graticule area is covered by an agglomerate of fibres and/or particles, reject the graticule area and select another area to count;

(f) count a minimum of 20 graticule area; stop counting when 100 fibres are counted or 100 graticule areas are examined.

- 8.4 The graticule area shall be selected at random within the exposed area of the filter. The counting starts from one end of the filter and progress along an axial line to the other end, shift either up or down on the filter, and continue in the reverse direction.
- 8.5 When counting a graticule area, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibres which have become embedded in the filter.
- 8.6 If more than 3 fibres per 100 graticule areas are found on the blank filter, the cause of filter contamination should be investigated and the airborne measurement shall be regarded as a rough estimate only.

9. Evaluation of Results

The airborne concentration is given by $\frac{1000ND^2}{Vnd^2}$ fibres/ml

where N = number of fibres counted;
 n = number of graticule areas examined;
 D (mm) = diameter of exposed area of filter;
 d (μ m) = diameter of Walton-Beckett graticule measured by a stage micrometer;
 V (litres) = volume of air sampled.

10. Calculation of cumulative exposure for comparison with the action level

- 10.1 Cumulative exposure is calculated by multiplying each airborne asbestos concentration by the time in which the worker is exposed to the dust and adding up all these products over the continuous 12-week period concerned. The airborne concentration can be estimated using available data or past experience of the process involved. In case of uncertainty, the airborne concentration shall be obtained by measurement. The following table is an example illustrating the steps for the calculation of cumulative exposure over a continuous 12-week period.

Duration of exposure (A hours)	Average Concentration (B f/ml)	Number of occurrences in 12 weeks (C)	Fibre-hours per millilitre (A x B x C)
2	0.10	5	1.00
3	0.28	7	5.88
5	0.25	28	35.00
4	0.16	20	12.80

Total fibre hours per millilitre is 54.68

The example is applicable for calculation of exposure to either chrysotile alone or asbestos other than chrysotile, including the mixture containing chrysotile.

- 10.2 In the continuous 12-week period, there may be some periods in which the exposure is solely to chrysotile and other periods in which the exposure is to any other form of asbestos either alone or in mixtures. Then the action level is considered to be exceeded if

$$\frac{E_{\text{chry}}}{AL_{\text{chry}}} + \frac{E_{\text{amp}}}{AL_{\text{amp}}} > 1$$

where E_{chry} = the cumulative exposure to chrysotile alone;
 E_{amp} = the cumulative exposure to other form of asbestos either alone or in mixtures;
 AL_{chry} = the action level for chrysotile alone;
 AL_{amp} = the action level for other form of asbestos either alone or in mixtures.